

Paper 1

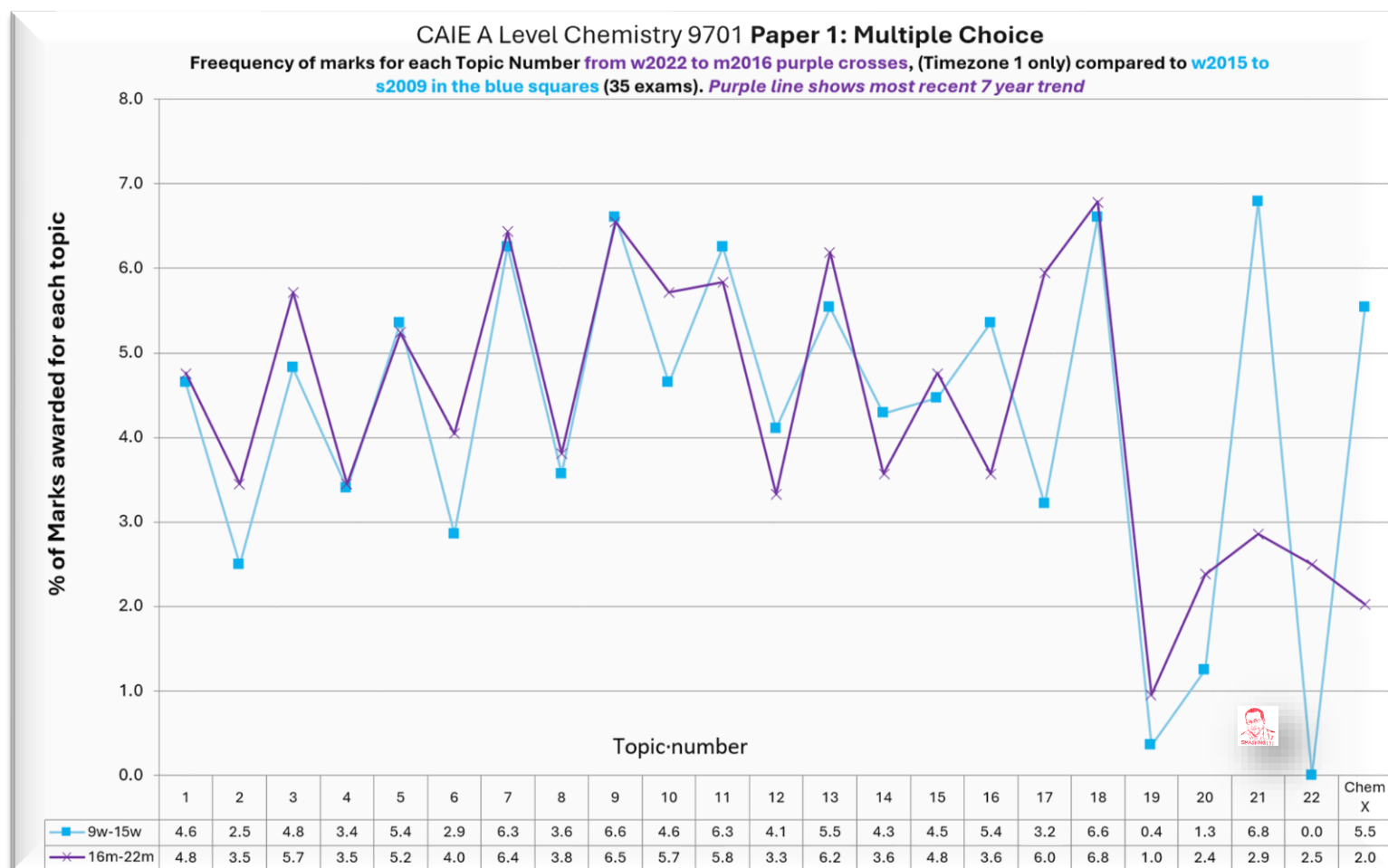
Past Exam Questions

Organised by Topic Number

Summer 2009 to Winter 2022 (35 Papers)

Name: _____

Class: _____



Main Features of this Paper 1 Workbook:

1. **Free.**¹
2. **Organises the exam questions by Topic Number**
 - a. You can see more clearly regular and repeating patterns in the kinds of knowledge, ideas, connections and distinctions questions on each Topic tends to focus on.
 - b. Other patterns in the structure of the question, the style it is asked and the patterns in finding the correct answer and selecting against the incorrect answers are also easier to see when you line up several questions assessing the same syllabus point side by side.
3. **Only uses CAIE 9701 A Level past exam questions**, which are all clearly labelled.
 - a. For students studying the CAIE 9701 Chemistry syllabus these questions are the very best resource to use to consolidate learning, to improve exam technique with and to practice on.
 - b. It can be used for other high school chemistry syllabi if specific exam questions similarly organised by chemistry topics do not exist.
 - c. Trends and changes in questions and marking, including across time, can be more easily identified (though the A Level 9701 syllabus has remained remarkably stable in the last 20 years).
4. Includes **all answers at the back** of this workbook in an easy to find referenced format.
5. Includes **exercises, activities and resources** to help students:
 - a. Focus thinking and build experiences to **help students grow their skills in planning** and in deliberate use of executive function to become more effective and increasingly more independent learners.
 - b. **Goal setting**, including extracurricular and **supra-curricular** activities (see also <https://www.smashingscience.org/expanding-your-mind>).
 - c. A scaffolded approach to a **systematic long term revision program** that helps build **incremental growth** in organisational skills from one test to the next.
 - d. Create plans to deliver achievable steps towards their **biggest dreams**, including **acceptance to the world's best universities** (see also: <https://www.smashingscience.org/uni-guidance>).
 - e. Links throughout to activities and techniques particularly useful or helpful **for English as an additional language learners**.
6. Includes an introduction with explanation and exercises to effective strategies to us **Active Learning, Active Reading** the **Cornell Notetaking System** to drive improvements in exam performance.
7. **Presents original Smashing!!! Analysis** on mark frequencies and other patterns.
 - a. This is intended to make it easier for students and teachers new to the syllabus to get a **deeper insight and understanding of the exam papers, exam questions and syllabus**. Broadening access to the highest quality materials to teach and learn science at school that were created using a data driven, goal orientated (empirical epistemic) approach is the **Smashing!!! Way**.
 - b. **This can help maximise the number of new marks a given study hour can deliver**. When used carefully this helps to direct revision towards the specific Topics which students are weaker in, but more common in the exam record. By **revising only to the topics that a student is weakest in**, but are more common, students will avoid wasting revision time on what they already know. In some cases, they can get 2- or even 3-times increase in the value of their revision when compared with simply working through a complete exam paper. A student that is already at a high A-grade level therefore knows about 75% of the answers in a typical Paper 1 exam: only 25% of the questions they encounter are relevant to their progress. This kind of Workbook could deliver to students only those specific questions they struggle with, so **the proportion of useful questions they are working on is closer to 100%**, instead of unstructured work on complete exam papers that would only deliver 15 minutes every revision hour on worthwhile questions (**up to a 4-fold increase in study efficiency**).
 - c. The most valuable intellectual skillset the best educational experiences can deliver is a deeper understanding of and a more effective ability **to use priorities to get big things done well**.

¹ To get a printed, paper-based version of this (by far the most effective study format of this resource), Google: 'paperback book printers near me' and send them the .pdf file. If you use the 2 pages per sheet .pdf file you'll be able to save resources with the same content. For the elite, premium experience, print the questions in black and white, and everything else in colour, with the first page being the front cover, and your favourite "Hang in there!" hanging kitten picture for the back cover.





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To-Do Checklists for the Paper 1 Workbook

1–2-minute task: Every time you open this book, read one statement, and think about another one, and **give yourself two ticks of progress almost instantly!**

- Eventually, the **Gold statements** with the most amount of ticks might be the things that you need to concentrate most on when you sit your exams at the end of your AS year.
- The **best students** will have also **made notes** that grow these ideas as starting points in their own learning journey to be more thoughtful, deliberate and thereby effective in organising themselves, their time and their progress in exam technique (see the section “*Exercise: My Notes about the Paper 1 To-Do Checklist*” in this Workbook)

5–10-minute task: Investigate a single one of the ideas, patterns, questions and issues that these statements lead to, like looking at websites, other exam papers or other subjects. *Do not do this if you have an important test really soon!*

ID	Learning and thinking about using this Workbook effectively	Iron Read it	Silver Thought about it (why is it included?)	Gold Revisited the idea a month later
1a	Read this statement.	✓		
1b	Find the page for “ Exercise: My Notes about the Paper 1 To-Do Checklist ” in the “ Contents Page ” of this Workbook. Put a paper clip on that page so you can always find it easily.			
1c	Identify, extend and develop your thinking about your AS studies by mapping the codes for the ideas and prompts found in “ Exercise: Structured Analysis and Investigation of the Paper 1 Checklist ” to the “ My Notes about the Paper 1 To-Do Checklist ”.			
1d	Read about “ The Cornell Notetaking System ” at the back of this Workbook.			
1e	Read through and complete the “ Exercise: Learning and Understanding the Five R’s of the Cornell Notetaking ”.			
1f	Try to use the Cornell Notetaking System for one or all of your AS subjects, either by getting a preprinted notepad, or by using the pages in the section “ Trying out the Cornell Notetaking System ”.			
1g	Read through the “ Learning to Learn ” section at the back. Why do you think it was included? How could you use the ideas in your AS year to make the time spent studying more effective? How would you know if one way of learning is more effective than another?			
1h	Look at www.SmashingScience.org for other free resources, especially about AS exam Papers 1, 2 and 3.			
2a	Think about your top 3 achievable goals for today.			
2b	Think about 3 recent goals you achieved. Nice work on each one! You can enjoy past successes whenever you want, and that joy and pride is especially helpful when things seem harder. Your brain is designed to work better on bigger ideas, like the ones you encounter in your studies when you are in a better mood. Stress shuts down your higher order thinking and prepares you for a fight or flight response so working on feeling happier more often actually helps you learn more effectively.			
2c	Think about your longer-term goals and how they map to your dreams. Complete the “ Exercise: Goal Setting AS Term 1 ”.			
2d	Think about and plan using the calendars in this Workbook other extracurricular subject goals you have for your AS year in things like clubs and societies, subject competitions, English language exams			

ID	Learning and thinking about using this Workbook effectively	Iron Read it	Silver Thought about it (why is it included?)	Gold Revisited the idea a month later
	and work experience and activities to do on your weekends and in your holidays, especially the AS to A2 summer holiday.			
2e	Calculate how much lesson and homework time in the year you have per AS level at your school using “ Exercise: Mapping your learning hours per year per AS and A2 qualification ”. Then work out how much scheduled time you will spend per mark if you get different kinds of grades by completing the 4 different tables.			
3a	Understand that your other CAIE AS Science subjects, like Physics and Biology all have the same exam paper structure. Complete the table in: “ Exercise: Investigate and analyse your AS Level syllabi ” in this Workbook.			
3b	Understand that all CAIE AS Level exams use the same command words in very similar ways.			
3c	Read through the command words at the back of this Workbook “ Command Words Used in AS Chemistry Exams ”. Tick each one whenever you encounter it. Which ones are the most common? Which ones have you never seen in chemistry? Do the same for your other subjects. What are the similarities and differences between how these command words are used in your different subjects?			
4a	Think about the format of CAIE AS Level MCQ answer options, which usually have very specific patterns and structures which helps the best prepared students gain an advantage in the hardest Paper 1 questions.			
4b	Learn about the “ distractor answer ” by finding it in most option selections. If you cannot see an option that is really close to being right, you may have missed out a thinking step, and your chosen answers is in fact the incorrect distractor answer.			
4c	Use Paper 1 questions as a starting point to learn about the new harder assessment level for each new AS topic. Compare the same topic from iGCSE Paper 2 (which is available from SmashingScience) and try to think about how the same chemistry idea might have been made more complex at AS level.			
4d	Learn that AS chemistry MCQ questions require more thinking steps to gain a mark compared to iGCSE MCQ questions by comparing questions from both levels on the same topic, like atomic structure in iGCSE Paper 2 and AS Paper 1 questions.			
4e	A highly effective way to tackle an MCQ is to extract and write on the question paper notes that will point to or even deliver the actual answer before you have seen the choices. This slows down your thinking and prevents you from jumping ahead and missing steps and accidentally choosing the wrong (distractor) answer.			
4f	The best way to eliminate silly mistakes is to write out your thinking steps on the question paper. It will help your brain see all of the ideas relevant to the question in one place. When questions are easy, as they often are at iGCSE level, this can feel unnecessary. But MCQ questions get harder and harder as you move into university level. You should be trying to grow your exam technique as well as getting the right answer, so that your skills mature and grow as you progress through education.			
4g	Use Paper 1 questions more often for the topics you struggle most with.			
4h	Discover that the Paper 1 choices are created based on ideas that AS level students often get wrong about for a syllabus point in Paper 2. Thinking through why each incorrect choice is wrong can help you			

ID	Learning and thinking about using this Workbook effectively	Iron Read it	Silver Thought about it (why is it included?)	Gold Revisited the idea a month later
	better understand the kinds of details you need to include in a hard Paper 2 written question. The strongest way to think through an idea is to explain it to yourself on the question paper with clear and easy to understand notes, including MCQ questions.			
4i	Investigate further exam technique ideas by incorporating the ideas in “Exam Technique: Top Tips for Smashing! your Exams” with “Exercise: My Notes about the Paper 1 To-Do Checklist” .			
5a	Use a weekly planner to plan study time outside of lesson time.			
5b	Use a calendar to map out when your big events in life, and especially at school, like topic tests and mock exams.			
5c	Spend 3 minutes each week thinking about which revision time slots are productive, and which are not. Update and correct your weekly planner with this new information.			
5d	Plan breaks in time slots you find hardest to study in. Realise that it is far better to plan a break in a timeslot you never study in, like on a Saturday, than to plan to work, but not. Taking a break is an active process doing something you enjoy, and it helps restore your energy levels. Planning to work, but then not working can often be a more emotionally draining use of time than even working.			
5e	Learn that you should not ask of yourself things you know will not happen. Learning about executive function , being able to work with yourself to lead yourself through a hard task you might not always enjoy to deliver an outcome you can be proud of is one of the most valuable and important things you can ever get better at.			
5f	Use a calendar to plan things you enjoy doing after big events, especially exams. Being able to bargain with yourself, but for yourself and your sense of joy can help make completing a hard task seem fairer: e.g. “If I revise an extra two slots earlier in the week, I can enjoy taking a break on Friday evening”			
5g	Think about unusual timeslots, like at on the way to school, lunchtime, breaktime or before school starts to add unusual kind of study, like listening to instructional YouTube videos, using flashcards or creating mind maps with just a pen and a piece of blank paper.			
5h	For your next exam, count the total number of revision slots you have assigned until that exam. Then map to that number separate tasks, like separate topics or subtopics or revising Paper 1 or Paper 2, to each session. If the exam includes several topics, like a mock exam, assign all topics to each of those slots. Knowing that you have 22 revision slots until the mock exam, and there are 22 topics can really help you understand the value of each session, mapping out all of the remaining time allows you to see what you will be missing out on. It will also help you see how prepared you are, and what is needed to do next, which helps reduce stress levels and makes the task feel achievable because it has been broken down into individual understandable steps.			
5i	Used the graphs and tables to identify the relative importance of different topics and plan more time slots to the most important.			

Use the syllabus (google “syllabus download [exam board, e.g. AQA or CAIE] + [you subject]” to complete this table to compare each of your exam papers and the whole subjects with each other.



Exercise: Goal Setting AS Year

A **dream is just a goal without the plan** with the steps you need to take to achieve it. **You should dream big** to live your most interesting, fun and meaningful life. The **most successful people use their dreams** to direct and create an effective plan to get **the most effective use out of their time**.

This brief academic background to yourself will also allow you to see where you are at, and especially show yourself your **interests**, and what kinds of goals would best help you to **use, explore and grow your curiosity and passions** to best **achieve your dreams**.

You could also use this to help you when talking to **teachers, parents** and others about your plans to make your best university application. A MS Word file of this and the other activities in this Workbook is available at:

<https://www.smashingscience.org/a-level-chemistry-caie>

Name: _____

Class: _____

Intending to apply to (circle all): Cambridge/Oxford/Imperial/UCL Yes/No

Intending to apply for medicine? Yes/No

Have you **STARTED** your Personal Statement? Yes/No

Are you interested in tutoring iGCSE students (chem OR biology)? Yes/No

Email address: _____

Subject	iGCSE UMS %	iGCSE Grade	AS Mid Sem %	AS End of semester Exam %	AS Target UMS %	A2 Target grade

What do you want to do after high school?

- What kinds of subjects might you be interested in studying at university?
- Which universities are you hoping to go to?
- What type of career, or profession, are you hoping to do after that university degree?

Rank possible subjects you might study and include what kind of career you might hope it could lead to, as well as the universities you are interested in (1 = 1st choice, your favourite, 5 = 5th choice, least favourite):

Number	Degree subject	Country	University	Career
1		UK		
2		UK		
3		UK		
4		UK		
5		UK		
6				
7				
8				
9				
10				



Achievements, goals and interests

What kinds of things do you find **interesting**? What are you **curious** about in the world around you? What would you **like to know more about**? What things make you **excited** to find out more?

What do you think will be **the best technological advancement** in your lifetime? What could be the **biggest scientific discovery**? What do you think is the **greatest question** we don't yet have an answer for?

Which **societies** or **organised activities** (at school or outside) are you doing or intending to do?

What do you intend to do **your summer holidays after AS** (e.g. work in a lab)? When are the **deadlines for applying**?

What **career** would you like, and why? If you are not sure yet, what kind of work would you like to do?

Which **competitions/awards** do you already have (e.g. International Chemistry/Maths/Physics Olympiad etc.)

Which **competitions/awards** do you intend to do, what is the **deadline for applying** and date you will get the result

Academic Targets for this term (and what you will do to achieve them):

Supra-curricular targets (subject-specific organised activities not linked to the subject syllabus):

Extracurricular targets (e.g. sports, music, performance, hobbies) for the first few weeks of term?

What are **top 3 best books** you have read? What was your **most fun book** to read?

What was the latest **big science news** you heard about? What is the **most amazing science news** you know?



Exercise: End of Topic Targets Checklist

Recording your targets as you achieve them

For each topic you ought to try to do as many of the following things to get the most out of your time, the most out of the resources available to you so that you grow as a thoughtful and deliberate student.

- Tick each goal off as you complete it in the table that follows.
- Growth is difficult and uncomfortable, but you should choose to do these things, and the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, **because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win!**²
- **For more copies of this checklist** see the editable Word file on: <https://www.smashingscience.org/a-level-chemistry-caie>
- Most of these targets can also be used for other sciences you might be studying, as well as (some) other non-science subjects.

Reviewing your performance

After you have completed every topic you can review your performance, not only in terms of the end of topic test, but also other important behaviours the highly effective students show and grow during their education.

- A structured way to do this reflection can be found in the **“Exercise: End of Topic Review and Reflection”**.
- These are systematic ways to reflect and think about a topic you have done, so that you can try new things to deliver a better performance in the next topic.
- As important as understanding what didn't work is to celebrate what did work. **Find your wins from the last topic, recognise them, and celebrate them.** You could, for instance include them when you think about the 3 goals you have accomplished in the To-do Checklist at the start.
- Being detailed and specific in what the problem could be if you didn't learn as well as you would like can help you be specific and detailed in how you will fix it. It will also help you find out more about your learning style and give you a better understanding of yourself, and better control over yourself.
- A key component to **executive function** is to think that there is a part of yourself that is the CEO or boss, of all of the other parts of your self and your mind. But most of yourself is not that boss part, so to develop an effective (functional) relationship with yourself it is important that you are working with yourself in a positive and thoughtful and kind way. Do not ask things of yourself that you know are unlikely to happen, or are impossible to achieve. When you are making plans about what you will do to improve, you should aim to be a good boss, someone who delivers important and meaningful outcomes for yourself. A great leader does not just do whatever is easiest, or most popular in the short term, but instead gives a clear plan (what to do, how to do it and when) for how success will happen next time.
- **Small, incremental growth across time is incredibly powerful.** Sometimes it happens by chance, or through luck, but the best way to get constant growth is to be deliberate about it, and rather than thinking (or hoping) you will be better next time, give yourself specific targets, for instance “I will put an extra 10 minutes every day to consolidate my notes and fill in the cue column to my notes in chemistry”.

² Another version of this famous quote is “We chose these things not because they are easy, but because we thought they would be easy.”



Exercise: End of Topic Targets Checklist

Topic title: _____

Topic number: _____ Textbook pages: _____

Aspect	What you should have done	Yes/No	Level
Interacted with your teacher	Ask your teacher 1 question , about anything, once a week.		FUNDAMENTAL
	Try to answer one question asked by your teacher at least once a week.		ESSENTIAL
	Ask your teacher one question about something you do not understand in science once a week.		ESSENTIAL
	Ask your teacher one question about something to do with science every lesson.		EXTENSION
	Ask your teacher about what they find most interesting in the topic you are currently studying.		SMASHING!!!
Notes and follow up notes	Complete set of class note.		FUNDAMENTAL
	Cornell Notetaking Attempted.		ESSENTIAL
	Cornell Notetaking Completed.		EXTENSION
	Cornell Notetaking Completed to an exemplary standard.		EXCEPTIONAL
	Attempted the Mind Map for this topic.		ESSENTIAL
	Completed the Mind Map for this topic.		EXTENSION
Textbook	Read ahead before the topic has been started.		EXTENSION
	Highlighted key ideas and translate any new words (for English as a second language learners).		FUNDAMENTAL
	Completed all of the questions in the textbook when you see them.		EXTENSION
	Used ideas and important information from the textbook to improve and expand your class notes.		EXTENSION
Past Exam Questions	Completed 10% of marks in this workbook (Bronze).		FUNDAMENTAL
	Completed 25% of marks in this workbook (Silver).		ESSENTIAL
	Completed 40% of marks in this workbook (Gold).		EXTENSION
	Completed 50% of marks in this workbook (Winner).		EXCEPTIONAL
	Completed 75% of marks in this workbook (Hero).		EXCEPTIONAL
	Completed 100% of marks in this workbook (Legend).		SMASHING!!!
Reading	Spend more than 1 hour a week reading a book you enjoy (in any language) about anything.		ESSENTIAL
	Spend more than 3 hours a week reading a book you enjoy (in any language) about anything.		EXTENSION
	Spend more than 5 hours a week reading a book you enjoy (in any language) about anything.		EXCEPTIONAL
	Spend at least one hour a week reading a book you enjoy in English about anything.		EXTENSION
	Spend more than 3 hours a week reading a book you enjoy in English about anything.		EXCEPTIONAL
End of Topic Test	Revised sufficiently well to improve upon your score from the previous test (except if you are scoring over 90%, then just write Y for this goal)		ESSENTIAL
	Scored 10% higher than your current average		EXTENSION
	Scored 15% or more than your previous end of topic average		EXCEPTIONAL
	Scored over 90%		EXTENSION
	Scored over 95%		SMASHING!!!
Reflection	You filled in all of the targets you have achieved in this table when you have finished the topic (after the end of topic test).		FUNDAMENTAL
	You have looked at the goals you have achieved and the ones you have not and added them up and entered them into the table in the "Exercise: End of Topic Review and Reflection" section.		ESSENTIAL
	You have given an answer (of any quality) for every question in the Review and Reflection section at the end of this topic		EXTENSION
	You have given good and thoughtful answers for every question in the Review and Reflection section at the end of this topic		EXCEPTIONAL

Exercise: End of Topic Review and Reflection

This exercise will allow you to see all of your progress in every topic you complete. It will also help you become a more deliberate student, so that you are doing things like talking to a teacher that you might not at the start be comfortable with, but will build really important life skills to allow you to leave your comfort zone and talk to someone who might be interesting, or important, or helpful, even if it might feel easier and therefore better to do less and avoid new people. Try to be as honest and as detailed as possible. Sometimes you may think you have thought about an idea well, but when you talk with someone else, or write it out, it helps you better understand and allows you think more completely and more clearly.

Did you achieve more goals this topic than last topic (circle)? Yes/No

Fill in this table:

Level	Number of goals achieved at each level	Success rate (%)
FUNDAMENTAL	/5	
ESSENTIAL	/8	
EXTENSION	/12	
EXCEPTIONAL	/7	
Smashing!!!	/3	

Do you feel you tried harder this topic than the previous topic? If yes, how do you know? What helped you to do so? If not, why not?

What could you do differently next time? Try to avoid simply saying "more of X", be specific instead, think carefully about the problem, try to think creatively, so if you found your notes less helpful, look at the section at the back about the **Cornell Notetaking System** and write out things you did not do last topic that you would like to try next topic:

What did you enjoy most about this topic? What was most interesting?

What did you find most difficult? What could you do to make success in this area more likely?

What did you find easiest? Why did you find it easy?

On a scale of 1 being hardest and 5 being most difficult, circle how challenging you found this topic relative to your other AS topics:

1 2 3 4 5

What could be done to make this topic easier to understand?

Do you have any questions about this topic? Is there anything you would like to follow up later?

Google: [topic name] news. **What is the most interesting news about this topic** you found out?



Calendars and time management

Organising your months in 2025

January							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
1			1	2	3	4	5
2	6	7	8	9	10	11	12
3	13	14	15	16	17	18	19
4	20	21	22	23	24	25	26
5	27	28	29	30	31		

Your notes:

February							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
5						1	2
6	3	4	5	6	7	8	9
7	10	11	12	13	14	15	16
8	17	18	19	20	21	22	23
9	24	25	26	27	28		

Your notes:

March							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
9						1	2
10	3	4	5	6	7	8	9
11	10	11	12	13	14	15	16
12	17	18	19	20	21	22	23
13	24	25	26	27	28	29	30
14	31						

Your notes:

April							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
14		1	2	3	4	5	6
15	7	8	9	10	11	12	13
16	14	15	16	17	18	19	20
17	21	22	23	24	25	26	27
18	28	29	30				

Your notes:

May							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
18				1	2	3	4
19	5	6	7	8	9	10	11
20	12	13	14	15	16	17	18
21	19	20	21	22	23	24	25
22	26	27	28	29	30	31	

Your notes:

June							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
22							1
23	2	3	4	5	6	7	8
24	9	10	11	12	13	14	15
25	16	17	18	19	20	21	22
26	23	24	25	26	27	28	29
27	30						

Your notes:

July							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
27		1	2	3	4	5	6
28	7	8	9	10	11	12	13
29	14	15	16	17	18	19	20
30	21	22	23	24	25	26	27
31	28	29	30	31			

Your notes:

August							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
31					1	2	3
32	4	5	6	7	8	9	10
33	11	12	13	14	15	16	17
34	18	19	20	21	22	23	24
35	25	26	27	28	29	30	31

Your notes:

September							
Wk	Mo	Tu	We	Th	Fr	Sa	Su
36	1	2	3	4	5	6	7
37	8	9	10	11	12	13	14
38	15	16	17	18	19	20	21
39	22	23	24	25	26	27	28
40	29	30					

Your notes:

Exercises: To-do Revision Checklist for Topics in Paper 1

By showing yourself your progress it often is much easier to get large projects, like revising for your AS exams done. Tick off each of these accomplishments as you get them done.

You can also use the “**3-minute rule**”. Instead of intending to do a 12-hour marathon revision session, just ask 3 minutes of yourself. This can break down what is often the biggest barrier to getting things done, just starting, and will help you start to learn about getting better at managing Executive Function, which is an essential work and life skill from education.

Just trying out and reading a part of the first AS Chemistry Topic 1 question will allow you to tick your first box here and will only take 3 minutes!

Paper 1 Topics ranked by mark frequency in 2022- 2016:	RANK: Marks	P1 Noob	P1 Novice	P1 Bronze	P1 Silver	P1 Gold	P1 Winner ³	P1 Hero ⁴	P1 Legend ⁵
		1 Q Started	1 Q done	10% of marks	25% of marks	40% of marks	50% of marks	75% of marks	100% of marks
18 Carboxylic acids and derivatives	66		/1	/7	/17	/26	/33	/50	/66
9 The Periodic Table: chemical periodicity	43		/1	/4	/11	/17	/22	/32	/43
7 Equilibria	75		/1	/8	/19	/30	/38	/56	/75
13 An introduction to AS Level organic chemistry	48		/1	/5	/12	/19	/24	/36	/48
17 Carbonyl compounds	73		/1	/7	/18	/29	/37	/55	/73
11 Group 17	50		/1	/5	/13	/20	/25	/38	/50
3 Chemical bonding	89		/1	/9	/22	/36	/45	/67	/89
10 Group 2	51		/1	/5	/13	/20	/26	/38	/51
5 Chemical energetics	90		/1	/9	/23	/36	/45	/68	/90
1 Atomic structure	74		/1	/7	/19	/30	/37	/56	/74
15 Halogen compounds	84		/1	/8	/21	/34	/42	/63	/84
6 Electrochemistry	51		/1	/5	/13	/20	/26	/38	/51
8 Reaction kinetics	82		/1	/8	/21	/33	/41	/62	/82
14 Hydrocarbons	54		/1	/5	/14	/22	/27	/41	/54
16 Hydroxy compounds	65		/1	/7	/16	/26	/33	/49	/65
2 Atoms, molecules and stoichiometry	60		/1	/6	/15	/24	/30	/45	/60
4 States of matter	68		/1	/7	/17	/27	/34	/51	/68
12 Nitrogen and sulfur	94		/1	/9	/24	/38	/47	/71	/94
21 Organic synthesis	10		/1	/1	/3	/4	/5	/8	/10
22 Analytical techniques	27		/1	/3	/7	/11	/14	/20	/27
20 Polymerisation	62		/1	/6	/16	/25	/31	/47	/62
19 Nitrogen compounds	21		/1	/2	/5	/8	/11	/16	/21
Total Time, at 75 seconds per mark (hours)			/0.5	/2.8	/7.0	/11.1	/13.9	/20.9	/27.9

³ **DO NOT** attempt these higher levels until you have at least a “Gold” rank on the Paper 2 & 3 topics you have so far completed.

⁴ Even better than simply solving all questions, you should also be reflecting on how your answers are missing out on marks, usually it is either misunderstanding the hardest part of the question or failing to be fully complete.

⁵ At this level of completion, it is often better to concentrate first on the parts of topics or questions you lose marks in, rather than all of it, which you can identify in tests and exams and through the marks you miss completing past exam questions.



What the most thoughtful students will get out of their extensive studying will be a capacity to do brain-based work under stressful circumstances, which is a part of the self-mastery skillset that will continue to deliver value for the whole of their lives. Outstanding grades are just a part of this larger ideal of understanding, managing and improving yourself in a productive and positive way to get essential, complex, important, urgent and meaningful things done, and done well.

- To complete these questions, as important as your answer, is checking your answer against the mark scheme.
- For each one or two pages of questions, convert your mark score into a percentage. This will allow you to see (and feel) your progress as you get more experience and understanding with each Topic.
- If you find you are better at short answer questions than multiple choice questions that usually means you are not properly applying the mark scheme for Paper 2 and Paper 3. Sometimes students think **correct but incomplete** answers should get a harder mark that an examiner would not allow.

Exercise: Long term revision planning

A bad academic outcome is not evidence of being a bad student, or bad person, it is just a lack of the skills needed to be more organised to make effective use of your time. **The more organised you become, the more successful you will be, regardless of what you want to do.** Some chaotic study habits will allow some students with strong memories to succeed even without a lot of apparent organisation, but it will almost always be a more stressful and less successful journey, and while it might sometimes deliver a similar academic outcome, the person at the other end has developed far fewer life skills.

The tables here will allow you to organise your revision and see your plan using a logical process. This will allow you to break down a project into smaller steps that is otherwise so large, so difficult to define and so complex that it a human brain cannot fully grasp it all at once. This will give you simple, straightforward steps that will turn this important task into an achievable goal. To be successful you do not need to always learn all of chemistry right now, or even most of the time learn all of AS chemistry soon, you just need next to do 50 minutes of past exam questions from Paper 3 this Tuesday at 7pm to win, for instance. And each slot you complete is a separate, distinct win.

Like a scientific experiment, a systematic revision plan will enable you to record and describe to your future self what you did and when so you can reproduce the successful parts of your revision method and have hard data you can use to see what went wrong in a detailed and objective way.

When a human brain encounters what it thinks is a substantial failure its capacity for higher order thinking (to think logically, creatively and analytically) is massively downregulated; it is adapted by natural selection instead to retreat and remove itself from the source of the failure. This is lifesaving when dealing with hungry lions and serious injury, but less helpful for figuring out how to improve next time on a chemistry exam. The work you do here recording what you did, and the updates and changes you made to your revision plan along the way may be far more valuable than you can imagine in learning to think about exam performance more like a logical, abstract puzzle. It will help you to remove some of the feelings associated with perceived lower performance. And like any puzzle, improved exam performance's best solution is found fastest in the gradual and **incremental growth** from the reasoned application of organisational skills.

Overview planning for: Next BIG Test	Subject Chemistry				
Date of exam or test					
Weeks until test					
Revision slots per subject per week					
Total revision slots per subject					

Overview planning for: AS Mock exam	Subject Chemistry				
Date of exam or test					
Weeks until test					
Revision slots per subject per week					
Total revision slots per subject					

Overview planning for: AS CAIE exams	Subject Chemistry				
Date of exam or test					
Weeks until test					
Revision slots per subject per week					
Total revision slots per subject					

Other tests:

Overview planning for: Title: _____	Subject Chemistry				
Date of exam or test					
Weeks until test					
Revision slots per subject per week					
Total revision slots per subject					

Overview planning for: Title: _____	Subject Chemistry				
Date of exam or test					
Weeks until test					
Revision slots per subject per week					
Total revision slots per subject					

Overview planning for: Title: _____	Subject Chemistry				
Date of exam or test					
Weeks until test					
Revision slots per subject per week					
Total revision slots per subject					



Planning your revisions slots

Using the tables found in this section ("*Exercise: Long term revision planning*") to work out how many revision slots you have for each subject based on the number of weeks left.

Add your other subjects into the headings. You can **map out the slots first in rough**, by **adding the topic number**. Later you can add **one- or two-word titles** and other details like which **exam paper** you would like to focus on and the **subtopic number** (check the syllabus for this detail, this will also help you ground your revision in the what the syllabus describes, helping eliminate misunderstandings).

You should allocate more overall revision time on topics:

- That you found most difficult from previous tests.
- That tend to be more common in the exams using the analysis found in the tables and graphs in this Workbook.
- By remember to break up your revision time to introduce a variety of revision tasks, types of exam questions, or chemistry topics, but especially create a blend of subjects. Making substantial changes regularly and often with your revision program is an example of a highly effective learning strategy called "**interleaving**"⁶.

You can even split single sessions into two or more smaller topics or subtopics, either by splitting one cell in the table, or taking up two or more cells. If you study for longer than you have planned on a topic, make sure you still record it on the table. This table not only helps you plan your work, but also helps you display your work which helps deliver feelings of accomplishment which are really important to getting big jobs done. After the exam, this extra work should also be visible so you can see what you did better, in part to celebrate the work you actually did, but also so that when you look back on your revision plan you do not have unknown amounts of work not recorded. You are trying to control and detail the variables in your revision method.

- Neatly put a line through the cell and tick each revision block you have finished so you can still read what you did.
- As your splendid revision plan contacts with reality, you are likely to find that some slots do not get done. Put 2 lines through and add a cross.

After you have finished a specific test, you can draw a strong line in the table and use the remaining unused parts for the next test. Or use the same tables in a workbook for a different exam paper. Or you can get the editable Word file of these Workbook exercises at: <https://www.smashingscience.org/a-level-chemistry-caie>

Date	Slot #	Chemistry	Subject and Revision Focus			
31/08	:o)	T2.4: Titrations calculations P3 ✓				
25/12	:o(	T19.1: Primary amines P2 ✗				
	1					
	2					
	3					
	4					
	5					
	6					

⁶ <https://www.coursera.org/articles/interleaving>
www.SmashingScience.org



Date	Slot #	Chemistry	Subject and Revision Focus			
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					



Date	Slot #	Chemistry	Subject and Revision Focus			
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47					
	48					
	49					
	50					
	51					
	52					
	53					
	54					
	55					
	56					
	57					
	58					
	59					
	60					
	61					
	62					
	63					
	64					
	65					
	66					
	67					
	68					
	69					
	70					



Organising your weeks towards your exams

Paper 1, **Paper 2**, **Paper 3**, **Paper 4**, **Paper 5**

Week Starting	Wk #	Events	Topic Focus
14-Apr			
21-Apr			
28-Apr			
05-May		Tues 6 th PM Paper 33 (TZ2) Fri 9 th PM Paper 4 (TZ2)	
12-May			
19-May		Mon 19 th PM Paper 2 (TZ2) Mon 19 th PM Paper 5 (TZ2)	
26-May		Thur 29 th PM Paper 34 (TZ2)	
02-Jun		Weds 4 th PM Paper 1 (TZ2)	
09-Jun			
16-Jun			
23-Jun			
30-Jun			
07-Jul			
14-Jul			
21-Jul			



Week Starting	Wk #	Events	Topic Focus
28-Jul			
04-Aug			
11-Aug			
18-Aug			
25-Aug			
01-Sep			
08-Sep			
15-Sep			
22-Sep			
29-Sep			
06-Oct			
13-Oct			
20-Oct			
27-Oct			
03-Nov			
10-Nov			



Cambridge Final Exam Timetable June 2025

Administrative zone 5

CAIE Chemistry 9701 A Level Chemistry Exam Timetable for *Administrative Zone 5 (Time Zone 2)*:

AS Science Exams

Cambridge Final Exam Timetable June 2025

Syllabus view (A–Z)



Cambridge International AS Level									
Syllabus/Component	Code	Duration	Date	Session	Syllabus/Component	Code	Duration	Date	Session
A					H				
Accounting (Multiple Choice)	9706/13	1h	Wednesday 04 June 2025	AM	History	9489/13	1h 15m	Tuesday 06 May 2025	AM
Accounting	9706/23	1h 45m	Tuesday 13 May 2025	AM	History	9489/23	1h 45m	Thursday 08 May 2025	AM
B					I				
Biology (Multiple Choice)	9700/12	1h 15m	Tuesday 10 June 2025	PM	Information Technology	9626/13	1h 45m	Friday 09 May 2025	AM
Biology	9700/22	1h 15m	Thursday 15 May 2025	PM	L				
Biology (Practical - Advanced)	9700/33	2h	Thursday 08 May 2025	PM	Language & Literature in English	8695/12	2h	Monday 05 May 2025	PM
Biology (Practical - Advanced)	9700/34	2h	Tuesday 27 May 2025	PM	Language & Literature in English	8695/22	2h	Monday 28 April 2025	PM
Business	9609/13	1h 15m	Tuesday 06 May 2025	AM	Law	9084/12	1h 30m	Tuesday 27 May 2025	PM
Business	9609/23	1h 30m	Monday 12 May 2025	AM	Law	9084/22	1h 30m	Thursday 29 May 2025	PM
C					Literature in English	9695/12	2h	Monday 28 April 2025	PM
Chemistry (Multiple Choice)	9701/12	1h 15m	Wednesday 04 June 2025	PM	Literature in English	9695/22	2h	Tuesday 13 May 2025	PM
Chemistry	9701/22	1h 15m	Monday 19 May 2025	PM	M				
Chemistry (Practical - Advanced)	9701/33	2h	Tuesday 06 May 2025	PM	Marine Science	9693/13	1h 45m	Friday 25 April 2025	EV
Chemistry (Practical - Advanced)	9701/34	2h	Thursday 29 May 2025	PM	Marine Science	9693/23	1h 45m	Tuesday 29 April 2025	EV
Chinese Language (Listening - Multiple Choice)	8238/12	1h	Monday 26 May 2025	PM	Mathematics (Pure Mathematics 1)	9709/13	1h 50m	Monday 28 April 2025	AM
Chinese Language (Multiple Choice)	8238/22	1h 30m	Wednesday 28 May 2025	PM	Mathematics (Pure Mathematics 2)	9709/23	1h 15m	Wednesday 07 May 2025	EV
Chinese Language	8238/32	1h 30m	Wednesday 30 April 2025	PM	Mathematics (Mechanics)	9709/43	1h 15m	Wednesday 07 May 2025	AM
Computer Science	9618/13	1h 30m	Friday 09 May 2025	AM	Mathematics (Probability & Statistics 1)	9709/53	1h 15m	Wednesday 14 May 2025	AM
Computer Science	9618/23	2h	Thursday 15 May 2025	AM	Media Studies	9607/22	2h	Wednesday 07 May 2025	PM
D					Music (Listening)	9483/13	2h	Tuesday 20 May 2025	AM
Design & Technology	9705/13	2h 15m	Wednesday 30 April 2025	AM	P				
Drama	9482/13	2h	Wednesday 21 May 2025	EV	Physics (Multiple Choice)	9702/12	1h 15m	Thursday 05 June 2025	PM
E					Physics	9702/22	1h 15m	Tuesday 20 May 2025	PM
Economics (Multiple Choice)	9708/12	1h	Monday 09 June 2025	PM	Physics (Practical - Advanced)	9702/33	2h	Tuesday 29 April 2025	PM
Economics	9708/22	2h	Wednesday 14 May 2025	PM	Physics (Practical - Advanced)	9702/34	2h	Thursday 22 May 2025	PM

A2 Science Exams

Cambridge International A Level									
Syllabus/Component	Code	Duration	Date	Session	Syllabus/Component	Code	Duration	Date	Session
A					I				
Accounting	9706/33	1h 30m	Thursday 15 May 2025	AM	Information Technology (Advanced)	9626/33	1h 45m	Wednesday 21 May 2025	AM
Accounting	9706/43	1h	Thursday 22 May 2025	AM	L				
B					Law	9084/32	1h 30m	Tuesday 03 June 2025	PM
Biology	9700/42	2h	Monday 12 May 2025	PM	Law	9084/42	1h 30m	Thursday 05 June 2025	PM
Biology	9700/52	1h 15m	Thursday 15 May 2025	PM	Literature in English	9695/32	2h	Wednesday 21 May 2025	PM
Business	9609/33	1h 45m	Friday 16 May 2025	AM	Literature in English	9695/42	2h	Friday 23 May 2025	PM
Business	9609/43	1h 15m	Tuesday 20 May 2025	AM	M				
C					Marine Science	9693/33	1h 45m	Monday 05 May 2025	AM
Chemistry	9701/42	2h	Friday 09 May 2025	PM	Marine Science	9693/43	1h 45m	Thursday 08 May 2025	AM
Chemistry	9701/52	1h 15m	Monday 19 May 2025	PM	Mathematics (Pure Mathematics 3)	9709/33	1h 50m	Monday 19 May 2025	AM
Chinese Language & Literature (Multiple Choice)	9868/12	1h 30m	Monday 26 May 2025	PM	Mathematics (Probability & Statistics 2)	9709/63	1h 15m	Wednesday 07 May 2025	AM
Chinese Language & Literature	9868/22	2h	Wednesday 30 April 2025	PM	Media Studies	9607/42	2h	Monday 19 May 2025	PM
Chinese Language & Literature	9868/32	2h	Thursday 08 May 2025	PM	P				
Computer Science (Advanced)	9618/33	1h 30m	Wednesday 21 May 2025	AM	Physics	9702/42	2h	Friday 16 May 2025	PM
D					Physics	9702/52	1h 15m	Tuesday 20 May 2025	PM
Design & Technology	9705/33	2h 30m	Thursday 08 May 2025	AM	Portuguese	9718/02	1h 45m	Tuesday 06 May 2025	AM
E					Portuguese	9718/03	1h 30m	Friday 09 May 2025	AM
Economics (Multiple Choice)	9708/32	1h 15m	Wednesday 11 June 2025	PM	Portuguese	9718/04	2h 30m	Wednesday 04 June 2025	AM
Economics	9708/42	2h	Thursday 22 May 2025	PM	Psychology	9990/32	1h 30m	Tuesday 13 May 2025	PM

Longer term planning for 2026 – 2027

2026																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
Sep	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We			
Oct	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa		
Nov	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo			
Dec	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th		
2027																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
Jan	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su		
Feb	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su					
Mar	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We		
Apr	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr			
May	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo		
Jun	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We			
Jul	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa		
Aug	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		

Planning your days

V1.0 – Continue to refine these to find and RECORD times you study best (and when you never study)

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							



Planning your days – v2.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							



Planning your days – v3.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:45 am							
	6:30 am							
	7:15 am							
	8:00 am							
	8:45 am							
	9:30 am							
	10:15 am							
	11:00 am							
	11:45 am							
	12:30 pm							
	1:15 pm							
	2:00 pm							
	2:45 pm							
	3:30 pm							
	4:15 pm							
	5:00 pm							
	5:45 pm							
	6:30 pm							
	7:15 pm							
	8:00 pm							
	8:45 pm							
	9:30 pm							
	10:15 pm							
	11:00 pm							
	11:45 pm							



Planning your days – v4.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:45 am							
	6:30 am							
	7:15 am							
	8:00 am							
	8:45 am							
	9:30 am							
	10:15 am							
	11:00 am							
	11:45 am							
	12:30 pm							
	1:15 pm							
	2:00 pm							
	2:45 pm							
	3:30 pm							
	4:15 pm							
	5:00 pm							
	5:45 pm							
	6:30 pm							
	7:15 pm							
	8:00 pm							
	8:45 pm							
	9:30 pm							
	10:15 pm							
	11:00 pm							
	11:45 pm							



Exercise: My Notes about the Paper 1 To-Do Checklist

Here you can explore your own thinking about each of these points in a deliberate, longer lasting and more effective way.

Your notes will be a fast-travel treasure map back to all of your thinking when you made them, they will also be a thing to be proud of and a strategy to feel better, especially useful on one of those days where the gentle ennui of being can sometimes feel a little more like a sharp, swift kick in the biscuits. Your notes, wherever they are, is solid evidence you can show yourself of all of the work you have already done, and a clear demonstration that progress is happening which ought to be a point of pride regardless of whatever else you might be feeling.

The most valuable part of your notes, however, will be what creating them does to your brain: you will have had to integrate these ideas into your thinking and ultimately into yourself when you made them.

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
1a	Read this statement.	
1b	Find the page for “ Exercise: My Notes about the Paper 1 To-Do Checklist ” in the “ Contents Page ” of this Workbook. Put a paper clip on that page so you can always find it easily.	 Put a paper clip here! → Try out a variety of ways to mark and find important pages in your Workbooks, textbooks and notebooks, e.g. paperclips, sticky notes, plastic coloured sticky tabs etc. Which works best for you? 
1c	Identify, extend and develop your thinking about your AS studies by mapping the codes for the ideas and prompts found in “ Exercise: Structured Analysis and Investigation of the Paper 1 Checklist ” to the “ My Notes about the Paper 1 To-Do Checklist ”.	
1d	Read about “ The Cornell Notetaking System ” at the back of this Workbook.	

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
1e	Read through and complete the “ Exercise: Learning and Understanding the Five R’s of the Cornell Notetaking ”.	
1f	Try to use the Cornell Notetaking System for one or all of your AS subjects, either by getting a preprinted notepad, or by using the pages in the section “ Trying out the Cornell Notetaking System ”	
1g	Read through the “ Learning to Learn ” section at the back. Why do you think it was included? How could you use the ideas in your AS year to make the time spent studying more effective? How would you know if one way of learning is more effective than another?	
1h	Look at www.SmashingScience.org for other free resources, especially about AS exam Papers 1, 2 and 3.	
2a	Think about your top 3 achievable goals for today.	
2b	Think about 3 recent goals you achieved. Nice work on each one! You can enjoy past successes whenever you want, and that joy and pride is especially helpful when things seem harder. Your brain is designed to work better on bigger ideas, like the ones you encounter in your studies when you are in a better mood. Stress shuts down your higher order thinking and prepares you for a fight or flight response so working on feeling happier more often	Listen to “Ten Percent Happier Podcast with Dan Harris”

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
	actually helps you learn more effectively.	
2c	Think about your longer-term goals and how they map to your dreams. Complete the “ Exercise: Goal Setting AS Term 1 ”.	
2d	Think about and plan using the calendars in this Workbook other extracurricular subject goals you have for your AS year in things like clubs and societies, subject competitions, English language exams and work experience and activities to do on your weekends and in your holidays, especially the AS to A2 summer holiday.	
2e	Calculate how much lesson and homework time in the year you have per AS level at your school using “ Exercise: Mapping your learning hours per year per AS and A2 qualification ”. Then work out how much scheduled time you will spend per mark if you get different kinds of grades by completing the 4 different tables.	
3a	Understand that your other CAIE AS Science subjects, like Physics and Biology all have the same exam paper structure. Complete the table in: “ Exercise: Investigate and analyse your AS Level syllabi ” in this Workbook.	
3b	Understand that all CAIE AS Level exams use the same command words in very similar ways.	

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
3c	Read through the command words at the back of this Workbook “<i>Command Words Used in AS Chemistry Exams</i>”. Tick each one whenever you encounter it. Which ones are the most common? Which ones have you never seen in chemistry? Do the same for your other subjects. What are the similarities and differences between how these command words are used in your different subjects?	
4a	Think about the format of CAIE AS Level MCQ answer options, which usually have very specific patterns and structures which helps the best prepared students gain an advantage in the hardest Paper 1 questions.	
4b	Learn about the “<i>distractor answer</i>” by finding it in most option selections. If you cannot see an option that is really close to being right, you may have missed out a thinking step, and your chosen answers is in fact the incorrect distractor answer.	
4c	Use Paper 1 questions as a starting point to learn about the new harder assessment level for each new AS topic. <i>Compare the same topic from iGCSE Paper 2</i> (which is available from SmashingScience) and try to think about how the same chemistry idea might have been made more complex at AS level.	4a (from next exercise)
4d	Learn that AS chemistry MCQ questions require more thinking steps to gain a	6a(i) (from next exercise)

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
	mark compared to iGCSE MCQ questions by comparing questions from both levels on the same topic, like atomic structure in iGCSE Paper 2 and AS Paper 1 questions.	
4e	A highly effective way to tackle an MCQ is to extract and write on the question paper notes that will point to or even deliver the actual answer before you have seen the choices. This slows down your thinking and prevents you from jumping ahead and missing steps and accidentally choosing the wrong (distractor) answer.	6a(i) (from next exercise)
4f	The best way to eliminate silly mistakes is to write out your thinking steps on the question paper. It will help your brain see all of the ideas relevant to the question in one place. When questions are easy, as they often are at iGCSE level, this can feel unnecessary. But MCQ questions get harder and harder as you move into university level. You should be trying to grow your exam technique as well as getting the right answer, so that your skills mature and grow as you progress through education.	4a (from next exercise)
4g	Use Paper 1 questions more often for the topics you struggle most with.	

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
4h	Discover that the Paper 1 choices are created based on ideas that AS level students often get wrong about for a syllabus point in Paper 2. Thinking through why each incorrect choice is wrong can help you better understand the kinds of details you need to include in a hard Paper 2 written question. The strongest way to think through an idea is to explain it to yourself on the question paper with clear and easy to understand notes, including MCQ questions.	
4i	Investigate further exam technique ideas by incorporating the ideas in “ Exam Technique: Top Tips for Smashing! your Exams ” with “ <i>Exercise: My Notes about the Paper 1 To-Do Checklist</i> ”.	
5a	Use a weekly planner to plan study time outside of lesson time.	
5b	Use a calendar to map out when your big events in life, and especially at school, like topic tests and mock exams.	
5c	Spend 3 minutes each week thinking about which revision time slots are productive, and which are not. Update and correct your weekly planner with this new information.	

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
5d	Plan breaks in time slots you find hardest to study in. Realise that it is far better to plan a break in a timeslot you never study in, like on a Saturday, than to plan to work, but not. Taking a break is an active process doing something you enjoy, and it helps restore your energy levels. Planning to work, but then not working can often be a more emotionally draining use of time than even working.	
5e	Learn that you should not ask of yourself things you know will not happen. Learning about executive function, being able to work with yourself to lead yourself through a hard task you might not always enjoy to deliver an outcome you can be proud of is one of the most valuable and important things you can ever get better at.	
5f	Use a calendar to plan things you enjoy doing after big events, especially exams. Being able to bargain with yourself, but for yourself and your sense of joy can help make completing a hard task seem fairer: e.g. "If I revise an extra two slots earlier in the week, I can enjoy taking a break on Friday evening"	

ID	Learning and thinking about using this Workbook effectively	My notes – What works well? What doesn't? How do you know?
5g	Think about unusual timeslots, like at on the way to school, lunchtime, breaktime or before school starts to add unusual kind of study, like listening to instructional YouTube videos, using flashcards or creating mind maps with just a pen and a piece of blank paper.	
5h	For your next exam, count the total number of revision slots you have assigned until that exam. Then map to that number separate tasks, like separate topics or subtopics or revising Paper 1 or Paper 2, to each session. If the exam includes several topics, like a mock exam, assign all topics to each of those slots. Knowing that you have 22 revision slots until the mock exam, and there are 22 topics can really help you understand the value of each session, mapping out all of the remaining time allows you to see what you will be missing out on. It will also help you see how prepared you are, and what is needed to do next, which helps reduce stress levels and makes the task feel achievable because it has been broken down into individual understandable steps.	
5i	Used the graphs and tables to identify the relative importance of different topics and plan more time slots to the most important.	5c(i) (from next exercise)

Exercise: Structured Analysis and Investigation of the Paper 1 Checklist

You can apply each of these statements or the answers to these questions into your notes for “Exercise: My Notes about the Paper 1 To-Do Checklist” by using the code below to link the two ideas together. A few have already been done for you.

Moving a similar idea from here to the boxes for your notes in the exercise before will not only require you to remember it, but also to use it and repurpose it. This is an example of active learning.

Some ideas here might have multiple applications. How could you make sure that you have found all of them?

You could use these statements and this exercise on your other AS subjects. A MS Word file of this and other exercises is available on <https://www.smashingscience.org/a-level-chemistry-caie>

1. Syllabus order and structure

- Why are certain topics included?
- Why are they covered to the level of detail they are?
- Why are they put in the order they are found in the syllabus?

2. Assessment

- How does the exam board measure your progress and understanding in this subject?
- Exam papers or coursework?
- Format of exams: MCQ, structured questions or practical skills?
 - What's a structured question? What is an unstructured question?
 - What are practical skills? Will you be successful in these questions if you are really good at the chemistry, or do they assess somethings else?
- Amount of time per exam paper.
- Total marks and weighting towards your AS and A Level grades.

3. Exam board

- What systems do they use to create a syllabus and assessment regime?
- What things are the same, and what is different between similar subjects, like chemistry and physics.
- What things are the same, and what is different between less similar subjects, like chemistry and maths.
- How can we learn about what they think is important to a subject and to an AS level: e.g. by comparing different subjects, different levels (iGCSE and AS Level), different exam papers etc.

4. Understanding AS and A2 Levels in context

- How is AS harder than iGCSE?
- How is A2 harder than AS? How could you find out?
- How might University level be harder than A2? How could you find out?

5. Goal setting and planning

- Thinking about what you want to achieve: your goals (e.g. acceptance to your dream university through gaining acceptable grades in your AS levels)
- And how you will achieve that: planning what you will do (e.g. work on past exam papers, become more deliberate and organise in making your progress happen)
- And when you will do this work, assigning these tasks to a timeline:
 - Longer term, using a calendar (mapping out major school events like UCAS deadlines, mock and AS exams and school holidays)
 - Medium term, planning your weeks (mapping out smaller tests, and other school events, coursework)
 - Short term, planning each day (assigning subjects to specific time slots outside of your lesson time)



Exercise: Exam Technique, Strategies and Building Stronger More Reliable Exam Habits

This section is a continuation of “*Exercise: Structured Analysis and Investigation of the Paper 1 Checklist*”.

You can apply each of these statements or the answers to these questions into your notes for “*Exercise: My Notes about the Paper 1 To-Do Checklist*” by using the code below to link the two ideas together. A few have already been done for you.

Practice until you get it right. Then practice until you cannot get it wrong. Also incorporating careful reflection to use a **fail-safe mindset** to identify and eliminate the patterns in exam behaviour that generates every kind of mistake.

Making Mistakes in an Exam Part 1: Blank Answer

6.1a. **Ran out of exam time.** This is one of **the most critical exam technique problems to solve**, it affects all aspects of your AS, A2 and usually university assessments.

Solution – Work first on the questions in topics you are most likely to get marks from.

- i. Learn which topics questions take the most time (seconds per mark) by ensuring you **always time yourself when practicing**. This is particularly important if you are often running out of time!
- ii. Learn which topics you score least well as a percentage. Calculate which topics you score least well per second.
- iii. As soon as you see a topic that you tend to score poorly on but take a long time on mark them with something like a large cross within the first 10 to 20 seconds and move on. Do not try to read your way through a whole question that you know you are likely to skip. **A quick early decision to skip** a question can save important minutes.
- iv. Aim to skip about 30 to 50% of all questions at the start. As you get faster and more comfortable you might only skip the hardest 20%, or even just 10%.
- v. The best students are unlikely to skip any of the questions, but will definitely leave some of the harder questions slightly unfinished until the end, where they will spend the last few minutes after checking through the exam forcing additional details into the questions they think are likely to have the hardest marks.

6.2b. Did not know the answer well enough to try. The biggest problem of students who struggle to get grade C or above is that they want to be certain before they make an attempt at an answer.

Solution – Always give an answer to every question if you have time.

- i. Skip the hardest questions quickly, so as soon as you have read enough to know it is one of your WTF (Wait ‘Till Finish) topics, question types or sections of the syllabus mark it with a large cross and move on, you don’t need to finish reading the question.
- ii. It is more effective to get more exam marks with a **good specific, deeper grasp of earlier topics**, especially atomic structure and bonding, than a rough, general but broad idea of the whole AS level.
- iii. Answer these hardest questions at the end of the exam.
- iv. Process the question. Make notes about whatever you recognise in the question content.
- v. Try to think through the subject content of what the question could be about. Write out keywords and important phrases for that topic that might be connected to the
- vi. The most valuable skill you can get from preparing well for any exam is trying your best, even if it will not be 100% successful. You should try your best to write anything, even if there is only 20% or 10% or 1% chance of being successful if you have the time.

Making Mistakes in an Exam Part 2: Incorrectly Read the Question.

6.2a. Missed out a key value in a calculation. Each value in a question is usually needed at some point.

Solution - Label each number you are given in a question (storing it in your short-term memory better):

- i. Tick each number off or cross it through so you can still read it when you have used it.
- ii. Any numbers that have not been ticked off at the end of the question might indicate that a step was missed was made in a calculation.

6.2b. Assuming a harder question is easier.

Solution – Learn how to recognise harder questions.

- i. **And take more care with questions that look too easy for AS level.**
- ii. Find out how question structure, e.g. (i) and (vii) can help indicate an easier and a harder question.
- iii. Find out how command terms like describe and state can indicate an easier question, and explain and analyse could be used for harder marks.
- iv. Multi-mark questions, especially 3 and 4 and higher mark questions tend to have the hardest marks in an exam paper.
- v. Use the number of lines of writing space given to understand how much writing the examiners think is needed to write a correct and complete answer.

6.2c. Simplified a harder question by ignoring or not fully understanding all of the details presented.

Solution – Write out your thinking using clear, well presented, easy to understand and complete question notes.

- i. Write out relevant details from your long-term memory, especially mnemonics, e.g. OIL RIG, Cat(ion)s are PAWsitive etc.
- ii. Annotate chemical equations, including highlighting molar ratios, highlight state changes, highlight changes in pH or ion concentrations, highlight colour changes, highlight Redox changes.
- iii. Annotate diagrams, include labels.
- iv. Annotate graphs (e.g. rate always has an initial component and a end point). Highlight any key differences, especially with regards to unusual features including unexpected axis labels.
- v. Write out top 3 keywords after reading through the question if you find circling key terms ineffective in helping them stand out in your thinking.
- vi. Draw arrows towards any words in bold. These are usually essential ideas to include in your answer to get the question right.
- vii. **Always try to annotate questions on the hardest topics as fully as you can.** Not only will it be a good habit, but the act of doing it will help to embed more deeply the ideas you are using to create those notes. Often when you have just started a new topic's questions you will need to create as full notes as possible, this will help guide and structure your thinking and allow your past exam questions practice to also help improve your and reinforce your subject learning.

6.2d. Mistook an increase in X in an **inverse relationship** to deliver an increase in Y.

Solution - Identify what types of topics this is common in, and try to see several kinds of questions like this:

- Common in $PV=nRT$, where volume is decreased which results in an increase in pressure.
- Common in rate questions, smaller time = faster rate.
- What other kinds of questions often use inverse relationships to add complexity to a question?

6.2e. Incorrectly read the labels of an axis for a common graph in textbooks that had been altered in the exam.

Solution – look at wide selection of Paper 1 questions on this graph types assessing this syllabus point.

6.2f. Some other class of mistake with the question.

Solution: Identify it from your past exam practice or test taking experience, look for the pattern in the problem.

- Fill out the relevant box in “**Exercise: Recording, Understanding and Eliminating New Categories of Mistakes**”.
- Write out the question ID so you can find it months or years from now.
- Describe the pattern.
- Describe the way to identify as new question where this could be a problem in the future.
- Describe how you could check to see if this mistake was made.
- Describe how to answer the question to eliminate this risk.

Making Mistakes in an Exam Part 3: Incorrectly Displayed Answer

6.3a. You knew the answer, but presented it incorrectly, or mixed up the category (e.g. CH_2O , or $52.3.6 \text{ mol dm}^{-3}$ or you wrote “higher”, instead of “lower”, or “+ve” instead of “-ve”).

Solution – Check BOTH your practice and exam answers more systematically:

- Whenever you discover a mistake like this, create a list of all categories of these kinds of mistakes you make.
- Fill out the relevant box in “**Exercise: Recording, Understanding and Eliminating New Categories of Mistakes**”.
- Pay special attention to each category when you are checking at the end of each practice or exam question or page of questions until you no longer make that kind of mistake.

6.3b. Incorrect recall of subject knowledge (e.g. chemistry). Less common in students getting the higher grades.

Solution - Learn the subject content better:

- In class make better notes when you are learning a topic
- After class, write out keywords and terms in the evening for each lesson.
- A week later create 1 or 2 summary sentences for each page of notes (using the Cornell Notetaking system)
- Use active reading to learn from textbooks more effectively

6.3c. Unreadable handwriting and ambiguous spelling. Spelling applies to a really small group of names, like chlorine, chloride and chlorate (VII) and organic compounds like propane, propene and propanone. Unreadable handwriting only to key terms that are underlined in mark schemes.



Solution – Write out chemical names and the most important words in an answer in clear printed block capital letters.

- i. Emphasise key parts of specific names whenever you are writing about them, like alk**A**nes, alk**E**nes, sulf**I**TE and sulphat**E** using a combination of **bold**, CAPITAL letters, underlining and **highlighting** to help your brain see the most important part of the word to show most clearly for future reference.
- ii. If unreadable handwriting is an ongoing problem make most or all of your answer in printed block letters.
- iii. Make sure that whatever you want to do in the real exam is something you do in your practice questions. To get better at writing legibly you need to do more of it!

Making Mistakes in an Exam Part 4: Correct but INCOMPLETE Answers.

Most students who get a B or above will know a good deal about the chemistry needed to answer the question, but they miss out on essential details necessary for the hardest marks for a variety of reasons.

6.4a. You are answering to an iGCSE standard, NOT AS level.

Solution – Compare and contrast exam questions on the same topic at both iGCSE and AS level.

- i. Describe and explain what makes the iGCSE question easier.
- ii. Describe and explain what makes the AS level mark scheme harder.
- iii. Look at the number of steps and the amount of information that is needed in a similar question at iGCSE and AS level.

iv. This is particularly important at the start of the AS year!

6.4b. You know the complete answer but hope that a shorter answer will often be enough.

Solution – always give as much detail as you know and can write quickly.

- i. When think you have enough details, but still have extra space for writing, or still have relevant but possibly unnecessary details, mark the question with a star next to the number.
- ii. Go back after you have finished the exam and add those details.
- iii. Try to think about how many hours you have invested in studying in class and outside of class. A small extra amount of work in an exam room can help you maximise the value of the work you have already done.
- iv. Try to think about how much more opportunities you could get with a grade higher than expected, and what you would miss out on if you got a grade lower. When thinking about the times of your life that have an extraordinary impact on your life choices, few times will ever have as much impact as the time spent in an exam. The best way to make sure that you always try your best in an exam is to make sure you always try your best when you are practicing. Your best answers should be delivered because it is a product of deeply held and well practiced exam habits, which you don't need to think about.

6.4c. You know the complete answer but skip steps in your answer to save time, and or do not think it is worth the effort.

Solution – Make sure that you build the habit when you are practicing to always include as much information as you can, not as much as you think might be needed.

- i. Habits are mental shortcuts to behaviours which you have worked on in the past. If you train yourself effectively when you are practicing exam questions when you are in an important test or exam the fullest answers you can give will be more likely, even if you are stressed, like you might be when dealing the most difficult questions in an exam.
- ii. You should not have to choose your best performance mode if you aim to be one of the best students. You should be aiming to always deliver the best you can, including when you are practicing. This is especially helpful for the hardest marks, where even very good students will drop the hardest marks.
- iii. Also, if you are the kind of student who always values every mark, every detail and every opportunity when you are practicing, this will be who you become later on in life, for instance in your professional life, making you a valuable member of any team at work, or in your personal life when someone you really care about needs the best help you can give them.

6.4d. You know the complete answer, but you don't feel it is worth the effort to put everything down all the time.

Solution – Work out how much time you are investing in each qualification using “**Exercise: Mapping your learning hours per year per AS and A2 qualification**”.

- i. Learn to respect the scheduled time you have been allocated per subject per calendar year by placing a much larger value on the marks you can get out of your time in an exam.
- ii. Also recognise that the best outcome from a high-quality education is not measured in grades, but essential life and work skills involving managing people, especially yourself, across a large timescales. But great grades are natural and inevitable outcomes if you get your priorities right and really make sure that you put everything you can into your exam answers. And this performance will naturally happen when you put everything you can into your practice answers.

Exercise: Exam Technique Recording, Understanding and Eliminating New Categories of Mistakes

You can complete this table using new kinds of categories of mistakes you encounter in your past exam paper studies and test taking expanding on the ideas in “**Exercise: Structured Analysis and Investigation of the Paper 1 Checklist**” and using the same codes here. For Paper ID you can use an abbreviation like 2022/w/TZ1/P1/Q# 4.

Code	Paper IDs	Notes
6.2(f)		Describe the pattern: How could you identify a question where this could be a problem? What habit or system could you use to make sure a future answer cannot include this type of mistake?
6.3(a)		Describe the pattern: How could you identify a question where this could be a problem? What habit or system could you use to make sure a future answer cannot include this type of mistake?
6.4(a)		Describe the pattern: How could you identify a question where this could be a problem? What habit or system could you use to make sure a future answer cannot include this type of mistake?



Code	Paper IDs	Notes
		Describe the pattern: How could you identify a question where this could be a problem? What habit or system could you use to make sure a future answer cannot include this type of mistake?
		Describe the pattern: How could you identify a question where this could be a problem? What habit or system could you use to make sure a future answer cannot include this type of mistake?
		Describe the pattern: How could you identify a question where this could be a problem? What habit or system could you use to make sure a future answer cannot include this type of mistake?

Exercise: Mapping Your Learning Hours Per Year Per AS and A2 Qualification

"Guided learning hours include direct teaching and any other supervised or directed study time. **They do not include private study by the candidate.** However, these figures are for guidance only, and the number of hours required may vary according to local curricular practice and the students' prior experience of the subject.

Guided learning hours:

- AS = 180
- A2 = 180
- AS + A2 = 360

<https://help.cambridgeinternational.org/hc/en-gb/articles/203558371-What-are-the-recommended-number-of-teaching-hours-for-Cambridge-International-A-Level>

TASK: Complete the tables below to work out the total time you have in your academic years per AS subject.

	Example	Your school's timetable
Lessons per week: AS Year	7	
Lessons per week: A2 Year	7	
Time per lesson /minutes	40	
Number of teaching weeks in year	38	
Total AS /minutes	10640	
Total AS and A2 time /minutes	21280	
Time /hours	354.7	
Total homework time for AS and A2 years (=0.5x class time) /hours	177.3j	
All time whole AS&A2 /hours	532	

These tables will show you the relative amount of time if you put all of those minutes in a year in different grade profiles. For a low A* which in 2024 winter would require about 78%, we can calculate the average amount of study time went into achieving each of those 78% of all marks. A student who achieved a C grade at the same school would get the same amount of lesson time, have the same amount of homework time, but would have gotten fewer marks to gain the 46% of all marks necessary for the grade.

Time spent at per mark at your school if 100% of marks were achieved:

Paper	Marks	Paper % YEAR weight	% ALL A- Level/ mark (weighting)	Class time hours/mark		Homework hours/mark		Total time studying hours/mark	
				Example	Your school	Example	Your school	Example	Your school
1	40	31	0.39	1.37		0.69		2.06	
2	60	46	0.38	1.36		0.68		2.04	
3	40	23	0.29	1.02		0.51		1.53	
4	100	77	0.39	1.37		0.68		2.05	
5	30	23	0.38	1.36		0.68		2.04	

This only shows SCHEDULED time in class and homework, time spent revising is NOT included here.

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It is important to note **that not all A* grades are the same**. The University of Cambridge, for instance requires applicants to submit their UMS scores as well as their grades, and on average chose students with an average of 95% UMS⁷ score across their best 3 AS levels, which might actually require a raw score of 89% or more. Even two students who got the same raw percentage score of 78% could have had wildly different A Level years. If you spent two years becoming much better at studying, learning how to create highly effective and time efficient notes, you would have made far more progress, even with the exact same percentage as a student who only did the minimum to learn the answers to get 78%. In fact, a student who was aiming for the minimum amount of effort to achieve the highest number of marks, or a specific grade at A Level, would have missed out on a key growth phase of the start of their adult life to become an expert at learning, and working, in an increasingly information centric global economy.

To get a C grade, the same amount of lesson time and homework time, in theory, and exactly the same amount of time in life, 1 academic year, went into getting fewer marks. This will help you understand how valuable, in hours already invested, each mark is, which is why if you are putting in a few extra seconds to make an answer longer and better in an exam you are better respecting the amount of life you have already poured into each AS Level.

TASK: Complete the tables below to work out the total time you have in your academic years per AS subject.

Time spent per mark at your school to achieve a low A* grade (with a raw score of 78%):

Paper	Marks	Paper % YEAR weight	% ALL A- Level/ mark (weighting)	Class time hours/mark		Homework hours/mark		Total time studying hours/mark	
				Example	Your school	Example	Your school	Example	Your school
1	40	31	0.39	1.76		0.88		2.64	
2	60	46	0.38	1.74		0.87		2.61	
3	40	23	0.29	1.31		0.65		1.96	
4	100	77	0.39	1.75		0.88		2.63	
5	30	23	0.38	1.74		0.87		2.61	

Time spent per mark at your school to achieve a C grade (with a raw score of 46%):

Paper	Marks	Paper % YEAR weight	% ALL A- Level/ mark (weighting)	Class time hours/mark		Homework hours/mark		Total time studying hours/mark	
				Example	Your school	Example	Your school	Example	Your school
1	40	31	0.39	2.99		1.49		4.48	
2	60	46	0.38	2.96		1.48		4.43	
3	40	23	0.29	2.22		1.11		3.33	
4	100	77	0.39	2.97		1.48		4.45	
5	30	23	0.38	2.96		1.48		4.43	

What you can see from this exercise is that as you do less well each mark becomes a larger part of your study investment. In an exam, if you get a C grade, more than 4 hours of your life goes into the study time to gain each mark, so spending a few extra seconds making sure you are getting all of your idea out on the paper is even more valuable.

Building the exam habits to always deliver the most information you can for every question is fundamental to the higher grades, not only at A level, but especially at university and beyond. These habits live most strongly in the students who have cultivated them by **always including as much as they can throughout all of their exam question practice**. Anyone can get better at this, and very little a student can do will have a stronger impact on future academic achievement.

⁷ <https://www.cao.cam.ac.uk/ums-performance-and-eventual-he-destination-cambridge-applicants>



Exercise: Exam Technique Strengths and Weaknesses of non-CAIE Exam Questions

Here are some of the problems any exam question could have:

1. Reliability - Incorrect chemistry
2. Reliability - Incorrectly printed:
 - a. typos
 - b. errors in formatting so Br^2 instead of Br_2
3. Reliability Incorrect mark scheme
4. Reliability Incorrect level
 - a. Too hard
 - b. Too easy
5. Reliability – Incorrect command terms or question structure.
6. Not in the syllabus
7. Not in the subject

For each source of exam question write out what the main strengths and weaknesses could be, and rank them in terms of importance to helping you do better on exams.

ID	Source of exam question	Possible strengths and weakness
SW 1	CAIE 9701 Chemistry exam papers	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 2	Artificial Intelligence Generated Content	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 3	ESAT (and NSAA) University of Cambridge entrance exam questions	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?

ID	Source of exam question	Possible strengths and weakness
SW 4	AS CAIE 9701 Textbook end of section questions	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 5	Other AS syllabus: OCR Chemistry A H032 (OCR is the UK version of CAIE, both are part of the University of Cambridge)	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 6	Other AS syllabus: OCR Chemistry B (H033, Salter's)	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 7	IB Chemistry Standard Level exam papers	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 8	IB Chemistry Higher Level exam papers	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?

ID	Source of exam question	Possible strengths and weakness
SW 9	Other high school, e.g. SAT II Chemistry and AP	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 10	CAIE iGCSE 0620 Chemistry	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 11	Coursera Intro to Chemistry	https://www.coursera.org/learn/intro-chemistry#modules There are lots of different options at different levels. Give it a go! If you will finish and get your grade before you submit your UCAS application, it could help your university application. These kinds of things are NOT a substitute for good or top AS grades, which will unlock the doors to the best universities, but it will give you an bit of an advantage getting past the doorway's threshold.
SW 12	Online textbook: LibreTexts	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 13	Non-SmashingScience websites (unpaid)	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?

ID	Source of exam question	Possible strengths and weakness
SW 14	Non-SmashingScience websites (paid)	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 15	Workbook (paid)	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?
SW 16	Smartphone app	If you lose a mark on this kind of question, what does it mean? If you gain all marks from a question like this, what does it mean?

You can check your ideas after you have thought about each and written your answers down against the Smashing!!! professional opinion in the pages that follow.

Task: Describe how are you are your answers different?

Task: Try to explain why your answers are different?

The Smashing!!! perspective on Strengths and Weaknesses of non-CAIE Exam Questions

Summary

The main problem with using non-CAIE exam questions is that you don't know what it means if you achieved all of the marks: you cannot easily or effectively predict what CAIE AS or A2 grade you are working at.

You also do not know what losing a mark means about your understanding of your syllabus. It could lead you to learn things you do not need, at the cost of time that would have been more effectively spent becoming even better at the specific tasks that CAIE AS and A2 9701 Chemistry assesses. A wide-ranging curiosity of yourself and the cosmos you live in is fundamental to the best lived lives, but being able to narrow your horizons to focus entirely on the task at hand is a supremely useful life and work skill. You can be both interested in everything, and at times, especially before exams, switch your curiosity towards a passion for understanding all important aspects of a particular syllabus.

You do not need to worry about your CAIE 9701 Chemistry, these Smashing!!! Workbooks cover all exam papers. If these are all completed you will be able to deliver a performance in your exams good enough to get a medium to high A* for most serious students with the time and ability to focus. But if you are studying another Chemistry syllabus, or for your other A Level subjects, then the considerations here can be useful in selecting the best resources to deliver the most learning impact, as assessed by your syllabus, from your study time.

ID	Source of exam question	Possible strengths and weakness
SW 1	CAIE 9701 Chemistry exam papers	If you lose a mark on this kind of question, what does it mean? Your understanding of the CAIE 9701 syllabus is incomplete and or incorrect with regards to the syllabus points this question was assessing, as well as this topic in general. If you gain all marks from a question like this, what does it mean? You have fully understood all aspects of the syllabus points being assessed in this instance. If this normally happens when you solve 20 or more marks under exam conditions in all your other topics and for all relevant exam paper questions you are likely to get an A*, and probably a good one. You might still not be able to achieve the hardest exam marks about the exact same syllabus points. You should first be thinking about also delivering A*s in your other A Levels, and then working towards the extracurricular activities that would help you demonstrate your subject passion to the best universities. If after all that you still have time, then to score the most difficult marks you can think about these main ideas: The exam question can be made harder: • more complex wording. • less information provided in the question. • less scaffolding so two or more smaller question parts become a single multi-mark question part. • counterintuitive wording or structure of the question, including changes axes on common graphs. • more unnecessary information in the question that does not help deliver the answer. The mark scheme can be made harder: • Requiring 2 or more details instead of 1 detail for a single mark. • Only giving marks for the most important details, which could mean ignoring details that in a previous exam session were acceptable. • Including <u>compulsory</u> words in the mark scheme that must be present (and are indicated by being <u>underlined</u>). • Changing which details deliver a mark for the same question from one exam session to the next e.g. "describe a face [2]":

ID	Source of exam question	Possible strengths and weakness
		○ 2023 summer: M1 = (One) Mouth; M2 = Nose ○ 2025 winter: M1 = Two eyes; M2 = (Two) ears ○ The ideal answer therefore will include: 1 mouth, one nose, two eyes and two ears. (and a nice hat). Always give as much details as you possibly can. • Requiring information that in a previous exam session was only included in the mark scheme but only in brackets (previously expected but not required). For students studying CAIE 9701 A Level Chemistry, these questions are by far the best, especially the ones from 2016 and later, though earlier questions are almost identical in terms of value and quality. You will only be measured in a syllabus through its assessment path. For CAIE AS and A2 Level 9701, that is exclusively through your answers on exam papers 1, 2, 3, 4 and 5. And if you want to get really good at something specific, practicing things like that thing, or have some similarities are no substitute for practicing that same thing.
SW 2	Artificial Intelligence Generated Content	If you lose a mark on this kind of question, what does it mean? Potentially nothing. The question could look in terms of formatting, feel and structure, exactly like a CAIE 9701 A Level Chemistry exam question. But it could be disconnected to not only the style of question but also accurate science in a variety of hard to spot ways. These are the most dangerous questions that you might encounter, because the mark scheme will likely also be generated through Artificially Intelligence. They are increasingly simple to mass produce so this could also be the most common kind of question that the internet will deliver to you. As this tainted data propagates, it could eventually find its way into the kinds of answers you could get from asking a search engine. The Smashing!!! Way gives an ID tag to all questions used in workbooks so that you can see the provenance of the question, that it really was from a past exam question, which you can check. This is the easiest way to overcome this growing challenge. If you gain all marks from a question like this, what does it mean? Hard to say, but likely it will be a positive indication that you are learning well. But you would not be able to make any reliable or accurate predictions about your A Level grade from this data. Yet. It will be interesting to see how AI and especially general AI impacts education, especially syllabi structure and content and the content and structure of the exam questions that flow from it.
SW 3	ESAT (and NSAA) University of Cambridge entrance exam questions	If you lose a mark on this kind of question, what does it mean? You do not fully understand the ESAT Chemistry syllabus, which could mean that you are less good at the CAIE 9701 syllabus, but not necessarily. More likely it could also be a problem with exam technique, these questions are structured quite differently from Paper 1 multiple choice questions. If you gain all marks from a question like this, what does it mean? You have fully understood the ESAT Chemistry syllabus. But you may not have a full grasp on the CAIE 9701 syllabus, they are different. You also have fully mastered the ESAT MCQ format, but some habits you pick up, like thinking there are always more steps than there normally are in Paper 1, might make Paper

ID	Source of exam question	Possible strengths and weakness
		1 questions seem too easy, and you will instead spend time looking for another answer instead of the correct one. The multiple choice questions especially offer good insights into how standard Paper 1 MCQ questions can be made harder by adding steps, and adding options (they have upwards of 8 answers to chose from). You can get these broken down by topic at: https://www.smashingscience.org/uni-guidance Be really careful about investigating these questions. Most students would get far more value out of time spent revising Paper 1 instead. If you are thinking about making a strong application to Cambridge, then there are only a small number of these questions, so be careful, if you try all of them, you'll quickly run out of effective questions to create mock exams with.
SW 4	AS CAIE 9701 Textbook end of section questions	If you lose a mark on this kind of question, what does it mean? You have not fully understood the chapter, and that part of the syllabus. This is likely evidence that your understanding of this part of they syllabus is weaker. If you gain all marks from a question like this, what does it mean? You have done well, but it will not allow you to make predictions on your actual exam performance. These questions are normally not from CAIE past exam questions, so they are designed to help you understand what you just studied, not differentiate students who are at different grade levels, like an A and B grade students. They are usually less complex, less reliable and at a lower level than a CAIE question, including less likely to use command terms in the same way as CAIE exam questions. If you don't have actual past exam questions broken down by topic, these questions are very useful to study subjects and syllabi not covered by SmashingScience.
SW 5	Other AS syllabus: OCR Chemistry A H032 (OCR is the UK version of CAIE, both are part of the University of Cambridge)	If you lose a mark on this kind of question, what does it mean? - You have not covered that part of your syllabus yet, so you should not yet know what this was assessing. - The content is not in your syllabus, so would never be on your exam (unlikely they're quite similar). - It uses a different question format that you do not need to be familiar with (e.g. assesses quality of written communication, or requires a level of English literacy above that expected at CAIE A Level because it is aimed at first language English speakers, rather than English as an additional language). - You are supposed to know it, and in this way, but you don't. This is a very similar syllabus in terms of content, but differs in terms of the structure of that chemistry, with the same ideas in different topics, which also includes changes to AS and A2 content. OCR H432 (Chemistry A) has A2 level MCQs, which is a neat thing for a teacher to know, but without extracting them into separate topics, a Smashing!!! future project, these MCQs are less useful right now. If you didn't have CAIE exam questions these would be a really good alternative, but there are important differences also in the format of questions and exam papers (OCR has more multi-mark, longer questions than CAIE for instance). For some helpful key points to counter common mistakes OCR examiners have created for OCR students: https://www.ocr.org.uk/Images/592305-exam-hints-for-students.pdf



ID	Source of exam question	Possible strengths and weakness
		If you gain all marks from a question like this, what does it mean? You are working at a very good AS and A2 level of Chemistry. You will do really well in you CAIE exams, and get one of the top grades. You likely have worked on improving good skills that will not be on your exams. And you could have missed out on skills that you need to get the higher grade from where you are at, but these questions will not give you any information about these missing skills.
SW 6	Other AS syllabus: OCR Chemistry B (H033, Salter's)	This has a slightly different syllabus than OCR Chemistry A, so it has all of those problems, and others relating to assessing slightly different chemistry content as well.
SW 7	IB Chemistry Standard Level exam papers	If you lose a mark on this kind of question, what does it mean? There are general problems related to using a different syllabus relating to different content, different exam style and different levels. Standard Level (SL) is considered by many universities as equivalent to AS standard, but while there is a lot of overlap with 9710 AS Chemistry, there are differences in scope and content. The exam paper structure is also substantially different, and it uses coursework to cover some of its assessment aims, which ought to have an impact on the kinds of questions that are not needed in an exam, particularly Papers 3 and 5 in 9701. SL MCQs (Paper 1) tend to be slightly easier than CAIE AS questions assessing the same syllabus. If you gain all marks from a question like this, what does it mean? You are working at a very good AS and A2 level of Chemistry. You will do really well in you CAIE exams, and get one of the top grades. But Paper 3 and 5 skills have not been assessed, so there are really big gaps in your exam technique that will be missing.
SW 8	IB Chemistry Higher Level exam papers	If you lose a mark on this kind of question, what does it mean? Higher Level (HL) multiple choice question exists for A2 content, like OCR A Level Chemistry. You would not be examined in this way at A2, but they are a highly effective tool for busy teachers to deliver effective formative assessment before end of topic written tests. If used after finishing A2, it will likely mean that you have gaps in your 9701 Chemistry content that need to be addressed. But there is a lot of finer details about what you know and what you can do with it that will be missed out. If you gain all marks from a question like this, what does it mean? For the short answer questions in IB HL Paper 2, there is substantial overlap in content, but it isn't quite as broad and doesn't always go as deep. You would therefore do really well at A2 Level, but if you always got 100% in IB HL exams, you'd probably get an A* or a really good A, which contrasts with 9701 exams, which would only require you to get about 85% raw score to always get an A*.
SW 9	Other high school, e.g. SAT II Chemistry and AP	If you lose a mark on this kind of question, what does it mean? 9701 A2 Chemistry tends to be the broadest and deepest conventional chemistry course. Without a great deal of experience with the SAT and AP chemistry courses, it is hard to say, but likely it means there are things in the 9701 syllabus you should know but do not know. But the structure of the questions, as well as the mark schemes, which might be more general than 9701 mark schemes, is different. It might be easier to learn from 9701 exam questions and especially the mark scheme to see exactly what is both necessary and sufficient for a strong answer, for some of these kinds of syllabus parts.

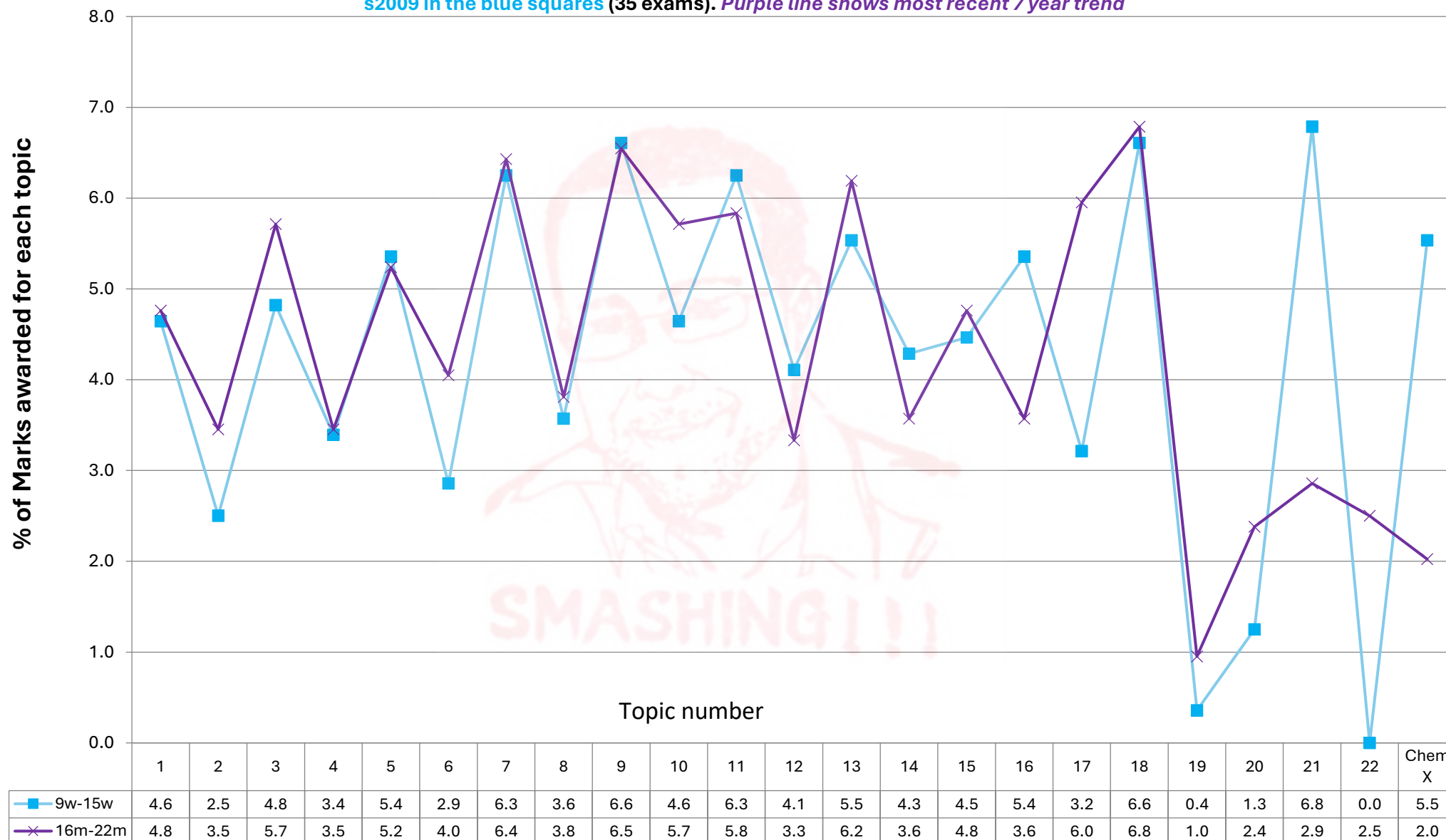
ID	Source of exam question	Possible strengths and weakness
		If you gain all marks from a question like this, what does it mean? It means you are good at high school chemistry, but much harder than other A level syllabi, or IB to predict how well you would do.
SW 10	CAIE iGCSE 0620 Chemistry	If you lose a mark on this kind of question, what does it mean? You are in big trouble, you should be able to answer these kinds of questions, and well, before you start each AS topic. If you struggled at iGCSE, or didn't do it, then SmashingScience has MCQ questions broken down by topic from iGCSEs which will be updated in 2025. If you gain all marks from a question like this, what does it mean? You are now ready to start well learning that relevant AS topic.
SW 11	Coursera Intro to Chemistry	https://www.coursera.org/learn/intro-chemistry#modules There are lots of different options at different levels. Give it a go! If you will finish and get your grade before you submit your UCAS application, it could help your university application. These kinds of things are NOT a substitute for good or top AS grades, which will unlock the doors to the best universities, but it will give you an bit of an advantage getting past the doorway's threshold.
SW 12	Online textbook: LibreTexts	If you lose a mark on this kind of question, what does it mean? I've not seen many questions, so cannot comment on their structure, but these texts are primarily a resource for US university students. So they will not cover the same range of content and same range of difficulty. So it is hard to know either way what your performance in these kinds of questions really means. It might be that there are not that many anyways.
SW 13	Non-SmashingScience websites (unpaid)	If you lose a mark on this kind of question, what does it mean? These could use real exam questions. If they use CAIE 9701 Chemistry exam questions, clearly marked, this has the potential to be as good as SmashingScience, but normally when these kinds of things organise exam questions they will be separated as entire questions, with multiple topics examined within a single question. If there were full 9701 questions you would not always know exactly which parts of the question are examining which of those topics, so an incorrect answer could just mean you have not studied that part, so that data point is less clear, you don't know exactly which topic you need to improve on. These could also use non-9701 exam questions, but say they do. Make sure, check them against real exam papers if that is possible. If you cannot check their work easily, then you should value your study time more and use another source. Full exam papers are harder to use, especially as you are in the middle of a subject, but they would be much better. If you gain all marks from a question like this, what does it mean? Hard to say. Usually most top A Level students do not have the time to explore too many different sources, try to stick with actual exam questions as much as possible. It could be that

ID	Source of exam question	Possible strengths and weakness
SW 14	Non-SmashingScience websites (paid)	These normally do not use real past exam questions. They might use language like having “experts” of the syllabus, but they could in reality use anyone, or the most cost effective would be a premium subscription to an AIGC service. There are no safeguards here. It is likely that no one serious is checking their work for its quality. If you could not understand a question from here, you would not know if it was because your understanding of the chemistry in the 9701 syllabus is at fault or is a problem with the question. All the reliability issues could also be the source of your problem with that question including of incorrect chemistry in the question, incorrect printing, incorrect mark scheme, incorrect level and the content assessed is not on the 9701 syllabus.
SW 15	Workbook (paid)	These have the same challenges as the non-SmashingScience websites, if the questions are written by non-CAIE people using non-CAIE methods, who is checking the work? CAIE exam question will not just be completed by tens of thousands of students. Classroom teachers, like Mr Smashing, all over the world will also be checking, and there are almost never any issues that come up. Sometimes you can see [question withdrawn] in a mark scheme which likely indicates something went awry there, but this is really rare. Also, slightly less rare, the problem is fixed in the mark scheme, which would mean two marks are given for a single point, for instance, which was probably not the question author’s intention.
SW 16	Smartphone app	All of the problems of a non-SmashingScience website could be important for this kind of source. If you gain all marks from a question like this, what does it mean? It could be that if it’s a paid for app, you are buying a kind of edutainment or infotainment. Like eating nuts and gum at the same time, you are getting all of the problems of each, and none of the strengths. It is not as enjoyable and relaxing as a specific rest activity like watching a good movie, playing a great computer game or going for a splendid walk. And the learning impact, the measurable progress per hour of use, will be less than real study. This is definitely a growth market, but nothing that you spend money on will be as effective a use of time as past exam questions, which are widely available online. If they are organised, as they are in these workbooks, that is an even more effective use study periods. For many of these kinds of educational experiences, including lots of tutoring, you, or more likely your parents, are paying for an easier path to learning. Euclid said “there is no royal road to geometry” to King Ptolemy, but lots of educators do not have his intellectual rigour or economic indifference, so there are a great many solutions available to buy that promise a path that for thousands of years we have known has never existed. Work, thoughtfully, diligently and incrementally applied is always how the most difficult but worthwhile outcomes are achieved.

Paper 1 Analysis and Graphs

CAIE A Level Chemistry 9701 Paper 1: Multiple Choice

Frequency of marks for each Topic Number from w2022 to m2016 purple crosses, (Timezone 1 only) compared to w2015 to s2009 in the blue squares (35 exams). Purple line shows most recent 7 year trend



Multiple choice frequencies across the years

Initially, there was a strong bias against making choice A to be the correct answer.

				01w P1/O	02s P1/O	02w P1/O	03s P1/O	03w P1/O	04s P1/O	04w P1/O	05s P1/O	05w P1/O	06s P1/O	06w P1/O	07s P1/O	07w P1/O	08s P1/O	08w P1/O	09s P1/O	09w P1/1	10s P1/1	10w P1/1	11s P1/1	11w P1/1	12s P1/1	
A	9.1			7	9	10	6	7	8	6	7	7	7	7	7	12	7	5	4	9	10	8	6	9	8	
B	10.1			10	11	8	8	14	10	8	11	12	13	15	8	6	6	8	10	10	10	11	12	10	12	
C	10.6			10	11	14	14	12	9	8	10	11	11	10	14	14	16	12	11	12	10	8	12	12	12	
D	10.2			13	9	8	12	7	13	18	12	10	9	8	11	8	11	15	15	9	10	13	10	9	8	
Rolling 5 year average:																										
A															7.4	7.4	7.6	7.4	7.3	7.0	7.1	7.5	7.5	7.5	7.6	7.7
B															10.9	10.7	10.3	10.1	10.1	9.7	9.7	9.9	9.9	9.6	9.4	
C															10.9	11.3	11.5	11.7	11.5	11.5	11.7	11.9	11.7	11.8	11.9	12.1
D															10.8	10.6	10.5	10.8	11.1	11.8	11.5	10.7	10.8	10.8	10.8	

Towards 2020 there was a consistency in the number of A, B, C and D correct answers. This pattern in format delivers even more information than a simple bias. At the end of the exam you should count the number of each of your answers, and any that have more than 10 are where you more likely have made mistakes, and the letter choice that you have selected less than 10 times could be the right answer, which would be particularly useful for students who only make a handful of mistakes.

	19m P1/2	19s P1/1	19s P1/2	19s P1/3	19w P1/1	19w P1/2	19w P1/3	20m P1/2	20s P1/1	20s P1/2	20s P1/3	20w P1/1	20w P1/2	20w P1/3	21m P1/2	21s P1/1	21s P1/2	21s P1/3	21w P1/1
A	10	10	9	9	11	11	11	10	11	10	11	10	9	10	10	10	10	10	10
B	11	9	11	10	9	8	9	10	9	10	10	10	11	10	10	10	10	10	10
C	10	11	10	11	10	12	10	10	10	11	9	11	10	11	10	10	10	10	10
D	9	10	10	10	10	9	10	10	10	9	10	9	10	9	10	10	10	10	10
Rolling 5 year average:																			
A	9.6	9.6	9.5	9.4	9.4	9.5	9.6	9.8	10.0	10.1	10.3	10.3	10.2	10.3	10.4	10.3	10.2	10.1	10.1
B	10.4	10.5	10.5	10.4	10.2	10.0	9.8	9.7	9.6	9.6	9.6	9.5	9.7	9.6	9.6	9.7	9.9	10.0	10.0
C	10.3	10.2	10.2	10.3	10.5	10.7	10.9	10.7	10.5	10.6	10.4	10.5	10.4	10.5	10.4	10.4	10.2	10.2	10.2
D	9.7	9.7	9.9	10.0	10.0	9.8	9.6	9.7	9.8	9.6	9.7	9.7	9.7	9.6	9.6	9.6	9.7	9.7	9.7

Most recently though, **this pattern has changed completely**, so it is better to avoid inferring too much into how many of each letter choice you have selected. But each letter choice has at least 5 correct answers, and none have more than 15, so there is some information there, but almost all **students would be better off ignoring MCQ Letter biases certainly for AS chemistry**, possibly for all CAIE exams (the Cambridge University Entrance exam, the NSAA, which used to be run by CAIE, had a strong bias here however).

	23m P1/2	23s P1/1	23s P1/2	23s P1/3	23w P1/1	23w P1/2	23w P1/3
A	9	10	5	9	11	6	11
B	12	10	13	12	8	10	8
C	8	15	12	9	6	15	6
D	11	5	10	10	15	9	15
Rolling 5 year average:							
A	10.0	10.0	9.5	9.5	9.4	9.1	9.2
B	10.0	10.0	10.4	10.5	10.5	10.5	10.3
C	10.2	10.6	10.7	10.6	10.2	10.5	10.2
D	9.8	9.4	9.4	9.4	10.0	9.9	10.4

Section B (until 2021 winter)

This section was used for questions 31 to 40 and required you to chose a letter based on a combination of options:

The responses **A to D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

For Section B, towards 2021w there was still a bias towards A (all options 1, 2 and 3) and against C (option 1 is incorrect, but 2 and 3 are correct):

	19m P1/2	19s P1/1	19s P1/2	19s P1/3	19w P1/1	19w P1/2	19w P1/3	20m P1/2	20s P1/1	20s P1/2	20s P1/3	20w P1/1	20w P1/2	20w P1/3	21m P1/2	21s P1/1	21s P1/2	21s P1/3	21w P1/1	21w P1/2	21w P1/3
A	3	3	5	4	2	3	2	3	3	4	3	4	3	4	2	4	4	3	3	3	3
B	2	2	2	3	4	3	4	2	3	2	3	3	3	3	5	2	3	2	2	2	2
C	3	3	1	1	1	2	1	3	2	2	2	1	2	1	2	1	2	3	2	3	2
D	2	2	2	2	3	2	3	2	2	2	2	2	2	2	1	3	1	2	3	2	3
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Rolling 5 year average:																				
A	3.3		3.1	3.3	3.5	3.3	3.4	3.3	3.1	3.0	3.3	3.2	3.3	3.3	3.2	3.0	3.2	3.3	3.4	3.4	3.4
B	2.6	2.6	2.5	2.5	2.5	2.6	2.7	2.7	2.7	2.7	2.7	2.8	2.9	3.0	3.2	3.0	3.0	2.8	2.8	2.7	2.7
C	1.8	2.0	2.1	2.0	2.1	2.0	1.8	1.8	1.8	1.9	1.9	1.7	1.6	1.6	1.7	1.7	1.7	1.9	1.8	1.9	1.9
D	2.3	2.3	2.1	2.1	2.1	2.0	2.2	2.4	2.5	2.1	2.2	2.2	2.2	2.2	2.1	2.1	2.0	1.9	2.0	2.0	2.0

For this format of question, which still appears very occasionally in Paper 1 exams, the bias seems to be towards all answers are correct (option A), and away from statements suggesting the first is incorrect (option D).



Paper 1: Notes and Points of Interest

Papers 1, 2 and 3 By Paper 1 Mark Frequency (m16-w22)

	P1 16-22 WTD	P1 9-15 WTD	P2 16-22 WTD	P2 9-15 WTD	P3 16-22 WTD	P3 9-15 WTD	P1,2,3 16-22 WTD	1,2,3 9-15 WTD
Paper/s (% weighted of A Level)	1	1	2	2	3	3	1,2,3	1,2,3
% of A Level	15.5	15.5	23.0	23.0	11.5	11.5	50.0	50.0
Years included	16-22	9-15	16-22	9-15	16-22	9-15	16-22	9-15
AS 18 Carboxylic acids and derivatives	1.1	1.0	0.7	0.6	0.1	0.0	1.9	1.6
AS 9 The Periodic Table: chemical periodicity	1.0	1.0	1.3	1.7	0.0	0.0	2.3	2.7
AS 7 Equilibria	1.0	1.0	1.2	2.1	1.8	1.8	4.0	4.9
AS 13 An introduction to AS Level organic chemistry	1.0	0.9	1.1	0.5	0.0	0.0	2.0	1.4
AS 3 Chemical bonding	0.9	0.7	1.8	1.0	0.0	0.0	2.7	1.8
AS 11 Group 17	0.9	1.0	1.5	0.5	0.0	0.0	2.4	1.5
AS 10 Group 2	0.9	0.7	1.3	1.1	2.1	0.3	4.3	2.2
AS 17 Carbonyl compounds	0.9	0.5	1.0	0.5	0.1	0.1	2.0	1.1
AS 5 Chemical energetics	0.8	0.8	1.2	1.6	0.4	0.3	2.5	2.7
AS 1 Atomic structure	0.7	0.7	1.7	0.9	0.0	0.0	2.4	1.6
AS 15 Halogen compounds	0.7	0.7	0.5	0.5	0.2	0.0	1.4	1.2
AS 14 Hydrocarbons	0.6	0.7	2.2	2.5	0.0	0.0	2.8	3.2
AS 16 Hydroxy compounds	0.6	0.8	0.9	0.5	0.1	0.0	1.6	1.4
AS 8 Reaction kinetics	0.6	0.6	0.7	0.3	0.6	1.8	1.9	2.6
AS 6 Electrochemistry	0.6	0.4	0.4	0.4	1.8	3.0	2.8	3.9
AS 2 Atoms, molecules and stoichiometry	0.5	0.4	1.0	1.2	0.3	0.2	1.8	1.8
AS 4 States of matter	0.5	0.5	0.9	0.4	0.0	0.0	1.5	0.9
AS 12 Nitrogen and sulfur	0.5	0.6	0.8	1.5	3.9	2.8	5.2	4.9
AS 21 Organic synthesis	0.4	1.1	1.2	4.3	0.0	0.0	1.6	5.4
AS 22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	1.3	0.0
AS 20 Polymerisation	0.4	0.2	0.3	0.0	0.0	0.0	0.7	0.2
AS 19 Nitrogen compounds	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.1
No longer assessed ("Chem X" in graphs)	0.3	0.9	0.3	0.8	0.0	1.1	0.6	2.8
AS Total (if <100%, then because some material moved to A2)	15.5	15.3	23.0	23.0	11.5	11.5	50.0	49.8
Physical Chemistry Totals	5.7	5.2	8.9	7.8	4.9	7.2	19.6	20.2
Inorganic Chemistry Totals	3.3	3.3	4.9	4.9	6.0	3.1	14.2	11.3
Organic Chemistry Totals	5.7	5.9	7.9	9.5	0.5	0.1	14.2	15.4
22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	1.3	0.0

Topics tend to be placed within the exam paper in order, so Topic 1 is at the start, and the last AS Topic 22 would be at around question 38 to 40 in exams 2022 and onwards⁸. But about 10-20% of the questions do not follow this general trend. This can be helpful when dealing with questions like those from Topic 10 Group 2, which are concerned with solubilities of salts and thermal decomposition. A harder question about unusual salts before a question about Group 17 (topic 11) can be solved by thinking of other Group 2 kinds of questions. And a harder question about unknown combustion gases after a question on Group 2 or 17 could be about Topic 12 Nitrogen and Sulfur.

⁸ Or at question 29 to 30 (relevant to winter 2021, the last year of Section B with the choice between a combination of 3 statements), or

Section B was last part (questions 31 to 40) of Paper 1 in winter 2021, you will encounter these in your revision, and in this Workbook.

A general principle used when assigning topic numbers to exam question marks is to give the mark to the earliest topic that a student would be able to answer it had they been taught earlier topics in syllabus order. The main exceptions to this rule include names of organic molecules, especially primary, secondary and tertiary alcohols, which appear first in Topic 13 An Introduction to AS Level Organic Chemistry, but the idea isn't really used in a substantial way until Topic 16 Hydroxy Compounds. So, it is put in Topic 16 because that is the first time the students would normally really work with the idea. Similarly, named carbonyls would be in Topic 17 rather than Topic 13. Topic 18 has a larger representation because often a question that has a choice of answers e.g. propanol, propanal, propanone and propanoic acid, would be classed as Topic 18 even if the answer was in topic 16. There is an argument for saying that a student ought to be able to identify the correct answer, even if they have yet to learn enough to identify that the remaining 3 options are incorrect, but this has generally been avoided here. There are a small number of the harder A Level questions however, where the main reason a MCQ option could be chosen is that it is correct, and most high scoring students would not know why all of the other 3 options were incorrect.

Overall, very little changed in the last 15 years, though Topic 21 Organic Synthesis has become easier to separate into individual organic chemistry topics.

Also of note is the fact that marks for Topic 19 Nitrogen Compounds rarely come up. It is possibly an artifact of the driving force of the spiral curriculum in action. In terms of exam relevance, it is a placeholder AS topic for its A2 counterpart, Topic 34 Nitrogen Compounds, which is, like Ron Burgandy, a pretty big deal, both to Paper 4 and the entire A level.

Esters, especially their breakdown hydrolysis products, have relatively large representation.

There is a pattern where odd-numbered topics tend to be more represented until Topic 19, while even numbers were less represented until Topic 18 Carboxylic Acids and Derivatives.

Generally, topics that are more common in one exam paper tend to be less common in another.

There are exam questions from A2 in Paper 4 that can be answered with chemistry theory only in an AS topic, but they are relatively rare (but available on www.SmashingScience.org). Most AS content assessed in the A2 Exam papers is in Paper 5, which is a skills-based exam that likely will have little or no positive value to most AS students. An AS student who focuses only on getting extremely good at answering questions about AS material using AS exam questions is likely to perform better at AS chemistry than a student who invests a substantial amount of time into A2 topics or A2 exam papers, it turns out.

Tables of Analysis of Mark Frequencies for Specific Syllabus Topics

Papers 1, 2 and 3 By Chemistry Category

	P1 16-22 WTD	P1 9-15 WTD	P2 16-22 WTD	P2 9-15 WTD	P3 16-22 WTD	P3 9-15 WTD	P1,2,3 16-22 WTD	1,2,3 9-15 WTD
Paper/s (% weighted of A Level)	1	1	2	2	3	3	1,2,3	1,2,3
% of A Level	15.5	15.5	23.0	23.0	11.5	11.5	50.0	50.0
Years included	16-22	9-15	16-22	9-15	16-22	9-15	16-22	9-15

Physical Chemistry

AS	1 Atomic structure	0.7	0.7	1.7	0.9	0.0	0.0	2.4	1.6
AS	2 Atoms, molecules and stoichiometry	0.5	0.4	1.0	1.2	0.3	0.2	1.8	1.8
AS	3 Chemical bonding	0.9	0.7	1.8	1.0	0.0	0.0	2.7	1.8
AS	4 States of matter	0.5	0.5	0.9	0.4	0.0	0.0	1.5	0.9
AS	5 Chemical energetics	0.8	0.8	1.2	1.6	0.4	0.3	2.5	2.7
AS	6 Electrochemistry	0.6	0.4	0.4	0.4	1.8	3.0	2.8	3.9
AS	7 Equilibria	1.0	1.0	1.2	2.1	1.8	1.8	4.0	4.9
AS	8 Reaction kinetics	0.6	0.6	0.7	0.3	0.6	1.8	1.9	2.6
	Physical Chemistry Totals	5.7	5.2	8.9	7.8	4.9	7.2	19.6	20.2

Inorganic Chemistry

AS	9 The Periodic Table: chemical periodicity	1.0	1.0	1.3	1.7	0.0	0.0	2.3	2.7
AS	10 Group 2	0.9	0.7	1.3	1.1	2.1	0.3	4.3	2.2
AS	11 Group 17	0.9	1.0	1.5	0.5	0.0	0.0	2.4	1.5
AS	12 Nitrogen and sulfur	0.5	0.6	0.8	1.5	3.9	2.8	5.2	4.9
	Inorganic Chemistry Totals	3.3	3.3	4.9	4.9	6.0	3.1	14.2	11.3

Organic Chemistry

AS	13 An introduction to AS Level organic chemistry	1.0	0.9	1.1	0.5	0.0	0.0	2.0	1.4
AS	14 Hydrocarbons	0.6	0.7	2.2	2.5	0.0	0.0	2.8	3.2
AS	15 Halogen compounds	0.7	0.7	0.5	0.5	0.2	0.0	1.4	1.2
AS	16 Hydroxy compounds	0.6	0.8	0.9	0.5	0.1	0.0	1.6	1.4
AS	17 Carbonyl compounds	0.9	0.5	1.0	0.5	0.1	0.1	2.0	1.1
AS	18 Carboxylic acids and derivatives	1.1	1.0	0.7	0.6	0.1	0.0	1.9	1.6
AS	19 Nitrogen compounds	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.1
AS	20 Polymerisation	0.4	0.2	0.3	0.0	0.0	0.0	0.7	0.2
AS	21 Organic synthesis	0.4	1.1	1.2	4.3	0.0	0.0	1.6	5.4
	Organic Chemistry Totals	5.7	5.9	7.9	9.5	0.5	0.1	14.2	15.4

Analysis

AS	22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	1.3	0.0
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No longer assessed	0.3	0.9	0.3	0.8	0.0	1.1	0.6	2.8
<i>AS Total (if <100%, then because some material moved to A2)</i>	15.5	15.3	23.0	23.0	11.5	11.5	50.0	49.8

Physical Chemistry Totals	5.7	5.2	8.9	7.8	4.9	7.2	19.6	20.2
Inorganic Chemistry Totals	3.3	3.3	4.9	4.9	6.0	3.1	14.2	11.3
Organic Chemistry Totals	5.7	5.9	7.9	9.5	0.5	0.1	14.2	15.4
22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	1.3	0.0

Topics Ordered by Mark Value Frequency of 2016-22 in Papers 1, 2 and 3

		P1 16-22 WTD	P1 9-15 WTD	P2 16-22 WTD	P2 9-15 WTD	P3 16-22 WTD	P3 9-15 WTD	P1,2,3 16-22 WTD	1,2,3 9-15 WTD
Paper/s (% weighted of A Level)		1	1	2	2	3	3	1,2,3	1,2,3
% of A Level		15.5	15.5	23.0	23.0	11.5	11.5	50.0	50.0
Years included		16-22	9-15	16-22	9-15	16-22	9-15	16-22	9-15
AS	12 Nitrogen and sulfur	0.5	0.6	0.8	1.5	3.9	2.8	5.2	4.9
AS	10 Group 2	0.9	0.7	1.3	1.1	2.1	0.3	4.3	2.2
AS	7 Equilibria	1.0	1.0	1.2	2.1	1.8	1.8	4.0	4.9
AS	6 Electrochemistry	0.6	0.4	0.4	0.4	1.8	3.0	2.8	3.9
AS	14 Hydrocarbons	0.6	0.7	2.2	2.5	0.0	0.0	2.8	3.2
AS	3 Chemical bonding	0.9	0.7	1.8	1.0	0.0	0.0	2.7	1.8
AS	5 Chemical energetics	0.8	0.8	1.2	1.6	0.4	0.3	2.5	2.7
AS	1 Atomic structure	0.7	0.7	1.7	0.9	0.0	0.0	2.4	1.6
AS	11 Group 17	0.9	1.0	1.5	0.5	0.0	0.0	2.4	1.5
AS	9 The Periodic Table: chemical periodicity	1.0	1.0	1.3	1.7	0.0	0.0	2.3	2.7
AS	13 An introduction to AS Level organic chemistry	1.0	0.9	1.1	0.5	0.0	0.0	2.0	1.4
AS	17 Carbonyl compounds	0.9	0.5	1.0	0.5	0.1	0.1	2.0	1.1
AS	8 Reaction kinetics	0.6	0.6	0.7	0.3	0.6	1.8	1.9	2.6
AS	18 Carboxylic acids and derivatives	1.1	1.0	0.7	0.6	0.1	0.0	1.9	1.6
AS	2 Atoms, molecules and stoichiometry	0.5	0.4	1.0	1.2	0.3	0.2	1.8	1.8
AS	16 Hydroxy compounds	0.6	0.8	0.9	0.5	0.1	0.0	1.6	1.4
AS	21 Organic synthesis	0.4	1.1	1.2	4.3	0.0	0.0	1.6	5.4
AS	4 States of matter	0.5	0.5	0.9	0.4	0.0	0.0	1.5	0.9
AS	15 Halogen compounds	0.7	0.7	0.5	0.5	0.2	0.0	1.4	1.2
AS	22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	1.3	0.0
AS	20 Polymerisation	0.4	0.2	0.3	0.0	0.0	0.0	0.7	0.2
	No longer assessed	0.3	0.9	0.3	0.8	0.0	1.1	0.6	2.8
AS	19 Nitrogen compounds	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.1
AS Total (if <TOTAL then because some material moved to A2)		15.5	15.3	23.0	23.0	11.5	11.5	50.0	49.8



Theory Papers (1, 2 and 4) Compared with Practical Papers (3 and 5) by Chemistry Topic

Paper/s (% weighted of A Level)

% of A Level:

Years included:

P1,2 16-22 WTD P1&2 WTD P1,2,4 16-22 WTD P1,2,4 9-15 WTD

1,2	1,2	1,2,4	1,2,4
38.5	38.5	77.0	77.0
2016-22	2009-15	2016-22	2009-15

Physical Chemistry

AS	1 Atomic structure	2.4	1.6	2.4	1.6
AS	2 Atoms, molecules and stoichiometry	1.5	1.6	1.7	2.1
AS	3 Chemical bonding	2.7	1.8	3.1	2.4
AS	4 States of matter	1.5	0.9	1.5	0.9
AS	5 Chemical energetics	2.1	2.4	2.1	3.0
AS	6 Electrochemistry	1.0	0.8	1.2	0.8
AS	7 Equilibria	2.2	3.1	2.2	3.7
AS	8 Reaction kinetics	1.3	0.9	1.3	0.9
A2	23 Chemical energetics	0.0	0.1	3.3	1.0
A2	24 Electrochemistry	0.0	0.0	3.2	3.1
A2	25 Equilibria	0.0	0.0	3.8	1.7
A2	26 Reaction kinetics	0.0	0.0	2.2	2.0
Physical Chemistry Totals		14.7	13.1	27.9	23.2
AS	Inorganic Chemistry				
AS	9 The Periodic Table: chemical periodicity	2.3	2.7	2.3	3.7
AS	10 Group 2	2.2	1.8	2.4	1.8
AS	11 Group 17	2.4	1.5	2.4	1.7
AS	12 Nitrogen and sulfur	1.3	2.2	1.3	2.8
A2	27 Group 2	0.0	0.0	2.0	0.6
A2	28 Chemistry of transition elements	0.0	0.0	7.6	2.7
Inorganic Chemistry Totals		8.2	8.2	18.2	13.2
AS	Organic Chemistry				
AS	13 An introduction to AS Level organic chemistry	2.0	1.4	2.4	1.8
AS	14 Hydrocarbons	2.8	3.2	2.9	3.8
AS	15 Halogen compounds	1.2	1.2	1.3	1.6
AS	16 Hydroxy compounds	1.4	1.4	1.6	1.4

P3,5 16-22 WTD P3&5 9-15 WTD

3,5	3,5
23.0	23.0
2016-22	2009-15
0.0	0.0
0.7	1.7
0.0	0.0
0.8	0.8
1.5	0.9
3.1	3.7
2.4	3.1
1.3	2.7
0.0	1.6
1.2	0.6
0.5	0.0
2.8	0.6
14.3	15.8
0.3	0.3
2.6	0.3
0.4	0.3
3.9	2.8
0.2	1.9
0.2	0.3
7.5	6.0
0.0	0.0
0.3	0.0
0.2	0.0
0.1	0.0



Theory Papers (1, 2 and 4) Compared with Practical Papers (3 and 5) by Chemistry Topic

Paper/s (% weighted of A Level)		P1,2 16-22 WTD	P1&2 WTD	P1,2,4 16-22 WTD	P1,2,4 9-15 WTD	P3,5 16-22 WTD	P3&5 9-15 WTD
		1,2	1,2	1,2,4	1,2,4	3,5	3,5
% of A Level:		38.5	38.5	77.0	77.0	23.0	23.0
Years included:		2016-22	2009-15	2016-22	2009-15	2016-22	2009-15
AS	17 Carbonyl compounds	1.9	1.0	2.0	1.5	0.1	0.1
AS	18 Carboxylic acids and derivatives	1.7	1.6	1.7	1.6	0.1	0.0
AS	19 Nitrogen compounds	0.2	0.1	0.2	0.1	0.0	0.0
AS	20 Polymerisation	0.7	0.2	0.7	0.3	0.0	0.0
AS	21 Organic synthesis	1.6	5.4	1.6	5.4	0.2	0.0
A2	29 An introduction to A Level organic chemistry	0.0	0.0	0.3	0.4	0.0	0.0
A2	30 Hydrocarbons	0.0	0.0	1.1	0.4	0.0	0.0
A2	31 Halogen compounds	0.0	0.0	0.1	0.0	0.0	0.0
A2	32 Hydroxy compounds	0.0	0.0	0.8	0.8	0.0	0.0
A2	33 Carboxylic acids and derivatives	0.0	0.0	1.2	0.7	0.0	0.0
A2	34 Nitrogen compounds	0.0	0.1	3.0	2.1	0.0	0.0
A2	35 Polymerisation	0.0	0.0	1.0	0.9	0.0	0.0
A2	36 Organic synthesis	0.0	0.0	3.2	6.1	0.0	0.0
Organic Chemistry Totals		13.7	15.4	25.2	28.9	1.0	0.1
Analysis							
AS	22 Analytical techniques	1.3	0.0	1.7	0.5	0.0	0.0
A2	37 Analytical techniques	0.0	0.0	3.0	1.9	0.1	0.0
Analysis Totals		1.3	0.0	4.7	2.4	0.1	0.0
No longer assessed		0.6	1.7	1.0	9.3	0.0	1.1
AS	AS Total	37.9	36.6	40.2	43.3	17.9	16.8
A2	A2 Total	0.0	0.2	35.8	24.4	5.1	5.1
AS+A2+no longer in syllabus		38.5	38.5	77.0	77.0	23.0	23.0
Physical Chemistry Totals		14.7	13.1	27.9	23.2	14.3	15.8
Inorganic Chemistry Totals		8.2	8.2	18.2	13.2	7.5	6.0
Organic Chemistry Totals		13.7	15.4	25.2	28.9	1.0	0.1
Analytical Techniques Totals		1.3	0.0	4.7	2.4	0.1	0.0



Papers 4 and 5, and AS papers by Topic

	P4 16-22 WTD	P4 9-15 WTD	P5 16-22 WTD	P5 9-15 WTD	P5 06w-02s WTD	P4,5 16-22 WTD	P4,5 9-15 WTD	P1to5 16-22 WTD	P1to5 9-15 WTD
Papers (% weighted of A Level)	4	4	5	5	5	4,5	4,5	1,2,3,4,5	1,2,3,4,5
% of A Level:	38.5	38.5	11.5	11.5	11.0	50.0	50.0	100.0	100.0
Years included:	2016-22	2009-15	2016-22	2009-15	2006-02	2016-22	2009-15	2016-22	2009-15

Physical Chemistry

AS	1 Atomic structure	0.0	0.1	0.0	0.0	0.0	0.0	0.1	2.4	1.6
AS	2 Atoms, molecules and stoichiometry	0.2	0.6	0.5	1.4	2.4	0.6	2.0	2.4	3.8
AS	3 Chemical bonding	0.4	0.6	0.0	0.0	0.0	0.4	0.6	3.1	2.4
AS	4 States of matter	0.0	0.0	0.8	0.8	1.1	0.8	0.8	2.3	1.7
AS	5 Chemical energetics	0.0	0.6	1.0	0.6	1.6	1.0	1.2	3.5	3.9
AS	6 Electrochemistry	0.2	0.0	1.4	0.6	1.7	1.5	0.6	4.3	4.5
AS	7 Equilibria	0.0	0.6	0.6	1.3	1.1	0.6	1.9	4.6	6.8
AS	8 Reaction kinetics	0.0	0.0	0.7	0.9	1.6	0.7	0.9	2.6	3.6
A2	23 Chemical energetics	3.2	0.9	0.0	1.6	0.0	3.2	2.5	3.3	2.6
A2	24 Electrochemistry	3.2	3.1	1.2	0.6	0.0	4.4	3.7	4.4	3.8
A2	25 Equilibria	3.8	1.7	0.5	0.0	0.0	4.3	1.7	4.3	1.7
A2	26 Reaction kinetics	2.2	2.0	2.8	0.6	0.7	5.1	2.6	5.1	2.6
	Physical Chemistry Totals	13.2	10.1	9.4	8.6	10.3	22.6	18.7	42.2	39.0

AS	Inorganic Chemistry									
AS	9 The Periodic Table: chemical periodicity	0.0	0.9	0.3	0.3	0.0	0.3	1.3	2.6	4.0
AS	10 Group 2	0.3	0.0	0.4	0.0	0.0	0.7	0.0	5.0	2.2
AS	11 Group 17	0.0	0.2	0.4	0.3	0.0	0.4	0.5	2.8	2.0
AS	12 Nitrogen and sulfur	0.0	0.6	0.0	0.0	0.0	0.0	0.6	5.2	5.5
A2	27 Group 2	2.0	0.6	0.2	1.9	0.7	2.3	2.5	2.3	2.5
A2	28 Chemistry of transition elements	7.6	2.7	0.2	0.3	0.0	7.8	3.1	7.8	3.1
	Inorganic Chemistry Totals	9.9	5.0	1.5	2.9	0.7	11.4	7.9	25.7	19.2

AS	Organic Chemistry									
AS	13 An introduction to AS Level organic chemistry	0.4	0.5	0.0	0.0	0.0	0.4	0.5	2.4	1.8
AS	14 Hydrocarbons	0.2	0.6	0.3	0.0	0.0	0.4	0.6	3.2	3.8
AS	15 Halogen compounds	0.1	0.4	0.0	0.0	0.0	0.1	0.4	1.5	1.6
AS	16 Hydroxy compounds	0.1	0.0	0.0	0.0	0.0	0.1	0.0	1.7	1.4

Papers 4 and 5, and AS papers by Topic

		P4 16-22 WTD	P4 9-15 WTD	P5 16-22 WTD	P5 9-15 WTD	P5 06w-02s WTD	P4,5 16-22 WTD	P4,5 9-15 WTD	P1to5 16-22 WTD	P1to5 9-15 WTD
Papers (% weighted of A Level)		4	4	5	5	5	4,5	4,5	1,2,3,4,5	1,2,3,4,5
% of A Level:		38.5	38.5	11.5	11.5	11.0	50.0	50.0	100.0	100.0
Years included:		2016-22	2009-15	2016-22	2009-15	2006-02	2016-22	2009-15	2016-22	2009-15
AS	17 Carbonyl compounds	0.1	0.5	0.0	0.0	0.0	0.1	0.5	2.1	1.6
AS	18 Carboxylic acids and derivatives	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.6
AS	19 Nitrogen compounds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
AS	20 Polymerisation	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.7	0.3
AS	21 Organic synthesis	0.0	0.0	0.2	0.0	0.0	0.2	0.0	1.9	5.4
A2	29 An introduction to A Level organic chemistry	0.3	0.4	0.0	0.0	0.0	0.3	0.4	0.3	0.4
A2	30 Hydrocarbons	1.1	0.4	0.0	0.0	0.0	1.1	0.4	1.1	0.4
A2	31 Halogen compounds	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
A2	32 Hydroxy compounds	0.8	0.8	0.0	0.0	0.0	0.8	0.8	0.8	0.8
A2	33 Carboxylic acids and derivatives	1.2	0.7	0.0	0.0	0.0	1.2	0.7	1.2	0.7
A2	34 Nitrogen compounds	3.0	2.0	0.0	0.0	0.0	3.0	2.0	3.0	2.1
A2	35 Polymerisation	1.0	0.9	0.0	0.0	0.0	1.0	0.9	1.0	0.9
A2	36 Organic synthesis	3.2	6.1	0.0	0.0	0.0	3.2	6.1	3.2	6.1
Organic Chemistry Totals		11.6	13.4	0.5	0.0	0.0	12.1	13.4	26.3	29.0
Analysis										
AS	22 Analytical techniques	0.4	0.5	0.0	0.0	0.0	0.4	0.5	1.7	0.5
A2	37 Analytical techniques	3.0	1.9	0.1	0.0	0.0	3.1	1.9	3.1	1.9
Analysis Totals		3.4	2.4	0.1	0.0	0.0	3.5	2.4	4.8	2.4
No longer assessed		0.4	7.6	0.0	0.0	0.0	0.4	7.6	1.0	10.4
AS	AS Total	2.3	6.8	6.4	6.4	9.6	8.7	13.2	58.1	60.1
A2	A2 Total	35.8	24.1	5.1	5.1	1.4	40.9	29.2	40.9	29.5
AS+A2+no longer in syllabus		38.5	38.5	11.5	11.5	11.0	50.0	50.0	100.0	100.0
Physical Chemistry Totals		13.2	10.1	9.4	8.6	10.3	22.6	18.7	42.2	39.0
Inorganic Chemistry Totals		9.9	5.0	1.5	2.9	0.7	11.4	7.9	25.7	19.2
Organic Chemistry Totals		11.6	13.4	0.5	0.0	0.0	12.1	13.4	26.3	29.0
Analytical Techniques Totals		3.4	2.4	0.1	0.0	0.0	3.5	2.4	4.8	2.4

Topics Ordered by Mark Value Frequency of 2016-22 in Papers 4 and 5

		P4 16-22 WTD	P4 9-15 WTD	P5 16-22 WTD	P5 9-15 WTD	P5 06w-02s WTD	P4,5 16-22 WTD	P4,5 9-15 WTD	P1to5 16-22 WTD	P1to5 9-15 WTD
Paper/s (% weighted of A Level)		4	4	5	5	5	4,5	4,5	1,2,3,4,5	1,2,3,4,5
% of A Level:		38.5	38.5	11.5	11.5	11.0	50.0	50.0	100.0	100.0
Years included:		2016-22	2009-15	2016-22	2009-15	2006-02	2016-22	2009-15	2016-22	2009-15
AS+A2+no longer in syllabus		38.5	38.5	11.5	11.5	11.0	50.0	50.0	100.0	100.0
A2	A2 Total	35.8	24.1	5.1	5.1	1.4	40.9	29.2	40.9	29.5
AS	AS Total	2.3	6.8	6.4	6.4	9.6	8.7	13.2	58.1	60.1
A2	28 Chemistry of transition elements	7.6	2.7	0.2	0.3	0.0	7.8	3.1	7.8	3.1
A2	26 Reaction kinetics	2.2	2.0	2.8	0.6	0.7	5.1	2.6	5.1	2.6
A2	24 Electrochemistry	3.2	3.1	1.2	0.6	0.0	4.4	3.7	4.4	3.8
A2	25 Equilibria	3.8	1.7	0.5	0.0	0.0	4.3	1.7	4.3	1.7
A2	23 Chemical energetics	3.2	0.9	0.0	1.6	0.0	3.2	2.5	3.3	2.6
A2	36 Organic synthesis	3.2	6.1	0.0	0.0	0.0	3.2	6.1	3.2	6.1
A2	37 Analytical techniques	3.0	1.9	0.1	0.0	0.0	3.1	1.9	3.1	1.9
A2	34 Nitrogen compounds	3.0	2.0	0.0	0.0	0.0	3.0	2.0	3.0	2.1
A2	27 Group 2	2.0	0.6	0.2	1.9	0.7	2.3	2.5	2.3	2.5
AS	6 Electrochemistry	0.2	0.0	1.4	0.6	1.7	1.5	0.6	4.3	4.5
A2	33 Carboxylic acids and derivatives	1.2	0.7	0.0	0.0	0.0	1.2	0.7	1.2	0.7
A2	30 Hydrocarbons	1.1	0.4	0.0	0.0	0.0	1.1	0.4	1.1	0.4
AS	5 Chemical energetics	0.0	0.6	1.0	0.6	1.6	1.0	1.2	3.5	3.9
A2	35 Polymerisation	1.0	0.9	0.0	0.0	0.0	1.0	0.9	1.0	0.9
AS	4 States of matter	0.0	0.0	0.8	0.8	1.1	0.8	0.8	2.3	1.7
A2	32 Hydroxy compounds	0.8	0.8	0.0	0.0	0.0	0.8	0.8	0.8	0.8
AS	10 Group 2	0.3	0.0	0.4	0.0	0.0	0.7	0.0	5.0	2.2
AS	8 Reaction kinetics	0.0	0.0	0.7	0.9	1.6	0.7	0.9	2.6	3.6
AS	7 Equilibria	0.0	0.6	0.6	1.3	1.1	0.6	1.9	4.6	6.8
AS	2 Atoms, molecules and stoichiometry	0.2	0.6	0.5	1.4	2.4	0.6	2.0	2.4	3.8
AS	14 Hydrocarbons	0.2	0.6	0.3	0.0	0.0	0.4	0.6	3.2	3.8
AS	3 Chemical bonding	0.4	0.6	0.0	0.0	0.0	0.4	0.6	3.1	2.4

Topics Ordered by Mark Value Frequency of 2016-22 in Papers 4 and 5

		P4 16-22 WTD	P4 9-15 WTD	P5 16-22 WTD	P5 9-15 WTD	P5 06w-02s WTD	P4,5 16-22 WTD	P4,5 9-15 WTD	P1to5 16-22 WTD	P1to5 9-15 WTD
Paper/s (% weighted of A Level)		4	4	5	5	5	4,5	4,5	1,2,3,4,5	1,2,3,4,5
% of A Level:		38.5	38.5	11.5	11.5	11.0	50.0	50.0	100.0	100.0
Years included:		2016-22	2009-15	2016-22	2009-15	2006-02	2016-22	2009-15	2016-22	2009-15
AS	11 Group 17	0.0	0.2	0.4	0.3	0.0	0.4	0.5	2.8	2.0
AS	13 An introduction to AS Level organic chemistry	0.4	0.5	0.0	0.0	0.0	0.4	0.5	2.4	1.8
AS	22 Analytical techniques	0.4	0.5	0.0	0.0	0.0	0.4	0.5	1.7	0.5
	No longer assessed	0.4	7.6	0.0	0.0	0.0	0.4	7.6	1.0	10.4
AS	9 The Periodic Table: chemical periodicity	0.0	0.9	0.3	0.3	0.0	0.3	1.3	2.6	4.0
A2	29 An introduction to A Level organic chemistry	0.3	0.4	0.0	0.0	0.0	0.3	0.4	0.3	0.4
AS	21 Organic synthesis	0.0	0.0	0.2	0.0	0.0	0.2	0.0	1.9	5.4
AS	17 Carbonyl compounds	0.1	0.5	0.0	0.0	0.0	0.1	0.5	2.1	1.6
AS	16 Hydroxy compounds	0.1	0.0	0.0	0.0	0.0	0.1	0.0	1.7	1.4
AS	15 Halogen compounds	0.1	0.4	0.0	0.0	0.0	0.1	0.4	1.5	1.6
A2	31 Halogen compounds	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
AS	12 Nitrogen and sulfur	0.0	0.6	0.0	0.0	0.0	0.0	0.6	5.2	5.5
AS	1 Atomic structure	0.0	0.1	0.0	0.0	0.0	0.0	0.1	2.4	1.6
AS	18 Carboxylic acids and derivatives	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.6
AS	20 Polymerisation	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.7	0.3
AS	19 Nitrogen compounds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1

SMASHING!!!



AS and A2 CAIE 9701 Chemistry Analysis

Each exam paper, or combination, like “Papers 1, 2 and 3” use the weighting, as a fraction of the whole A Level (AS and A2 years) given in the syllabus:

Paper	% of AS/ A2	% of ALvl	Marks	Time in min	secs/ marks	% YEAR	% ALL A-Level/ mark (weighting)
1	31	15.5	40	75	112.5	0.78	0.39
2	46	23	60	75	75	0.77	0.38
3	23	11.5	40	120	180	0.58	0.29
4	77	38.5	100	120	72	0.77	0.39
5	23	11.5	30	75	150	0.77	0.38

Variability in UMS/PUM Grade Thresholds from 2014s to 2024w

PUM = Percentage Uniform Mark; **UMS** = Uniform Mark Scale (UK version of PUM)

UMS/PUM allows 2 scores from 2 different versions of the same exam paper that may have been slightly different in terms of difficulty, to be made. A student sitting a slightly harder exam paper will have a lower grade threshold compared to a student, for instance doing their exam papers in a different time zone that is slightly easier. Each grade always has the same UMS score, so an A* is always 90% UMS, but the raw score can be different, often a lower percentage. The table below shows how this threshold has changed in the last 10 years.

Grade:		A*	A	B	C	D	E
UMS/PUM %		90%	80%	70%	60%	50%	40%
2014s to 2024w	Highest Raw % Score	79	70	62	53	44	35
	Lowest Raw % Score	62	54	46	38	30	21
	Variability	17	16	17	15	14	14
	Average Raw % Score	73	64	55	46	37	28

Grade:		A*	A	B	C	D	E
2020m and before:	Highest Raw % Score	79	70	62	53	44	35
	Lowest Raw % Score	72	63	54	46	37	28
	Variability	7	7	8	7	7	7
	Average Raw % Score	76	67	58	49	41	32

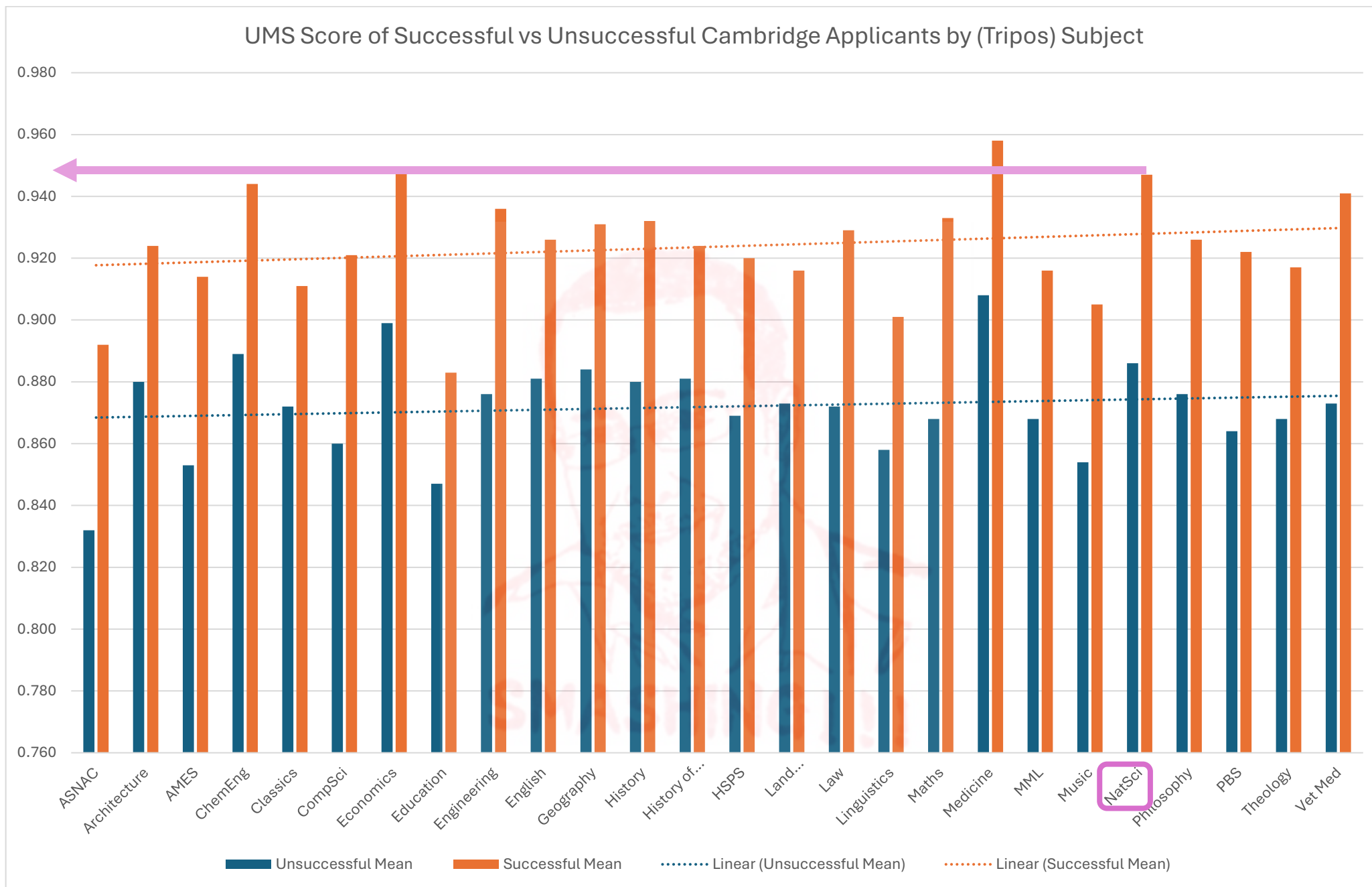
Grade:		A*	A	B	C	D	E
2020w and later:	Highest Raw % Score	78	68	58	47	37	28
	Lowest Raw % Score	62	54	46	38	30	21
	Variability	16	14	12	9	7	7
	Average Raw % Score	70	61	51	42	33	24

Most courses and almost all universities generally do not explain if they use your UMS/PUM score, with the exception of Cambridge, which always requires you to give your UMS/PUM as additional information when you apply, but not through the UCAS form. They have also created and published a report analysing 14,000 applicants dated July 2015:

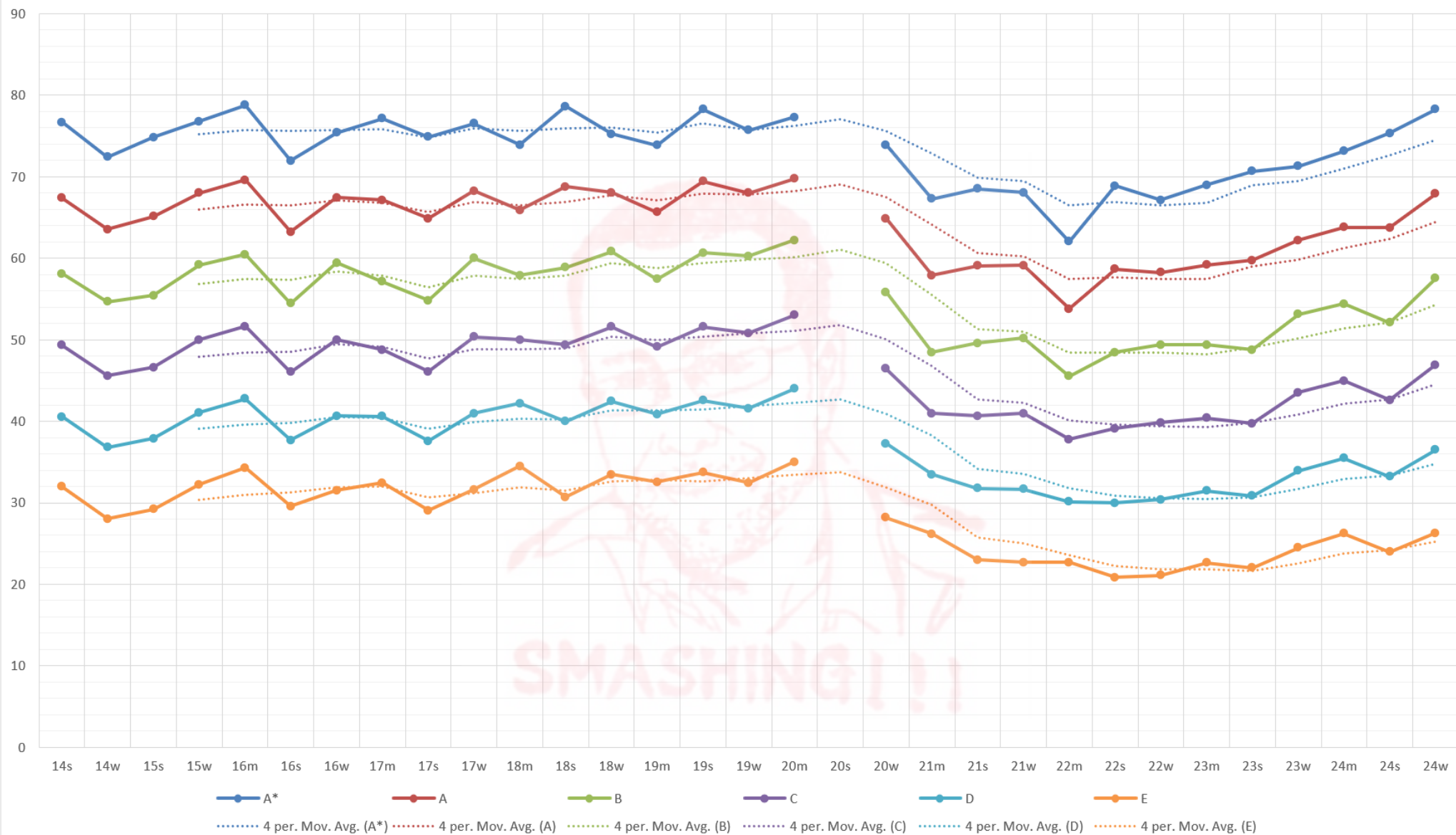
https://www.cao.cam.ac.uk/sites/www.cao.cam.ac.uk/files/ar_ums_performance_the_destination_of_cambridge_applicants.pdf

The mean average UMS/PUM score for a successful Cambridge applicant was 92% average (for the best 3 AS level subjects), but that average was about 95% for (natural) science applicants, a bar chart using their statistics follows.





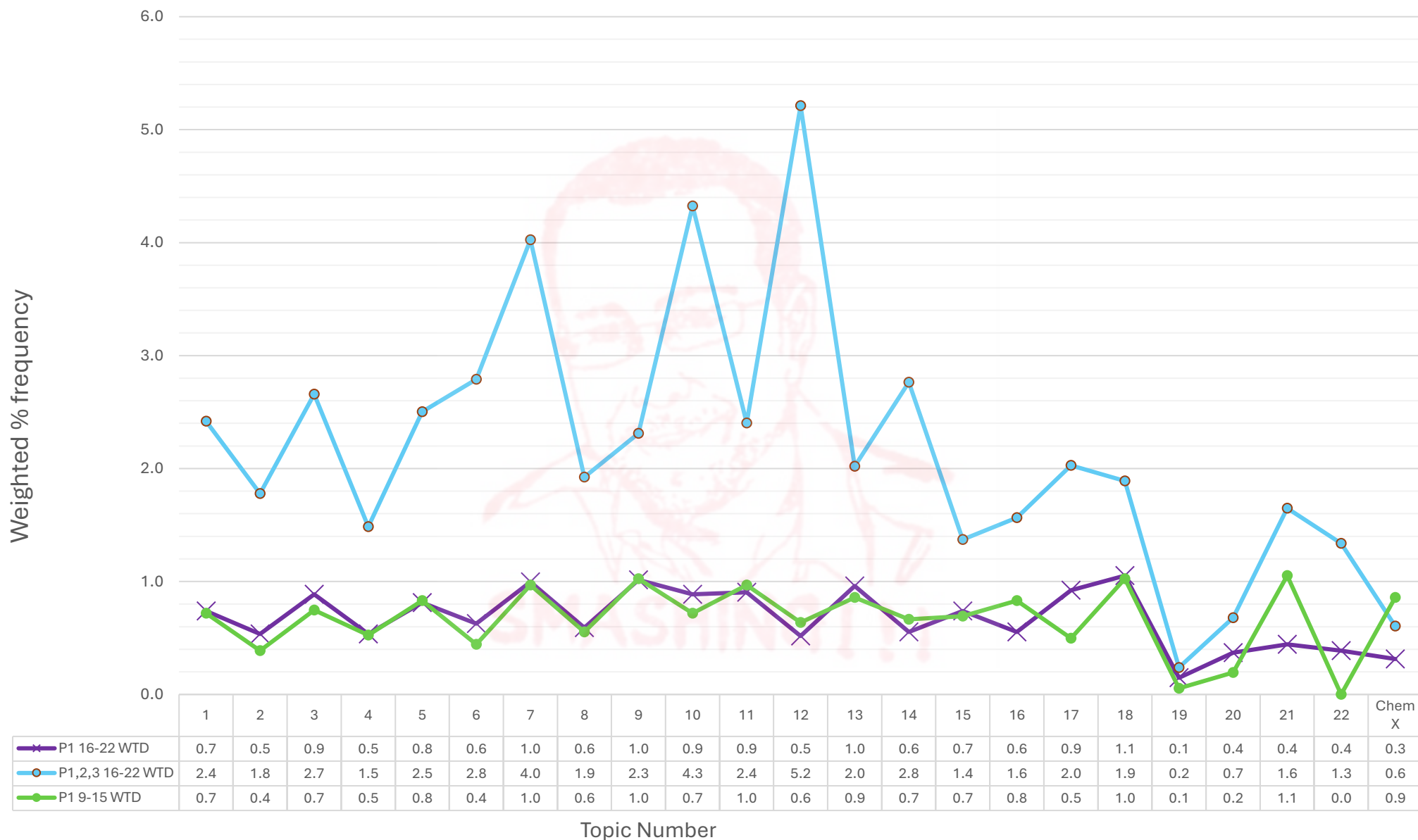
CIE AS Chemistry 9701 Grade boundaries from 2014s to 2024w average % of all variants of component combinations awarding the A Level



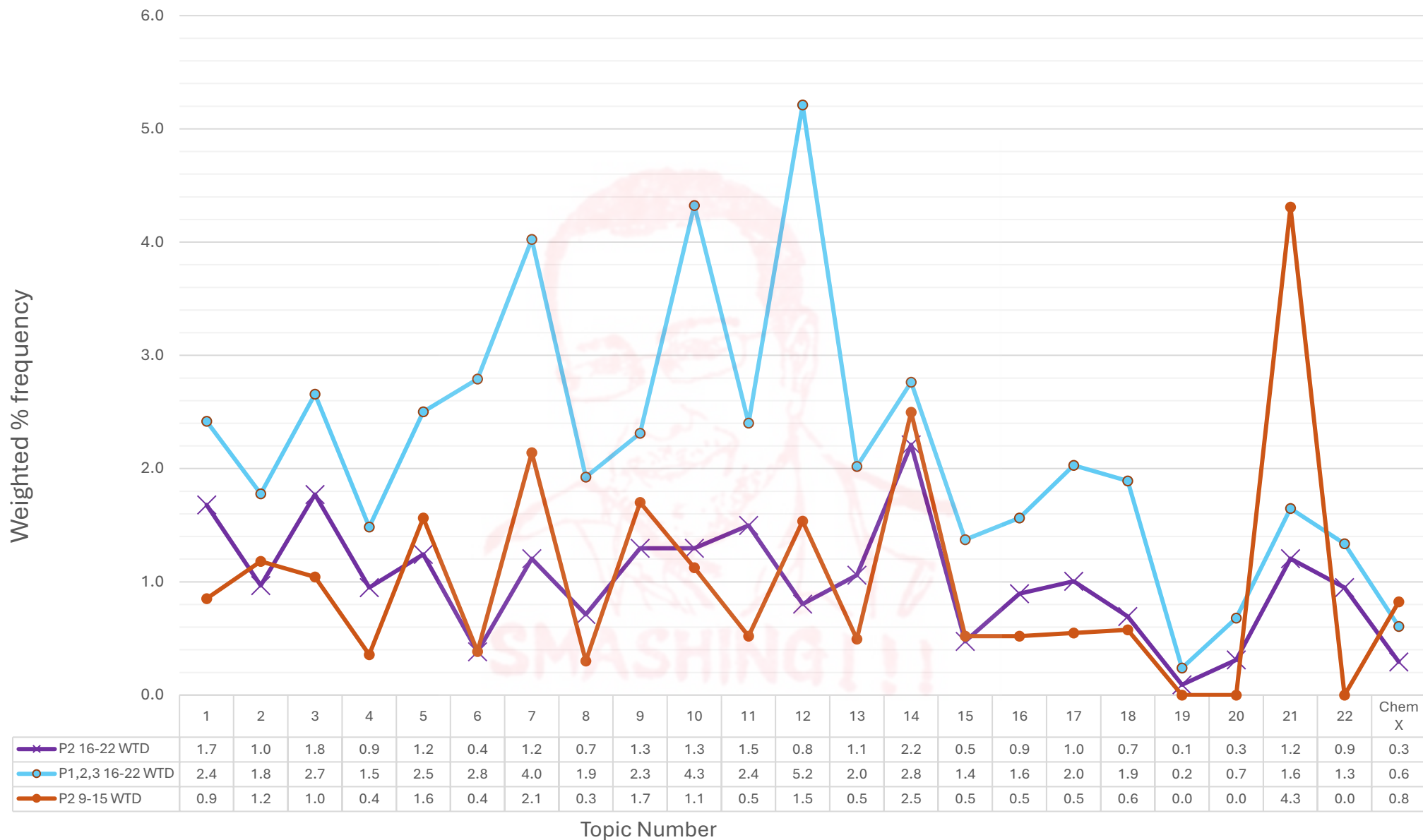
Graphs of Analysis of Mark Frequencies for Specific Syllabus Topics

9701 Chemistry Weighted Mark Frequency: Paper 1

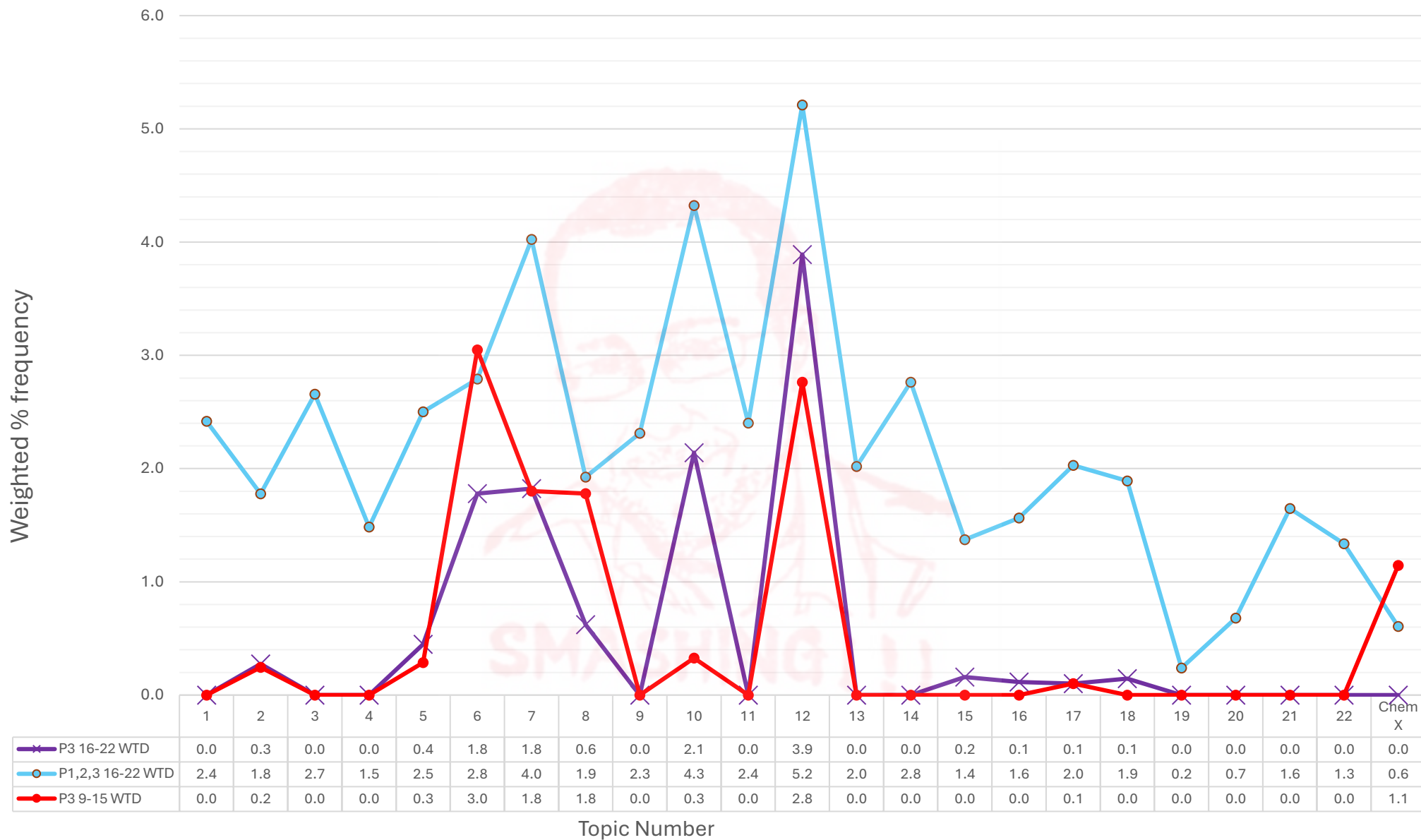
2022w to 2016m in purple crosses, compared to earlier and all AS exams combined



9701 Chemistry Weighted Mark Frequency: Paper 2
2022w to 2016m in purple crosses, compared to earlier and all AS exams combined

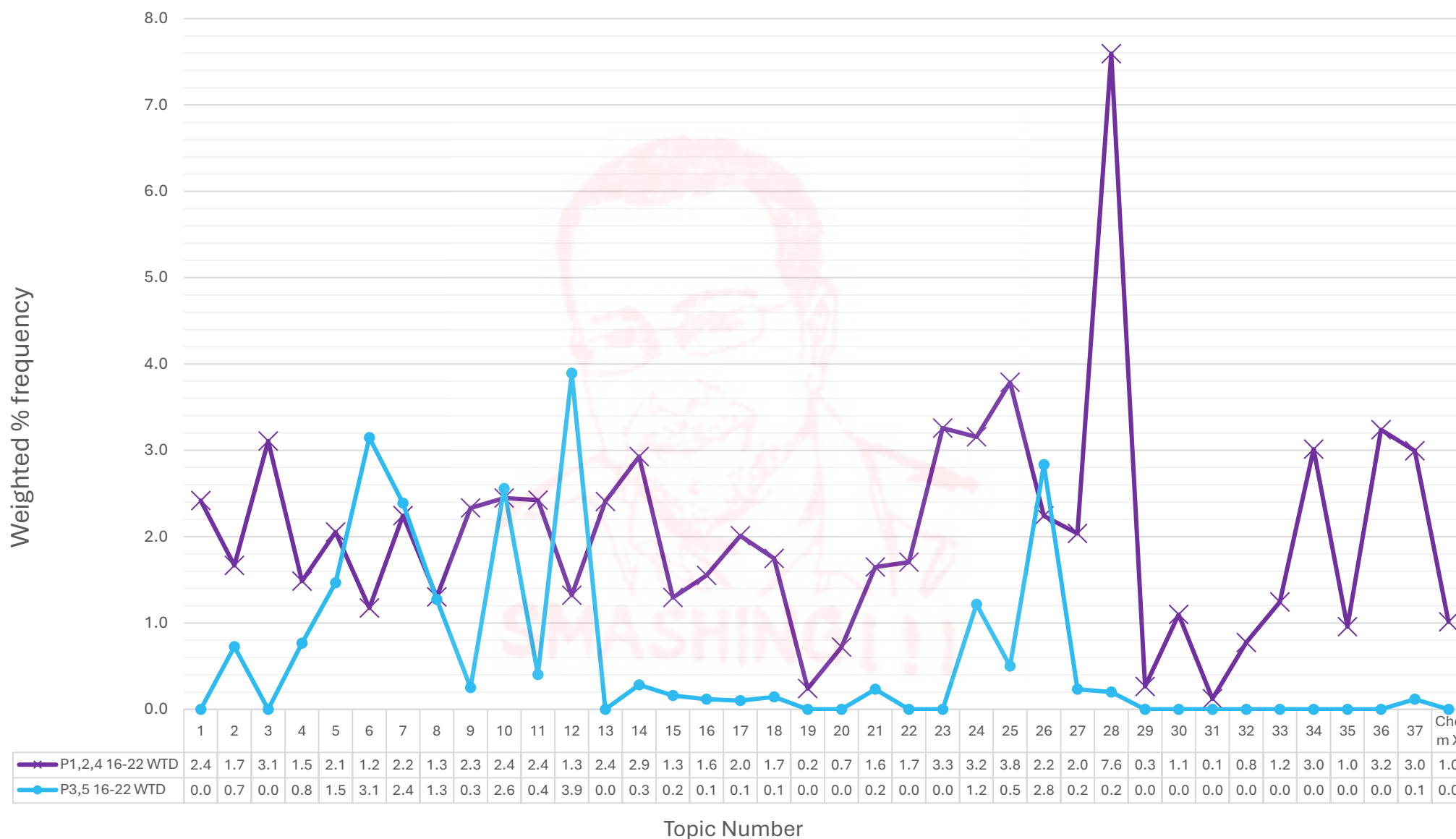


9701 Chemistry Weighted Mark Frequency: Paper 3
2022w to 2016m in purple crosses, compared to earlier and all AS exams combined

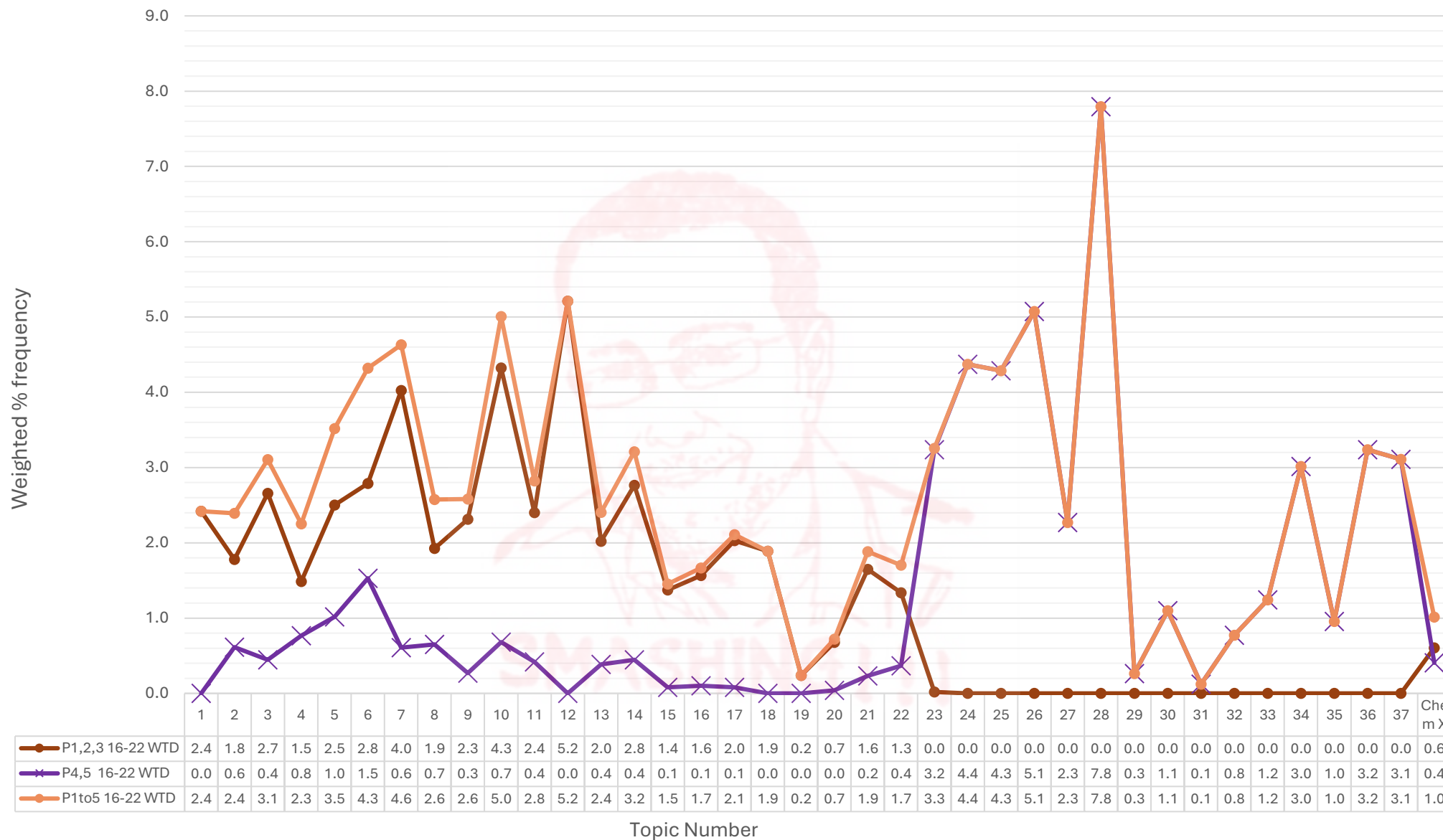


9701 Chemistry Weighted Mark Frequency: Theory Papers (1, 2 and 4) vs. Practical Papers (3 and 5)

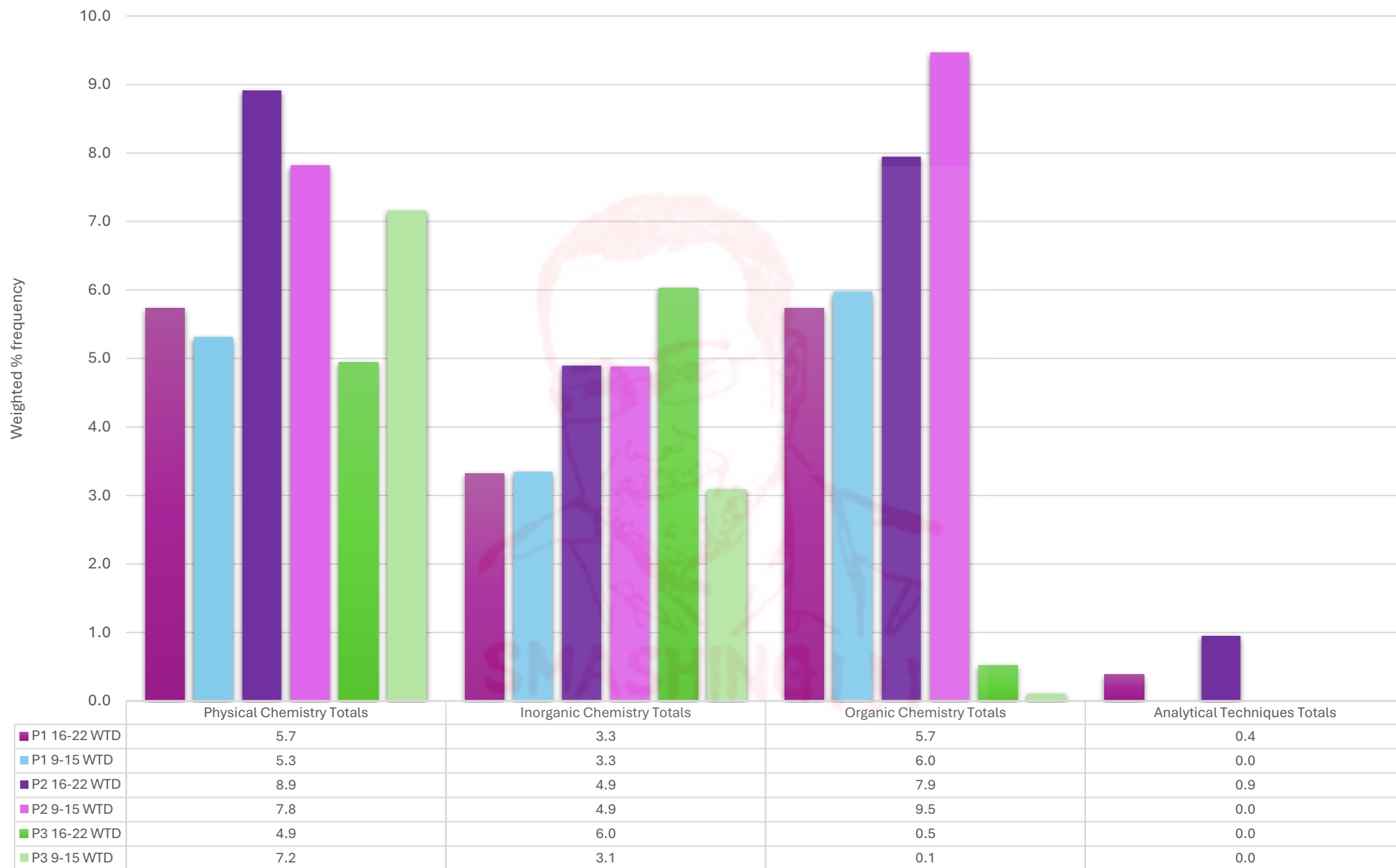
Theory papers in purple crosses, compared to practical papers



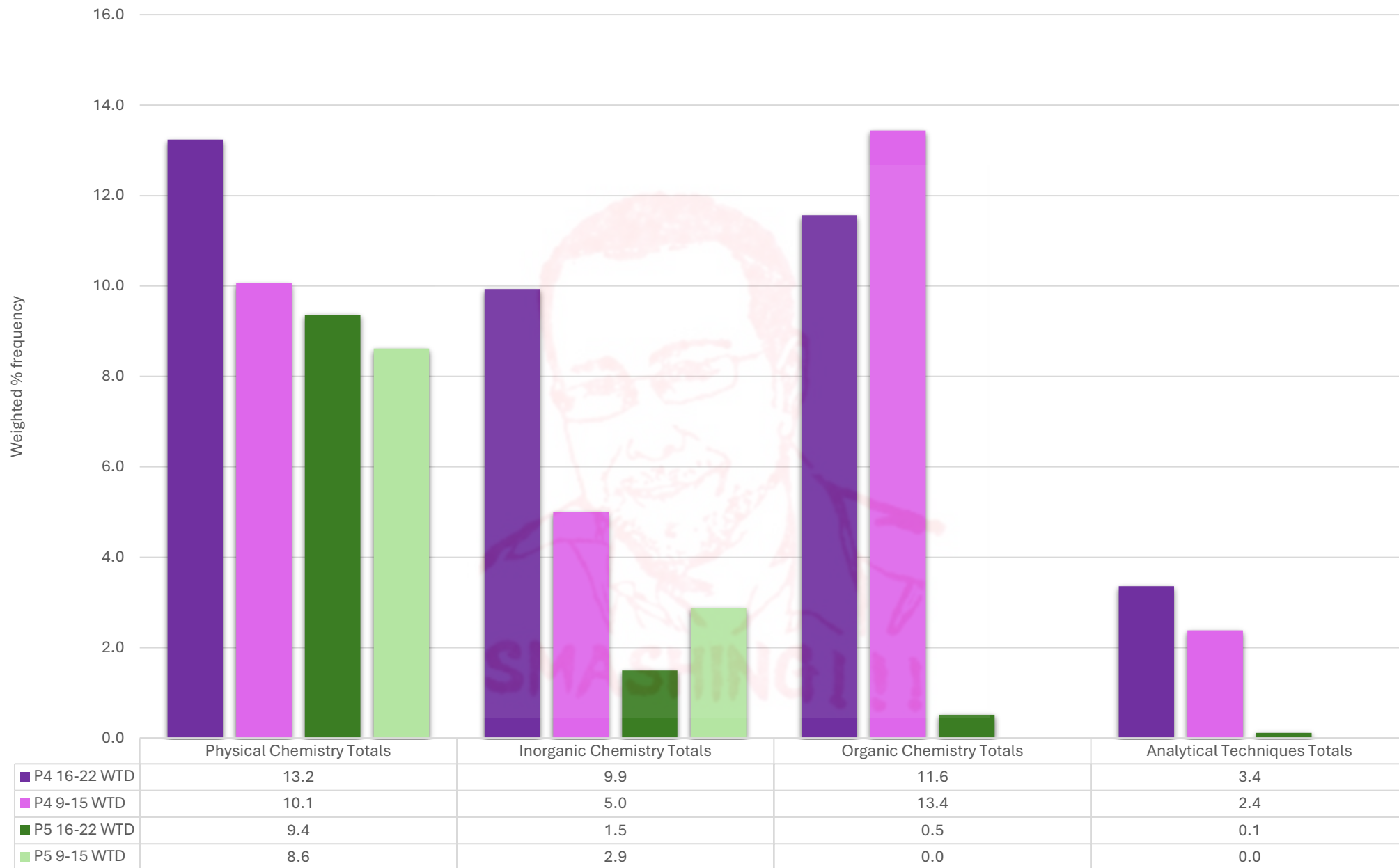
9701 Chemistry Weighted Mark Frequency: AS compared to A2
A2 papers in purple crosses, compared to AS and ALL papers for 2022w to 2016m



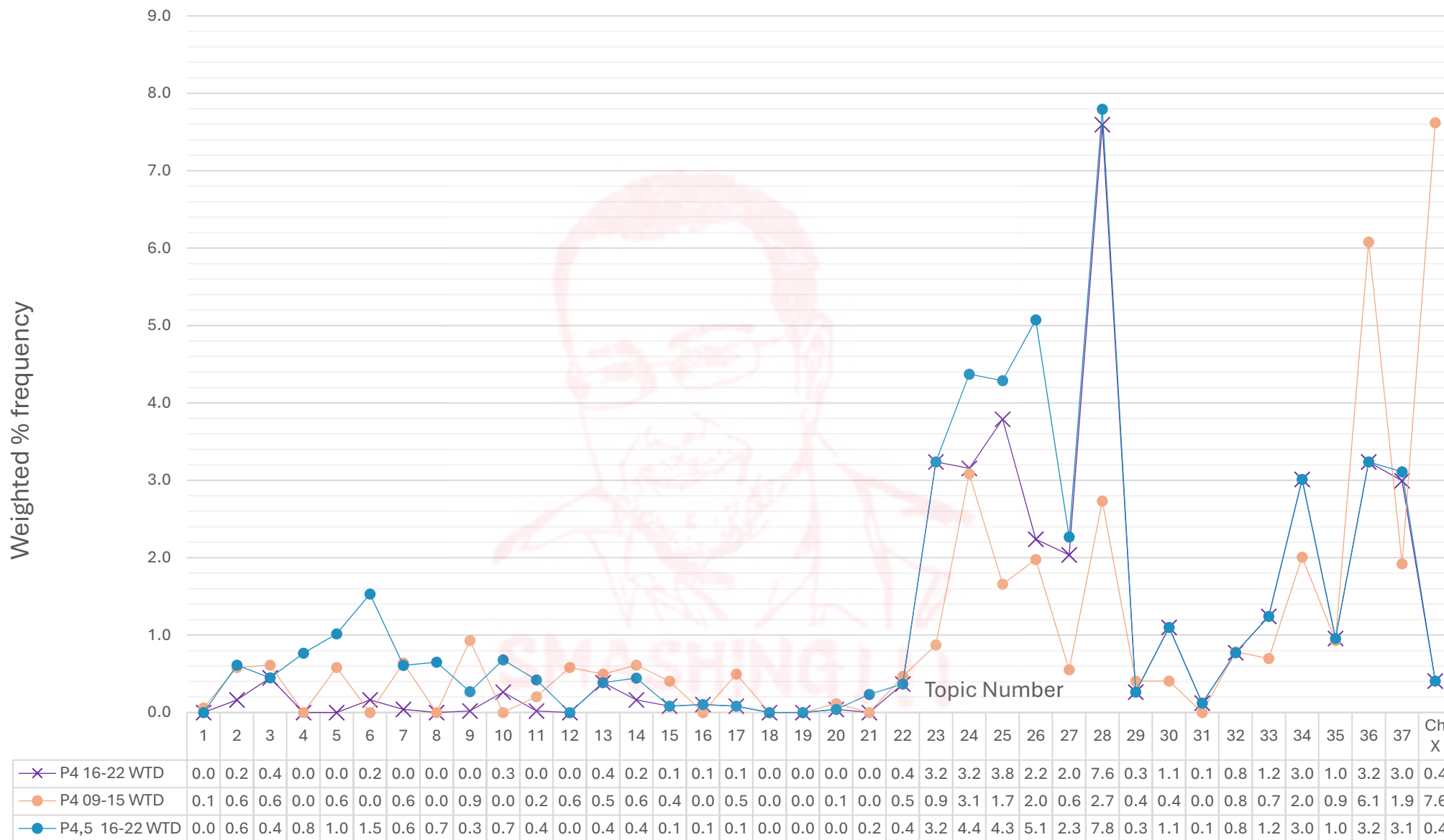
9701 Chemistry Categories Totals Weighted for Papers 1, 2 and 3



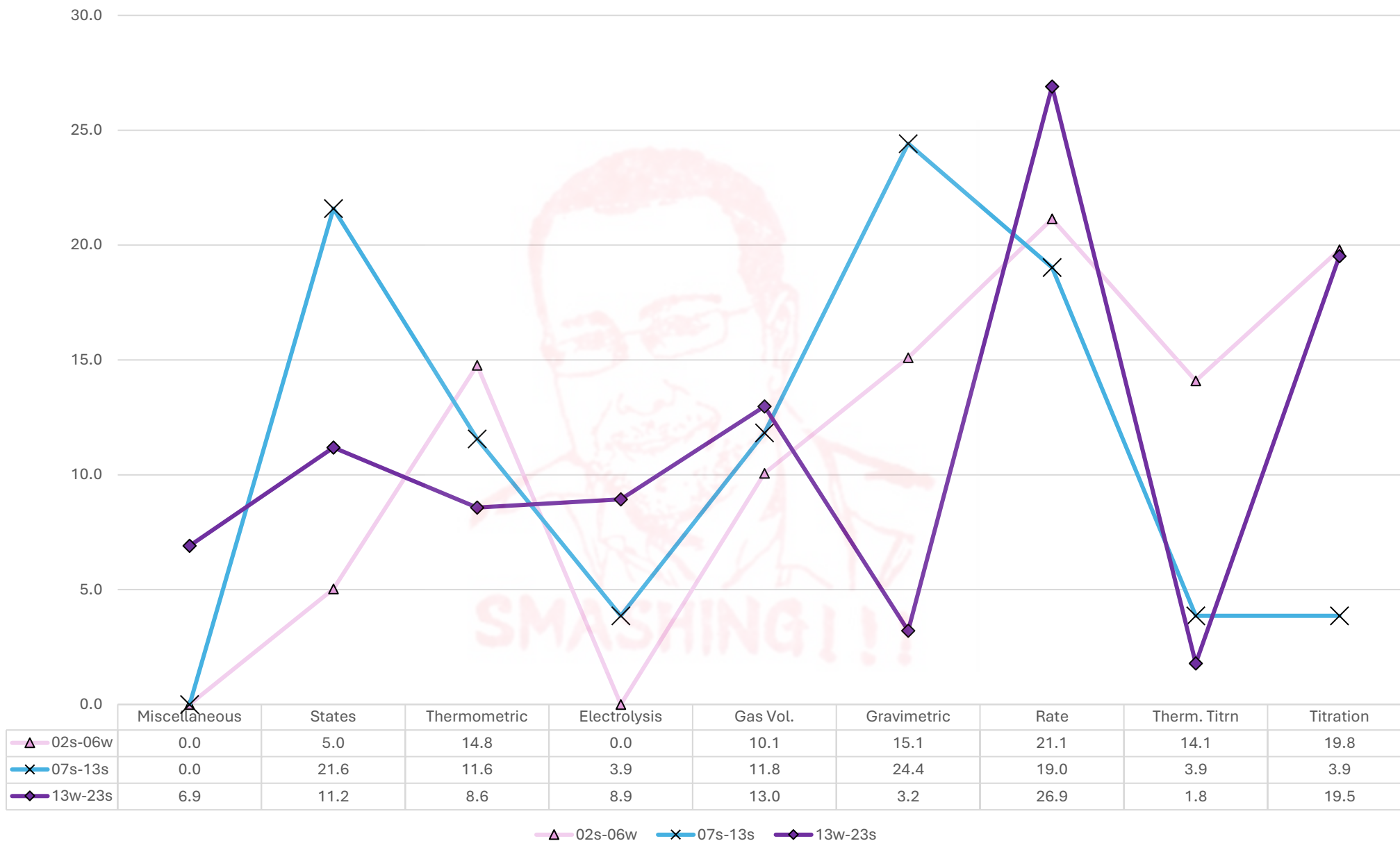
9701 Chemistry Categories Totals Weighted for Papers 4 and 5



9701 Chemistry Weighted Mark Frequency: Paper 4
2022w to 2016m in purple crosses, compared to earlier and all A2 exams combined



CAIE A Level Chemistry 9701 **Paper 5: Planning, Analysis and Evaluation**
Percentage of all marks awarded for each Experiment Type from w2022 to s2002, Timezone 1 for summer and winter only (51 exam papers in total). *Purple shows most recent 10 years trend.*



Content overview

AS Level subject content

Candidates for Cambridge International AS Level Chemistry study the following topics:

Physical chemistry

- 1 Atomic structure
- 2 Atoms, molecules and stoichiometry
- 3 Chemical bonding
- 4 States of matter
- 5 Chemical energetics
- 6 Electrochemistry
- 7 Equilibria
- 8 Reaction kinetics

Inorganic chemistry

- 9 The Periodic Table: chemical periodicity
- 10 Group 2
- 11 Group 17
- 12 Nitrogen and sulfur

Organic chemistry

- 13 An introduction to AS Level organic chemistry
- 14 Hydrocarbons
- 15 Halogen compounds
- 16 Hydroxy compounds
- 17 Carbonyl compounds
- 18 Carboxylic acids and derivatives
- 19 Nitrogen compounds
- 20 Polymerisation
- 21 Organic synthesis

Analysis

- 22 Analytical techniques

AS Level candidates also study practical skills.

A Level subject content

Candidates for Cambridge International A Level Chemistry study the AS topics and the following topics:

Physical chemistry

- 23 Chemical energetics
- 24 Electrochemistry
- 25 Equilibria
- 26 Reaction kinetics

Inorganic chemistry

- 27 Group 2
- 28 Chemistry of transition elements

Organic chemistry

- 29 An introduction to A Level organic chemistry
- 30 Hydrocarbons
- 31 Halogen compounds
- 32 Hydroxy compounds
- 33 Carboxylic acids and derivatives
- 34 Nitrogen compounds
- 35 Polymerisation
- 36 Organic synthesis

Analysis

- 37 Analytical techniques

A Level candidates also study practical skills.

School feedback: 'Cambridge International AS & A Levels prepare students well for university because they've learnt to go into a subject in considerable depth. There's that ability to really understand the depth and richness and the detail of a subject. It's a wonderful preparation for what they are going to face at university.'

Feedback from: US Higher Education Advisory Council

Paper 1 Exam Questions

Topic **Chem 1 Q# 1** / AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 For the element sulfur, which pair of ionisation energies has the largest difference between them?

- A third and fourth ionisation energies
- B fourth and fifth ionisation energies
- C fifth and sixth ionisation energies
- D sixth and seventh ionisation energies

Topic **Chem 1 Q# 2** / AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Which statement about the electrons in a ground state carbon atom is correct?

- A Electrons are present in four different energy levels.
- B There are more electrons in p orbitals than there are in s orbitals.
- C The occupied orbital of highest energy is spherical.
- D The occupied orbital of lowest energy is spherical.

Topic **Chem 3 Q# 3** / AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 Which atom has the same number of electrons as the hydroxide ion, OH^- ?

- A F
- B Ne
- C Na
- D Mg

Topic **Chem 1 Q# 4** / AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 Which atom has its outermost electron in an orbital of the shape shown, with principal quantum number 3?



- A sodium
- B chlorine
- C calcium
- D bromine

Topic **Chem 1 Q# 5** / AS Chemistry/2022/m/TZ 2/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 What is the electronic configuration of Mg^{2+} ?

- A $1s^2 2s^2 2p^6$
- B $1s^2 2s^2 2p^6 3s^2$
- C $1s^2 2s^2 2p^6 3s^2 3p^2$
- D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

- 1 The first ionisation energy of potassium, K, is 418 kJ mol^{-1} . The first ionisation energy of strontium, Sr, is 548 kJ mol^{-1} .

Which statement helps to explain why Sr has a greater first ionisation energy than K?

- A The charge on a Sr nucleus is greater than the charge on a K nucleus.
- B The outer electron in a Sr atom experiences greater shielding than the outer electron in a K atom.
- C The outer electron in a Sr atom experiences spin-pair repulsion.
- D The outer electron in a Sr atom is further from the nucleus than the outer electron in a K atom.

- 4 The ion X^{2+} has the same electronic configuration as the atom Kr.

What is the electronic configuration of an atom of X?

- A $[\text{Ar}]4s^23d^{10}4p^6$
- B $[\text{Ar}]4s^23d^{10}4p^65s^2$
- C $[\text{Ar}]4s^24d^{10}4p^6$
- D $[\text{Ar}]4s^24d^{10}4p^65s^2$

- 3 Which of these elements has the highest fifth ionisation energy?

- A C
- B N
- C P
- D Si

- 7 Why is the first ionisation energy of oxygen less than that of nitrogen?

- A The nitrogen atom has its outer electron in a different subshell.
- B The nuclear charge on the oxygen atom is greater than that on the nitrogen atom.
- C The oxygen atom has a pair of electrons in one p orbital that repel one another.
- D There is more shielding in an oxygen atom.

- 2 In which pair of species do both species have only one unpaired p electron?

- A Ar^+ and C^-
- B B and Ti^+
- C F and Ga
- D Se^- and Si^-

- 2 Where in the Periodic Table is the element that has an outer electron shell arrangement of $4s^24p^3$?

	Group	Period
A	13	3
B	13	4
C	15	3
D	15	4

- 1** The table shows the numbers of protons, neutrons and electrons in four different particles, W, X, Y, and Z.

	number of protons	number of neutrons	number of electrons
W	32	40	32
X	32	40	34
Y	32	42	32
Z	34	40	34

Which pair represents the atoms of two isotopes of the same element?

- A** W and Y **B** W and Z **C** X and Y **D** X and Z

Topic **Chem 1 Q# 13/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

- 3** A single ^{32}P nucleus can be produced when a single ^{32}S nucleus joins with particle X. In the process a proton is emitted.

What is particle X?

- A** a deuteron, $^2_1\text{H}^+$
B an electron
C a neutron
D a proton

Topic **Chem 1 Q# 14/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

- 1** Which statement is correct?

- A** Cl has a relative isotopic mass of 35.5.
B Cl_2 has a relative molecular mass of 70.
C ICl has a relative molecular mass of 162.4.
D NaCl has a relative molecular mass of 58.5.

Topic **Chem 1 Q# 15/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

- 10** In which pair does each species have the same number of unpaired electrons?

- A** Al and Cu^{2+}
B Ca and Cr^{3+}
C Ca and Ni^{2+}
D Fe^{3+} and O^{2-}



1 What number of protons, neutrons and electrons are present in the ion $^{54}\text{Fe}^{3+}$?

	protons	neutrons	electrons
A	26	28	23
B	26	28	29
C	29	25	23
D	29	25	26

Topic **Chem 1 Q# 17/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 The first ionisation energy of chlorine is greater than that of sulfur.

Which factors contribute to this?

- Chlorine has more protons in its nucleus than sulfur does.
- Chlorine has greater electron shielding than sulfur does.
- The covalent bonds in chlorine molecules are stronger than those in sulfur molecules.

Topic **Chem 1 Q# 18/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 A particular atom of germanium, Ge, has a nucleon number of 70.

Which statements about a $^{70}_{32}\text{Ge}$ atom are correct?

- It has the same number of electrons as a $^{79}_{34}\text{Se}^{2+}$ ion.
- It has the same number of neutrons as an atom of $^{68}_{30}\text{Zn}$.
- It has half as many protons as an atom of $^{160}_{64}\text{Gd}$.

Topic **Chem 1 Q# 19/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



31 An atom of calcium-48 can form a 2+ ion.

Which statements about this ion are correct?

- 1 It has 20 protons.
- 2 It has 28 neutrons.
- 3 It has 22 electrons.

Topic **Chem 1 Q# 20/** AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 In which pairs do both species have the same number of unpaired electrons in p orbitals?

- 1 O and Cl^+
- 2 F^+ and Ga^-
- 3 N and Kr^{3+}

Topic **Chem 1 Q# 21/** AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Which statement about a 3p orbital is correct?

- A It can hold a maximum of 6 electrons.
- B It has the highest energy of the orbitals with principal quantum number 3.
- C It is at a higher energy level than a 3s orbital but has the same shape.
- D It is occupied by one electron in an isolated phosphorus atom.

Topic **Chem 1 Q# 22/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Which ions contain one or more unpaired electrons?

- 1 Cu^{2+}
- 2 Mn^{3+}
- 3 V^{3+}



1 The first four ionisation energies for element X are shown in the table.

ionisation energy	1st	2nd	3rd	4th
value / kJ mol ⁻¹	577	1980	2960	6190

Which ion of X is produced by removing an electron from a filled shell?

- A** X⁺ **B** X²⁺ **C** X³⁺ **D** X⁴⁺

Topic **Chem 1 Q# 24/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 Element X has a higher first ionisation energy than element Y.

Two students state what they believe is one factor that helps to explain this.

student 1 "X has a higher first ionisation energy than Y because an atom of X has more protons in its nucleus than an atom of Y."

student 2 "X has a higher first ionisation energy than Y because X has a smaller atomic radius than Y."

Only **one** of the two students is correct.

What could X and Y be?

	X	Y
A	carbon	boron
B	magnesium	aluminium
C	oxygen	nitrogen
D	oxygen	sulfur

Topic **Chem 1 Q# 25/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 This question refers to isolated gaseous atoms.

In which atom are all electrons paired?

- A** Ba **B** Br **C** S **D** Si

Topic **Chem 1 Q# 26/** AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 Which molecule contains a nitrogen atom with sp hybridised orbitals?

- A** CH₃CH₂NH₂ **B** HNO₃ **C** HCN **D** NH₃

Topic **Chem 1 Q# 27/** AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Drinking water may contain dissolved calcium hydrogencarbonate, Ca(HCO₃)₂.

How many electrons are present in a hydrogencarbonate anion?

- A** 30 **B** 31 **C** 32 **D** 33



2 The electronic configuration of the two outermost shells of an atom is $3s^23p^63d^54s^2$.

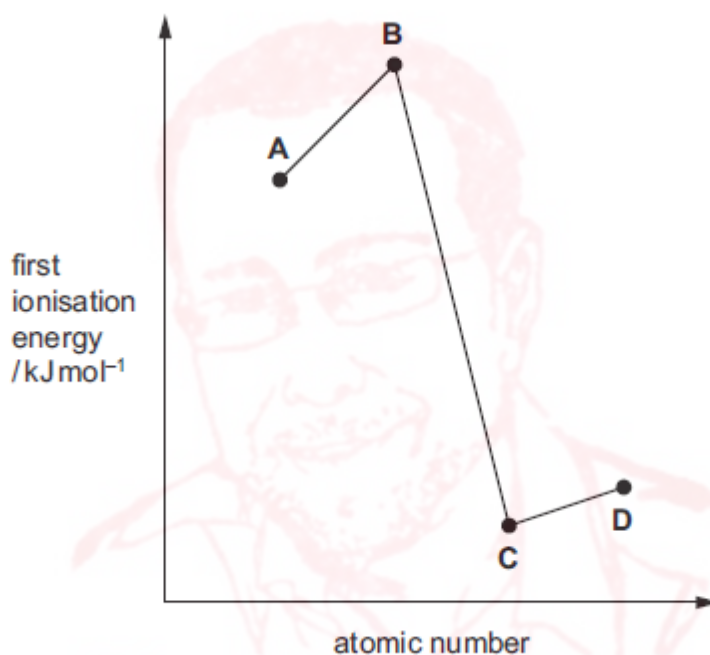
What is this atom?

- A manganese
- B phosphorus
- C strontium
- D vanadium

2 The relative first ionisation energies of four elements with consecutive atomic numbers below 20 are shown on the graph.

One of the elements reacts with hydrogen to form a covalent compound with formula HX.

Which element could be X?



4 Which property of an atom does **not** affect its first ionisation energy?

- A the atomic radius
- B the number of electron shells
- C the number of neutrons
- D the number of protons

12 Why is the second ionisation energy of sodium larger than the second ionisation energy of magnesium?

- A The attraction between the nucleus and the outer electron is greater in Na^+ than in Mg^+ .
- B The nuclear charge of Na^+ is greater than that of Mg^+ .
- C The outer electron of Na^+ is more shielded than the outer electron of Mg^+ .
- D The outer electron of Na is in the same orbital as the outer electron of Mg.

1 Which ion has the same electronic configuration as Cl^- ?

- A F^- B P^+ C Sc^{3+} D Si^{4+}

5 The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give an isotope of a different element, ^{68}X , which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.

Which statement about the composition of an atom of ^{68}X is correct?

- A It has 4 electrons in its outer p orbitals.
- B It has 13 electrons in its outer shell.
- C It has 37 neutrons.
- D Its proton number is 32.

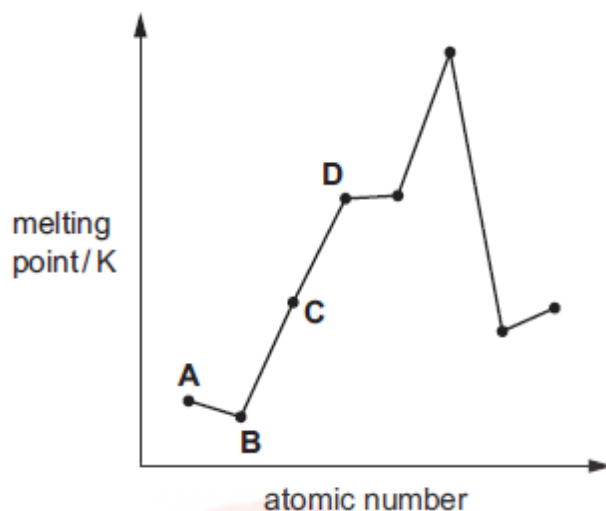
4 Sodium azide, NaN_3 is an explosive used to inflate airbags in cars when they crash. It consists of positive sodium ions and negative azide ions.

What are the numbers of electrons in the sodium ion and the azide ion?

	sodium ion	azide ion
A	10	20
B	10	22
C	12	20
D	12	22

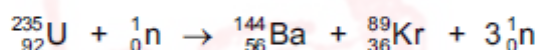
13 The diagram shows the melting points of eight elements with consecutive atomic numbers.

Which element could be sodium?



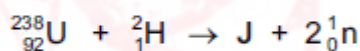
Topic **Chem 1 Q# 36/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 When nuclear reactions take place, the elements produced are different from the elements that reacted. Nuclear equations, such as the one below, are used to represent the changes that occur.



The nucleon (mass) number total is constant at 236 and the proton number total is constant at 92.

In another nuclear reaction, uranium-238 is reacted with deuterium atoms, ${}_1^2\text{H}$. An isotope of a new element, J, is formed as well as two neutrons.



What is isotope J?

- A** ${}_{92}^{238}\text{Np}$ **B** ${}_{92}^{238}\text{Pu}$ **C** ${}_{92}^{240}\text{Np}$ **D** ${}_{92}^{240}\text{Pu}$

Topic **Chem 1 Q# 37/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

- 1** ${}_{18}^{38}\text{Ar}$
2 ${}_{20}^{40}\text{Ca}^{2+}$
3 ${}_{19}^{39}\text{K}^{+}$



4 Which species contains the smallest number of electrons?

- A B^{3+} B Be^{2+} C H^{-} D He^{+}

3 Which ion has both more electrons than protons and more protons than neutrons?

[$H = {}^1_1H$; $D = {}^2_1H$; $O = {}^{16}_8O$]

- A D^{-} B H_3O^{+} C OD^{-} D OH^{-}

2 For the element sulfur, which pair of ionisation energies has the largest difference between them?

- A third and fourth ionisation energies
B fourth and fifth ionisation energies
C fifth and sixth ionisation energies
D sixth and seventh ionisation energies

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Which statements about orbitals in a krypton atom are correct?

- The 1s and 2s orbitals have the same energy as each other but different sizes.
- The third energy level ($n=3$) has three subshells and nine orbitals.
- The 3d subshell has five orbitals that have the same energy as each other in an isolated atom.

1 The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
ionisation energy/ kJ mol^{-1}	950	1800	2700	4800	6000	12300

What could be the formula of a chloride of X?

- A XCl B XCl_2 C XCl_3 D XCl_4

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



31 Use of the Data Booklet is relevant to this question.

The isotope ^{99}Tc is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc ?

- 1 It has 13 more neutrons than protons.
- 2 It has 43 protons.
- 3 It has 99 nucleons.

Topic **Chem 1 Q# 44/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Use of the Data Booklet is relevant to this question.

Which ions contain one or more unpaired electrons?

- 1 Cu^{2+}
- 2 Mn^{3+}
- 3 V^{3+}

Topic **Chem 1 Q# 45/** AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 Use of the Data Booklet is relevant to this question.

Atoms of element X have six unpaired electrons.

What could be element X?

- A carbon
- B chromium
- C iron
- D selenium

Topic **Chem 1 Q# 46/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 Use of the Data Booklet is relevant to this question.

In which set do all species contain the same number of electrons?

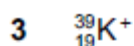
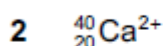
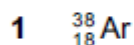
- A Co^{2+} , Co^{3+} , Co^{4+}
- B F^- , Br^- , Cl^-
- C Na^+ , Mg^{2+} , Al^{3+}
- D K_2SO_4 , K_2SeO_4 , K_2TeO_4

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

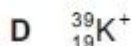
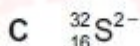
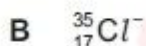
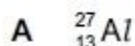
31 X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?



Topic **Chem 1 Q# 48/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 In which species are the numbers of protons, neutrons and electrons all different?



Topic **Chem 1 Q# 49/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Use of the Data Booklet is relevant to this question.

Free-radicals play an important part in reactions involving the destruction of the ozone layer and the substitution of alkanes by chlorine.

Some free-radicals contain two unpaired electrons. Such species are called diradicals.

Which species are diradicals?



Topic **Chem 1 Q# 50/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

A All atoms are very small in size.

B All the atoms of a particular element have the same mass.

C All the atoms of one element are different in mass from all the atoms of other elements.

D No atom can be split into simpler parts.



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 *Use of the Data Booklet is relevant to this question.*

The isotope ^{99}Tc is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc ?

- 1 It has 13 more neutrons than protons.
- 2 It has 43 protons.
- 3 It has 99 nucleons.

Topic **Chem 1 Q# 52/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 *Use of the Data Booklet is relevant to this question.*

The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give a gallium isotope, ^{68}Ga , which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus, changing a proton into a neutron.

Which statement about the composition of an atom of the ^{68}Ga isotope is correct?

- A It has 4 electrons in its outer p subshell.
- B It has 13 electrons in its outer shell.
- C It has 37 neutrons.
- D Its proton number is 32.

Topic **Chem 1 Q# 53/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 Why is the ionic radius of a chloride ion larger than the ionic radius of a sodium ion?

- A A chloride ion has one more occupied electron shell than a sodium ion.
- B Chlorine has a higher proton number than sodium.
- C Ionic radius increases regularly across the third period.
- D Sodium is a metal, chlorine is a non-metal.

Topic **Chem 1 Q# 54/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 The value of the second ionisation energy of calcium is 1150 kJ mol^{-1} .

Which equation correctly represents this statement?

- A $\text{Ca(g)} \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^{-}; \quad \Delta H^{\ominus} = +1150 \text{ kJ mol}^{-1}$
- B $\text{Ca}^{+}(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^{-}; \quad \Delta H^{\ominus} = +1150 \text{ kJ mol}^{-1}$
- C $\text{Ca}^{+}(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^{-}; \quad \Delta H^{\ominus} = -1150 \text{ kJ mol}^{-1}$
- D $\text{Ca(g)} \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^{-}; \quad \Delta H^{\ominus} = -1150 \text{ kJ mol}^{-1}$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Use of the Data Booklet is relevant to this question.

In which pairs do both species have the same number of unpaired p electrons?

- 1 O and Cl^+
- 2 F^+ and Ga^-
- 3 P and Ne^+

Topic **Chem 1 Q# 56/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

- A beryllium
- B carbon
- C nitrogen
- D oxygen

Topic **Chem 1 Q# 57/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 Which equation represents the second ionisation energy of an element X?

- A $X(g) \rightarrow X^{2+}(g) + 2e^-$
- B $X^+(g) \rightarrow X^{2+}(g) + e^-$
- C $X(g) + 2e^- \rightarrow X^{2-}(g)$
- D $X^-(g) + e^- \rightarrow X^{2-}(g)$

Topic **Chem 1 Q# 58/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

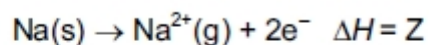
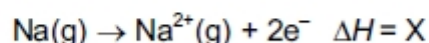
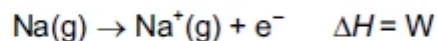
6 Which ion has more electrons than protons and more protons than neutrons?

[H = 1_1H ; D = 2_1H ; O = ${}^{16}_8O$]

- A D^-
- B H_3O^+
- C OD^-
- D OH^-

Topic **Chem 1 Q# 59/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Equations involving four enthalpy changes are shown.



What is the second ionisation energy of sodium?

- A 2W
- B X – W
- C Y – W
- D Z – Y



2 A simple ion X^+ contains eight protons.

What is the electronic configuration of X^+ ?

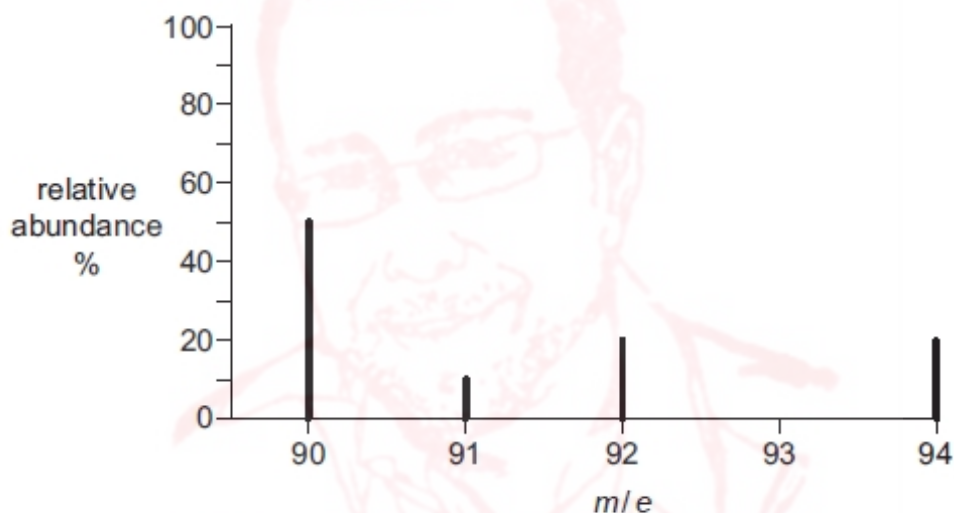
- A** $1s^2 \quad 2s^1 \quad 2p^6$
- B** $1s^2 \quad 2s^2 \quad 2p^3$
- C** $1s^2 \quad 2s^2 \quad 2p^5$
- D** $1s^2 \quad 2s^2 \quad 2p^7$

1 *Use of the Data Booklet is relevant to this question.*

What could be the proton number of an element that has three unpaired electrons in each of its atoms?

- A** 5
- B** 13
- C** 15
- D** 21

1 An element **X** consists of four isotopes. The mass spectrum of **X** is shown in the diagram.

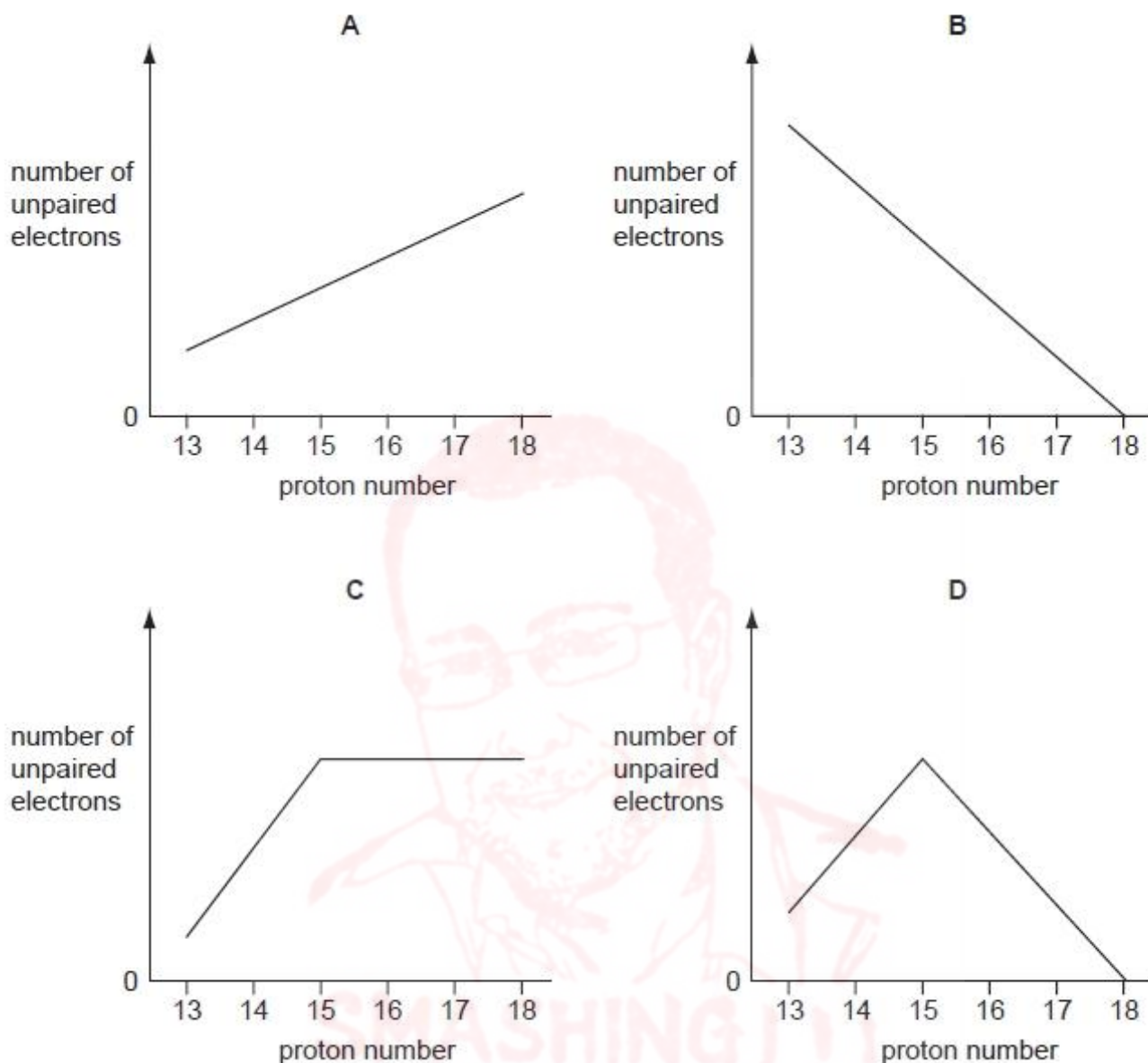


What is the relative atomic mass of **X**?

- A** 91.00
- B** 91.30
- C** 91.75
- D** 92.00

4 Use of the Data Booklet is relevant to this question.

Which graph represents the number of unpaired p orbital electrons for atoms with proton numbers 13 to 18?



Topic **Chem 1 Q# 64/** AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 On a scale in which the mass of a ^{12}C atom is 12 the relative molecular mass of a particular sample of chlorine is 72.

Which properties of the atoms in this sample are always the same?

- 1** radius
- 2** nucleon number
- 3** isotopic mass

- 3** The first seven ionisation energies of an element between lithium and neon in the Periodic Table are as follows.

1310 3390 5320 7450 11 000 13 300 71 000 kJ mol^{-1}

What is the outer electronic configuration of the element?

- A** $2s^2$ **B** $2s^2 2p^1$ **C** $2s^2 2p^4$ **D** $2s^2 2p^6$

- 12** Which group of particles is in order of increasing size?

- A** N O F
B N^{3-} O^{2-} F^-
C Na^+ Mg^{2+} Al^{3+}
D Na^+ Ne F^-

- 2** Mixture R consists of one mole of C_3H_6 and one mole of C_4H_6 .

What is the minimum number of moles of oxygen molecules needed for complete combustion of mixture R?

- A** 6.5 **B** 7 **C** 10 **D** 20

- 1** Which sample contains the same number of the named species as the number of molecules in 35.5 g of chlorine?

- A** atoms in 16 g of sulfur
B atoms in 23 g of sodium
C ions in 74.5 g of potassium chloride
D molecules in 88 g of carbon dioxide

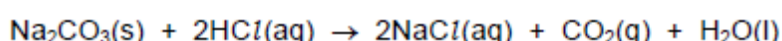
- 4** A student reacts 1 mol of copper with concentrated nitric acid to produce 1 mol of copper(II) nitrate, 2 mol of water and substance X. No other product is formed.

Substance X does not contain copper or hydrogen.

What could be substance X?

- A** N_2 **B** N_2O **C** NO **D** NO_2

- 16** A 3.0 g sample of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HCl. The volume of CO_2 produced is 600 cm^3 .



[M_r : Na_2CO_3 , 106.0]

Which volume of CO_2 is produced if 1.0 g of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HCl under the same conditions?

- A** 600 cm^3 **B** 452 cm^3 **C** 226 cm^3 **D** 200 cm^3



3 Compound X contains the elements C, H and O only.

2.00 g of X produces 4.00 g of carbon dioxide and 1.63 g of water when completely combusted.

What is the empirical formula of X?

- A CHO_2 B $\text{C}_2\text{H}_2\text{O}$ C $\text{C}_2\text{H}_4\text{O}$ D CH_2O_2

14 Which statement about atoms and molecules is correct?

- A The molecular formula of a compound is the simplest whole number ratio of atoms of each element in the compound.
- B One mole of any substance contains 6×10^{23} atoms.
- C The relative atomic mass of an element is the ratio of the average mass of one atom of the element to the mass of an atom of carbon-12.
- D The relative formula mass of a compound is the sum of the individual atomic masses of all the atoms in the formula.

2 2.0 g of ammonium nitrate, NH_4NO_3 , decomposes to give 0.90 g of water and a single gas.

What is the identity of the gas?

- A NO B NO_2 C N_2O D N_2

4 Originally, chemists thought indium oxide had the formula InO . By experiment they showed that 4.8 g of indium combined with 1.0 g of oxygen to produce 5.8 g of indium oxide. The A_r of oxygen was known to be 16.

Which value for the A_r of indium is calculated using these data?

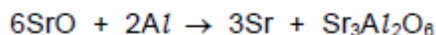
- A 38 B 77 C 115 D 154

3 Substance Q is a hydrocarbon. When 1.00 g of Q is completely burned, 3.22 g of carbon dioxide is produced.

What could be the identity of Q?

- A cyclohexene
- B cyclopentane
- C ethene
- D pentane

- 2** Strontium metal can be extracted from strontium oxide, SrO, by reduction with aluminium. One of the possible reactions is shown.



What is the maximum mass of strontium metal that can be produced from the reduction of 100 g of strontium oxide using this reaction?

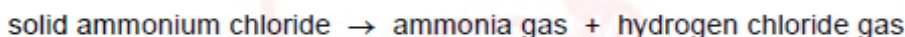
- A** 41.3 g **B** 42.3 g **C** 84.6 g **D** 169.2 g

- 13** 6.90 g of an ammonium salt is heated with an excess of aqueous sodium hydroxide. The volume of ammonia produced, measured under room conditions, is 2.51 dm³.

Which ammonium salt is used?

- A** ammonium carbonate ($M_r = 96.0$)
B ammonium chloride ($M_r = 53.5$)
C ammonium nitrate ($M_r = 80.0$)
D ammonium sulfate ($M_r = 132.1$)

- 11** A sample of solid ammonium chloride decomposes on heating.

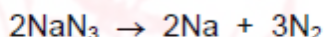


A total of 2.4×10^{21} molecules of gas is formed.

How many hydrogen atoms are present in the gaseous products?

- A** 1.2×10^{21} **B** 2.4×10^{21} **C** 4.8×10^{21} **D** 9.6×10^{21}

- 7** Sodium azide, NaN₃, decomposes as shown.



Which volume of nitrogen, measured at room temperature and pressure, will be produced by the decomposition of 150 g of sodium azide?

- A** 166 dm³ **B** 83 dm³ **C** 55 dm³ **D** 37 dm³

- 2** Diamond is a pure form of carbon. The mass of a diamond can be measured in carats. One carat is 0.200 g of carbon.

Which expression gives the number of carats that contain 6.02×10^{23} carbon atoms?

- A** 0.200×12.0
B $\frac{0.200}{12.0}$
C $\frac{12.0}{0.200}$
D $\frac{0.200}{6.02 \times 10^{23}} \times 12.0$



3 A washing powder contains sodium hydrogencarbonate, NaHCO_3 , as one of the ingredients.

In a titration, a solution containing 1.00g of this washing powder requires 7.15 cm^3 of $0.100 \text{ mol dm}^{-3}$ sulfuric acid for complete reaction. The sodium hydrogencarbonate is the only ingredient that reacts with the acid.

What is the percentage by mass of sodium hydrogencarbonate in the washing powder?

- A** 3.0% **B** 6.0% **C** 12.0% **D** 24.0%

12 1.15g of a metallic element needs 300 cm^3 of oxygen for complete reaction, under room conditions, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

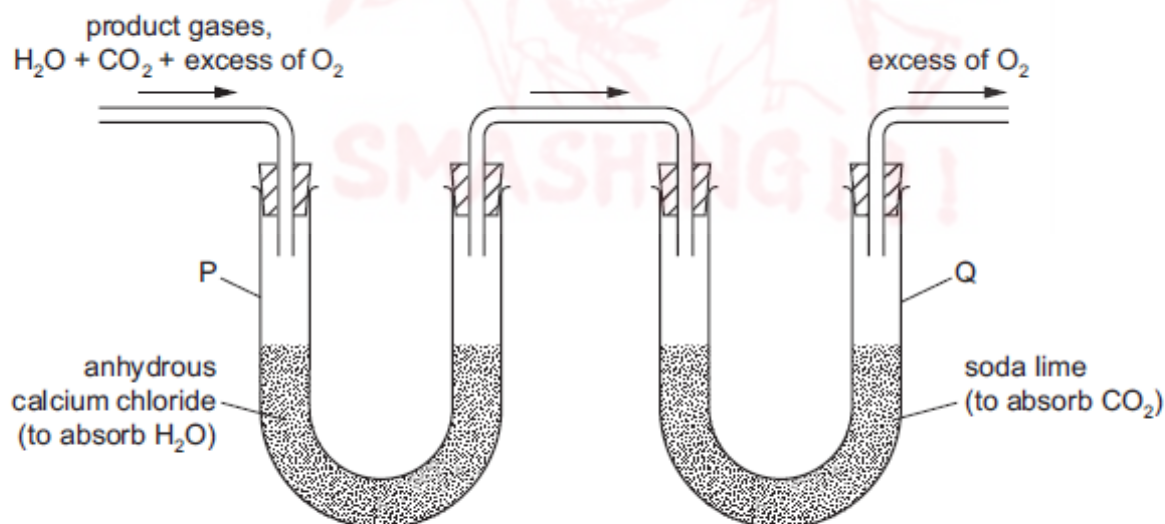
- A** calcium
B magnesium
C potassium
D sodium

2 A 3.7 g sample of copper(II) carbonate is added to 25 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.

Which volume of gas is produced under room conditions?

- A** 0.60 dm^3 **B** 0.72 dm^3 **C** 1.20 dm^3 **D** 2.40 dm^3

3 A sample of the hydrocarbon C_6H_{12} is completely burned in dry oxygen and the product gases are collected as shown.



The increases in mass of the collecting vessels P and Q are M_P and M_Q , respectively.

What is the ratio M_P / M_Q ?

- A** 0.41 **B** 0.82 **C** 1.2 **D** 2.4

- 3** Which fuel would produce the largest mass of CO_2 when 10 kg of the fuel undergo complete combustion?
- A biodiesel, $\text{C}_{17}\text{H}_{34}\text{O}_2$
- B ethanol, $\text{C}_2\text{H}_6\text{O}$
- C octane, C_8H_{18}
- D propane, C_3H_8

- 5** Which mass of solid residue is obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?
- A 0.70 g B 1.00 g C 1.40 g D 2.25 g

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31** Compound Q contains 40% carbon by mass.

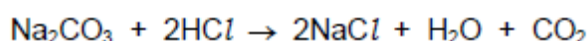
What could Q be?

- 1 glucose, $\text{C}_6\text{H}_{12}\text{O}_6$
- 2 starch, $(\text{C}_6\text{H}_{10}\text{O}_5)_n$
- 3 sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 32** A student makes sodium chloride by reacting together 0.025 mol of sodium carbonate with an excess of 0.2 mol dm^{-3} hydrochloric acid.



Which statements about the quantities of substance are correct?

- 1 600 cm^3 of carbon dioxide are produced at room temperature and pressure.
- 2 250 cm^3 of the hydrochloric acid are needed to exactly neutralise the sodium carbonate.
- 3 1.46 g of sodium chloride are produced.



16 Which fertiliser contains the greatest percentage of nitrogen by mass?

- A ammonium nitrate, NH_4NO_3
- B ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$
- C diammonium hydrogen phosphate, $(\text{NH}_4)_2\text{HPO}_4$
- D urea, $\text{CO}(\text{NH}_2)_2$

Topic **Chem 2 Q# 90/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 1//

1 Which formula represents the empirical formula of a compound?

- A $\text{C}_2\text{H}_4\text{O}$
- B $\text{C}_2\text{H}_4\text{O}_2$
- C C_6H_{12}
- D H_2O_2

Topic **Chem 2 Q# 91/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 A sports medal has a total surface area of 150 cm^2 . It was evenly coated with silver by electrolysis. Its mass increased by 0.216 g .

How many atoms of silver were deposited per cm^2 on the surface of the medal?

- A 8.0×10^{18}
- B 1.8×10^{19}
- C 8.7×10^{20}
- D 1.2×10^{21}

Topic **Chem 2 Q# 92/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 The mass spectrum of a sample of lithium shows that it contains two isotopes, ${}^6\text{Li}$ and ${}^7\text{Li}$.

The isotopic abundances are shown in the table.

isotope	isotopic abundance
${}^6\text{Li}$	7.42%
${}^7\text{Li}$	92.58%

What is the relative atomic mass of this sample of lithium, given to three significant figures?

- A 6.07
- B 6.50
- C 6.90
- D 6.93

Topic **Chem 2 Q# 93/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 Compounds J and K each contain 40% carbon by mass.

What could J and K be?

	J	K
A	a hexose, $\text{C}_6\text{H}_{12}\text{O}_6$	starch, $(\text{C}_6\text{H}_{10}\text{O}_5)_n$
B	a pentose, $\text{C}_5\text{H}_{10}\text{O}_5$	a hexose, $\text{C}_6\text{H}_{12}\text{O}_6$
C	a pentose, $\text{C}_5\text{H}_{10}\text{O}_5$	sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
D	starch, $(\text{C}_6\text{H}_{10}\text{O}_5)_n$	sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$



- 12** 1.15 g of a metallic element needs 300 cm³ of oxygen for complete reaction, at 298 K and 1 atm pressure, to form an oxide which contains O²⁻ ions.

What could be the identity of this metallic element?

- A calcium
- B magnesium
- C potassium
- D sodium

- 3** Tetraethyl lead, Pb(C₂H₅)₄, has been used as a petrol additive.

What is the percentage by mass of carbon in tetraethyl lead?

- A 10.2
- B 14.9
- C 29.7
- D 32.0

- 3** Use of the Data Booklet is relevant to this question.

The compound S₂O₇ is hydrolysed by water to produce sulfuric acid and oxygen only.

Which volume of oxygen, measured at room temperature and pressure, is evolved when 0.352 g of S₂O₇ is hydrolysed?

- A 12 cm³
- B 24 cm³
- C 48 cm³
- D 96 cm³

- 6** Aluminium carbide, Al₄C₃, reacts readily with aqueous sodium hydroxide. The two products of the reaction are NaAlO₂ and a hydrocarbon. Water molecules are also involved as reactants.

What is the formula of the hydrocarbon?

- A CH₄
- B C₂H₆
- C C₃H₈
- D C₆H₁₂

- 8** Use of the Data Booklet is relevant to this question.

The approximate percentage composition of the atmosphere on four different planets is given in the table below.

The density of a gas may be defined as the mass of 1 dm³ of the gas measured at s.t.p.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules
A	Jupiter	H ₂ 89.8, He 10.2
B	Neptune	H ₂ 80.0, He 19.0, CH ₄ 1.0
C	Saturn	H ₂ 96.3, He 3.25, CH ₄ 0.45
D	Uranus	H ₂ 82.5, He 15.2, CH ₄ 2.3

10 Use of the Data Booklet is relevant to this question.

Which sodium compound contains 74.2 % by mass of sodium?

- A sodium carbonate
- B sodium chloride
- C sodium hydroxide
- D sodium oxide

17 Use of the Data Booklet is relevant to this question.

1.15 g of a metallic element reacts with 300 cm³ of oxygen at 298 K and 1 atm pressure, to form an oxide which contains O²⁻ ions.

What could be the identity of the metal?

- A calcium
- B magnesium
- C potassium
- D sodium

14 Use of the Data Booklet is relevant to this question.

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

Which volume of nitrogen, measured under room conditions, is produced when 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

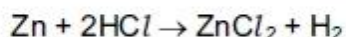
- A 46.8 cm³ B 72.0 cm³ C 93.6 cm³ D 144 cm³

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Use of the Data Booklet is relevant to this question.

Zinc reacts with hydrochloric acid according to the following equation.



Which statements are correct?

[All volumes are measured at room conditions.]

- 1 A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.
- 2 A 6.54 g sample of zinc reacts completely with exactly 100 cm³ of 1.00 mol dm⁻³ hydrochloric acid.
- 3 A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm³ of hydrogen.

Topic **Chem 2 Q# 103/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 Use of the Data Booklet is relevant to this question.

Nickel makes up 20 % of the total mass of a coin. The coin has a mass of 10.0g.

How many nickel atoms are in the coin?

- A 2.05×10^{22} B 4.30×10^{22} C 1.03×10^{23} D 1.20×10^{24}

Topic **Chem 2 Q# 104/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

- 12 Camphor is a white solid which was used to make the early plastic celluloid. Camphor contains the same percentage by mass of hydrogen and oxygen.

What is the molecular formula of camphor?

- A C₁₀H₆O₆ B C₁₀H₈O C C₁₀H₁₆O D C₁₀H₁₀O₂

Topic **Chem 2 Q# 105/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

- 9 Which mass of gas would occupy a volume of 3 dm³ at 25 °C and 1 atmosphere pressure?
[1 mol of gas occupies 24 dm³ at 25 °C and 1 atmosphere pressure.]

- A 3.2g O₂ gas
B 5.6g N₂ gas
C 8.0g SO₂ gas
D 11.0g CO₂ gas

Topic **Chem 2 Q# 106/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

8 Use of the Data Booklet is relevant to this question.

2.920 g of a Group II metal, X, reacts with an excess of chlorine to form 5.287 g of a compound with formula XCl₂.

What is metal X?

- A barium
B calcium
C magnesium
D strontium

Topic **Chem 2 Q# 107**/ AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

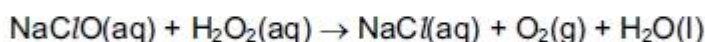
- 2 0.200 mol of a hydrocarbon undergo complete combustion to give 35.2 g of carbon dioxide and 14.4 g of water as the only products.

What is the molecular formula of the hydrocarbon?

- A C_2H_4 B C_2H_6 C C_4H_4 D C_4H_8

Topic **Chem 2 Q# 108**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

- 2 A household bleach contains sodium chlorate(I), $NaClO$, as its active ingredient. The concentration of $NaClO$ in the bleach can be determined by reacting a known amount with aqueous hydrogen peroxide, H_2O_2 .



When 25.0 cm^3 of bleach is treated with an excess of aqueous H_2O_2 , 0.0350 mol of oxygen gas is given off.

What is the concentration of $NaClO$ in the bleach?

- A $8.75 \times 10^{-4}\text{ mol dm}^{-3}$
B 0.700 mol dm^{-3}
C 0.875 mol dm^{-3}
D 1.40 mol dm^{-3}

Topic **Chem 2 Q# 109**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

- 1 Use of the Data Booklet is relevant to this question.

In leaded petrol there is an additive composed of lead, carbon and hydrogen only. This compound contains 29.7 % carbon and 6.19 % hydrogen by mass.

What is the value of x in the empirical formula PbC_8H_x ?

- A 5 B 6 C 16 D 20

Topic **Chem 3 Q# 110**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

- 6 Which molecule has an equal number of bonding electrons and lone-pair electrons?

- A BH_3 B CO_2 C F_2O D SO_2

Topic **Chem 3 Q# 111**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

- 5 How many σ bonds are present in one $H-C\equiv C-C(CH_3)=CH(CH_3)$ molecule?

- A 5 B 11 C 13 D 16

Topic **Chem 3 Q# 112**/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

- 8 For which pair is the boiling point of the first compound **higher** than the boiling point of the second compound?

- A CH_3CH_2OH and CH_3CH_2SH
B $CH_3CO_2CH_3$ and $CH_3CH_2CO_2H$
C CH_3OCH_3 and CH_3CH_2OH
D CH_3CH_2CHO and $CH_3CH_2CO_2H$



7 Elements X, Y and Z are all in the first two periods of the Periodic Table.

Their Pauling electronegativity values, E_N , are shown.

element	E_N
X	1.0
Y	2.1
Z	4.0

Substances exist with formulae XZ, YZ and Z_2 .

Which row puts these substances in order of increasing melting point?

	lowest melting point	→	highest melting point
A	XZ	YZ	Z_2
B	XZ	Z_2	YZ
C	Z_2	YZ	XZ
D	Z_2	XZ	YZ

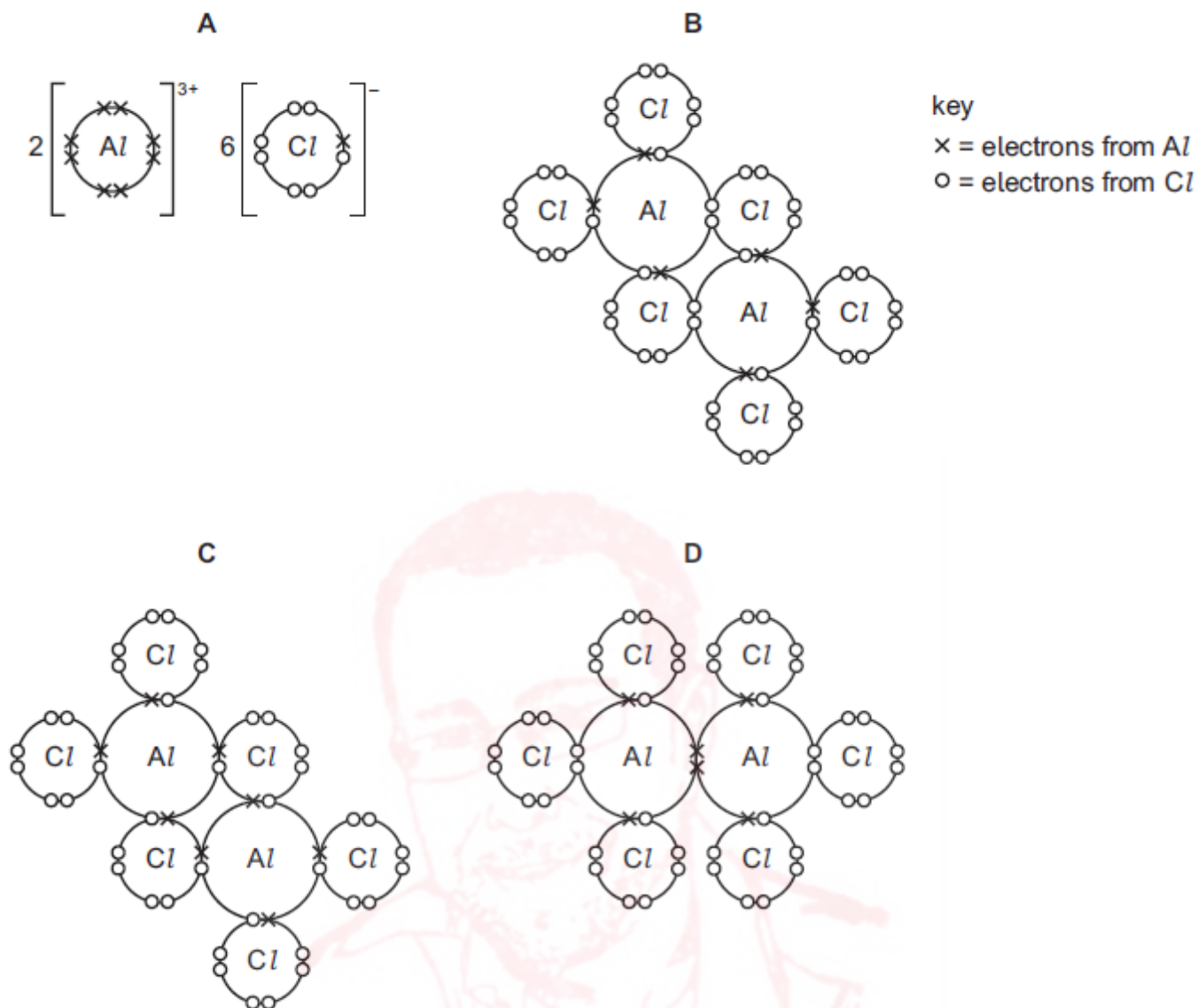
6 The boiling points of some hydrogen halides are shown.

hydrogen halide	boiling point / K
H-Cl	188
H-Br	206
H-I	238

What is the explanation for the trend in boiling point for the hydrogen halides from HCl to HI?

- A The bond energies of the hydrogen halides increase from HCl to HI.
- B There is an increase in the strength of the intermolecular forces of attraction from HCl to HI.
- C The intermolecular hydrogen bonds become stronger from HCl to HI.
- D There is an increase in the bond polarity from HCl to HI.

5 Which dot-and-cross diagram is correct for Al_2Cl_6 ?



Topic **Chem 3 Q# 116**/ AS Chemistry/2022/m/TZ 2/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 For which molecule is the dipole moment zero?

- A** CH_3Cl **B** CH_2Cl_2 **C** $CHCl_3$ **D** CCl_4

- 25** When ammonia, NH_3 , is dissolved in water, a small concentration of ammonium ions, NH_4^+ , is formed.

Which row is correct?

	number of electrons in one ammonium ion	change of the H–N–H angle from ammonia to the ammonium ion
A	8	decreases
B	8	increases
C	10	decreases
D	10	increases

Topic **Chem 3 Q# 118**/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

- 5** Which type of interaction exists between water molecules and metal cations in aqueous solution?

- A** dipole-dipole interactions
- B** hydrogen bonds
- C** ion-dipole interactions
- D** ionic bonds

Topic **Chem 3 Q# 119**/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 35** Which elements form a chloride in which both covalent bonding and coordinate (dative covalent) bonding are present?

- 1** Al
- 2** Si
- 3** Mg

Topic **Chem 3 Q# 120**/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34** Which molecules contain at least one unpaired electron?

- 1** NO
- 2** NO_2
- 3** NH_3



18 Which row is correct?

	shape		bonds present	
	ammonia molecule	ammonium ion	ammonia molecule	ammonium ion
A	pyramidal	regular tetrahedral	σ	σ
B	pyramidal	regular tetrahedral	σ	π
C	regular tetrahedral	pyramidal	σ	σ
D	regular tetrahedral	pyramidal	π	σ

Topic **Chem 3 Q# 122/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 Which molecules contain at least one bond angle of 120° ?

- 1 C_2H_4
- 2 PF_5
- 3 NCI_3

Topic **Chem 3 Q# 123/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)3 Phosphorus forms two chlorides. Phosphorus(III) chloride, PCl_3 , is a covalent liquid.Phosphorus(V) chloride is an ionic solid. One of the ions present is $[PCl_4]^+$.What is the shape of the PCl_3 molecule and the $[PCl_4]^+$ ion?

	PCl_3	$[PCl_4]^+$
A	pyramidal	square planar
B	pyramidal	tetrahedral
C	tetrahedral	square planar
D	trigonal planar	tetrahedral

Topic **Chem 3 Q# 124/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 In which substance are the only intermolecular forces temporary dipole-induced dipole attractions?

- A hydrogen chloride
- B methanol
- C octane
- D water



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 Which species can accept a lone pair of electrons to form a coordinate (dative covalent) bond?

- 1** BF_3
- 2** H^+
- 3** CH_3^+

Topic **Chem 3 Q# 126/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 Copper has a high melting point.

What is the reason for the high melting point of copper?

- A** strong attractive forces between copper atoms only
- B** strong attractive forces between copper ions and delocalised electrons
- C** strong attractive forces between copper ions only
- D** strong attractive forces between copper atoms and delocalised electrons

Topic **Chem 3 Q# 127/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 In which of the following, when in liquid form, are there only intermolecular forces based on temporary dipoles between the particles?

- A** bromine
- B** ethanol
- C** hydrogen chloride
- D** water

Topic **Chem 3 Q# 128/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

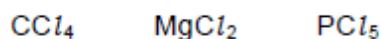
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which molecules have no overall dipole moment?

- 1** boron trifluoride
- 2** methane
- 3** phosphorus pentafluoride



19 What is the order of increasing melting point of the three chlorides shown?

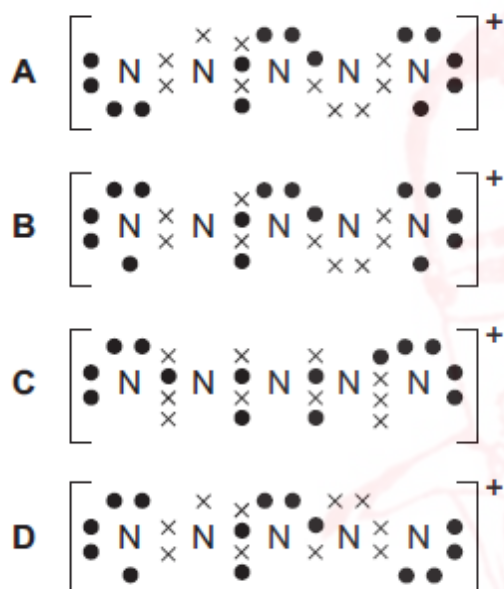


	lowest melting point	→	highest melting point
A	CCl_4		PCl_5 MgCl_2
B	MgCl_2		CCl_4 PCl_5
C	MgCl_2		PCl_5 CCl_4
D	PCl_5		CCl_4 MgCl_2

Topic **Chem 3 Q# 130/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

8 A stable ion N_5^+ has been produced by research chemists.

Which structure is most likely to show the electron arrangement of this ion?



Topic **Chem 3 Q# 131/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 The strong hydrogen bonding present in liquid water causes an increase in which properties?

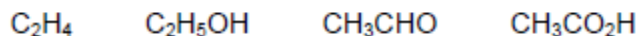
- 1 viscosity
- 2 boiling point
- 3 surface tension

Topic **Chem 3 Q# 132/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Which molecule does **not** have any 90° or 180° bond angles?

- A** C_2H_6 **B** CO_2 **C** PF_5 **D** SF_6

4 Four compounds are shown.



How many of these compounds have an odd number of σ bonds?

- A** 1 **B** 2 **C** 3 **D** 4

Topic **Chem 3 Q# 134/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Which molecule or ion contains the smallest bond angle?

- A** C_2H_4 **B** CH_3COCH_3 **C** NH_4^+ **D** NH_3

Topic **Chem 3 Q# 135/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 In which species is there a lone pair of electrons?

- A** CH_3 **B** CH_3^+ **C** CH_3^- **D** CH_4

Topic **Chem 3 Q# 136/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 The outermost electron in an atom of neon occupies a particular orbital.

Which row shows the relative energy and shape of this orbital?

	energy of orbital relative to other occupied orbitals	shape of orbital
A	higher or equal	
B	higher or equal	
C	lower or equal	
D	lower or equal	

Topic **Chem 3 Q# 137/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Four elements, W, X, Y and Z, have electronic configurations as shown.

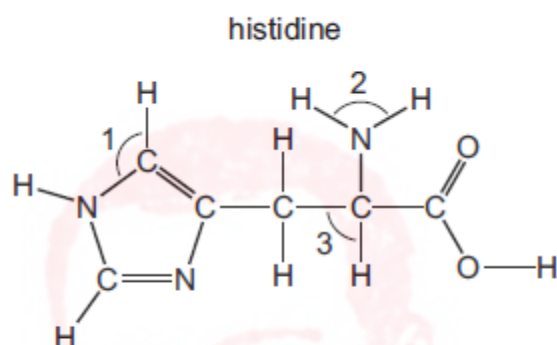
W	X	Y	Z
2,4	2,6	2,8,2	2,8,8,1

Which formulae represent compounds that have boiling points below room temperature?

- 1 WX_2
- 2 YX
- 3 Z_2X

Topic **Chem 3 Q# 138**/ AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 Histidine is an amino acid.



What are the approximate bond angles 1, 2, and 3?

	1	2	3
A	109.5	107	90
B	120	107	109.5
C	120	120	90
D	120	120	109.5

Topic **Chem 3 Q# 139**/ AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 The eight species that follow all have covalent bonds.

In which pair do the species have different shapes from each other?

- A $BeCl_2$ and CO_2
- B CH_4 and NH_4^+
- C NH_3 and BF_3
- D SCl_2 and H_2O

Topic **Chem 3 Q# 140**/ AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



36 Which types of bonding are present in ammonium carbonate, $(\text{NH}_4)_2\text{CO}_3$?

- 1 ionic
- 2 covalent
- 3 co-ordinate (dative covalent)

Topic **Chem 3 Q# 141**/ AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which molecules and ions have a bond angle of 120° ?

- 1 BF_3
- 2 CH_3^-
- 3 NH_3

Topic **Chem 3 Q# 142**/ AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 Which solid contains more than one type of bonding?

- A iodine
- B silicon dioxide
- C sodium chloride
- D zinc

Topic **Chem 3 Q# 143**/ AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 Which molecule has no overall dipole?

- A CH_3Cl
- B CH_2Cl_2
- C CHCl_3
- D CCl_4

Topic **Chem 3 Q# 144**/ AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 Which compound has a boiling point that is influenced by hydrogen bonding?

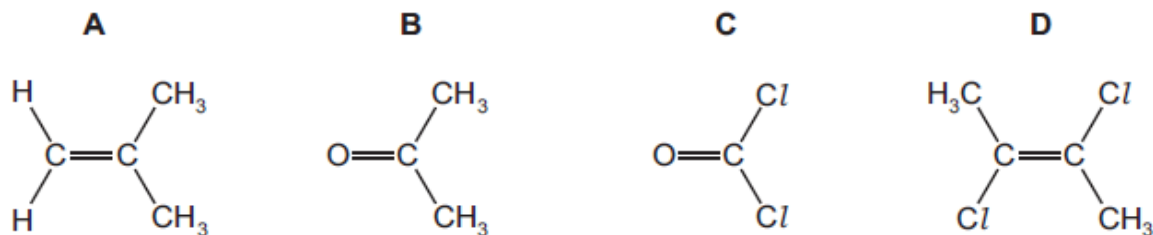
- A CH_3CHO
- B CH_3OCH_3
- C HCO_2CH_3
- D HCO_2H

Topic **Chem 3 Q# 145**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 What are the shapes of the molecules of water and boron trifluoride?

	H_2O	BF_3
A	linear	pyramidal
B	linear	trigonal
C	non-linear	pyramidal
D	non-linear	trigonal

5 Which molecule has the largest overall dipole?



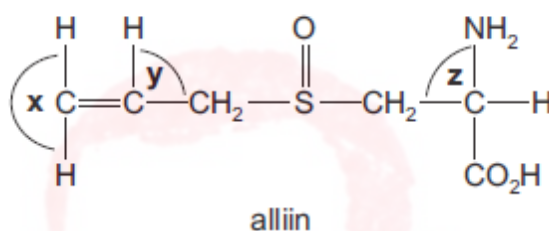
Topic **Chem 3 Q# 147/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 Which molecule contains six bonding electrons?

- A** C₂H₄
B H₂S
C NCl₃
D SF₆

Topic **Chem 3 Q# 148/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 The characteristic smell of garlic is due to alliin.



What are the approximate bond angles x, y and z in a molecule of alliin?

	x	y	z
A	90°	90°	109°
B	120°	109°	90°
C	120°	120°	109°
D	180°	109°	109°

Topic **Chem 3 Q# 149/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

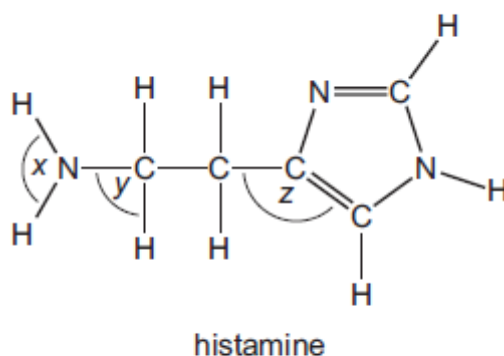
4 The boiling points of methane, ethane, propane and butane are given.

compound	CH ₄	CH ₃ CH ₃	CH ₃ CH ₂ CH ₃	CH ₃ CH ₂ CH ₂ CH ₃
boiling point /K	112	185	231	273

Which statement explains the increase in boiling point from methane to butane?

- A** Closer packing of molecules results in stronger van der Waals' forces.
B More covalent bonds are present and therefore more energy is required to break the bonds.
C More electrons in the molecules results in stronger van der Waals' forces.
D More hydrogen atoms in the molecules results in stronger hydrogen bonding.

- 6** Histamine is produced in the body to help fight infection. Its shape allows it to fit into receptors which expand blood vessels.



What are the bond angles x , y and z in histamine, from the smallest to the largest?

	smallest bond angle	→	largest bond angle
A	x	y	z
B	y	x	z
C	y	z	x
D	z	y	x

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 32** Which elements can form π bonds in their compounds?

- 1 carbon
- 2 oxygen
- 3 nitrogen

- 7** At room temperature and pressure, H_2O is a liquid and H_2S is a gas.

What is the reason for this difference?

- A** O has higher first and second ionisation energies than S.
- B** The covalent bond between O and H is stronger than the covalent bond between S and H.
- C** There is significant hydrogen bonding between H_2O molecules but not between H_2S molecules.
- D** The instantaneous dipole-induced dipole forces between H_2O molecules are stronger than the instantaneous dipole-induced dipole forces between H_2S molecules.



- 5 Dicarbon monoxide, C_2O , is found in dust clouds in space. The structure of this molecule is $C=C=O$. The molecule contains no unpaired electrons.

How many lone pairs of electrons are present in a molecule of C_2O ?

A 1 B 2 C 3 D 4

- 2 What is the correct number of bonds of each type in the Al_2Cl_6 molecule?

	covalent	co-ordinate (dative covalent)
A	6	1
B	6	2
C	7	0
D	7	1

- 6 Which series shows molecules in order of increasing bond angle?

- A $CH_4 \rightarrow BF_3 \rightarrow NH_3$
 B $H_2O \rightarrow CO_2 \rightarrow BF_3$
 C $NH_3 \rightarrow CH_4 \rightarrow CO_2$
 D $NH_3 \rightarrow CH_4 \rightarrow H_2O$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31 Which molecules have an overall dipole moment?

- 1 carbon monoxide, CO
 2 phosphine, PH_3
 3 carbon dioxide, CO_2

15 Which row of the table is correct?

	shape		bonds present	
	ammonia molecule	ammonium ion	ammonia molecule	ammonium ion
A	pyramidal	regular tetrahedral	σ	σ
B	pyramidal	regular tetrahedral	σ	π
C	regular tetrahedral	pyramidal	σ	σ
D	regular tetrahedral	pyramidal	π	σ

Topic **Chem 3 Q# 158**/ AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 Nitrogen, N_2 , and carbon monoxide, CO, both have $M_r = 28$.

The boiling point of N_2 is 77 K.

The boiling point of CO is 82 K.

What could be responsible for this difference in boiling points?

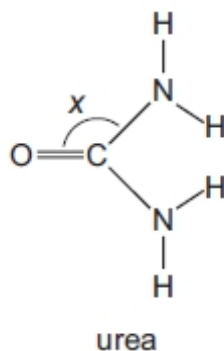
- A** CO molecules have a permanent dipole, the N_2 molecules are not polar.
- B** N_2 has σ and π bonding, CO has σ bonding only.
- C** N_2 has a strong $N \equiv N$ bond, CO has a $C=O$ bond.
- D** The CO molecule has more electrons than the N_2 molecule.

Topic **Chem 3 Q# 159**/ AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Urea is a product of animal metabolism. It can also be used as a fertiliser.



The diagram shows angle x in this molecule.

Which statements about the structure of urea are correct?

- 1 Angle x is approximately 120° .
- 2 The molecule has two π bonds.
- 3 The molecule has only three lone pairs of electrons.

Topic **Chem 3 Q# 160**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 The table shows the physical properties of four substances.

Which substance could be hydrogen chloride?

	melting point / $^\circ\text{C}$	electrical conductivity of solid	electrical conductivity of liquid	electrical conductivity of aqueous solution
A	-119	poor	poor	insoluble
B	-115	poor	poor	good
C	-50	poor	poor	poor
D	993	poor	good	good

Topic **Chem 3 Q# 161**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 AlCl_3 vapour forms molecules with formula Al_2Cl_6 as it is cooled.

What happens to the bond angles during the change from AlCl_3 to Al_2Cl_6 ?

- A Some decrease, some remain the same.
- B Some increase, some remain the same.
- C They all decrease.
- D They all increase.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 32** P and Q are two liquid compounds with similar M_r values. Molecules of P attract each other by hydrogen bonds. Molecules of Q attract each other by van der Waals' forces only.

How do the properties of P and Q differ?

- 1 P has a higher surface tension than Q.
- 2 P is less soluble in water than Q.
- 3 P has a lower melting point than Q.

Topic **Chem 3 Q# 163/** AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31** Use of the Data Booklet is relevant to this question.

When the liquid N_2F_4 is heated, it decomposes into a single product, X.

Which statements are correct?

- 1 N–F bonds are broken during this decomposition.
- 2 The enthalpy change when N_2F_4 decomposes into X is approximately $+160 \text{ kJ mol}^{-1}$.
- 3 Molecules of X are non-linear.

Topic **Chem 3 Q# 164/** AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

- 14** What is the order of increasing melting point of the four chlorides shown?



	lowest melting point	→			highest melting point
A	CCl_4	HCl	PCl_5	$MgCl_2$	
B	HCl	CCl_4	PCl_5	$MgCl_2$	
C	HCl	PCl_5	CCl_4	$MgCl_2$	
D	$MgCl_2$	PCl_5	CCl_4	HCl	



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which types of bonding are present in ammonium carbonate, $(\text{NH}_4)_2\text{CO}_3$?

- 1 ionic
- 2 covalent
- 3 co-ordinate (dative covalent)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 *Use of the Data Booklet is relevant to this question.*

Carbon and nitrogen are adjacent in the Periodic Table.

Which properties do they both have?

- 1 There is an empty 2p orbital in one atom of the element.
- 2 The principal quantum number of the highest occupied orbital is 2.
- 3 They form compounds in which their atoms form bonds with four other atoms.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Valence shell electron pair repulsion theory should be used to answer this question.

Which species are trigonal planar?

- 1 BH_3
- 2 CH_3^+
- 3 PH_3



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 The Group II metals have higher melting points than the Group I metals.

Which factors could contribute towards the higher melting points?

- 1 There are smaller interatomic distances in the metallic lattices of the Group II metals.
- 2 More electrons are available from each Group II metal atom for bonding the atom into the metallic lattice.
- 3 Group II metals have a higher first ionisation energy than the corresponding Group I metal.

Topic **Chem 3 Q# 169/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 How may nitrogen exist in compounds?

- 1 bonded by a triple covalent bond
- 2 as part of a cation
- 3 having lost 3 electrons to form an anion

Topic **Chem 3 Q# 170/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Sodium borohydride, NaBH_4 , and boron trifluoride, BF_3 , are compounds of boron.

What are the shapes around boron in the borohydride ion and in boron trifluoride?

	borohydride ion	boron trifluoride
A	square planar	pyramidal
B	square planar	trigonal planar
C	tetrahedral	pyramidal
D	tetrahedral	trigonal planar

Topic **Chem 3 Q# 171/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 In which pair do the molecules have the same shape as each other?

- A H_2O and CO_2
- B H_2O and SCl_2
- C NH_3 and BH_3
- D SCl_2 and BeCl_2



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33 Nitrogen and phosphorus are both in Group V of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5 .

Why is it **not** possible for nitrogen to form NCl_5 ?

- 1 Nitrogen's outer shell can only contain eight electrons.
- 2 Nitrogen cannot have oxidation state +5.
- 3 Nitrogen is almost inert.

Topic **Chem 3 Q# 173/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

- 1 In which species does the underlined atom have an incomplete outer shell?

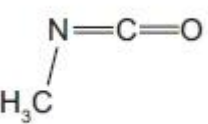
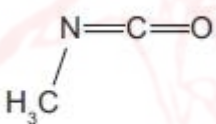
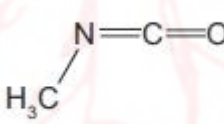
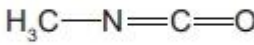
- A** BF_3 **B** CH_3^- **C** F_2O **D** H_3O^+

Topic **Chem 3 Q# 174/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

- 4 Methyl isocyanate, CH_3NCO , is a toxic liquid which is used in the manufacture of some pesticides.

In the methyl isocyanate molecule, the sequence of atoms is $\text{H}_3\text{C}-\text{N}=\text{C}=\text{O}$.

What is the approximate angle between the bonds formed by the N atom?

A	B	C	D
			
104°	109°	120°	180°

Topic **Chem 3 Q# 175/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 32 Why does aluminium chloride, Al_2Cl_6 , sublime at the relatively low temperature of 180 °C?

- 1 The intermolecular forces between the Al_2Cl_6 molecules are weak.
- 2 The co-ordinate bonds between aluminium and chlorine are weak.
- 3 The covalent bonds between aluminium and chlorine are weak.



13 Which element shows the greatest tendency to form some covalent compounds?

- A aluminium
- B magnesium
- C neon
- D potassium

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which are features of the structure of metallic copper?

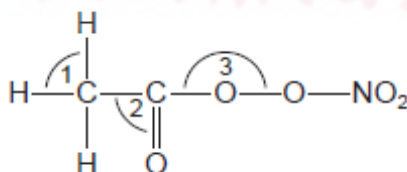
- 1 a lattice of ions
- 2 delocalised electrons
- 3 ionic bonds

11 In which change would only van der Waals' forces have to be overcome?

- | | |
|-----------------------------------|---|
| A evaporation of ethanol | $\text{C}_2\text{H}_5\text{OH}(\text{l}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{g})$ |
| B melting of ice | $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$ |
| C melting of solid carbon dioxide | $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{l})$ |
| D solidification of butane | $\text{C}_4\text{H}_{10}(\text{l}) \rightarrow \text{C}_4\text{H}_{10}(\text{s})$ |

7 Organic nitrates in photochemical smog can cause breathing difficulties.

The diagram shows an example of an organic nitrate molecule.



What is the correct order of the bond angles shown in ascending order (smallest first)?

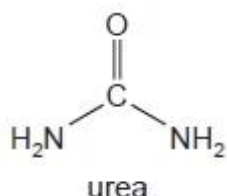
- A** 1 → 2 → 3 **B** 2 → 1 → 3 **C** 3 → 1 → 2 **D** 3 → 2 → 1

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



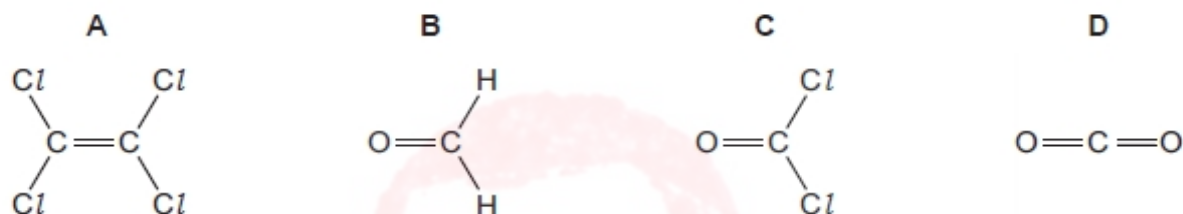
33 Which types of intermolecular forces can exist between adjacent urea molecules?



- 1 hydrogen bonding
- 2 permanent dipole-dipole forces
- 3 temporary induced dipole-dipole forces

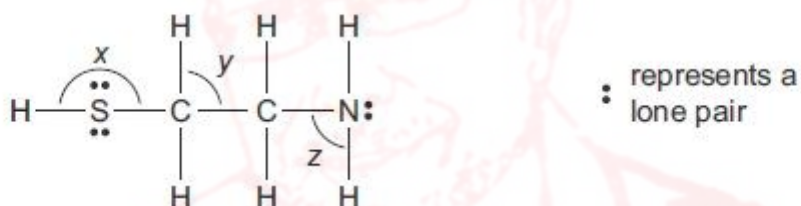
Topic **Chem 3 Q# 181**/ AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 Which molecule has the largest overall dipole?



Topic **Chem 3 Q# 182**/ AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 The antidote molecule shown can help to prevent liver damage if someone takes too many paracetamol tablets.



What is the order of **decreasing** size of the bond angles x, y and z?

	largest	→	smallest
A	x	y	z
B	x	z	y
C	y	z	x
D	z	y	x

Topic **Chem 3 Q# 183**/ AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which physical properties are due to hydrogen bonding between water molecules?

- 1 Water has a higher boiling point than H_2S .
- 2 Ice floats on water.
- 3 The $\text{H}-\text{O}-\text{H}$ bond angle in water is approximately 104° .

Topic **Chem 3 Q# 184**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 Which statement explains why the boiling point of methane is higher than that of neon?
[A_r: H, 1; C, 12; Ne, 20]

- A A molecule of methane has a greater mass than a molecule of neon.
- B Molecules of methane form hydrogen bonds, but those of neon do not.
- C Molecules of methane have stronger intermolecular forces than those of neon.
- D The molecule of methane is polar, but that of neon is not.

Topic **Chem 4 Q# 185**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

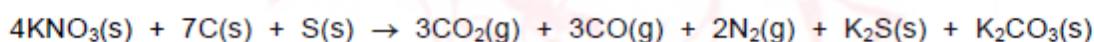
7 The table shows properties of four solids held together by different types of bonding.

Which row correctly describes the properties of a solid with a giant covalent structure?

	melting point	solubility in polar solvents
A	high	insoluble
B	high	soluble
C	low	insoluble
D	low	soluble

Topic **Chem 4 Q# 186**/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 'Black powder' is a mixture of potassium nitrate, carbon and sulfur. The mixture reacts as shown.



A sealed tube containing black powder has a volume of 10.0 cm^3 . When all of the black powder reacts, the reaction causes a pressure of $2 \times 10^6\text{ Pa}$ and a temperature of 2500 K .

The volume of the K_2CO_3 and K_2S produced can be ignored.

How many moles of KNO_3 are contained in the sealed tube?

- A 4.81×10^{-4} B 9.63×10^{-4} C 1.93×10^{-3} D 9.63×10^{-1}

Topic **Chem 4 Q# 187**/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 Which substance shows the greatest deviation from the properties of an ideal gas under room conditions?

- A $\text{CO}_2(\text{g})$ B $\text{H}_2(\text{g})$ C $\text{Ne}(\text{g})$ D $\text{NH}_3(\text{g})$



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33** Ethylene glycol, HOCH₂CH₂OH, is used as a de-icer. It allows ice to melt at temperatures below 0 °C.

Which statements are correct?

- 1 Ethylene glycol disrupts the extensive network of hydrogen bonds in ice.
- 2 Ethylene glycol molecules form hydrogen bonds with other ethylene glycol molecules.
- 3 Ethylene glycol molecules will dissolve in the water formed from the ice.

Topic **Chem 4 Q# 189**/ AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

- 8** Which gas would behave most like an ideal gas under room conditions?

- A helium
- B nitrogen
- C ammonia
- D krypton

Topic **Chem 4 Q# 190**/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

- 6** A solution contains 0.25 g of sulfur dioxide in 1.00 dm³ of water.

Which volume of sulfur dioxide, measured at 50 °C and a pressure of 1×10^5 Pa, must be added to 1.00 dm³ of water to produce this solution?

- A** 0.0162 cm³ **B** 0.105 cm³ **C** 16.2 cm³ **D** 105 cm³

Topic **Chem 4 Q# 191**/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33** Many gases do **not** obey the general gas equation at high pressures.

Why is this?

- 1 At higher pressures the molecules have more energy.
- 2 At higher pressures the volume of the molecules is a larger proportion of the total volume.
- 3 At higher pressures the molecules experience greater intermolecular forces.



- 9** A sample of argon gas has a mass of 0.20 g, at a pressure of 100 000 Pa and a temperature of 12 °C.

Which volume does the gas occupy?

- A** $1.2 \times 10^{-4} \text{ cm}^3$
B 5.0 cm^3
C 59 cm^3
D 119 cm^3

- 4** 10 cm^3 of ethane is burned in 45 cm^3 of oxygen at a pressure of 101 kPa and a temperature of 200 °C. Complete combustion takes place.

What is the total volume of gas present when the reaction is complete, measured under the same conditions?

- A** 30 cm^3 **B** 50 cm^3 **C** 55 cm^3 **D** 60 cm^3

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33** Carbon exists in several different forms. Two of these forms are buckminsterfullerene and graphene. Buckminsterfullerene is a fullerene allotrope of carbon.

Which statements about buckminsterfullerene and graphene are correct?

- 1** Both have delocalised electrons.
2 Buckminsterfullerene has a giant molecular structure.
3 The carbon atoms in graphene form a tetrahedral lattice.

- 9** 1.8 g of water, heated to 227 °C in a sealed container, turns to steam with a pressure of 200 kPa.

What is the approximate volume of the container?

- A** $9 \times 10^{-4} \text{ m}^3$ **B** $2 \times 10^{-3} \text{ m}^3$ **C** 2 m^3 **D** $8 \times 10^7 \text{ m}^3$

- 7** Under which conditions will nitrogen behave most like an ideal gas?

	temperature	pressure
A	low	high
B	high	low
C	low	low
D	high	high

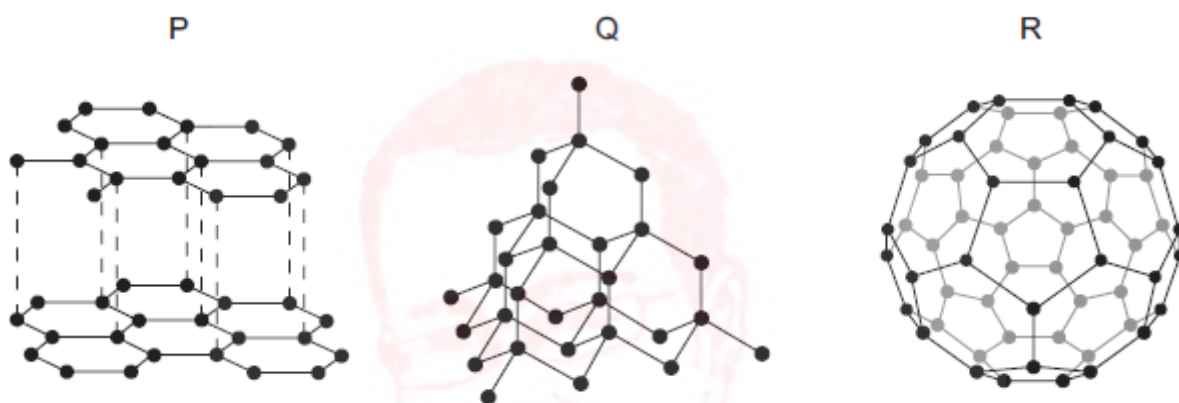
- 6** When an evacuated tube of volume 400 cm^3 is filled with gas at 300 K and 101 kPa , the mass of the tube increases by 0.65 g .

Assume the gas behaves as an ideal gas.

What could be the identity of the gas?

- A argon
- B helium
- C krypton
- D neon

- 7** P, Q and R represent three different structures of an element.



Which structures are giant molecular?

- A P, Q and R
- B P and Q only
- C P and R only
- D Q and R only

- 6** A sample of gas occupies 240 cm^3 at 37°C and 100 kPa .

How many moles of gas are present in the sample?

- A 9.32×10^{-6}
- B 9.32×10^{-3}
- C 0.0781
- D 78.1

- 5** In this question you should assume methane behaves as an ideal gas.

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

The volume of a sample of methane is measured at a temperature of 60°C and a pressure of 103 kPa . The volume measured is $5.37 \times 10^{-3} \text{ m}^3$.

What is the mass of the sample of methane, given to two significant figures?

- A 0.0032 g
- B 0.018 g
- C 3.2 g
- D 18 g

2 What is a basic assumption of the kinetic theory, as applied to an ideal gas?

- A** Collisions between gas molecules are elastic.
- B** Each gas molecule occupies a finite volume.
- C** Gases consist of particles that experience the force of gravity.
- D** Gas molecules attract each other with weak intermolecular forces.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which statements are correct?

- 1** The hydrogen bonds in ice are more regularly arranged than in water.
- 2** The solidification of water to form ice is exothermic.
- 3** Pure water is less dense than ice.

7 The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.960 g of oxygen gas is contained in a vessel of volume $7.00 \times 10^{-3} \text{ m}^3$ at a temperature of 30°C .

Assume that the gas behaves as an ideal gas.

What is the pressure in the vessel?

- A** 1.07 kPa
- B** 2.14 kPa
- C** 10.8 kPa
- D** 21.6 kPa

5 A fluorescent light tube has an internal volume of 400 cm^3 and an internal pressure of 200 kPa.

It is filled with 0.03 moles of an ideal gas.

What is the temperature of the gas inside the fluorescent light tube?

- A** $3.21 \times 10^{-1} \text{ K}$
- B** $3.21 \times 10^2 \text{ K}$
- C** $3.21 \times 10^5 \text{ K}$
- D** $3.21 \times 10^8 \text{ K}$



- 4** In the sodium chloride lattice the number of chloride ions that surround each sodium ion is called the *co-ordination number* of the sodium ions.

What are the co-ordination numbers of the sodium ions and the chloride ions in the sodium chloride lattice?

	sodium ions	chloride ions
A	4	6
B	6	4
C	6	6
D	8	6

Topic **Chem 4 Q# 206/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

- 6** Which gas sample contains the **fewest** molecules?

- A** 1.00 dm³ of carbon dioxide at 27 °C and 2.0 kPa
- B** 1.00 dm³ of hydrogen at 100 °C and 2.0 kPa
- C** 1.00 dm³ of nitrogen at 300 °C and 4.0 kPa
- D** 1.00 dm³ of oxygen at 250 °C and 3.0 kPa

Topic **Chem 4 Q# 207/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 32** When a sample of a gas is compressed at constant temperature from 1500 kPa to 6000 kPa, its volume changes from 76.0 cm³ to 20.5 cm³.

Which statements are possible explanations for this result?

- 1** The gas does not behave ideally.
- 2** The gas partially liquefies.
- 3** Some of the gas is lost from the container.

7 The approximate percentage composition of the atmospheres on four different planets is given in the table below.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules		
		H ₂	He	CH ₄
A	Jupiter	89.8	10.2	0.0
B	Neptune	80.0	19.0	1.0
C	Saturn	96.3	3.3	0.4
D	Uranus	82.5	15.2	2.3

2 In the ideal gas equation, $pV = nRT$, what are the units of n and T ?

	n	T
A	no units	°C
B	no units	K
C	mol	°C
D	mol	K

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 What are basic assumptions of the kinetic theory as applied to an ideal gas?

- 1 Gas particles are in continuous random motion.
- 2 Gas particles experience no intermolecular forces.
- 3 The volume of each gas particle is zero.



9 An article in a science magazine contains the following statement.

'It is lighter than a feather, stronger than steel, yet incredibly flexible and more conductive than copper.'

Which form of carbon is being described?

- A buckminsterfullerene
- B diamond
- C graphene
- D graphite

8 Solid carbon dioxide, CO_2 , is similar to solid iodine, I_2 , in its structure and properties. Carbon is in Group 14. Silica, SiO_2 , is a Group 14 compound.

Which statement about solid CO_2 and solid SiO_2 is correct?

- A Both solids exist in a lattice structure.
- B Both solids have a simple molecular structure.
- C Both solids have atoms joined by single covalent bonds.
- D Both solids change spontaneously to gas at s.t.p.

7 What is the volume of steam produced when 1.00g of ice is heated to 323°C at a pressure of 101 kPa?

- A 0.27 dm^3
- B 1.3 dm^3
- C 2.7 dm^3
- D 48 dm^3

5 Some car paints contain small flakes of silica, SiO_2 .

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic



5 Use of the Data Booklet is relevant to this question.

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

0.96 g of oxygen gas is contained in a glass vessel of volume $7.0 \times 10^{-3} \text{ m}^3$ at a temperature of 30°C .

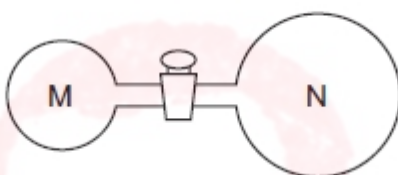
Assume the gas behaves as an ideal gas.

What is the pressure in the vessel?

- A** 1.1 kPa **B** 2.1 kPa **C** 10.8 kPa **D** 21.6 kPa

Topic **Chem 4 Q# 216**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 Two glass vessels M and N are connected by a closed valve.



M contains helium at 20°C at a pressure of $1 \times 10^5 \text{ Pa}$. N has been evacuated, and has three times the volume of M. In an experiment, the valve is opened and the temperature of the whole apparatus is raised to 100°C .

What is the final pressure in the system?

- A** $3.18 \times 10^4 \text{ Pa}$
B $4.24 \times 10^4 \text{ Pa}$
C $1.25 \times 10^5 \text{ Pa}$
D $5.09 \times 10^5 \text{ Pa}$

Topic **Chem 4 Q# 217**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 A student borrowed a friend's chemistry notes and copied out the notes in the box below.

Which statements are correct?

A gas behaves **less** like an ideal gas when the gas

- 1** is at low pressure.
2 is at low temperature.
3 can be easily liquefied.

4 The table shows the physical properties of four substances.

Which substance has a giant covalent structure?

	melting point /°C	boiling point /°C	electrical conductivity of solid	electrical conductivity of liquid	electrical conductivity of aqueous solution
A	-119	39	poor	poor	insoluble
B	-115	-85	poor	poor	good
C	993	1695	poor	good	good
D	1610	2230	poor	poor	insoluble

Topic **Chem 4 Q# 219**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 Use of the Data Booklet is relevant to this question.

Iodine is a black, shiny, non-metallic solid and a member of Group VII. It sublimes easily on heating to give a purple vapour.

A sample of iodine vapour of mass 6.35g has a volume of 1.247 dm³ when maintained at constant temperature and a pressure of 1.00×10^5 Pa.

If iodine vapour acts as an ideal gas, what is the temperature of the iodine vapour?

- A** 300 K **B** 600 K **C** 300000 K **D** 600000 K

Topic **Chem 4 Q# 220**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 Which would behave the **least** like an ideal gas at room temperature?

- A** carbon dioxide
B helium
C hydrogen
D nitrogen

Topic **Chem 4 Q# 221**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 The general gas equation can be used to calculate the M_r value of a gas.

For a sample of a gas of mass mg , which expression will give the value of M_r ?

- A** $M_r = \frac{mpV}{RT}$ **B** $M_r = \frac{pVRT}{m}$ **C** $M_r = \frac{mRT}{pV}$ **D** $M_r = \frac{pV}{mRT}$

8 Some car paints contain small flakes of silica, SiO₂.

In the structure of solid SiO₂

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in this statement?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

6 *Use of the Data Booklet is relevant to this question.*

The volume of a sample of ammonia is measured at a temperature of 60 °C and a pressure of 103 kPa. The volume measured is $5.37 \times 10^{-3} \text{ m}^3$.

What is the mass of the sample of ammonia, given to two significant figures?

- A** 0.00019 g **B** 0.0034 g **C** 0.19 g **D** 3.4 g

8 Under which set of conditions is a gas most likely to behave ideally?

	temperature	pressure
A	high	high
B	high	low
C	low	high
D	low	low

6 *Use of the Data Booklet is relevant to this question.*

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.56 g of ethene gas is contained in a vessel at a pressure of 102 kPa and a temperature of 30 °C.

What is the volume of the vessel?

- A** 49 cm³ **B** 494 cm³ **C** 48 900 cm³ **D** 494 000 cm³



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

where each symbol has its usual meaning.

Which statements are correct?

- 1 One mole of an ideal gas occupies the same volume under the same conditions of temperature and pressure.
- 2 The density of an ideal gas at constant pressure is inversely proportional to the temperature, T .
- 3 The volume of a given mass of an ideal gas is doubled if its temperature is raised from 25°C to 50°C at constant pressure.

Topic **Chem 4 Q# 227**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 At room temperature and pressure chlorine does not behave as an ideal gas.

At which temperature and pressure would the behaviour of chlorine become more ideal?

	pressure /kPa	temperature /K
A	50	200
B	50	400
C	200	200
D	200	400

10 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp /°C	801	2852	3550
bp /°C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T?

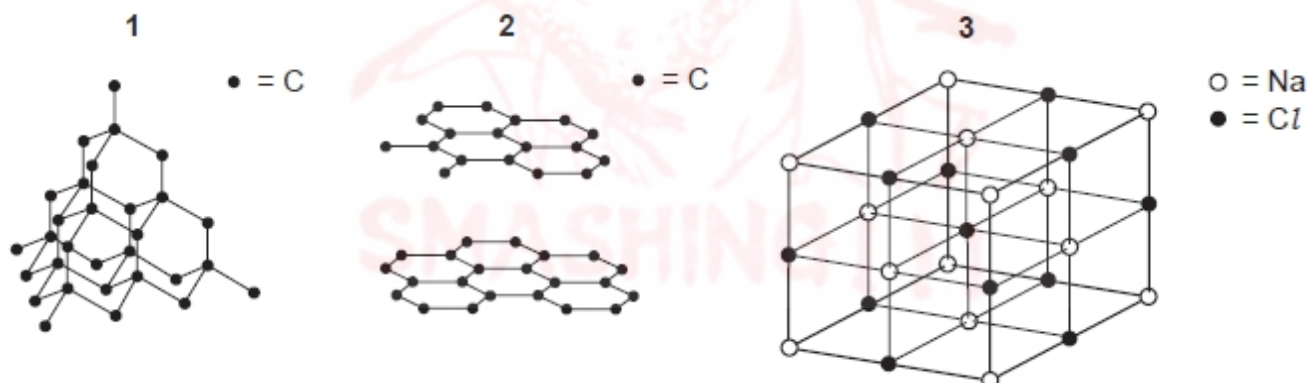
	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO ₂
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO ₂

Topic **Chem 4 Q# 229/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Which diagrams represent part of a giant molecular structure?



Topic **Chem 4 Q# 230/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Which gas closely approaches ideal behaviour at room temperature and pressure?

- A** ammonia
- B** carbon dioxide
- C** helium
- D** oxygen

7 A crystal of iodine produces a purple vapour when gently heated.

Which pair of statements correctly describes this process?

	type of bond broken	formula of purple species
A	covalent	I
B	covalent	I ₂
C	induced dipole-dipole	I ₂
D	permanent dipole-dipole	I ₂

Topic **Chem 4 Q# 232**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 An ideal gas obeys the gas laws under all conditions of temperature and pressure.

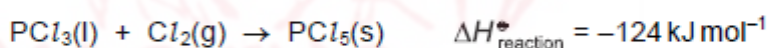
Which of the following are true for an ideal gas?

- The molecules have negligible volume.
- There are no forces of attraction between molecules.
- The molecules have an average kinetic energy which is proportional to its absolute temperature.

Topic **Chem 5 Q# 233**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 The enthalpy changes of formation, ΔH_f° , of both PCl_3 and PCl_5 are exothermic.

PCl_3 reacts with chlorine.



Which pair of statements is correct?

	statement 1	statement 2
A	$\Delta H_{\text{reaction}}^\circ$ is less negative than $\Delta H_f^\circ (\text{PCl}_5)$.	The Cl_2 bond energy is needed in calculating $\Delta H_{\text{reaction}}^\circ$ from enthalpies of formation.
B	$\Delta H_{\text{reaction}}^\circ$ is more negative than $\Delta H_f^\circ (\text{PCl}_5)$.	The Cl_2 bond energy is needed in calculating $\Delta H_{\text{reaction}}^\circ$ from enthalpies of formation.
C	$\Delta H_{\text{reaction}}^\circ$ is less negative than $\Delta H_f^\circ (\text{PCl}_5)$.	The Cl_2 bond energy is not needed in calculating $\Delta H_{\text{reaction}}^\circ$ from enthalpies of formation.
D	$\Delta H_{\text{reaction}}^\circ$ is more negative than $\Delta H_f^\circ (\text{PCl}_5)$.	The Cl_2 bond energy is not needed in calculating $\Delta H_{\text{reaction}}^\circ$ from enthalpies of formation.



- 10** A student mixes 25.0 cm^3 of 0.350 mol dm^{-3} sodium hydroxide solution with 25.0 cm^3 of 0.350 mol dm^{-3} hydrochloric acid. The temperature increases by 2.5°C . No heat is lost to the surroundings.

The final mixture has a specific heat capacity of $4.2\text{ J cm}^{-3}\text{ K}^{-1}$.

What is the molar enthalpy change for the reaction?

- A -150 kJ mol^{-1}
- B -60 kJ mol^{-1}
- C -30 kJ mol^{-1}
- D -0.15 kJ mol^{-1}

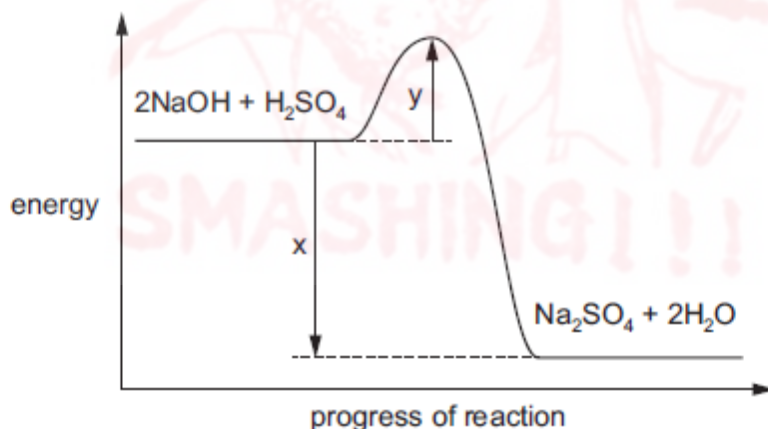
- 9** The equation for an enthalpy change is shown. The enthalpy change is Q .



What is the correct expression to calculate Q ?

- A $2 \times \Delta H_c^\circ [\text{CO}_2\text{(g)}] - 3 \times \Delta H_f^\circ [\text{H}_2\text{(g)}]$
- B $3 \times \Delta H_f^\circ [\text{H}_2\text{O(g)}] + 2 \times \Delta H_c^\circ [\text{CO}_2\text{(g)}]$
- C $2 \times \Delta H_f^\circ [\text{CO}_2\text{(g)}] - 3 \times \Delta H_f^\circ [\text{H}_2\text{(g)}]$
- D $3 \times \Delta H_f^\circ [\text{H}_2\text{O(l)}] + 2 \times \Delta H_f^\circ [\text{CO}_2\text{(g)}]$

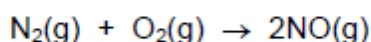
- 10** A reaction pathway diagram for the reaction of aqueous sodium hydroxide and dilute sulfuric acid is shown.



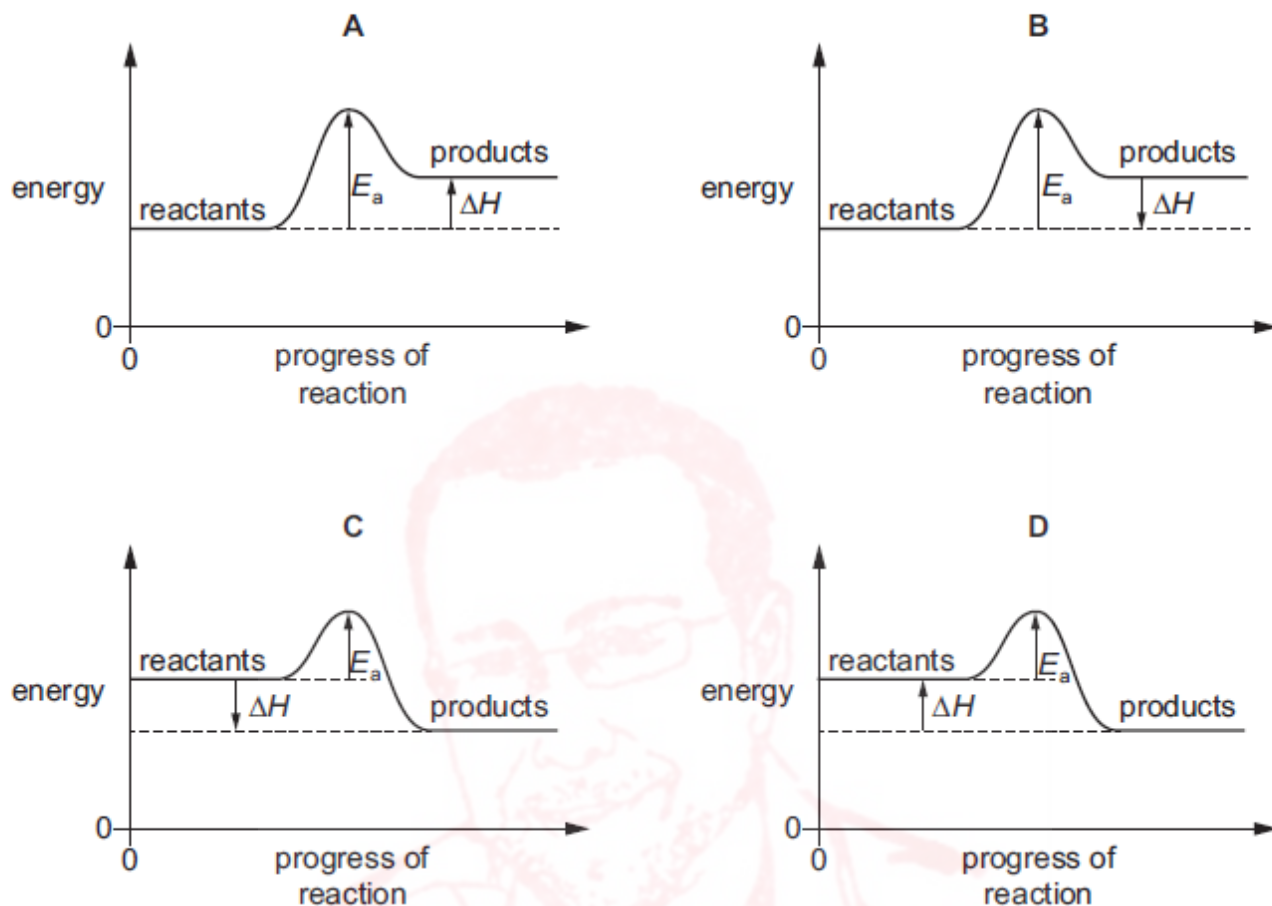
What is the value of the enthalpy change of neutralisation, ΔH_{neut} ?

- A x
- B $x - y$
- C $\frac{x}{2}$
- D $\frac{(x - y)}{2}$

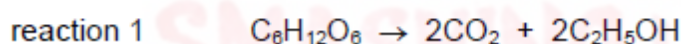
- 9** Nitrogen monoxide is an atmospheric pollutant that is formed inside car engines by an endothermic reaction between nitrogen and oxygen.



Which diagram correctly represents the energy profile for this reaction?



- 8** The equation for reaction 1 is shown.



	$\Delta H_c^\circ / \text{kJ mol}^{-1}$
$\text{C}_6\text{H}_{12}\text{O}_6$	<i>a</i>
$\text{C}_2\text{H}_5\text{OH}$	<i>b</i>

What is the correct expression for the enthalpy change of reaction 1?

- A** $a + b$ **B** $a - b$ **C** $a + 2b$ **D** $a - 2b$



8 Which equation represents the enthalpy change of atomisation of iodine?

- A $\frac{1}{2} \text{I}_2(\text{g}) \rightarrow \text{I}(\text{g})$
 B $\text{I}_2(\text{g}) \rightarrow 2\text{I}(\text{g})$
 C $\frac{1}{2} \text{I}_2(\text{s}) \rightarrow \text{I}(\text{g})$
 D $\text{I}_2(\text{s}) \rightarrow 2\text{I}(\text{g})$

Topic **Chem 5 Q# 240/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 In order to determine the enthalpy of neutralisation of a strong acid and a strong alkali, 25.0 cm³ of 2.00 mol dm⁻³ sodium hydroxide is added to 25.0 cm³ of 2.00 mol dm⁻³ hydrochloric acid. The increase in temperature is 12 °C.

In a second experiment, the same method is used, but 50.0 cm³ of 2.00 mol dm⁻³ sodium hydroxide is added to 50.0 cm³ of 2.00 mol dm⁻³ hydrochloric acid.

What is the increase in temperature in the second experiment?

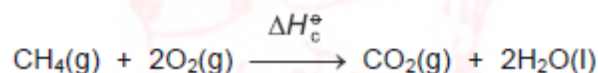
- A 6 °C B 12 °C C 24 °C D 48 °C

Topic **Chem 5 Q# 241/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 ΔH_1° is the standard enthalpy of formation of methane.

ΔH_2° is the standard enthalpy of combustion of carbon.

ΔH_3° is the standard enthalpy of combustion of hydrogen.



Which expression is equivalent to ΔH_c° ?

- A $\Delta H_1^\circ - \Delta H_2^\circ + \Delta H_3^\circ$
 B $\Delta H_1^\circ - 2\Delta H_3^\circ - \Delta H_2^\circ$
 C $\Delta H_2^\circ - \Delta H_3^\circ + \Delta H_1^\circ$
 D $\Delta H_2^\circ + 2\Delta H_3^\circ - \Delta H_1^\circ$

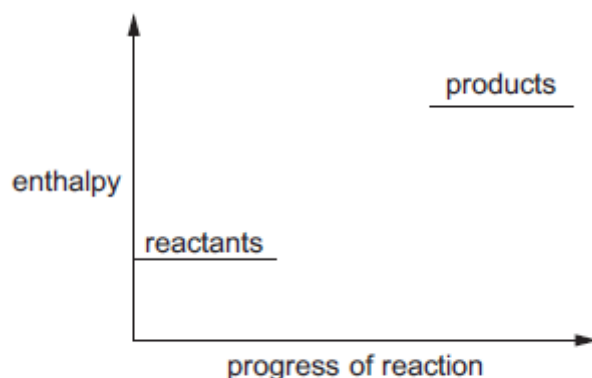
Topic **Chem 5 Q# 242/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



32 The diagram shows an incomplete energy profile diagram for a reaction.

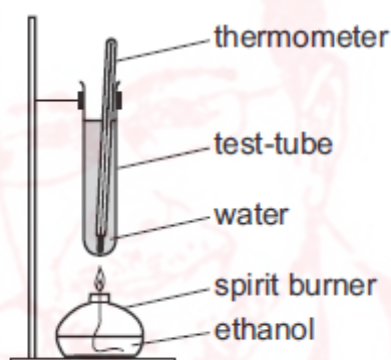


Which reactions could this diagram refer to?

- 1 $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
- 2 $\text{H}_2(\text{g}) \rightarrow 2\text{H}(\text{g})$
- 3 $\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}^-(\text{g}) + \text{aq}$

Topic Chem 5 Q# 243/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 An experiment was performed to determine the enthalpy of combustion of ethanol.



The data collected are shown.

mass of water = $W\text{g}$

mass of ethanol burned = $X\text{g}$

temperature rise = $Y^\circ\text{C}$

molar mass of ethanol = $Z\text{g mol}^{-1}$

specific heat capacity of water = $4.2\text{J K}^{-1}\text{g}^{-1}$

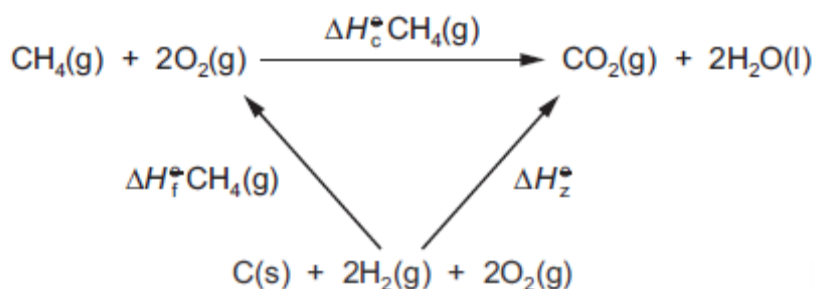
Which expression can be used to calculate the enthalpy of combustion of ethanol in kJ mol^{-1} ?

- A $\frac{-4.2WYZ}{1000X}$ B $\frac{-4.2WYX}{1000Z}$ C $\frac{-4.2XYZ}{1000W}$ D $\frac{-4.2X(Y + 273)Z}{1000W}$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 An energy cycle for the combustion of methane is shown.

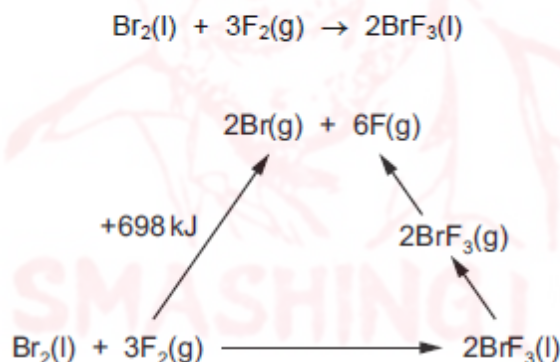


Which expressions can be used to calculate the energy change, ΔH_z° ?

- 1 $\Delta H_f^\circ \text{CH}_4(\text{g}) + \Delta H_c^\circ \text{CH}_4(\text{g})$
- 2 $\Delta H_c^\circ \text{C}(\text{s}) + 2\Delta H_c^\circ \text{H}_2(\text{g})$
- 3 $\Delta H_c^\circ \text{CO}(\text{g}) + 2\Delta H_c^\circ \text{H}_2(\text{g})$

Topic **Chem 5 Q# 245/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 An energy cycle is drawn for the following reaction.



The standard enthalpy of formation of $\text{BrF}_3(\text{l}) = -301 \text{ kJ mol}^{-1}$.

The enthalpy change of $\text{BrF}_3(\text{l})$ to $\text{BrF}_3(\text{g})$ is $+44 \text{ kJ mol}^{-1}$.

What is the average bond energy of the Br–F bond in BrF_3 ?

- A** 152 kJ mol^{-1} **B** 202 kJ mol^{-1} **C** 304 kJ mol^{-1} **D** 404 kJ mol^{-1}

Topic **Chem 5 Q# 246/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 Which pair of standard enthalpy changes are numerically equal?

- A** atomisation of $\text{CH}_4(\text{g})$ and formation of $\text{CH}_4(\text{g})$
- B** combustion of $\text{CH}_3\text{OH}(\text{l})$ and combustion of graphite + 2(combustion of $\text{H}_2(\text{g})$)
- C** combustion of graphite and formation of $\text{CO}_2(\text{g})$
- D** neutralisation of $\text{HCl}(\text{aq})$ with $\text{NaOH}(\text{aq})$ and formation of $\text{H}_2\text{O}(\text{l})$



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which statements are correct?

- 1 enthalpy of combustion of H_2 = enthalpy of formation of H_2O
- 2 enthalpy of formation of H_2 = $-(\text{enthalpy of atomisation of } \text{H}_2)$
- 3 enthalpy of solution of HCl = enthalpy of hydration of H^+ + enthalpy of hydration of Cl^-

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Nitrogen forms a number of oxides. Their enthalpies of formation are given.

$$\Delta H_f^\circ[\text{NO}(\text{g})] = +90 \text{ kJ mol}^{-1}$$

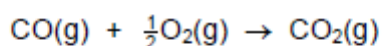
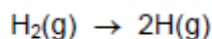
$$\Delta H_f^\circ[\text{N}_2\text{O}(\text{g})] = +82 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ[\text{NO}_2(\text{g})] = +33 \text{ kJ mol}^{-1}$$

Which statements are correct?

- 1 If $\text{N}_2\text{O}(\text{g})$ is oxidised by $\text{O}_2(\text{g})$ to $\text{NO}_2(\text{g})$, 16 kJ is released per mole of N_2O .
- 2 The decomposition of $\text{N}_2\text{O}(\text{g})$ to $\text{N}_2(\text{g})$ and $\text{O}_2(\text{g})$ is exothermic.
- 3 The reaction between NO and oxygen is exothermic.

5 Two reactions are shown.

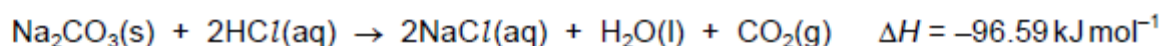
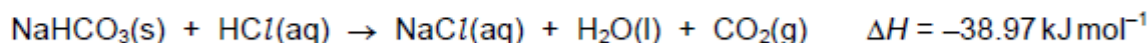


If molar amounts are used, how can the two energy changes associated with these reactions be described?

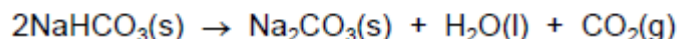
- A enthalpy of atomisation and enthalpy of combustion
- B enthalpy of atomisation and enthalpy of formation
- C bond energy and enthalpy of combustion
- D bond energy and enthalpy of formation



4 The following data are needed for this question.



On heating, sodium hydrogencarbonate decomposes as shown.



What is the enthalpy change for this decomposition?

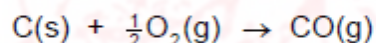
- A $-57.62 \text{ kJ mol}^{-1}$
- B $-18.65 \text{ kJ mol}^{-1}$
- C $18.65 \text{ kJ mol}^{-1}$
- D $57.62 \text{ kJ mol}^{-1}$

Topic **Chem 5 Q# 251**/ AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 A reaction between carbon and oxygen is shown.

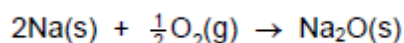


How can the standard enthalpy change of this reaction be described correctly?

- 1 standard enthalpy change of formation
- 2 standard enthalpy change of combustion
- 3 standard enthalpy change of atomisation

Topic **Chem 5 Q# 252**/ AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

8 Sodium burns in oxygen giving out heat energy and forming the compound Na_2O . The equation for this reaction is shown.



Which statement about the reaction is correct?

- A ΔH° for the reaction is equal to twice the bond energy of the Na–O bond.
- B ΔH° for the reaction is positive.
- C The equation represents the standard enthalpy change of combustion of sodium.
- D The equation represents the standard enthalpy change of formation of sodium oxide.



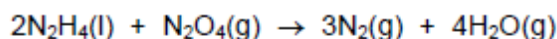
7 The following data are needed for this question.

$$\Delta H_f^\circ(\text{N}_2\text{H}_4(\text{l})) = 50.6 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ(\text{N}_2\text{O}_4(\text{g})) = 9.2 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ(\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ mol}^{-1}$$

Hydrazine, $\text{N}_2\text{H}_4(\text{l})$, reacts with dinitrogen tetraoxide, $\text{N}_2\text{O}_4(\text{g})$, to form nitrogen gas and water vapour.

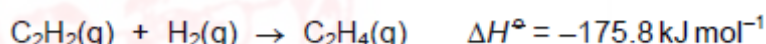
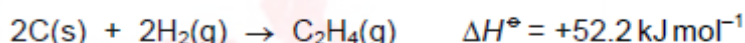


What is the enthalpy change for this reaction?

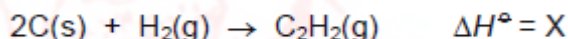
- A $-1077.6 \text{ kJ mol}^{-1}$
- B $-856.8 \text{ kJ mol}^{-1}$
- C $-301.6 \text{ kJ mol}^{-1}$
- D $-182.0 \text{ kJ mol}^{-1}$

Topic **Chem 5 Q# 254/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

8 Two reactions and their enthalpy changes are shown.



These data can be used to calculate the enthalpy change for the reaction shown.



What is the value of X?

- A $-228.0 \text{ kJ mol}^{-1}$
- B $-123.6 \text{ kJ mol}^{-1}$
- C $+123.6 \text{ kJ mol}^{-1}$
- D $+228.0 \text{ kJ mol}^{-1}$

Topic **Chem 5 Q# 255/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Which statements about enthalpy changes are correct?

- 1 The enthalpy change of atomisation is always positive.
- 2 The enthalpy change when a C–C bond is broken is positive.
- 3 The enthalpy change of neutralisation of a weak acid is always negative.



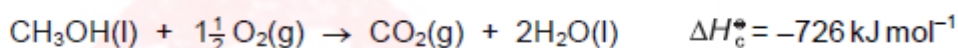
9 The equation for a chemical reaction is shown. All substances are in their standard states.



Which statement describes the standard enthalpy change of reaction for this reaction?

- A** the enthalpy change when a total of one mole of products is produced
- B** the enthalpy change when a total of one mole of reactants is reacted
- C** the enthalpy change when one mole of water reacts
- D** the enthalpy change when six moles of hydrogen fluoride are produced

8 The standard enthalpy changes of combustion of carbon, hydrogen and methanol are shown.



Which expression gives the standard enthalpy change of formation of methanol in kJ mol^{-1} ?

- A** $-394 + (-286) - (-726)$
- B** $-394 + (-286 \times 2) - 726$
- C** $-394 + (-286 \times 2) - (-726)$
- D** $-726 - (-394) - (-286 \times 2)$

6 A butane burner is used to heat water. The M_r of butane is 58.

- ΔH_c° of butane is $-2877 \text{ kJ mol}^{-1}$.
- 250 g of water is heated from 12°C to 100°C .
- The burner transfers 47% of the heat released from the burning fuel to the water.

Assume that the butane undergoes complete combustion and none of the water evaporates.

What is the minimum mass of butane that must be burnt?

- A** 0.068 g **B** 1.85 g **C** 3.94 g **D** 4.48 g

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

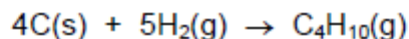


33 Which statements are correct for **all** exothermic reactions?

- 1 ΔH for the reaction is negative.
- 2 On a reaction pathway diagram the products are shown lower than the reactants.
- 3 The reaction will occur without heating.

Topic **Chem 5 Q# 260**/ AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.



By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^\ominus$, of butane?

substance	$\Delta H_c^\ominus/\text{kJ mol}^{-1}$
C(s)	-394
H ₂ (g)	-286
C ₄ H ₁₀ (g)	-2877

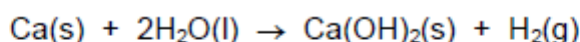
- A -5883 kJ mol⁻¹
B -129 kJ mol⁻¹
C +129 kJ mol⁻¹
D +2197 kJ mol⁻¹

Topic **Chem 5 Q# 261**/ AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Calcium reacts with water to form calcium hydroxide and hydrogen.



The standard enthalpy change for this reaction is -414 kJ mol⁻¹.

What further information is needed in order to calculate the standard enthalpy change of formation of calcium hydroxide, $\Delta H_f^\ominus \text{Ca(OH)}_2\text{(s)}$?

- 1 $\Delta H_f^\ominus$ for H₂O(l)
- 2 $\Delta H_f^\ominus$ for H₂(g)
- 3 first and second ionisation energies of Ca

9 Hess' Law and bond energy data can be used to calculate the enthalpy change of a reaction.

Bromoethane, $\text{CH}_3\text{CH}_2\text{Br}$, can be made by reacting ethene with hydrogen bromide.



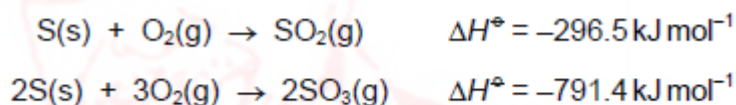
What is the enthalpy change for this reaction?

- A -674 kJ mol^{-1}
- B -64 kJ mol^{-1}
- C $+186 \text{ kJ mol}^{-1}$
- D $+346 \text{ kJ mol}^{-1}$

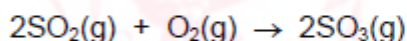
8 Which equation represents the standard enthalpy change of formation of water?

- A $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$
- B $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$
- C $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$
- D $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$

8 Sulfur can be oxidised in two ways.



Sulfur trioxide can be made from sulfur dioxide and oxygen.



What is the standard enthalpy change for this reaction?

- A $-1384.4 \text{ kJ mol}^{-1}$
- B $-989.8 \text{ kJ mol}^{-1}$
- C $-494.9 \text{ kJ mol}^{-1}$
- D $-198.4 \text{ kJ mol}^{-1}$

11 200 g of water are at 25°C .

The water is heated to 75°C by burning 2 g of ethanol.

What is the amount of energy transferred to the water?

- A 0.418 kJ
- B 10.4 kJ
- C 41.8 kJ
- D 62.7 kJ



7 Which expression gives the standard enthalpy change of combustion of methane?

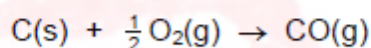
- A $\Delta H_f^\circ(\text{CH}_4) + \Delta H_f^\circ(\text{CO}_2) - 2\Delta H_f^\circ(\text{H}_2\text{O})$
- B $\Delta H_f^\circ(\text{CO}_2) + 2\Delta H_f^\circ(\text{H}_2\text{O}) + \Delta H_f^\circ(\text{CH}_4)$
- C $\Delta H_f^\circ(\text{CH}_4) + 2\Delta H_f^\circ(\text{H}_2\text{O}) - \Delta H_f^\circ(\text{CO}_2)$
- D $\Delta H_f^\circ(\text{CO}_2) + 2\Delta H_f^\circ(\text{H}_2\text{O}) - \Delta H_f^\circ(\text{CH}_4)$

Topic **Chem 5 Q# 267**/ AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 A reaction between carbon and oxygen is shown.



How can the enthalpy change of this reaction be described correctly?

- 1 enthalpy change of formation
- 2 enthalpy change of combustion
- 3 enthalpy change of atomisation

Topic **Chem 5 Q# 268**/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 All the reactants and products of an exothermic reaction are gaseous.

Which statement about this reaction is correct?

- A The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is negative.
- B The total bond energy of the products is less than the total bond energy of the reactants, and ΔH for the reaction is positive.
- C The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is negative.
- D The total bond energy of the products is more than the total bond energy of the reactants, and ΔH for the reaction is positive.

- 7 A student mixed 25.0 cm^3 of 4.00 mol dm^{-3} hydrochloric acid with an equal volume of 4.00 mol dm^{-3} sodium hydroxide. The initial temperature of both solutions was 15.0°C . The maximum temperature recorded was 30.0°C .

Using these results, what is the enthalpy change of neutralisation of hydrochloric acid?

- A $-62.7 \text{ kJ mol}^{-1}$
 B $-31.4 \text{ kJ mol}^{-1}$
 C $-15.7 \text{ kJ mol}^{-1}$
 D $-3.14 \text{ kJ mol}^{-1}$

- 8 An important reaction in the manufacture of nitric acid is the catalytic oxidation of ammonia.



For every mole of O_2 that reacts in this way, 181.8 kJ of energy are released.

A factory makes $2.50 \times 10^5 \text{ mol}$ of NO every day.

How much energy, in kJ , is released every day?

- A 3.64×10^7 B 4.55×10^7 C 5.68×10^7 D 2.27×10^8

The responses **A** to **D** should be selected on the basis of

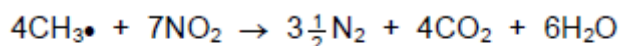
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33 For which enthalpy changes is the value of ΔH always negative?

- 1 combustion
 2 hydration
 3 solution



- 15** At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as $\text{CH}_3\bullet$ in the catalytic converter of a motor vehicle.



The following table lists types of energy change for this reaction and possible reasons for them.

Which row gives the energy change for this reaction and the reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the $\text{N}\equiv\text{N}$ bond energy is very high
C	exothermic	CO_2 and H_2O have large negative ΔH_f° values
D	exothermic	double bonds are broken in NO_2

- 8** Gaseous phosphorus pentachloride can be decomposed into gaseous phosphorus trichloride and chlorine by heating. The table gives the bond energies.

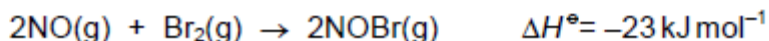
bond	bond energy / kJ mol^{-1}
$\text{P}-\text{Cl}$ (in both chlorides)	330
$\text{Cl}-\text{Cl}$	242

What is the enthalpy change for the decomposition of PCl_5 to PCl_3 and Cl_2 ?

- A** -418 kJ mol^{-1}
- B** -88 kJ mol^{-1}
- C** $+88 \text{ kJ mol}^{-1}$
- D** $+418 \text{ kJ mol}^{-1}$

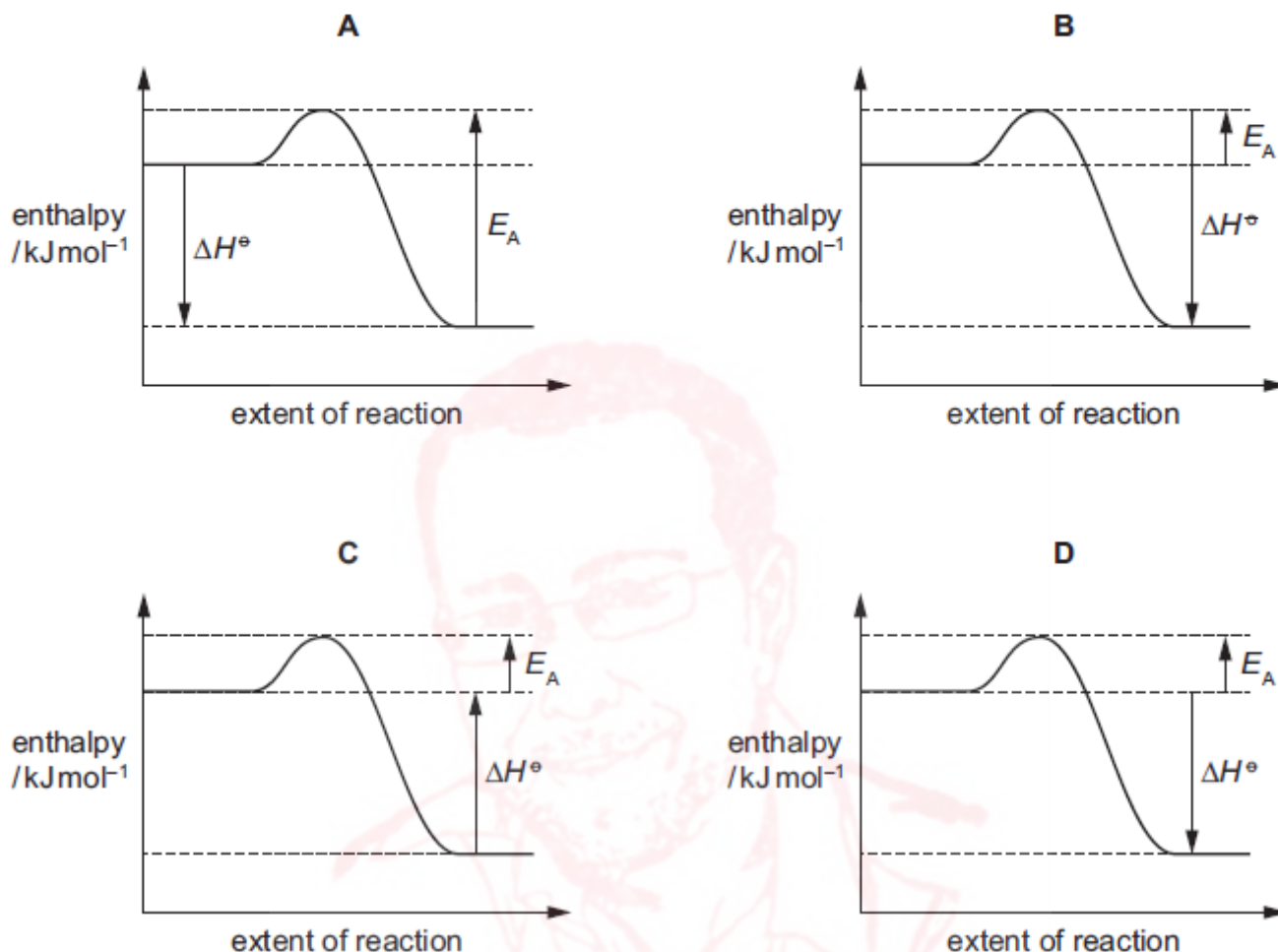


5 Nitric oxide, NO, and bromine vapour react together according to the following equation.



The reaction has an activation energy of $+5.4 \text{ kJ mol}^{-1}$.

What is the correct reaction pathway diagram for this reaction?

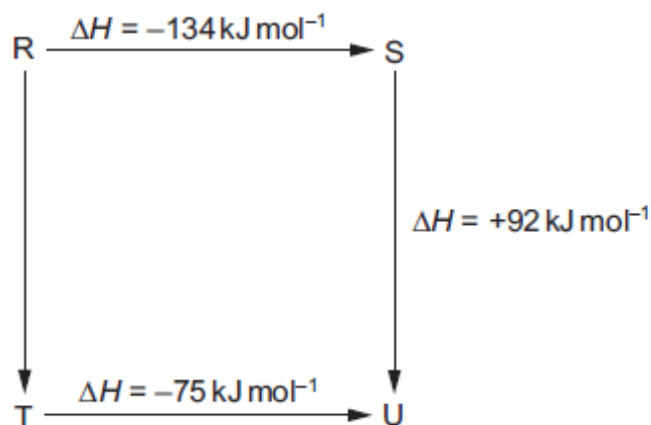


Topic **Chem 5 Q# 275/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 The diagram illustrates the enthalpy changes of a set of reactions



Which statements are correct?

- 1 The enthalpy change for the transformation $U \rightarrow R$ is $+42 \text{ kJ mol}^{-1}$.
- 2 The enthalpy change for the transformation $T \rightarrow S$ is endothermic.
- 3 The enthalpy change for the transformation $R \rightarrow T$ is -33 kJ mol^{-1} .

Topic Chem 5 Q# 276/ AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 Which equation has an enthalpy change of reaction which corresponds to the standard enthalpy change of atomisation of chlorine?

- A $\frac{1}{2} \text{Cl}_2(\text{g}) \rightarrow \text{Cl}(\text{g})$
- B $\frac{1}{2} \text{Cl}_2(\text{l}) \rightarrow \text{Cl}(\text{g})$
- C $\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$
- D $\text{Cl}_2(\text{l}) \rightarrow 2\text{Cl}(\text{g})$

Topic Chem 5 Q# 277/ AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 Use of the Data Booklet is relevant for this question.

In an experiment, the burning of 1.45 g (0.025 mol) of propanone was used to heat 100 g of water. The initial temperature of the water was 20.0°C and the final temperature of the water was 78.0°C .

Which experimental value for the enthalpy change of combustion for propanone can be calculated from these results?

- A $-1304 \text{ kJ mol}^{-1}$
- B -970 kJ mol^{-1}
- C -352 kJ mol^{-1}
- D $-24.2 \text{ kJ mol}^{-1}$

6 Solid sulfur consists of molecules made up of eight atoms covalently bonded together.

The bonding in sulfur dioxide is O=S=O.

enthalpy change of combustion of S₈, $\Delta H_c^\circ \text{S}_8(\text{s}) = -2376 \text{ kJ mol}^{-1}$

energy required to break 1 mole S₈(s) into gaseous atoms = 2232 kJ mol⁻¹

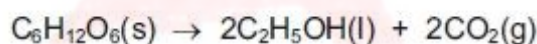
O=O bond enthalpy = 496 kJ mol⁻¹

Using these data, what is the value of the S=O bond enthalpy?

- A** 239 kJ mol⁻¹ **B** 257 kJ mol⁻¹ **C** 319 kJ mol⁻¹ **D** 536 kJ mol⁻¹

7 The standard enthalpy changes of combustion of glucose and ethanol are given as -2820 and -1368 kJ mol⁻¹ respectively.

Glucose, C₆H₁₂O₆, can be converted into ethanol.

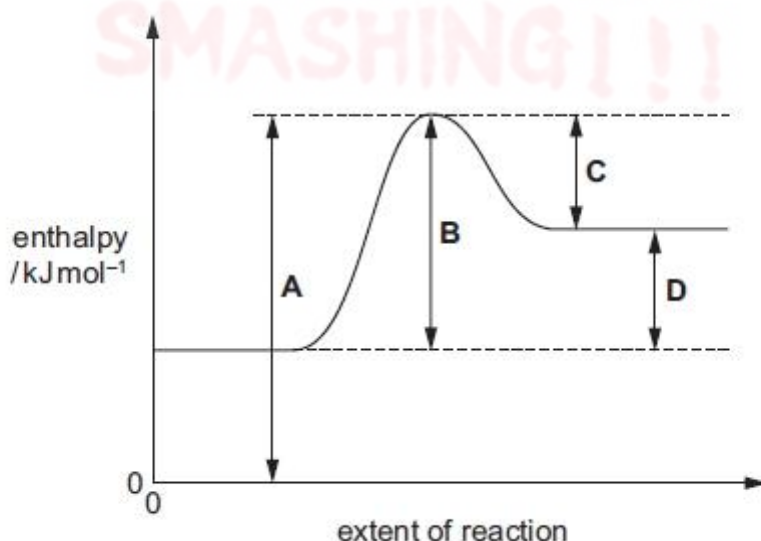


What is the standard enthalpy change for this reaction?

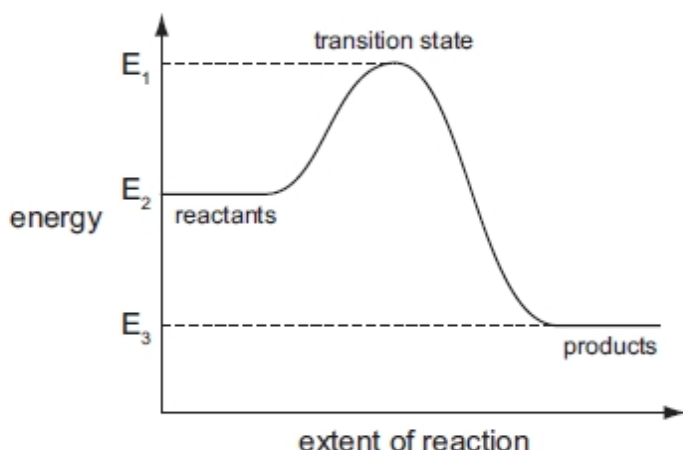
- A** -1452 kJ mol⁻¹
B -84 kJ mol⁻¹
C +84 kJ mol⁻¹
D +1452 kJ mol⁻¹

11 The diagram shows a reaction pathway for an endothermic reaction.

Which arrow represents the activation energy for the forward reaction?



- 8 The reaction pathway diagram below illustrates the energies of the reactants, the products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

- A** $E_1 - E_2$ **B** $E_2 - E_1$ **C** $E_2 - E_3$ **D** $E_3 - E_2$

Topic **Chem 5 Q# 282**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

- 7 In an experiment to calculate the enthalpy change of combustion of a fuel, 1.5g (0.0326 mol) of the fuel was used to heat 200g of water. The temperature of the water rose from 25 °C to 55 °C. The specific heat capacity of water is 4.18 Jg⁻¹ K⁻¹.

There is significant heat loss in this experiment. Therefore, the experimental value for the enthalpy change of combustion, ΔH_c , of the fuel will be different from the theoretical value.

Using the information above, what is the experimental value for the enthalpy change of combustion, ΔH_c , of the fuel?

- A** -1410 kJ mol⁻¹
B -769 kJ mol⁻¹
C -30.7 kJ mol⁻¹
D -16.7 kJ mol⁻¹

Topic **Chem 5 Q# 283**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

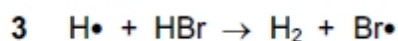
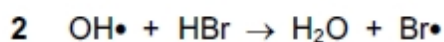
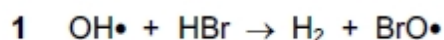
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



32 Use of the Data Booklet is relevant to this question.

The bond energy of the Br–O bond is 235 kJ mol^{-1} .

Which reactions are exothermic?



Topic **Chem 5 Q# 284/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 Ethanol is increasingly being used as a fuel for cars.

The standard enthalpy change of formation of carbon dioxide is -393 kJ mol^{-1} .

The standard enthalpy change of formation of water is -286 kJ mol^{-1} .

The standard enthalpy change of formation of ethanol is -277 kJ mol^{-1} .

What is the standard enthalpy change of combustion of ethanol?

A -1921 kJ mol^{-1}

B -1367 kJ mol^{-1}

C -956 kJ mol^{-1}

D -402 kJ mol^{-1}

Topic **Chem 5 Q# 285/** AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 A student mixed 25.0 cm^3 of 0.350 mol dm^{-3} sodium hydroxide solution with 25.0 cm^3 of 0.350 mol dm^{-3} hydrochloric acid. The temperature rose by 2.50°C . Assume that no heat was lost to the surroundings.

The final mixture had a specific heat capacity of $4.20\text{ J cm}^{-3}\text{ K}^{-1}$.

What is the molar enthalpy change for the reaction?

A -150 kJ mol^{-1}

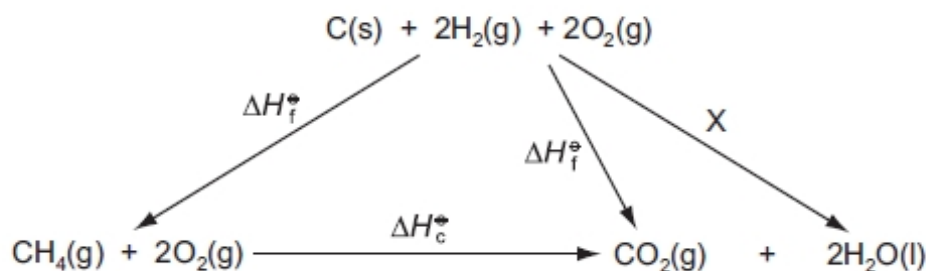
B -60.0 kJ mol^{-1}

C -30.0 kJ mol^{-1}

D $-0.150\text{ kJ mol}^{-1}$

- 3 Enthalpy changes that are difficult to measure directly can often be determined using Hess' Law to construct an enthalpy cycle.

Which enthalpy change is indicated by X in the enthalpy cycle shown?

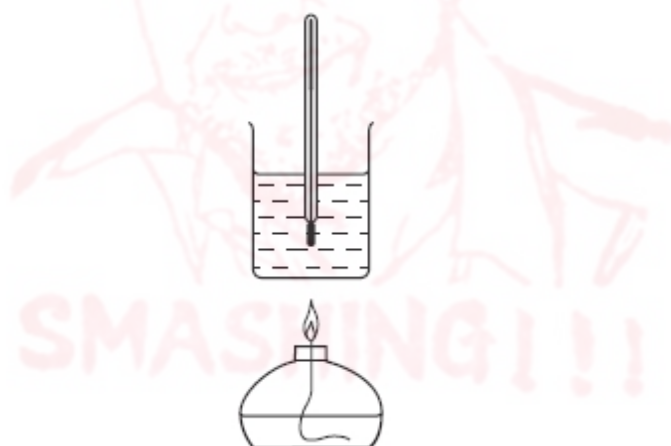


- A $-4 \times$ the enthalpy of combustion of hydrogen
- B $+4 \times$ the enthalpy of combustion of hydrogen
- C $-2 \times$ the enthalpy of formation of water
- D $+2 \times$ the enthalpy of formation of water

- 11 Use of the Data Booklet is relevant to this question.

A student carried out an experiment to determine the enthalpy change for the combustion of methanol.

The following results were obtained by the student.

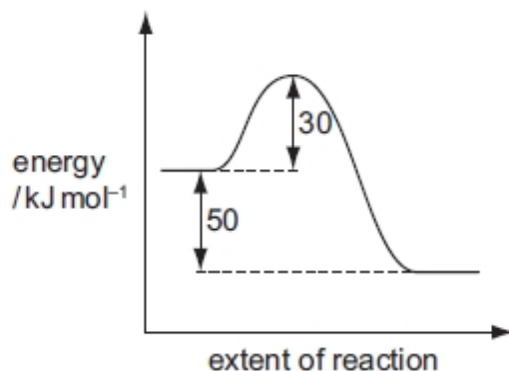


start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

How much of the heat energy produced by the burning of methanol went into the water?

- A 209 J
- B 13 794 J
- C 20 691 J
- D 22 154 J

7 The reaction pathway for a reversible reaction is shown below.



Which statement is correct?

- A The activation energy of the reverse reaction is $+80 \text{ kJ mol}^{-1}$.
- B The enthalpy change for the forward reaction is $+30 \text{ kJ mol}^{-1}$.
- C The enthalpy change for the forward reaction is $+50 \text{ kJ mol}^{-1}$.
- D The enthalpy change for the reverse reaction is $+30 \text{ kJ mol}^{-1}$.

Topic **Chem 5 Q# 289**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 Use of the Data Booklet is relevant to this question.

This question should be answered using bond enthalpy data. The equation for the complete combustion of methane is given below.



What is the enthalpy change of combustion of methane?

- A $-1530 \text{ kJ mol}^{-1}$
- B $-1184 \text{ kJ mol}^{-1}$
- C -770 kJ mol^{-1}
- D -688 kJ mol^{-1}

Topic **Chem 5 Q# 290**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 Use of the Data Booklet is relevant to this question.

A reaction which causes the presence of oxides of nitrogen in car exhausts is the formation of NO.



What is the bond energy in kJ mol^{-1} of the bond between the atoms in NO?

- A 655
- B 835
- C 1310
- D 1670

11 Which process could be used to calculate the bond energy for the covalent bond X-Y by dividing its ΔH by n ?

- A $XY_n(g) \rightarrow X(g) + nY(g)$
- B $2XY_n(g) \rightarrow 2XY_{n-1}(g) + Y_2(g)$
- C $Y(g) + XY_{n-1}(g) \rightarrow XY_n(g)$
- D $nXY(g) \rightarrow nX(g) + \frac{n}{2} Y_2(g)$

10 A student calculated the standard enthalpy change of formation of ethane, C_2H_6 , using a method based on standard enthalpy changes of combustion.

He used correct values for the standard enthalpy change of combustion of ethane ($-1560 \text{ kJ mol}^{-1}$) and hydrogen (-286 kJ mol^{-1}) but he used an incorrect value for the standard enthalpy change of combustion of carbon. He then performed his calculation correctly. His final answer was -158 kJ mol^{-1} .

What did he use for the standard enthalpy change of combustion of carbon?

- A $-1432 \text{ kJ mol}^{-1}$
- B -860 kJ mol^{-1}
- C -430 kJ mol^{-1}
- D -272 kJ mol^{-1}

7 Propanone has the molecular formula C_3H_6O .

The enthalpy change of combustion of hydrogen is -286 kJ mol^{-1} .

The enthalpy change of combustion of carbon is -394 kJ mol^{-1} .

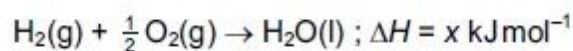
The enthalpy change of combustion of propanone is $-1786 \text{ kJ mol}^{-1}$.

Using this information, what is the enthalpy change of formation of propanone?

- A $-1106 \text{ kJ mol}^{-1}$
- B -540 kJ mol^{-1}
- C -254 kJ mol^{-1}
- D $+1106 \text{ kJ mol}^{-1}$



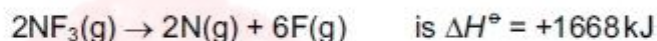
3 The equation for a reaction is shown.



Which pair of descriptions is fully correct for this reaction?

	type(s) of enthalpy change	value of x
A	formation only	positive
B	formation only	negative
C	combustion, formation	positive
D	combustion, formation	negative

6 The standard enthalpy change for the reaction



What is the bond energy of the N–F bond?

- A** -556 kJ mol^{-1}
- B** -278 kJ mol^{-1}
- C** $+278 \text{ kJ mol}^{-1}$
- D** $+556 \text{ kJ mol}^{-1}$

19 Which reaction is endothermic?

- A** $2\text{HBr} \rightarrow \text{H}_2 + \text{Br}_2$
- B** $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
- C** $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
- D** $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

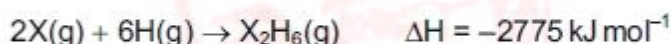
- 9 50 cm³ of 2.50 mol dm⁻³ hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then 50 cm³ of 2.50 mol dm⁻³ NaOH at the same temperature was quickly added, with stirring. The temperature rose by 17 °C.

The resulting solution may be considered to have a specific heat capacity of 4.2 J g⁻¹ K⁻¹.

What is an approximate value for the molar enthalpy change of neutralisation of hydrochloric acid and sodium hydroxide from this experiment?

- A $\frac{-(50 \times 4.2 \times 17)}{(0.050 \times 2.5)} \text{ J mol}^{-1}$
- B $\frac{-(50 \times 4.2 \times 17)}{(0.10 \times 2.5)} \text{ J mol}^{-1}$
- C $\frac{-(100 \times 4.2 \times 17)}{(0.050 \times 2.5)} \text{ J mol}^{-1}$
- D $\frac{-(100 \times 4.2 \times 17)}{(50 \times 2.5)} \text{ J mol}^{-1}$

- 8 The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X₂H₆ molecules.



The bond energy of an X–H bond is 395 kJ mol⁻¹.

What is the bond energy of an X–X bond?

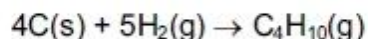
- A -405.0 kJ mol⁻¹
- B -202.5 kJ mol⁻¹
- C +202.5 kJ mol⁻¹
- D +405.0 kJ mol⁻¹

- 9 In a calorimetric experiment 1.60 g of a fuel is burnt. 45 % of the energy released is absorbed by 200 g of water whose temperature rises from 18 °C to 66 °C. The specific heat capacity of water is 4.2 J g⁻¹ K⁻¹.

What is the total energy released per gram of fuel burnt?

- A 25 200 J B 56 000 J C 89 600 J D 143 360 J

- 8 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.

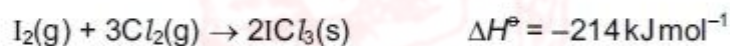


By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, ΔH_f° , for this reaction?

compound	$\Delta H_c^\circ / \text{kJ mol}^{-1}$
carbon	-394
hydrogen	-286
butane	-2877

- A -5883 kJ mol⁻¹
- B -129 kJ mol⁻¹
- C +129 kJ mol⁻¹
- D +2197 kJ mol⁻¹

- 5 Given the following enthalpy changes,



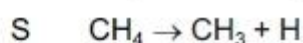
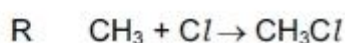
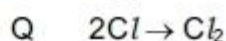
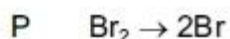
What is the standard enthalpy change of formation of iodine trichloride, $\text{ICl}_3\text{(s)}$?

- A +176 kJ mol⁻¹
- B -88 kJ mol⁻¹
- C -176 kJ mol⁻¹
- D -214 kJ mol⁻¹

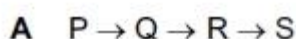
4 Some bond energy values are listed below.

bond	bond energy / kJ mol ⁻¹
C-H	410
C-Cl	340
Cl-Cl	244
Br-Br	193

These bond energy values relate to the following four reactions.



What is the order of enthalpy changes of these reactions from most negative to most positive?



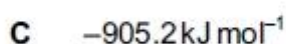
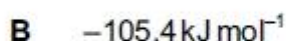
Topic **Chem 5 Q# 303**/ AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 The first stage in the industrial production of nitric acid from ammonia can be represented by the following equation.



Using the following standard enthalpy change of formation data, what is the value of the standard enthalpy change, ΔH° , for this reaction?

compound	$\Delta H_f^\circ / \text{kJ mol}^{-1}$
$\text{NH}_3(\text{g})$	-46.1
$\text{NO}(\text{g})$	+90.3
$\text{H}_2\text{O}(\text{g})$	-241.8

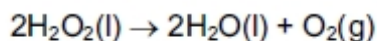


- 8** Hydrogen peroxide slowly decomposes into water and oxygen. The enthalpy change of reaction can be calculated using standard enthalpies of formation.

$$\Delta H_f^\circ(\text{hydrogen peroxide(l)}) = -187.8 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ(\text{water(l)}) = -285.8 \text{ kJ mol}^{-1}$$

Using a Hess cycle, what is the enthalpy change of reaction for this decomposition?



- A** +98 kJ mol⁻¹
- B** -98 kJ mol⁻¹
- C** -196 kJ mol⁻¹
- D** -947.2 kJ mol⁻¹

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33** For which reactions does the value of ΔH° represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

- 1** $\text{C(s)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$
- 2** $2\text{C(s)} + \text{O}_2(\text{g}) \rightarrow 2\text{CO(g)}$
- 3** $\text{CO(g)} + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$

- 12** Sodium dichromate(VI), $\text{Na}_2\text{Cr}_2\text{O}_7$, reacts with hydrogen peroxide, H_2O_2 , producing Cr^{3+} ions, water and oxygen.

What is the correctly balanced ionic equation for this reaction?

- A** $\text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ + \text{H}_2\text{O}_2 \rightarrow 2\text{Cr}^{3+} + 2\text{H}_2\text{O} + 4\text{O}_2$
- B** $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{H}_2\text{O}_2 \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{O}_2$
- C** $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 6\text{H}_2\text{O}_2 \rightarrow 2\text{Cr}^{3+} + 10\text{H}_2\text{O} + 6\text{O}_2$
- D** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 3\text{H}_2\text{O}_2 \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{O}_2$

- 11** Ammonium ions are converted into nitrate ions by bacteria.

What is the change in the oxidation number of nitrogen?

- A** -6
- B** +6
- C** +8
- D** +9



- 17** Solid sodium iodide reacts with concentrated sulfuric acid to form more than one product that contains sulfur.

What is the lowest oxidation number of sulfur in these products?

- A** -2 **B** 0 **C** +4 **D** +6

- 12** In the treatment of domestic water supplies, chlorine is added to water to kill bacteria. Some ClO^- ions are formed.

What is the change in oxidation number of chlorine when forming the ClO^- ion from aqueous chlorine?

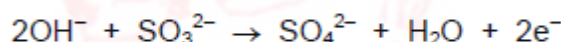
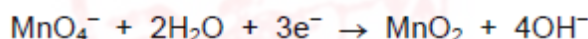
- A** -1 **B** 0 **C** +1 **D** +2

- 11** A student reacts 4 mol of ammonia with oxygen to produce an oxide of nitrogen and water only. Each nitrogen atom increases its oxidation state by 5 in the reaction.

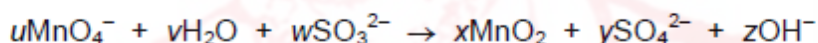
How many moles of oxygen gas react with 4 mol of ammonia in this reaction?

- A** 4 mol **B** 5 mol **C** 7 mol **D** 10 mol

- 10** Two half-equations are shown.



The equation for the reaction between manganate(VII) ions and sulfite ions is shown.



Which statements are correct?

- 1 $u = x = z$
- 2 Manganese is reduced to oxidation state +4.
- 3 Sulfur is oxidised from oxidation state +4 to +6.

- A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

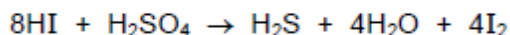
- 9** Zinc atoms can be oxidised to Zn^{2+} ions by dichromate(VI) ions in acid solution. Chromium is reduced to Cr^{3+} in this reaction.

Which equation is correct?

- A** $\text{Cr}_2\text{O}_7^{2-} + \text{Zn} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + \text{Zn}^{2+} + 7\text{H}_2\text{O}$
- B** $\text{Cr}_2\text{O}_7^{2-} + \text{Zn} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{Zn}^{2+} + 7\text{H}_2\text{O}$
- C** $\text{Cr}_2\text{O}_7^{2-} + 3\text{Zn} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{Zn}^{2+} + 7\text{H}_2\text{O}$
- D** $2\text{Cr}_2\text{O}_7^{2-} + 3\text{Zn} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{Zn}^{2+} + 7\text{H}_2\text{O}$



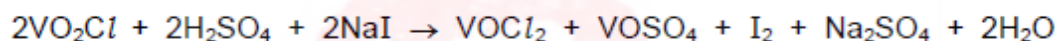
- 9** When hydrogen iodide is reacted with concentrated sulfuric acid, several reactions occur, including:



Which row gives the change in oxidation number of iodine and of sulfur in this reaction?

	change in oxidation number of iodine	change in oxidation number of sulfur
A	−1	+6
B	−1	+8
C	+1	−6
D	+1	−8

- 8** VO_2Cl reacts with NaI under acidic conditions.



The oxidation state of Cl is -1 in VO_2Cl and in VOCl_2 .

Which row about this reaction is correct?

	vanadium	iodine
A	is oxidised	is oxidised
B	is oxidised	is reduced
C	is reduced	is oxidised
D	is reduced	is reduced

- 9** The first stage in the chloride process for the manufacture of titanium consists of the following reaction.



What is reduced in this reaction?

- A** carbon
- B** chlorine
- C** oxygen
- D** titanium

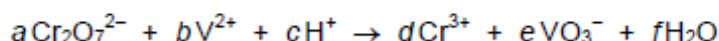


8 In which reaction does the greatest change in the oxidation number of sulfur occur?

- A $\text{S(s)} + \text{O}_2\text{(g)} \rightarrow \text{SO}_2\text{(g)}$
 B $\text{SO}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightleftharpoons \text{SO}_3\text{(g)}$
 C $\text{SO}_3\text{(g)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{H}_2\text{S}_2\text{O}_7\text{(l)}$
 D $\text{H}_2\text{S}_2\text{O}_7\text{(l)} + \text{H}_2\text{O(l)} \rightarrow 2\text{H}_2\text{SO}_4\text{(l)}$

8 In this question you should use changes in oxidation numbers to balance a chemical equation.

Acidified potassium dichromate(VI) solution can oxidise a solution of V^{2+} ions. The equation for this reaction is shown.



What is the ratio $a : b$ in the correctly balanced equation?

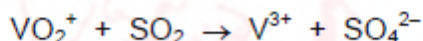
- A 1:1 B 1:2 C 2:1 D 4:1

2 Cobalt can form the positive ion $\text{Co}(\text{NH}_3)_4\text{Cl}_2^+$.

What is the oxidation number of cobalt in this ion?

- A +1 B +2 C +3 D +6

5 In the redox reaction shown, how do the oxidation states of vanadium and sulfur change?



	vanadium		sulfur	
	from	to	from	to
A	+1	+3	0	-2
B	+1	+3	+4	+6
C	+5	+3	0	-2
D	+5	+3	+4	+6

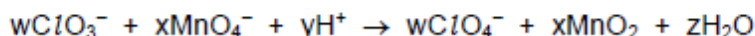
10 When the equation is correctly balanced, what is the value of c ?



- A 3 B 4 C 5 D 6



9 In the chemical equation, w, x, y and z are all whole numbers.



When the equation is balanced, what are w, x and y?

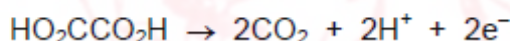
	w	x	y
A	1	1	2
B	2	2	2
C	2	3	8
D	3	2	2

6 What is the oxidation number of sulfur in each species?

	H ₂ S	SO ₂	H ₂ SO ₃
A	-2	+4	+4
B	-2	+4	+6
C	+2	-4	+4
D	+2	-4	+6

9 Ethanedioic acid, HO₂CCO₂H, can be oxidised by KMnO₄ in dilute sulfuric acid. The products of this reaction are carbon dioxide, water, potassium sulfate and manganese(II) sulfate.

In this reaction each ethanedioic acid molecule loses two electrons as it is oxidised. A half-equation for this process is shown.



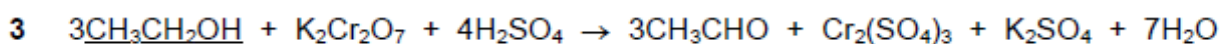
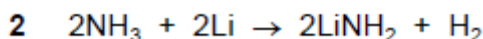
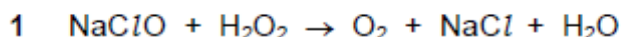
How many water molecules are produced when five ethanedioic acid molecules are oxidised by KMnO₄ in dilute sulfuric acid?

A 5 **B** 8 **C** 10 **D** 16

The responses **A** to **D** should be selected on the basis of

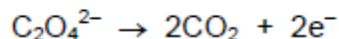
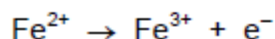
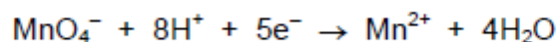
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 In which reactions is the underlined element or compound reduced?



10 Acidified potassium manganate(VII) reacts with iron(II) ethanedioate, FeC_2O_4 .

The reactions taking place are shown.



How many moles of iron(II) ethanedioate react with **one** mole of potassium manganate(VII)?

- A** 0.60 **B** 1.67 **C** 2.50 **D** 5.00

Topic **Chem 6 Q# 326/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

8 A transition metal ion, M^{2+} , reacts with acidified dichromate(VI) ions to form M^{4+} ions, Cr^{3+} ions, and H_2O .

Which equation correctly represents this reaction?

- A** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + \text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + \text{M}^{4+}$
B $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 2\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 2\text{M}^{4+}$
C $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 3\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{M}^{4+}$
D $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 6\text{M}^{4+}$

Topic **Chem 6 Q# 327/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 Nitric acid is known to take part in the oxidation of atmospheric sulfur dioxide. One possible reaction is shown.



Which row shows the correct changes in oxidation numbers of nitrogen and sulfur?

	nitrogen	sulfur
A	-3	+3
B	-2	+2
C	-2	+3
D	-1	+2



14 Chlorine reacts with **cold** aqueous sodium hydroxide to produce sodium chloride, water and compound X.

Chlorine reacts with **hot** aqueous sodium hydroxide to produce sodium chloride, water and compound Y.

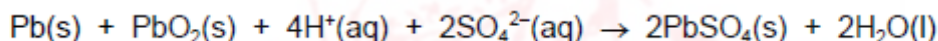
What are the oxidation states of chlorine in compound X and compound Y?

	X	Y
A	-1	-5
B	-1	+5
C	+1	-5
D	+1	+5

10 Which reaction is **not** a redox reaction?

- A** $\text{Mg} + 2\text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2$
- B** $2\text{Mg}(\text{NO}_3)_2 \rightarrow 2\text{MgO} + 4\text{NO}_2 + \text{O}_2$
- C** $\text{SO}_2 + \text{NO}_2 \rightarrow \text{SO}_3 + \text{NO}$
- D** $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

6 One of the reactions in a lead/acid cell is shown.



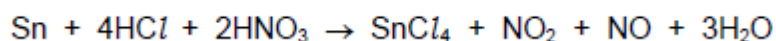
Which statement about this reaction is correct?

- A** Lead is both oxidised and reduced.
- B** Lead is neither oxidised nor reduced.
- C** Lead is oxidised only.
- D** Lead is reduced only.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33** One way of recovering tin from old printed circuit boards is to dissolve it in a mixture of concentrated hydrochloric acid and concentrated nitric acid. The tin dissolves because it reacts with the mixture of these concentrated acids.

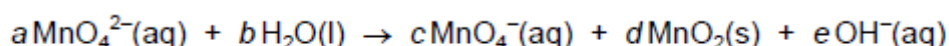


Which statements about this reaction are correct?

- 1 Nitrogen is present in three different oxidation states in the reactants and products.
- 2 The oxidation state of tin increases from 0 to +4.
- 3 The oxidation state of chlorine remains the same.

Topic **Chem 6 Q# 332/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

- 9** When K_2MnO_4 is dissolved in water, the following reaction occurs.



What are the values of a and c in the balanced chemical equation?

	a	c
A	2	1
B	3	2
C	4	3
D	5	4

Topic **Chem 6 Q# 333/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

- 17** When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

- A** Hydrogen sulfide is the product of a reduction reaction.
- B** Iodide ions are stronger oxidising agents than sulfate ions.
- C** Sulfur atoms from the sulfuric acid are both oxidised and reduced.
- D** Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

Topic **Chem 6 Q# 334/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



36 Sodium chloride and sodium iodide react with concentrated sulfuric acid.

Which statements are correct?

- 1 Sodium chloride is not oxidised by concentrated sulfuric acid.
- 2 No colour change is seen when concentrated sulfuric acid is added to sodium chloride.
- 3 Sodium iodide is oxidised by concentrated sulfuric acid.

Topic **Chem 6 Q# 335/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

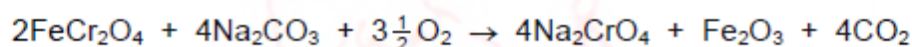
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Which of these statements are always correct?

- 1 The sum of the oxidation numbers of all the atoms in a compound is zero.
- 2 The oxidation number of sodium in a salt is positive.
- 3 The oxidation number of chlorine in a compound is negative.

Topic **Chem 6 Q# 336/** AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

- 9 Sodium chromate(VI), Na_2CrO_4 , is manufactured by heating chromite, FeCr_2O_4 , with sodium carbonate in an oxidising atmosphere. Chromite contains $\text{Cr}_2\text{O}_4^{2-}$ ions.



What happens in this reaction?

- A Chromium and iron are the only elements oxidised.
- B Chromium, iron and carbon are oxidised.
- C Only chromium is oxidised.
- D Only iron is oxidised.

Topic **Chem 6 Q# 337/** AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

- 3 The reaction between acidified dichromate(VI) ions, $\text{Cr}_2\text{O}_7^{2-}$, and aqueous Fe^{2+} ions results in the dichromate(VI) ions being reduced to Cr^{3+} ions.

What is the correct equation for this reaction?

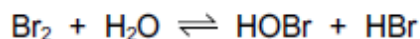
- A $\text{Cr}_2\text{O}_7^{2-} + \text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + \text{Fe}^{3+} + 7\text{H}_2\text{O}$
- B $\text{Cr}_2\text{O}_7^{2-} + 2\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 2\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- C $\text{Cr}_2\text{O}_7^{2-} + 3\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- D $\text{Cr}_2\text{O}_7^{2-} + 6\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Bromine reacts with water.



Which oxidation states of bromine are present in the equilibrium mixture?

1 +3

2 0

3 -1

Topic **Chem 6 Q# 339**/ AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 Which compound contains two different elements with identical oxidation states?

A HClO

B $\text{Mg}(\text{OH})_2$

C Na_2SO_4

D NH_4Cl

Topic **Chem 6 Q# 340**/ AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 The salt NaClO_3 is used as a non-selective weedkiller.

On careful heating, this reaction occurs: $4\text{NaClO}_3 \rightarrow \text{NaCl} + 3\text{NaClO}_4$.

On strong heating this reaction occurs: $\text{NaClO}_4 \rightarrow \text{NaCl} + 2\text{O}_2$.

The overall reaction is $2\text{NaClO}_3 \rightarrow 2\text{NaCl} + 3\text{O}_2$.

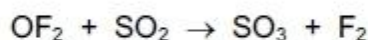
What do these equations show?

1 NaClO_3 can behave as an oxidising agent.

2 NaClO_3 can behave as a reducing agent.

3 The oxidation numbers of chlorine in the three compounds shown are +6, +8 and -1.

- 4 In oxygen difluoride, OF_2 , fluorine has an oxidation number of -1 . OF_2 will react with sulfur dioxide according to the following equation.



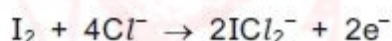
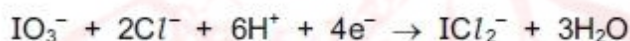
What is oxidised and what is reduced in this reaction?

	fluorine	oxygen in OF_2	sulfur
A	oxidised	oxidised	reduced
B	oxidised	reduced	oxidised
C	reduced	oxidised	reduced
D	reduced	reduced	oxidised

- 2 In which reaction does hydrogen behave as an oxidising agent?

- A** $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$
B $\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$
C $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
D $2\text{Na} + \text{H}_2 \rightarrow 2\text{NaH}$

- 3 The following half reactions occur when potassium iodate(V), KIO_3 , in hydrochloric acid solution oxidises iodine to ICl_2^- .



What is the ratio of IO_3^- to I_2 in the balanced chemical equation for the overall reaction?

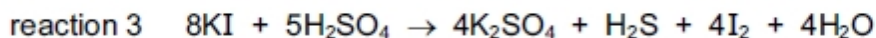
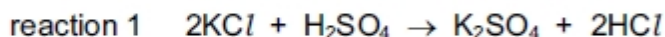
- A** 1:1 **B** 1:2 **C** 1:4 **D** 2:1

- 2 In which reaction does a single nitrogen atom have the greatest change in oxidation number?

- A** $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$
B $3\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3 + \text{NO}$
C $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$
D $4\text{NH}_3 + 6\text{NO} \rightarrow 5\text{N}_2 + 6\text{H}_2\text{O}$



16 Solid potassium halides react with concentrated sulfuric acid, according to the following equations.



What is the largest **change** in the oxidation number of sulfur in each of these reactions?

	reaction 1	reaction 2	reaction 3
A	0	0	4
B	0	2	4
C	0	2	8
D	0	4	8

Topic **Chem 6 Q# 346/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 11//www.SmashingScience.org :o)

11 A solution of Sn^{2+} ions will reduce an acidified solution of MnO_4^- ions to Mn^{2+} ions. The Sn^{2+} ions are oxidised to Sn^{4+} ions in this reaction.

How many moles of Mn^{2+} ions are formed when a solution containing 9.5 g of $SnCl_2$ (M_r : 190) is added to an excess of acidified $KMnO_4$ solution?

- A** 0.010 **B** 0.020 **C** 0.050 **D** 0.125

Topic **Chem 6 Q# 347/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 In which reaction does an element undergo the largest change in oxidation state?

- A** $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$
B $3Cl_2 + 6OH^- \rightarrow ClO_3^- + 5Cl^- + 3H_2O$
C $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$
D $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

Topic **Chem 6 Q# 348/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 The oxide of titanium, TiO_2 , is used as a 'whitener' in toothpaste. It is obtained from the ore iron(II) titanate, $FeTiO_3$.

What is the change, if any, in the oxidation number (oxidation state) of titanium in the reaction $FeTiO_3 \rightarrow TiO_2$?

- A** It is oxidised from +3 to +4.
B It is reduced from +3 to +2.
C It is reduced from +6 to +4.
D There is no change in the oxidation number.

2 Use of the Data Booklet is relevant to this question.

Lead(IV) chloride will oxidise bromide ions to bromine. The Pb^{4+} ions are reduced to Pb^{2+} ions in this reaction.

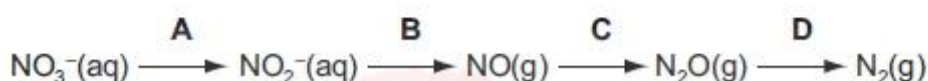
If 6.980 g of lead(IV) chloride is added to an excess of sodium bromide solution, what mass of bromine would be produced?

- A** 0.799g **B** 1.598g **C** 3.196g **D** 6.392g

Topic **Chem 6 Q# 350**/ AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?



Topic **Chem 6 Q# 351**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 4//www.SmashingScience.org :o)

4 Sulfur dioxide, SO_2 , is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2 , a sample of wine is titrated with iodine, I_2 . In this reaction, **one** mole of SO_2 is oxidised by **one** mole of I_2 .

What is the change in oxidation number of sulfur in this reaction?

- A** +2 to +4 **B** +2 to +6 **C** +4 to +5 **D** +4 to +6

Topic **Chem 6 Q# 352**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 Ammonium nitrate, NH_4NO_3 , can decompose explosively when heated.



What are the changes in the oxidation numbers of the two nitrogen atoms in NH_4NO_3 when this reaction proceeds?

- A** -2, -4 **B** +2, +6 **C** +4, -6 **D** +4, -4

Topic **Chem 6 Q# 353**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Sodium hydrosulfide, NaSH , is used to remove hair from animal hides.

Which statements about the SH^- ion are correct?

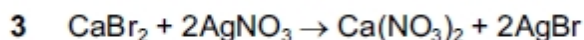
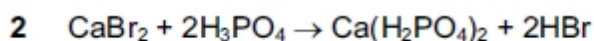
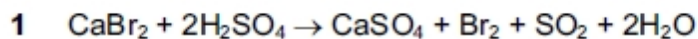
- 1 It contains 18 electrons.
- 2 Three lone pairs of electrons surround the sulfur atom.
- 3 Sulfur has an oxidation state of +2.



The responses **A** to **D** should be selected on the basis of

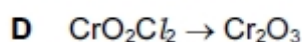
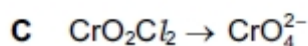
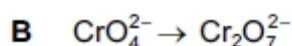
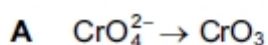
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which reactions are redox reactions?



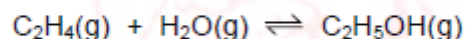
Topic **Chem 6 Q# 355**/ AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 Which conversion involves a reduction of chromium?



Topic **Chem 7 Q# 356**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 Ethanol is produced industrially by reacting ethene and steam.



K_p has a value of 1.8×10^{-5} and the partial pressures of the reactants at equilibrium are shown.

reactant	partial pressure /kPa
ethene	4.8×10^3
steam	2.8×10^3

Which row is correct?

	partial pressure of ethanol at equilibrium /kPa	units of K_p
A	2.42×10^2	kPa^{-1}
B	2.42×10^2	kPa
C	7.47×10^{11}	kPa^{-1}
D	7.47×10^{11}	kPa

13 In which equilibrium reaction is the position of equilibrium moved to the right-hand side by increasing the temperature and also by decreasing the pressure?

- A** $\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g}) \quad \Delta H = 40 \text{ kJ mol}^{-1}$
B $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) \quad \Delta H = 58 \text{ kJ mol}^{-1}$
C $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -197 \text{ kJ mol}^{-1}$
D $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g}) \quad \Delta H = -10 \text{ kJ mol}^{-1}$

14 SO_3 is manufactured from SO_2 and O_2 in the Contact process.

The reaction is exothermic.

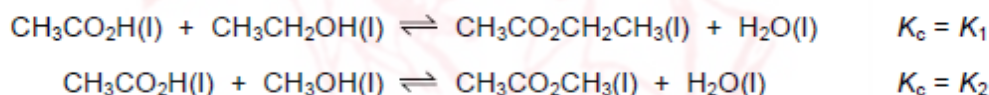
Which row shows the effect on the equilibrium yield obtained in the Contact process of increasing the temperature and of adding a vanadium(V) oxide catalyst?

	increasing the temperature	adding vanadium(V) oxide as catalyst
A	equilibrium yield decreases	equilibrium yield increases
B	equilibrium yield decreases	equilibrium yield unchanged
C	equilibrium yield increases	equilibrium yield unchanged
D	equilibrium yield increases	equilibrium yield increases

13 Ethanoic acid is mixed with ethanol.

The ethanol is contaminated with a small amount of methanol.

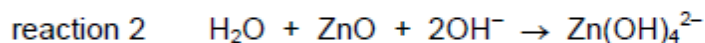
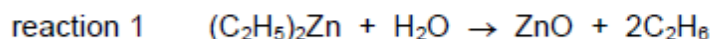
The following equilibria are established.



Which statement about the equilibrium mixture is correct?

- A** Only ethyl ethanoate will be formed because there is much more ethanol present than methanol.
B In this mixture $\frac{[\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3]}{[\text{CH}_3\text{CO}_2\text{CH}_3]} = \frac{K_1}{K_2}$.
C Adding water to the mixture will alter the mole ratio of the two esters.
D Adding methyl ethanoate to the mixture will increase the number of moles of ethyl ethanoate.

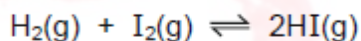
13 Diethylzinc, $(\text{C}_2\text{H}_5)_2\text{Zn}$, is added to $\text{NaOH}(\text{aq})$. Two reactions occur.



In these reactions, which compounds act as Brønsted–Lowry acids?

	reaction 1	reaction 2
A	$(\text{C}_2\text{H}_5)_2\text{Zn}$	H_2O
B	H_2O	H_2O
C	H_2O	ZnO
D	the reaction is not acid/base	ZnO

12 Hydrogen and iodine react to form hydrogen iodide in an exothermic reaction. The equation is shown.



A 1 m^3 reaction vessel contains H_2 , I_2 and HI gases at equilibrium. The temperature is changed such that the total pressure in the 1 m^3 vessel doubles.

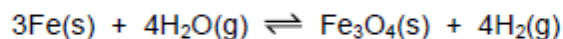
What is the effect on the value of K_p and on the position of equilibrium?

	effect on the value of K_p	effect on the position of equilibrium
A	decreases	moves left
B	increases	moves right
C	no change	moves left
D	no change	no change

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Iron reacts with steam to produce hydrogen and an oxide of iron.



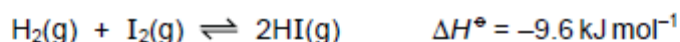
A system containing all four substances is at equilibrium.

Which changes will decrease the mass of Fe present at equilibrium?

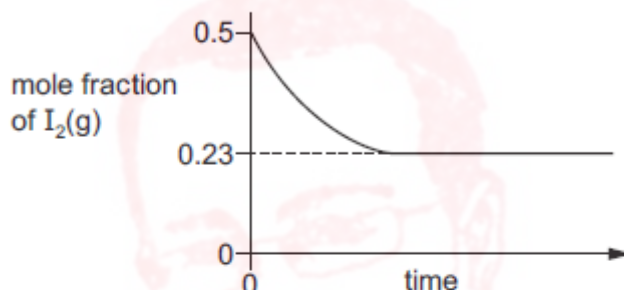
- 1 addition of steam at constant pressure
- 2 increase in overall pressure
- 3 addition of an effective catalyst

Topic **Chem 7 Q# 363**/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 The equation shows that $\text{H}_2\text{(g)}$ and $\text{I}_2\text{(g)}$ react to form an equilibrium mixture.

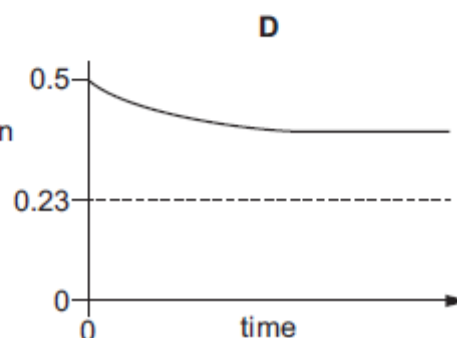
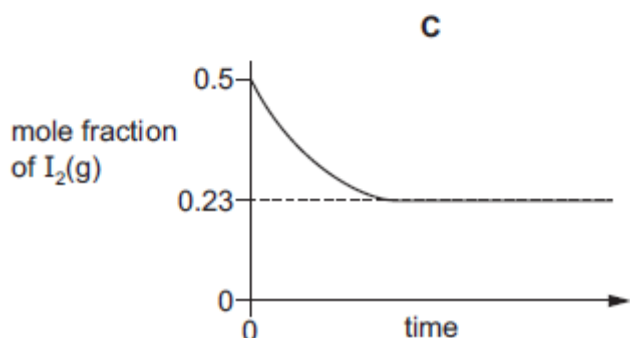
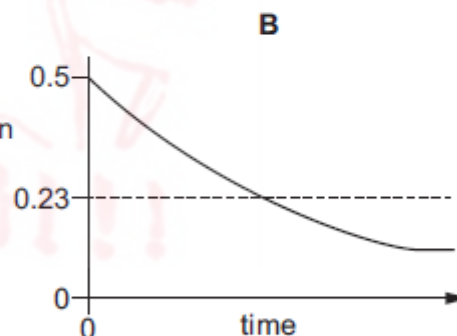
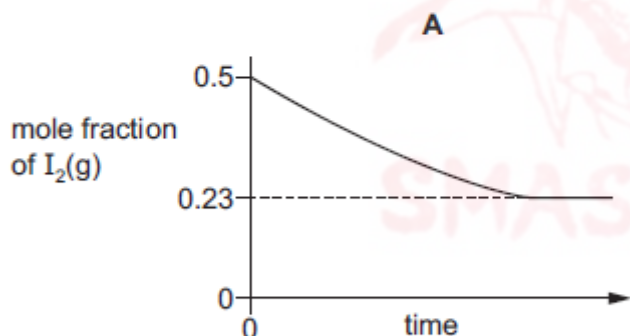


A mixture containing equal amounts of $\text{H}_2\text{(g)}$ and $\text{I}_2\text{(g)}$ is made at temperature T_1 and the composition of the mixture is monitored. A graph of the results is shown.



The experiment is repeated at a lower temperature, T_2 .

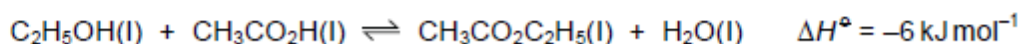
Which new graph would be obtained?



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Ethanol combines with ethanoic acid to form ethyl ethanoate according to the following reaction.



9.2g ethanol, 12g ethanoic acid and 8.8g ethyl ethanoate are mixed and allowed to stand at 298 K, until equilibrium is reached.

(M_r : $\text{C}_2\text{H}_5\text{OH}$, 46; $\text{CH}_3\text{CO}_2\text{H}$, 60; $\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5$, 88)

The resulting equilibrium mixture is found to contain 4.8g ethanoic acid.

The experiment is repeated at 323 K.

Which statements are correct?

- 1 There are 0.22 moles of ethyl ethanoate in the mixture at equilibrium at 298 K.
- 2 The equilibrium mixture at 323 K will contain more than 4.8 g of ethanoic acid.
- 3 If a small amount of water is added at the start of either experiment the value of K_c would not be affected.

Topic **Chem 7 Q# 365**/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 In which reaction is water behaving as a Brønsted–Lowry base?

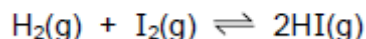
- A $\text{H}_2\text{O} + \text{Na} \rightarrow \text{NaOH} + \frac{1}{2}\text{H}_2$
- B $\text{H}_2\text{O} + \text{H}_3\text{PO}_4 \rightarrow \text{H}_3\text{O}^+ + \text{H}_2\text{PO}_4^-$
- C $\text{H}_2\text{O} + \text{CaO} \rightarrow \text{Ca}(\text{OH})_2$
- D $\text{NH}_3 + [\text{Cu}(\text{H}_2\text{O})_6]^{2+} \rightarrow \text{NH}_4^+ + [\text{Cu}(\text{H}_2\text{O})_5(\text{OH})]^+$

Topic **Chem 7 Q# 366**/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31 A sample of 17.15 mol HI(g) is in dynamic equilibrium with 2.27 mol H₂(g) and 2.84 mol I₂(g) in a volume of 1 m³ at 764 K and 141 kPa.



Two equilibrium constants, K_c and K_p , can be calculated for this mixture.

Which statements about the equilibrium constants for this mixture are correct?

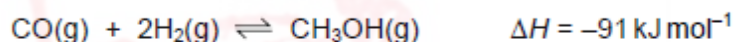
- 1 neither K_c nor K_p has any units
- 2 $K_c = 45.6$
- 3 $K_c > K_p$

Topic **Chem 7 Q# 367**/ AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34 Methanol, CH₃OH, can be produced industrially by reacting CO with H₂.



The process can be carried out at 4×10^3 kPa and 1150 K.

Which statements about this reaction are correct?

- 1 Increasing the temperature will increase the rate of reaction because more effective collisions will occur.
- 2 Lowering the temperature will reduce the rate of reaction because the forward reaction is exothermic.
- 3 Increasing the pressure will reduce the rate of reaction because there are a larger number of moles on the left-hand side of the equation.

Topic **Chem 7 Q# 368**/ AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

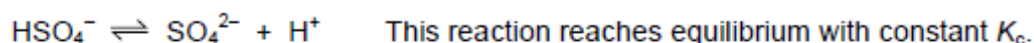
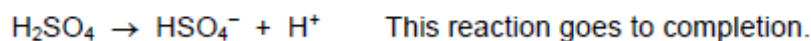
- 33 The units of K_c for an equilibrium reaction are mol⁻¹ dm³.

What could be the equation for the equilibrium?

- 1 $\text{A}(\text{aq}) + \text{B}(\text{aq}) \rightleftharpoons \text{C}(\text{s}) + \text{D}(\text{aq})$
- 2 $\text{P}(\text{aq}) + \text{Q}(\text{aq}) \rightleftharpoons \text{R}(\text{aq})$
- 3 $\text{W}(\text{aq}) + 2\text{X}(\text{aq}) \rightleftharpoons \text{Y}(\text{aq}) + \text{Z}(\text{aq})$



10 In aqueous solution, sulfuric acid dissociates as shown.



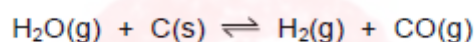
Analysis of a 2.00 mol dm^{-3} solution of H_2SO_4 found the HSO_4^- concentration to be $1.988 \text{ mol dm}^{-3}$.

What is K_c ?

- A $1.381 \times 10^5 \text{ dm}^3 \text{ mol}^{-1}$
- B $82.34 \text{ dm}^3 \text{ mol}^{-1}$
- C $1.214 \times 10^{-2} \text{ mol dm}^{-3}$
- D $7.244 \times 10^{-5} \text{ mol dm}^{-3}$

Topic **Chem 7 Q# 370**/ AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 What are the units of K_p for the reaction shown?



- A Pa^{-1}
- B Pa
- C Pa^2
- D no units

Topic **Chem 7 Q# 371**/ AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

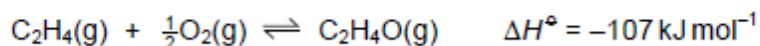
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 Carbon monoxide burns readily in oxygen to form carbon dioxide.

What does this information suggest?

- 1 The +4 oxidation state of carbon is more stable than the +2 state.
- 2 The standard enthalpy change of formation of carbon dioxide is more negative than the standard enthalpy change of formation of carbon monoxide.
- 3 The value of the equilibrium constant for the reaction, $2\text{CO(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{CO}_2\text{(g)}$, is likely to be high.

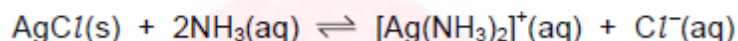
1 Ethene can be oxidised to form epoxyethane, C₂H₄O.



Which set of conditions gives the greatest yield of epoxyethane at equilibrium?

	pressure	temperature / °C
A	high	100
B	high	200
C	low	100
D	low	200

6 The equation for the reaction between silver chloride and aqueous ammonia is shown.



What are the units of K_c for this reaction?

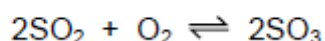
- A** no units **B** mol⁻¹ dm³ **C** mol dm⁻³ **D** mol² dm⁻⁶

15 Solid ammonium nitrate is put into a test-tube and solution X is added to it. The resulting mixture is warmed and the gas given off is tested with damp red litmus paper. The litmus paper changes colour from red to blue.

What could be the identity of X and its role in the reaction?

	identity of X	role of X
A	NaOH(aq)	proton donor
B	NaOH(aq)	proton acceptor
C	HCl(aq)	proton donor
D	HCl(aq)	proton acceptor

11 The main stage in the Contact process is an equilibrium reaction.



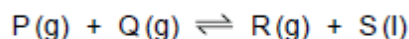
Which row describes the effect of the named condition on the equilibrium yield?

	presence of catalyst	high pressure	high temperature
A	no effect on yield	decreases yield	increases yield
B	no effect on yield	increases yield	decreases yield
C	increases yield	decreases yield	increases yield
D	increases yield	increases yield	decreases yield

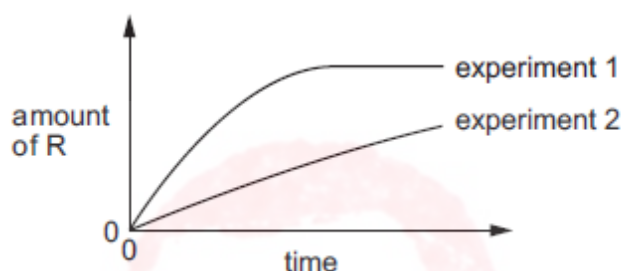
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 The stoichiometry of a catalysed reaction is shown by the equation below.



Two experiments are carried out in which the amount of R is measured. The results are shown in the diagram.



Which changes in the conditions could explain the results shown?

- 1 A lower pressure was used in experiment 2.
- 2 A different catalyst was used in experiment 2.
- 3 Product S was continuously removed from the reaction vessel in experiment 2.

Topic **Chem 7 Q# 377/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Which type of reaction occurs when solid ammonium sulfate is heated with an excess of sodium hydroxide solution?

- A** acid-base
- B** precipitation
- C** redox
- D** thermal decomposition

Topic **Chem 7 Q# 378/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 11//www.SmashingScience.org :o)

11 The reaction between sulfur dioxide and oxygen is reversible.



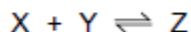
In an equilibrium mixture at 1000 K the sulfur dioxide concentration is $0.200 \text{ mol dm}^{-3}$ and the oxygen concentration is $0.100 \text{ mol dm}^{-3}$.

What is the sulfur trioxide concentration?

- A** $1.058 \text{ mol dm}^{-3}$
- B** $1.120 \text{ mol dm}^{-3}$
- C** $2.366 \text{ mol dm}^{-3}$
- D** $5.600 \text{ mol dm}^{-3}$

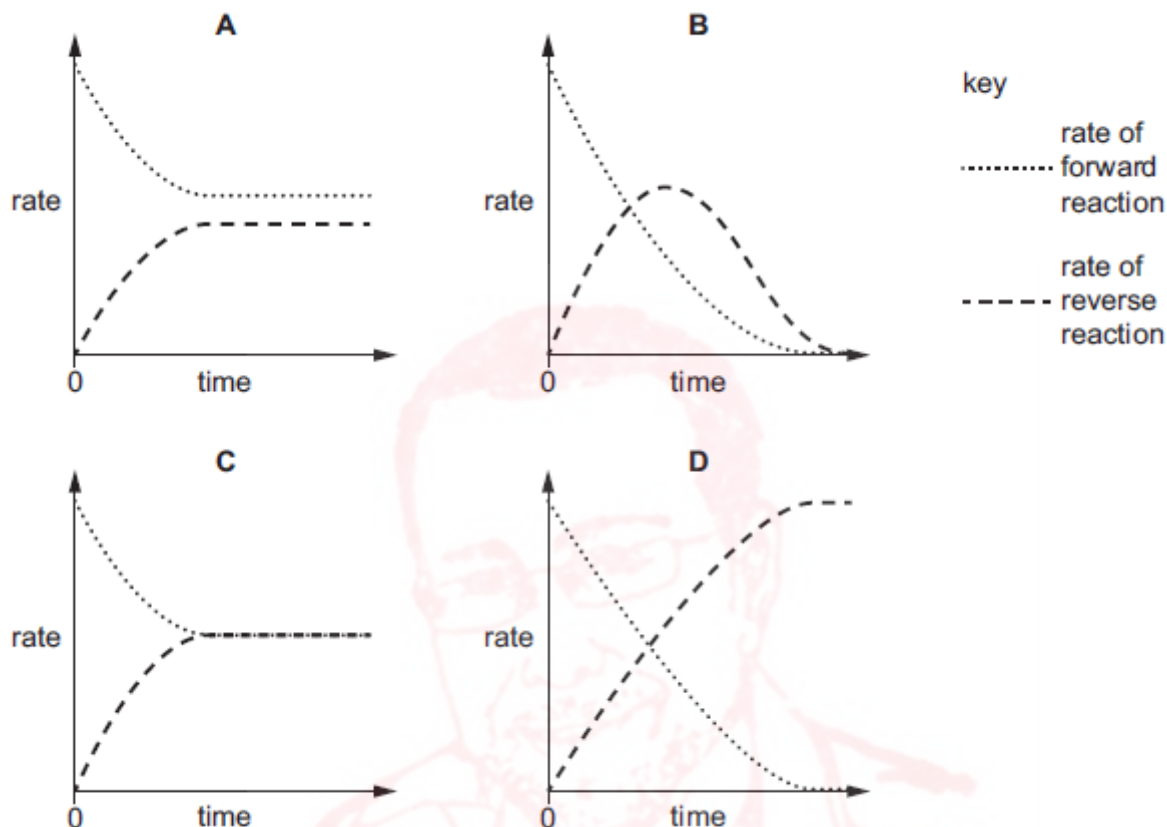


10 Two compounds X and Y react to produce compound Z. The reaction is reversible.



When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.

Which graph could represent the change in the rates of the forward and reverse reactions over time?



Topic **Chem 7 Q# 380**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 11//www.SmashingScience.org :o)

11 The reaction between sulfur dioxide and oxygen is reversible.



In an equilibrium mixture at 1000 K the sulfur trioxide concentration is 6.00 mol dm^{-3} .

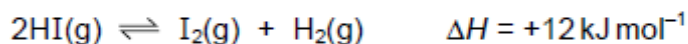
The sulfur dioxide concentration is twice the oxygen concentration.

What is the sulfur dioxide concentration?

- A $0.175 \text{ mol dm}^{-3}$
- B $0.254 \text{ mol dm}^{-3}$
- C $0.318 \text{ mol dm}^{-3}$
- D $0.636 \text{ mol dm}^{-3}$



10 Hydrogen iodide gas decomposes reversibly producing iodine vapour and hydrogen.

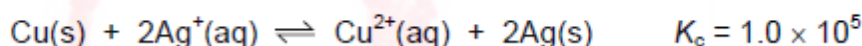


The position of the equilibrium for this reaction may be altered by changing the external conditions.

Which row correctly describes the change in position of equilibrium?

	effect of increasing the pressure	effect of increasing the temperature
A	moves to the right	moves to the right
B	moves to the right	moves to the left
C	no change	moves to the right
D	no change	moves to the left

11 When copper is added to a solution of silver ions, the following equilibrium is established.

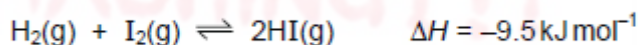


What is the concentration of silver ions at equilibrium when $[\text{Cu}^{2+}] = 0.10 \text{ mol dm}^{-3}$?

- A** $5.0 \times 10^{-7} \text{ mol dm}^{-3}$
- B** $5.0 \times 10^{-4} \text{ mol dm}^{-3}$
- C** $1.0 \times 10^{-3} \text{ mol dm}^{-3}$
- D** $1.0 \times 10^2 \text{ mol dm}^{-3}$

9 In this question you should assume that all gases behave ideally.

Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.

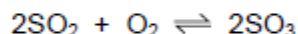


Which statement **must** be true for the K_p of this equilibrium to be constant?

- A** The partial pressures of H_2 , I_2 and HI are equal.
- B** The external pressure is constant.
- C** The forward and reverse reactions have stopped.
- D** The temperature is constant.



- 10** 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm³ sealed container. The gases are allowed to react until equilibrium is reached.



At equilibrium there is 0.100 mol of SO₃ in the container.

What is the value of K_c?

- A** 0.150 mol dm⁻³
- B** 0.800 mol dm⁻³
- C** 1.25 mol⁻¹ dm³
- D** 6.67 mol⁻¹ dm³

- 9** Oxidation numbers should be used to answer this question.

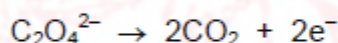
A redox reaction takes place between hydroxylammonium ions, [NH₃OH]⁺, and acidified iron(III) ions, Fe³⁺. The products are iron(II) ions, Fe²⁺, H⁺ ions, water and a compound of nitrogen.

The mole ratio of reacting hydroxylammonium ions to reacting iron(III) ions is 1 : 2.

Which nitrogen-containing compound could be formed in the reaction?

- A** NH₃
- B** N₂O
- C** NO
- D** NO₂

- 8** Ethanedioate ions, C₂O₄²⁻, react with a suitable reagent to form CO₂. A half-equation for this reaction is shown.



Which row is correct?

	oxidation state of carbon in C ₂ O ₄ ²⁻	type of reaction
A	+3	oxidation
B	+3	reduction
C	+5	oxidation
D	+5	reduction

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 Which statements are correct when a reversible reaction is at equilibrium?

- 1 All species are at equal concentration.
- 2 The concentrations of all species remain constant.
- 3 The rate of the forward reaction equals the rate of the reverse reaction.

Topic **Chem 7 Q# 388/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 One mole of sulfuric acid is used to make an aqueous solution. The solution contains H_2SO_4 molecules, H^+ ions, SO_4^{2-} ions and HSO_4^- ions.

Which statements are correct?

- 1 The solution contains 6.02×10^{23} sulfur atoms.
- 2 The solution contains an exactly equal number of H^+ ions and HSO_4^- ions.
- 3 One mole of SO_4^{2-} ions contains two moles of electrons.

Topic **Chem 7 Q# 389/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 In which reaction does ammonia behave as a Brønsted-Lowry base?

- A $\text{NH}_3 + \text{CH}_3\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{HBr}$
- B $\text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow (\text{NH}_4)\text{HCO}_3$
- C $2\text{NH}_3 + 2\text{Na} \rightarrow 2\text{NaNH}_2 + \text{H}_2$
- D $4\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O}$

Topic **Chem 7 Q# 390/** AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 Sodium hydroxide neutralises acid.



In a 11000dm^3 sample of an aqueous solution, the concentration of acid, $[\text{H}^+]$, is $1.26 \times 10^{-3}\text{mol dm}^{-3}$.

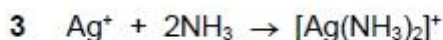
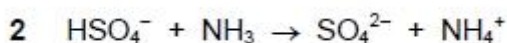
Which mass of solid sodium hydroxide neutralises the acid?

- A 0.0214g B 0.0504g C 236g D 554g

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 In which reactions does NH_3 behave as a Brønsted-Lowry acid?



Topic **Chem 7 Q# 392**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Ammonia and chlorine react together in the gas phase.



Which statements are correct?

- 1** Ammonia behaves as a reducing agent.
- 2** Ammonia behaves as a base.
- 3** The oxidation number of hydrogen changes.

Topic **Chem 7 Q# 393**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 Which statement about the effect of a catalyst on a reversible reaction is correct?

- A** The activation energy of the forward reaction stays the same.
- B** The composition of the equilibrium mixture stays the same.
- C** The rate of the backward reaction stays the same.
- D** The value of the equilibrium constant changes.



11 The reaction between sulfur dioxide and oxygen is reversible.

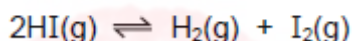


Which conditions of pressure and temperature favour the **reverse** reaction?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

Topic **Chem 7 Q# 395/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 9//

9 Hydrogen iodide dissociates into hydrogen and iodine.



In an experiment, b mol of hydrogen iodide were put into a sealed vessel at pressure p . At equilibrium, x mol of the hydrogen iodide had dissociated.

Which expression for K_p is correct?

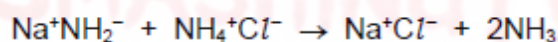
A $\frac{x^2}{(b-x)^2}$
 B $\frac{x^2 p^2}{(b-x)^2}$
 C $\frac{x^2 p^2}{4b(b-x)}$
 D $\frac{x^2}{4(b-x)^2}$

Topic **Chem 7 Q# 396/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 34//

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 The following reaction takes place in a suitable solvent.

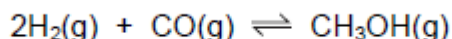


Which statements explain why this reaction should be classified as a Brønsted-Lowry acid-base reaction?

- 1 The ammonium ion acts as a proton donor.
- 2 Na^+Cl^- is a salt.
- 3 Ammonia is a nucleophile.



10 Methanol can be produced from hydrogen and carbon monoxide.



What is the expression for K_p for this reaction?

A $K_p = \frac{(2p_{\text{H}_2})^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

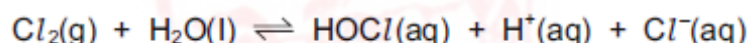
B $K_p = \frac{(p_{\text{H}_2})^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

C $K_p = \frac{p_{\text{CH}_3\text{OH}}}{(p_{\text{H}_2})^2 \times p_{\text{CO}}}$

D $K_p = \frac{p_{\text{CH}_3\text{OH}}}{p_{\text{CO}} \times (2p_{\text{H}_2})^2}$

8 $\text{HOCl}(\text{aq})$ is the molecule that kills bacteria when chlorine is added to water.

The following reaction produces this molecule.



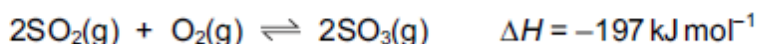
Which statement about this reaction is correct?

- A** Chlorine is both oxidised and reduced.
- B** Chlorine is oxidised but not reduced.
- C** Hydrogen is both oxidised and reduced.
- D** Hydrogen is oxidised but not reduced.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 Sulfur dioxide and oxygen react in the gas phase.



Which statements are correct?

- 1** Increasing the pressure increases the equilibrium yield of SO_3 .
- 2** Increasing the temperature lowers the value of the equilibrium constant K_p .
- 3** The presence of a vanadium(V) oxide catalyst increases the equilibrium yield of SO_3 .



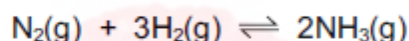
- 3 Two moles of compound P were placed in a sealed container. The container was heated and P was partially decomposed to produce Q and R only. A dynamic equilibrium between P, Q and R was established.

At equilibrium x moles of R were present and the total number of moles present was $\left(2 + \frac{x}{2}\right)$.

What is the equation for this reversible reaction?

- A $P \rightleftharpoons 2Q + R$
 B $2P \rightleftharpoons 2Q + R$
 C $2P \rightleftharpoons Q + R$
 D $2P \rightleftharpoons Q + 2R$

- 11 Ammonia is manufactured from nitrogen and hydrogen using the Haber process.



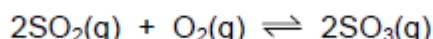
What is the expression for K_c for this equilibrium?

- A $\frac{2[NH_3(g)]}{[N_2(g)] + 3[H_2(g)]}$
 B $\frac{2[NH_3(g)]}{[N_2(g)] \times 3[H_2(g)]}$
 C $\frac{[NH_3(g)]^2}{[N_2(g)] + [H_2(g)]^3}$
 D $\frac{[NH_3(g)]^2}{[N_2(g)] \times [H_2(g)]^3}$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34 In the manufacture of sulfuric acid, the following exothermic reaction occurs.



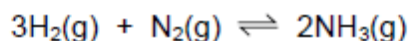
Which changes will move the position of the equilibrium to the right?

- increasing the pressure
- increasing the temperature
- using twice as much catalyst



10 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000



What is the numerical value of the equilibrium constant, K_p , for this reaction?

- A 4.46×10^{-9}
- B 4.76×10^{-5}
- C 7.14×10^{-5}
- D 2.24×10^8

Topic **Chem 7 Q# 404**/ AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 An aqueous solution was prepared containing a mixture of 1.0 mol of AgNO_3 and 1.0 mol of FeSO_4 in 1.00 dm^3 of water. When equilibrium was established, there was 0.44 mol of $\text{Ag}^+(\text{aq})$ in the mixture.



What is the numerical value of K_c ?

- A 0.62
- B 1.40
- C 1.62
- D 2.89

Topic **Chem 7 Q# 405**/ AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 A white powder is known to be a mixture of magnesium oxide and aluminium oxide.

100 cm^3 of 2 mol dm^{-3} $\text{NaOH}(\text{aq})$ is just sufficient to cause the aluminium oxide in x grams of the mixture to dissolve.

The reaction occurring is $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 3\text{H}_2\text{O} \rightarrow 2\text{Al}(\text{OH})_4^-$.

800 cm^3 of 2 mol dm^{-3} $\text{HCl}(\text{aq})$ is just sufficient to cause all of the oxide in x grams of the mixture to dissolve.

The reactions occurring are $\text{Al}_2\text{O}_3 + 6\text{H}^+ \rightarrow 2\text{Al}^{3+} + 3\text{H}_2\text{O}$
and $\text{MgO} + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2\text{O}$.

How many moles of each oxide are present in x grams of the mixture?

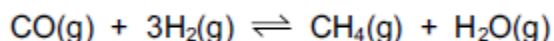
	aluminium oxide	magnesium oxide
A	0.05	0.25
B	0.05	0.50
C	0.10	0.25
D	0.10	0.50

17 A piece of rock has a mass of 2.00g. It contains calcium carbonate, but no other basic substances. It neutralises exactly 36.0 cm³ of 0.500 mol dm⁻³ hydrochloric acid.

What is the percentage of calcium carbonate in the 2.00g piece of rock?

- A** 22.5% **B** 45.0% **C** 72.0% **D** 90.1%

10 The equation for the reaction between carbon monoxide and hydrogen is shown.



What are the units of K_p for this reaction?

- A** kPa **B** kPa⁻¹ **C** kPa² **D** kPa⁻²

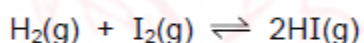
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Which statements about reversible reactions are correct?

- An increase in concentration of a reactant always increases the concentration of the product.
- An increase in temperature always increases the rate at which the equilibrium is established.
- An increase in temperature always increases the concentration of the product at equilibrium.

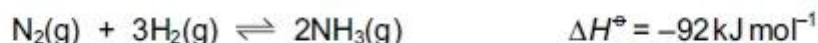
11 In an experiment, 2.00 mol of hydrogen and 3.00 mol of iodine were heated together in a sealed container and allowed to reach equilibrium at a fixed temperature. The container had a fixed volume of 1.00 dm³. At equilibrium, there were 2.40 mol of iodine present in the mixture.



What is the value of the equilibrium constant, K_c ?

- A** 0.107 **B** 0.357 **C** 0.429 **D** 2.33

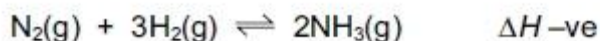
2 Which set of conditions gives the highest yield of ammonia at equilibrium?



	catalyst	pressure	temperature
A	absent	high	low
B	absent	low	high
C	present	high	high
D	present	low	low



11 Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.

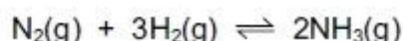


What will increase the rate of the forward reaction?

- A adding argon to the mixture but keeping the total volume constant
- B decreasing the temperature
- C increasing the total pressure by reducing the total volume at constant temperature
- D removing ammonia as it is made but keeping the total volume of the mixture the same

Topic **Chem 7 Q# 412**/ AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 A mixture of nitrogen and hydrogen gases, at a temperature of 500K, was put into an evacuated vessel of volume 6.0 dm^3 . The vessel was then sealed.



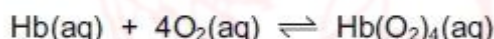
The mixture was allowed to reach equilibrium. It was found that 7.2mol of N_2 and 12.0 mol of H_2 were present in the equilibrium mixture. The value of the equilibrium constant, K_c , for this equilibrium is 6.0×10^{-2} at 500 K.

What is the concentration of ammonia present in the equilibrium mixture at 500K?

- A 0.58 mol dm^{-3}
- B 0.76 mol dm^{-3}
- C 3.5 mol dm^{-3}
- D 27 mol dm^{-3}

Topic **Chem 7 Q# 413**/ AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 One molecule of haemoglobin, Hb, can bind with four molecules of oxygen according to the following equation.



When the equilibrium concentration of O_2 is $7.6 \times 10^{-6} \text{ mol dm}^{-3}$, the equilibrium concentrations of Hb and $\text{Hb}(\text{O}_2)_4$ are equal.

What is the value of K_c for this equilibrium?

- A 3.0×10^{20}
- B 1.3×10^5
- C 7.6×10^{-6}
- D 3.3×10^{-21}

Topic **Chem 7 Q# 414**/ AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

8 In which reaction is the underlined substance acting as a base?

- A $\text{HNO}_3 + \underline{\text{H}_2\text{SO}_4} \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-$
- B $\text{HSiO}_3^- + \underline{\text{HCN}} \rightarrow \text{CN}^- + \text{H}_2\text{O} + \text{SiO}_2$
- C $\text{HNO}_2 + \underline{\text{HCO}_3^-} \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{NO}_2^-$
- D $\text{C}_6\text{H}_5\text{O}^- + \underline{\text{CH}_2\text{ClCO}_2\text{H}} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{CH}_2\text{ClCO}_2^-$



- 6 One mole of phosphorus(V) chloride, PCl_5 , is heated to 600 K in a sealed flask of volume 1 dm^3 . Equilibrium is established and measurements are taken.



The experiment is repeated with one mole of phosphorus(V) chloride heated to 600 K in a sealed flask of volume 2 dm^3 .

How will the measurements vary?

- A The equilibrium concentrations of $\text{PCl}_3(\text{g})$ and $\text{Cl}_2(\text{g})$ are higher in the second experiment.
- B The equilibrium concentration of $\text{PCl}_5(\text{g})$ is lower in the second experiment.
- C The equilibrium concentrations of all three gases are the same in both experiments.
- D The value of the equilibrium constant is higher in the second experiment.

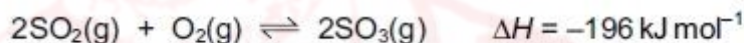
- 15 Use of the Data Booklet is relevant to this question.

A sample of potassium oxide, K_2O , is dissolved in 250 cm^3 of distilled water. 25.0 cm^3 of this solution is titrated against sulfuric acid of concentration 2.00 mol dm^{-3} . 15.0 cm^3 of this sulfuric acid is needed for complete neutralisation.

Which mass of potassium oxide was originally dissolved in 250 cm^3 of distilled water?

- A 2.83 g
- B 28.3 g
- C 47.1 g
- D 56.6 g

- 7 The Contact process is used in the manufacture of sulfuric acid. The equation for the main reaction is shown below.



Which statement about this reaction is **incorrect**?

- A Increased pressure gives a higher yield of SO_3 .
- B Increased temperature gives a higher yield of SO_3 .
- C In the forward reaction the oxidation state of sulfur changes from +4 to +6.
- D Vanadium(V) oxide is used as a catalyst.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



34 The Brønsted-Lowry theory describes acid and base character.

When concentrated sulfuric acid and concentrated nitric acid are mixed, the following reactions occur.



Which species are bases in these reactions?

1 HSO_4^-

2 HNO_3

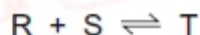
3 NO_2^+

Topic **Chem 7 Q# 419**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 R and S react together.



Which factors affect the rate of the forward reaction?

1 the activation energy of the reaction

2 the enthalpy change of the reaction

3 the equilibrium constant of the reaction

Topic **Chem 7 Q# 420**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Use of the Data Booklet is relevant to this question.

A chemist took 2.00 dm^3 of nitrogen gas, measured under room conditions, and reacted it with a large volume of hydrogen gas, in order to produce ammonia. Only 15.0% of the nitrogen gas reacted to produce ammonia.

What mass of ammonia was formed?

A 0.213g

B 0.425g

C 1.42g

D 2.83g

Topic **Chem 7 Q# 421**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 The equilibrium constant, K_c , for the reaction $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$, is 60 at 450°C .

What is the number of moles of hydrogen iodide in equilibrium with 2 mol of hydrogen and 0.3 mol of iodine at 450°C ?

A $\frac{1}{100}$

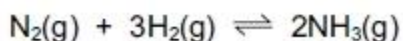
B $\frac{1}{10}$

C 6

D 36



9 Nitrogen reacts with hydrogen to produce ammonia.



A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen, and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm³ under certain conditions. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\frac{(1.76)^2}{(2.32)(6.96)^3}$

B $\frac{(1.76)^2}{(2.32)(6.32)^3}$

C $\frac{(2.08)^2}{(2.32)(6.32)^3}$

D $\frac{(2.40)^2}{(2.32)(6.00)^3}$

Topic **Chem 7 Q# 423/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 If N_2O_4 gas is placed in a sealed vessel the following equilibrium is established.



The forward reaction is endothermic.

What happens when the temperature is increased?

- 1** The equilibrium constant increases.
- 2** The partial pressure of NO_2 increases.
- 3** The activation energy is unchanged.

Topic **Chem 7 Q# 424/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



33 What are necessary properties of a dynamic equilibrium?

- 1 Equal amounts of reactants and products are present.
- 2 Concentrations of reactants and products remain constant.
- 3 The rate of the forward reaction is the same as the rate of the reverse reaction.

Topic **Chem 7 Q# 425/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Transition metals and their compounds are used as catalysts.

Which row is correct?

	transition metal present in the catalyst used in the Contact process	transition metal present in the catalyst used in the Haber process
A	iron	iron
B	iron	vanadium
C	vanadium	iron
D	vanadium	vanadium

Topic **Chem 7 Q# 426/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Sulfur trioxide is manufactured from sulfur dioxide and oxygen, using the Contact process.

Which condition affects the value of the equilibrium constant, K_c ?

- A adjusting the temperature
- B increasing the pressure
- C removing SO_3 from the equilibrium mixture
- D using a catalyst

Topic **Chem 7 Q# 427/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which equations represent stages in the Contact process for manufacturing sulfuric acid?

- 1 $\text{SO}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{SO}_3$
- 2 $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$
- 3 $\text{H}_2\text{SO}_3 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{SO}_4$



- 9 Two moles of compound P were placed in a vessel. The compound P was partly decomposed by heating. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium, x mol of R were present and the total number of moles present was (2 + x).

What is the equation for this equilibrium?

- A $P \rightleftharpoons 2Q + R$
 B $2P \rightleftharpoons 2Q + R$
 C $2P \rightleftharpoons Q + R$
 D $2P \rightleftharpoons Q + 2R$

Topic **Chem 7 Q# 429/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36 In the manufacture of sulfuric acid the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ usually takes place at 400 °C and 1 atm pressure. In one industrial plant, it is decided to change the pressure to 20 atm.

What will be the consequences of this change?

- 1 increased running costs
 2 an increased percentage of sulfur trioxide in the equilibrium mixture
 3 the rate of the backward reaction increases

Topic **Chem 7 Q# 430/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

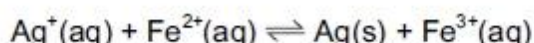
- 2 Ammonia is manufactured by the Haber Process, in an exothermic reaction.

Assuming that the amount of catalyst remains constant, which change will **not** bring about an increase in the rate of the forward reaction?

- A decreasing the size of the catalyst pieces
 B increasing the pressure
 C increasing the temperature
 D removing the ammonia as it is formed

Topic **Chem 7 Q# 431/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

- 9 An aqueous solution was prepared containing 1.0 mol of $AgNO_3$ and 1.0 mol of $FeSO_4$ in 1.00 dm³ of water. When equilibrium was established, there was 0.44 mol of $Ag^+(aq)$ in the mixture.



What is the numerical value of K_c ?

- A 0.35 B 0.62 C 1.62 D 2.89



8 Sulfur dioxide is used as a preservative in wine making.

The following equations describe how sulfur dioxide dissolves.

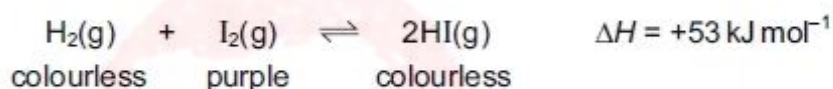


Which statement about these two reactions is correct?

- A HSO_3^- acts as a base.
- B SO_2 acts as an oxidising agent.
- C SO_3^{2-} acts as an acid.
- D SO_3^{2-} acts as a reducing agent.

Topic **Chem 7 Q# 433/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

10 When gaseous iodine is heated with hydrogen at 450 °C, an equilibrium is established.



Which change of conditions will cause the purple colour of the equilibrium mixture to become paler?

- A decrease in pressure
- B decrease in temperature
- C increase in pressure
- D increase in temperature

Topic **Chem 7 Q# 434/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

7 In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at pressures below 100 atm.

What is the reason for this change?

- A An iron catalyst is used.
- B Maintaining the higher pressures is more expensive.
- C The equilibrium yield of ammonia is increased at lower pressures.
- D The rate of the reaction is increased at lower pressures.

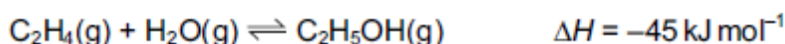
Topic **Chem 7 Q# 435/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



- 31 Ethanol is manufactured by reacting ethene gas and steam in the presence of phosphoric(V) acid.



The reaction is carried out at 570 K and 60 atm.

What would be the consequences of carrying out the reaction at the same temperature but at a pressure of 200 atm?

- 1 The manufacturing costs would increase.
- 2 The maximum yield at equilibrium would be higher.
- 3 The reaction would proceed at a faster rate.

Topic **Chem 7 Q# 436**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

- 10 The value of the equilibrium constant, K_c , for the reaction to form ethyl ethanoate from ethanol and ethanoic acid is 4.0 at 60 °C.



When 1.0 mol of ethanol and 1.0 mol of ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

- A $\frac{1}{3}$ B $\frac{2}{3}$ C $\frac{1}{4}$ D $\frac{3}{4}$

Topic **Chem 7 Q# 437**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 7//www.SmashingScience.org :o)

- 7 The Haber process for the manufacture of ammonia is represented by the following equation.

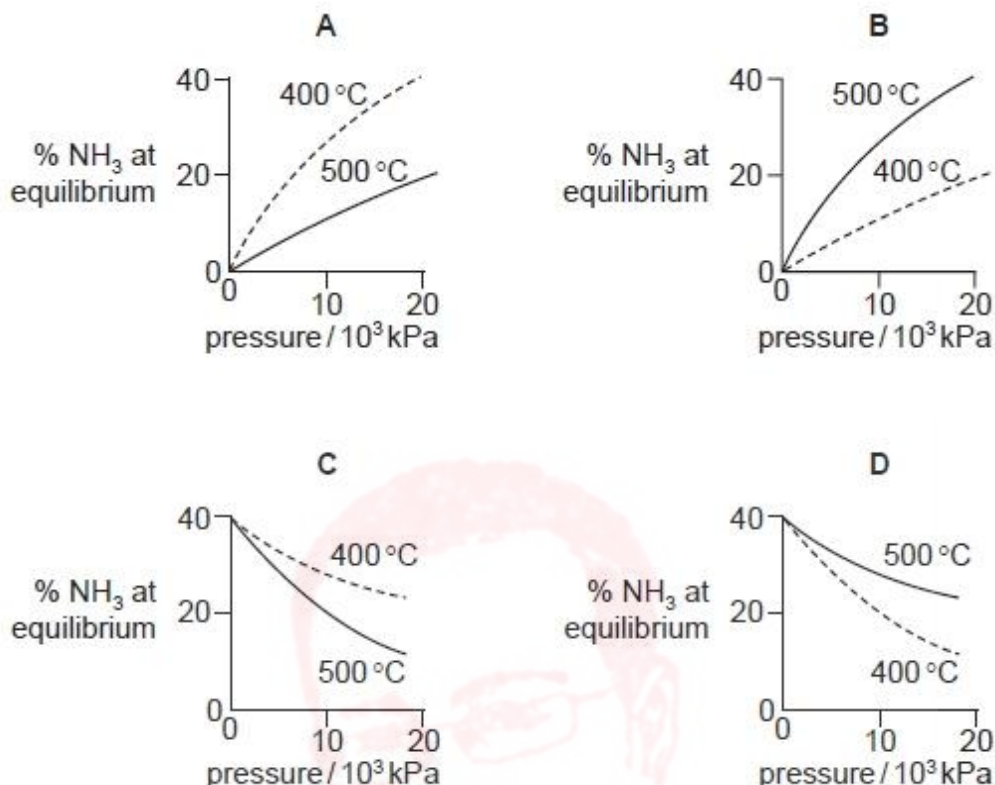


Which statement is correct about this reaction when the temperature is increased?

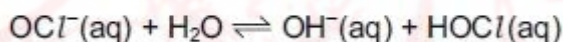
- A Both forward and backward rates increase.
- B The backward rate only increases.
- C The forward rate only increases.
- D There is no effect on the backward or forward rate.

- 15** The percentage of ammonia obtainable, if equilibrium were established during the Haber process, is plotted against the operating pressure for two temperatures, 400 °C and 500 °C.

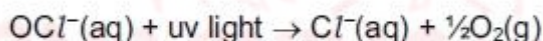
Which diagram correctly represents the two graphs?



- 11** Swimming pool water can be kept free of harmful bacteria by adding aqueous sodium chlorate(I), NaOCl. This reacts with water to produce HOCl molecules which kill bacteria.



In bright sunshine, the OCl^- ion is broken down by ultra-violet light.



Which method would maintain the highest concentration of $\text{HOCl}(\text{aq})$?

- A** acidify the pool water
- B** add a solution of chloride ions
- C** add a solution of hydroxide ions
- D** bubble air through the water

- 10** The table gives the concentrations and pH values of the aqueous solutions of two compounds, X and Y. Either compound could be an acid or a base.

	X	Y
concentration	2 mol dm^{-3}	2 mol dm^{-3}
pH	6	9

Student P concluded that X is a strong acid.

Student Q concluded that the extent of dissociation is lower in X(aq) than in Y(aq).

Which of the students are correct?

- A** both P and Q
- B** neither P nor Q
- C** P only
- D** Q only

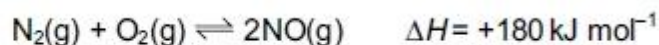
- 9** PCl_5 dissociates as follows.



The extent of dissociation is 13% at 160°C and 100% at 300°C .

Which pair of statements about this formation of PCl_3 is correct?

	shape of PCl_3 molecule	the reaction is
A	pyramidal	endothermic
B	pyramidal	exothermic
C	trigonal	endothermic
D	trigonal	exothermic

8 The equilibrium

contributes to a series of reactions producing photochemical smog.

Which factors would affect the value of K_p of the above equilibrium?

	change in pressure	change in temperature	presence or absence of a catalyst
A	✓	✓	x
B	✓	x	✓
C	x	✓	✓
D	x	✓	x

Topic **Chem 7 Q# 443/** AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 Which equilibria, in which all species are gaseous, would have equilibrium constants, K_p , with no units?

- 1** sulfur dioxide and oxygen in equilibrium with sulfur trioxide
- 2** hydrogen and iodine in equilibrium with hydrogen iodide
- 3** carbon monoxide and steam in equilibrium with carbon dioxide and hydrogen

Topic **Chem 7 Q# 444/** AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

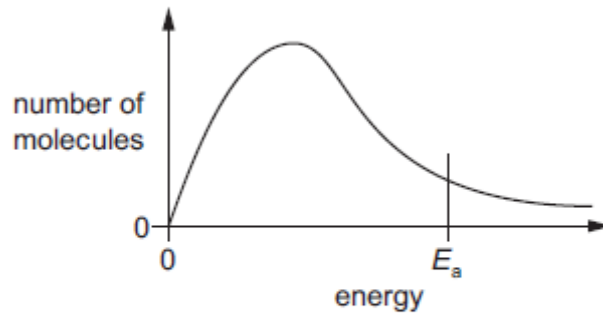
17 When sulfur trioxide is manufactured from sulfur dioxide and oxygen, using the Contact process, which condition affects the value of the equilibrium constant, K_c ?

- A** adjusting the temperature
- B** adjusting the pressure
- C** using a catalyst
- D** removing SO_3 from the equilibrium mixture



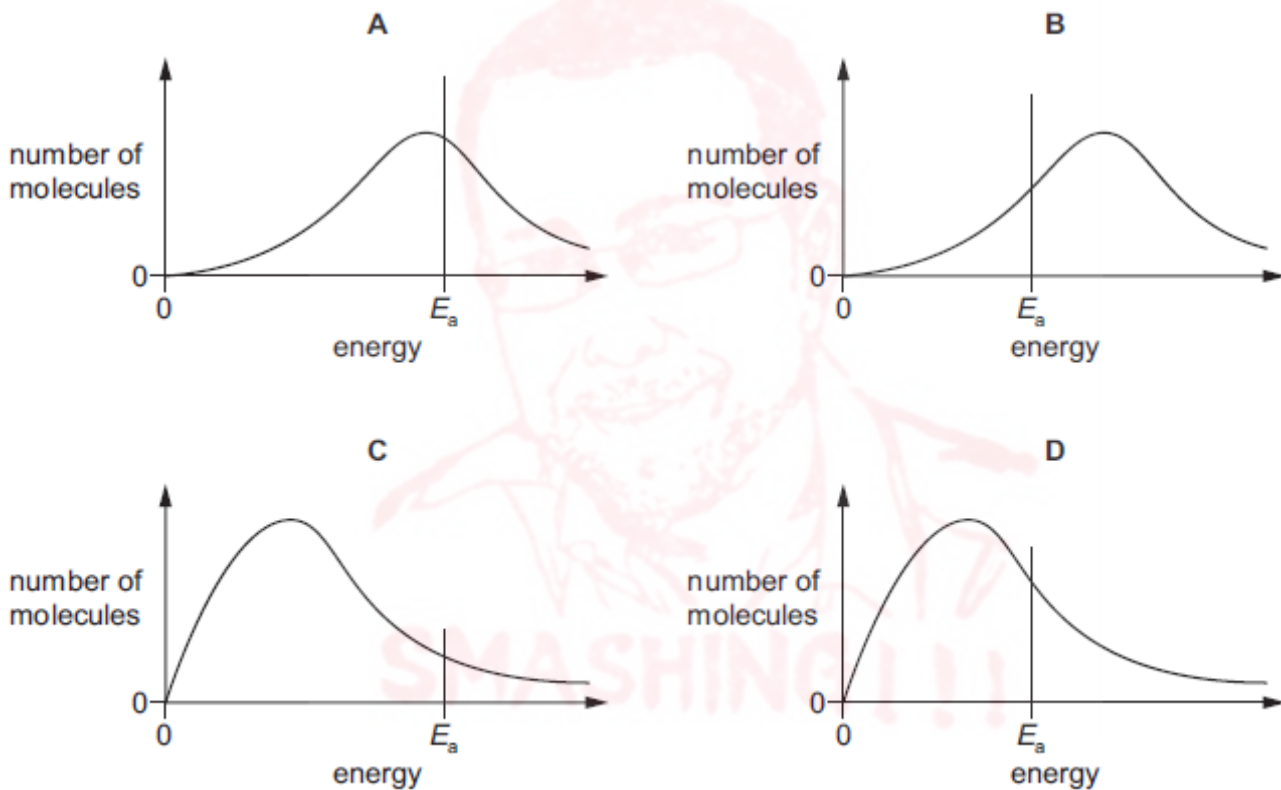
- :o)
- 16** Measurements are made to determine the activation energy, E_a , of a reaction.

The diagram shows E_a on the Boltzmann distribution at temperature T_1 .



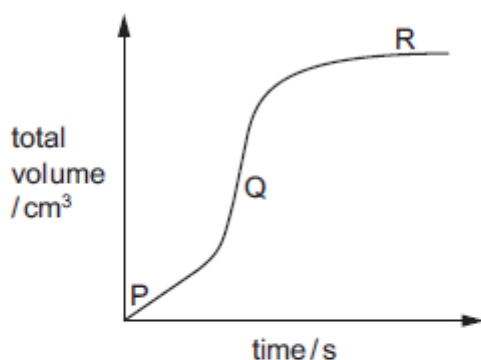
Measurements are then made at a higher temperature, T_2 .

Which diagram correctly shows the Boltzmann distribution and E_a at T_2 ?



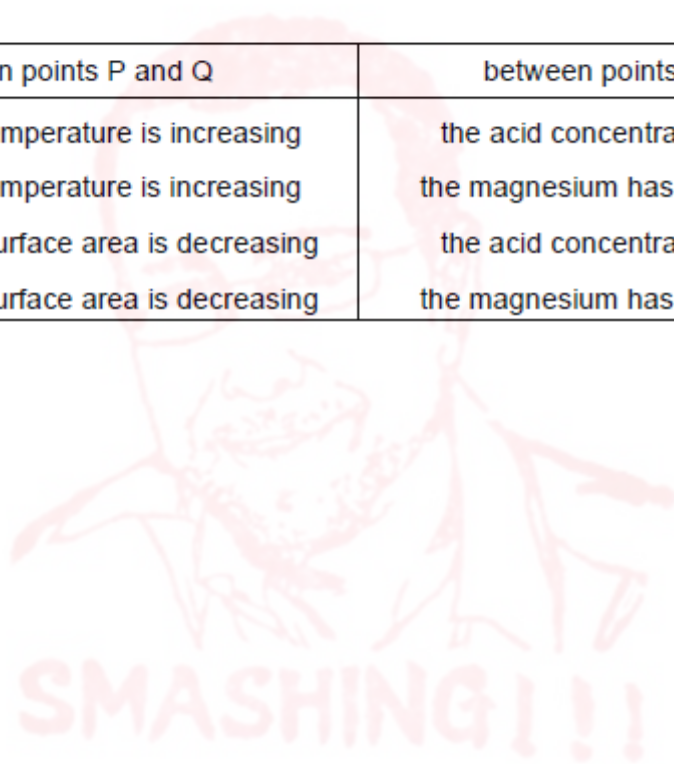
15 A large excess of magnesium ribbon is added to dilute hydrochloric acid and the volume of hydrogen gas produced is measured as the reaction proceeds. The reaction is exothermic.

The results are shown.

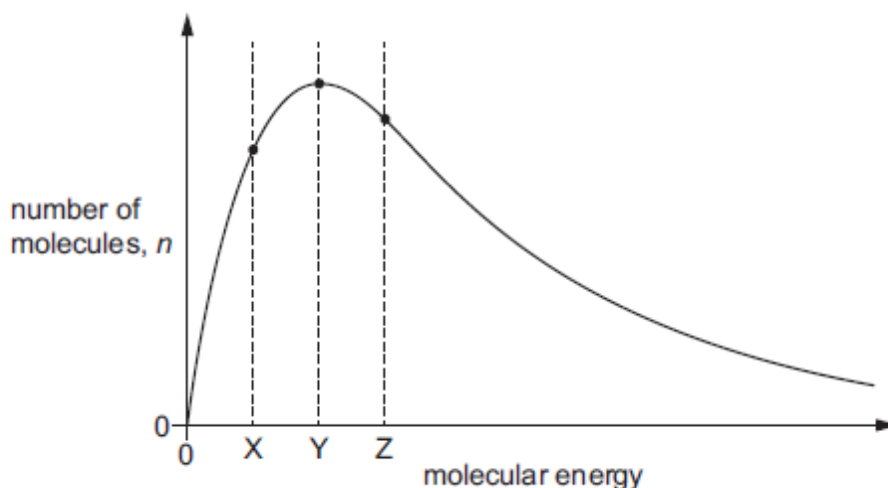


Which row explains the changes in the rate of reaction between points P and Q and between points Q and R?

	between points P and Q	between points Q and R
A	the reaction temperature is increasing	the acid concentration is falling
B	the reaction temperature is increasing	the magnesium has been used up
C	magnesium's surface area is decreasing	the acid concentration is falling
D	magnesium's surface area is decreasing	the magnesium has been used up



15 The Boltzmann distribution for a gas at a constant temperature of 50 °C is shown.

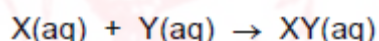


If the temperature of the gas is **reduced** by 10 °C, the graph changes shape.

What happens to the values of n for the molecular energies X, Y and Z?

	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

16 In the reaction shown, the concentrations of both X and Y are reduced to half of their original values whilst keeping the total volume of the solution constant.



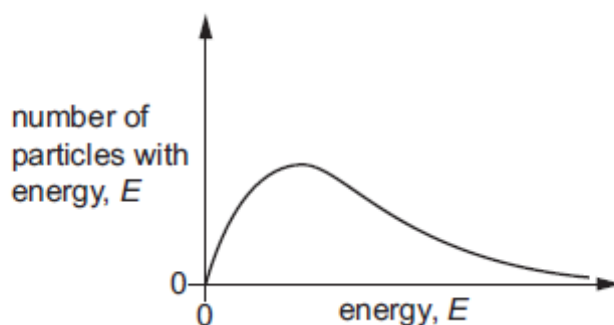
Simultaneously the temperature is increased from 298 K to 348 K.

Which prediction is definitely true?

- A** A smaller proportion of collisions between particles of X and particles of Y will be successful.
- B** The average kinetic energy of particles of X and particles of Y will increase.
- C** The rate of the reaction will be unaffected.
- D** The frequency of collisions between particles of X and particles of Y will halve.

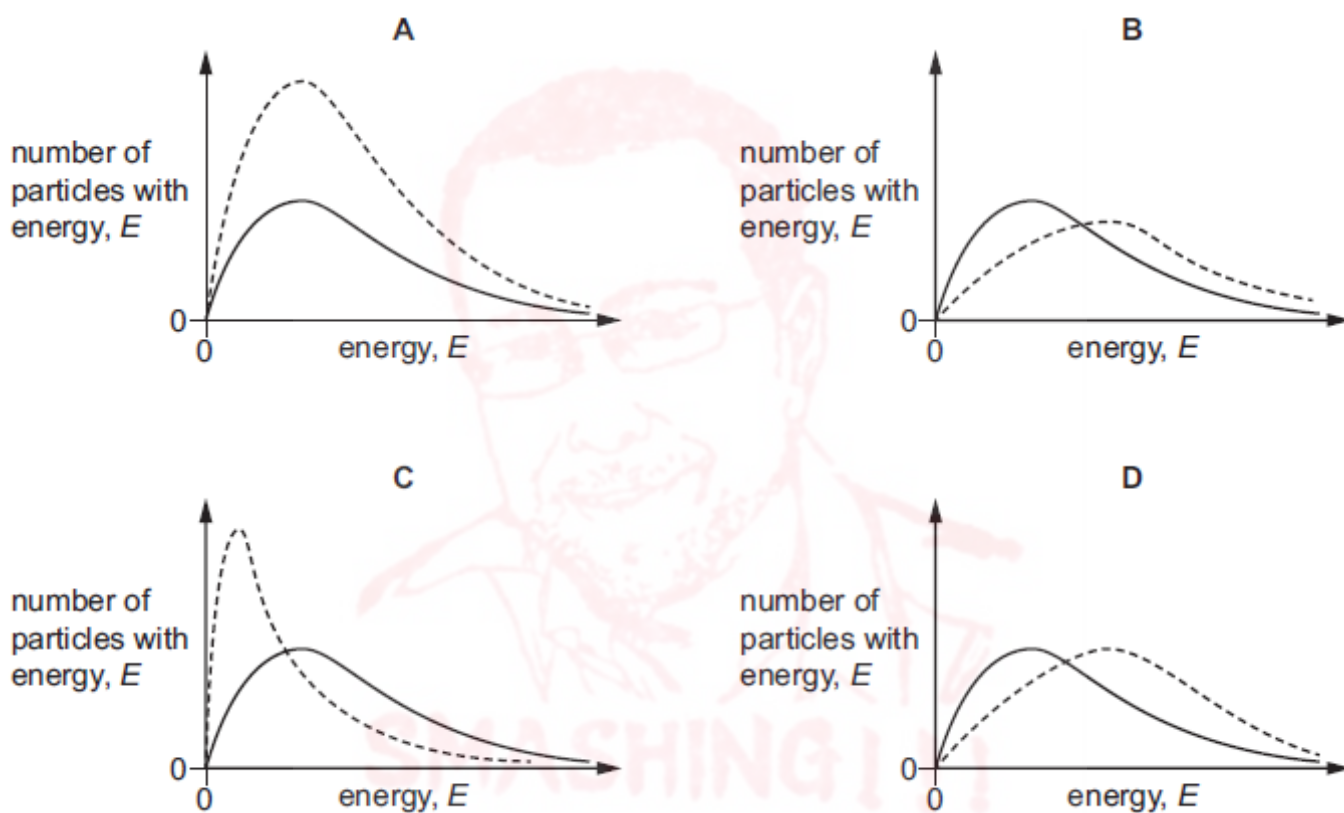


15 The Boltzmann distribution for one mole of a gas at temperature T is shown.



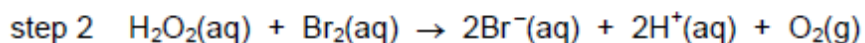
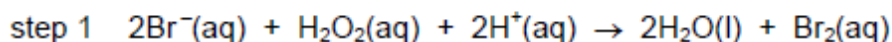
One mole of the same gas is added, and the gas remains at temperature T .

Which dotted curve shows the distribution with the added gas?



11 Hydrogen peroxide, H_2O_2 , decomposes to form water and oxygen.

The reaction is catalysed by bromide ions.



Which row is correct?

	type of catalyst	in step 1
A	heterogeneous	bromide ions are oxidised
B	heterogeneous	bromide ions are reduced
C	homogeneous	bromide ions are oxidised
D	homogeneous	bromide ions are reduced

Topic **Chem 8 Q# 451/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

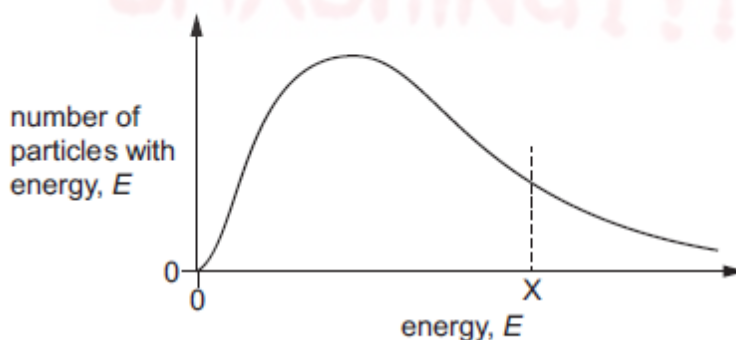
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Which changes can be used to measure the rates of chemical reactions?

- 1** the decrease in concentration of a reactant per unit time
- 2** the rate of appearance of a product
- 3** the increase in total volume of gas per unit time at constant pressure

Topic **Chem 8 Q# 452/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 11//www.SmashingScience.org :o)

11 The diagram shows the Boltzmann distribution of energies for a reactant gas. For a particular reaction, the activation energy is X .

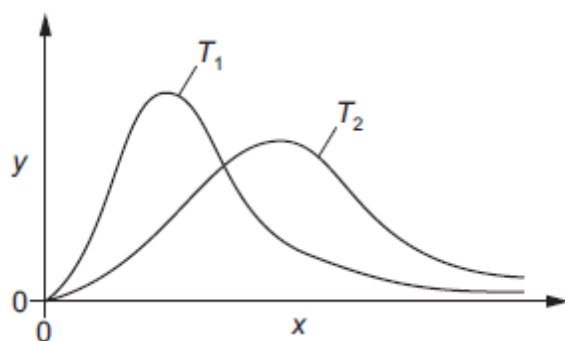


Which change to the diagram occurs if an effective catalyst is added at the same temperature?

- A** More particles will possess higher values of E .
- B** The peak will move to the left.
- C** The peak will move to the right.
- D** The value of the activation energy decreases.



- 5** The diagram shows the Boltzmann distribution for the same gas at two different temperatures, T_1 and T_2 .



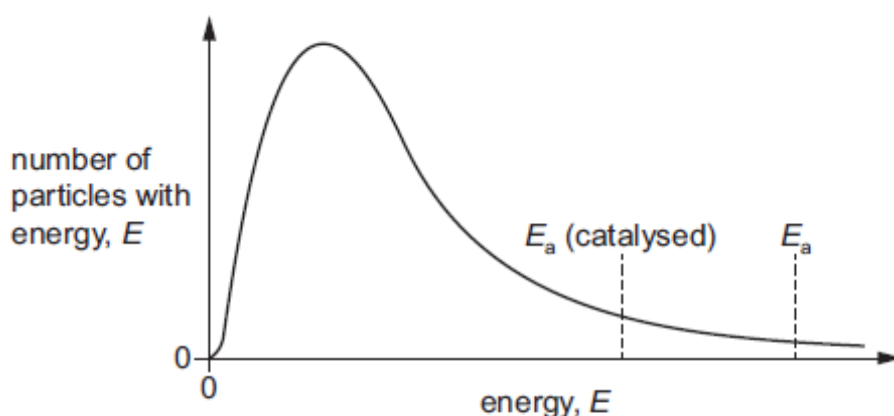
What is plotted on the y-axis and which line represents the higher temperature?

	plotted on y-axis	higher temperature
A	number of molecules	T_1
B	number of molecules	T_2
C	molecular energy	T_1
D	molecular energy	T_2

- 11** Which statement about catalysts is correct?

- A** They change the reaction pathway by increasing the activation energy.
- B** They increase the rate of reaction by lowering the enthalpy change of the reaction.
- C** They increase the number of particles that have sufficient energy to react.
- D** Heterogeneous catalysts are in the same state as the reactant.

- 11** The Boltzmann distribution curve for a gaseous mixture of ethene and hydrogen is shown. Nickel is an effective catalyst for the reaction that occurs.



How does the diagram appear if the same reaction mixture is at a higher temperature?

- A The curve is unchanged.
- B The values of both E_a (catalysed) and E_a decrease.
- C The values of both E_a (catalysed) and E_a increase.
- D The values of both E_a (catalysed) and E_a remain the same.

Topic **Chem 8 Q# 456/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 10//www.SmashingScience.org :o)

- 10** A large excess of marble chips is reacted with 25 cm^3 of 1.0 mol dm^{-3} hydrochloric acid at 40°C .

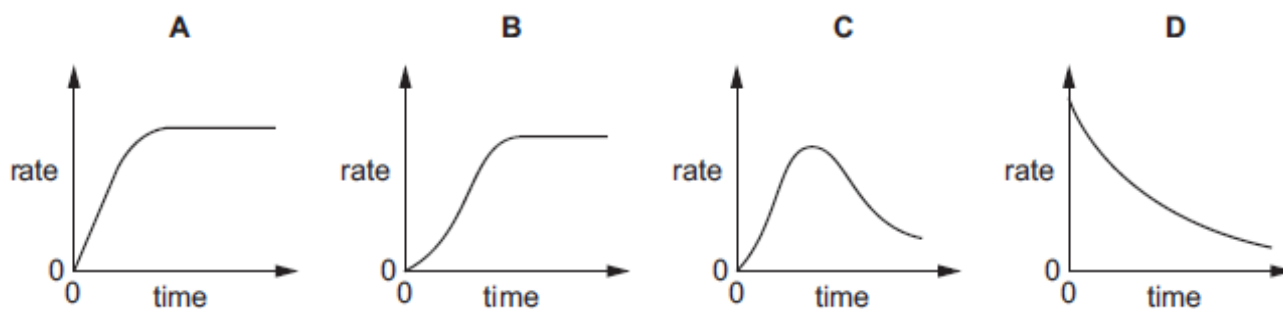
How is the result different when the reaction is repeated with 60 cm^3 of 0.5 mol dm^{-3} hydrochloric acid at 40°C ?

- A The reaction is faster and more of the products are made when the reaction is complete.
- B The reaction is faster and less of the products are made when the reaction is complete.
- C The reaction is slower and more of the products are made when the reaction is complete.
- D The reaction is slower and less of the products are made when the reaction is complete.

Topic **Chem 8 Q# 457/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 11//www.SmashingScience.org :o)

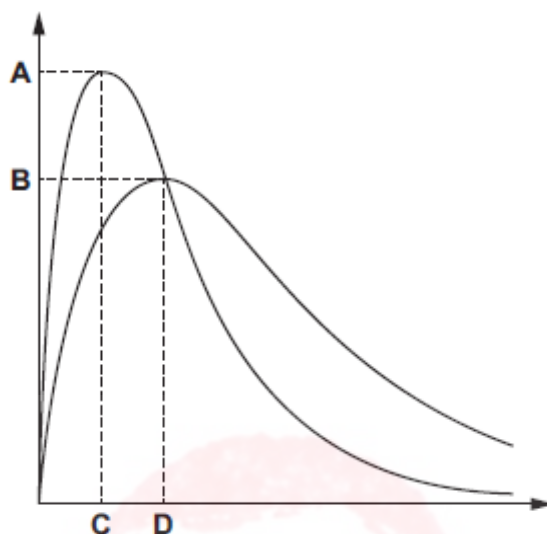
- 11** An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?



- 6** The diagram shows the Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.

Which letter on the axes represents the most probable energy for molecules of the same sample of gas at the **lower** temperature?



Topic **Chem 8 Q# 459/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

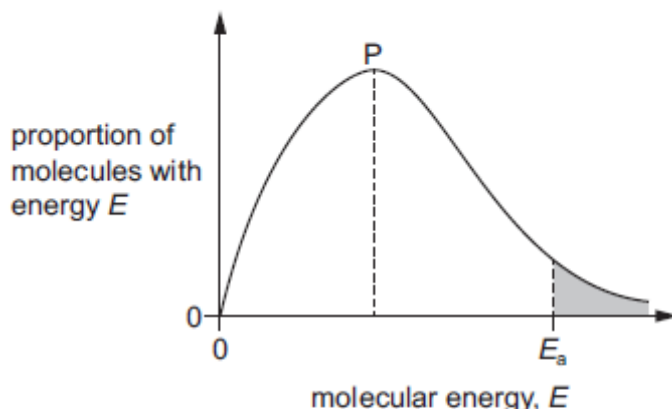
- 34** Hydrochloric acid reacts with zinc.



What will increase the rate of this reaction but will **not** change the Boltzmann distribution of molecular energies?

- 1 addition of a suitable catalyst
- 2 an increase in concentration of hydrochloric acid
- 3 an increase in temperature of hydrochloric acid

- 1 The diagram shows the Boltzmann distribution of energies in a gas. The gas undergoes a reaction with an activation energy, E_a . The peak of the distribution is labelled P.



If the same reaction is carried out in the presence of a catalyst, which statement is correct?

- A The peak P is at a lower height and the position of E_a moves to the left.
- B The peak P is at a lower height and the position of E_a moves to the right.
- C The peak P remains at the same height and the position of E_a moves to the left.
- D The peak P remains at the same height and the position of E_a moves to the right.

Topic **Chem 8 Q# 461**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

- 1 The temperature of a sample of an inert gas is increased.

What effect does this have on the number of molecules with the most probable energy and on the number of molecules with high energy?

	number of molecules with the most probable energy	number of molecules with high energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Topic **Chem 8 Q# 462**/ AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



34 Some polluting gases are removed from car exhaust fumes using a catalytic converter.

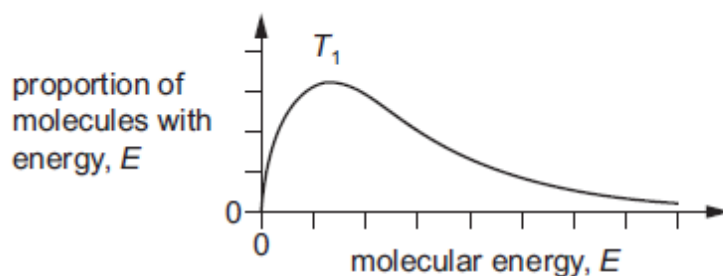
Platinum or palladium can be used as the catalyst. The reactions are faster when platinum is the catalyst than they are when palladium is the catalyst.

Which statements are correct?

- 1 Platinum acts as a heterogeneous catalyst in these reactions.
- 2 The palladium-catalysed reactions have higher activation energies than the platinum-catalysed reactions.
- 3 The platinum-catalysed reactions are more exothermic than the palladium-catalysed reactions.

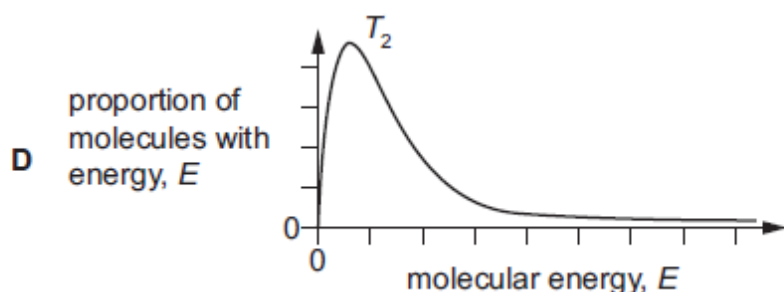
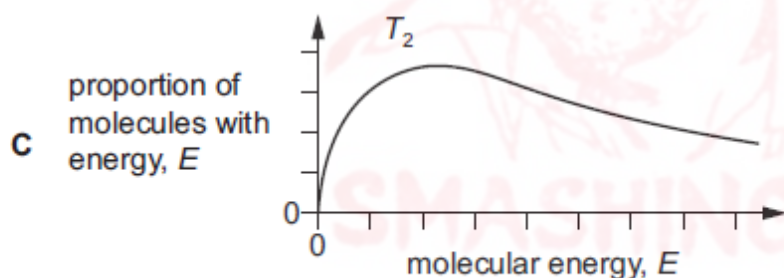
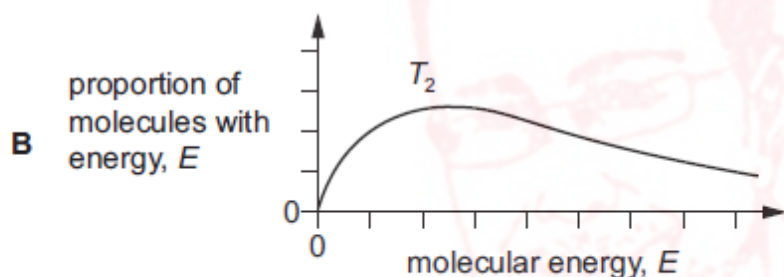
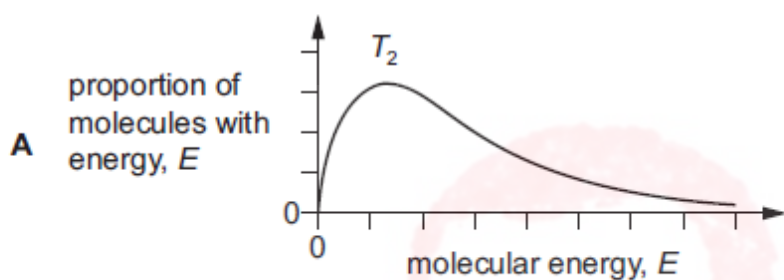


1 The Boltzmann distribution is shown for a sample of gas at an initial temperature, T_1 .



The sample of gas was heated to temperature, T_2 .

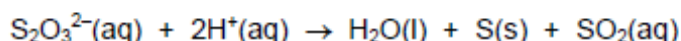
What is the correct distribution for the higher temperature, T_2 ?



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34** The factors affecting the rate of reaction between aqueous sodium thiosulfate and hydrochloric acid can be investigated. The ionic equation for the reaction is shown.

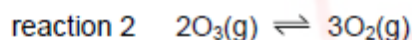
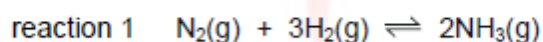


Which of the following can be used to investigate the rate of this reaction?

- 1** change of mass
- 2** change of appearance caused by formation of a precipitate
- 3** change of electrical conductivity

Topic **Chem 8 Q# 465**/ AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 11//www.SmashingScience.org :o)

- 11** Two reactions are shown.



In reaction 1, a finely powdered iron catalyst is used.

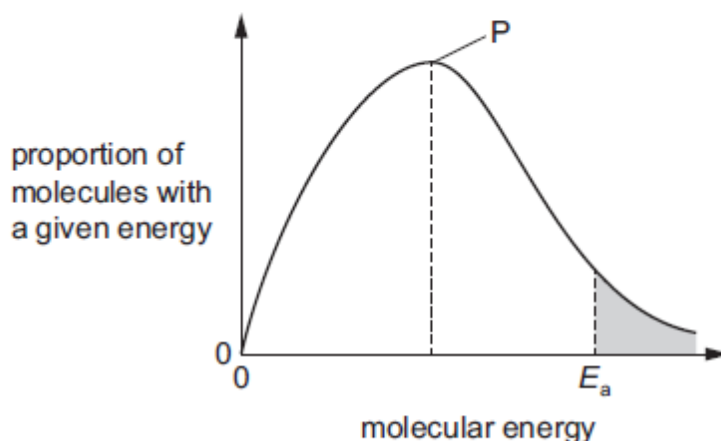
In reaction 2, a vaporised tetrachloromethane catalyst in ultraviolet light is used.

Which statement about the catalysts used is correct?

- A** Both reaction 1 and reaction 2 use a heterogeneous catalyst.
- B** Both reaction 1 and reaction 2 use a homogeneous catalyst.
- C** Reaction 1 uses a heterogeneous catalyst and reaction 2 uses a homogeneous catalyst.
- D** Reaction 1 uses a homogeneous catalyst and reaction 2 uses a heterogeneous catalyst.



- 4 The diagram shows the Boltzmann distribution of energies in a gas. The gas can take part in a reaction with an activation energy, E_a . The gas is maintained at a constant temperature.



Which statement is correct?

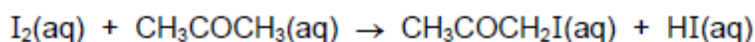
- A If a catalyst is added, peak P will be lower and E_a will move to the left.
- B If a catalyst is added, peak P will be lower and E_a will move to the right.
- C If a catalyst is added, peak P will be the same and E_a will move to the left.
- D If a catalyst is added, peak P will be the same and E_a will move to the right.

- 11 Hydrogen ions catalyse the hydrolysis of esters.

Which statement is correct?

- A The hydrogen ions act as a heterogeneous catalyst.
- B The hydrogen ions are in the same phase as the reactants.
- C The hydrogen ions are used up in the reaction.
- D The hydrogen ions have no effect on the activation energy of the reaction.

- 7 Iodine and propanone react according to the following equation.

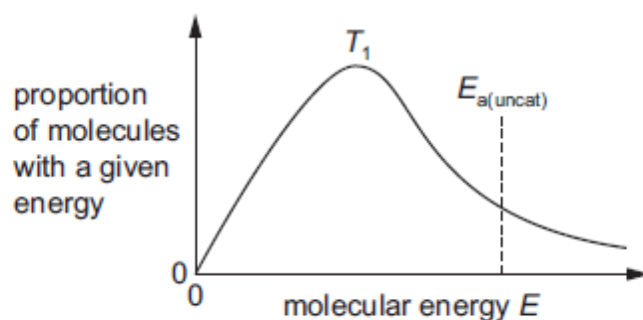


If the concentration of propanone is increased, keeping the total reaction volume constant, the rate of the reaction also increases.

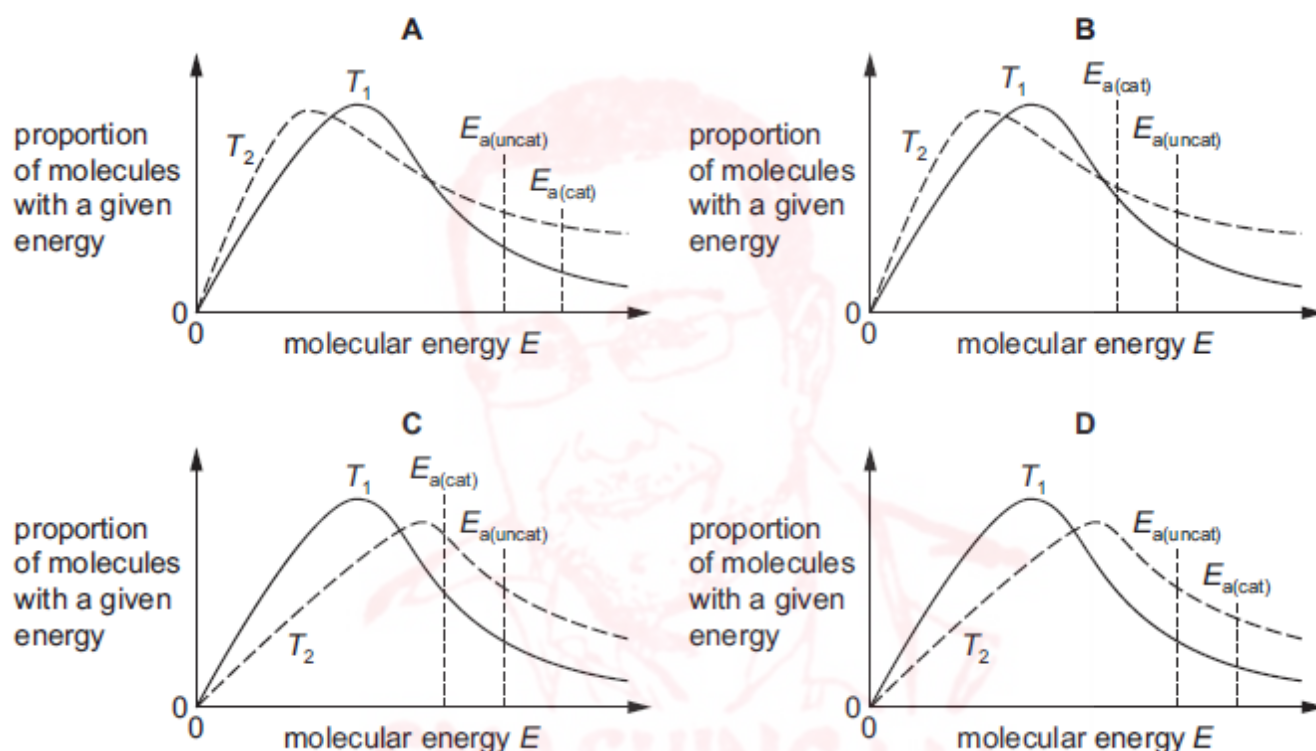
What could be the reason for this?

- A A greater proportion of collisions is successful at the higher concentration.
- B The particles are further apart at the higher concentration.
- C The particles have more energy at the higher concentration.
- D There are more collisions between reactant particles per second at the higher concentration.

- 10** The diagram shows the distribution of molecular energies in a sample of gas at a temperature T_1 . The activation energy for an uncatalysed reaction of this gas, $E_{a(\text{uncat})}$, is shown.



Which diagram correctly shows the new distribution and new activation energy, $E_{a(\text{cat})}$, when the temperature is increased to T_2 , and a catalyst is used that increases the rate of the reaction?



Topic **Chem 8 Q# 470/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34** Which changes can be used to measure the rates of chemical reactions?

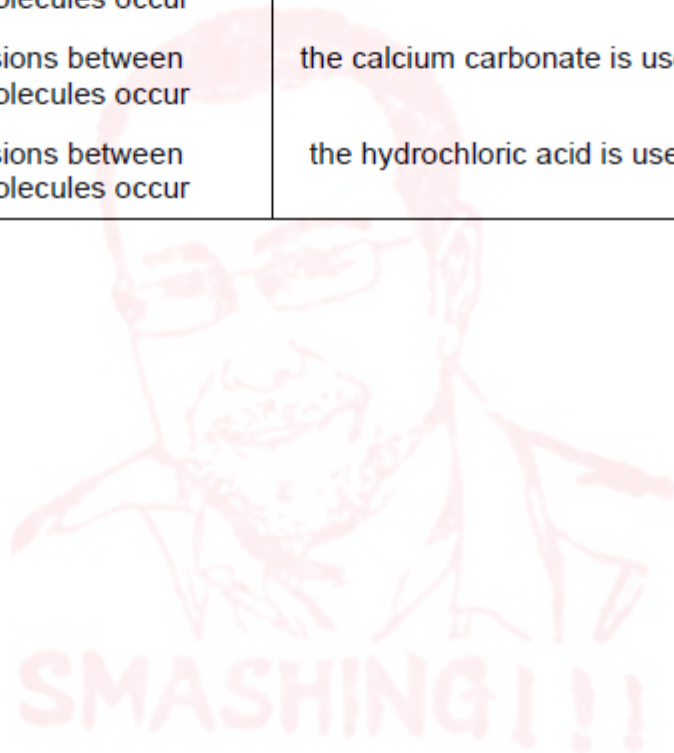
- 1 the decrease in concentration of a reactant per unit time
- 2 the rate of appearance of a product
- 3 the increase in total volume per unit time at constant pressure

11 When 4 g of powdered calcium carbonate, $M_r = 100$, were added to 100 cm^3 of 0.10 mol dm^{-3} hydrochloric acid the volume of carbon dioxide produced was recorded.

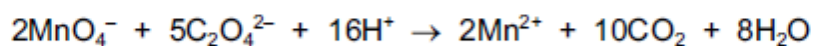
time / s	30	60	90	120	150	180	210	240
total volume of carbon dioxide given off / cm^3	40	70	88	101	110	116	120	120

Which row gives the correct explanations about these results?

	why the rate of the reaction changes with time	why the reaction stops
A	fewer collisions between reacting molecules occur	the calcium carbonate is used up
B	fewer collisions between reacting molecules occur	the hydrochloric acid is used up
C	more collisions between reacting molecules occur	the calcium carbonate is used up
D	more collisions between reacting molecules occur	the hydrochloric acid is used up

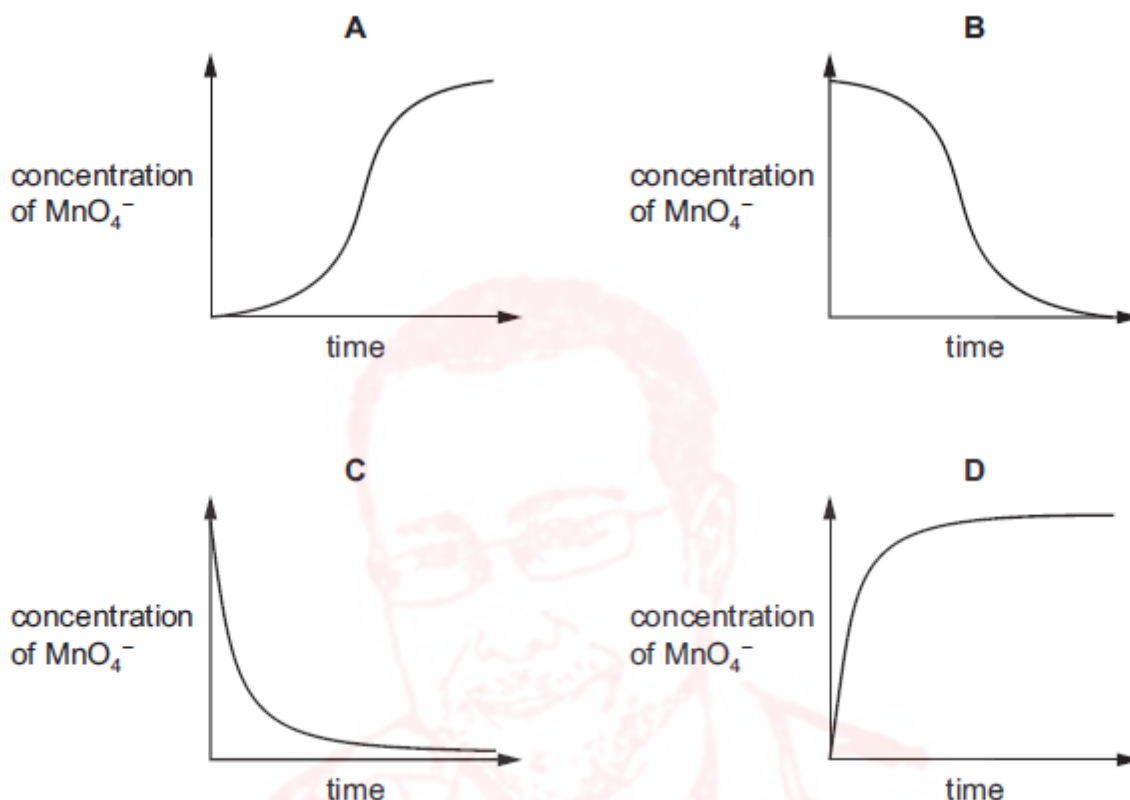


- 10** Oxidation of ethanedioate ions by acidified manganate(VII) ions is very slow at room temperature.



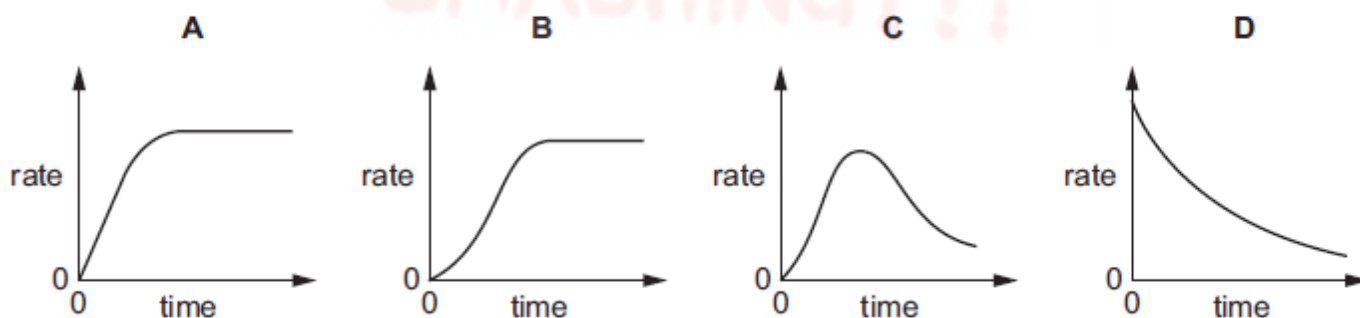
Mn^{2+} ions catalyse this reaction.

Which graph shows how the concentration of acidified manganate(VII) ions varies after ethanedioate ions are added?

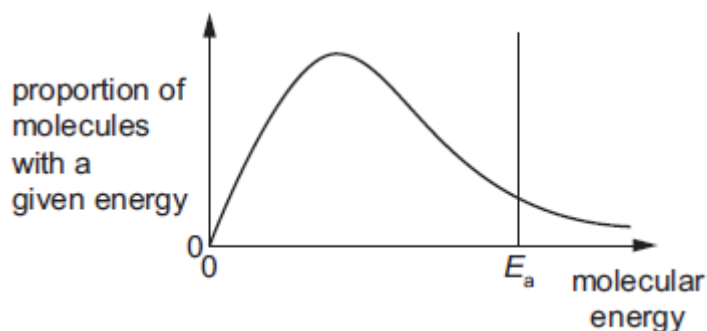


- 11** An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?

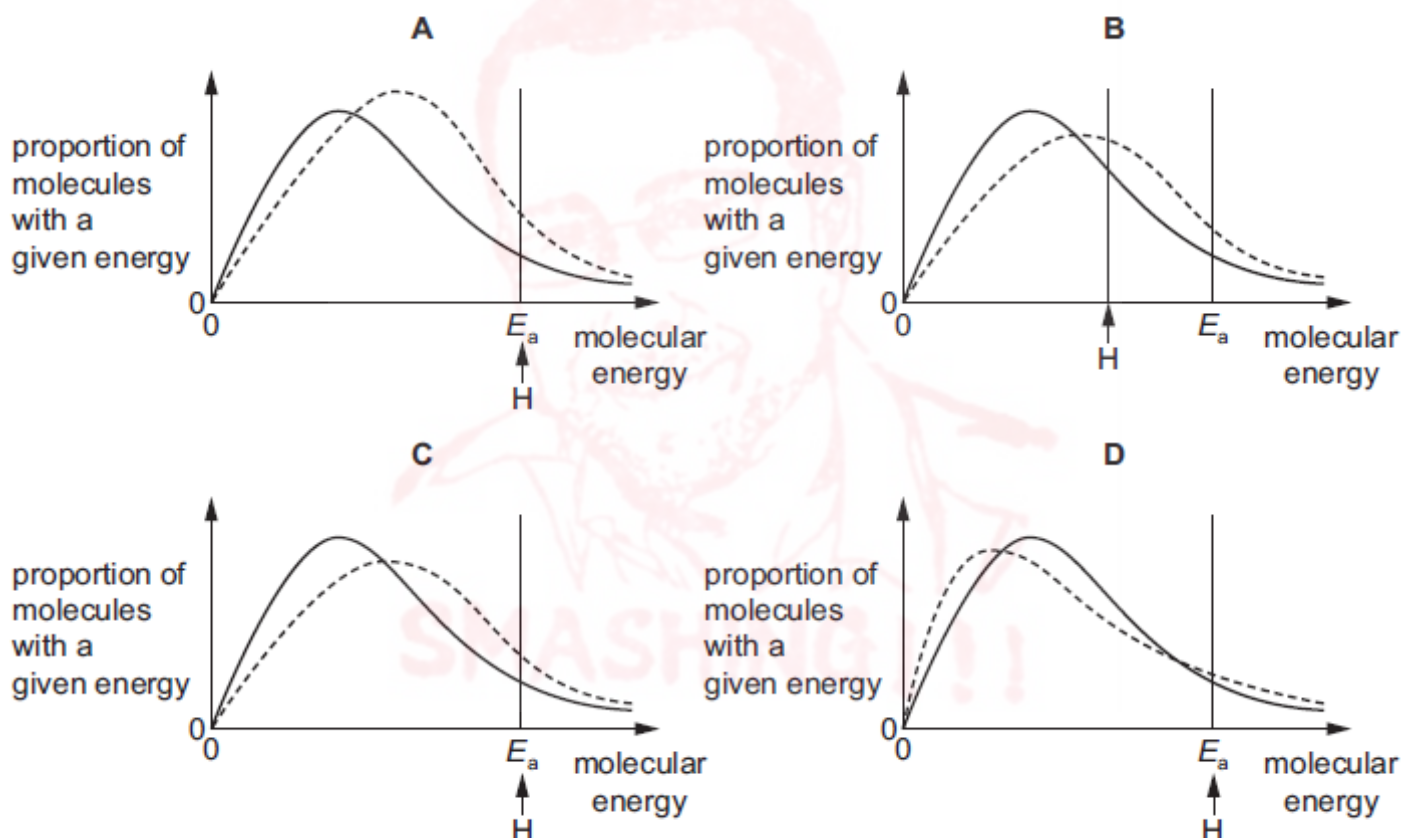


- 1 The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that react together. The activation energy for the reaction, E_a , is marked.



The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, H represents the activation energy at the higher temperature.

Which diagram is correct?

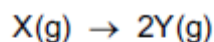


Topic **Chem 8 Q# 475/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

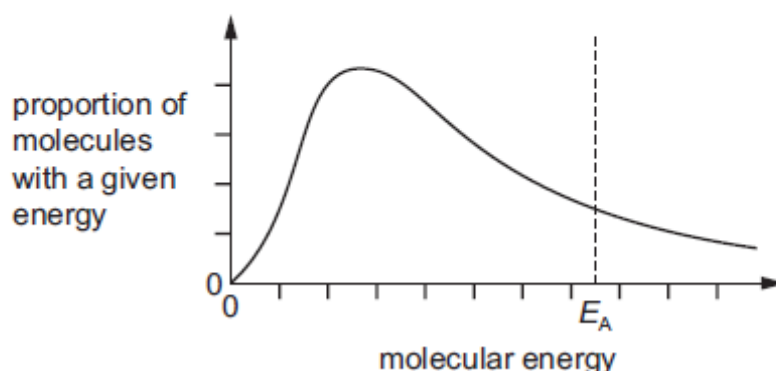
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 The equation shows a gas phase reaction.

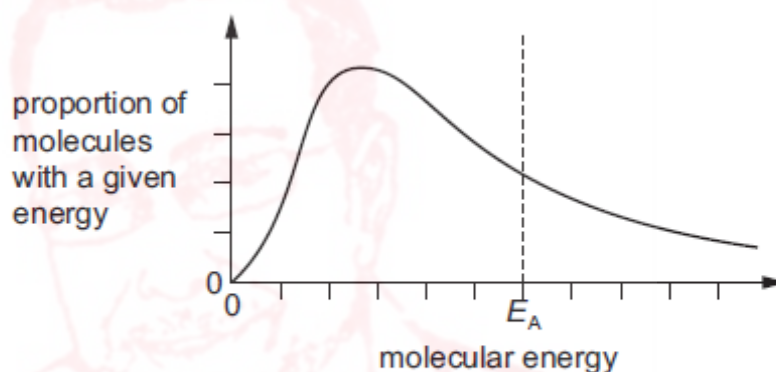


The diagram shows the Boltzmann distribution of a fixed mass of X(g) at temperature T in the absence of a catalyst. The line E_A indicates the activation energy.

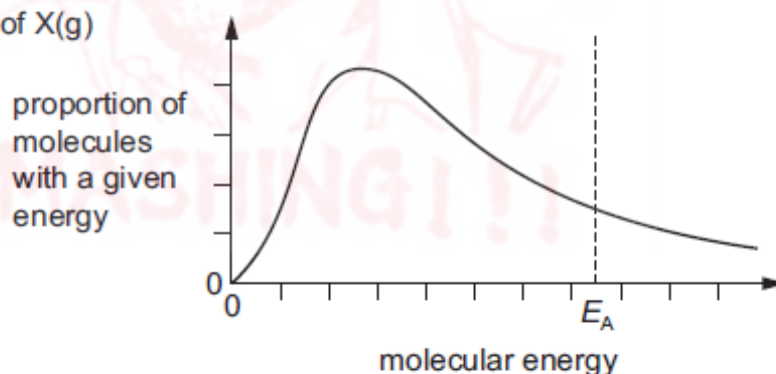


Which diagrams correctly show the effect of the following changes made separately and independently?

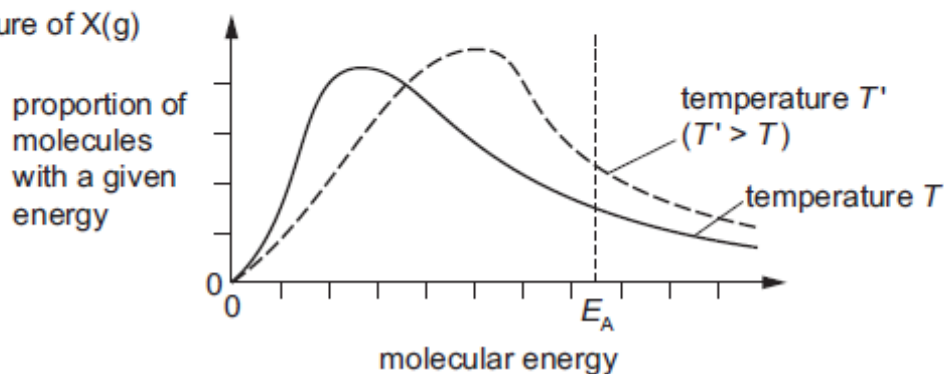
1 adding a catalyst



2 increasing the pressure of X(g)



3 increasing the temperature of X(g)



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34** A chemist puts a sample of dilute aqueous hydrochloric acid into beaker 1. She adds a sample of zinc and measures the rate of production of hydrogen gas.

She then puts a different sample of dilute aqueous hydrochloric acid into beaker 2. She adds a different sample of zinc and measures the rate of production of hydrogen gas.

The rate of the reaction in beaker 2 is greater than the rate of the reaction in beaker 1.

Which factors **could** help to explain this observation?

- 1 The reaction in beaker 1 has a higher activation energy than the reaction in beaker 2.
- 2 The zinc in beaker 1 is in larger pieces than the zinc in beaker 2.
- 3 The acid in beaker 1 is at a lower concentration than the acid in beaker 2.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34** Which statements correctly describe an effect of a rise in temperature on a gas-phase reaction?

- 1 More particles now have energies greater than the activation energy.
- 2 The energy distribution profile changes with more particles having the most probable energy.
- 3 The activation energy of the reaction is decreased.

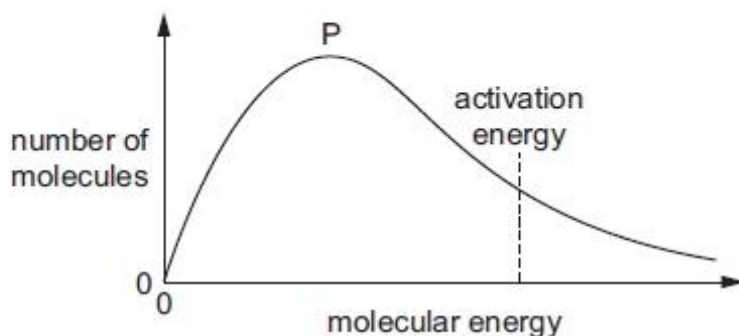
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34** Why does raising the pressure of a fixed mass of gaseous reactants at a constant temperature cause an increase in the rate of reaction?

- 1 More collisions occur per second when the pressure is increased.
- 2 More molecules have energy greater than the activation energy at the higher pressure.
- 3 Raising the pressure lowers the activation energy.

- 1** The diagram shows a Boltzmann distribution of molecular energies for a gaseous mixture. The distribution has a peak, labelled P on the diagram.



What happens when an effective catalyst is added to the mixture?

- A** The height of the peak decreases and the activation energy moves to the right.
- B** The height of the peak decreases and the activation energy moves to the left.
- C** The height of the peak remains the same and the activation energy moves to the right.
- D** The height of the peak remains the same and the activation energy moves to the left.

Topic **Chem 8 Q# 480**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

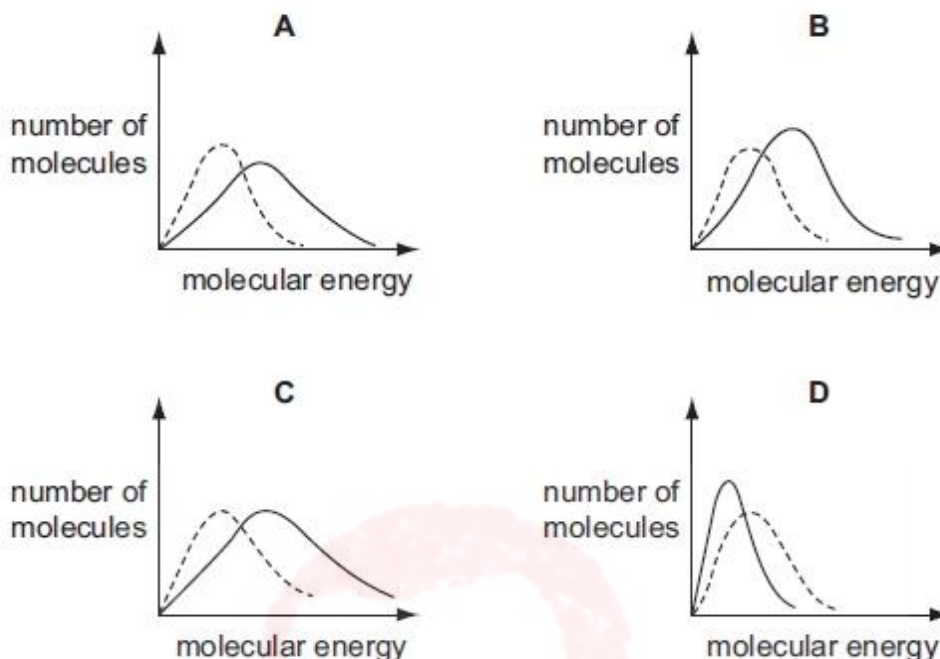
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33** A reversible reaction is catalysed.

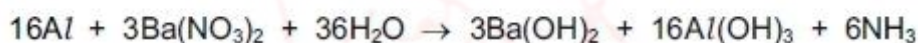
Which statements about the effects of the catalyst on this system are correct?

- 1** The catalyst alters the mechanism of the reaction.
- 2** The catalyst reduces the activation energy for both the forward and the backward reaction.
- 3** The catalyst alters the composition of the equilibrium mixture.

- 1 Which solid-line curve most accurately represents the distribution of molecular energies in a gas at 500K if the dotted-line curve represents the corresponding distribution for the same gas at 300K?



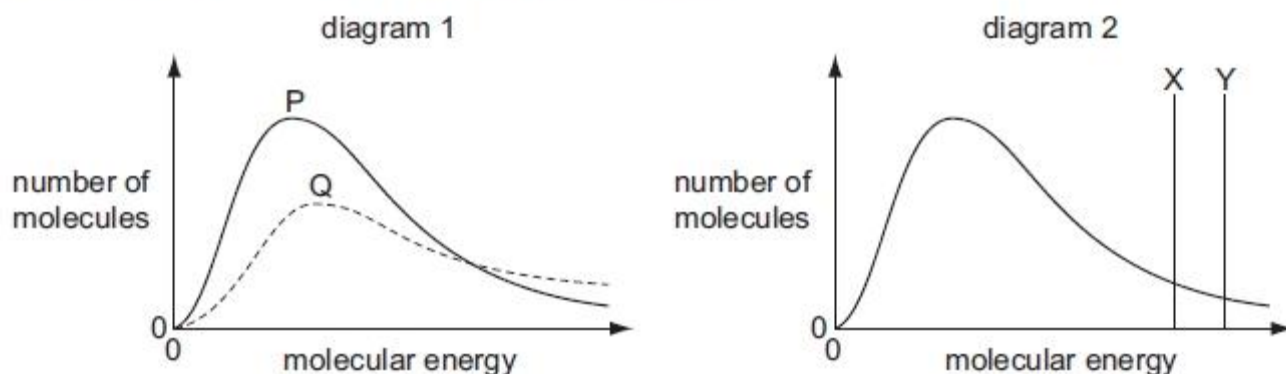
- 8 When making sparkler fireworks, a mixture of barium nitrate powder with aluminium powder, water and glue is coated onto wires and allowed to dry. At this stage, the following exothermic reaction may occur.



Which conditions would be best to reduce the rate of this reaction during the drying process, and would also keep the aluminium and barium nitrate unchanged?

	temperature /K	pH
A	298	7
B	298	14
C	398	7
D	398	14

11 Boltzmann distributions are shown in the diagrams.



In diagram 1, one curve, P or Q, corresponds to a temperature higher than that of the other curve.

In diagram 2, one line, X or Y, corresponds to the activation energy in the presence of a catalyst and the other line corresponds to the activation energy of the same reaction in the absence of a catalyst.

Which combination gives the correct curve and line?

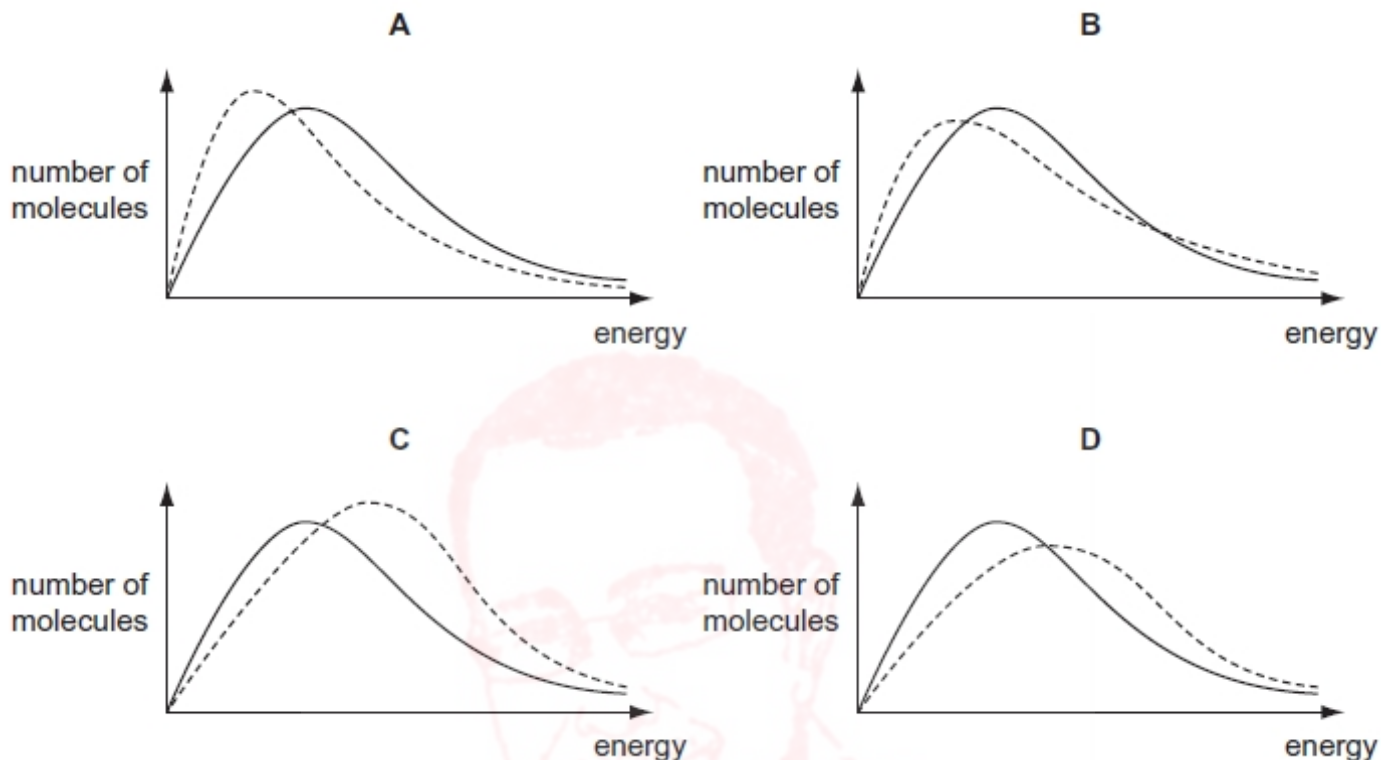
	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

6 The diagrams below show the Boltzmann distribution for air at two temperatures.

The solid line represents the distribution at -20°C .

The dotted line represents the distribution at -10°C .

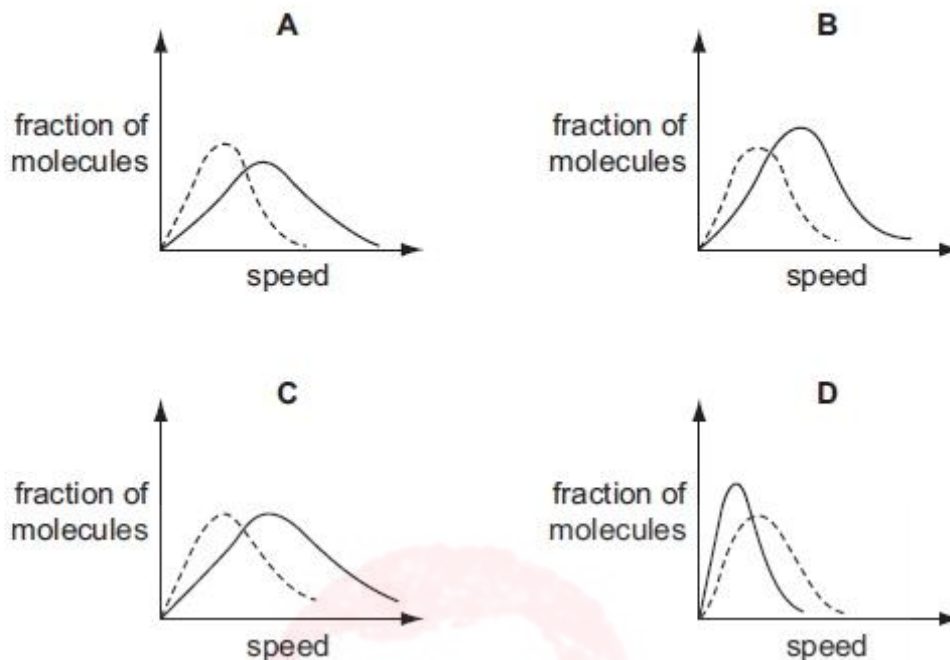
Which diagram is correct?



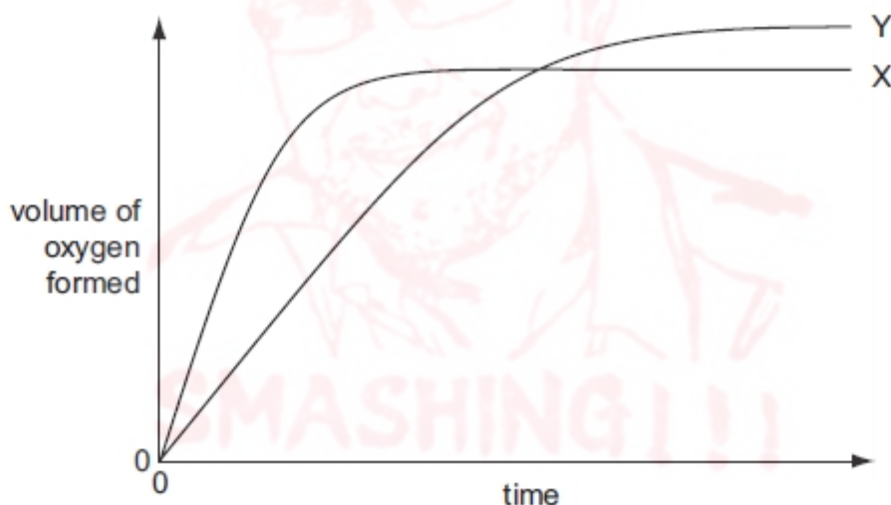
8 Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

- A More particles have energy that exceeds the activation energy.
- B The particles have more space in which to move.
- C The particles move faster.
- D There are more frequent collisions between particles.

- 11** Which solid-line curve most accurately represents the distribution of molecular speeds in a gas at 500K if the dotted-line curve represents the corresponding distribution for the same gas at 300K?



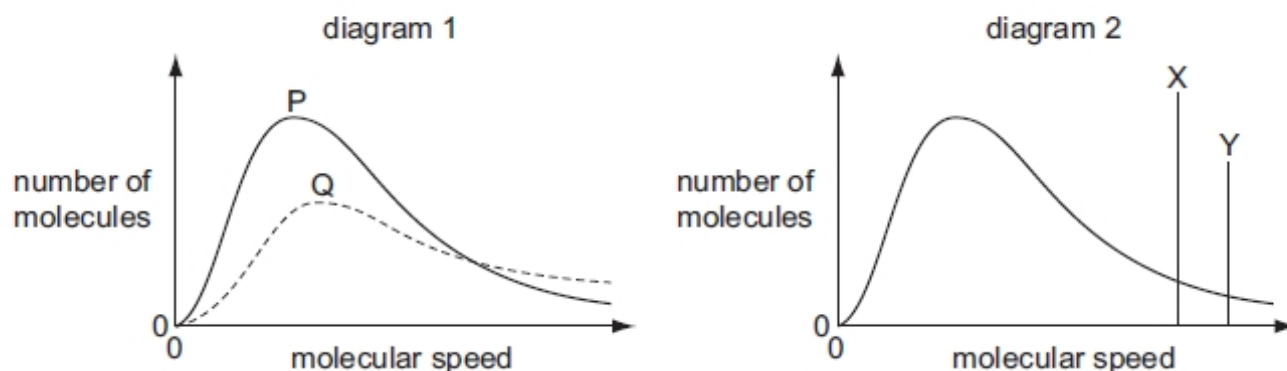
- 6** In the diagram, curve X was obtained by observing the decomposition of 100 cm³ of 1.0 mol dm⁻³ hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve Y?

- A** adding some 0.1 mol dm⁻³ hydrogen peroxide
- B** adding water
- C** lowering the temperature
- D** using less manganese(IV) oxide

4 Different Boltzmann distributions are shown in the diagrams.



In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.

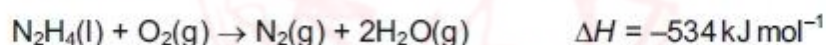
In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.

Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

Topic **Chem 8 Q# 489/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 Hydrazine, N_2H_4 , is widely used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.



Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.

Which statement explains why hydrazine does **not** burn spontaneously?

- A** Hydrazine is a liquid.
- B** The activation energy is too high.
- C** The $\text{N}\equiv\text{N}$ bond is very strong.
- D** The reaction is exothermic.

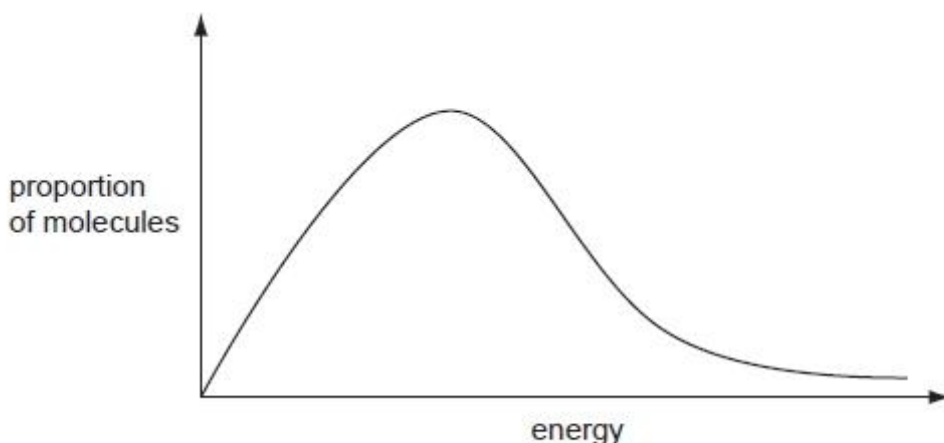
Topic **Chem 8 Q# 490/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



32 The diagram represents the Boltzmann distribution of molecular energies at a given temperature.



Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

- 1 increasing the concentration of reactants
- 2 increasing the temperature
- 3 the addition of a catalyst

Topic **Chem 8 Q# 491**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 $\text{Na}_2\text{S}_2\text{O}_3$ reacts with dilute HCl to give a pale yellow precipitate. If 1 cm^3 of 0.1 mol dm^{-3} HCl is added to 10 cm^3 of 0.02 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ the precipitate forms slowly.

If the experiment is repeated with 1 cm^3 of 0.1 mol dm^{-3} HCl and 10 cm^3 of 0.05 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ the precipitate forms more quickly.

Why is this?

- A** The activation energy of the reaction is lower when 0.05 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ is used.
- B** The reaction proceeds by a different pathway when 0.05 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ is used.
- C** The collisions between reactant particles are more violent when 0.05 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ is used.
- D** The reactant particles collide more frequently when 0.05 mol dm^{-3} $\text{Na}_2\text{S}_2\text{O}_3$ is used.

Topic **Chem 8 Q# 492**/ AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

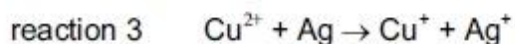
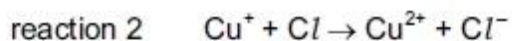
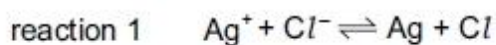
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 Why does a mixture of hydrogen gas and bromine gas react together faster at a temperature of 500 K than it does at a temperature of 400 K ?

- 1 A higher proportion of effective collisions occurs at 500 K .
- 2 Hydrogen molecules and bromine molecules collide more frequently at 500 K .
- 3 The activation energy of the reaction is lower at 500 K .

- 11** Photochromic glass, used for sunglasses, darkens when exposed to bright light and becomes more transparent again when the light is less bright. The depth of colour of the glass is related to the concentration of silver atoms.

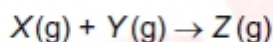
The following reactions are involved.



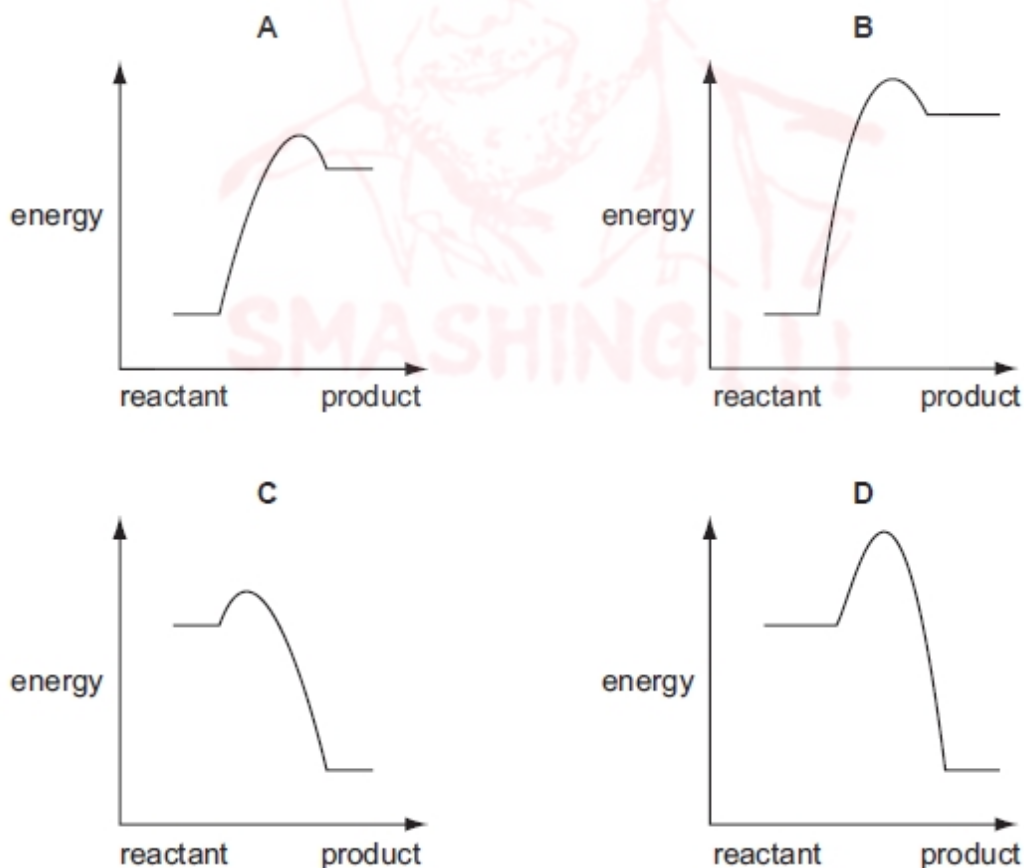
Which statement about these reactions is correct?

- A** Cu^+ and Cu^{2+} ions act as catalysts.
- B** Cu^+ ions act as an oxidising agent in reaction 2.
- C** Reaction 2 is the one in which light is absorbed.
- D** Ag^+ ions are oxidised in reaction 1.

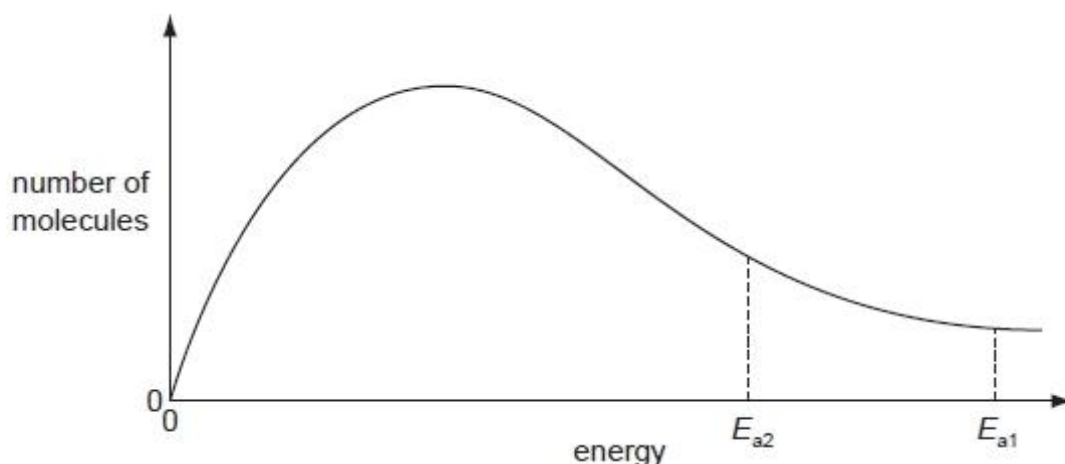
- 10** Four reactions of the type shown are studied at the same temperature.



Which is the correct reaction pathway diagram for the reaction that would proceed **most** rapidly and with the **highest** yield?



- 10** The diagram shows the Maxwell-Boltzmann energy distribution curve for molecules of a mixture of two gases at a given temperature. For a reaction to occur the molecules must collide together with sufficient energy.



E_a is the activation energy for the reaction between the gases. Of the two values shown, one is for a catalysed reaction, the other for an uncatalysed one.

Which pair of statements is correct when a catalyst is used?

A	E_{a1} catalysed reaction fewer effective collisions	E_{a2} uncatalysed reaction more effective collisions
B	E_{a1} uncatalysed reaction fewer effective collisions	E_{a2} catalysed reaction more effective collisions
C	E_{a1} catalysed reaction more effective collisions	E_{a2} uncatalysed reaction fewer effective collisions
D	E_{a1} uncatalysed reaction more effective collisions	E_{a2} catalysed reaction fewer effective collisions

Topic **Chem 9 Q# 496**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org

:o)

- 25** Separate 1.0g samples of Na_2O , MgO , Al_2O_3 , SiO_2 , NaCl , MgCl_2 , Al_2Cl_6 and SiCl_4 are added to separate beakers containing water and stirred.

The number of beakers containing a white solid is Q.

An excess of NaOH(aq) is then added to each beaker and stirred.

The number of beakers now containing a white solid is R.

Which row is correct?

	Q	R
A	3	2
B	3	3
C	4	3
D	4	4

19 The oxides BaO, CaO, MgO and SrO all produce alkaline solutions when added to water.

Which oxide produces the saturated solution with the highest pH?

- A** BaO **B** CaO **C** MgO **D** SrO

18 Which row describes the relative sizes of the ionic radii of Na^+ , Mg^{2+} and S^{2-} ?

	smallest $\longrightarrow$ largest		
A	Na^+	Mg^{2+}	S^{2-}
B	Mg^{2+}	Na^+	S^{2-}
C	S^{2-}	Na^+	Mg^{2+}
D	S^{2-}	Mg^{2+}	Na^+

17 The electrical conductivities of two compounds, Y and Z, are shown.

	for Y	for Z
conductivity of the compound in the liquid state	good	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good

What are compounds Y and Z?

	Y	Z
A	Al_2O_3	SiCl_4
B	NaCl	Al_2O_3
C	NaCl	SiCl_4
D	SiCl_4	Al_2O_3

6 Which statement about aluminium chloride is correct?

- A** Aluminium chloride has a much higher melting point than magnesium chloride due to the small size of the aluminium ion.
- B** Anhydrous aluminium chloride reacts vigorously with water to form a solution with a pH greater than 7.
- C** Each Al_2Cl_6 molecule found in aluminium chloride vapour contains two coordinate bonds.
- D** The bonding between aluminium and chlorine is strongly ionic due to the large difference in electronegativity.

23 Silicon is heated in an excess of chlorine, producing compound J.

An excess of water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

19 A student reacts 0.100 mol of each of sodium, magnesium and phosphorus atoms separately with an excess of oxygen.

Which rows are correct?

	oxide	mass of oxide formed /g
1	sodium	3.10
2	magnesium	4.03
3	phosphorus	7.10

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

18 Which statement for the element in Period 3 and Group 13 of the Periodic Table is correct?

- A** It has the highest melting point of the elements in its period.
- B** It has exactly one electron in its shell with principal quantum number 3.
- C** It forms an oxide that reacts with aqueous sodium hydroxide.
- D** It forms a chloride that dissolves in water to give a neutral solution.

19 The table shows the melting points of SiO₂ and P₄O₆.

oxide	SiO ₂	P ₄ O ₆
melting point / K	1883	297

Which statement explains the difference between the melting points of SiO₂ and P₄O₆?

- A** The bonding of the oxides changes from ionic to covalent.
- B** The metallic character of the elements decreases across Period 3.
- C** The oxidation number of the element increases from Si to P.
- D** The structure changes from giant molecular to simple molecular.

18 The elements in Period 3 and their compounds show trends across the period from sodium to chlorine.

Which row is correct?

	electronegativity of the elements	acid / base behaviour of the oxides of the elements
A	decreases	basic → amphoteric → acidic
B	decreases	acidic → amphoteric → basic
C	increases	basic → amphoteric → acidic
D	increases	acidic → amphoteric → basic

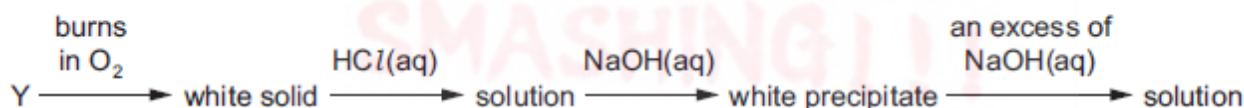
17 A student investigated the chloride of a Period 3 element. This is what the student wrote down as a record.

The compound was a white crystalline solid. It dissolved easily in water to give a solution of pH 12. When placed in a test-tube and heated in a roaring Bunsen flame, the compound melted after several minutes heating.

What can be deduced from this record?

- A** At least one of the recorded observations is incorrect.
- B** The compound was magnesium chloride, MgCl_2 .
- C** The compound was phosphorus pentachloride, PCl_5 .
- D** The compound was sodium chloride, NaCl .

13 An element, Y, reacts according to the following sequence.



What could be element Y?

- A** Na **B** Mg **C** Al **D** P

12 Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?

- A** aluminium
- B** magnesium
- C** phosphorus
- D** sodium



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which statements are correct going across Period 3 from sodium to chlorine?

- 1** The charge on the nucleus increases, pulling the electrons closer to it.
- 2** The radius of the most common ion of each element decreases.
- 3** The shielding caused by inner electrons decreases, so the outer electrons are pulled closer to the nucleus.

Topic **Chem 9 Q# 510**/ AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 R is an oxide of Period 3 element T. 5.00 g of R contains 2.50 g of T.

What is T?

- A** magnesium
- B** aluminium
- C** silicon
- D** sulfur

Topic **Chem 9 Q# 511**/ AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 Element X is in Period 3. Element X forms a solid oxide Y.

Y reacts with hot concentrated hydrochloric acid. Y reacts with hot aqueous sodium hydroxide to form a compound in which X is part of an anion.

How many p electrons does one atom of X have in its outer shell?

- A** 0
- B** 1
- C** 2
- D** 3

Topic **Chem 9 Q# 512**/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 A sample containing x mol of Al_2Cl_6 is dissolved in water to give solution W.

In order to precipitate all of the aluminium as its hydroxide, y mol of sodium hydroxide are required.

More of the alkali is added to re-dissolve the precipitate, giving solution Z.

Which statements are correct?

- 1 the initial pH of solution W is below 7
- 2 $y = 3x$
- 3 Z contains x mol of aluminium

Topic **Chem 9 Q# 513/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 Which row is correct?

	statement	reason
A	The first ionisation energy of phosphorus is greater than that of magnesium.	electron is lost from a 3p orbital in both cases
B	The melting point of phosphorus is greater than that of magnesium.	phosphorus has more valence electrons than magnesium
C	The atomic radius of phosphorus is smaller than that of magnesium.	phosphorus has greater nuclear charge than magnesium
D	The electrical conductivity of phosphorus is smaller than that of magnesium.	bonding changes from ionic in magnesium to covalent in phosphorus

Topic **Chem 9 Q# 514/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

- A No visible change is observed.
- B Steamy fumes and a precipitate are both observed.
- C The appearance of a precipitate is the only observation.
- D The appearance of steamy fumes is the only observation.

Topic **Chem 9 Q# 515/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Three test-tubes, X, Y and Z, each contain water.

- A small amount of NaCl is added to test-tube X.
- A small amount of SiCl_4 is added to test-tube Y.
- A small amount of AlCl_3 is added to test-tube Z.

After a short time, two drops of universal indicator solution are added to each test-tube.

Which statements can be correct?

- 1 The pH in test-tube X is 7.
- 2 The pH in test-tube Y is 2.
- 3 The pH in test-tube Z is 2.

Topic **Chem 9 Q# 516/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which rows correctly show the relative electrical conductivities of the sets of three Period 3 elements?

	greatest conductivity	→	least conductivity
1	sodium	silicon	chlorine
2	aluminium	magnesium	phosphorus
3	sulfur	silicon	phosphorus

Topic **Chem 9 Q# 517/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 X and Y are two elements in Period 3 of the Periodic Table. They combine to form compound Z.

X forms a soluble acidic oxide. The oxidation number of X in this oxide is +4.

Y forms an amphoteric oxide.

What is the formula of compound Z?

- A** AlP **B** Al_2S_3 **C** Si_2P_5 **D** SiS_2

Topic **Chem 9 Q# 518/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 Sodium, aluminium and silicon are three elements in Period 3. Each element forms an oxide.

Which row has three correct properties of these oxides?

	sodium oxide	aluminium oxide	silicon dioxide
A	basic	basic	amphoteric
B	giant ionic	giant ionic	simple molecular
C	high melting point	low melting point	high melting point
D	reacts with water	no reaction with water	no reaction with water



15 Element Z has a giant structure.

The chloride of Z reacts with water to give a solution with a pH less than 5.

Which pair shows two elements which could be Z?

- A** aluminium, magnesium
- B** aluminium, silicon
- C** phosphorus, magnesium
- D** phosphorus, silicon

Topic **Chem 9 Q# 520/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Which statements are correct?

- 1** Aluminium chloride dissolves in water to give an acidic solution.
- 2** Magnesium chloride dissolves in water to give a solution of pH close to 7.
- 3** Sodium chloride dissolves in water to give an alkaline solution.

Topic **Chem 9 Q# 521/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Carbon and nitrogen are adjacent in the Periodic Table.

Which properties do they both have?

- 1** There is an empty 2p orbital in each atom of the element.
- 2** The principal quantum number of the highest occupied orbital is 2.
- 3** They can form compounds in which their atoms form four bonds.

16 Sodium, magnesium and aluminium are three elements in Period 3 of the Periodic Table. Each element forms an oxide.

Which row is correct?

	sodium oxide	magnesium oxide	aluminium oxide
A	basic	amphoteric	amphoteric
B	giant ionic	giant ionic	simple molecular
C	high melting point	high melting point	low melting point
D	readily reacts with water	slight reaction with water	no reaction with water

12 X and Y are oxides of different Period 3 elements.

If one mole of X is added to water, the solution formed is neutralised by exactly one mole of Y.

What could be the identities of X and Y?

	X	Y
A	P_4O_{10}	Al_2O_3
B	SO_3	Al_2O_3
C	P_4O_{10}	Na_2O
D	SO_3	Na_2O

13 X, Y and Z are consecutive elements in Period 3 of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of X, Y and Z?

	X	Y	Z
A	Na	Mg	Al
B	Mg	Al	Si
C	Al	Si	P
D	Si	P	S

12 Which oxide will cause an increase in pH when added to water?

- A** MgO **B** Al_2O_3 **C** SiO_2 **D** SO_2



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

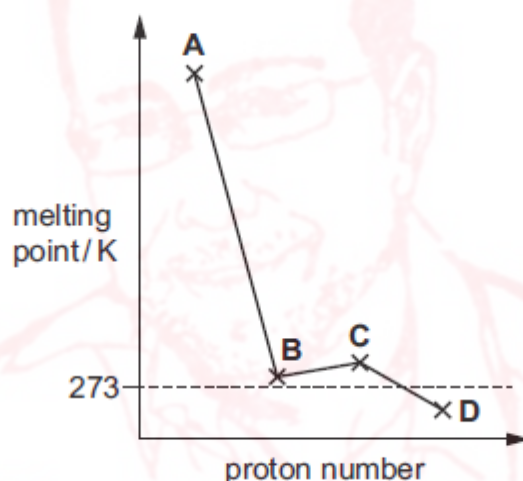
35 Which oxides, when placed in cold water for one day, will react with the water?

- 1** MgO
- 2** Al₂O₃
- 3** SiO₂

13 The relative melting points of four consecutive elements in the Periodic Table are shown in the graph.

The elements all have proton numbers less than 20.

Which element is in Group 16?



13 A solid Period 3 element, Q, is reacted with oxygen gas. Compound R is formed.

When R is added to water the pH decreases.

What could be the empirical formula of R?

- A** Q₂O₄
- B** Q₂O₅
- C** Q₄O₁₀
- D** Q₅O₂

12 X, Y and Z are elements in Period 3 of the Periodic Table. The results of some experiments carried out with compounds of these elements are shown.

element	result of adding the oxide of the element to $\text{H}_2\text{O}(\text{l})$	result of adding the chloride of the element to $\text{H}_2\text{O}(\text{l})$	result of adding the oxide of the element to $\text{HCl}(\text{aq})$
X	no reaction	hydrolyses	forms chloride salt
Y	forms hydroxide	dissolves	forms chloride salt
Z	forms acid	hydrolyses	hydrolyses

Which statement could be correct?

- A X is Al and Y is Mg.
- B X is Si and Y is Na.
- C Y is Al and Z is P.
- D Y is Na and Z is Al.

Topic **Chem 9 Q# 530**/ AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 Which row describes the structure and bonding of SiO_2 and SiCl_4 ?

	SiO_2		SiCl_4	
	bonding	structure	bonding	structure
A	covalent	giant	covalent	giant
B	covalent	giant	covalent	simple
C	ionic	giant	covalent	giant
D	ionic	giant	covalent	simple

Topic **Chem 9 Q# 531**/ AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 X and Y are elements in Period 3 of the Periodic Table.

- The oxide of X is a solid at room temperature. This oxide has a giant structure.
- The chloride of X does not react with water.
- Argon is the only element in Period 3 with a lower melting point than Y.

What could be the formula of a compound formed between elements X and Y?

- A Al_2S_3
- B MgS
- C NaCl
- D PCl_5

12 Sodium and sulfur are burned separately in oxygen.

Each reaction has a distinctive coloured flame.

Which row is correct?

	Na + O ₂	S + O ₂
A	white	blue
B	white	yellow
C	yellow	blue
D	yellow	yellow

Topic **Chem 9 Q# 533/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 Which element has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

- A** boron
- B** calcium
- C** magnesium
- D** sodium

Topic **Chem 9 Q# 534/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 Silicon is heated in an excess of chlorine, producing compound J.

Excess water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

Topic **Chem 9 Q# 535/** AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 X, Y and Z are three elements in the third period.

- X reacts with chlorine to give a liquid product.
- Y reacts with chlorine to give a solid product that dissolves in water to give a solution of pH 7.
- Z reacts with chlorine to give a solid product that dissolves in water to give a solution of pH 6.

Which elements are good conductors of electricity?

- A** X and Y
- B** Y and Z
- C** Y only
- D** Z only

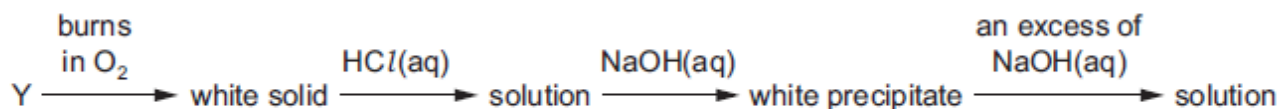


13 Which oxide is insoluble in aqueous sodium hydroxide?

- A MgO B Al_2O_3 C P_4O_{10} D SO_2

Topic **Chem 9 Q# 537/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 13//

13 An element Y reacts according to the following sequence.



What could be element Y?

- A Al B Ca C Mg D P

Topic **Chem 9 Q# 538/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 12//

12 The elements Cl, Mg, Si and S are all in Period 3.

What is the correct sequence of the melting points of these elements, from lowest to highest?

	lowest melting point			highest melting point
A	Cl	S	Mg	Si
B	Cl	S	Si	Mg
C	Mg	Si	S	Cl
D	Si	Mg	S	Cl

Topic **Chem 9 Q# 539/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

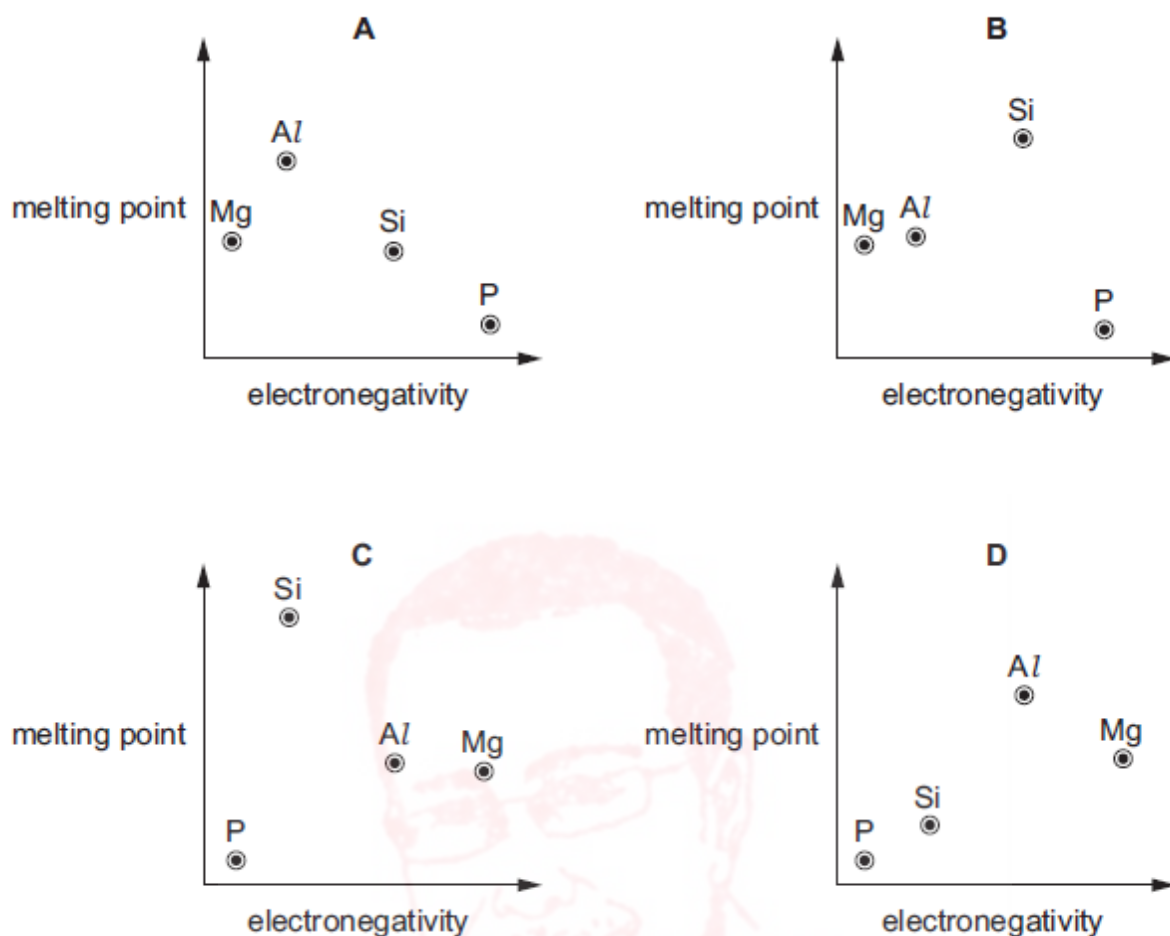
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which statements describe a trend in Period 3 between **every pair** of adjacent elements from sodium to chlorine?

- The atomic radius decreases.
- The 1st ionisation energy decreases.
- The melting point decreases.



13 Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative electronegativities?



Topic **Chem 9 Q# 541/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Three test-tubes, X, Y, and Z, each contain a small amount of water.

- A small amount of NaCl is added to test-tube X.
- A small amount of SiCl_4 is added to test-tube Y.
- A small amount of AlCl_3 is added to test-tube Z.

After a short time, two drops of Universal Indicator solution are added to each test-tube.

Which observations are made?

- 1 The indicator added to test-tube X stays green.
- 2 The indicator added to test-tube Y turns red.
- 3 The indicator added to test-tube Z turns red.



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

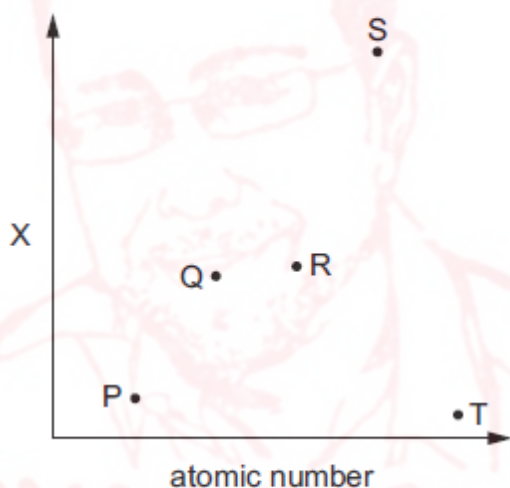
- 31 Nitrogen and phosphorus are both in Group 15 of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5 but nitrogen does not form NCl_5 .

Which statements help to explain this?

- 1 Nitrogen's outer shell cannot contain more than eight electrons.
- 2 Nitrogen cannot have an oxidation state of +5.
- 3 Nitrogen is less electronegative than phosphorus.

Topic **Chem 9 Q# 543/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

- 15 The magnitude of property X of five elements from the third period of the Periodic Table, P, Q, R, S and T is shown. P, Q, R, S and T have consecutive atomic numbers. The letters do not represent the symbols of the elements.



Which row correctly identifies property X and element R?

	property X	element R
A	electrical conductivity	Al
B	electronegativity	Si
C	melting point	Al
D	melting point	Si

12 The electrical conductivities of two compounds, Y and Z, are shown in the table.

	Y	Z
conductivity of the compound in the liquid state	good	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good

What could compounds Y and Z be?

	Y	Z
A	Al_2O_3	$SiCl_4$
B	NaF	Al_2O_3
C	NaF	$SiCl_4$
D	$SiCl_4$	Al_2O_3

Topic **Chem 9 Q# 545/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 A little water is added to each of the following compounds and the mixture warmed.

For which compounds will an acidic gas be evolved?

- 1 aluminium chloride
- 2 silicon tetrachloride
- 3 phosphorous pentachloride

Topic **Chem 9 Q# 546/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 Why is the ionic radius of a chloride ion larger than the ionic radius of a sodium ion?

- A** A chloride ion has one more occupied electron shell than a sodium ion.
- B** Chlorine has a higher proton number than sodium.
- C** Ionic radius increases regularly across the third period.
- D** Sodium is a metal, chlorine is a non-metal.



- 13** When dealing with a spillage of metallic sodium it is important that no toxic or flammable products are formed.

Which material should be used if there is a spillage of metallic sodium?

- A dilute hydrochloric acid
- B ethanol
- C sand
- D water spray

- 12** Consecutive elements **X**, **Y** and **Z** are in Period 3 of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of **X**, **Y** and **Z**?

- A sodium, magnesium, aluminium
- B magnesium, aluminium, silicon
- C aluminium, silicon, phosphorus
- D silicon, phosphorus, sulfur

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 32** The Group IV elements carbon, silicon and germanium can all exist in the giant molecular structure which is also found in diamond. The bond lengths in these structures are given below.

element X	C	Si	Ge
bond length X–X / nm	0.154	0.234	0.244

Why does the bond length increase down the group?

- 1 Orbital overlap decreases down the group.
- 2 Atomic radius increases down the group.
- 3 Nuclear charge increases down the group.

- 16** **X** is the oxide of a Period 3 element. **X** reacts with water to give an acidic solution.

A solution is prepared by reacting 0.100 g of **X** with excess water. This solution was neutralised by exactly 25.0 cm³ of 0.100 mol dm⁻³ sodium hydroxide solution.

What could be the identity of **X**?

- A Al₂O₃
- B MgO
- C P₄O₁₀
- D SO₃

15 The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	Al
mp/K	371	923	932

Which factor explains the **increase** in melting points from sodium to aluminium?

- A** the changes in first ionisation energy from sodium to aluminium
- B** the increase in electronegativity from sodium to aluminium
- C** the increase in the A_r of the elements from sodium to aluminium
- D** the increase in the number of outer electrons in each atom from sodium to aluminium

Topic **Chem 9 Q# 552**/ AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 *Use of the Data Booklet is relevant to this question.*

Which of the elements sodium, magnesium, aluminium, silicon, phosphorus, sulfur and chlorine

- has a lower first ionisation energy than the preceding element in the Periodic Table,
- conducts electricity and
- has a lower atomic radius than the preceding element in the Periodic Table?

- A** aluminium
- B** magnesium
- C** phosphorus
- D** sulfur

Topic **Chem 9 Q# 553**/ AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 *Use of the Data Booklet is relevant to this question.*

1.00 g of carbon is combusted in a limited supply of pure oxygen. 0.50 g of the carbon combusts to form CO_2 and 0.50 g of the carbon combusts to form CO .

The resultant mixture of CO_2 and CO is passed through excess NaOH(aq) and the remaining gas is then dried and collected.

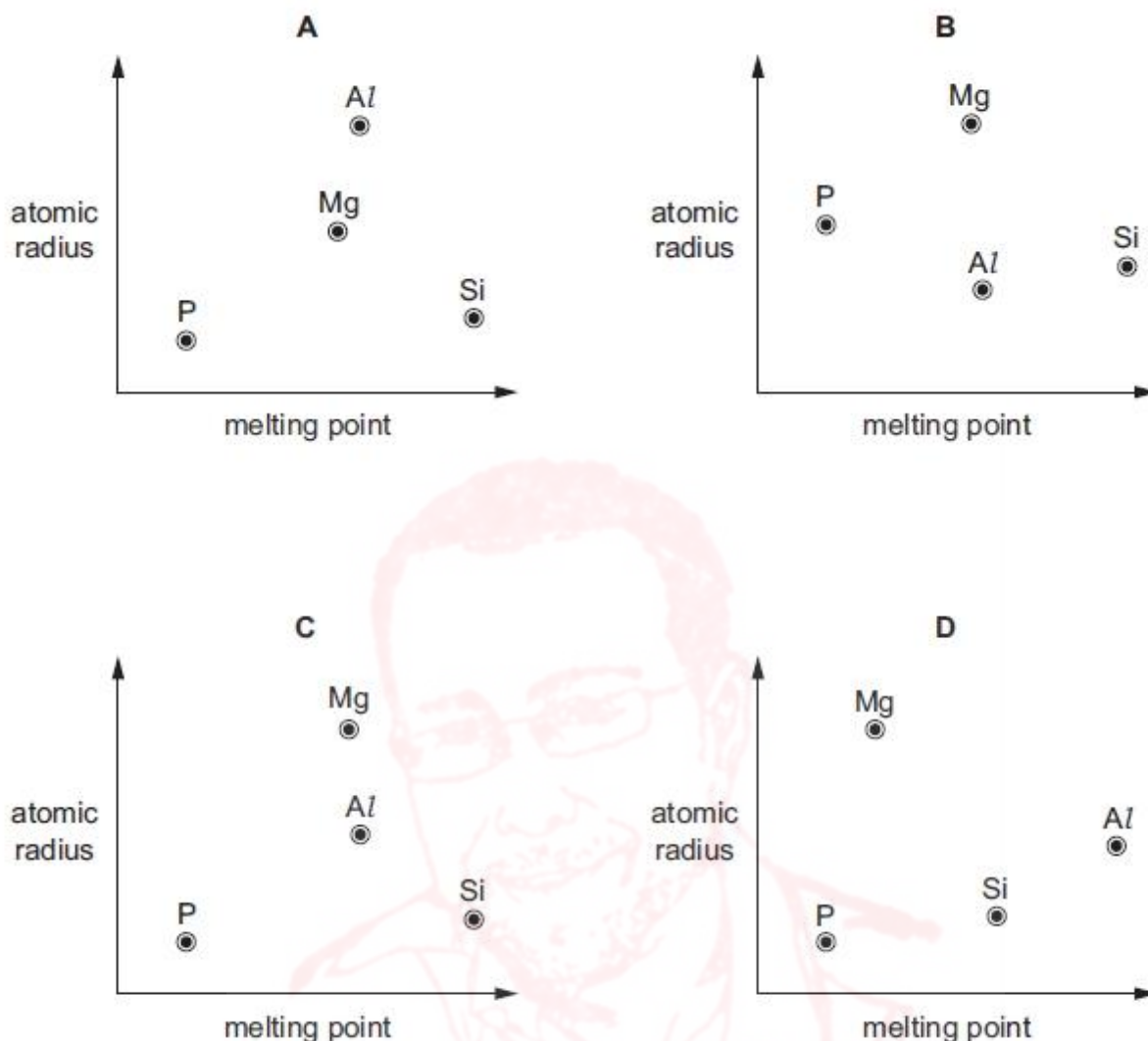
What is the volume of the remaining gas? (All gas volumes are measured at 25°C and 1 atmosphere pressure.)

- A** 1 dm^3
- B** 1.5 dm^3
- C** 2 dm^3
- D** 3 dm^3



15 Use of the Data Booklet is relevant to this question.

Which diagram correctly shows the atomic radii of the elements Mg, Al, Si and P plotted against their melting points?



Topic **Chem 9 Q# 555/** AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 Which observations are made when a sample of silicon chloride, SiCl_4 , is added to a beaker of water?

- A No visible changes are observed.
- B Steamy fumes and a white precipitate are both observed.
- C The appearance of a white precipitate is the only observation.
- D The appearance of steamy fumes is the only observation.

Topic **Chem 9 Q# 556/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 Which oxide does **not** react with cold dilute sodium hydroxide to produce a salt?

- A Al_2O_3
- B P_4O_{10}
- C SO_2
- D SiO_2



- 18** Total removal of the pollutant sulfur dioxide, SO_2 , is difficult. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are reacted with calcium hydroxide to remove the SO_2 .

What is the main product formed initially?

- A** $\text{Ca}(\text{HSO}_4)_2$ **B** CaS **C** CaSO_3 **D** CaSO_4

- 14** Use of the Data Booklet is relevant to this question.

Sir Humphrey Davy discovered boron, calcium, magnesium and sodium.

Which of these elements has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

- A** boron
B calcium
C magnesium
D sodium

- 13** Which property is **not** associated with the element sodium?

- A** It can react with cold water to form hydrogen.
B It forms a basic oxide.
C It forms a neutral chloride.
D It is an oxidising agent.

- 12** Element X, in Period 3, has the following properties.

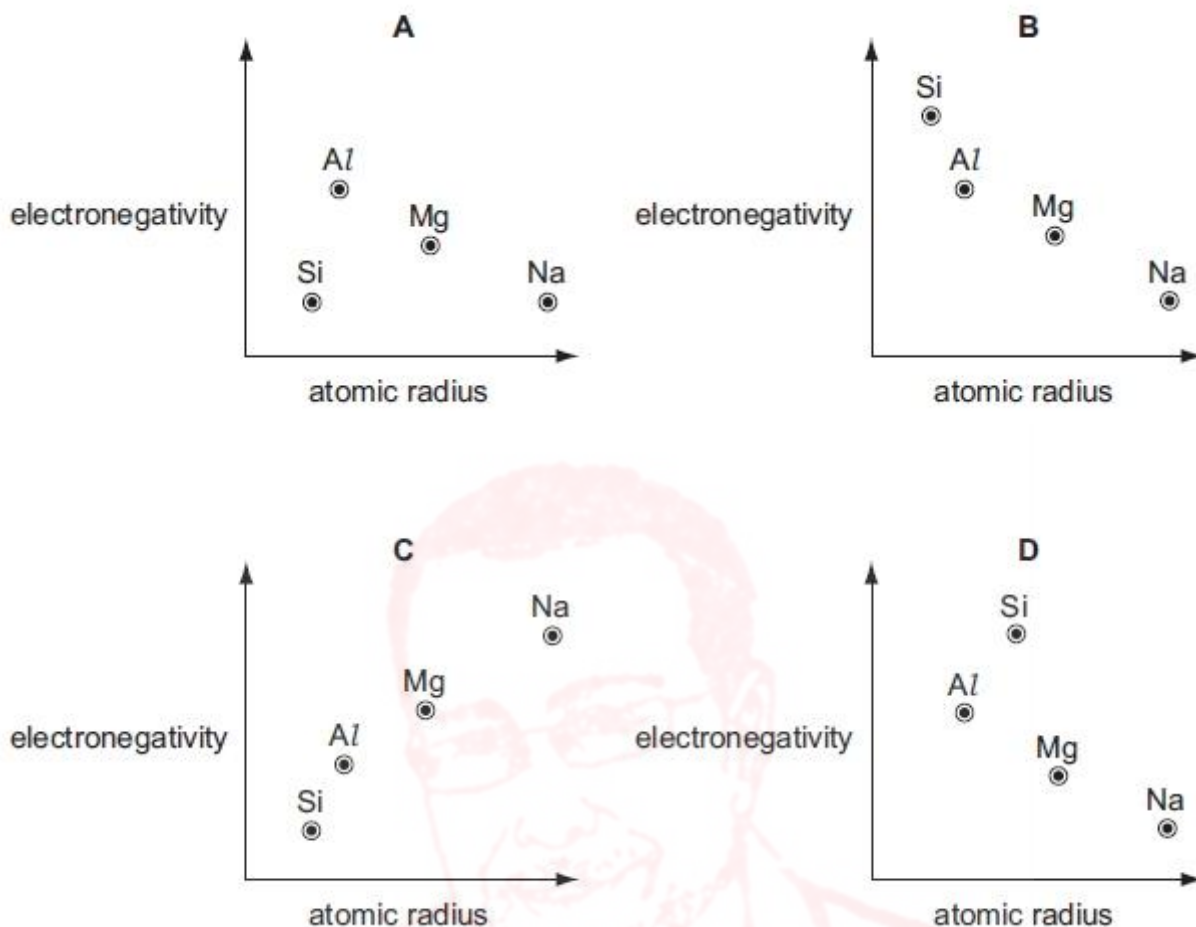
- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise $\text{HCl}(\text{aq})$.

What is element X?

- A** Mg **B** Al **C** Si **D** P

19 Use of the Data Booklet is relevant to this question.

Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



16 Which description of the bonding and acid / base nature of aluminium oxide is correct?

	bonding	acid / base nature
A	covalent	amphoteric
B	covalent	basic
C	ionic	amphoteric
D	ionic	basic

15 When calcium is burnt in oxygen, what colour is the flame?

- A** green
- B** red
- C** white
- D** yellow



19 Consecutive elements **X**, **Y** and **Z** are in the third period of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What could be the identities of **X**, **Y** and **Z**?

- A** sodium, magnesium, aluminium
- B** magnesium, aluminium, silicon
- C** aluminium, silicon, phosphorus
- D** silicon, phosphorus, sulfur

4 Use of the Data Booklet is relevant to this question.

The elements radon (Rn), francium (Fr) and radium (Ra) have proton numbers 86, 87 and 88 respectively.

What is the order of their first ionisation energies?

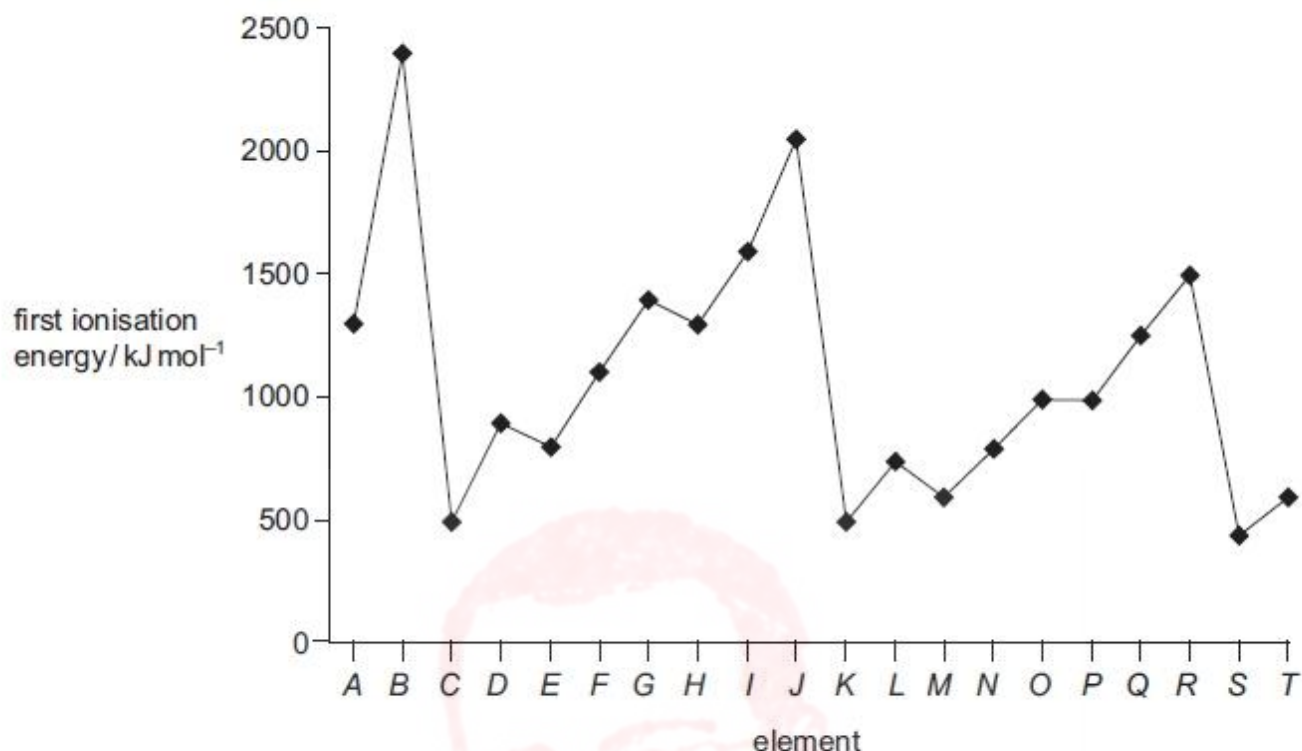
	least endothermic	—————→	most endothermic
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34 The first ionisation energies of twenty successive elements in the Periodic Table are represented in the graph.

The letters given are not the normal symbols for these elements.



Which statements about this graph are correct?

- 1 Elements B, J and R are in Group 0 of the Periodic Table.
- 2 Atoms of elements D and L contain two electrons in their outer shells.
- 3 Atoms of elements G and O contain a half-filled p subshell.

Topic **Chem 9 Q# 567**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

- 2 A mixture of 10 cm³ of methane and 10 cm³ of ethane was sparked with an excess of oxygen. After cooling to room temperature, the residual gas was passed through aqueous potassium hydroxide.

All gas volumes were measured at the same temperature and pressure.

What volume of gas was absorbed by the alkali?

- A** 15 cm³ **B** 20 cm³ **C** 30 cm³ **D** 40 cm³

Topic **Chem 9 Q# 568**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

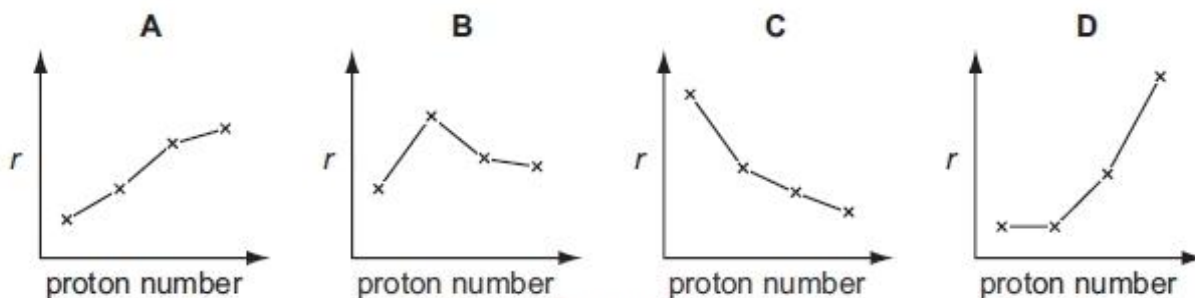
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 When added to water, which oxides will **not** cause a change in pH?

- 1 Al_2O_3
- 2 SiO_2
- 3 P_4O_{10}

Topic **Chem 9 Q# 569**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 Which diagram shows the variation of the metallic radius r of the Group I elements, Li, Na, K and Rb, with increasing proton (atomic) number?



Topic **Chem 9 Q# 570**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Elements X and Y are both in period three.

When the chloride of X is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of Y is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

- A Both chlorides hydrolyse in water.
- B X is phosphorus and Y is aluminium.
- C X is silicon and Y is sodium.
- D X is sodium and Y is phosphorus.

Topic **Chem 9 Q# 571**/ AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 The oxides BaO, CaO, MgO and SrO all produce alkaline solutions when added to water.

Which oxide produces the saturated solution with the highest pH?

- A BaO(aq) B CaO(aq) C MgO(aq) D SrO(aq)

Topic **Chem 9 Q# 572**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Total removal of the pollutant sulfur dioxide, SO_2 , is difficult, both for economic and technical reasons. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are scrubbed (washed) with calcium hydroxide to remove the SO_2 .

What is the main product formed initially?

- A $\text{Ca}(\text{HSO}_4)_2$ B CaS C CaSO_3 D CaSO_4



1 Three elements, **X**, **Y** and **Z**, have the physical properties shown in the table.

element	melting point /°C	boiling point /°C	density /g cm ⁻³
X	-7	59	3.12
Y	98	883	0.97
Z	649	1107	1.74

What could be the identities of **X**, **Y** and **Z**?

	X	Y	Z
A	Br ₂	Al	Si
B	Br ₂	Na	Mg
C	I ₂	Mg	Na
D	I ₂	Si	K

Topic **Chem 9 Q# 574/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

5 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?

- A** The nuclear charge of the elements increases.
- B** The outer electron is in an 's' subshell.
- C** The repulsion between spin-paired electrons increases.
- D** The shielding effect of the inner shells increases.

Topic **Chem 9 Q# 575/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which oxides react with water to give a solution of pH 10 or higher?

- 1** CaO
- 2** Na₂O
- 3** SrO

Topic **Chem 9 Q# 576/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



34 Which statements are correct?

- 1 Aluminium chloride dissolves in water to give an acidic solution.
- 2 Magnesium chloride dissolves in water to give a slightly acidic solution.
- 3 Sodium chloride dissolves in water to give an alkaline solution.

Topic **Chem 9 Q# 577**/ AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.

What minimum volume of acid will be required for complete reaction?

- A** 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 60 cm^3

Topic **Chem 9 Q# 578**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

- A** A phosphorus atom has one more proton in its nucleus.
B The atomic radius of a phosphorus atom is greater.
C The outer electron in a phosphorus atom is more shielded.

Topic **Chem 9 Q# 579**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 2//www.SmashingScience.org :o)

2 Use of the Data Booklet is relevant to this question.

The elements radon (Rn), francium (Fr) and radium (Ra) have consecutive proton numbers in the Periodic Table.

What is the order of their first ionisation energies?

	least endothermic	→	most endothermic
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

Topic **Chem 9 Q# 580**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 Two properties of non-metallic elements and their atoms are as follows.

property 1 has an oxide that can form a strong acid in water

property 2 has **no** paired 3p electrons

Which properties do phosphorus and sulfur have?

	phosphorus	sulfur
A	1 and 2	1 only
B	1 only	1 and 2
C	1 and 2	1 and 2
D	2 only	1 only

18 Which element of the third period requires the least number of moles of oxygen for the complete combustion of 1 mol of the element?

- A aluminium
- B magnesium
- C phosphorus
- D sodium

16 Consecutive elements X, Y, Z are in the third period of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point.

What could be the identities of X, Y and Z?

- A aluminium, silicon, phosphorus
- B magnesium, aluminium, silicon
- C silicon, phosphorus, sulfur
- D sodium, magnesium, aluminium

14 The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What is element **X**?

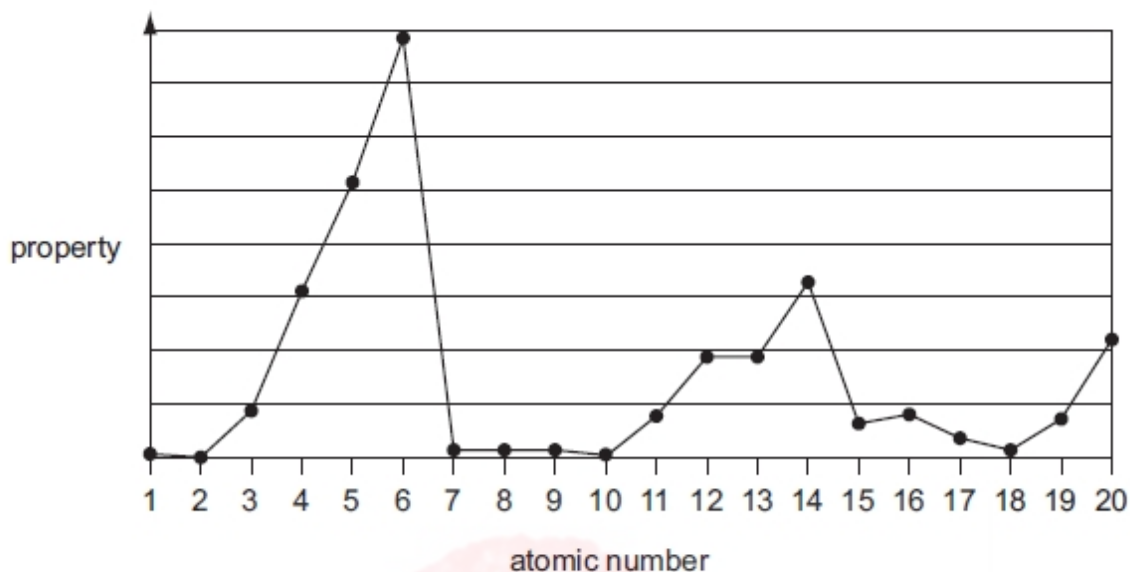
- A sodium
- B magnesium
- C aluminium
- D phosphorus

13 Which statement correctly describes what happens when silicon tetrachloride is added to water?

- A The SiCl_4 dissolves to give a neutral solution only.
- B The SiCl_4 reacts to give an acidic solution only.
- C The SiCl_4 reacts to give a precipitate and an acidic solution.
- D The SiCl_4 reacts to give a precipitate and a neutral solution.



12 The following graph shows the variation of a property of the first 20 elements in the Periodic Table with the atomic number of the element.



What is the property?

- A** atomic radius
- B** first ionisation energy
- C** ionic radius
- D** melting point

Topic **Chem 10 Q# 586**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

8 The carbonate of an s-block element is reacted with an excess of hydrochloric acid.

0.833 g of the carbonate releases 200 cm³ of gas, measured under room conditions.

What is the identity of the metal carbonate?

- A** Na₂CO₃
- B** K₂CO₃
- C** MgCO₃
- D** CaCO₃

Topic **Chem 10 Q# 587**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 Which row is correct?

	the temperature needed to decompose Group 2 metal nitrates	the solubility of Group 2 sulfates
A	decreases down the group	decreases down the group
B	decreases down the group	increases down the group
C	increases down the group	increases down the group
D	increases down the group	decreases down the group

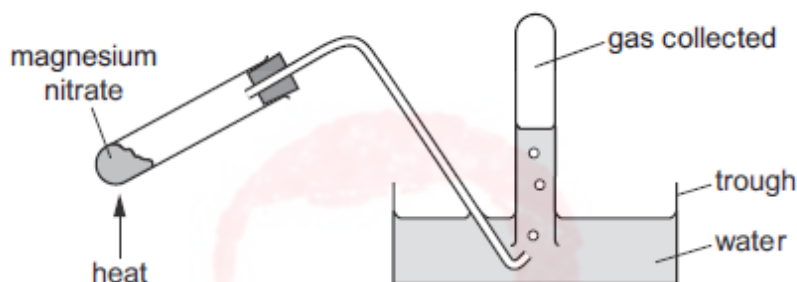


- 3** In separate experiments, 5.0 g samples of each of four s-block metals are added to an excess of water. The gas evolved is collected and its volume measured under the same conditions of temperature and pressure for each sample.

Which metal produces the largest volume of gas?

- A calcium
- B potassium
- C rubidium
- D strontium

- 21** A sample of magnesium nitrate is heated in the apparatus shown.



The pH of the solution in the trough is measured.

The gas collected is tested with a glowing splint.

What are the results?

	pH of solution in trough	splint test
A	8	relights
B	2	relights
C	8	extinguished
D	2	extinguished

- 20** A mixture contains magnesium carbonate and barium carbonate only. A sample of the mixture is dissolved in nitric acid to produce a solution.

How could this solution be processed into a magnesium compound and a separate barium compound?

- A Add HCl(aq) , filter off the solid barium chloride.
- B Add HCl(aq) , filter off the solid magnesium chloride.
- C Add $\text{H}_2\text{SO}_4\text{(aq)}$, filter off the solid barium sulfate.
- D Add $\text{H}_2\text{SO}_4\text{(aq)}$, filter off the solid magnesium sulfate.

- 21** Which row gives correct comparisons between the solubilities of calcium hydroxide and barium hydroxide and the thermal stabilities of calcium carbonate and barium carbonate?

	solubility		thermal stability	
	calcium hydroxide	barium hydroxide	calcium carbonate	barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

- 20** Equal masses of CaCO_3 , $\text{Ca}(\text{NO}_3)_2$, BaCO_3 and $\text{Ba}(\text{NO}_3)_2$ are thermally decomposed. The volume of gas produced in each experiment is measured under the same conditions.

Which compound will produce the greatest volume of gas?

- A** CaCO_3 **B** $\text{Ca}(\text{NO}_3)_2$ **C** BaCO_3 **D** $\text{Ba}(\text{NO}_3)_2$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36** Which statements about calcium oxide are correct?

- 1** It can be reduced by heating with magnesium.
- 2** It is produced when calcium nitrate is heated.
- 3** It reacts with cold water.

- 15** Anhydrous magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, decomposes when heated, giving a white solid and a mixture of two gases, X and Y.

Y is oxygen.

What is the ratio $\frac{\text{mass of X released}}{\text{mass of Y released}}$?

- A** $\frac{1}{0.174}$ **B** $\frac{1}{0.267}$ **C** $\frac{1}{0.348}$ **D** $\frac{1}{3.43}$

- 14** In which list are all three compounds soluble in water?

- A** barium chloride, calcium carbonate, magnesium hydroxide
- B** barium hydroxide, calcium hydroxide, strontium carbonate
- C** barium chloride, barium hydroxide, magnesium sulfate
- D** barium sulfate, calcium sulfate, magnesium hydroxide



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Which statements are correct?

- 1** Magnesium carbonate decomposes at a lower temperature than calcium carbonate.
- 2** Calcium hydroxide is more soluble in water than magnesium hydroxide.
- 3** Calcium is a stronger reducing agent than magnesium.

Topic **Chem 10 Q# 597/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 Which substance will **not** be a product of the thermal decomposition of hydrated magnesium nitrate?

- A** dinitrogen monoxide
- B** magnesium oxide
- C** oxygen
- D** steam

Topic **Chem 10 Q# 598/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 Q is a mixture of a Group 2 oxide and a Group 2 sulfate. Q contains equal amounts of the two compounds.

Q is shaken with water and the resulting mixture filtered; a solid residue is obtained. There is no reaction when the solid residue is shaken with HCl(aq) . Shaking the filtrate with $\text{H}_2\text{SO}_4\text{(aq)}$ produces a white precipitate.

What could be Q?

- A** $\text{BaO} + \text{BaSO}_4$
- B** $\text{BaO} + \text{MgSO}_4$
- C** $\text{MgO} + \text{BaSO}_4$
- D** $\text{MgO} + \text{MgSO}_4$

Topic **Chem 10 Q# 599/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 An anhydrous white salt, Z, is heated strongly for 30 minutes. A mixture of gases is given off. The solid remaining in the test-tube is then dissolved in a small volume of dilute hydrochloric acid. The addition of a few drops of dilute sulfuric acid to the test-tube causes a white precipitate to form.

Which substance could be Z?

- A** barium carbonate
- B** barium nitrate
- C** magnesium carbonate
- D** magnesium nitrate



14 Which row correctly describes one property of barium and one property of barium oxide?

	observation when barium metal is added to water	pH of solution obtained when a spatula measure of BaO is added to 100 cm ³ of water
A	a few gas bubbles form on the metal surface	8
B	a few gas bubbles form on the metal surface	13
C	rapid effervescence is seen	8
D	rapid effervescence is seen	13

19 Sulfur dioxide, SO₂, reacts with calcium hydroxide in aqueous solution.

What is the main product that is first formed?

A Ca(HSO₄)₂ **B** CaS **C** CaSO₃ **D** CaSO₄

18 What are the trends in the stated properties as Group 2 is descended from magnesium to barium?

	decomposition temperature of the carbonate	first ionisation energy
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

15 A student mixes pairs of chemicals together in separate test-tubes.

- excess calcium (s) + water (l)
- barium chloride (aq) + strontium hydroxide (aq)
- calcium carbonate (s) + excess hydrochloric acid (aq)
- magnesium sulfate (aq) + barium nitrate (aq)

How many of the mixtures produce a white, solid product?

A 0 **B** 1 **C** 2 **D** 3

13 This question is about two elements in Group 2, Q and R.

Three of the statements shown are correct for metal Q.

The one remaining statement is correct for metal R.

Which statement applies to R?

- A** A saturated solution of the hydroxide of this metal has the higher pH value.
- B** This metal has a carbonate that is used in agriculture to reduce the acidity of soil.
- C** This metal has the greater atomic radius.
- D** This metal reacts more quickly with cold water.

Topic **Chem 10 Q# 605/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 0.25 g of anhydrous magnesium nitrate is heated strongly until it completely decomposes.

What is the total volume of gas produced, measured under room conditions?

- A** 40 cm³
- B** 81 cm³
- C** 101 cm³
- D** 202 cm³

Topic **Chem 10 Q# 606/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 An excess of MgO is shaken with water. The resulting mixture is filtered into test-tube P.

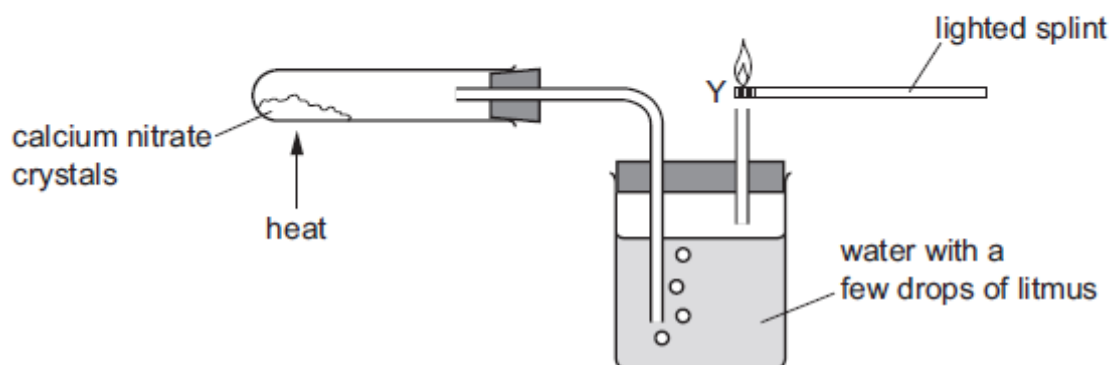
An excess of BaO is shaken with water. The resulting mixture is filtered into test-tube Q.

Which oxide reacts more readily with water and which filtrate has the **lower** pH?

	oxide reacts more readily with water	test-tube with filtrate of lower pH
A	BaO	P
B	BaO	Q
C	MgO	P
D	MgO	Q

17 A student investigates calcium nitrate crystals by heating them in the apparatus shown.

A colourless gas leaves the apparatus at Y. A flame is held to this gas.



Which observations would the student make?

	litmus solution	flame at Y
A	changes to blue	flame burns more brightly
B	changes to blue	flame goes out
C	changes to red	flame burns more brightly
D	changes to red	flame goes out

13 Compound Z is insoluble in water but soluble at low pH.

What could be compound Z?

- A** barium carbonate
- B** barium chloride
- C** barium hydroxide
- D** barium sulfate

15 Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg^{2+} , the other contains Ba^{2+} . Tests are carried out on separate 5 cm^3 samples of P and Q.

test 1: add 1 cm^3 of $0.1\text{ mol dm}^{-3}\text{ Na}_2\text{SO}_4(\text{aq})$

test 2: add 1 cm^3 of $0.1\text{ mol dm}^{-3}\text{ NaOH}(\text{aq})$

What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba^{2+}	more precipitate with Ba^{2+}
B	more precipitate with Ba^{2+}	more precipitate with Mg^{2+}
C	more precipitate with Mg^{2+}	more precipitate with Ba^{2+}
D	more precipitate with Mg^{2+}	more precipitate with Mg^{2+}

- 14** A 5.00g sample of an anhydrous Group 2 metal nitrate loses 3.29g in mass when heated strongly.

Which metal is present?

- A** magnesium
- B** calcium
- C** strontium
- D** barium

Topic **Chem 10 Q# 611**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

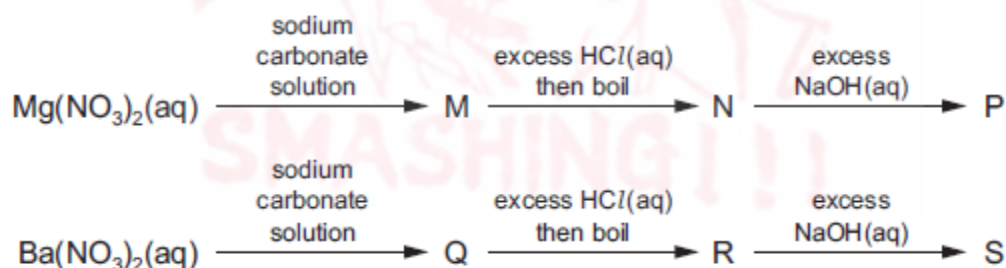
- 36** A mixture of magnesium carbonate and magnesium nitrate is heated strongly in a hard-glass test-tube.

Which gases are formed?

- 1** carbon dioxide
- 2** nitrogen dioxide
- 3** oxygen

Topic **Chem 10 Q# 612**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

- 15** Solutions of $0.1 \text{ mol dm}^{-3} \text{ Mg(NO}_3)_2$ and $0.1 \text{ mol dm}^{-3} \text{ Ba(NO}_3)_2$ separately undergo a series of reactions using pure reagents.



M, N and P are magnesium compounds.

Q, R and S are barium compounds.

How many of M, N, P, Q, R and S are white precipitates?

- A** 2
- B** 3
- C** 4
- D** 5



- 14** Substance X reacts with water. A gas is given off and the pH of the solution increases. The solution is then reacted with sulfuric acid and a white precipitate forms.

What could be substance X?

- A barium
- B barium oxide
- C magnesium
- D magnesium oxide

- 16** L, M and N are Group 2 metals. L reacts more vigorously with dilute hydrochloric acid than N does. $M(OH)_2$ is more soluble than $N(OH)_2$.

What could be the identities of L, M and N?

	L	M	N
A	Ba	Ca	Sr
B	Ba	Sr	Ca
C	Ca	Ba	Sr
D	Sr	Ca	Ba

- 15** When calcium nitrate thermally decomposes, oxygen is one of the products.

Which volume of oxygen is produced under room conditions when 0.50 mol of calcium nitrate thermally decomposes?

- A 6.0 dm^3
- B 12.0 dm^3
- C 18.0 dm^3
- D 30.0 dm^3

- 14** Metal T reacts with water to produce a colourless solution. A white precipitate is produced when this colourless solution is mixed with aqueous sulfuric acid.

What is metal T?

- A barium
- B magnesium
- C potassium
- D sodium

- 4** 5.0 g samples of the carbonates of barium, copper, lithium and magnesium are decomposed to the metal oxides and carbon dioxide.

For which compound is there the greatest loss in mass?

- A** barium carbonate
- B** copper(II) carbonate
- C** lithium carbonate
- D** magnesium carbonate

Topic **Chem 10 Q# 618**/ AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36** Which properties increase from magnesium to barium?

- 1** ionic radius of the cation M^{2+}
- 2** screening of outermost electrons by inner shells
- 3** solubility of the hydroxides, $M(OH)_2$, in water

Topic **Chem 10 Q# 619**/ AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 35** Which reaction routes can be used to make a pure sample of barium sulfate?

- 1** Ba metal $\xrightarrow[\text{in } O_2]{\text{heat}}$ product $\xrightarrow[HCl]{\text{dilute}}$ product 2 $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 3 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$
- 2** $Ba(NO_3)_2$ $\xrightarrow[\text{heat in air}]{\text{strong}}$ solid product $\xrightarrow[\text{of water}]{\text{an excess}}$ product 2 $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 3 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$
- 3** $Ba(OH)_2$ $\xrightarrow[HNO_3]{\text{dilute}}$ product $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 2 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$



- 15** A sample of anhydrous calcium nitrate is placed in a test-tube and heated in a roaring Bunsen flame until it decomposes. The description of the gas in the test-tube is then noted. A glowing splint is then put into the test-tube and any changes are noted.

Which observations are correct?

	description of the gas in the test-tube	result of glowing splint test
A	brown	the splint goes out
B	brown	the splint relights
C	colourless	the splint goes out
D	colourless	the splint relights

- 18** When 3.00g of an anhydrous nitrate of a Group 2 metal is decomposed, 1.53g of gas is produced.

What is the nitrate compound?

- A** beryllium nitrate
- B** calcium nitrate
- C** magnesium nitrate
- D** strontium nitrate

- 15** A solution contains both $\text{Mg}^{2+}(\text{aq})$ and $\text{Sr}^{2+}(\text{aq})$ at the same concentration.

The solution is divided into two equal portions. Aqueous sodium hydroxide is added dropwise to one portion. Dilute sulfuric acid is added dropwise to the other portion.

Which row is correct?

	precipitate seen first when $\text{NaOH}(\text{aq})$ is added	precipitate seen first when $\text{H}_2\text{SO}_4(\text{aq})$ is added
A	magnesium hydroxide	magnesium sulfate
B	magnesium hydroxide	strontium sulfate
C	strontium hydroxide	magnesium sulfate
D	strontium hydroxide	strontium sulfate

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which statements about the elements barium and calcium and their compounds are correct?

- 1 Barium nitrate decomposes at a higher temperature than calcium nitrate.
- 2 Barium hydroxide is more soluble in water than is calcium hydroxide.
- 3 Calcium is more reactive with water than is barium.

Topic **Chem 10 Q# 624/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 15//

15 The mineral dolomite is a mixture of magnesium carbonate and calcium carbonate.

An aqueous reagent, X, was added to a small sample of dolomite. Effervescence was seen and a white solid, Y, was formed.

What could be the correct identity of reagent X and solid Y?

	reagent X	solid Y
A	hydrochloric acid	calcium chloride
B	hydrochloric acid	magnesium chloride
C	sulfuric acid	calcium sulfate
D	sulfuric acid	magnesium sulfate

Topic **Chem 10 Q# 625/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 Samples of magnesium carbonate, MgCO_3 , are placed in crucibles R and S. The sample in crucible R is heated until there is no further loss in mass, and then allowed to cool. The sample in crucible S is left unheated.

Dilute hydrochloric acid is then added to both crucibles.

On adding the dilute hydrochloric acid, which observations are correct?

	R	S
A	gas produced	gas produced
B	gas produced	no gas produced
C	no gas produced	gas produced
D	no gas produced	no gas produced

14 An excess of MgO is shaken with water. The resulting mixture is filtered into test-tube X.

An excess of BaO is shaken with water. The resulting mixture is filtered into test-tube Y.

Which oxide reacts more readily with water and which filtrate has the **lower** pH?

	oxide reacts more readily with water	test-tube with filtrate of lower pH
A	barium oxide	X
B	barium oxide	Y
C	magnesium oxide	X
D	magnesium oxide	Y

18 Z is an anhydrous compound of a Group 2 element. When it is heated, Z undergoes thermal decomposition to produce two different gases. Z has relatively low thermal stability compared to other Group 2 compounds containing the same anion as Z.

What is compound Z?

- A** barium carbonate
- B** barium nitrate
- C** magnesium carbonate
- D** magnesium nitrate

14 Why does barium react more rapidly with cold water than magnesium does?

- A** Barium atoms are larger and form ions more easily than magnesium atoms.
- B** Barium floats on the surface of the water but magnesium sinks in the water.
- C** Barium hydroxide is less soluble than magnesium hydroxide.
- D** The sum of the 1st and 2nd ionisation energies of barium is more than that for magnesium.

18 Which row of the table gives correct comparisons between the solubilities of calcium and barium hydroxide and the thermal stabilities of calcium and barium carbonate?

	solubility		thermal stability	
	calcium hydroxide	barium hydroxide	calcium carbonate	barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher



16 Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

- A** 1.5 g **B** 2.3 g **C** 3.0 g **D** 4.6 g

14 X and Y are both Group 2 metals.

X and Y both form hydroxide compounds, but $\text{X}(\text{OH})_2$ is more soluble in water than $\text{Y}(\text{OH})_2$.

If a piece of metal Y is put into cold water a very slow reaction occurs, and only a very few, small hydrogen bubbles can be seen.

What could be the identities of X and Y?

	X	Y
A	barium	magnesium
B	barium	strontium
C	calcium	strontium
D	magnesium	calcium

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 A sample containing 0.40 mol of calcium nitrate was decomposed by heating in a roaring Bunsen burner flame until there was no further decomposition.

What are the products of this reaction?

- 1** 0.40 mol of calcium oxide
2 0.40 mol of nitrogen, $\text{N}_2(\text{g})$
3 0.40 mol of oxygen, $\text{O}_2(\text{g})$

18 River water in a chalky agricultural area contains Ca^{2+} , Mg^{2+} , CO_3^{2-} , HCO_3^- , Cl^- and NO_3^- ions. In a water treatment plant, such water is treated by adding a calculated quantity of calcium hydroxide.

What will be precipitated from the river water following the addition of calcium hydroxide?

- A** CaCl_2 **B** CaCO_3 **C** $\text{Ca}(\text{NO}_3)_2$ **D** $\text{Mg}(\text{NO}_3)_2$



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which statements concerning the Group II elements magnesium, calcium and barium are correct?

- 1** Their reactivity increases with increasing relative atomic mass.
- 2** The oxidation number exhibited in their stable compounds is +2.
- 3** On strong heating, their nitrates give off oxygen only.

Topic **Chem 10 Q# 635/** AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

- A** barium carbonate
- B** barium chloride
- C** barium hydroxide
- D** barium sulfate

Topic **Chem 10 Q# 636/** AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

12 **X** is a Group II metal. The carbonate of **X** decomposes when heated in a Bunsen flame to give carbon dioxide and a white solid residue as the only products. This white solid residue is sparingly soluble in water. Even when large amounts of the solid residue are added to water the pH of the saturated solution is less than that of limewater.

What could be the identity of **X**?

- A** magnesium
- B** calcium
- C** strontium
- D** barium

Topic **Chem 10 Q# 637/** AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36 X is a Group II metal. It forms a sulfate which is more soluble than barium sulfate. It forms a hydroxide which is more soluble than calcium hydroxide.

What could be the identity of X?

- 1 strontium
- 2 magnesium
- 3 beryllium

Topic **Chem 10 Q# 638/** AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 Use of the Data Booklet is relevant to this question.

Which mass of solid residue will be obtained from the thermal decomposition of 4.10g of anhydrous calcium nitrate?

- A** 0.70g **B** 1.00g **C** 1.40g **D** 2.25g

Topic **Chem 10 Q# 639/** AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

- 13 The three minerals below are obtained from mines around the world. Each one behaves as a mixture of two carbonate compounds. They can be used as fire retardants because they decompose in the heat, producing CO₂. This gas smothers the fire.

barytocide	BaCa(CO ₃) ₂
dolomite	CaMg(CO ₃) ₂
huntite	Mg ₃ Ca(CO ₃) ₄

What is the order of effectiveness as fire retardant, from best to worst?

	best → worst		
A	dolomite	barytocide	huntite
B	dolomite	huntite	barytocide
C	huntite	barytocide	dolomite
D	huntite	dolomite	barytocide

Topic **Chem 10 Q# 640/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

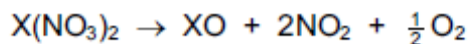
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36 Which statements about calcium oxide are correct?

- 1 It reacts with cold water.
- 2 It is produced when calcium nitrate is heated.
- 3 It can be reduced by heating with magnesium.

17 Group II nitrates undergo thermal decomposition according to the following equation.



Which Group II nitrate requires the highest temperature to bring about its thermal decomposition?

- A barium nitrate
- B calcium nitrate
- C magnesium nitrate
- D strontium nitrate

13 When equal volumes of saturated solutions of barium hydroxide and calcium hydroxide are mixed, a white precipitate, Y, forms. The mixture is filtered and carbon dioxide is bubbled through the filtrate, producing a second white precipitate, Z.

What are Y and Z?

	Y	Z
A	Ba(OH) ₂	Ca(OH) ₂
B	Ba(OH) ₂	CaCO ₃
C	Ca(OH) ₂	BaCO ₃
D	Ca(OH) ₂	Ba(OH) ₂

14 Which property **increases** in value going down Group II?

- A electronegativity
- B ionic radius
- C maximum oxidation number
- D second ionisation energy

13 A metal, X, reacts with water to produce a colourless solution which gives a white precipitate when mixed with aqueous sulfuric acid.

What is metal X?

- A barium
- B magnesium
- C potassium
- D sodium

16 Use of the Data Booklet is relevant to this question.

Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

- A** 1.5g **B** 2.3g **C** 3.0g **D** 4.6g

13 In which row of the table are all statements comparing the compounds of magnesium and barium correct?

	solubility of hydroxides		solubility of sulfates	
	solubility of magnesium hydroxide	solubility of barium hydroxide	solubility of magnesium sulfate	solubility of barium sulfate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

15 Use of the Data Booklet is relevant to this question.

The nitrates of beryllium, calcium, magnesium, and strontium all decompose in the same way when heated. When 2.00 g of one of these anhydrous nitrates is decomposed, 1.32 g of gas is produced.

What is the nitrate?

- A** beryllium nitrate
B calcium nitrate
C magnesium nitrate
D strontium nitrate

14 What are the trends in the stated properties as Group II is descended from magnesium to barium?

	decomposition temperature of the carbonate	first ionisation energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

13 *Use of the Data Booklet is relevant to this question.*

When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

- A aragonite, CaCO_3
- B artinite, $\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$
- C barytocalcite, $\text{BaCO}_3 \cdot \text{CaCO}_3$
- D dolomite, $\text{CaCO}_3 \cdot \text{MgCO}_3$

15 *Use of the Data Booklet is relevant to this question.*

A 5.00 g sample of an anhydrous Group II metal nitrate loses 3.29 g in mass when heated strongly.

Which metal is present?

- A magnesium
- B calcium
- C strontium
- D barium

14 *Use of the Data Booklet is relevant to this question.*

A significant contribution to atmospheric carbon dioxide levels comes from the thermal decomposition of limestone, in the manufacture of cement and of lime for agricultural purposes.

Cement works roast 1000 million tonnes of limestone per year and a further 200 million tonnes is roasted in kilns to make lime.

What is the total annual mass output of carbon dioxide (in million tonnes) from these two processes?

- A 440 B 527 C 660 D 880

14 Steam is passed over heated magnesium to give compound X and hydrogen.

What is **not** a property of compound X?

- A It has an M_r of 40.3.
- B It is basic.
- C It is a white solid.
- D It is very soluble in water.



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34** Samples of calcium and barium are separately added to beakers of cold water containing a few drops of litmus solution.

Which observations will be made with **only** the calcium and **not** with the barium?

- 1** A white suspension appears in the water.
- 2** The solution turns blue.
- 3** A gas is evolved.

Topic **Chem 10 Q# 654/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

- 19** Which property of beryllium and its compounds is typical of the elements below it in Group II?

- A** Be does not react with hot water.
- B** BeCl_2 is covalent.
- C** $\text{Be}(\text{NO}_3)_2$ produces BeO on thermal decomposition.
- D** BeO dissolves in alkalis.

Topic **Chem 10 Q# 655/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

- 14** When magnesium nitrate, $\text{Mg}(\text{NO}_3)_2 \cdot 7\text{H}_2\text{O}$, is heated, which three gases are given off?

- A** dinitrogen oxide, oxygen, water vapour
- B** hydrogen, nitrogen, oxygen
- C** hydrogen, nitrogen dioxide, oxygen
- D** nitrogen dioxide, oxygen, water vapour

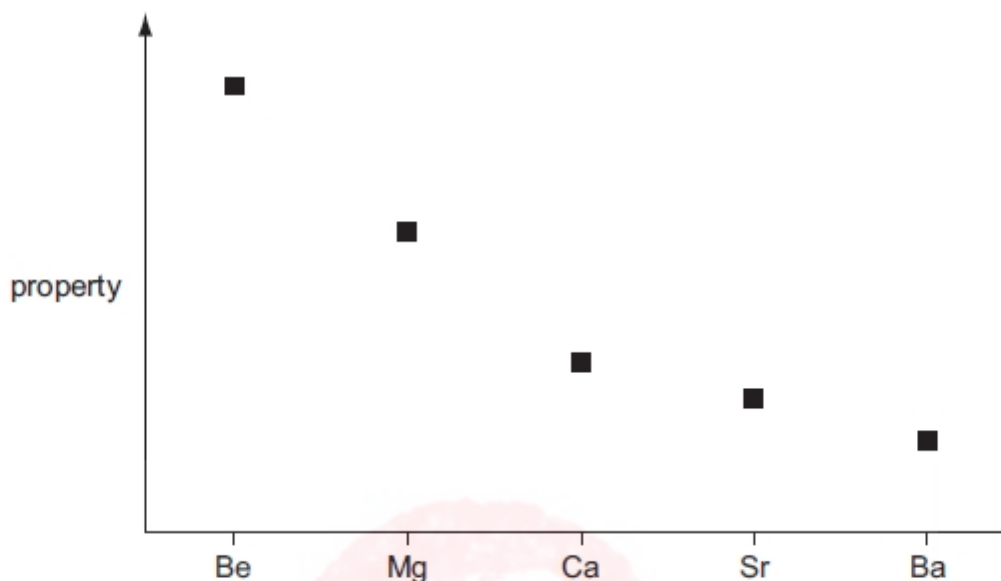
Topic **Chem 10 Q# 656/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

- 17** Which property of Group II elements (beryllium to barium) decreases with increasing atomic number?

- A** reactivity with water
- B** second ionisation energy
- C** solubility of hydroxides
- D** stability of the carbonates

3 Use of the Data Booklet is relevant to this question.

The graph represents the variation of a property of the Group II elements.



What is this property?

- A ionic radius
- B ionisation energy
- C neutron/proton ratio
- D rate of reaction with water

Topic **Chem 10 Q# 658**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

- 13** River water in a chalky agricultural area may contain Ca^{2+} , Mg^{2+} , CO_3^{2-} , HCO_3^- , Cl^- and NO_3^- ions. In a waterworks, such water is treated by adding a calculated quantity of calcium hydroxide.

What will be precipitated following the addition of calcium hydroxide?

- A CaCl_2
- B CaCO_3
- C $\text{Ca}(\text{NO}_3)_2$
- D $\text{Mg}(\text{NO}_3)_2$

Topic **Chem 10 Q# 659**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 11//www.SmashingScience.org :o)

- 11** In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate in which heat is evolved and an unreactive gas is produced.

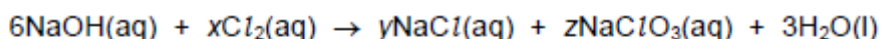
What is the equation for this reaction?

- A $2\text{Al} + \text{Ba}(\text{NO}_3)_2 \rightarrow \text{Al}_2\text{O}_3 + \text{BaO} + 2\text{NO}$
- B $4\text{Al} + 4\text{Ba}(\text{NO}_3)_2 \rightarrow 2\text{Al}_2\text{O}_3 + 4\text{Ba}(\text{NO}_2)_2 + \text{O}_2$
- C $10\text{Al} + 3\text{Ba}(\text{NO}_3)_2 \rightarrow 5\text{Al}_2\text{O}_3 + 3\text{BaO} + 3\text{N}_2$
- D $10\text{Al} + 18\text{Ba}(\text{NO}_3)_2 \rightarrow 10\text{Al}(\text{NO}_3)_3 + 18\text{BaO} + 3\text{N}_2$



:o)

- 22** Chlorine is bubbled through 100 cm^3 of hot 4.0 mol dm^{-3} sodium hydroxide until the reaction is complete.



Which row is correct?

	x	$[\text{Na}^+](\text{aq})$ after reaction / mol dm^{-3}
A	3	4.0
B	3	less than 4.0
C	6	4.0
D	6	less than 4.0

Topic Chem 11 Q# 661/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

- 21** Which statement about Group 17 elements and compounds is correct?

- A** Sodium chloride produces chlorine when reacted with concentrated sulfuric acid.
- B** Sodium chloride produces chlorine when reacted with bromine.
- C** Sodium bromide produces bromine when reacted with concentrated sulfuric acid.
- D** Sodium bromide produces bromine when reacted with iodine in aqueous potassium iodide.

Topic Chem 11 Q# 662/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

- 22** The results of tests performed on a white crystalline solid, X, are given in the table.

reagent and conditions	observation
X is gently heated	X sublimes
X is shaken with H_2O	a colourless solution, Y, forms
Y is warmed with $\text{NaOH}(\text{aq})$	a gas is given off
$\text{AgNO}_3(\text{aq})$ is added to Y	a white precipitate, Z, forms
Z is shaken with $\text{NH}_3(\text{aq})$	a colourless solution forms

What is the identity of X?

- A** aluminium bromide
- B** aluminium chloride
- C** ammonium bromide
- D** ammonium chloride

Topic Chem 11 Q# 663/ AS Chemistry/2022/m/TZ 2/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

- 23** An excess of chlorine was bubbled into 100 cm^3 of hot 6.0 mol dm^{-3} sodium hydroxide.

How many moles of sodium chloride would be produced in the reaction?

- A** 0.30
- B** 0.50
- C** 0.60
- D** 0.72



22 Which statement relating to the elements in Group 17 and their compounds is correct?

- A Bromine will reduce KI to form iodine.
- B Iodide ions react to form a white precipitate when added to silver nitrate solution.
- C Bromide ions react to form a white precipitate when added to silver nitrate solution.
- D Chlorine reacts with hydrogen to form a colourless gas.

Topic **Chem 11 Q# 665/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 Z is a compound of sodium, chlorine and oxygen.

It contains 45.1% by mass of oxygen.

Z is prepared by reacting sodium hydroxide with chlorine.

Which row shows the conditions used for the reaction and the oxidation state of chlorine in Z?

	reaction conditions	oxidation state of Cl in Z
A	cold dilute NaOH	+1
B	cold dilute NaOH	+5
C	hot concentrated NaOH	+1
D	hot concentrated NaOH	+5

Topic **Chem 11 Q# 666/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 In a series of nine experiments, to test the reactivity of the halogens, an aqueous solution of each halogen is added to an equal volume of an aqueous solution containing halide ions, as shown in the table.

halogen solution	halide solution		
	sodium chloride (aq)	sodium bromide (aq)	sodium iodide (aq)
chlorine (aq)	experiment 1	experiment 2	experiment 3
bromine (aq)	experiment 4	experiment 5	experiment 6
iodine (aq)	experiment 7	experiment 8	experiment 9

The nine resulting mixtures are then shaken separately with an equal volume of hexane. The nine tubes are left to stand so that the aqueous and organic solvents separate into layers.

How many test-tubes contain a purple upper hexane layer?

- A** 1 **B** 2 **C** 3 **D** 5

Topic **Chem 11 Q# 667/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 The volatility of the Group 17 elements, chlorine, bromine and iodine, decreases down the group.

What is responsible for this trend?

- A bond length in the halogen molecule
- B bond strength in the halogen molecule
- C electronegativity of the halogen atom
- D number of electrons in the halogen atom



- 16** A 5 cm^3 sample of 0.05 mol dm^{-3} sodium chloride is mixed with a 5 cm^3 sample of 0.05 mol dm^{-3} potassium iodide. 10 cm^3 of acidified 0.05 mol dm^{-3} silver nitrate is then added, followed by concentrated ammonia solution.

What is seen after the addition of an excess of concentrated ammonia solution?

- A a cream precipitate
- B a white precipitate
- C a yellow precipitate
- D no precipitate

- 17** When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

- A Hydrogen sulfide is the product of a reduction reaction.
- B Iodide ions are stronger oxidising agents than sulfate ions.
- C Sulfur atoms from the sulfuric acid are both oxidised and reduced.
- D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

- 16** Chlorine gas is reacted with aqueous sodium hydroxide. The oxidation number of chlorine changes from 0 to -1 and also from 0 to $+1$.

Under which conditions does this reaction occur and what is the colour of the solid silver salt with chlorine in the oxidation state -1 ?

	reaction conditions	colour of silver salt
A	cold, dilute alkali	white
B	cold, dilute alkali	yellow
C	hot, concentrated alkali	white
D	hot, concentrated alkali	yellow

- 16** With which compound does concentrated sulfuric acid react **both** as a strong acid **and** as an oxidising agent?

- A magnesium carbonate
- B potassium chloride
- C sodium bromide
- D sulfur trioxide

14 The electronic arrangement for atoms of four elements is given.

Which element is the strongest oxidising agent?

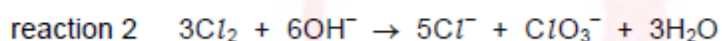
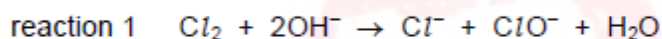
- A $1s^2 2s^2 2p^5$
- B $1s^2 2s^2 2p^6 3s^2$
- C $1s^2 2s^2 2p^6 3s^2 3p^5$
- D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

Topic **Chem 11 Q# 673/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Chlorine reacts with sodium hydroxide in two different ways depending upon the temperature.



Which statements about these reactions are correct?

- 1 Reaction 2 requires a higher temperature than reaction 1.
- 2 The products of reaction 1 show chlorine in two different oxidation states.
- 3 The products of reaction 2 show oxygen in two different oxidation states.

Topic **Chem 11 Q# 674/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Astatine, At, is below iodine in Group 17 of the Periodic Table.

Which statement is most likely to be correct?

- A $AgAt(s)$ reacts with an excess of dilute aqueous ammonia to form a solution of a soluble complex.
- B Astatine and $KCl(aq)$ react to form $KAt(aq)$ and chlorine.
- C $KAt(aq)$ and dilute sulfuric acid react to form $HAt(g)$.
- D $NaAt(s)$ and concentrated sulfuric acid react to form astatine.



12 A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. An excess of aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.

An excess of concentrated ammonia is then added to the test-tube containing X. After the test-tube has been shaken, a precipitate, Y, is observed.

Which statement about X or Y is correct?

- A X is a pure white colour.
- B X is pure silver iodide.
- C Y is pure silver chloride.
- D Y is yellow.

Topic **Chem 11 Q# 676/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 The element astatine, At, is below iodine in Group 17 of the Periodic Table.

Which statements concerning At are likely to be correct?

- 1 It is a dark-coloured solid at room temperature.
- 2 It is a more powerful oxidising agent than iodine.
- 3 Its hydride is more thermally stable than HBr.

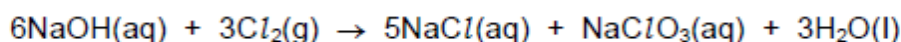
Topic **Chem 11 Q# 677/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 How does concentrated sulfuric acid behave when it reacts with sodium chloride?

- A as an acid only
- B as an acid and oxidising agent
- C as an oxidising agent only
- D as a reducing agent only

Topic **Chem 11 Q# 678/** AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 Hot aqueous sodium hydroxide reacts with chlorine.



Which statement is correct?

- A The oxidation numbers of chlorine and hydrogen both change in the reaction.
- B The oxidation numbers of chlorine in the products are -1 and $+1$.
- C If the aqueous sodium hydroxide is cold the reaction produces NaClO instead of NaClO_3 .
- D Sodium undergoes disproportionation in this reaction.



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which statements are correct?

- Chloride ions are oxidised when concentrated sulfuric acid is added to NaCl(s) .
- A disproportionation reaction takes place when chlorine is added to cold NaOH(aq) .
- An acidic solution forms when chlorine is added to water.

Topic **Chem 11 Q# 680/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 Sodium azide, NaN_3 , is dissolved in water. Acidified silver nitrate is added to the solution and a white precipitate forms. Aqueous ammonia is then added to the white precipitate.

The azide ion, N_3^- , has similar chemical properties to the Cl^- ion.

Which row of the table can be predicted from this information?

	formula of white precipitate	observation on adding aqueous ammonia
A	AgN_3	colourless solution formed
B	AgN_3	precipitate remains
C	Ag_3N	colourless solution formed
D	Ag_3N	precipitate remains

Topic **Chem 11 Q# 681/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

17 The reaction of bromine with warm NaOH(aq) produces products with the same oxidation numbers, in the same ratios, as the reaction of chlorine with hot NaOH(aq).

In one reaction between bromine and warm NaOH(aq), 30.2 g of a product containing sodium, bromine and oxygen is produced.

Which mass of NaOH has reacted?

- A** 8.00 g **B** 10.2 g **C** 20.3 g **D** 48.0 g

16 Concentrated sulfuric acid is added to separate solid samples of sodium chloride, sodium bromide and sodium iodide.

With which samples does sulfuric acid act as an oxidising agent?

- A** sodium chloride only
B sodium chloride and sodium bromide
C sodium bromide and sodium iodide
D sodium iodide only

18 Under standard conditions, which statement is correct?

- A** $\text{Cl}_2(\text{aq})$ can oxidise $\text{Br}^-(\text{aq})$.
B $\text{Cl}_2(\text{aq})$ can reduce $\text{Br}^-(\text{aq})$.
C $\text{Cl}^-(\text{aq})$ can oxidise $\text{Br}_2(\text{aq})$.
D $\text{Cl}^-(\text{aq})$ can reduce $\text{Br}_2(\text{aq})$.

17 The table shows some reactions of a white compound, G.

test	observation
silver nitrate is added to a solution of G followed by aqueous ammonia	a precipitate is formed which does not dissolve when the ammonia is added
solid G is warmed with concentrated sulfuric acid	a mixture of gases is formed including hydrogen sulfide

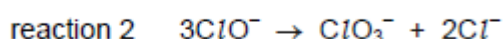
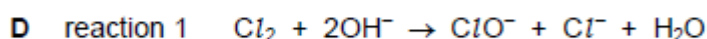
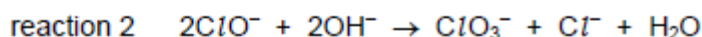
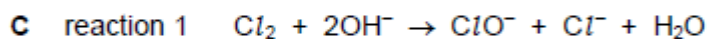
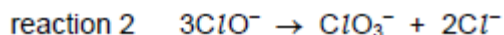
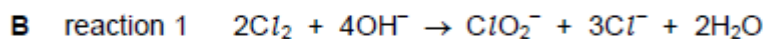
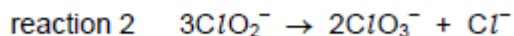
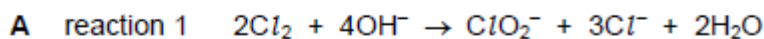
What could be the identity of G?

- A** caesium chloride
B lithium bromide
C potassium sulfate
D sodium iodide

17 Reaction 1: chlorine reacts with cold aqueous sodium hydroxide to form solution Z.

Reaction 2: solution Z is heated and forms $\text{ClO}_3^-(\text{aq})$ and $\text{Cl}^-(\text{aq})$.

Which equations represent reaction 1 and reaction 2?



Topic **Chem 11 Q# 687/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 Which row correctly describes the properties of the halogens as Group 17 is descended from chlorine to iodine?

	volatility	strength as oxidising agent
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Topic **Chem 11 Q# 688/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Each of the three mixtures shown can result in a chemical reaction.

Which mixtures result in a redox reaction?

1 bromine + hydrogen

2 sodium chloride + concentrated sulfuric acid

3 potassium iodide + silver nitrate

19 Which row correctly describes one property of barium and one property of barium oxide?

	observation when barium metal is added to water	pH of solution obtained when a spatula measure of BaO is added to 100 cm ³ of water
A	a few gas bubbles form on the metal surface	8
B	a few gas bubbles form on the metal surface	13
C	rapid effervescence is seen	8
D	rapid effervescence is seen	13

16 Aqueous silver nitrate is added to a solution of potassium iodide.

Aqueous ammonia is then added.

What would be observed?

- A** a cream precipitate that dissolves on addition of aqueous ammonia
- B** a cream precipitate that does not dissolve on addition of aqueous ammonia
- C** a yellow precipitate that dissolves on addition of aqueous ammonia
- D** a yellow precipitate that does not dissolve on addition of aqueous ammonia

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

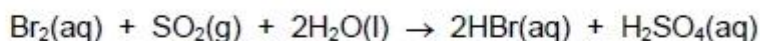
35 Chlorine reacts with **hot** aqueous sodium hydroxide.

Which oxidation states does chlorine show in the products of this reaction?

- 1** -1
- 2** +3
- 3** +1

17 Bromine is extracted from sea-water.

In the final stages of the process two redox reactions take place.



Which row is correct?

	strongest oxidising agent	→	weakest oxidising agent
A	Br_2	SO_2	Cl_2
B	Cl_2	Br_2	SO_2
C	Cl_2	SO_2	Br_2
D	SO_2	Br_2	Cl_2

Topic **Chem 11 Q# 693/** AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 The volatility of the Group 17 elements, chlorine, bromine and iodine, decreases down the group.

What is responsible for this?

- A** bond length in the halogen molecule
- B** bond strength in the halogen molecule
- C** electronegativity of the halogen
- D** number of electrons in the halogen molecule

Topic **Chem 11 Q# 694/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 19//

19 The strengths of the covalent bonds within halogen molecules, and the van der Waals' forces between halogen molecules, vary going down Group 17 from chlorine to bromine to iodine.

Which row shows these correctly?

	strength of covalent bonds	strength of van der Waals' forces
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Topic **Chem 11 Q# 695/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 18//

18 Compound Q is a white crystalline solid which dissolves easily in water. When concentrated sulfuric acid is added to a dry sample of Q steamy white fumes are formed which, when passed through aqueous silver nitrate solution, form a white precipitate. This precipitate is soluble in dilute ammonia solution.

What could be the identity of compound Q?

- A** AgCl
- B** NaBr
- C** NaCl
- D** PbBr_2



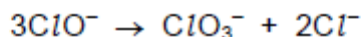
- 17** 71.0g of chlorine, Cl_2 , react with an excess of sodium hydroxide solution at a particular temperature. The reaction produces exactly 35.5g of product **X**.

What is product **X**?

- A** H_2O **B** NaCl **C** NaClO **D** NaClO_3

Topic **Chem 11 Q# 697/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 8//www.SmashingScience.org :o)

- 8** Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.



Which oxidation state is shown by chlorine in each of these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	-1
B	-1	+3	+1
C	+1	+5	-1
D	-1	+5	+1

Topic **Chem 11 Q# 698/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

- 19** Redox reactions are common in the chemistry of Group 17.

Which statement is correct?

- A** Br^- ions will reduce Cl_2 but not I_2 .
B Cl_2 will oxidise Br^- ions but not I^- ions.
C F_2 is the weakest oxidising agent out of F_2 , Cl_2 , Br_2 and I_2 .
D I^- ions are the weakest reducing agent out of F^- , Cl^- , Br^- and I^- .

Topic **Chem 11 Q# 699/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

- 18** A solution of sodium hydroxide reacts with 3 mol of chlorine under certain conditions. The reaction produces 5 mol of sodium chloride and 1 mol of **X**, the only other chlorine-containing product.

What is the formula of compound **X**?

- A** NaClO **B** NaClO_2 **C** NaClO_3 **D** NaClO_4

Topic **Chem 11 Q# 700/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

- 17** In an experiment, 0.600mol of chlorine gas, Cl_2 , is reacted with an excess of hot aqueous sodium hydroxide. One of the products is NaClO_3 .

Which mass of NaClO_3 is formed?

- A** 21.3g **B** 44.7g **C** 63.9g **D** 128g



16 Some uses of chlorine and bromine are given.

Which is a use of bromine?

- A** making bleaches for textiles and the paper industry
- B** making CFCs
- C** making flame retardants and fire extinguishers
- D** making the polymer PVC

19 X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2 , Y_2 and Z_2 were separately added to separate aqueous solutions containing X^- , Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row of the following table contains the ions X^- , Y^- and Z^- in order of their **decreasing** strength as reducing agents?

	strongest	→	weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

14 The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

- A** bond strength of the hydrogen-halide bond
- B** first ionisation energy
- C** solubility of the silver halide in $NH_3(aq)$
- D** strength of the van der Waals' forces between molecules of the element

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



35 The element astatine, At, is below iodine in Group 17 of the Periodic Table.

Which statements concerning At are likely to be correct?

- 1 It is a dark-coloured solid at room temperature.
- 2 It is a more powerful oxidising agent than iodine.
- 3 Its hydride is thermally stable.

Topic **Chem 11 Q# 705/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.

With NaCl, the products are NaHSO₄ and HCl.

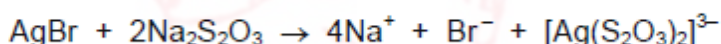
With NaI, the products are NaHSO₄, HI, I₂, SO₂, H₂O, S and H₂S.

What is the best explanation for this difference in products?

- A Chloride ions will displace iodine from solution.
- B Hydrogen chloride is more volatile than hydrogen iodide.
- C Iodide ions are better reducing agents than chloride ions.
- D Sulfuric acid is able to act as a dehydrating agent with NaI.

Topic **Chem 11 Q# 706/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 After black and white photographic film has been developed, unreacted silver bromide is removed by reaction with sodium thiosulfate.



What is the function of the thiosulfate ion?

- A to make the silver ions soluble
- B to oxidise the silver ions
- C to reduce the bromine
- D to reduce the silver ions

Topic **Chem 11 Q# 707/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 Hydrogen chloride gas and hydrogen iodide gas have different thermal stabilities. The difference is due to a difference in the energies of some of the covalent bonds that are involved in the decomposition.

Which row identifies the more stable of the two compounds, and gives the correct explanation?

	identity of the more thermally stable compound	explanation for the difference in stability
A	hydrogen chloride	the Cl-Cl bond is stronger than the I-I bond
B	hydrogen chloride	the H-Cl bond is stronger than the H-I bond
C	hydrogen iodide	the Cl-Cl bond is stronger than the I-I bond
D	hydrogen iodide	the H-Cl bond is stronger than the H-I bond



14 Chlorine gas is widely used to treat contaminated water.

Which species present in water when chlorine gas has been added is responsible for killing bacteria?

- A ClO_2^- B Cl^- C HCl D OCl^-

18 The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in excess dilute aqueous ammonia to form a colourless solution.

The addition of excess dilute nitric acid to the colourless solution produces a white precipitate, **Z**.

What is **Z**?

- A AgCl B BaCl_2 C $\text{Ba}(\text{NO}_3)_2$ D NH_4NO_3

17 Which statement about bromine is correct?

- A Bromine is insoluble in non-polar solvents.
B Bromine vapour is more dense than air.
C Bromine will not vaporise significantly under normal conditions.
D Gaseous bromine is purple.

17 Astatine, At, is below iodine in Group VII of the Periodic Table.

Which statement is most likely to be correct?

- A AgAt(s) reacts with excess dilute aqueous ammonia to form a solution of a soluble complex.
B Astatine and KCl(aq) react to form KAt(aq) and chlorine.
C KAt(aq) and dilute sulfuric acid react to form white fumes of HAt(g) .
D NaAt(s) and concentrated sulfuric acid react to form astatine.

16 Chlorine is widely used in water treatment plants.

Which reaction takes place when chlorine dissolves in water?

- A $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HClO}$
B $2\text{Cl}_2 + 2\text{H}_2\text{O} \rightarrow 3\text{HCl} + \text{HClO}_2$
C $3\text{Cl}_2 + 3\text{H}_2\text{O} \rightarrow 5\text{HCl} + \text{HClO}_3$
D $4\text{Cl}_2 + 4\text{H}_2\text{O} \rightarrow 7\text{HCl} + \text{HClO}_4$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 On being heated, hydrogen iodide breaks down more quickly than hydrogen chloride.

Which statements explain this faster rate?

- 1** The HI bond is weaker than the HCl bond.
- 2** The reaction of the breakdown of HI has a smaller activation energy than that of HCl.
- 3** The breakdown of HI is more exothermic than that of HCl.

Topic **Chem 11 Q# 714/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 Under standard conditions, which statement is correct?

- A** $\text{Cl}^-(\text{aq})$ can oxidise $\text{Br}_2(\text{aq})$.
- B** $\text{Cl}^-(\text{aq})$ can reduce $\text{Br}_2(\text{aq})$.
- C** $\text{Cl}_2(\text{aq})$ can oxidise $\text{Br}^-(\text{aq})$.
- D** $\text{Cl}_2(\text{aq})$ can reduce $\text{Br}^-(\text{aq})$.

Topic **Chem 11 Q# 715/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 Chlorine gas reacts with cold aqueous sodium hydroxide. It can also react with hot aqueous sodium hydroxide.

What are the oxidation numbers of chlorine in the products of these reactions?

	cold aqueous sodium hydroxide	hot aqueous sodium hydroxide
A	-1, +1	-1, +5
B	-1, +1	+1, +6
C	-1, +2	-1, +5
D	-1, +2	+1, +6

Topic **Chem 11 Q# 716/** AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36 A test-tube of HI gas and a test-tube of HBr gas are placed together in an environment at temperature, T.

Which combinations of observations are possible depending on the temperature, T?

- 1 A brown vapour appears in one of the test-tubes. No change is apparent in the other test-tube.
- 2 A brown vapour appears in one of the test-tubes. A purple vapour appears in the other test-tube.
- 3 No change is apparent in either test-tube.

Topic **Chem 11 Q# 717**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 12//www.SmashingScience.org :o)

- 12 Redox reactions occur very frequently in the chemistry of Group VII.

Which statement is correct?

- A Chlorine will oxidise bromide ions but not iodide ions.
- B Fluorine is the weakest oxidising agent out of F_2 , Cl_2 , Br_2 and I_2 .
- C Iodide ions are the weakest reducing agent out of F^- , Cl^- , Br^- and I^- .
- D When chlorine reacts with water, chlorine is both oxidised and reduced.

Topic **Chem 11 Q# 718**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36 When a red-hot platinum wire is plunged into a test tube of hydrogen iodide, the gas is decomposed into its elements. If the experiment is repeated with hydrogen chloride, no change occurs.

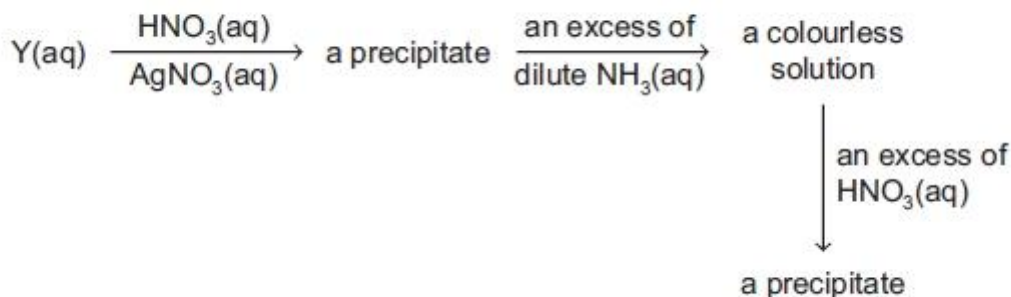
Which factors contribute to this behaviour?

- 1 the strength of the hydrogen-halogen bond
- 2 the size of the halogen atom
- 3 the standard enthalpy of formation, ΔH_f° , of each of the products of decomposition



17 Y is a salt of one of the halogens chlorine, bromine, iodine, or astatine (element 85).

The reaction scheme shows a series of reactions using a solution of Y as the starting reagent.



What could Y be?

- A sodium chloride
- B sodium bromide
- C potassium iodide
- D potassium astatide

Topic **Chem 11 Q# 720/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 Element 85, astatine, is in Group VII. Concentrated sulfuric acid is added to sodium astatide. The mixture of products includes astatine, hydrogen astatide, hydrogen sulfide, and sodium sulfate.

Which product is formed by the oxidation of one of the constituents of sodium astatide?

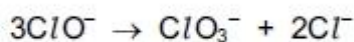
- A astatine
- B hydrogen astatide
- C hydrogen sulfide
- D sodium sulfate

Topic **Chem 11 Q# 721/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 14//www.SmashingScience.org :o)

14 What happens when iodine solution is added to a solution of sodium bromide?

- A A reaction occurs without changes in oxidation state.
- B Bromide ions are oxidised, iodine atoms are reduced.
- C Bromide ions are reduced, iodine atoms are oxidised.
- D No reaction occurs.

- 1 Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.



Which oxidation state is shown by chlorine in each of these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	-1
B	-1	+3	+1
C	+1	+5	-1
D	-1	+5	+1

Topic **Chem 11 Q# 723/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 34 The element astatine, At, is below iodine in Group VII of the Periodic Table.

Which statements concerning At will be correct?

- 1 It is a dark-coloured solid at room temperature.
- 2 It is a more powerful oxidising agent than iodine.
- 3 Its hydride is thermally stable.

Topic **Chem 11 Q# 724/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 35 Which statements are correct for all three halogens, chlorine, bromine and iodine?

- 1 They all form hydrides that are strong acids in aqueous solution.
- 2 They all react with aqueous sodium hydroxide to form oxo-anions.
- 3 They all require one more electron to fill the p orbitals of their outer shells.

- 18** The following two experiments are carried out with anhydrous potassium chloride and observations X and Y are made at the end of each experiment.

Concentrated sulfuric acid is added to the potassium chloride and the fumes produced are bubbled into aqueous potassium iodide solution - observation X.

The potassium chloride is dissolved in aqueous ammonia and this is then added to aqueous silver nitrate - observation Y.

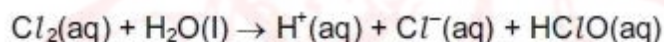
What are the observations X and Y?

	X	Y
A	brown solution	colourless solution
B	brown solution	white precipitate
C	colourless solution	colourless solution
D	colourless solution	white precipitate

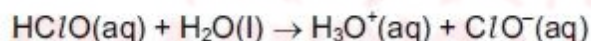
- 17** What trend is observed on descending Group VII?

- A** The colours of the elements become lighter.
- B** The elements become more volatile.
- C** The hydrides of the elements become more thermally stable.
- D** The reactions of the elements with hydrogen become less vigorous.

- 16** In the treatment of domestic water supplies, chlorine is added to the water to form HClO .



The HClO reacts further to give ClO^- ions.



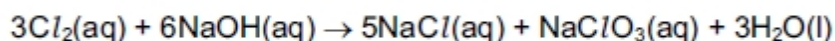
Both HClO and ClO^- kill bacteria by oxidation.

What is the overall change in oxidation number of chlorine when forming the ClO^- ion from the aqueous chlorine?

- A** -1
- B** 0
- C** +1
- D** +2



- 7 When chlorine and aqueous sodium hydroxide are heated together the following overall reaction occurs.



What are the oxidation numbers for chlorine in each of the following species?

	Cl_2	NaCl	NaClO_3
A	0	+1	-5
B	+2	-1	+3
C	0	-1	+5
D	-2	+1	-3

Topic **Chem 11 Q# 729/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 35 Which of the halide ions, chloride, bromide or iodide, acts as a reducing agent when its sodium salt reacts with concentrated sulfuric acid?

- 1 at least one of Cl^- , Br^- and I^-
- 2 at least two of Cl^- , Br^- and I^-
- 3 all three of Cl^- , Br^- and I^-

Topic **Chem 11 Q# 730/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

- 17 Why do the halogens become less volatile as Group VII is descended?

- A** The halogen-halogen bond energy decreases.
- B** The halogen-halogen bond length increases.
- C** The number of electrons in each molecule increases.
- D** The van der Waals' forces between molecules become weaker.

Topic **Chem 11 Q# 731/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



36 Use of the Data Booklet is relevant to this question.

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

- 1 It forms diatomic molecules which dissociate more readily than chlorine molecules.
- 2 It reacts explosively with hydrogen.
- 3 It can oxidise iodide to iodine.

Topic **Chem 11 Q# 732/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

- 16** A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

- A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.
- B Concentrated phosphoric acid is a stronger oxidising agent than iodine.
- C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.
- D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

Topic **Chem 11 Q# 733/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

- 15** X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2 , Y_2 and Z_2 were separately added to separate aqueous solutions containing X^- , Y^- and Z^- ions.

	$\text{X}^-(\text{aq})$	$\text{Y}^-(\text{aq})$	$\text{Z}^-(\text{aq})$
$\text{X}_2(\text{aq})$	no reaction	no reaction	no reaction
$\text{Y}_2(\text{aq})$	X_2 formed	no reaction	Z_2 formed
$\text{Z}_2(\text{aq})$	X_2 formed	no reaction	no reaction

Which row in the following table contains the ions X^- , Y^- and Z^- in order of their decreasing strength as reducing agents?

	strongest	→	weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 35** Disproportionation is the term used to describe a reaction in which a reactant is simultaneously both oxidised and reduced.

To which incomplete equations does the term disproportionation apply?

- 1** $\text{Cl}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{Cl}^-(\text{aq}) + \dots\dots$
- 2** $3\text{Cl}_2(\text{g}) + 6\text{OH}^-(\text{aq}) \rightarrow 3\text{H}_2\text{O}(\text{l}) + \text{ClO}_3^-(\text{aq}) + \dots\dots$
- 3** $2\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{HNO}_3(\text{aq}) + \dots\dots$

Topic **Chem 11 Q# 735/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

- 17** Which statement describes the halogens chlorine, bromine and iodine?

- A** Their bond energies decrease with increasing proton number.
- B** Their first ionisation energies increase with increasing proton number.
- C** They are all coloured gases at room temperature.
- D** They are all good reducing agents.

Topic **Chem 11 Q# 736/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

- 16** Chile saltpetre, NaNO_3 , contains sodium iodide as an impurity.

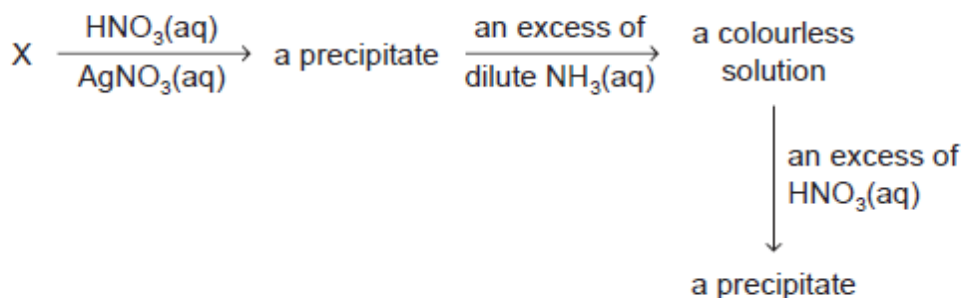
Aqueous silver nitrate is added to an aqueous solution of Chile saltpetre. Concentrated aqueous ammonia is then added.

Which observations are made?

	with acidified silver nitrate	with concentrated aqueous ammonia
A	no precipitate	no further reaction
B	no precipitate	precipitate forms
C	precipitate forms	precipitate dissolves
D	precipitate forms	precipitate remains

14 X is a salt of one of the halogens chlorine, bromine, iodine, or astatine (proton number 85).

The reaction scheme shows a series of reactions using a solution of X as the starting reagent.



What could X be?

- A** sodium chloride
- B** sodium bromide
- C** potassium iodide
- D** potassium astatide

13 How does concentrated sulfuric acid behave when it reacts with sodium chloride?

- A** as an acid only
- B** as an acid and oxidising agent
- C** as an oxidising agent only
- D** as a reducing agent only

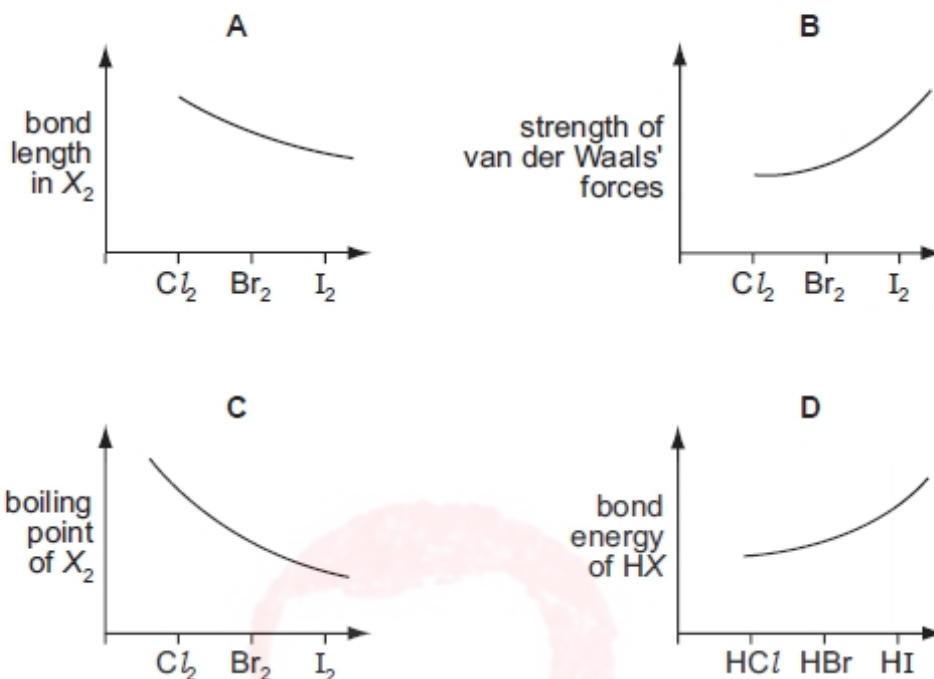
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36** Which statements about the reaction of solid sodium bromide with concentrated sulfuric acid are correct?
- 1** Hydrogen bromide is a product of the reaction.
 - 2** Sulfuric acid is oxidised to sulfur dioxide.
 - 3** Bromide ions are reduced to bromine.

15 Which graph correctly describes a trend found in the halogen group?

[X represents a halogen atom.]



Topic **Chem 11 Q# 741/** AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Which properties in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide steadily increase?

- 1 thermal stability
- 2 bond length
- 3 ease of oxidation

Topic **Chem 11 Q# 742/** AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 Which statement is most likely to be true for astatine, which is below iodine in Group VII of the Periodic Table?

- A Astatine and aqueous potassium chloride react to form aqueous potassium astatide and chlorine.
- B Potassium astatide and hot dilute sulfuric acid react to form white fumes of only hydrogen astatide.
- C Silver astatide reacts with dilute aqueous ammonia in excess to form a solution of a soluble complex.
- D Sodium astatide and hot concentrated sulfuric acid react to form astatine.



- 15** In black and white photographic film, light converts silver chloride into metallic silver. After the film has been developed, the unreacted silver chloride is removed by reaction with sodium thiosulfate to produce a 'fixed' negative.



What is the function of the thiosulfate ion?

- A** to make the silver ions soluble
- B** to oxidise the silver ions
- C** to oxidise the silver metal
- D** to reduce the silver ions

Topic **Chem 12 Q# 744**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

- 23** Which statement about ammonia or the ammonium ion is correct?

- A** Ammonia gas is produced when an aqueous solution containing the ammonium ion is reacted with a strong acid.
- B** Silver iodide is soluble in a concentrated aqueous solution of ammonia.
- C** The ammonium ion has the same number of electrons as a methane molecule.
- D** The square planar ammonium ion contains a dative covalent bond.

Topic **Chem 12 Q# 745**/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

- 29** Carbon monoxide, CO, nitrogen dioxide, NO₂, and sulfur dioxide, SO₂, are all atmospheric pollutants.

Which reaction occurs in the atmosphere?

- A** CO is spontaneously oxidised to CO₂.
- B** NO₂ is reduced to NO by SO₂.
- C** NO₂ is reduced to NO by CO.
- D** SO₂ is oxidised to SO₃ by CO₂.

Topic **Chem 12 Q# 746**/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

- 25** Which reaction mixture produces an acidic gas?

- A** aqueous ammonium nitrate and solid calcium oxide
- B** calcium and aqueous hydrochloric acid
- C** potassium chloride and concentrated sulfuric acid
- D** sodium oxide and water



24 The product of the Contact process is Z.

Which reaction or process leads to the formation of a gas that can neutralise an aqueous solution of Z?

- A atmospheric lightning
- B combustion of fuel in an internal combustion engine
- C the Haber process
- D thermal decomposition of Group 2 nitrates

18 Acid rain is a dilute solution of sulfuric acid.

Which pollutant also contributes to the formation of acid rain?

- A carbon monoxide
- B carbon dioxide
- C nitrogen dioxide
- D hydrocarbons

13 The gaseous products of heating a mixture of $\text{Ca}(\text{OH})_2$ and NH_4Cl are passed through solid CaO . A single gaseous product, W, is collected.

A sample of W reacts with $\text{Cl}_2(\text{g})$ to produce two gases, X and Y.

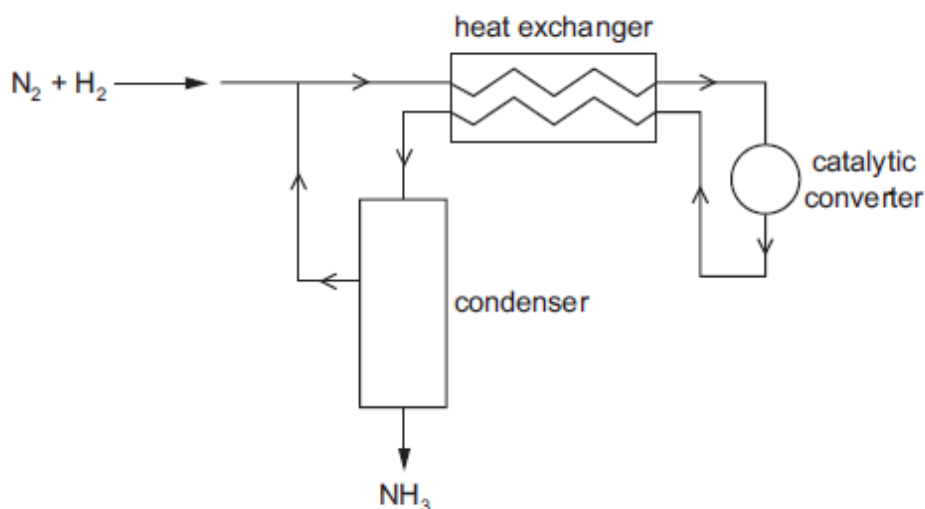
X is an element. Y is acidic.

Y reacts with W to produce Z.

What are X and Z?

	X	Z
A	N_2	CaCl_2
B	N_2	NH_4Cl
C	O_2	CaCl_2
D	O_2	NH_4Cl

- 10** The diagram represents the Haber process for the manufacture of ammonia from nitrogen and hydrogen.



What is the purpose of the heat exchanger?

- A** to cool the incoming gas mixture to avoid overheating the catalyst
- B** to cool the reaction products and separate the NH_3 from unused N_2 and H_2
- C** to warm the incoming gas mixture and shift the equilibrium to give more NH_3
- D** to warm the incoming gas mixture and speed up the reaction

Topic **Chem 12 Q# 751/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

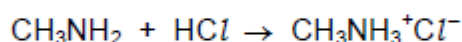
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 36** Nitrogen dioxide gas is produced when petrol is burned in car engines.

Which acids are made in the atmosphere as a result of this release of nitrogen dioxide into the air?

- 1** H_2SO_3
- 2** H_2SO_4
- 3** HNO_3

19 Methylamine, CH_3NH_2 , has similar chemical properties to ammonia, NH_3 . Methylamine reacts with hydrogen chloride to form a white crystalline salt, methylammonium chloride.



A sample of methylammonium chloride is heated with aqueous sodium hydroxide.

What are the products?

- A** ammonia, sodium chloride and water
- B** ammonia, sodium hydrogencarbonate and sodium chloride
- C** methylamine, hydrogen chloride and water
- D** methylamine, sodium chloride and water

18 NO , NO_2 , CO and unburnt hydrocarbons are present in the exhaust gases of internal combustion engines. When catalytic converters are used to remove these compounds from the exhaust gases, redox reactions occur.

What happens to each compound in the catalytic converter?

	NO	NO_2	CO	unburnt hydrocarbons
A	oxidised	oxidised	reduced	oxidised
B	oxidised	oxidised	oxidised	oxidised
C	reduced	reduced	oxidised	oxidised
D	reduced	reduced	reduced	reduced

17 Ammonia can undergo an acid–base reaction with hydrogen chloride to form ammonium chloride.

Which statement is correct?

- A** The ammonium ion is basic.
- B** The hydrogen atom from HCl donates a lone pair of electrons to the nitrogen atom.
- C** The H–N–H bond angle in ammonia is the same as the H–N–H bond angle in the ammonium ion.
- D** The H–N–H bond angle in the ammonium ion is the same as the H–C–H bond angle in methane.



19 Which statement about nitrogen or its compounds is correct?

- A** In the Haber process the temperature is kept high to give a good equilibrium yield of ammonia.
- B** Nitrogen gas is unreactive because of the strong nitrogen–nitrogen double bond.
- C** Nitrogen monoxide will react with carbon monoxide under suitable conditions.
- D** The formula of ammonium sulfate is NH_4SO_4 .

Topic **Chem 12 Q# 756/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Nitrogen gas is unreactive, whereas oxygen gas and chlorine gas are reactive.

Which statements help to explain this difference?

- 1** The two N atoms in an N_2 molecule are held together by a very strong triple bond.
- 2** The triple bond between two N atoms is not polar. The bonds in O_2 and Cl_2 are polar.
- 3** The atoms in N_2 have a full outer shell of electrons. The atoms in O_2 and Cl_2 do not have a full outer shell of electrons.

Topic **Chem 12 Q# 757/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 Catalytic converters are fitted in the exhaust systems of many cars.

Which gas:

- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter?

- A** carbon dioxide
- B** carbon monoxide
- C** hydrocarbon vapour
- D** nitrogen dioxide

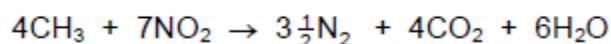
Topic **Chem 12 Q# 758/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 Which statement is correct?

- A** Ammonia reacts with alkalis to form the ammonium ion.
- B** Ammonium chloride contains ionic, covalent and co-ordinate bonds.
- C** The ammonium ion reacts with acids to produce ammonia.
- D** The bond angle in the ammonium ion is approximately 107° .



18 At 550°C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as CH₃ in the catalytic converter of a motor vehicle.



Which row gives the energy change for this reaction and a possible reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the N≡N bond energy is very high
C	exothermic	CO ₂ and H ₂ O have negative ΔH_f° values
D	exothermic	double bonds are broken in NO ₂

19 Ammonia, NH₃, and hydrazine, NH₂NH₂, are two compounds of nitrogen, N₂.

Which statement is correct?

- A The N–N bond in NH₂NH₂ is polar.
- B NH₃ and NH₂NH₂ have lone pairs of electrons but N₂ does not.
- C The oxidation number of each nitrogen in NH₂NH₂ is +2.
- D The reaction of nitrogen with hydrogen has a high activation energy.

19 Transition elements and their compounds are widely used as catalysts.

What is the identity and what is the oxidation number of the element present in the catalyst used in the Contact process?

	element	oxidation number
A	iron	0
B	iron	+3
C	vanadium	0
D	vanadium	+5

18 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

- A The ionic radius of the NH₄⁺ ion is similar to that of Mg²⁺ but not that of Na⁺.
- B NH₄Cl dissociates less fully than NaCl.
- C The Na⁺ and Mg²⁺ ions have the same number of electrons.
- D The NH₄⁺ ion can donate a proton.



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Which statements correctly describe an oxide of nitrogen acting as an atmospheric pollutant?

- 1** Nitrogen monoxide, NO, reacts with oxygen to form nitrogen dioxide which contributes to acid rain.
- 2** Nitrogen dioxide reacts with sulfur dioxide to form sulfur trioxide which reacts with water to form sulfuric acid.
- 3** Nitrogen oxides react with unburnt hydrocarbons in sunlight to form other pollutants.

Topic **Chem 12 Q# 764/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 Oxides of nitrogen are present in the environment due to natural and man-made sources.

Which row is correct?

	natural source of nitrogen oxides	man-made source of nitrogen oxides
A	electrical discharges in the atmosphere	internal combustion engines
B	electrical discharges in the atmosphere	as a by-product of the Haber process
C	decomposition of dead plants in rivers	internal combustion engines
D	decomposition of dead plants in rivers	as a by-product of the Haber process

Topic **Chem 12 Q# 765/** AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 When burned, sulfur forms a gaseous product X which can be oxidised to produce a gas Y.

Gas Y reacts with water to produce a product Z.

Which row correctly shows the oxidation states of sulfur in X, Y and Z?

	X	Y	Z
A	-2	+4	+4
B	-2	+4	+6
C	+4	+6	+4
D	+4	+6	+6

Topic **Chem 12 Q# 766/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 36//

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



36 Which statements explain why nitrogen gas is unreactive?

- 1 Nitrogen atoms are highly electronegative.
- 2 Nitrogen molecules are non-polar.
- 3 The triple bond between nitrogen atoms is very strong.

Topic **Chem 12 Q# 767/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 X is either nitrogen or sulfur and forms pollutant oxide Y in a car engine.

Further oxidation of Y to Z occurs in the atmosphere. In this further oxidation, 1 mol of Y reacts with 0.5 mol of gaseous oxygen molecules.

Which statements about X, Y and Z can be correct?

- 1 The oxidation number of X increases by two from Y to Z.
- 2 Y has an unpaired electron in its molecule.
- 3 Y is a polar molecule.

Topic **Chem 12 Q# 768/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 13//www.SmashingScience.org :o)

13 Which reagent, when mixed with ammonium sulfate and then heated, liberates ammonia?

- A aqueous bromine
- B dilute hydrochloric acid
- C limewater
- D potassium dichromate(VI) in acidic solution

Topic **Chem 12 Q# 769/** AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 Compound **T** is a white crystalline solid.

When a sample of **T** was mixed with aqueous sodium hydroxide and heated, a pungent smelling gas was produced which turned damp red litmus paper blue. This same gas produced dense white smoke with hydrogen chloride gas.

Further testing of a solution of **T** with barium chloride solution produced a dense white precipitate which did not dissolve when dilute hydrochloric acid was added to the mixture.

What is the identity of compound **T**?

- A ammonium carbonate
- B ammonium sulfate
- C sodium carbonate
- D sodium sulfate



18 Which statement about the ammonia molecule and/or the ammonium ion is correct?

- A Ammonia molecules are basic because they can donate H^+ ions.
- B Ammonium ions are basic because they can accept H^+ ions.
- C If ammonium ions are heated with $NaOH(aq)$, ammonia molecules are formed.
- D The bond angle in NH_4^+ is 2.5° less than the bond angle in NH_3 .

17 Ammonium sulfate, $(NH_4)_2SO_4$, and ammonium nitrate, NH_4NO_3 , are used as fertilisers.

These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of neutral soil.

Which row is correct?

	higher percentage of nitrogen by mass	effect on pH of soil
A	ammonium nitrate	decrease
B	ammonium nitrate	increase
C	ammonium sulfate	decrease
D	ammonium sulfate	increase

19 Element X forms a pollutant oxide Y. Y can be further oxidised to Z. Two students made the following statements.

Student P 'The molecule of Y contains lone pairs of electrons.'

Student Q 'The oxidation number of X increases by 1 from Y to Z.'

X could be carbon or nitrogen or sulfur.

Which student(s) made a correct statement?

- A P only
- B Q only
- C both P and Q
- D neither P nor Q

- 18** Mohr's salt is a pale green crystalline solid which is soluble in water. It contains two cations, one of which is Fe^{2+} , and one anion which is SO_4^{2-} .

The identity of the second cation was determined by heating Mohr's salt with aqueous sodium hydroxide. A colourless gas was evolved which readily dissolved in water giving an alkaline solution.

A green precipitate was also formed.

What are the identities of the gas and the precipitate?

	gas	precipitate
A	NH_3	$\text{Fe}(\text{OH})_2$
B	NH_3	Na_2SO_4
C	SO_2	$\text{Fe}(\text{OH})_2$
D	SO_2	Na_2SO_4

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 35** Pollutant oxide **Y**, which contains non-metallic element **X**, is formed in a car engine.

Further oxidation of **Y** to **Z** occurs in the atmosphere. In this further oxidation, 1 mol of **Y** reacts with 0.5 mol of gaseous oxygen molecules.

X could be either nitrogen or sulfur.

Which statements about **X**, **Y** and **Z** can be correct?

- The oxidation number of **X** increases by two from **Y** to **Z**.
- Y** has an unpaired electron in its molecule.
- Y** is a polar molecule.

- 17** Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

- The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+ .
- NH_4Cl dissociates less fully than NaCl .
- The Na^+ and Mg^{2+} ions have the same number of electrons.
- The NH_4^+ ion can donate a proton.

25 One of the reactions taking place in a catalytic converter in a car exhaust system is between nitrogen oxide and octane (unburned petrol). The products of this reaction are non-toxic.

Which is the correct equation for the reaction?

- A** $\text{C}_8\text{H}_{16} + 16\text{NO} \rightarrow 8\text{CO} + 8\text{N}_2 + 8\text{H}_2\text{O}$
- B** $\text{C}_8\text{H}_{16} + 24\text{NO} \rightarrow 8\text{CO}_2 + 12\text{N}_2 + 8\text{H}_2\text{O}$
- C** $\text{C}_8\text{H}_{18} + 17\text{NO} \rightarrow 8\text{CO} + 8\frac{1}{2}\text{N}_2 + 9\text{H}_2\text{O}$
- D** $\text{C}_8\text{H}_{18} + 25\text{NO} \rightarrow 8\text{CO}_2 + 12\frac{1}{2}\text{N}_2 + 9\text{H}_2\text{O}$

16 In a car engine, non-metallic element X forms a pollutant oxide Y. Y can be further oxidised to Z. Two students made the following statements.

Student P The molecule of Y contains lone pairs of electrons.

Student Q The oxidation number of X increases by 1 from Y to Z.

X could be carbon or nitrogen or sulfur.

Which student could be correct if X were any of these elements?

- A** P only
- B** Q only
- C** both P and Q
- D** neither P nor Q

5 Two conversions are outlined below.



What similar feature do these two conversions have?

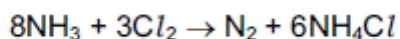
- A** a lone pair of electrons in the product
- B** change in oxidation state of an element
- C** decrease in bond angle of the species involved
- D** disappearance of a π bond

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



34 Ammonia and chlorine react in the gas phase.



Which statements are correct?

- 1 Ammonia behaves as a reducing agent.
- 2 Ammonia behaves as a base.
- 3 The oxidation number of the hydrogen changes

Topic **Chem 12 Q# 780/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 Carbon monoxide, CO, nitrogen monoxide, NO, and sulfur dioxide, SO₂, may all be present in the exhaust fumes from a car engine.

Which reaction concerning these compounds occurs in the atmosphere?

- A CO is spontaneously oxidised to CO₂
- B NO₂ is reduced to NO by CO
- C NO₂ is reduced to NO by SO₂
- D SO₂ is oxidised to SO₃ by CO₂

Topic **Chem 12 Q# 781/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 In a car engine, non-metallic element X forms a pollutant oxide Y.

Further oxidation of Y to Z occurs spontaneously in the atmosphere. In this further oxidation, 1 mol of Y reacts with 0.5 mol of gaseous oxygen.

Which statements about X, Y and Z are correct?

- 1 X forms a basic hydride.
- 2 Y is a diatomic molecule.
- 3 Z is a polar molecule.

Topic **Chem 12 Q# 782/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



- 34 A farmer spreads lime on land which has already been treated with an ammonium nitrate fertiliser.

Which reactions will occur in the treated soil?

- 1 $\text{Ca(OH)}_2 + 2\text{NH}_4^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{NH}_3 + 2\text{H}_2\text{O}$
- 2 $\text{Ca(OH)}_2 + 2\text{H}^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{H}_2\text{O}$
- 3 $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$

Topic **Chem 12 Q# 783/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 37 Which descriptions of the ammonium ion are correct?

- 1 It contains ten electrons.
- 2 It has a bond angle of 109.5° .
- 3 It has only three bonding pairs of electrons.

Topic **Chem 12 Q# 784/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

- 18 Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

- A $\text{NO(g)} + \text{CO(g)} \rightarrow \text{NO}_2(\text{g}) + \text{C(s)}$
- B $\text{NO(g)} + \text{CO}_2(\text{g}) \rightarrow \text{NO}_2(\text{g}) + \text{CO(g)}$
- C $2\text{NO(g)} + 2\text{CO(g)} \rightarrow \text{N}_2(\text{g}) + 2\text{CO}_2(\text{g})$
- D $2\text{NO(g)} + \text{CO}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g}) + \text{C(s)}$

Topic **Chem 12 Q# 785/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Element X is a solid. It occurs as a contaminant of carbonaceous fuels.

Its oxide Y is formed in car engines.

Further oxidation of Y to Z can occur in the atmosphere.

Which statements about Y and Z are correct?

- 1 Molecule Y has lone pairs of electrons.
- 2 The atmospheric oxidation of Y to Z is a catalysed reaction.
- 3 Y is a colourless gas.

Topic **Chem 12 Q# 786/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

30 Which environmental problem is **not** made worse by the release of oxides of nitrogen from car engines?

- A acidification of lakes
- B corrosion of buildings
- C photochemical smog
- D the hole in the ozone layer

Topic **Chem 12 Q# 787/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 15//www.SmashingScience.org :o)

15 Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.

How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?

- A 1 B 2 C 3 D 4

Topic **Chem 12 Q# 788/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 In a car engine, non-metallic element X forms a pollutant oxide Y.

Further oxidation of Y to Z occurs in the atmosphere. In this further oxidation, 1 mol of Y reacts with $\frac{1}{2}$ mol of gaseous oxygen.

What can X be?

- 1 carbon
- 2 nitrogen
- 3 sulfur



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 35** A farmer added lime to damp soil, followed by the nitrogenous fertiliser ammonium sulfate. A chemical reaction occurred in the soil.

Which substances were formed in this reaction?

- 1** sulfuric acid
- 2** calcium sulfate
- 3** ammonia

- 19** In an historically famous experiment Wöhler heated 'inorganic' ammonium cyanate in the absence of air. The only product of the reaction was 'organic' urea, $\text{CO}(\text{NH}_2)_2$. No other products were formed in the reaction.

What is the formula of the cyanate ion present in ammonium cyanate?

- A** CNO^- **B** CNO^{2-} **C** CO^- **D** NO^-

- 18** Most modern cars are fitted with three-way catalytic converters in the exhaust system.

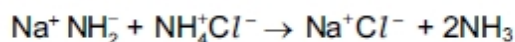
Which three gases are removed by such a catalytic converter?

- A** carbon monoxide, hydrocarbons, nitrogen oxides
- B** carbon monoxide, carbon dioxide, nitrogen oxides
- C** carbon monoxide, nitrogen oxides, sulfur dioxide
- D** hydrocarbons, nitrogen oxides, sulfur dioxide

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 The following reaction takes place using liquid ammonia as a solvent.



Which statements best explain why this reaction should be classified as a Brønsted-Lowry acid-base reaction?

- 1 The ammonium ion acts as a proton donor.
- 2 $\text{Na}^+ \text{Cl}^-$ is a salt.
- 3 Ammonia is always basic.

Topic **Chem 12 Q# 793**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 18//www.SmashingScience.org :o)

18 Mohr's salt is a pale green crystalline solid which is soluble in water. It is a 'double sulfate' which contains two cations, one of which is Fe^{2+} .

The identity of the second cation was determined by heating solid Mohr's salt with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution. A grey-green solid residue was also formed which was insoluble in water.

What are the identities of the gas and the solid residue?

	gas	residue
A	H_2	FeSO_4
B	NH_3	Na_2SO_4
C	NH_3	$\text{Fe}(\text{OH})_2$
D	SO_2	$\text{Fe}(\text{OH})_2$

Topic **Chem 12 Q# 794**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 17//www.SmashingScience.org :o)

17 Deposits of ammonium compounds have been discovered in areas of high atmospheric pollution.

They are believed to arise from the following reaction.



What does **not** occur in this reaction?

- A acid /base neutralisation
- B dative bond formation
- C ionic bond formation
- D oxidation /reduction

Topic **Chem 13 Q# 795**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

35 Structural isomerism and stereoisomerism should be considered when answering this question.

How many isomeric compounds with molecular formula $\text{C}_5\text{H}_8\text{O}_4$ contain two $-\text{CO}_2\text{H}$ groups and one $\text{C}=\text{C}$ double bond?

- A 5 B 6 C 7 D 8



27 How many chiral carbon atoms are there in one molecule of 2,2,4,5-tetramethylhexan-3-ol?

- A** 1 **B** 2 **C** 3 **D** 4

24 Sulfur dioxide can be catalytically oxidised by an oxide of nitrogen in the atmosphere.

Which reaction shows how the catalyst is reformed?

- A** $\text{N}_2 + 2\text{O}_2 \rightleftharpoons 2\text{NO}_2$
B $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$
C $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$
D $\text{NO} + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}_2$

33 17.6 g of pentan-1-ol is completely combusted.

Which volume of gaseous products is formed when measured at s.t.p.?

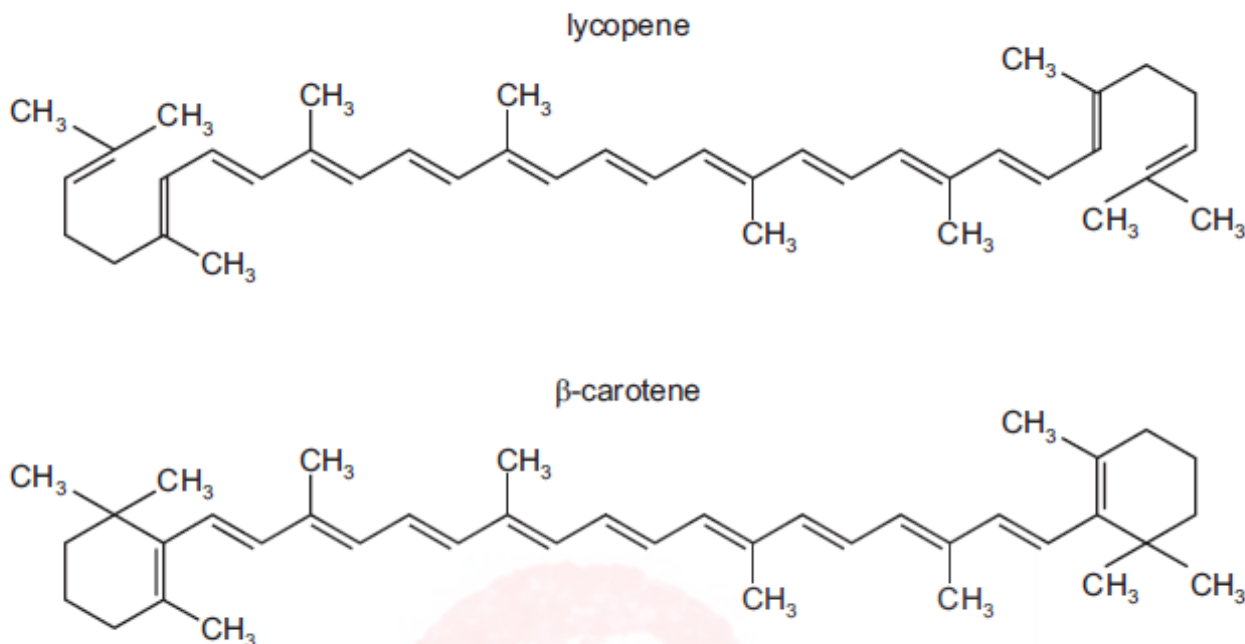
- A** 22.4 dm³ **B** 24.0 dm³ **C** 49.3 dm³ **D** 52.8 dm³

24 In a catalytic converter, 5.6 g of carbon monoxide react with an excess of nitrogen monoxide.

What is produced in this reaction?

- A** 2.4 g of C and 6.0 g of NO₂
B 2.4 g of C and 9.2 g of NO₂
C 8.8 g of CO₂ and 1.4 g of N₂
D 8.8 g of CO₂ and 2.8 g of N₂

39 The diagrams show the structures of lycopene and β -carotene.



When lycopene is converted into β -carotene, what is the gain or loss of hydrogen atoms per molecule?

- A 4 gained
- B 2 gained
- C no change
- D 2 lost

Topic **Chem 13 Q# 801**/ AS Chemistry/2022/m/TZ 2/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

36 What is the least number of carbon atoms in a non-cyclic alkane molecule that has a chiral centre?

- A 7
- B 8
- C 9
- D 10

Topic **Chem 13 Q# 802**/ AS Chemistry/2022/m/TZ 2/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

26 In this question, alkenes and cyclic alkanes should be considered.

How many **structural** isomers of C_4H_8 are there?

- A 3
- B 4
- C 5
- D 6

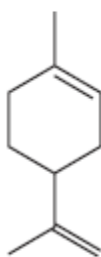
Topic **Chem 13 Q# 803**/ AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 6//www.SmashingScience.org :o)

6 What is the minimum mass of oxygen required to ensure the complete combustion of 12 dm^3 of propane measured under room conditions?

- A 60 g
- B 80 g
- C 120 g
- D 160 g

23 Limonene is a hydrocarbon found in the rind of citrus fruits.

limonene

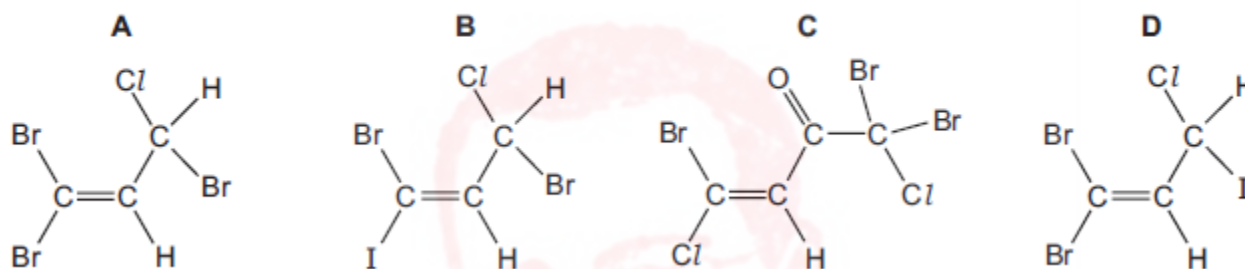


What is the molecular formula of limonene?

- A** $C_{10}H_{12}$ **B** $C_{10}H_{14}$ **C** $C_{10}H_{16}$ **D** $C_{10}H_{18}$

Topic **Chem 13 Q# 805/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

22 Which compound could show **both** *cis-trans* isomerism and optical isomerism?



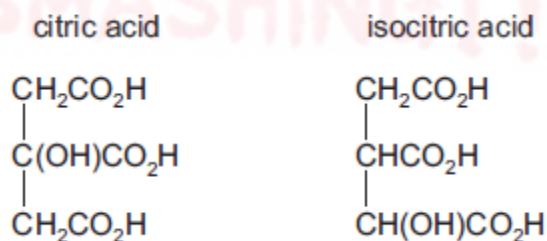
Topic **Chem 13 Q# 806/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 1//www.SmashingScience.org :o)

1 Which contains the largest number of hydrogen atoms?

- A** 0.10 mol of pentane
B 0.20 mol of but-2-ene
C 1.00 mol of hydrogen molecules
D 6.02×10^{23} hydrogen atoms

Topic **Chem 13 Q# 807/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 The structures of citric acid and isocitric acid are shown.



How many chiral centres does each acid possess?

	citric acid	isocitric acid
A	1	1
B	1	2
C	0	1
D	0	2

The responses **A** to **D** should be selected on the basis of

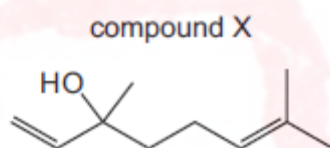
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 38** During the bromination of methane, the free radical $\text{CH}_3\cdot$ is generated. A possible termination step of this reaction is the formation of C_2H_6 by the combination of two free radicals.

What could be produced in a termination step during the bromination of **propane**?

- 1 $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- 2 $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)_2$
- 3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$

- 30** The skeletal formula of compound X is shown.

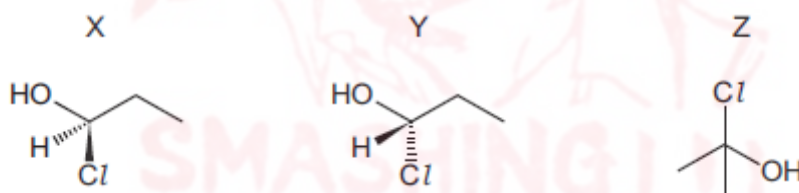


What is the molecular formula of compound X?

- A** $\text{C}_{10}\text{H}_{18}\text{O}$ **B** $\text{C}_{10}\text{H}_{20}\text{O}$ **C** $\text{C}_{11}\text{H}_{22}\text{O}$ **D** $\text{C}_{11}\text{H}_{24}\text{O}$

- 20** Structural and stereoisomerism should be considered when answering this question.

Compounds X, Y and Z are shown.



How many other isomers of $\text{C}_3\text{H}_7\text{ClO}$ are there that are alcohols?

- A** 2 **B** 3 **C** 4 **D** 5

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that includes the formation of a positive ion?

- 1 first ionisation energy
- 2 heterolytic fission of a covalent bond
- 3 enthalpy change of atomisation

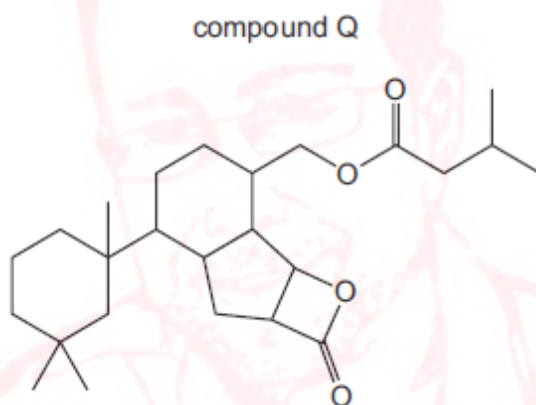
Topic **Chem 13 Q# 812/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 3//www.SmashingScience.org :o)

3 When considering one molecule of ethene, which row describes both the hybridisation of the atomic orbitals in the carbon atoms and the overall bonding?

	hybridisation	bonding
A	sp^2	4 σ bonds 1 π bond
B	sp^2	5 σ bonds 1 π bond
C	sp^3	4 σ bonds 1 π bond
D	sp^3	5 σ bonds 1 π bond

Topic **Chem 13 Q# 813/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 The structure of compound Q is shown.



How many chiral centres are present in a molecule of Q?

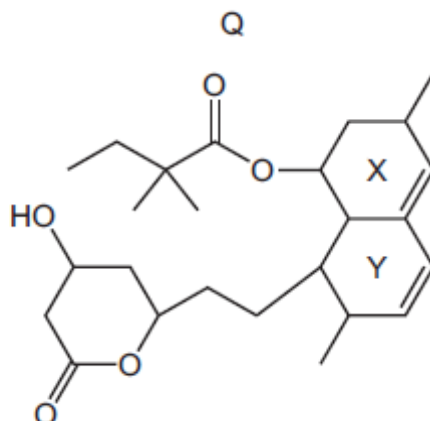
- A 4 B 5 C 6 D 7

Topic **Chem 13 Q# 814/** AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 Which statement is correct?

- A 2,2-dimethylpropanoic acid is an isomer of propyl methanoate.
- B 2-methylbutan-2-ol is an isomer of hexan-3-ol.
- C 3-methylbutan-2-one is an isomer of pentanal.
- D 3,3-dimethylbutan-2-one is an isomer of pentan-3-one.

30 The diagram shows the structure of compound Q.



Two of the rings, X and Y, contain a C=C bond.

Which row is correct?

	number of ester groups in one molecule of Q	description of rings X and Y
A	1	both are planar
B	1	neither is planar
C	2	both are planar
D	2	neither is planar

25 Structural isomerism and stereoisomerism should be considered when answering this question.

How many non-cyclic isomers have the molecular formula C_5H_{10} ?

- A 3 B 4 C 5 D 6

20 Which pair of compounds are functional group isomers of each other?

- A butan-1-ol and butanal
 B ethylpropanoate and pentanoic acid
 C hex-1-ene and hex-2-ene
 D propylamine and propanenitrile

2 For which hydrocarbon are the molecular and empirical formulae the same?

- A butane
 B ethane
 C pent-1-ene
 D propane

- 5** Ethanal, CH_3CHO , ethanol, $\text{C}_2\text{H}_5\text{OH}$, and methoxymethane, CH_3OCH_3 , are three organic compounds.

Which compound has the highest boiling point and what is the interaction that causes this boiling point to be the highest?

	highest boiling point	interaction
A	methoxymethane	permanent dipole-dipole forces
B	ethanal	hydrogen bonds
C	ethanol	hydrogen bonds
D	ethanal	permanent dipole-dipole forces

Topic **Chem 13 Q# 820/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 37** The structure of tiglic acid is $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{CO}_2\text{H}$.

Which statements about the properties of one molecule of this acid are correct?

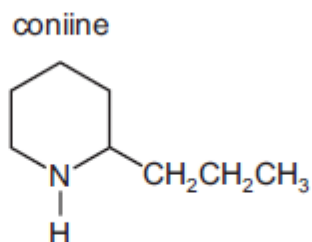
- 1** It contains two π bonds.
- 2** It contains four lone pairs of electrons.
- 3** It has all its atoms in the same plane.

Topic **Chem 13 Q# 821/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

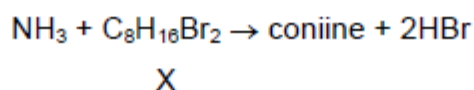
- 30** Which compound is chiral?

- A** 1-chloro-3-methylbutane
- B** 2-chloro-2-methylbutane
- C** 2-chloro-3-methylbutane
- D** 3-chloropentane

25 The structure of coniine is shown.



Coniine can be synthesised by reacting ammonia with a dibromo compound, X.

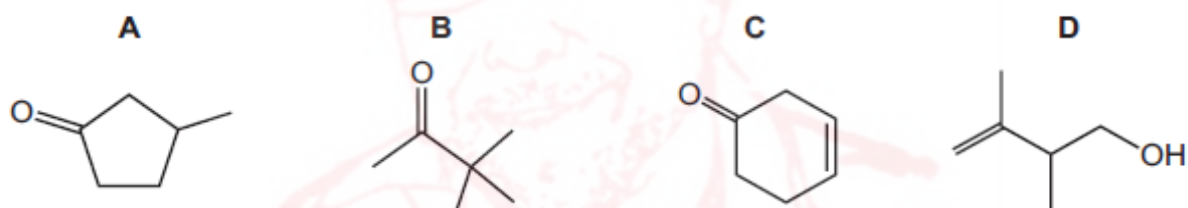


What is the name of compound X?

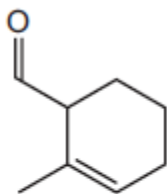
- A 1,1-dibromo-2-propylcyclopentane
- B 1,2-dibromo-2-propylcyclopentane
- C 1,4-dibromooctane
- D 1,5-dibromooctane

Topic **Chem 13 Q# 823**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

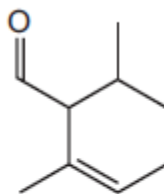
21 Which compound has the molecular formula $\text{C}_8\text{H}_{10}\text{O}$?



20 The diagrams show two different compounds.



1



2

What is

- the total number of structural isomers, including compound 2, that could be formed by adding a second methyl group to the ring of compound 1,
- the number of π electrons in each compound?

	number of isomers	number of π electrons
A	3	2
B	3	4
C	5	2
D	5	4

Topic **Chem 13 Q# 825/** AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31** In an experiment, 10 cm^3 of an organic compound, J, in the gaseous state is reacted with an excess of oxygen. Steam, 20 cm^3 of carbon dioxide and 5 cm^3 of nitrogen are the only products.

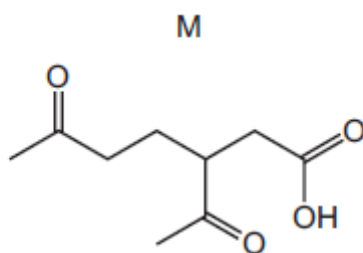
All gas volumes were measured at the same temperature and pressure.

What could be the identity of J?

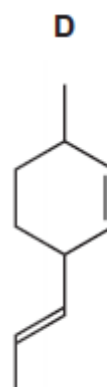
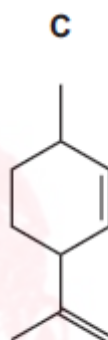
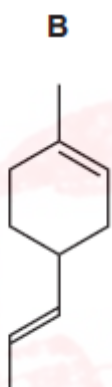
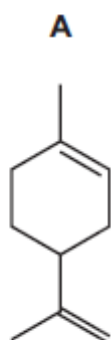
- $\text{C}_2\text{H}_6\text{N}_2$
- $\text{C}_2\text{H}_3\text{N}$
- $\text{C}_2\text{H}_7\text{N}$

21 Compound L has the molecular formula $C_{10}H_{16}$.

A sample of L reacted with an excess of hot, concentrated, acidified potassium manganate(VII). Compound M is produced.



What could be the structure of compound L?



20 How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

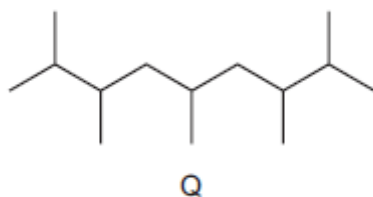
A 3

B 4

C 5

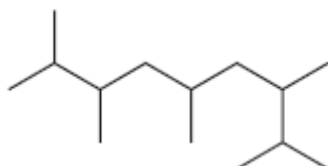
D 6

22 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.

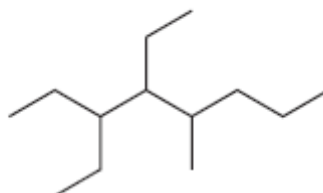


Which skeletal formula represents a **structural isomer** of Q?

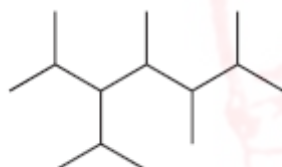
A



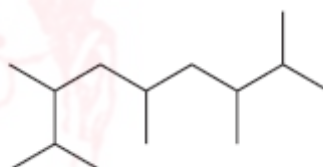
B



C



D



21 X has the molecular formula $C_5H_{12}O$. X has a branched carbon skeleton and a secondary alcohol functional group.

How many **structural** isomers fit this description of X?

A 1

B 2

C 3

D 4

21 Which pair of alcohols are isomers of each other?

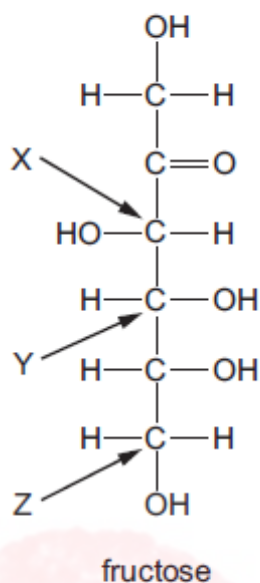
A butan-1-ol and 2,2-dimethylpropan-1-ol

B butan-2-ol and 2-methylpropan-2-ol

C pentan-1-ol and 2-methylpropan-2-ol

D propan-2-ol and 2-methylpropan-2-ol

20 Fructose is a sugar with more than one chiral centre. The fructose molecule is shown with X, Y and Z indicating three carbon atoms.



Which carbon atoms are chiral centres?

- A** X, Y and Z **B** X and Y only **C** X only **D** Y only

20 Which types of stereoisomerism are shown by 2,4-dimethylhex-2-ene?

- A** both cis-trans isomerism and optical isomerism
B cis-trans isomerism only
C neither cis-trans isomerism nor optical isomerism
D optical isomerism only

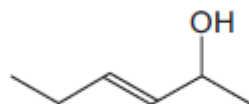
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 In which molecules do all the carbon atoms lie in the same plane?

- 1** 2,3-dimethylbut-2-ene
2 propane
3 cyclohexane

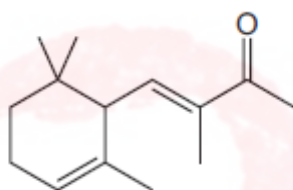
21 What is the name of compound X?



compound X

- A *trans*-2-hydroxyhex-3-ene
- B *trans*-2-hydroxyhexene
- C *trans*-5-hydroxyhex-3-ene
- D *trans*-5-hydroxyhexene

20 The structural formula of compound Q is shown.



Q

How many stereoisomers exist with this structural formula?

- A 1
- B 2
- C 4
- D 8

6 The complete combustion of 2 moles of a straight chain alkane produces 400 dm³ of carbon dioxide measured at 301 K and 1 × 10⁵ Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the straight chain alkane?

- A C₈H₁₈
- B C₁₆H₃₄
- C C₂₀H₄₂
- D C₄₀H₈₂

The responses **A** to **D** should be selected on the basis of

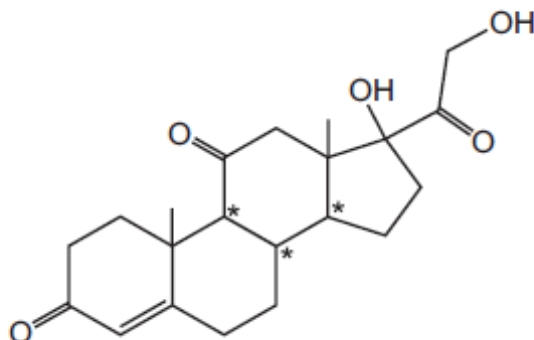
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 P and Q are a pair of cis-trans isomers.

What **must** be the same for P and Q?

- 1 their empirical formula
- 2 their functional groups
- 3 their skeletal formula

21 The drug cortisone has the formula shown.



In addition to those chiral centres marked by an asterisk (*), how many **other** chiral centres are present in the cortisone molecule?

- A 0 B 1 C 2 D 3

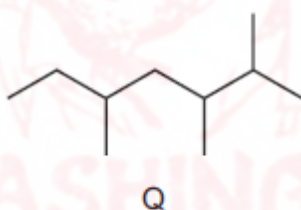
Topic **Chem 13 Q# 839**/ AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 16//www.SmashingScience.org :o)

16 Which statement about nitrogen or its compounds is correct?

- A In the Haber process the temperature is kept high to give a good equilibrium yield of ammonia.
 B Nitrogen gas is unreactive because of the strong nitrogen-nitrogen double bond.
 C Nitrogen monoxide will react with carbon monoxide under suitable conditions.
 D The formula of ammonium sulfate is NH_4SO_4 .

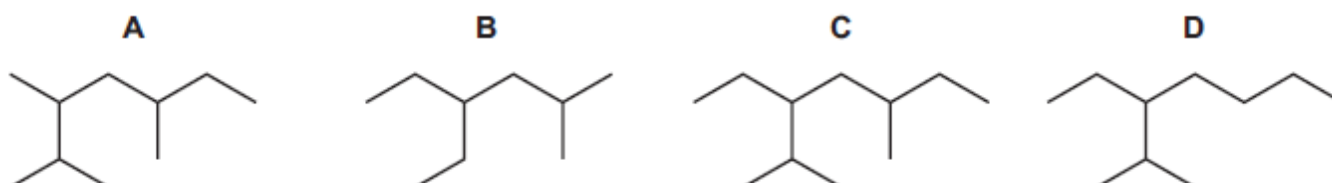
Topic **Chem 13 Q# 840**/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 Kerosene is used as an aircraft fuel. Q is one of the molecules in kerosene and has the skeletal formula shown.



Other structural isomers of this molecule are also found in kerosene.

Which structure is a structural isomer of Q?

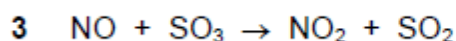
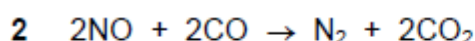
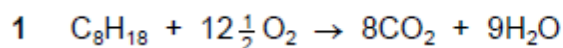


The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

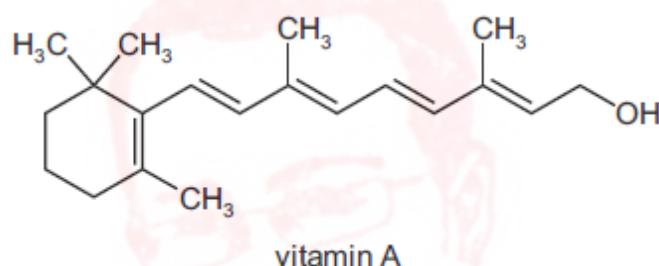
36 Catalytic converters are used to modify exhaust emissions from motor vehicles.

Which reactions occur in catalytic converters?



Topic **Chem 13 Q# 842**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 The diagram shows the structure of vitamin A.

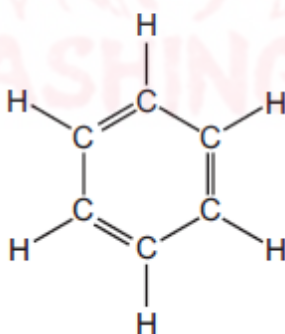


How many chiral centres are present in one vitamin A molecule?

- A 0 B 1 C 2 D 3

Topic **Chem 13 Q# 843**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 In 1865 Kekulé suggested a ring structure for benzene, C_6H_6 , in which a hydrogen atom is attached to each carbon atom.

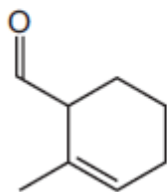


Kekulé structure

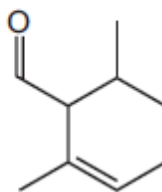
In this structure all of the bonds remain in the places shown. Assuming this is the structure of benzene, how many isomers of dichlorobenzene, $\text{C}_6\text{H}_4\text{Cl}_2$, would exist?

- A 3 B 4 C 5 D 6

20 The diagrams show two different compounds.



1



2

What is

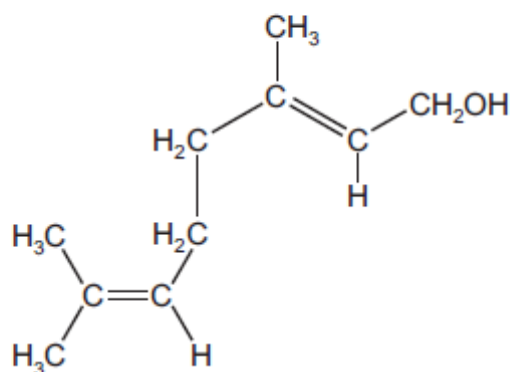
- the total number of structural isomers, including compound 2, that could be formed by adding a second methyl group to the ring of compound 1,
- the number of π electrons in each compound?

	number of isomers	number of π electrons
A	3	2
B	3	4
C	5	2
D	5	4

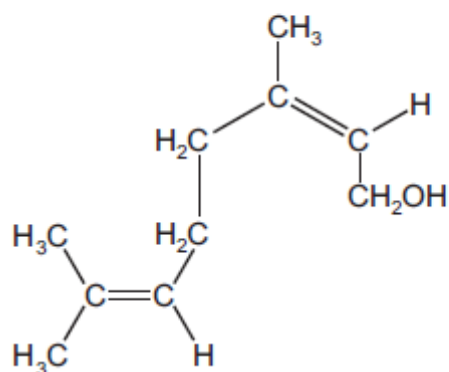
19 Which reaction **does not** contribute to the problem of acid rain?

- A the combustion of fossil fuels
- B the oxidation of sulfur dioxide to sulfur trioxide catalysed by nitrogen dioxide
- C the reaction between nitrogen monoxide and carbon monoxide in a catalytic converter
- D the reaction of sulfur trioxide with water

21 Geraniol and nerol are compounds found in some flower fragrances. They are isomers of each other.



geraniol



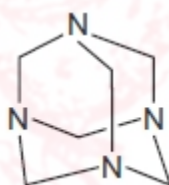
nerol

Which type of isomerism is shown here?

- A chain
- B geometrical (cis-trans)
- C optical
- D positional

9 Hexamine is a crystalline solid used as a fuel in portable stoves.

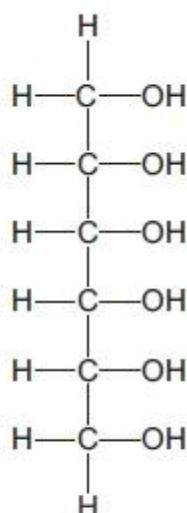
The diagram shows its skeletal structure.



What is the empirical formula of hexamine?

- A CH_2N
- B $\text{C}_3\text{H}_6\text{N}_2$
- C $\text{C}_4\text{H}_8\text{N}_4$
- D $\text{C}_6\text{H}_{12}\text{N}_4$

- 29** Sorbitol is a naturally-occurring compound with a sweet taste. It is often used as a substitute for sucrose by the food industry.



sorbitol

How many chiral centres are present in sorbitol?

- A** 3 **B** 4 **C** 5 **D** 6

- 22** Crude oil is a mixture of many hydrocarbons ranging in size from 1 to 40 carbon atoms per molecule. The alkanes in crude oil can be separated because they have different boiling points.

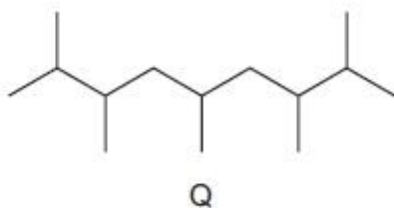
The table below shows the boiling points of some alkanes.

alkane	boiling point / °C	M_r
butane	0	58
pentane	36	72
hexane	69	86
2-methylbutane	28	72
dimethylpropane	10	72
2,3-dimethylbutane	58	86

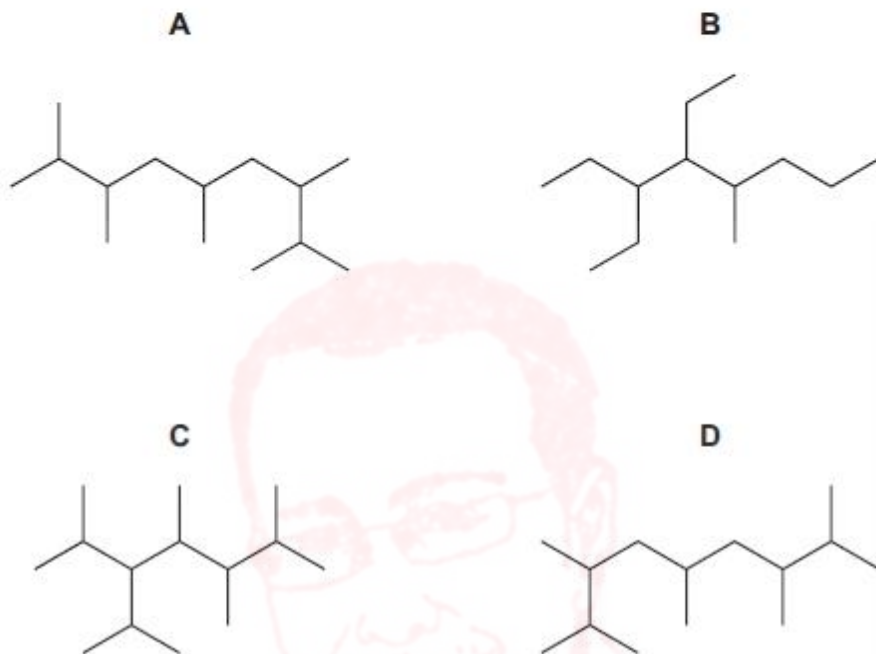
What is the correct explanation for the difference in the boiling points of the three isomers with $M_r = 72$?

- A** Boiling point is dependent upon the length of the carbon chain **only**.
B Increased branching on a carbon chain increases the boiling point.
C Increased branching reduces the strength of the intermolecular hydrogen bonding.
D Increased branching reduces the strength of the intermolecular van der Waals' forces.

21 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



Which skeletal formula represents a **structural isomer** of Q?

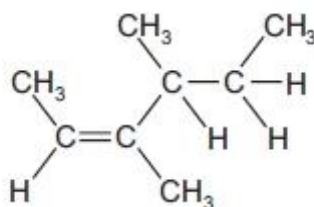


Topic **Chem 13 Q# 851**/ AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

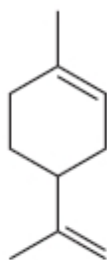
37 The diagram shows the structure of an alkene molecule.



Which statements about this molecule are correct?

- 1 All the carbon atoms are in the same plane.
- 2 It has geometrical isomers.
- 3 It is optically active.

29 The citrus flavour of lemons is due to the compound limonene, present in both the peel and the juice.

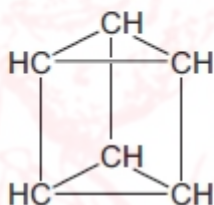


limonene

What is the mole ratio of carbon dioxide to water produced when limonene is completely burnt in oxygen?

	number of moles carbon dioxide	number of moles water
A	4	3
B	5	4
C	5	8
D	9	7

28 In 1869 Ladenburg suggested a structure for benzene, C_6H_6 , in which one hydrogen atom is attached to each carbon atom.



Ladenburg structure

A compound $C_6H_4Cl_2$ could be formed with the same carbon skeleton as the Ladenburg structure.

How many structural isomers would this compound have?

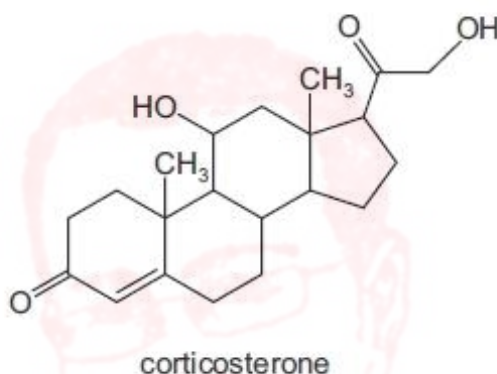
- A** 3 **B** 4 **C** 5 **D** 6

- 10** The double bond between the two carbon atoms in an ethene molecule consists of one σ bond and one π bond.

Which orbitals overlap to form each of these bonds?

	σ bond	π bond
A	sp^2-sp^2	p-p
B	sp^2-sp^2	sp^2-sp^2
C	sp^3-sp^3	p-p
D	sp^3-sp^3	sp^2-sp^2

- 26** Corticosterone is a hormone involved in the metabolism of carbohydrates and proteins.

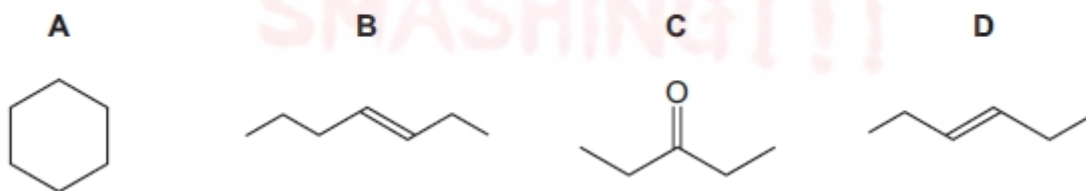


How many chiral centres are there in one molecule of corticosterone?

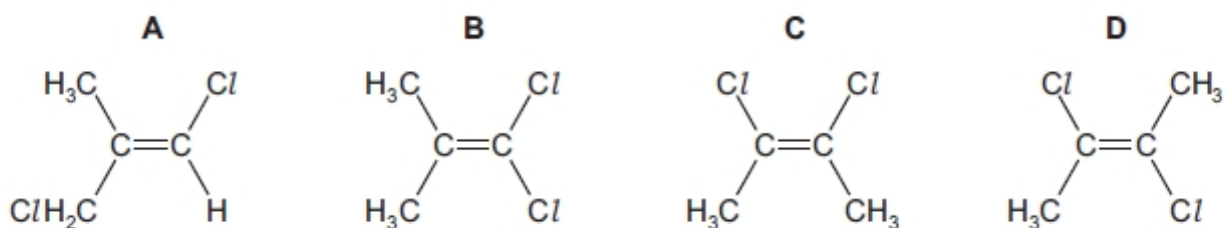
- A** 5 **B** 6 **C** 7 **D** 8

- 21** Use of the Data Booklet is relevant to this question.

Which compound has an M_r of 84 and will react with HBr to give a product with an M_r of 164.9?



- 9** Which molecular structure will have the **smallest** overall dipole?



24 There are three structural isomers with the formula C_5H_{12} .

Which formulae correctly represent these three structural isomers?

- A** $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH_2CHCH_3CH_3$ $CH_3CH_3CCH_3CH_3$
B $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH_2(CH)CH_3CH_3$ $C(CH_3)_4$
C $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $CH_3C(CH_3)_2CH_3$
D $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $CH_3CH_2CH(CH_3)CH_3$

Topic **Chem 13 Q# 859/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

23 Which compound exhibits stereoisomerism?

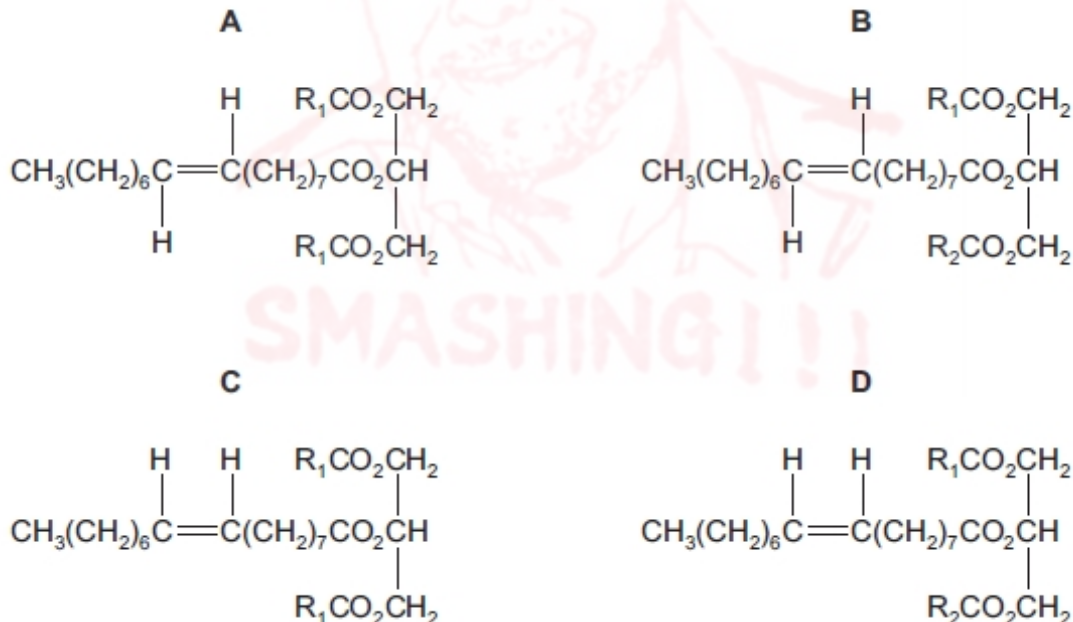
- A** $CH_3CHClCH_3$
B $CH_3CHClCH_2Cl$
C $CH_3CCl_2CH_3$
D $CH_2ClCH_2CH_2Cl$

Topic **Chem 13 Q# 860/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

30 Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood.

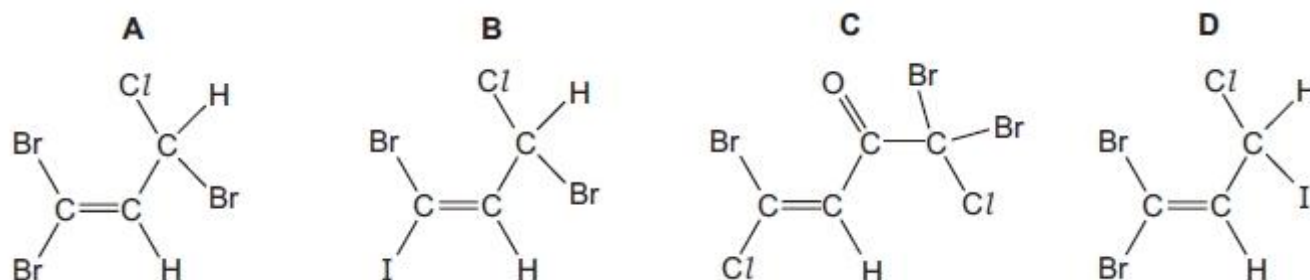
In the diagrams below, R_1 and R_2 are different hydrocarbon chains.

Which diagram correctly illustrates an optically active 'trans fat'?



20 The following compounds are found in the seaweed *Asparagopsis taxiformis*.

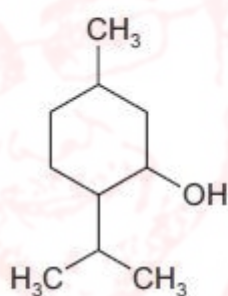
Which compound could show **both** *cis-trans* isomerism and optical isomerism?



19 Which reagent, when mixed and heated with ammonium sulfate, liberates ammonia?

- A** aqueous bromine
- B** dilute hydrochloric acid
- C** limewater
- D** potassium dichromate(VI) in acidic solution

22 Menthol is an important compound extracted from the peppermint plant.



menthol

How many chiral centres are there in one molecule of menthol?

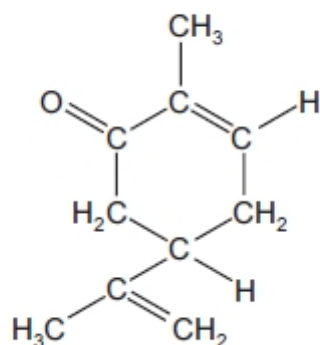
- A** 1
- B** 2
- C** 3
- D** 4

21 An alkene has the formula $\text{CH}_3\text{CH}=\text{CRCH}_2\text{CH}_3$ and does **not** possess *cis-trans* isomers.

What is *R*?

- A** H
- B** Cl
- C** CH_3
- D** C_2H_5

20 Carvone is found in spearmint.



carvone

How many σ and π bonds are present in this molecule?

	σ	π
A	13	3
B	22	3
C	22	6
D	25	3

Topic **Chem 13 Q# 866**/ AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

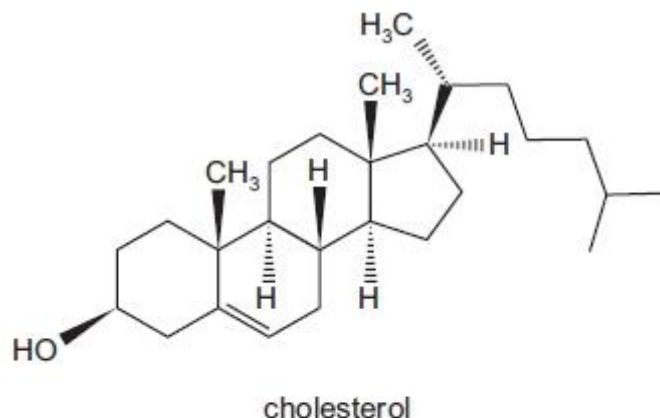
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 What is **always** involved in a carbon-carbon π bond?

- 1** a shared pair of electrons
- 2** a sideways overlap of p orbitals
- 3** delocalised electrons

24 The diagram shows the structure of the naturally-occurring molecule cholesterol.



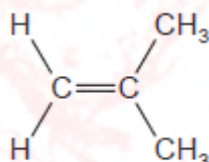
Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y claimed that this molecule displays *cis-trans* isomerism at the C=C double bond.

Which of the students are correct?

- A** both X and Y
- B** neither X nor Y
- C** X only
- D** Y only

29 The compound 2-methylpropene, C_4H_8 , is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8 , structural or otherwise, which contain a double bond.

What is the value of x ?

- A** 1
- B** 2
- C** 3
- D** 4

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Which structural formulae represent 2,2-dimethylpentane?

- 1 $(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{CH}_3)_2$
- 2 $(\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{CH}_3$
- 3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}(\text{CH}_3)_3$

Topic **Chem 13 Q# 870/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

30 Which compound exhibits both *cis-trans* and optical isomerism?

- A $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$
- B $\text{CH}_3\text{CHBrCH}=\text{CH}_2$
- C $\text{CH}_3\text{CBr}=\text{CBrCH}_3$
- D $\text{CH}_3\text{CH}_2\text{CHBrCH}=\text{CHBr}$

Topic **Chem 13 Q# 871/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 When gaseous chemicals are transported by road or by rail they are classified as follows.

flammable

non-flammable

poisonous

Which commonly transported gas is non-flammable?

- A butane
- B hydrogen
- C oxygen
- D propene

Topic **Chem 13 Q# 872/** AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

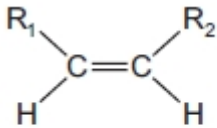
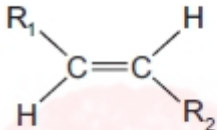
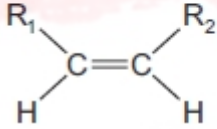
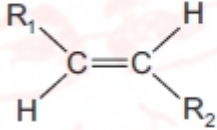
22 What is the least number of carbon atoms in a non-cyclic alkane molecule that has a chiral centre?

- A 7
- B 8
- C 9
- D 10

21 The presence of 11-*cis* retinal, $C_{20}H_{28}O$, in cells in the eye is important for vision.

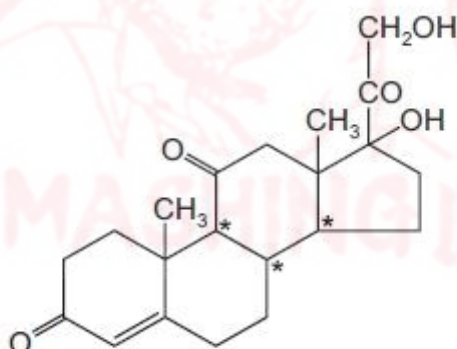
The structure of retinal includes an aldehyde group, a cyclohexene ring and a long aliphatic side chain, in which a carbon-carbon double bond exists between carbons numbered 11 and 12.

Which pair of statements about 11-*cis* retinal could be correct?

	total number of >C=C< double bonds	arrangement around the adjacent carbons 11 and 12
A	5	
B	5	
C	6	
D	6	

Topic **Chem 13 Q# 874/** AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

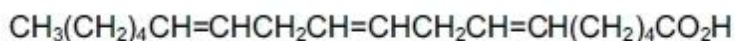
20 The drug cortisone has the formula shown.



In addition to those chiral centres marked by an asterisk (*), how many other chiral centres are present in the cortisone molecule?

- A 0 B 1 C 2 D 3

- 20** The compound known as 'gamma-linolenic acid' is found in significant amounts in the seeds of the Evening Primrose plant. There is evidence that the compound may help patients with diabetes.

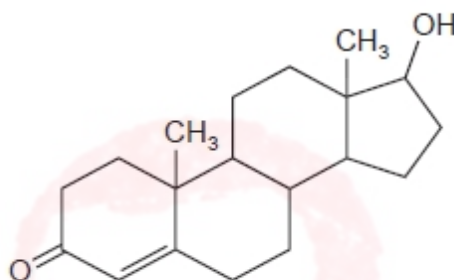


gamma-linolenic acid

How many *cis-trans* isomers does gamma-linolenic acid have?

- A** 3 **B** 6 **C** 8 **D** 12

- 19** In recent years a number of athletes have been banned from sports because of their illegal use of synthetic testosterone, a naturally occurring hormone in the body.



testosterone

How many chiral centres are present in a testosterone molecule?

- A** 1 **B** 2 **C** 3 **D** 6

- 30** Oct-1-ene, $\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}_2$, can be thermally cracked.

Which of the compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?

W	X	Y	Z
$\text{CH}_2=\text{CH}_2$	$\text{CH}_3\text{CH}=\text{CH}_2$	$\text{CH}_3\text{CH}_2\text{CH}_3$	$\text{CH}_2=\text{CHCH}=\text{CH}_2$

- A** W, X, Y and Z
B W, X and Y only
C W, X and Z only
D W and X only

28 Alkenes react with aqueous hydrogen bromide. The reaction proceeds via an intermediate carbocation. The more stable the intermediate, the faster the reaction.

Which sequence correctly shows an **increase** in the speed of reaction of the alkenes with hydrogen bromide?

- A ethene, propene, 2-methylpropene
- B 2-methylpropene, ethene, propene
- C propene, ethene, 2-methylpropene
- D propene, 2-methylpropene, ethene

27 Which compound will decolourise $\text{Br}_2(\text{aq})$?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$
- C $\text{CH}_3\text{CHCHCH}_2\text{CH}_2\text{CH}_2\text{OH}$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_3$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 One molecule of dodecane, $\text{C}_{12}\text{H}_{26}$, is cracked, producing three product molecules, X, Y and Z.

X is a straight chain alkane. Y and Z are straight chain alkenes with different M_r values.

Which statements about X, Y and Z are correct?

- 1 If Y and Z are but-1-ene and ethene respectively, X will be hexane.
- 2 If X is butane, then Y and Z could both show *cis-trans* isomerism.
- 3 X could be octane.

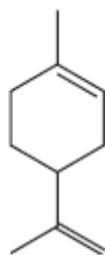
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

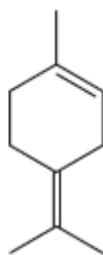


37 A diketo acid is a compound with two ketone groups and one carboxylic acid group.

limonene



terpinolene



Which statements about the reactions of limonene and terpinolene are correct?

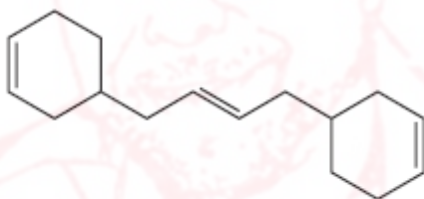
- 1 When reacted with an excess of hydrogen and a nickel catalyst, limonene and terpinolene produce the same compound.
- 2 An excess of hot concentrated acidified KMnO_4 reacts with limonene and with terpinolene to form different diketo acids.
- 3 The reactions of limonene and terpinolene with an excess of Br_2 produce positional isomers with the same number of chiral carbon atoms.

Topic **Chem 14 Q# 882/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 Structural isomerism **only** should be considered when answering this question.

Molecule X contains three $\text{C}=\text{C}$ double bonds. One mole of X is reacted with three moles of HBr . The carbon skeleton is unchanged.

molecule X



How many different products are formed?

- A** 3 **B** 4 **C** 6 **D** 8

Topic **Chem 14 Q# 883/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

33 A gaseous hydrocarbon has a density of 2.42 g dm^{-3} under room conditions.

What could be the skeletal formula of this hydrocarbon?

- 1 
- 2 
- 3 

Topic **Chem 14 Q# 884/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 The table describes four reactions of propene.

Which row is correct?

	reagent used	name of main organic product
A	aqueous bromine	2-bromopropane
B	cold acidified aqueous potassium manganate(VII)	propane-1,3-diol
C	hydrogen chloride	2-chloropropane
D	steam	propan-1-ol

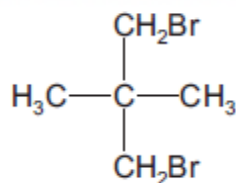
Topic **Chem 14 Q# 885/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?



Topic **Chem 14 Q# 886/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

22 The diagram shows the structure of a bromo compound that may be formed by the reaction of bromine with a hydrocarbon.



Which row is correct?

	type of reaction	mechanism
A	addition	electrophilic
B	addition	nucleophilic
C	substitution	nucleophilic
D	substitution	free-radical

21 Two students each make a statement about 2-methylbut-1-ene.

Student 1 states that 2-methylbut-1-ene has geometrical isomers.

Student 2 states that 2-methylbut-1-ene reacts with HBr in an addition reaction to give 1-bromo-2-methylbutane as the main product.

Which students are correct?

- A** both 1 and 2
- B** 1 only
- C** 2 only
- D** neither 1 nor 2

Topic **Chem 14 Q# 888**/ AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 The catalytic converters fitted to cars remove pollutants from the exhaust gases. Some of the reactions that occur involve oxygen, which comes from the air.

Which pollutants in the exhaust gases will react with oxygen on the surface of the catalytic converter?

- 1** NO₂
- 2** unburnt fuel
- 3** CO

Topic **Chem 14 Q# 889**/ AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

22 But-1-ene and but-2-ene are treated separately with cold, dilute acidified manganate(VII) ions.

Four students, W, X, Y and Z, make statements about these alkenes and the diols formed from them.

- W** One diol contains two primary alcohol groups.
- X** One diol contains a primary and a secondary alcohol group.
- Y** One diol contains two secondary alcohol groups.
- Z** Both alkenes exhibit *cis-trans* isomerism.

Which two students are correct?

- A** W and Y
- B** W and Z
- C** X and Y
- D** X and Z



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Which statements comparing ethene and ethane are correct?

- 1 The bond angles in ethene are larger than the bond angles in ethane.
- 2 Ethene reacts much more quickly with bromine in the dark than ethane does.
- 3 Complete combustion of 0.01 mol of ethene or ethane produces the same volume of gas measured at room temperature and pressure.

Topic **Chem 14 Q# 891/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 Compound Q shows the following reactions.

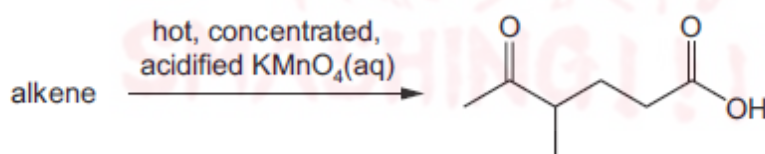
- It gives an orange precipitate with 2,4-dinitrophenylhydrazine.
- It gives a red-brown precipitate with Fehling's reagent.
- It gives a pale yellow precipitate with alkaline aqueous iodine.

What could be the identity of Q?

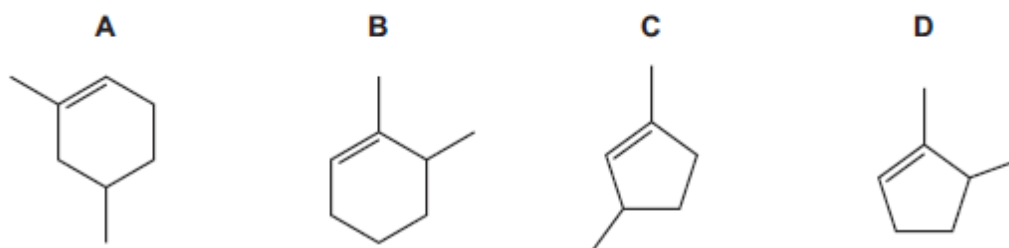
- A ethanal
- B propan-2-ol
- C propanal
- D propanone

Topic **Chem 14 Q# 892/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

22 An alkene reacts with hot, concentrated, acidified potassium manganate(VII) to produce a single organic product as shown.



What is the structure of the alkene?



21 Alkanes are saturated hydrocarbons.

Which type of reaction are alkanes most likely to undergo?

- A electrophilic addition
- B electrophilic substitution
- C free radical substitution
- D nucleophilic addition

20 Which substance reacts with trichloroethene to give a chiral product?

- A Br_2
- B HCl
- C NaCN
- D NaOH

22 What is the structural formula of the major product when hydrogen bromide reacts with 2-methylbut-2-ene?

- A $\text{CH}_2\text{BrCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- B $(\text{CH}_3)_2\text{CBrCH}_2\text{CH}_3$
- C $(\text{CH}_3)_2\text{CHCHBrCH}_3$
- D $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{Br}$

22 Many reactions take place in the engine and catalytic converter of a car.

Which pair of substances is produced **both** by the reactions in a car engine and in a catalytic converter?

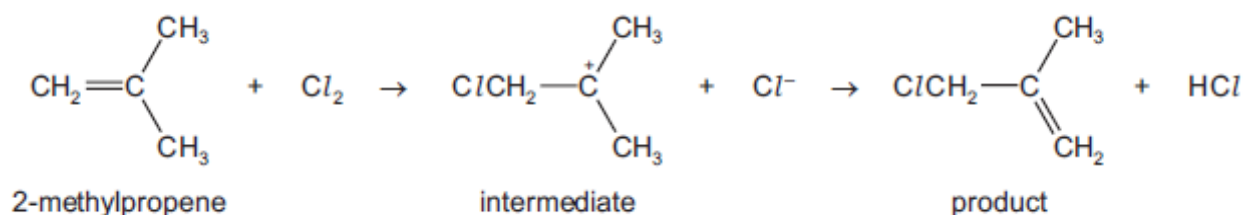
- A carbon dioxide and unburnt hydrocarbons
- B carbon dioxide and water
- C carbon monoxide and nitrogen
- D carbon monoxide and unburnt hydrocarbons

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 2-methylpropene can react in more than one way with chlorine.

One of the reactions follows the pathway shown.



Which statements about this mechanism are correct?

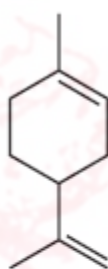
- 1 The intermediate has all carbon atoms in the same plane.
- 2 There is an electrophilic attack on the double bond.
- 3 It is a free radical mechanism.

Topic **Chem 14 Q# 898**/ AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Limonene is found in lemons.



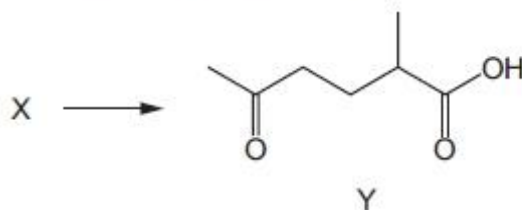
limonene

Limonene is heated with concentrated acidified potassium manganate(VII).

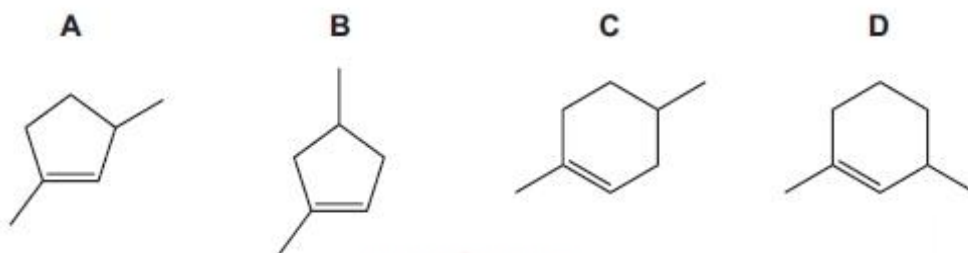
Which compounds are produced?

- 1 $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}(\text{CH}_2\text{CO}_2\text{H})_2$
- 2 CO_2
- 3 $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}(\text{COCH}_3)\text{CH}_2\text{CO}_2\text{H}$

22 Compound X can be converted into compound Y in a single step.



What could be the identity of X?



22 Many, but not all, organic reactions need to be heated before a reaction occurs.

Which reaction occurs quickly at room temperature, 20 °C?

- A** $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$
- B** $C_2H_4 + H_2O \rightarrow CH_3CH_2OH$
- C** $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$
- D** $CH_3CH_2OH + HBr \rightarrow CH_3CH_2Br + H_2O$

22 An alkene is reacted with acidified manganate(VII) ions, MnO_4^- . The desired organic product has a relative molecular mass greater than that of the alkene by 34.

What conditions should be used?

- A** cold, concentrated MnO_4^-
- B** cold, dilute MnO_4^-
- C** hot, concentrated MnO_4^-
- D** hot, dilute MnO_4^-

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which compounds can be obtained from but-2-ene in a single reaction?

- 1 $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_3$
- 2 $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$
- 3 $\text{CH}_3\text{CO}_2\text{H}$

Topic Chem 14 Q# 903/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

23 Propene undergoes a variety of reactions.

Which row is correct?

	reagent added to propene	products include
A	$\text{Br}_2(\text{aq})$	1-bromopropane
B	cold, dilute, acidified $\text{KMnO}_4(\text{aq})$	propanoic acid
C	$\text{HBr}(\text{g})$	2-bromopropane
D	hot, concentrated, acidified $\text{KMnO}_4(\text{aq})$	propanoic acid

Topic Chem 14 Q# 904/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 Structural isomerism and stereoisomerism should be considered when answering this question.

How many isomers with the formula C_4H_8 have structures that contain a π bond?

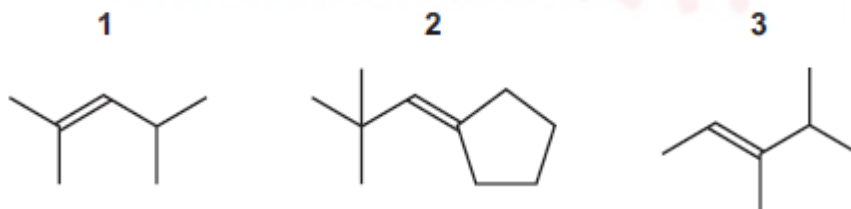
- A 1 B 2 C 3 D 4

Topic Chem 14 Q# 905/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses A to D should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which compounds would produce a carboxylic acid and a ketone when treated with hot, concentrated, acidified KMnO_4 ?



Topic Chem 14 Q# 906/ AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

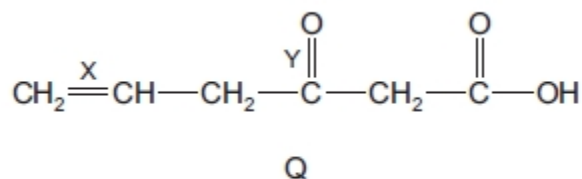
23 The first propagation step in the reaction between methane and chlorine is shown.



How many different first propagation steps are possible in the reaction between pentane and chlorine?

- A 2 B 3 C 4 D 5

23 Compound Q contains three double bonds per molecule.



Which bond, X or Y, will be ruptured by hot, concentrated acidified KMnO_4 and how many lone pairs of electrons are present in one molecule of Q?

	bond ruptured by hot, concentrated acidified KMnO_4	number of lone pairs
A	X	5
B	X	6
C	Y	5
D	Y	6

23 Which intermediate ion forms in the greatest amount during the addition of HBr to propene?

- A** $\text{CH}_3\text{CH}^+\text{CH}_3$
- B** $\text{CH}_3\text{CH}_2\text{CH}_2^+$
- C** $\text{CH}_3\text{CH}^-\text{CH}_2\text{Br}$
- D** $\text{CH}_3\text{CHBrCH}_2^-$

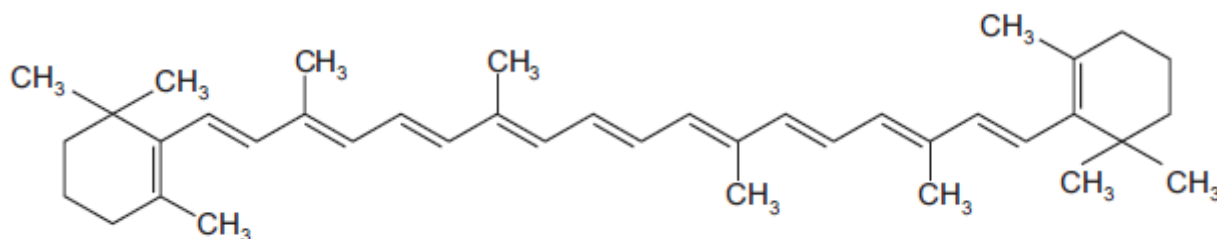
22 Cottonseed oil contains large amounts of polyunsaturated carboxylic acids. When this oil is used to make margarine, the $\text{C}=\text{C}$ double bonds in the unsaturated carboxylic acids are hydrogenated.

What reagents and conditions would be suitable to bring about this hydrogenation reaction?

- A** H_2 gas, nickel catalyst, 400°C
- B** LiAlH_4 in dry ether
- C** NaBH_4 , aqueous solution
- D** steam, concentrated H_2SO_4 , 300°C and 60 atm pressure



30 β -carotene is responsible for the orange colour of carrots.



β -carotene

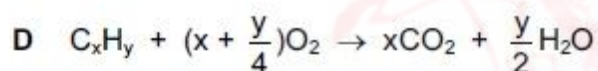
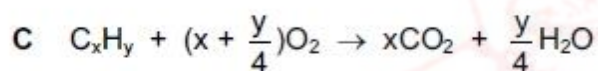
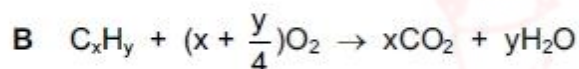
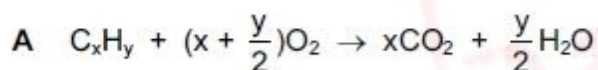
β -carotene is oxidised by hot, concentrated, acidified KMnO_4 .

When an individual molecule of β -carotene is oxidised in this way, many product molecules are formed.

How many of these product molecules contain a ketone functional group?

- A** 4 **B** 6 **C** 9 **D** 11

29 Which equation correctly represents the balanced equation for the complete combustion of a hydrocarbon with the formula C_xH_y ?



20 Which row correctly describes the reaction between propene and bromine, $\text{Br}_2(\text{l})$?

	reaction mechanism	organic product
A	electrophilic addition	$\text{CH}_3\text{CHBrCH}_2\text{Br}$
B	electrophilic addition	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
C	nucleophilic substitution	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
D	nucleophilic substitution	$\text{CH}_3\text{CHBrCH}_2\text{Br}$

27 The hydrocarbon $\text{C}_{17}\text{H}_{36}$ can be cracked.

Which compound is the **least** likely to be produced in this reaction?

- A** C_3H_8 **B** C_4H_8 **C** C_8H_{16} **D** $\text{C}_{16}\text{H}_{34}$

26 How many moles of oxygen molecules are needed for the complete combustion of one mole of 3-methylpent-2-ene?

- A** 9 **B** $9\frac{1}{2}$ **C** 18 **D** 19

7 Which stage in the free radical substitution of methane by chlorine will have the lowest activation energy?

- A** $\text{CH}_3\bullet + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\bullet$
B $\text{Cl}\bullet + \text{Cl}\bullet \rightarrow \text{Cl}_2$
C $\text{Cl}\bullet + \text{CH}_4 \rightarrow \text{CH}_3\bullet + \text{HCl}$
D $\text{Cl}_2 \rightarrow \text{Cl}\bullet + \text{Cl}\bullet$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which molecules would be present in the mixture produced by the photochemical chlorination of methane?

- 1** hydrogen
2 hydrogen chloride
3 dichloromethane

25 Pentane, C_5H_{12} , is reacted with chlorine in the presence of ultraviolet light. A compound **R** is found in the products. **R** has molecular formula $\text{C}_5\text{H}_{10}\text{Cl}_2$. Each molecule of **R** contains **one** chiral carbon atom.

Which two atoms of the pentane chain could be bonded to chlorine atoms in this isomer?

- A** 1 and 3 **B** 1 and 5 **C** 2 and 3 **D** 2 and 4

22 Bromine reacts with ethene to form 1,2-dibromoethane.

What is the correct description of the organic intermediate in this reaction?

- A** It has a negative charge.
B It is a free radical.
C It is a nucleophile.
D It is an electrophile.



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which reagents and conditions will convert propane into 1-chloropropane?

- 1 Cl_2 and sunlight
- 2 conc. HCl , reflux
- 3 PCl_5

Topic **Chem 14 Q# 920**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

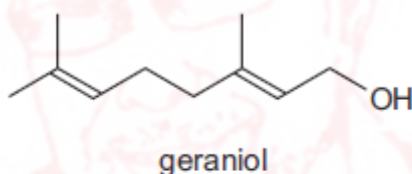
23 The cracking of a single hydrocarbon molecule, $\text{C}_n\text{H}_{2n+2}$, produces two hydrocarbon molecules only. Each hydrocarbon product contains the same number of carbon atoms in one molecule. Each hydrocarbon product has non-cyclic structural isomers.

What is the value of n ?

- A 4 B 6 C 8 D 9

Topic **Chem 14 Q# 921**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Geraniol is a constituent of some perfumes.



Which statement about geraniol is **not** correct?

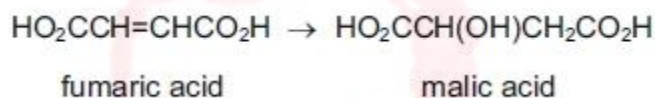
- A Geraniol causes hot acidified potassium dichromate(VI) to change colour from orange to green.
- B Geraniol decolourises bromine water.
- C There are three methyl groups and three methylene (CH_2) groups in geraniol.
- D There are two pairs of *cis-trans* isomers of geraniol.

27 A reaction between chlorine and propane in ultraviolet light produces two isomeric monochloropropanes, C_3H_7Cl , as products.

Which information about this reaction is correct?

	type of bond fission in initiation step	expected ratio of 1-chloropropane to 2-chloropropane produced
A	heterolytic	1 : 1
B	heterolytic	3 : 1
C	homolytic	1 : 1
D	homolytic	3 : 1

26 Energy is released in the human body by the oxidation of glucose in a complex sequence of reactions. Part of this sequence is the Krebs cycle. One reaction in the Krebs cycle is the conversion of fumaric acid into malic acid.



Which reagents could achieve this transformation in the laboratory?

- A** acidified KMnO_4
- B** $\text{Br}_2(\text{aq})$ followed by hot $\text{NaOH}(\text{aq})$
- C** H_2O with Pt catalyst
- D** steam with H_2SO_4

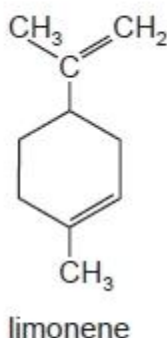
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

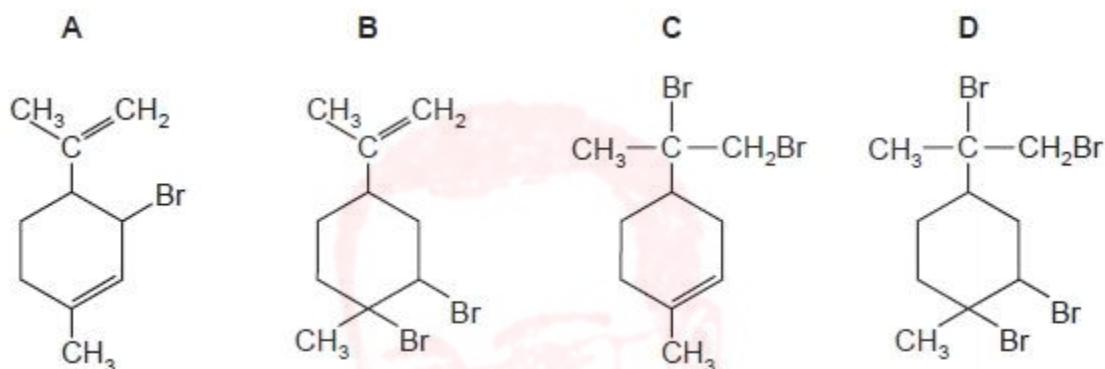
38 Which alkenes, on reaction with steam at 600 K and 6×10^6 Pa pressure in the presence of a phosphoric acid catalyst, could produce an alcohol containing a chiral carbon atom?

- 1** $(\text{CH}_3)_2\text{C}=\text{CH}_2$
- 2** $\text{CH}_3\text{CH}=\text{CHCH}_3$
- 3** $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$

25 Limonene is an oil formed in the peel of citrus fruits.



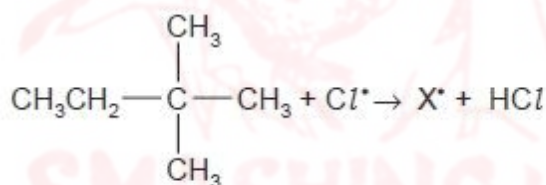
Which product is formed when an excess of bromine, $\text{Br}_2(\text{l})$, reacts with limonene at room temperature in the dark?



Topic **Chem 14 Q# 926/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 When heated with chlorine, the hydrocarbon 2,2-dimethylbutane undergoes free radical substitution.

In a propagation step the free radical $\text{X}^\bullet$ is formed.



How many different forms of $\text{X}^\bullet$ are possible?

- A** 1 **B** 2 **C** 3 **D** 4

Topic **Chem 14 Q# 927/** AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

26 Which equation represents a valid propagation step in the free radical reaction between ethane and chlorine?

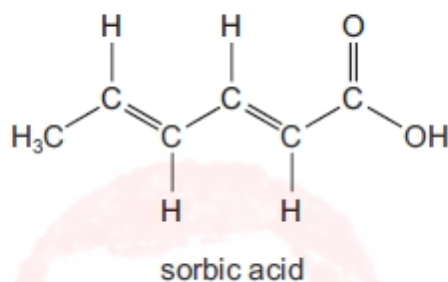
- A** $\text{C}_2\text{H}_6 + \text{Cl}^\bullet \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{H}^\bullet$
B $\text{C}_2\text{H}_5\text{Cl} + \text{Cl}^\bullet \rightarrow \text{C}_2\text{H}_4\text{Cl}^\bullet + \text{HCl}$
C $\text{C}_2\text{H}_6 + \text{H}^\bullet \rightarrow \text{C}_2\text{H}_5^\bullet + \text{HCl}$
D $\text{C}_2\text{H}_5^\bullet + \text{Cl}^\bullet \rightarrow \text{C}_2\text{H}_5\text{Cl}$

25 Bromine reacts with ethene to form 1,2-dibromoethane.

What is the correct description of the organic intermediate in this reaction?

- A** It has a negative charge.
- B** It is a free radical.
- C** It is a nucleophile.
- D** It is an electrophile.

24 Sorbic acid is used as a food preservative because it kills fungi and moulds.



Sorbic acid will react with

- hydrogen in the presence of a nickel catalyst,
- bromine in an organic solvent.

How many moles of hydrogen and of bromine will be incorporated into one mole of sorbic acid by these reactions?

	moles of hydrogen	moles of bromine
A	2	2
B	2	$2\frac{1}{2}$
C	3	2
D	3	$2\frac{1}{2}$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 37 A fraction of distilled crude oil contains molecules with between 15 and 19 carbon atoms. This fraction is cracked by strong heating.

Why is this done?

- 1 To produce alkenes.
- 2 To produce smaller molecules which are in higher demand.
- 3 To insert oxygen atoms into the hydrocarbons.

Topic Chem 15 Q# 931 / AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org

:o)

- 37 2-bromopropane reacts with hot ethanolic sodium hydroxide.

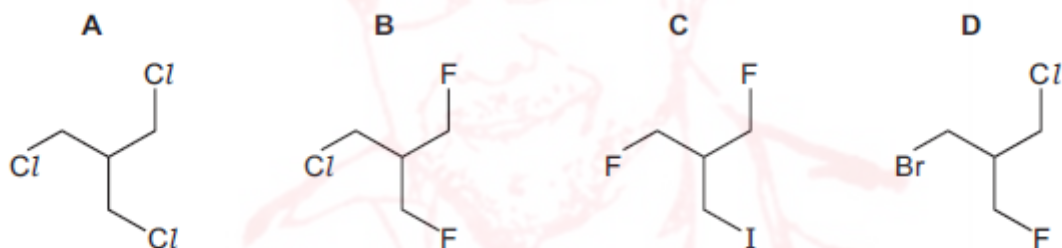
Which substance is the major product of this reaction?

- A propan-1-ol
- B propan-2-ol
- C 2-hydroxypropene
- D propene

Topic Chem 15 Q# 932 / AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

- 32 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?



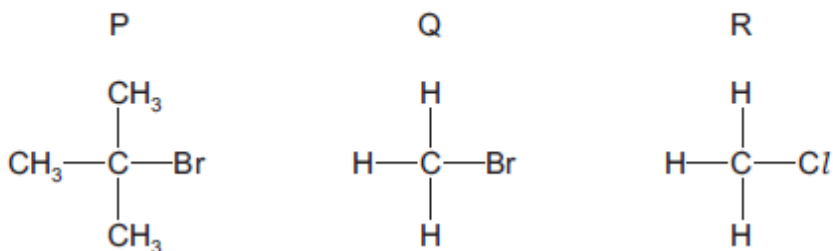
Topic Chem 15 Q# 933 / AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

- 31 Structural isomerism and stereoisomerism should be taken into account when answering this question.

How many isomeric alkenes with formula C_5H_8 are present in the mixture produced when 1,4-dibromopentane is reacted with NaOH in ethanol?

- A 1 B 2 C 3 D 4

30 The diagram shows the structures of three halogenoalkanes.



P, Q and R can all be hydrolysed.

Which row is correct?

	relative speed of hydrolysis		mechanism of hydrolysis	
	Q	R	P	Q
A	fast	slow	S _N 1	S _N 2
B	fast	slow	S _N 2	S _N 1
C	slow	fast	S _N 1	S _N 2
D	slow	fast	S _N 2	S _N 1

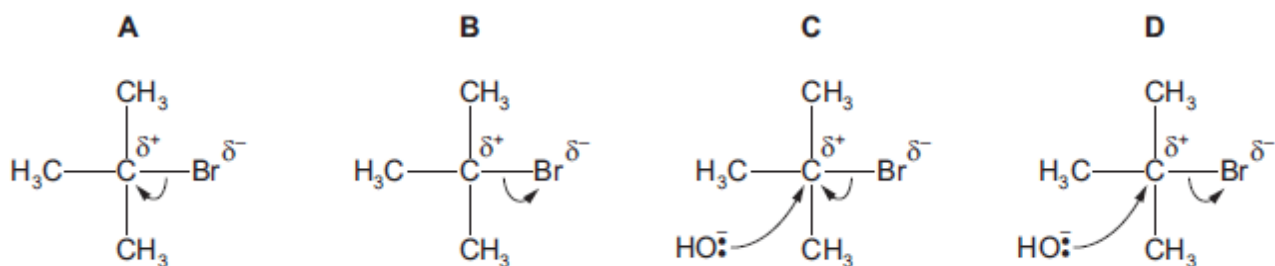
29 A reaction occurs when a sample of 1-chloropropane is heated under reflux with sodium hydroxide dissolved in ethanol.

Which row is correct?

	type of reaction	name of product
A	elimination	propan-1-ol
B	elimination	propene
C	substitution	propan-1-ol
D	substitution	propene

23 When 2-bromo-2-methylpropane reacts with aqueous sodium hydroxide, an alcohol is formed.

Which diagram describes the first step in the reaction mechanism?



22 Structural isomerism **and** stereoisomerism should be considered when answering this question.

A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

When heated with sodium hydroxide in ethanol, a mixture of **only two** alkenes is formed.

What could the colourless liquid be?

- A $(CH_3CH_2)_2CHCl$
- B $CH_3CH_2CH_2CHClCH_3$
- C $CH_3CH_2CCl(CH_3)_2$
- D $(CH_3)_2CHCHClCH_3$

Topic **Chem 15 Q# 938/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which statements are correct?

- 1 1,1-difluoroethane is less reactive than 1,1-dichloroethane.
- 2 1,1-difluoroethane is polar.
- 3 The C–F bond is stronger than the C–Cl bond.

Topic **Chem 15 Q# 939/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 Bromoethane reacts with cyanide ions, producing propanenitrile.

Which statement about the S_N2 mechanism of this reaction is correct?

- A The lone pair of electrons on C of CN^- attacks the carbon atom of the C–Br bond.
- B The lone pair of electrons on C of CN^- attacks the carbocation formed when the C–Br bond breaks.
- C The lone pair of electrons on N of CN^- attacks the carbon atom of the C–Br bond.
- D The lone pair of electrons on N of CN^- attacks the carbocation formed when the C–Br bond breaks.

Topic **Chem 15 Q# 940/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

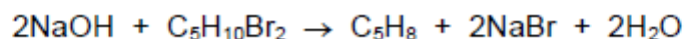


37 In which reactions is the major product formed by a nucleophilic substitution reaction?

- 1 bromoethane + potassium cyanide in ethanol
- 2 bromoethane + ammonia in ethanol under pressure
- 3 bromoethane + hot concentrated sodium hydroxide in ethanol

Topic **Chem 15 Q# 941/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

25 Dibromopentanes can undergo 'double elimination' reactions to produce hydrocarbons.

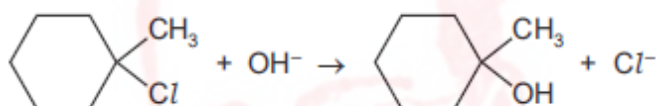


Which isomer produces only one hydrocarbon product?

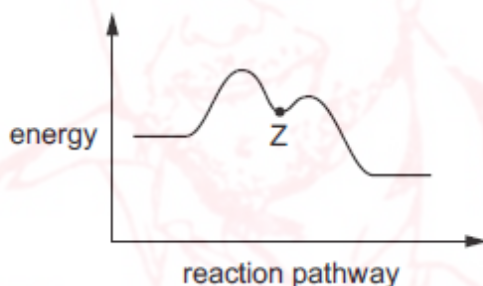
- A 1,5-dibromopentane
- B 1,4-dibromopentane
- C 2,3-dibromopentane
- D 2,4-dibromopentane

Topic **Chem 15 Q# 942/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

25 1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq).



The reaction pathway is shown.



One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.

What is the charge on this carbon atom at point Z?

- A 1- B δ^- C δ^+ D 1+

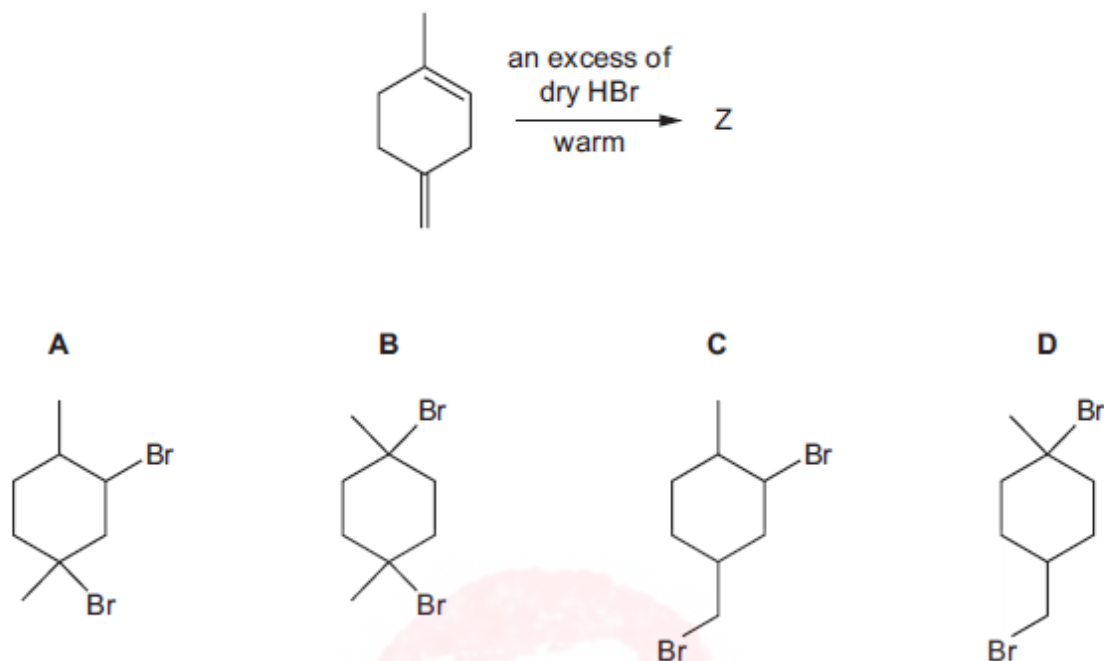
Topic **Chem 15 Q# 943/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

23 Iodoethane, $\text{CH}_3\text{CH}_2\text{I}$, reacts with aqueous silver nitrate at 50°C . A precipitate forms during this reaction.

Which row of the table is correct about this reaction?

	type of organic reaction	colour of precipitate
A	electrophilic substitution	cream
B	electrophilic substitution	yellow
C	nucleophilic substitution	cream
D	nucleophilic substitution	yellow

27 What is the major product Z of the following reaction?



23 2-bromo-2-methylpentane is a tertiary halogenoalkane.

Which organic products are formed when 2-bromo-2-methylpentane reacts with a hot concentrated ethanolic solution of sodium hydroxide?

- A** 2-methylpent-1-ene only
- B** 2-methylpent-1-ene and 2-methylpent-2-ene
- C** 2-methylpent-2-ene only
- D** 2-methylpent-2-ene and 4-methylpent-2-ene

21 Which row identifies a suitable starting material and reagent that can be used to produce butanenitrile?

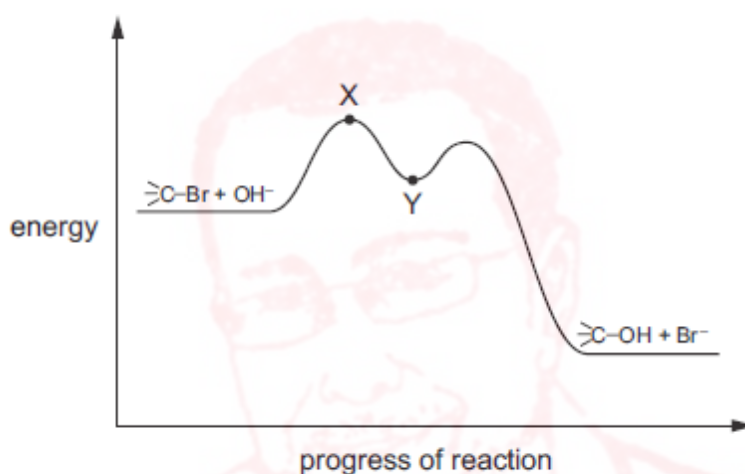
	starting material	reagent
A	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$	HCN
B	$\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$	NaCN
C	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$	HCN
D	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$	NaCN

24 Bromoethane and chloroethane are added separately to water. Hydrolysis reactions occur.

Which compound hydrolyses more rapidly and what is the mechanism?

	compound that hydrolyses more rapidly	mechanism
A	bromoethane	electrophilic substitution
B	bromoethane	nucleophilic substitution
C	chloroethane	electrophilic substitution
D	chloroethane	nucleophilic substitution

23 A tertiary bromoalkane, indicated here by >C-Br , reacts with aqueous NaOH. The mechanism has the reaction pathway shown.



Which point in the diagram is correctly identified?

A X is >C^+

B X is $\left[\text{HO} \cdots \text{C} \cdots \text{Br} \right]^-$

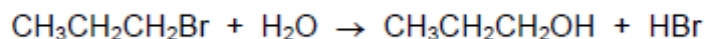
C Y is >C^+

D Y is $\left[\text{HO} \cdots \text{C} \cdots \text{Br} \right]^-$

23 Which reaction is most likely to involve the formation of a positively charged intermediate?

- A** 1-bromopentane and warm dilute NaOH(aq)
- B** 1-bromo-2,2-dimethylpropane and warm dilute NaOH(aq)
- C** 1-bromo-3-methylbutane and warm dilute NaOH(aq)
- D** 2-bromo-2-methylbutane and warm dilute NaOH(aq)

24 Bromopropane reacts with water as shown.



Which statement is correct?

- A** This is an elimination reaction.
- B** This is a hydrolysis reaction.
- C** This is a redox reaction.
- D** This reaction tends to proceed via the $\text{S}_{\text{N}}1$ mechanism.

23 Structural isomerism and stereoisomerism should be considered when answering this question.

2-bromopentane is heated with an excess of ethanolic sodium hydroxide.

How many different hydrocarbons are produced?

- A** 1 **B** 2 **C** 3 **D** 4

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

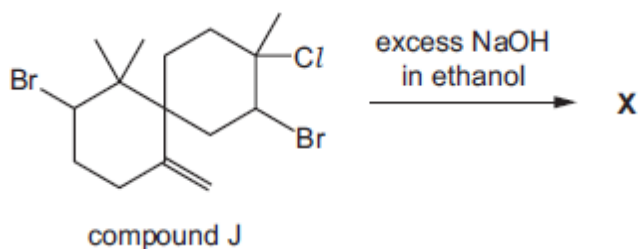
38 The halogenoalkanes listed below all react with NaOH(aq) .

Which reactions proceed mainly by an $\text{S}_{\text{N}}1$ mechanism?

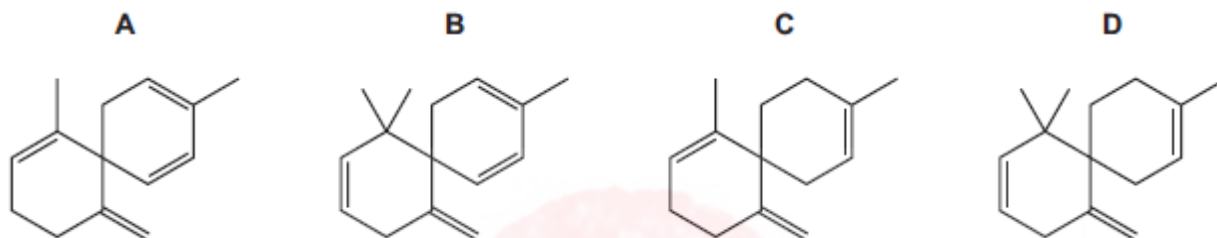
- 1** 1-iodopropane
- 2** 2-iodo-2-methylpropane
- 3** 2-bromo-2-methylbutane



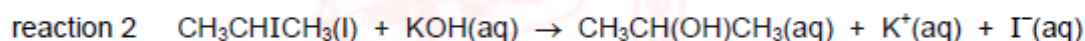
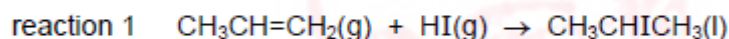
- 25** Compound J, $C_{15}H_{23}Br_2Cl$, is reacted with an excess of a hot concentrated solution of sodium hydroxide in ethanol. One of the products is X.



What could be the skeletal formula of X?



- 23** The conversion of propene to propan-2-ol can be carried out in two stages represented by the equations shown.



How can these two reactions be described?

	reaction 1	reaction 2
A	addition	elimination
B	addition	substitution
C	elimination	substitution
D	substitution	elimination

- 20** What is true of **every** nucleophile?

- A** It attacks a double bond.
- B** It donates a lone pair of electrons.
- C** It is a single atom.
- D** It is negatively charged.

22 Sodium methoxide, $\text{Na}^+\text{CH}_3\text{O}^-$, reacts with 2-chloro-2-methylpropane in a nucleophilic substitution reaction. The nucleophile is the CH_3O^- ion.

Which row is correct?

	intermediate or transition state	product
A	$(\text{CH}_3)_3\text{C}^+$	$(\text{CH}_3)_3\text{COCH}_3$
B	$(\text{CH}_3)_3\text{C}^+$	$(\text{CH}_3)_3\text{CCH}_2\text{OH}$
C	$[\text{HOCH}_2 - - \text{C}(\text{CH}_3)_3 - - \text{Cl}]^-$	$\text{HOCH}_2\text{C}(\text{CH}_3)_3$
D	$[\text{H}_3\text{CO} - - \text{C}(\text{CH}_3)_3 - - \text{Cl}]^-$	$\text{H}_3\text{COC}(\text{CH}_3)_3$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Organic compound X gives a precipitate when warmed with aqueous silver nitrate. This precipitate dissolves when concentrated aqueous ammonia is added.

What could X be?

- 1** 1-bromopropane
- 2** 2-chlorobutane
- 3** 2-iodo-2-methylpropane

27 A reaction occurs when a sample of 1-chloropropane is heated under reflux with sodium hydroxide dissolved in ethanol.

Which row is correct?

	type of reaction	name of product
A	elimination	propan-1-ol
B	elimination	propene
C	substitution	propan-1-ol
D	substitution	propene

21 An organic ion containing a carbon atom with a negative charge is called a carbanion.

An organic ion containing a carbon atom with a positive charge is called a carbocation.

The reaction between aqueous sodium hydroxide and 1-bromobutane proceeds by an S_N2 mechanism.

What is the first step in the mechanism?

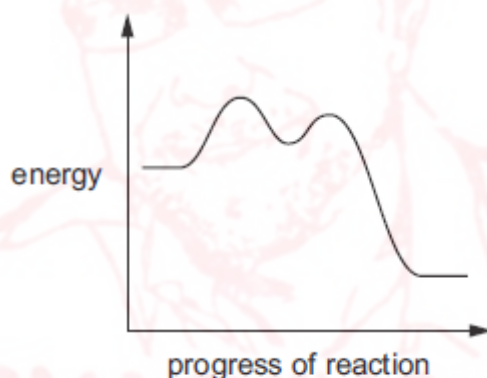
- A** attack by a nucleophile on a carbon atom with a partial positive charge
- B** heterolytic bond fission followed by attack by an electrophile on a carbanion
- C** heterolytic bond fission followed by attack by a nucleophile on a carbocation
- D** homolytic bond fission followed by attack by a nucleophile on a carbocation

Topic **Chem 15 Q# 960/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 38//

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 A reaction pathway diagram is shown.



Which reactions would have this reaction pathway diagram?

- 1** $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$
- 2** $CH_3CH_2CH_2Br + NaOH \rightarrow CH_3CH_2CH_2OH + NaBr$
- 3** $(CH_3)_3CCH_2CH_2Cl + 2NH_3 \rightarrow (CH_3)_3CCH_2CH_2NH_2 + NH_4Cl$

Topic **Chem 15 Q# 961/** AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 31//

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that includes the formation of a positive ion?

- 1 first ionisation energy
- 2 heterolytic fission of a covalent bond
- 3 enthalpy change of atomisation

Topic Chem 15 Q# 962/ AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 24//

24 Which organic reaction is an example of nucleophilic substitution?

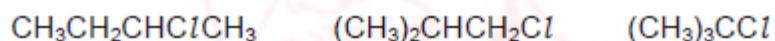
- A $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_2\text{CH}_2 + \text{H}_2\text{O} + \text{NaBr}$
- B $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- C $\text{CH}_2\text{CH}_2 + \text{HCl} \rightarrow \text{C}_2\text{H}_5\text{Cl}$
- D $\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl}$

Topic Chem 15 Q# 963/ AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses A to D should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 The following statements are about the reaction of NaOH(aq) with the three chloroalkanes shown.



Which statements are correct?

- 1 $(\text{CH}_3)_2\text{CHCH}_2\text{Cl}$ reacts with NaOH(aq) by an $\text{S}_{\text{N}}2$ mechanism.
- 2 The tertiary chloroalkane reacts more quickly than the others because the carbon atom bonded to the Cl atom is more positive in this molecule.
- 3 The Cl atoms in the three chloroalkanes are attacked by OH^- .

Topic Chem 15 Q# 964/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses A to D should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Which statements help to explain the mechanism of the reaction between 1-chloropropane and ammonia?

- 1 1-chloropropane has a δ^- chlorine atom that forms hydrogen bonds with a δ^+ hydrogen atom in ammonia.
- 2 1-chloropropane is a polar compound with a δ^+ carbon atom.
- 3 There is a lone pair of electrons on the nitrogen atom in ammonia.

22 Which radical is most likely to form by the homolytic fission of one covalent bond in bromochloromethane, CH_2BrCl ?

- A** $\cdot\text{CH}_2\text{Cl}$ **B** $\cdot\text{CH}_2\text{Br}$ **C** $\cdot\text{CHBrCl}$ **D** $\cdot\text{CH}_2\text{BrCl}$

Topic **Chem 15 Q# 966**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Bromoethane reacts with NaOH in different ways depending on the solvent used.

Which statements about these reactions are correct?

	solvent used	main organic product
1	water	ethane-1,2-diol
2	ethanol	ethene
3	water	ethanol

Topic **Chem 15 Q# 967**/ AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Which types of reaction can occur with 1-bromobutane?

- 1** elimination
- 2** hydrolysis
- 3** free radical substitution

25 A student prepares pentan-1-ol by the alkaline hydrolysis of 1-iodopentane. She gently warms the reaction mixture for 20 minutes.



When the student uses 1-chloropentane to prepare the same alcohol she has to change the condition of the reaction.

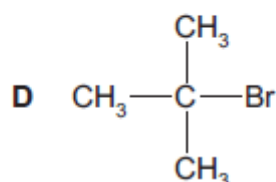
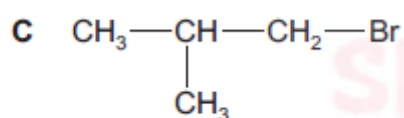
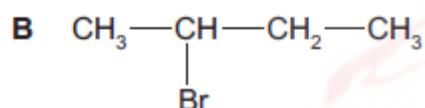
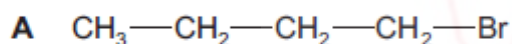
Which change in condition should she use and what is the correct reason for its use?

	change in condition	reason
A	heat under reflux	C–Cl bond is more polar than the C–I bond
B	heat under reflux	C–Cl bond is stronger than the C–I bond
C	room temperature	C–Cl bond is more polar than the C–I bond
D	room temperature	C–Cl bond is shorter than the C–I bond

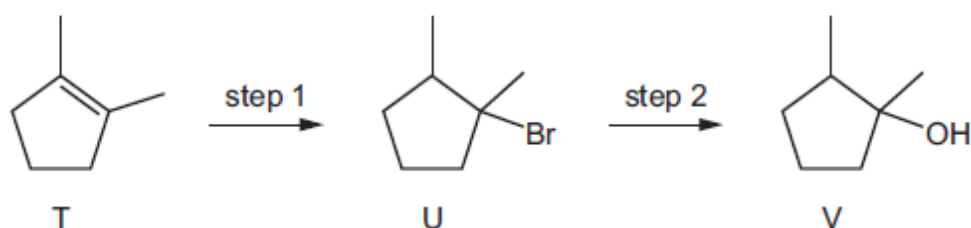
25 Structural isomerism and stereoisomerism should be considered in answering this question.

Compound J is reacted with KOH dissolved in ethanol. Three isomeric alkenes with molecular formula C_4H_8 are formed.

What is J?



24 Hydrogen bromide can be added to T to give compound U. Compound U can be hydrolysed to compound V.



Four students, W, X, Y and Z, made the following statements.

W All the atoms in a molecule of compound T lie in the same plane.

X Compound V contains only one chiral centre.

Y Step 1 is an electrophilic addition reaction.

Z Step 2 is a nucleophilic substitution reaction.

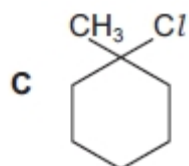
Which two students are correct?

- A** W and Y **B** W and Z **C** X and Y **D** Y and Z

24 Which compound undergoes an S_N1 substitution reaction with NaOH(aq) ?

A $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$

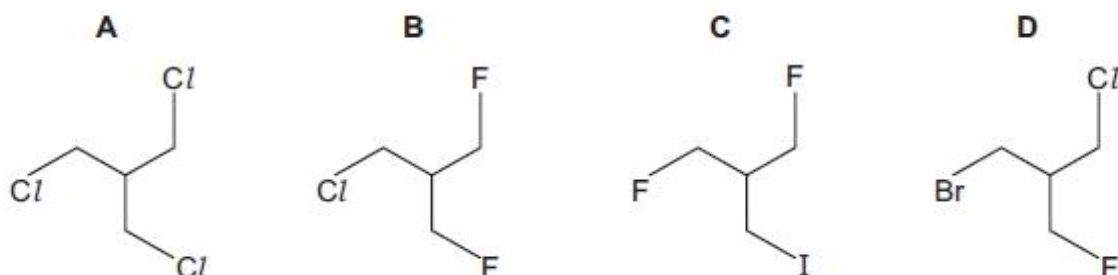
B $(\text{CH}_3)_3\text{CCH}_2\text{I}$



D $\text{CH}_2=\text{CHCl}$

26 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?

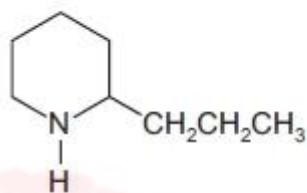


Topic **Chem 15 Q# 973/** AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)
25 2-bromopropane reacts with a hot concentrated solution of sodium hydroxide in ethanol.

Which substance is the major product of this reaction?

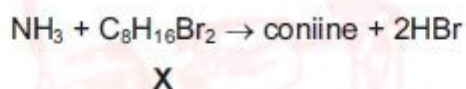
- A propan-1-ol
- B propan-2-ol
- C 2-hydroxypropene
- D propene

Topic **Chem 15 Q# 974/** AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)
24 Coniine is the major constituent of the poison 'oil of hemlock'.



coniine

Coniine can be synthesised by reacting ammonia with a dibromo compound, X.



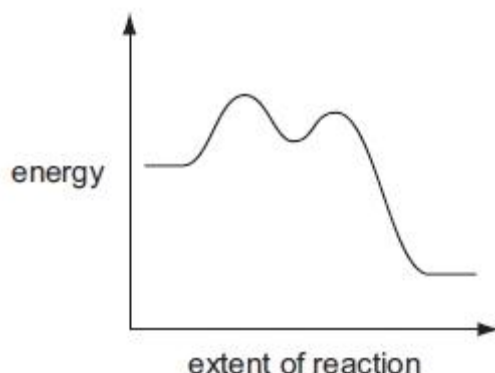
What is the name of compound X?

- A 1,1-dibromo-2-propylcyclopentane
- B 1,2-dibromo-2-propylcyclopentane
- C 1,4-dibromooctane
- D 1,5-dibromooctane

Topic **Chem 15 Q# 975/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 A reaction pathway diagram is shown.



Which reactions would have this profile?

- 1 $(\text{CH}_3)_3\text{CBr} + \text{NaOH} \rightarrow (\text{CH}_3)_3\text{COH} + \text{NaBr}$
- 2 $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- 3 $(\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{Cl} + 2\text{NH}_3 \rightarrow (\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Cl}$

Topic **Chem 15 Q# 976/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 **X** is an organic compound that gives a precipitate with aqueous silver nitrate. This precipitate remains undissolved when concentrated aqueous ammonia is added.

What is a possible identity for **X**?

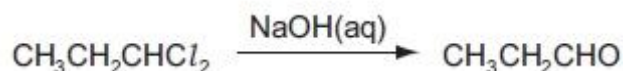
- 1 iodomethane
- 2 2-bromobutane
- 3 2-chlorobutane

Topic **Chem 15 Q# 977/** AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

25 In the hydrolysis of bromoethane by aqueous sodium hydroxide, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

22 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.



Which term describes the first step of this reaction?

- A** addition
- B** elimination
- C** oxidation
- D** substitution

23 The hydrolysis of 1-chloropropane to produce propan-1-ol is much slower than the corresponding hydrolysis of 1-iodopropane.

Which statement explains this observation?

- A** Chlorine is more electronegative than iodine.
- B** The bond strength of the C–I bond is less than that of the C–Cl bond.
- C** The carbon atom in the C–Cl bond is more δ^+ than that in the C–I bond.
- D** The hydrolysis involves a nucleophilic addition reaction.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 The organic compound **X** gives a precipitate when warmed with aqueous silver nitrate. This precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for **X**?

- 1** 1-bromopropane
- 2** 2-chlorobutane
- 3** 2-iodo,2-methylpropane

- 24** A carbanion is an organic ion in which a carbon atom has a negative charge. A carbocation is an organic ion in which a carbon atom has a positive charge.

The reaction between aqueous sodium hydroxide and 1-bromobutane proceeds by an S_N2 mechanism.

How should the first step in the mechanism be described?

- A** attack by a nucleophile on a carbon atom with a partial positive charge
- B** heterolytic bond fission followed by an attack by an electrophile on a carbanion
- C** heterolytic bond fission followed by an attack by a nucleophile on a carbocation
- D** homolytic bond fission followed by an attack by a nucleophile on a carbocation

- 24** Aqueous sodium hydroxide reacts with 1-bromopropane to give propan-1-ol.

How should the first step in the mechanism be described?

- A** by a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 1-bromopropane
- B** by a curly arrow from the $C^{\delta+}$ atom of 1-bromopropane to the OH^- ion
- C** by a curly arrow from the C–Br bond to the C atom
- D** by the homolytic fission of the C–Br bond

- 23** Chloroethane can be used to make sodium propanoate.



The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide, to give sodium propanoate.

Which reagent would produce the intermediate, Q, from chloroethane?

- A** concentrated ammonia solution
- B** dilute sulfuric acid
- C** hydrogen cyanide
- D** potassium cyanide

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



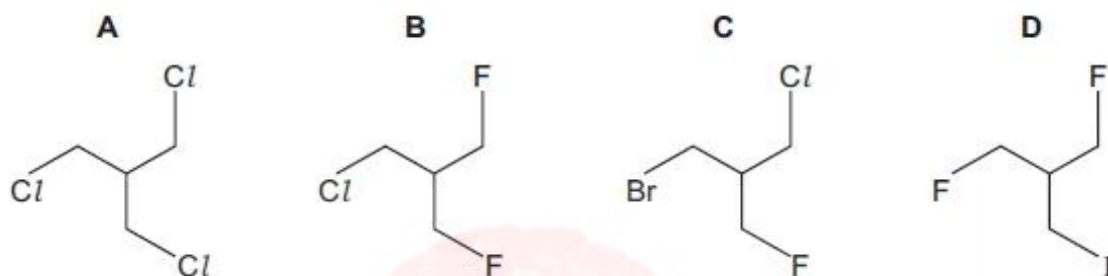
40 How can a good yield of ethylamine be made using bromoethane as starting material?

- 1 by heating bromoethane with an excess of ammonia gas in a sealed tube
- 2 by adding dilute aqueous ammonia to bromoethane at room temperature
- 3 by heating bromoethane under reflux with aqueous ammonium chloride

Topic **Chem 15 Q# 985/** AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 The presence of halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would produce a precipitate quickest?



Topic **Chem 15 Q# 986/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 **X** is an organic compound. **X** gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when an excess of dilute aqueous ammonia is added.

What could be the identity of **X**?

- 1 2-chlorobutane
- 2 2-bromobutane
- 3 iodomethane

Topic **Chem 15 Q# 987/** AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 1-bromobutane?

- A attack by a nucleophile on a carbon atom with a partial positive charge
- B heterolytic bond fission and attack by a nucleophile on a carbocation
- C homolytic bond fission and attack by an electrophile on a carbanion
- D homolytic bond fission and attack by a nucleophile on a carbocation

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Bromoethane undergoes all of the conversions shown.

Which conversions are examples of nucleophilic substitution?

- 1 $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{CN}$
- 2 $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{OH}$
- 3 $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{NH}_2$

Topic **Chem 15 Q# 989/** AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

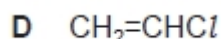
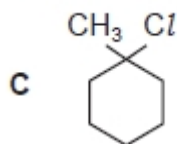
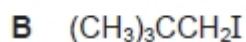
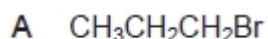
22 The formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons must be present for CH_3 to act in these different ways?

	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

Topic **Chem 15 Q# 990/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 Which compound undergoes an $\text{S}_{\text{N}}1$ substitution reaction?



Topic **Chem 15 Q# 991/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



39 Which reactions are examples of nucleophilic substitution?

- 1 $\text{CH}_3\text{CH}_2\text{Br} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{Br}^-$
- 2 $\text{CH}_3\text{I} + \text{H}_2\text{O} \xrightarrow{\text{H}^+} \text{CH}_3\text{OH} + \text{HI}$
- 3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl} + \text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 + \text{HCl}$

Topic **Chem 15 Q# 992/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 When an isomer Y of molecular formula $\text{C}_4\text{H}_9\text{Br}$ undergoes hydrolysis in aqueous alkali to form an alcohol $\text{C}_4\text{H}_9\text{OH}$, the rate of reaction is found to be unaffected by changes in the concentration of OH^- ions present.

Which is the most likely molecular structure of Y?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$
- B $\text{CH}_3\text{CH}_2\text{CHBrCH}_3$
- C $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$
- D $(\text{CH}_3)_3\text{CBr}$

Topic **Chem 15 Q# 993/** AS Chemistry/2009/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which statements are true for an $\text{S}_{\text{N}}2$ reaction?

- 1 One bond is broken as another bond is formed.
- 2 The formation of a transition state involves the collision of two molecules or ions.
- 3 A carbon atom in the transition state is bonded, either fully or partially, to five other atoms.

Topic **Chem 15 Q# 994/** AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 In the hydrolysis of bromoethane by aqueous sodium hydroxide, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

Topic **Chem 15 Q# 995/** AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 What always applies to a nucleophile?

- A It attacks a double bond.
- B It has a lone pair of electrons.
- C It is a single atom.
- D It is negatively charged.

26 Which pair of alcohols are isomers of each other?

- A butan-1-ol and 2,2-dimethylpropan-1-ol
- B butan-2-ol and 2-methylpropan-2-ol
- C pentan-1-ol and 2-methylpropan-2-ol
- D propan-2-ol and 2-methylpropan-2-ol

Topic Chem 16 Q# 997/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

34 Crotyl alcohol, $\text{CH}_3\text{CH}=\text{CHCH}_2\text{OH}$, is a colourless liquid which is used as a solvent.

Crotyl alcohol will react separately with Br_2 , $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$, conc. KMnO_4/H^+ and PCl_5 under suitable conditions.

Which row is correct?

	reactant	conditions	main product
A	Br_2	room temperature	$\text{CH}_3\text{CH}=\text{CHCH}_2\text{Br}$
B	$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$	heat under reflux	$\text{CH}_3\text{CH}=\text{CHCHO}$
C	conc. KMnO_4/H^+	heat under reflux	$\text{CH}_3\text{CH}=\text{CHCO}_2\text{H}$
D	PCl_5	room temperature	$\text{CH}_3\text{CH}=\text{CHCH}_2\text{Cl}$

Topic Chem 16 Q# 998/ AS Chemistry/2022/m/TZ 2/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

31 A sample of 2.30 g of ethanol is mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture is boiled under reflux for one hour. The required organic product is then collected by distillation. The yield of product is 60.0%.

Which mass of product is collected?

- A 1.32 g
- B 1.38 g
- C 1.80 g
- D 3.00 g

Topic Chem 16 Q# 999/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses A to D should be selected on the basis of

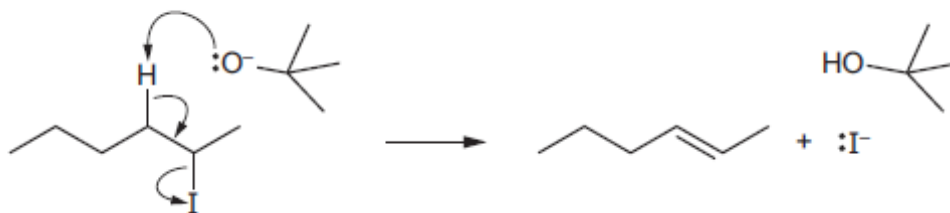
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Which reactions of propan-1-ol have water as one of the products?

- 1 passing propan-1-ol vapour over hot Al_2O_3
- 2 mixing propan-1-ol with warm ethanoic acid and a few drops of concentrated sulfuric acid
- 3 warming propan-1-ol with HBr



20 Hex-2-ene can be made by the reaction shown.



Which statement about this reaction is correct?

- A** $(\text{CH}_3)_3\text{CO}^-$ is behaving as a Brønsted-Lowry base.
- B** $(\text{CH}_3)_3\text{CO}^-$ is behaving as an oxidising agent.
- C** The C–I bond breaks via homolytic fission.
- D** This is a hydrolysis reaction.

Topic **Chem 16 Q# 1001/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 Which compound produces a ketone when refluxed with an acidified solution of potassium dichromate(VI)?

- A** pentan-1-ol
- B** 2-methylbutan-1-ol
- C** 2-methylbutan-2-ol
- D** 3-methylbutan-2-ol

Topic **Chem 16 Q# 1002/** AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 How many tertiary alcohols have the molecular formula $\text{C}_6\text{H}_{14}\text{O}$?

- A** 1
- B** 2
- C** 3
- D** 4

Topic **Chem 16 Q# 1003/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Three reactions of primary alcohols are listed.

Which reactions give water as one of the products?

- 1** reaction with ethanoic acid
- 2** reaction with concentrated HBr
- 3** passing the alcohol vapour over heated Al_2O_3

26 An alcohol with the molecular formula $C_5H_{12}O$ decolourises warm acidified potassium manganate(VII). The alcohol also gives a yellow precipitate with alkaline aqueous iodine.

What could be the identity of the alcohol?

- A 2-methylbutan-2-ol
- B 3-methylbutan-2-ol
- C pentan-1-ol
- D pentan-3-ol

25 An alcohol has the molecular formula $C_5H_{12}O$. It has several isomers.

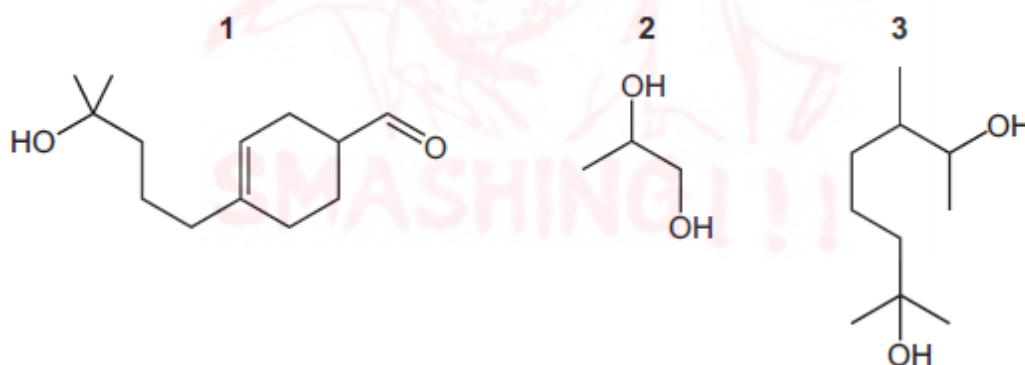
Which isomer forms a yellow precipitate with alkaline aqueous iodine?

- A 2,2-dimethylpropan-1-ol
- B 2-methylbutan-2-ol
- C 3-methylbutan-2-ol
- D pentan-3-ol

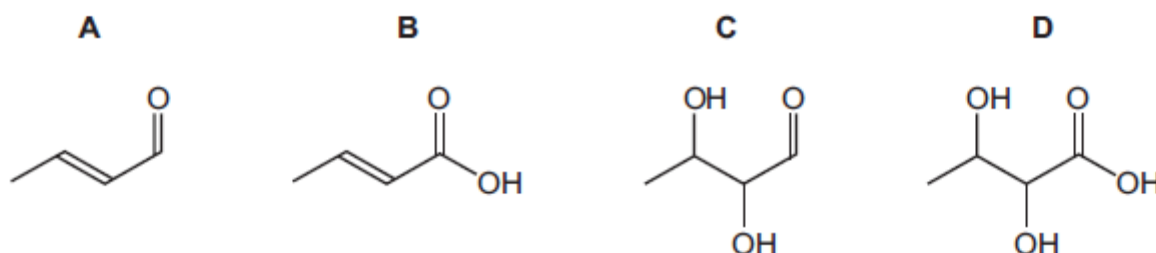
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

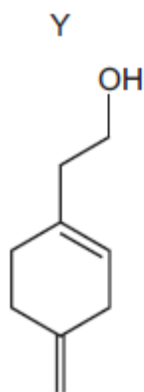
38 Which compounds will produce a yellow precipitate with alkaline aqueous iodine?



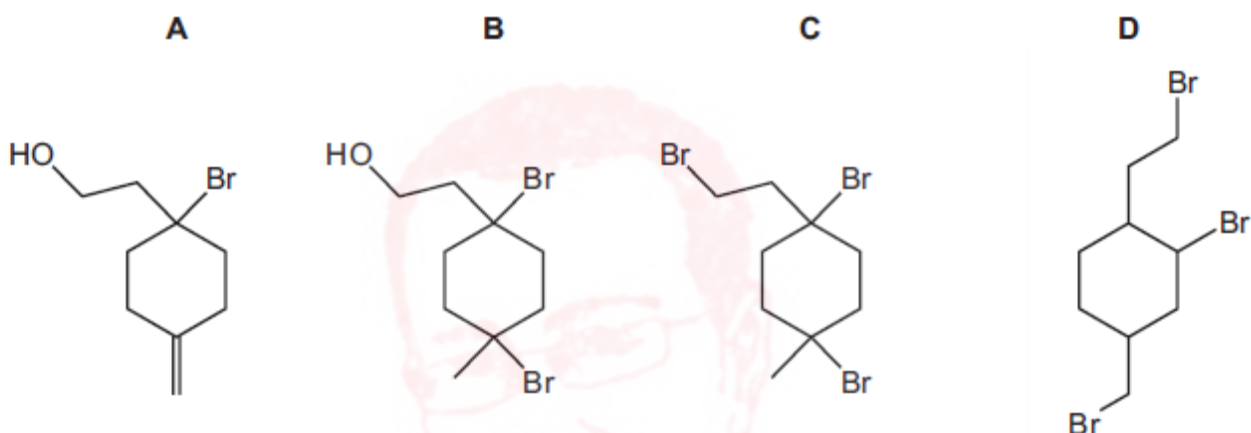
29 What is the skeletal formula of the compound formed when $CH_3CH=CHCH_2OH$ is heated, under reflux, with $K_2Cr_2O_7/H^+$?



26 An excess of dry HBr is warmed with compound Y.



What is the major product of the reaction?

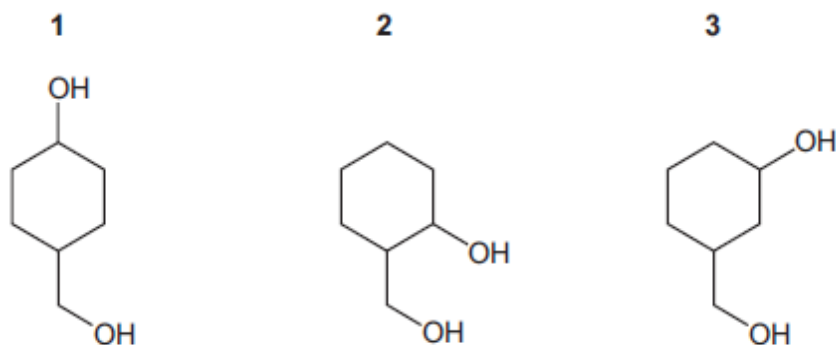


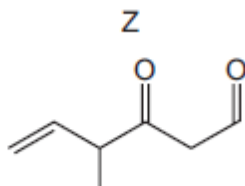
Topic **Chem 16 Q# 1009**/ AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

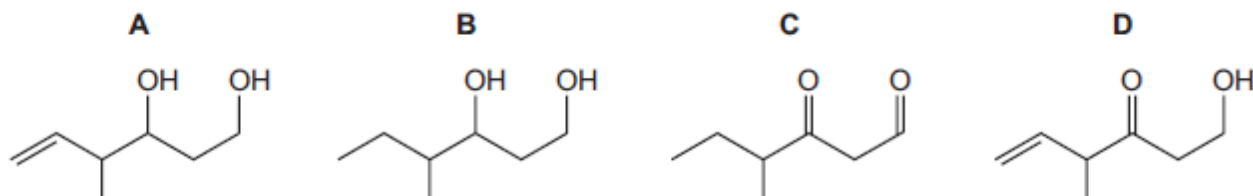
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Which compounds, on heating with an excess of concentrated sulfuric acid, produce **only one** product with molecular formula C_7H_{10} ?





What is the product of the reaction between compound Z and an excess of NaBH₄?



25 Alcohol X is oxidised to form compound Y.

The composition of Y is 54.54% carbon, 36.36% oxygen and 9.10% hydrogen. The *M_r* of Y is 88.0.

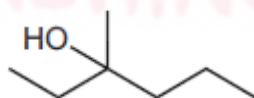
What could be the structure of alcohol X?

- A** CH₃CH₂CH(OH)CH₃
- B** CH₃CH₂CH₂CH₂CH₂OH
- C** CH₃CH₂CH₂CH₂OH
- D** CH₃CH₂CH(OH)CH₂CH₃

26 Structural isomerism and stereoisomerism should be considered when answering this question.

3-methylhexan-3-ol reacts with hot, concentrated sulfuric acid to form several isomeric compounds with the molecular formula C₇H₁₄.

3-methylhexan-3-ol



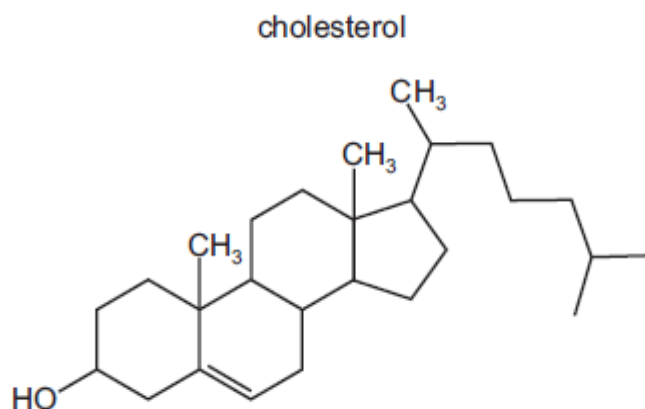
How many isomeric compounds could be formed in this reaction?

- A** 3
- B** 4
- C** 5
- D** 6

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 The diagram shows the structure of cholesterol.



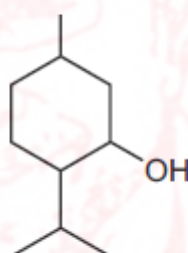
Which statements about cholesterol are correct?

- 1 The molecule contains a secondary alcohol group.
- 2 The molecule contains two π bonds.
- 3 All carbon atoms in the four rings lie in the same plane.

Topic **Chem 16 Q# 1014**/ AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

26 Menthol is a naturally occurring alcohol.

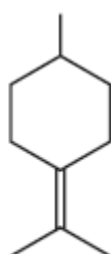
menthol



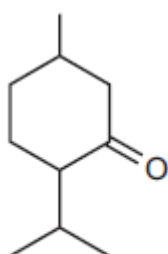
When menthol is heated with concentrated sulfuric acid it reacts. The products formed include compound T.

What could be the structure of compound T?

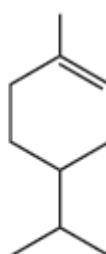
A



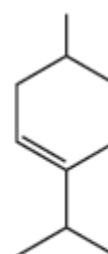
B



C



D



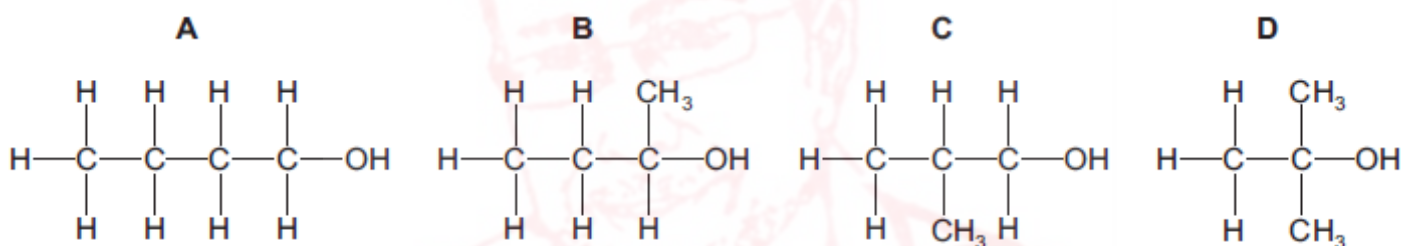
25 Which product is formed when 3-methylpentane-1,3,4-triol is heated under reflux with an excess of acidified potassium dichromate(VI)?

- A $\text{HO}_2\text{CCH}_2\text{C}(\text{CH}_3)(\text{OH})\text{COCH}_3$
- B $\text{HO}_2\text{CCH}_2\text{COC}(\text{OH})(\text{CH}_3)_2$
- C $\text{OHCCH}_2\text{C}(\text{CH}_3)(\text{OH})\text{COCH}_3$
- D $\text{HO}_2\text{CCH}_2\text{CO}(\text{CH}_3)\text{COCH}_3$

24 Which reagent could detect the presence of alcohol in a mixture consisting mainly of alkanes and alkenes?

- A Na
- B Br_2 (in CCl_4)
- C $\text{KMnO}_4(\text{aq})$
- D 2,4-dinitrophenylhydrazine

23 Which alcohol can be dehydrated to give two products which are structural isomers of each other?



25 Which volume of hydrogen, measured under room conditions, is produced when 0.160 g of methanol reacts with an excess of sodium?

- A 60 cm^3
- B 120 cm^3
- C 240 cm^3
- D 480 cm^3

24 Structural isomerism and stereoisomerism should be considered when answering this question.

The molecular formula of compound X is $\text{C}_5\text{H}_{12}\text{O}$.

Compound X:

- reacts with alkaline aqueous iodine
- can be dehydrated to form two alkenes only.

What could be the identity of compound X?

- A $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$
- B $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$
- C $(\text{CH}_3)_2\text{CHCH}(\text{OH})\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$

28 A sample of 2.30g of ethanol was mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The required organic product was then collected by distillation. The yield of product was 60.0%.

Which mass of product was collected?

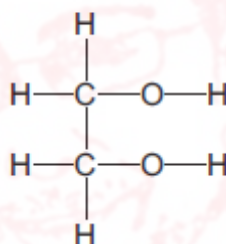
- A 1.32 g B 1.38 g C 1.80 g D 3.00 g

27 Q is a compound with the molecular formula $C_4H_{10}O$. Q can be oxidised with acidified potassium dichromate(VI). Q cannot be made by reducing a carboxylic acid with $LiAlH_4$.

What is the structure of Q?

- A $CH_3CH(OH)CH_2CH_3$
 B $CH_3CH_2CH_2CH_2OH$
 C $(CH_3)_3COH$
 D $(CH_3)_2CHCH_2OH$

27 Ethane-1,2-diol has the following structure.



Without breaking the C—C bond, there are five possible oxidation products.

What is the total number of aldehyde groups and carboxylic acid groups in these five products?

	—CHO	—COOH
A	3	3
B	3	4
C	4	3
D	4	4

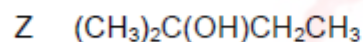
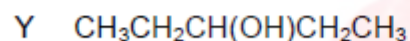
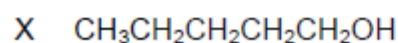
26 Propan-2-ol undergoes many reactions.

Which row is correct?

	reagent added to propan-2-ol	product
A	acidified KMnO_4	$\text{CH}_3\text{CH}_2\text{CHO}$
B	Cl_2	$\text{CH}_3\text{CHClCH}_3$
C	conc. H_2SO_4	CH_3CHCH_2
D	methanoic acid	$\text{HCO}_2\text{CH}_2\text{CH}_2\text{CH}_3$

Topic **Chem 16 Q# 1024/** AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

25 X, Y and Z are three isomeric alcohols.



Two or more of these alcohols react with mild oxidising agents.

One of these alcohols, when dehydrated, will give a pair of cis-trans isomers with molecular formula C_5H_{10} .

Which row is correct?

	reacts with mild oxidising reagents	gives cis-trans isomers
A	X, Y and Z	Y only
B	X, Y and Z	Z only
C	X and Y only	Y only
D	X and Y only	Z only

26 Which row correctly shows a primary, a secondary and a tertiary alcohol?

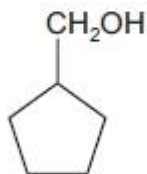
	primary	secondary	tertiary
A	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_2 \\ \\ \text{CH}_3 \end{array}$	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CHOH} \\ \\ \text{CH}_3 \end{array}$	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CHOH} \\ \\ \text{CH}_2\text{OH} \end{array}$
B	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_3-\text{C}-\text{H} \\ \\ \text{CH}_3 \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{OH} \\ \\ \text{CH}_3 \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{H} \\ \\ \text{CH}_2\text{OH} \end{array}$
C	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_3-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_3-\text{C}-\text{CH}_2\text{OH} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_3-\text{C}-\text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \end{array}$
D	$\begin{array}{c} \text{H} \\ \\ \text{CH}_3-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{OH} \\ \\ \text{CH}_3 \end{array}$

26 Which compound **cannot** be oxidised by acidified potassium dichromate(VI) solution but **does** react with sodium metal?

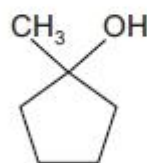
- A** $(\text{CH}_3)_3\text{COH}$
- B** $\text{CH}_3\text{COCH}_2\text{CH}_3$
- C** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- D** $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$



27 Which reagent will give a different observation with compounds W and X?



W



X

- A hot SOCl_2
- B hot acidified $\text{K}_2\text{Cr}_2\text{O}_7$
- C NaOH(aq)
- D warm Fehling's reagent

Topic **Chem 16 Q# 1028**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 9//www.SmashingScience.org :o)

9 Methylpropan-1-ol and butan-1-ol are structural isomers. Methylpropan-1-ol has a lower boiling point.

Which statement explains why the boiling point of methylpropan-1-ol is lower than that of butan-1-ol?

- A Methylpropan-1-ol cannot form hydrogen bonds.
- B Methylpropan-1-ol has weaker covalent bonds than butan-1-ol.
- C Methylpropan-1-ol has weaker van der Waals' forces than butan-1-ol.
- D Methylpropan-1-ol molecules have more surface area than butan-1-ol molecules.

Topic **Chem 16 Q# 1029**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 Lactic acid, $\text{CH}_3\text{CH(OH)CO}_2\text{H}$, causes pain when it builds up in muscles.

Which reagent reacts with **both** of the $-\text{OH}$ groups in lactic acid?

- A acidified potassium dichromate(VI)
- B ethanol
- C sodium
- D sodium hydroxide

Topic **Chem 16 Q# 1030**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

23 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $\text{C}_5\text{H}_{12}\text{O}$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 The compound pentan-1,4-diol has two OH groups per molecule and can be oxidised.

Which statements about pentan-1,4-diol or its oxidation products are correct?

- 1 When one mole of pentan-1,4-diol reacts with an excess of sodium metal, one mole of hydrogen molecules is produced.
- 2 At least one of the possible oxidation products of pentan-1,4-diol will react with 2,4-dinitrophenylhydrazine reagent.
- 3 Dehydration of pentan-1,4-diol could produce a compound with empirical formula C_5H_8 .

Topic **Chem 16 Q# 1032**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 Compound X has the molecular formula $C_4H_{10}O_2$. X has an unbranched carbon chain and contains two OH groups.

On reaction with an excess of hot, acidified, aqueous manganate(VII) ions, X is converted into a compound of molecular formula $C_4H_6O_4$.

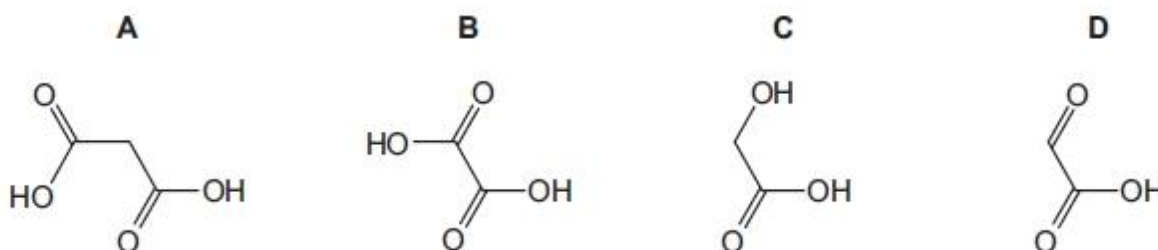
To which two carbon atoms in the chain of X are the two OH groups attached?

- 1st and 2nd
- 1st and 3rd
- 1st and 4th
- 2nd and 3rd

Topic **Chem 16 Q# 1033**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 Hydroxyethanal, $HOCH_2CHO$, is heated under reflux with an excess of acidified potassium dichromate(VI) until no further oxidation takes place.

What is the skeletal formula of the organic product?

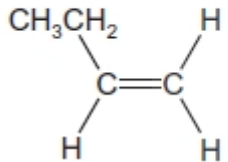
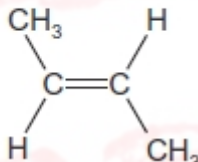
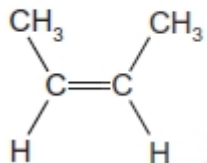
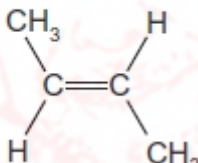
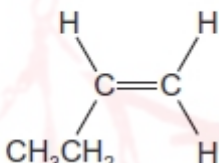
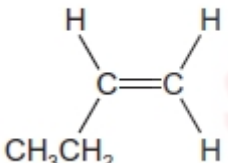
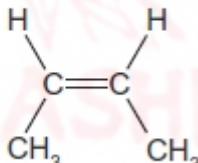
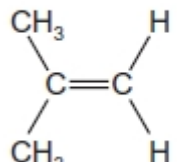
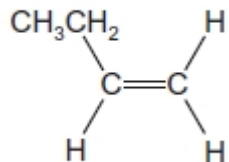
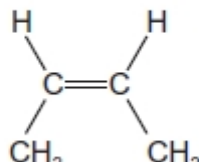


- 27** Primary alcohols can be oxidised to aldehydes using either acidified potassium dichromate(VI) or acidified potassium manganate(VII). Both these oxidising agents change colour as they are reduced.

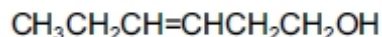
What is the colour of each oxidising agent before and after it has reacted?

	acidified potassium dichromate(VI)		acidified potassium manganate(VII)	
	before	after	before	after
A	green	orange	purple	colourless
B	orange	green	colourless	purple
C	orange	green	purple	colourless
D	purple	colourless	orange	green

- 25** What are the only structures formed when butan-2-ol is heated with concentrated H_2SO_4 ?

A			
B			
C			
D			

22 The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.



leaf alcohol

What will be formed when 'leaf alcohol' is oxidised using an excess of hot, acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$?

- A** $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$
- B** $\text{CH}_3\text{CH}_2\text{COCOCH}_2\text{CO}_2\text{H}$
- C** $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CO}_2\text{H}$
- D** $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ and $\text{HO}_2\text{CCH}_2\text{CO}_2\text{H}$

Topic **Chem 16 Q# 1037/** AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

26 Use of the Data Booklet is relevant to this question.

2.30 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The desired organic product was then collected by distillation. The yield of product was 60.0%.

What mass of product was collected?

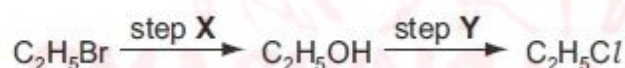
- A** 1.32 g **B** 1.38 g **C** 1.80 g **D** 3.20 g

Topic **Chem 16 Q# 1038/** AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

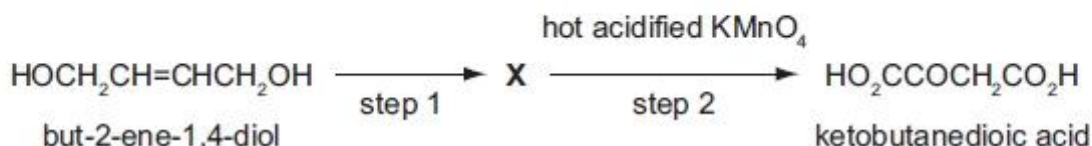
38 Chloroethane can be formed from bromoethane in two steps.



Which statements about these steps are correct?

- 1** Step X involves nucleophilic substitution.
- 2** Hot aqueous sodium hydroxide is the reagent in step X.
- 3** Hot aqueous sodium chloride is the reagent in step Y.

24 But-2-ene-1,4-diol is converted in two steps through an intermediate **X** into ketobutanedioic acid.



What could be the reagent for step 1 and the intermediate **X**?

	reagent for step 1	X
A	cold acidified KMnO ₄	HOCH ₂ CH ₂ CH(OH)CH ₂ OH
B	hot acidified KMnO ₄	OHCCH(OH)CH ₂ CHO
C	steam and concentrated H ₂ SO ₄	HOCH ₂ CH(OH)CH ₂ CH ₂ OH
D	warm acidified K ₂ Cr ₂ O ₇	HO ₂ CCH=CHCO ₂ H

Topic **Chem 16 Q# 1040**/ AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

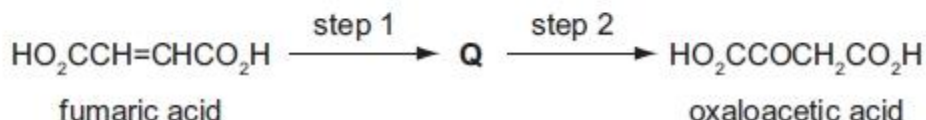
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 A number of alcohols with the formula C₄H₁₀O are separately oxidised. Using 70 g of the alcohols a 62% yield of organic product is achieved.

What mass of product could be obtained?

- 1** 42.2 g of butanone
- 2** 51.6 g of butanoic acid
- 3** 51.6 g of 2-methyl propanoic acid

- 20** Fumaric acid can be converted into oxaloacetic acid by a two-step process involving the intermediate **Q**.



Each of these steps can be achieved in the laboratory by a single reagent.

What could be the intermediate **Q** and the reagent for step 2?

	Q	reagent for step 2
A	$\text{HO}_2\text{CCHBrCH}_2\text{CO}_2\text{H}$	warm acidified KMnO_4
B	$\text{HO}_2\text{CCHBrCH}(\text{OH})\text{CO}_2\text{H}$	warm $\text{NaOH}(\text{aq})$
C	$\text{HO}_2\text{CCH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$	Fehling's solution
D	$\text{HO}_2\text{CCH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$	warm acidified $\text{K}_2\text{Cr}_2\text{O}_7$

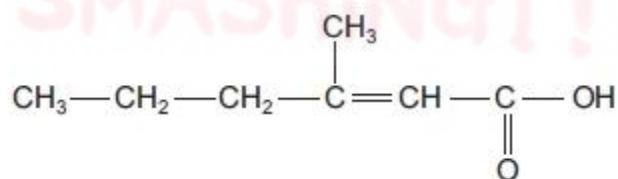
- 12** Aluminium chloride catalyses certain reactions by forming carbocations with chloroalkanes as shown.



Which property makes this reaction possible?

- A** AlCl_3 exists as the dimer Al_2Cl_6 in the vapour.
- B** AlCl_3 is a covalent molecule.
- C** The aluminium atom in AlCl_3 has an incomplete octet of electrons.
- D** The chlorine atom in RCl has a vacant p orbital.

- 28** An unpleasant smelling chemical produced in the human armpit is 3-methylhex-2-enoic acid.



If this compound is reacted with a cold, dilute, acidified solution of potassium manganate(VII), how many chiral centres will be produced?

- A** 0
- B** 1
- C** 2
- D** 3



25 Use of the Data Booklet is relevant to this question.

2.76 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The organic product was then collected by distillation.

The yield of product was 75.0%.

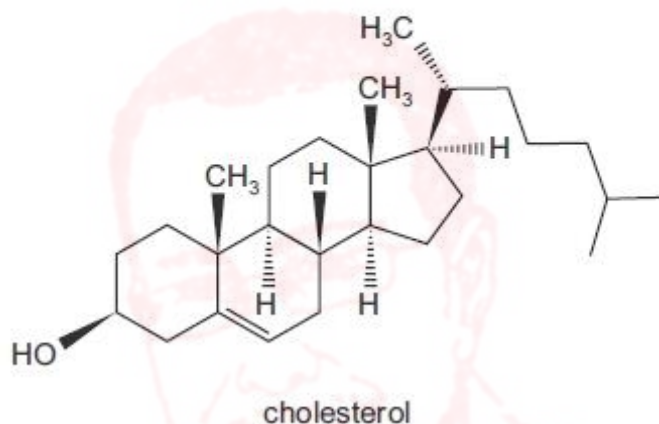
What mass of product was collected?

- A** 1.98 g **B** 2.07 g **C** 2.70g **D** 4.80g

Topic **Chem 16 Q# 1045**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 This question should be answered by considering the reactions of KMnO_4 with different functional groups under the stated conditions.

The diagram shows the structure of the naturally-occurring molecule cholesterol.



Separate oxidation reactions are carried out using different conditions.

- cold, dilute acidified KMnO_4
- hot, concentrated acidified KMnO_4

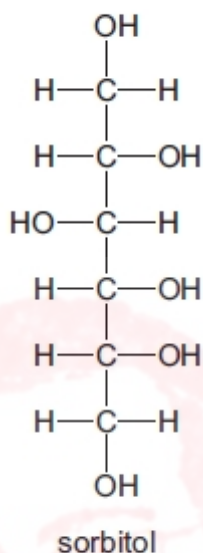
Which statements about the **products** formed are correct?

	cold, dilute acidified KMnO_4 : number of hydroxy groups present	hot, concentrated acidified KMnO_4 : number of 6-membered rings remaining
A	1	2
B	1	3
C	3	2
D	3	3

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Sorbitol is an artificial sweetener used to sweeten chocolate which is suitable for diabetics.



Which functional groups can be produced when this molecule is subjected to oxidation under suitable conditions?

- 1 aldehyde
- 2 carboxylic acid
- 3 ketone

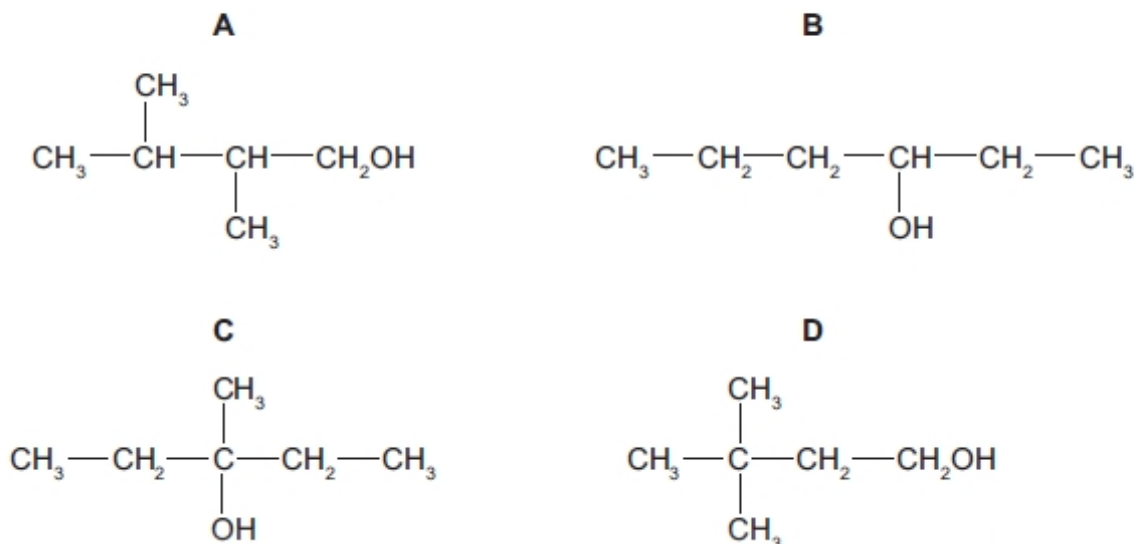
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?

- 1 Water can act as either an acid or a base.
- 2 Sulfuric acid, H_2SO_4 , does not behave as an acid when dissolved in ethanol, $\text{C}_2\text{H}_5\text{OH}$.
- 3 The ammonium ion acts as a base when dissolved in liquid ammonia.

25 Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

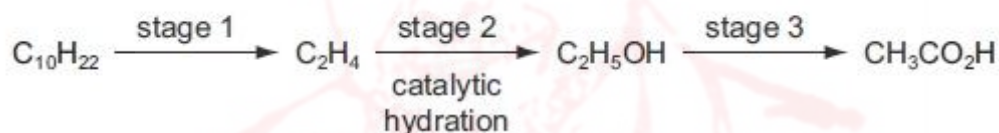


23 Pentanol, $C_5H_{11}OH$, has four structural isomers that are primary alcohols.

How many of these primary alcohols contain a chiral carbon atom?

- A** 0 **B** 1 **C** 2 **D** 3

19 In the reaction pathway below, an alkane is converted into a carboxylic acid through several stages.



Which processes occur at stage 1 and at stage 3?

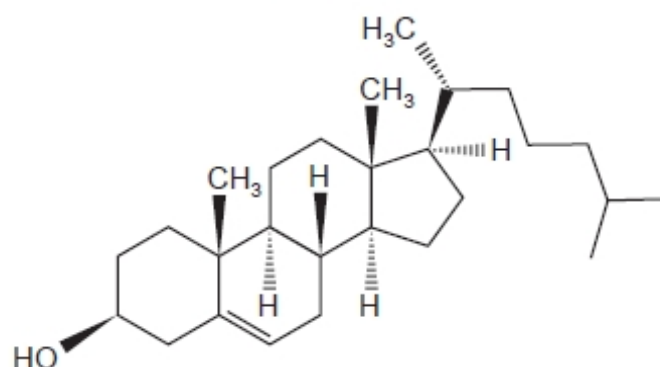
	stage 1	stage 3
A	condensation	combustion
B	cracking	dehydration
C	cracking	oxidation
D	dehydration	combustion

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



37 The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Which statements about cholesterol are correct?

- 1 The molecule contains a secondary alcohol group.
- 2 The molecule contains two π bonds.
- 3 All carbon atoms in the four rings lie in the same plane.

Topic **Chem 16 Q# 1052/** AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 Which alcohol gives only **one** possible oxidation product when warmed with dilute acidified potassium dichromate(VI)?

- A butan-1-ol
- B butan-2-ol
- C 2-methylpropan-1-ol
- D 2-methylpropan-2-ol

Topic **Chem 16 Q# 1053/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Which isomer of $C_4H_{10}O$ forms three alkenes on dehydration?

- A butan-1-ol
- B butan-2-ol
- C 2-methylpropan-1-ol
- D 2-methylpropan-2-ol

Topic **Chem 16 Q# 1054/** AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

22 What will react differently with the two isomeric alcohols, $(CH_3)_3CCH_2OH$ and $(CH_3)_2CHCH_2CH_2OH$?

- A acidified aqueous potassium manganate(VII)
- B concentrated sulfuric acid
- C phosphorus pentachloride
- D sodium

29 2-Methylbuta-1,3-diene, $\text{CH}_2=\text{C}(\text{CH}_3)-\text{CH}=\text{CH}_2$, is used as a monomer in the manufacture of synthetic rubbers.

Which compound would **not** produce this monomer on treatment with concentrated sulfuric acid at 170°C ?

- A** $(\text{CH}_3)_2\text{C}(\text{OH})\text{CH}(\text{OH})\text{CH}_3$
- B** $\text{HOCH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$
- C** $\text{HOCH}_2\text{CH}(\text{CH}_3)\text{CH}(\text{OH})\text{CH}_3$
- D** $\text{HOCH}_2\text{C}(\text{CH}_3)(\text{OH})\text{CH}_2\text{CH}_3$

Topic **Chem 17 Q# 1056**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q#

33//www.SmashingScience.org :o)

33 W reacts with alkaline $\text{I}_2(\text{aq})$ to form a yellow precipitate and $\text{CH}_3\text{CH}_2\text{CO}_2^-$ ions.

Which row identifies W and the yellow precipitate?

	identity of W	identity of yellow precipitate
A	butanone	CHI_3
B	butanone	CH_3I
C	propanone	CHI_3
D	propanone	CH_3I

Topic **Chem 17 Q# 1057**/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 36//www.SmashingScience.org :o)

36 A carbonyl compound, X, reacts with HCN in the presence of NaCN to make a compound with M_r 85. Compound X does **not** react with Fehling's reagent.

What is compound X?

- A** butanal
- B** butanone
- C** propanal
- D** propanone

Topic **Chem 17 Q# 1058**/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 35//www.SmashingScience.org :o)

35 The skeletal formulae of two organic compounds are shown.



Which reagents can be used to distinguish these two compounds?

- 1 alkaline $\text{I}_2(\text{aq})$
- 2 acidified $\text{K}_2\text{Cr}_2\text{O}_7$
- 3 2,4-dinitrophenylhydrazine (2,4-DNPH reagent)

- A** 1, 2 and 3
- B** 1 and 3 only
- C** 2 and 3 only
- D** 2 only

33 Which compound gives both:

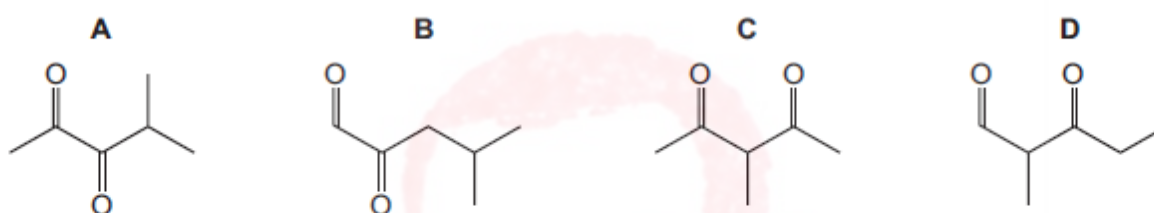
- an orange precipitate with 2,4-DNPH reagent
- and a yellow precipitate with alkaline $I_2(aq)$?

- A ethanol
B methanal
C propanal
D propanone

Topic **Chem 17 Q# 1060/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 Reduction of compound R with $LiAlH_4$ gives the compound 4-methylpentane-2,3-diol.

What could be the identity of compound R?



Topic **Chem 17 Q# 1061/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

25 Alcohol Y gives a yellow precipitate with alkaline aqueous iodine. It can be oxidised to give a mixture of products including substance Z. Substance Z gives a red-brown precipitate with Fehling's solution.

Which alcohol could be Y?

- A $CH_3CH(OH)CH(CH_3)CH_2OH$
B $CH_3C(OH)(CH_3)CH_2CH_2OH$
C $CH_3CH(OH)CH_2CH(OH)CH_3$
D $CH_2(OH)CH_2CH(OH)CH_2CH_3$

Topic **Chem 17 Q# 1062/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Which reactions have a coloured organic product?

- 1 ethanal + 2,4-dinitrophenylhydrazine reagent
- 2 ethanol + acidified potassium dichromate(VI)
- 3 ethene + cold dilute acidified potassium manganate(VII)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Which pairs of compounds may be distinguished by testing with alkaline aqueous iodine?

- 1 butanal and butanone
- 2 pentan-2-one and pentan-3-ol
- 3 propanone and propan-2-ol

Topic **Chem 17 Q# 1064**/ AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 Which statement is correct for the reaction of carbonyl compounds with HCN?

- A The reaction is catalysed by concentrated H_2SO_4 .
- B Pentan-2-one and HCN react to give a chiral product.
- C The reaction is a condensation reaction.
- D The reaction is nucleophilic substitution.

Topic **Chem 17 Q# 1065**/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Two carbonyl compounds have the molecular formula $\text{C}_3\text{H}_6\text{O}$.

Which reagents give **different** observations with these two compounds?

- 1 acidified aqueous potassium manganate(VII)
- 2 Fehling's reagent
- 3 alkaline aqueous iodine

Topic **Chem 17 Q# 1066**/ AS Chemistry/2021/m/TZ 2/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

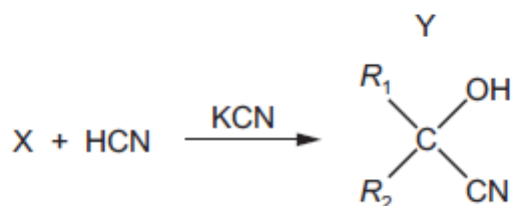
28 Ethanedioic acid has the formula $\text{HO}_2\text{CCO}_2\text{H}$.

What is the formula of aluminium ethanedioate?

- A AlC_2O_4 B $\text{Al}(\text{C}_2\text{O}_4)_3$ C $\text{Al}_2\text{C}_2\text{O}_4$ D $\text{Al}_2(\text{C}_2\text{O}_4)_3$



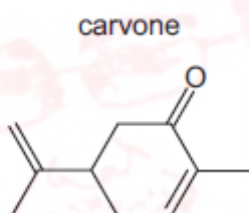
26 The diagram shows the formation of compound Y from compound X in a chemical reaction. R_1 and R_2 are alkyl groups.



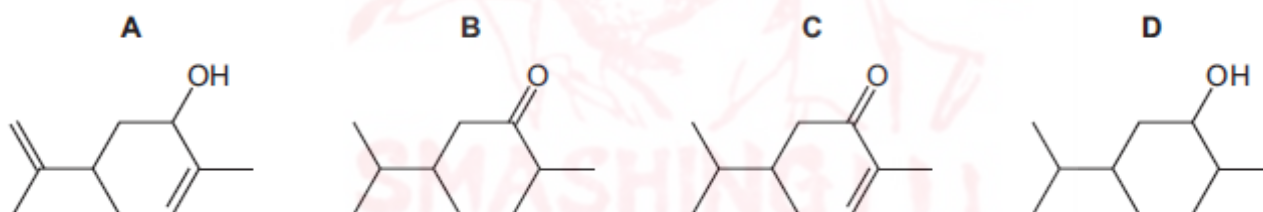
Which row about this reaction is correct?

	mechanism	compound X
A	electrophilic addition	aldehyde
B	electrophilic addition	ketone
C	nucleophilic addition	ketone
D	nucleophilic addition	aldehyde

28 Carvone is found in spearmint oil.



Which product is formed when carvone is reacted with NaBH_4 ?



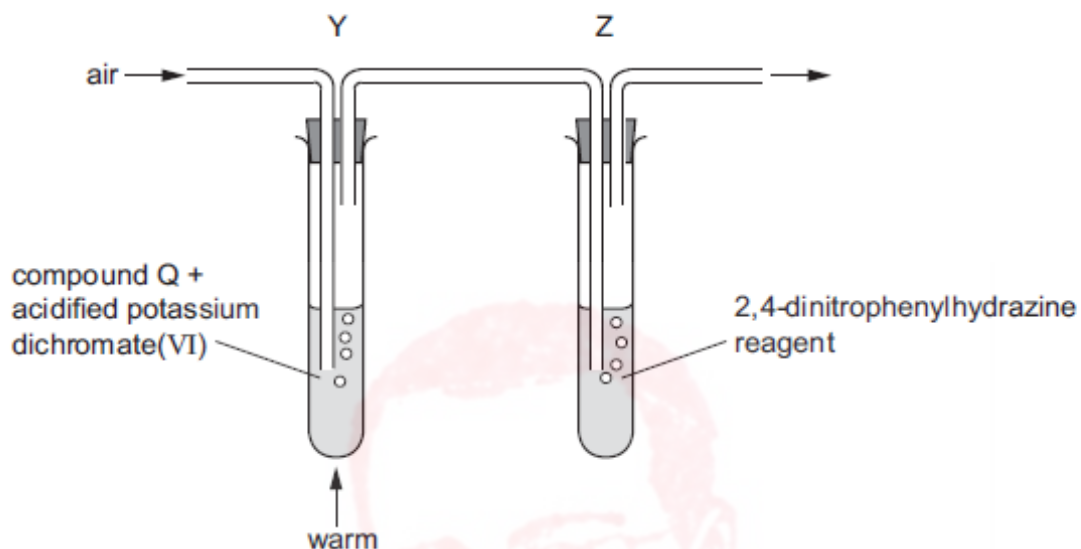
27 Which pair of test results would prove that a substance, X, is a ketone?

- A** X has no reaction with Tollens' reagent. X reacts with alkaline aqueous iodine.
- B** X is reduced by lithium aluminium hydride. X is oxidised by acidified dichromate(VI).
- C** X reacts with 2,4-DNPH reagent. X has no reaction with Fehling's reagent.
- D** X reacts with hydrogen cyanide. X is reduced by lithium aluminium hydride.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 When the apparatus is set up as shown, an orange precipitate forms in test-tube Z.



What could compound Q be?

- 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- 2 $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
- 3 $(\text{CH}_3)_3\text{COH}$

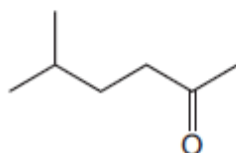
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 In which of the reactions is the organic compound oxidised by the given reagent?

- 1 $\text{CH}_3\text{CHO} + \text{HCN reagent}$
- 2 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO} + \text{Tollens' reagent}$
- 3 $\text{CH}_3\text{CH}_2\text{CHO} + \text{Fehling's reagent}$

20 The skeletal formula of compound X is shown.



Which row is correct?

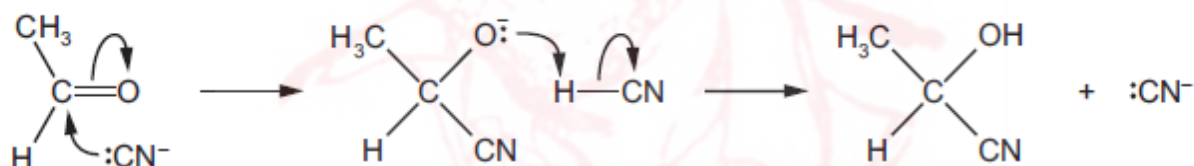
	molecular formula of X	observation on addition of X to Fehling's reagent
A	$C_7H_{14}O$	no change
B	$C_7H_{14}O$	red precipitate forms
C	$C_7H_{16}O$	no change
D	$C_7H_{16}O$	red precipitate forms

Topic **Chem 17 Q# 1073**/ AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

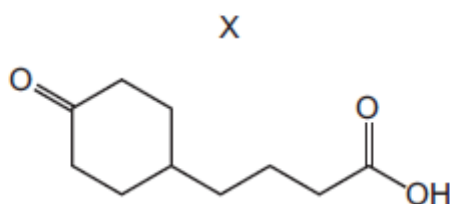
37 Ethanal and hydrogen cyanide react together. The reaction mechanism involves cyanide ions.



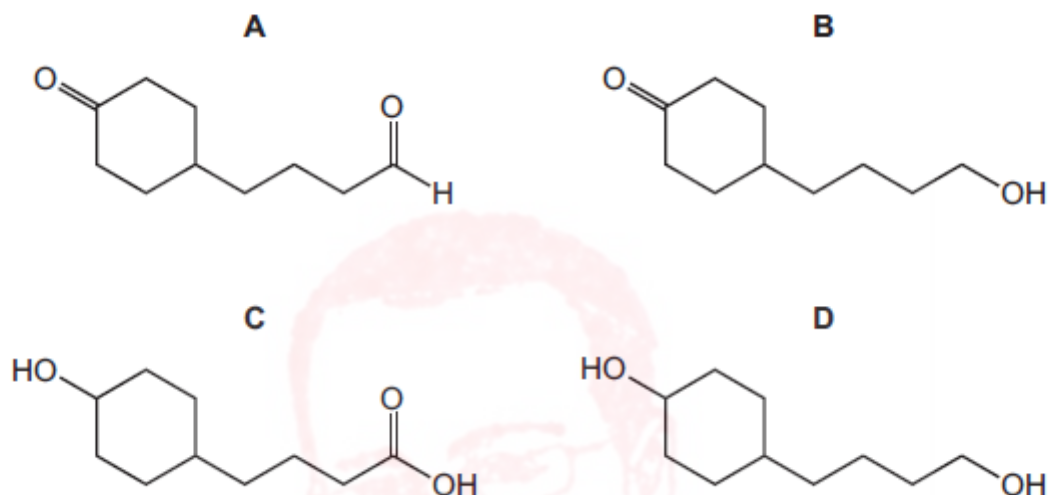
Which statements about this mechanism are correct?

- CN^- acts as a catalyst.
- CN^- is a nucleophile.
- It is an addition reaction.

- 28** Compound X is treated with an excess of lithium aluminium hydride. The reaction is allowed to go to completion.



What is the structure of the organic product?



Topic **Chem 17 Q# 1075/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 39** Hydrogen cyanide reacts with propanone in the presence of potassium cyanide.

Which statements about this reaction are correct?

- 1 The cyanide ion is a catalyst for the reaction.
- 2 This is an addition reaction.
- 3 The intermediate behaves as a base.

Topic **Chem 17 Q# 1076/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

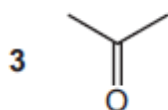
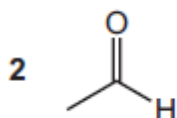
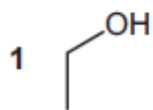
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Compound Y

- reacts with alkaline aqueous iodine to form a yellow precipitate
- changes the colour of warm, acidified potassium dichromate(VI) solution.

What could be compound Y?



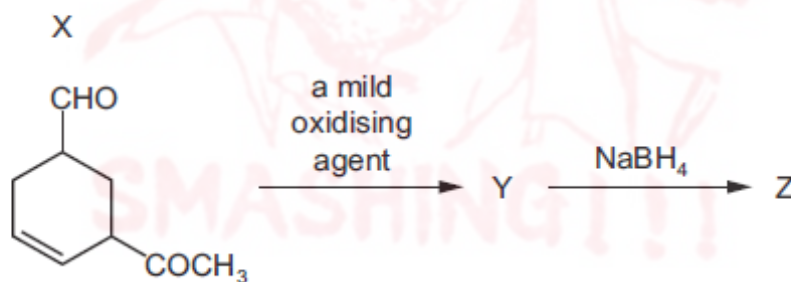
Topic **Chem 17 Q# 1077**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Which reagent may be used to distinguish between propanone and ethanol?

- A 2,4-dinitrophenylhydrazine
- B bromine water
- C Fehling's reagent
- D Tollens' reagent

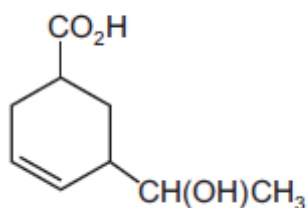
Topic **Chem 17 Q# 1078**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 Compound X is treated with two reagents successively, forming compound Z.

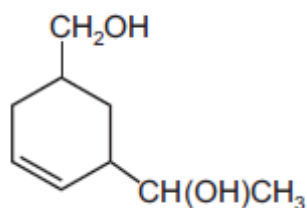


What could be Z?

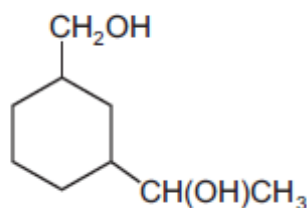
A



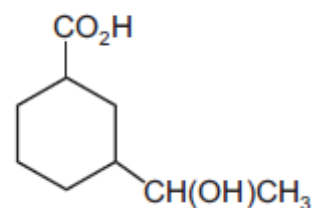
B



C



D



27 An organic compound T undergoes the following reactions.

- T is oxidised by hot, acidified potassium manganate(VII).
- T reacts with sodium to give hydrogen.

What could be compound T?

- A** $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
C $(\text{CH}_3)_3\text{COH}$
D $\text{CH}_3\text{CH}_2\text{COCH}_3$

Topic **Chem 17 Q# 1080/** AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 The compounds listed are reacted with hydrogen cyanide.

Which compounds produce a molecule containing a chiral centre?

- 1** butanal
2 butanone
3 pentan-2-one

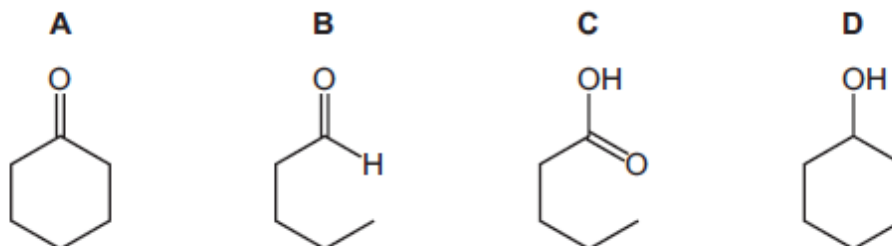
Topic **Chem 17 Q# 1081/** AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 When compound X is heated with $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$, a colour change from orange to green is observed.

Two tests are carried out on the organic product of this reaction.

test	result
Tollens' reagent	no change
2,4-dinitrophenylhydrazine	orange precipitate

What could be compound X?



27 Structural isomerism only should be considered when answering this question.

All the isomeric alcohols with the molecular formula $C_5H_{12}O$ are added separately to warm alkaline aqueous iodine.

How many of the isomers give a yellow precipitate?

- A** 0 **B** 1 **C** 2 **D** 3

Topic **Chem 17 Q# 1083/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Ethanal reacts with HCN in the presence of KCN.

Which changes in bonding occur during this reaction?

- 1** A carbon-carbon bond is formed.
- 2** A carbon-hydrogen bond is broken.
- 3** A carbon-nitrogen bond is broken.

Topic **Chem 17 Q# 1084/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 Which compound shows optical isomerism and gives a positive test with alkaline aqueous iodine?

- A** $CH_3COCH(OH)CH_3$
B $CH_3COCH_2CH_2OH$
C $HOCH_2CH(CH_3)CHO$
D $(CH_3)_2C(OH)CHO$

Topic **Chem 17 Q# 1085/** AS Chemistry/2018/s/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

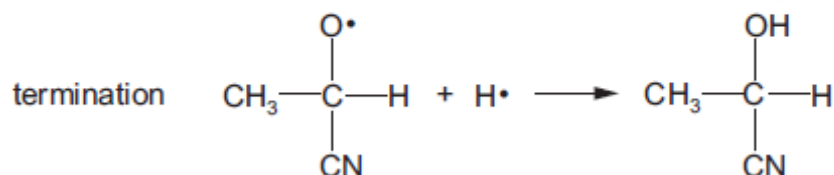
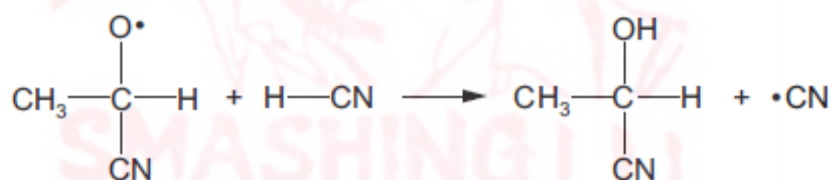
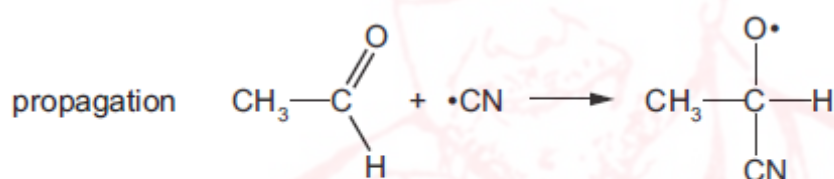
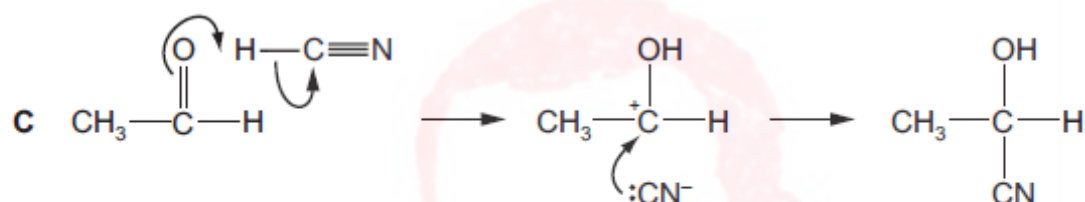
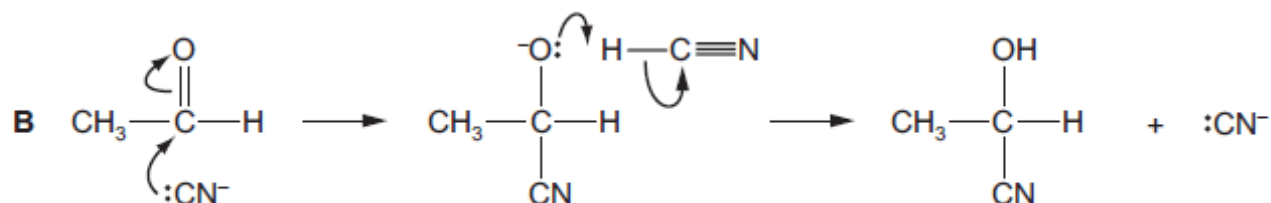
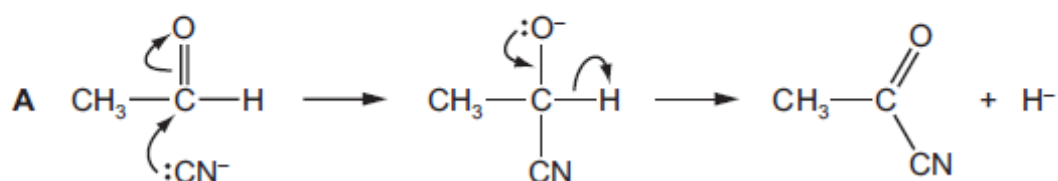
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 The M_r of compound X is 72. The composition by mass of X is 66.7% carbon, 11.1% hydrogen and 22.2% oxygen. X gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent. X does not react with Fehling's reagent.

What can be deduced from this information?

- 1** X is a carbonyl compound.
- 2** X is a ketone.
- 3** X is butanone.

26 What is the mechanism for the reaction of ethanal, CH_3CHO , with hydrogen cyanide, HCN , in the presence of NaCN ?



25 Compound Q

- contains a chiral centre,
- gives a positive result with Fehling's reagent,
- gives a positive result with alkaline aqueous iodine.

What could compound Q be?

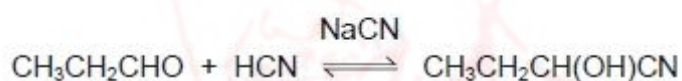
- A 1-hydroxybutanone
 B 2-hydroxybutanal
 C 3-hydroxybutanal
 D 3-hydroxybutanone

Topic **Chem 17 Q# 1088**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 39** Propanal reacts with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.



Which statements about the reaction of propanal with hydrogen cyanide are correct?

- HCN is a weaker nucleophile than the nucleophile provided by NaCN.
- The reaction mechanism involves two steps.
- The product of the reaction has a chiral carbon atom.

Topic **Chem 17 Q# 1089**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

- 26** Compound X produces a carboxylic acid when heated under reflux with acidified potassium dichromate(VI). Compound X does not react with sodium metal.

What could be the identity of compound X?

- A propanal
 B propanone
 C propan-1-ol
 D propan-2-ol



23 Which compound reacts with 2,4-dinitrophenylhydrazine reagent but does **not** react with Tollen's reagent?

- A $\text{CH}_3\text{COCO}_2\text{H}$
- B $\text{CH}_3\text{CH}(\text{OH})\text{CHO}$
- C CH_3COCHO
- D $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

Topic **Chem 17 Q# 1091**/ AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 40//

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 The reaction of ethanal, CH_3CHO , with HCN to form 2-hydroxypropanenitrile is catalysed by NaCN .

What are features of the intermediate of this reaction?

- 1 It is chiral.
- 2 It has a single negative charge on one of its atoms.
- 3 It is a nucleophile.

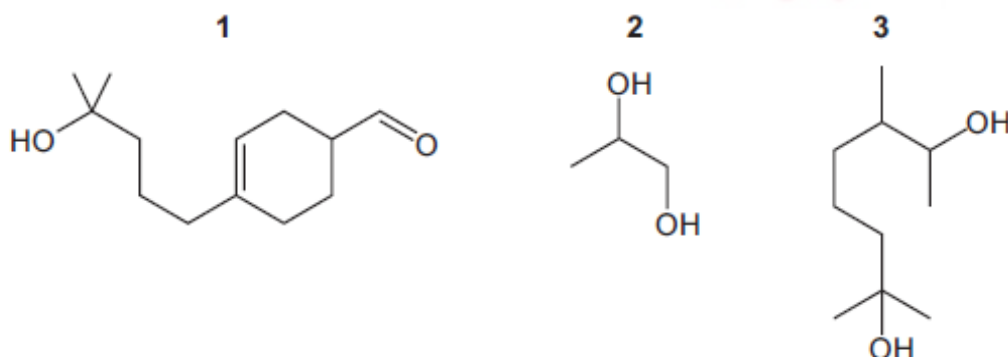
Topic **Chem 17 Q# 1092**/ AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 39//

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 The compounds below are used to make perfumes.

Which compounds will produce a yellow precipitate with alkaline aqueous iodine?



20 Structural isomerism and stereoisomerism should be considered when answering this question.

Each of the following carbonyl compounds is reacted with NaBH_4 . The product of each reaction is heated with Al_2O_3 at 600°C , generating one product or a mixture of isomers.

Which carbonyl compound will produce the most isomers?

- A butanal
- B butanone
- C pentan-3-one
- D propanone

Topic **Chem 17 Q# 1098**/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Which compounds react with alkaline aqueous iodine to give a pale yellow precipitate of tri-iodomethane?

- 1 butanone
- 2 ethanal
- 3 propan-2-ol

Topic **Chem 17 Q# 1099**/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Compound X, $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{CHO})\text{CH}_3$, is heated under reflux with an excess of acidified $\text{K}_2\text{Cr}_2\text{O}_7$ to form compound Y.

Both X and Y are separately warmed with Fehling's solution and the observations noted.

What are the observations?

- A Both X and Y give a red precipitate.
- B Only X gives a red precipitate.
- C Only Y gives a red precipitate.
- D Neither X nor Y gives a red precipitate.



28 $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$ reacts with hydrogen cyanide to form an organic product called a cyanohydrin.

Which statement is correct?

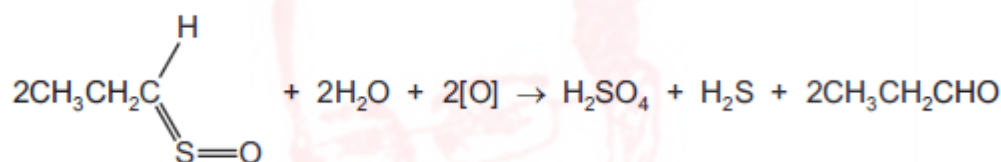
- A** The cyanohydrin product has one chiral centre.
- B** The cyanohydrin product is formed by electrophilic addition.
- C** The cyanohydrin product is formed via an intermediate which contains a C–OH group.
- D** The formation of the cyanohydrin product requires the use of cyanide ions as a catalyst.

Topic **Chem 17 Q# 1101**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 When onions are peeled in air, the reaction shown is thought to occur.

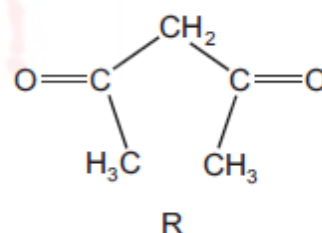
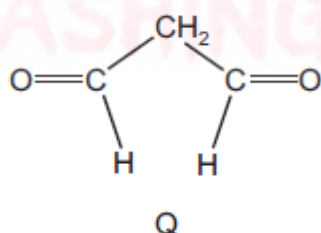
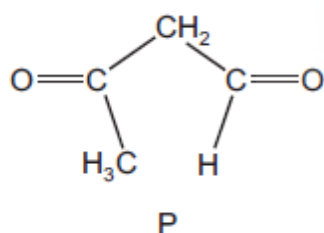


Which tests would give a positive reaction with the organic product?

- 1** warming with Tollens' reagent
- 2** warming with acidified potassium manganate(VII)
- 3** warming with alkaline aqueous iodine

Topic **Chem 17 Q# 1102**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 P, Q and R are carbonyl compounds.



Fehling's solution can be used to help identify these compounds.

Which compounds form a red-brown precipitate on warming with Fehling's solution?

- A** P, Q and R
- B** P and Q only
- C** P only
- D** Q only



28 Which reagent cannot be used to distinguish between ethanal and propanone?

- A acidified sodium dichromate(VI) solution
- B alkaline aqueous iodine
- C cold acidified potassium manganate(VII) solution
- D Fehling's reagent

Topic **Chem 17 Q# 1104**/ AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 Alcohol Y gives product Z after mild oxidation. Z gives a positive result with Tollens' reagent and with 2,4-dinitrophenylhydrazine reagent.

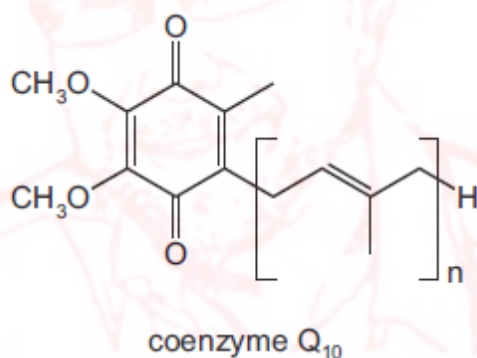
What could be the identity of alcohol Y?

- A butan-1-ol
- B butan-2-ol
- C butan-2,3-diol
- D 2-methylbutan-2-ol

Topic **Chem 17 Q# 1105**/ AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 People who take statin drugs to control their blood cholesterol may also take 'coenzyme Q₁₀'.

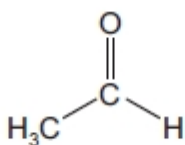
The diagram shows a simplified structure of one form of this coenzyme.



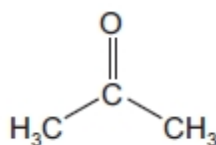
Which row describes this structure correctly?

	the coenzyme is	number of π bonds in one molecule
A	an aldehyde	$n + 2$
B	an aldehyde	$n + 4$
C	a ketone	$n + 2$
D	a ketone	$n + 4$

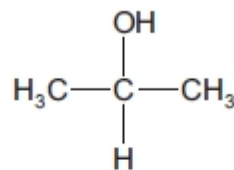
28 Tollens' reagent can be used to help identify compounds P, Q and R.



P



Q



R

Which compound(s) form a silver precipitate on warming with Tollens' reagent?

- A** P and Q **B** P only **C** Q only **D** R only

Topic **Chem 17 Q# 1107**/ AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 Which reagent will give a different observation with compounds P and Q?



P



Q

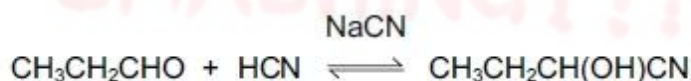
- A** $\text{Br}_2(\text{aq})$
B hot acidified KMnO_4
C silver nitrate in ammonia solution
D warm acidified $\text{K}_2\text{Cr}_2\text{O}_7$

Topic **Chem 17 Q# 1108**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 37** Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.



Which statements about the reaction of propanal with hydrogen cyanide are correct?

- The CN^- ion attacks the propanal molecule to form an intermediate ion.
- The product of the reaction has a chiral carbon atom.
- The CN^- ion is a stronger electrophile than the HCN molecule.



25 Which compound, on reaction with hydrogen cyanide, produces a compound with a chiral centre?

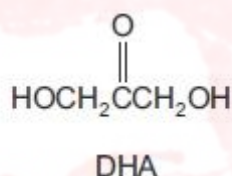
- A** CH_3CHO
- B** $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
- C** $\text{CH}_3\text{CO}_2\text{CH}_3$
- D** HCHO

Topic **Chem 17 Q# 1114**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 DHA is a colourless liquid which reacts with protein in skin to cause it to darken. It has the structure shown.



Which observations would be made when testing this substance?

- 1** Hydrogen is produced when sodium is added.
- 2** A coloured precipitate is produced when 2,4-dinitrophenylhydrazine reagent is added.
- 3** A silver precipitate is produced when Tollens' reagent is added.

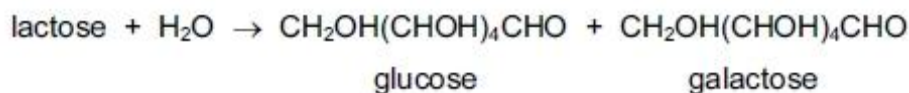
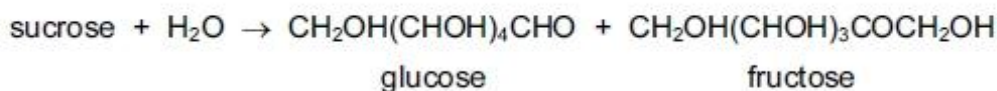
Topic **Chem 17 Q# 1115**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 37 Disaccharides, $C_{12}H_{22}O_{11}$, are important in the human diet. For example, sucrose is found in pastries and lactose occurs in milk products.

Both of these compounds can be hydrolysed.



Which statements about these hydrolysis products are correct?

- 1 Glucose and fructose have structural isomers.
- 2 Glucose and galactose are optical isomers.
- 3 Glucose and galactose are ketones.

Topic **Chem 17 Q# 1116**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 33//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 33 The three statements that follow are all true.

Which of these can be explained, at least in part, by reference to hydrogen bonding?

- 1 At 0°C ice floats on water.
- 2 The boiling point of propan-2-ol is 82°C . The boiling point of propanone is 56°C .
- 3 At 20°C propanone and propanal mix completely.

Topic **Chem 17 Q# 1117**/ AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

- 29 Aldehydes and ketones are carbonyl compounds.

Which of them react with NaBH_4 and react with Fehling's reagent?

- A** both aldehydes and ketones
B aldehydes only
C ketones only
D neither aldehydes nor ketones



- 28** A compound Y is treated with warm acidified potassium dichromate(VI). The resulting organic product gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent but does not give a silver mirror with Tollens' reagent.

What is Y?

- A** butan-1-ol
- B** butan-2-ol
- C** butanal
- D** 2-methylpropan-2-ol

- 26** Compound X changes the colour of warm acidified sodium dichromate(VI) from orange to green. 1 mol of X reacts with 2 mol of HCN in the presence of KCN.

What could X be?

- A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
- B** $\text{CH}_3\text{COCH}_2\text{COCH}_3$
- C** $\text{H}_2\text{C}=\text{CHCH}_2\text{CHO}$
- D** $\text{OHCCH}_2\text{CH}_2\text{CHO}$

- 24** What is formed when propanone is refluxed with a solution of NaBH_4 ?

- A** propanal
- B** propan-1-ol
- C** propan-2-ol
- D** propane

- 23** Which reagent will give similar results with both butanone and butanal?

- A** acidified aqueous potassium dichromate(VI)
- B** an alkaline solution containing complexed Cu^{2+} ions (Fehling's solution)
- C** an aqueous solution containing $[\text{Ag}(\text{NH}_3)_2]^+$ (Tollens' reagent)
- D** 2,4-dinitrophenylhydrazine reagent

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



- 40 A compound has a relative molecular mass of 88 and its molecule contains only four carbon atoms.

What could this compound be?

- 1 a saturated non-cyclic diol
- 2 a secondary alcohol containing an aldehyde group
- 3 a primary alcohol containing a ketone group

Topic Chem 17 Q# 1123/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

- 26 Glycol, used in anti-freeze, has the formula $\text{HOCH}_2\text{CH}_2\text{OH}$. It can be oxidised to give a number of products.

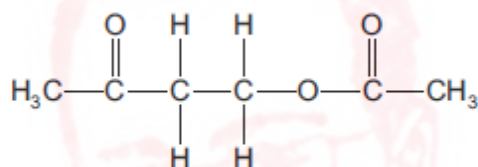
What is the molecular formula of an oxidation product of glycol that will **not** react with sodium?

- A $\text{C}_2\text{H}_2\text{O}_2$ B $\text{C}_2\text{H}_2\text{O}_3$ C $\text{C}_2\text{H}_2\text{O}_4$ D $\text{C}_2\text{H}_4\text{O}_2$

Topic Chem 18 Q# 1124/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q#

36//www.SmashingScience.org :o)

- 36 Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound shown.



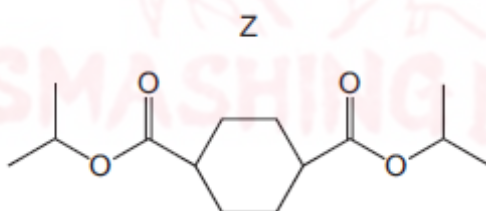
What is the molecular formula of compound X?

- A $\text{C}_2\text{H}_4\text{O}$ B $\text{C}_2\text{H}_6\text{O}_2$ C $\text{C}_4\text{H}_8\text{O}$ D $\text{C}_4\text{H}_8\text{O}_2$

Topic Chem 18 Q# 1125/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

- 32 An alcohol, X, reacts with a dicarboxylic acid, Y, to form a double ester, Z.

The diagram shows the structure of the ester.



Which row about the reactants forming ester Z is correct?

	the class of alcohol X	the shape of the ring in Y
A	secondary	non-planar
B	secondary	planar
C	tertiary	non-planar
D	tertiary	planar

- 38** Two 1g samples of Y are reacted separately and completely with sodium and with sodium carbonate. The volumes of the gases produced are collected and measured.

	relative volumes of gases	
	with Na	with Na ₂ CO ₃
Y	2	1

What could Y be?

- A $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{OH}$
- B $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$
- C $\text{CH}_3\text{COCH}_2\text{OH}$
- D $\text{CH}_3\text{COCO}_2\text{H}$

- 37** Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

- A $\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)_2$
- B $\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}(\text{CH}_3)\text{CO}_2\text{CH}_2\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$

- 28** How many esters have the molecular formula $\text{C}_4\text{H}_8\text{O}_2$?

- A 2 B 3 C 4 D 5

- 27** Which compound will react with LiAlH_4 to form two optical isomers?

- A $\text{CH}_3\text{CH}_2\text{COCH}_3$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
- C $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
- D $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$

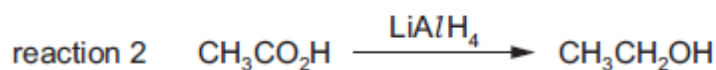
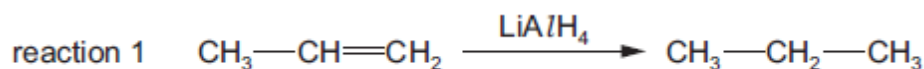
- 35** Compound X contains a single ester group.

X contains 27.6% by mass of oxygen.

Which pair of products could be produced by the hydrolysis of X?

- A butan-1-ol and ethanoic acid
- B ethanol and propanoic acid
- C methanol and methanoic acid
- D propan-2-ol and butanoic acid

34 A student suggests two uses of LiAlH_4 .

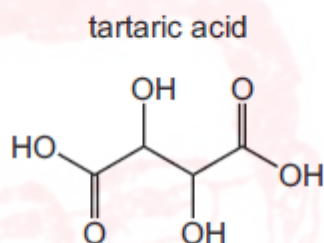


Which reactions would give the product shown?

- A both reactions
- B reaction 1 only
- C reaction 2 only
- D neither reaction

Topic **Chem 18 Q# 1132**/ AS Chemistry/2022/m/TZ 2/Paper 1/Exam Q# 32//www.SmashingScience.org :o)

32 The structure of tartaric acid is shown.



Four moles of substance X react with one mole of tartaric acid.

What could be substance X?

- A sodium
- B sodium carbonate
- C sodium hydrogencarbonate
- D sodium hydroxide

Topic **Chem 18 Q# 1133**/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 The structural formula of an ester is $(\text{CH}_3)_2\text{CHOCO}(\text{CH}_2)_2\text{CH}_3$.

This ester is boiled with aqueous hydrochloric acid.

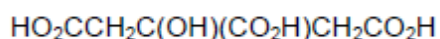
Which two products are formed?

- A propan-1-ol and butanoic acid
- B propan-2-ol and butanoic acid
- C propan-1-ol and propanoic acid
- D propan-2-ol and propanoic acid



28 Citric acid is found in lemon juice.

citric acid



Which volume of 0.40 mol dm^{-3} sodium hydroxide solution is required to neutralise a solution containing 0.0050 mol of citric acid?

- A** 12.5 cm^3 **B** 25.0 cm^3 **C** 37.5 cm^3 **D** 50.0 cm^3

Topic **Chem 18 Q# 1135/** AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 When an organic compound, Q, is treated with phosphorus pentachloride, fumes of hydrogen chloride are evolved. When Q is warmed with acidified aqueous potassium dichromate(VI), the solution turns green.

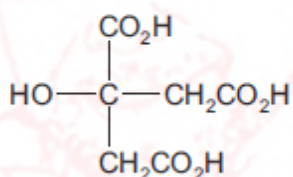
What is Q?

- A** $\text{CH}_3\text{CH}_2\text{CHO}$
B $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
C $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
D $(\text{CH}_3)_3\text{COH}$

Topic **Chem 18 Q# 1136/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 How many moles of hydrogen, H_2 , are evolved when an excess of sodium metal is added to one mole of citric acid?

citric acid



- A** 0.5 **B** 1.5 **C** 2 **D** 4

Topic **Chem 18 Q# 1137/** AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 The compound cetyl palmitate, $\text{C}_{15}\text{H}_{31}\text{CO}_2\text{C}_{16}\text{H}_{33}$, is a waxy solid.

Cetyl palmitate is heated under reflux with an excess of aqueous sodium hydroxide.

Which products will be formed?

- A** $\text{C}_{15}\text{H}_{31}\text{ONa}$ and $\text{C}_{16}\text{H}_{33}\text{CO}_2\text{Na}$
B $\text{C}_{15}\text{H}_{31}\text{CO}_2\text{Na}$ and $\text{C}_{16}\text{H}_{33}\text{ONa}$
C $\text{C}_{15}\text{H}_{31}\text{OH}$ and $\text{C}_{16}\text{H}_{33}\text{CO}_2\text{Na}$
D $\text{C}_{15}\text{H}_{31}\text{CO}_2\text{Na}$ and $\text{C}_{16}\text{H}_{33}\text{OH}$



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 An organic compound, T, does **not** fizz when aqueous sodium carbonate is added to it.

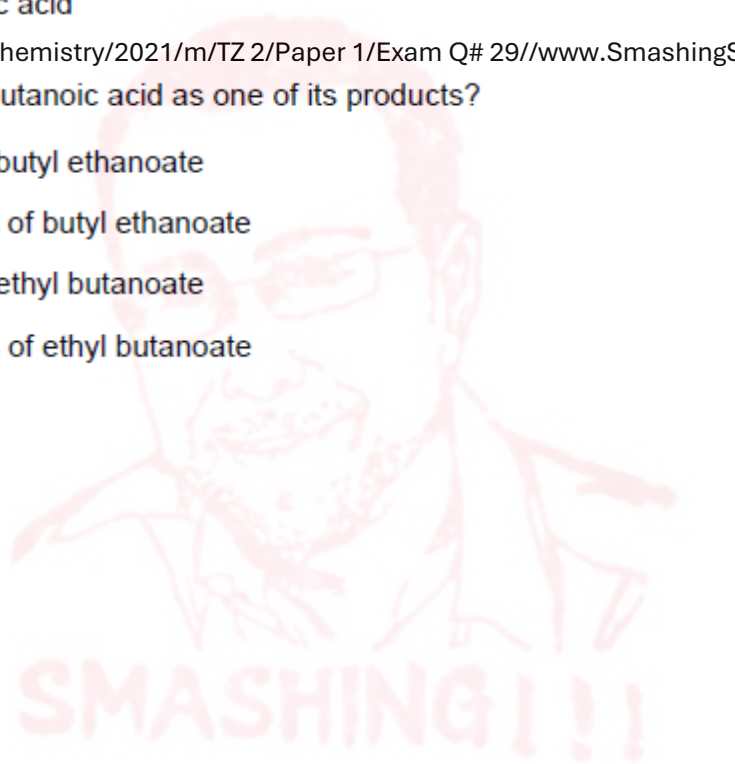
Compound T contains 27.6% by mass of oxygen.

What could be the identity of T?

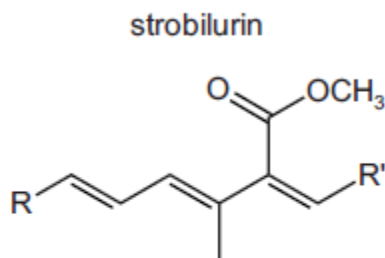
- 1** propanal
- 2** ethyl butanoate
- 3** 3-methylpentanoic acid

29 Which reaction gives butanoic acid as one of its products?

- A** acid hydrolysis of butyl ethanoate
- B** alkaline hydrolysis of butyl ethanoate
- C** acid hydrolysis of ethyl butanoate
- D** alkaline hydrolysis of ethyl butanoate

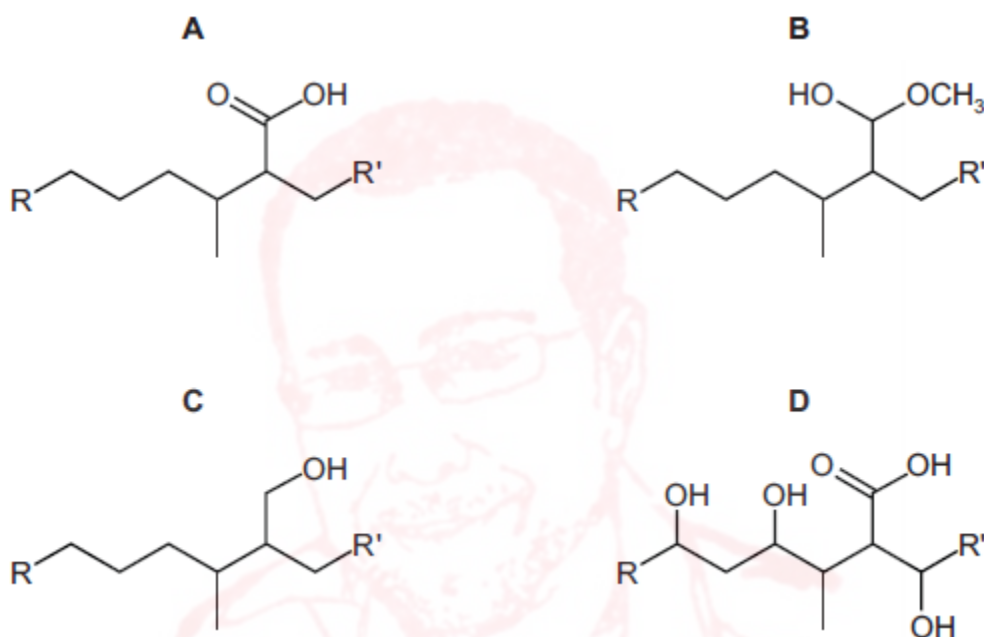


23 Part of the structure of strobilurin is shown. R and R' are inert groups.



Strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

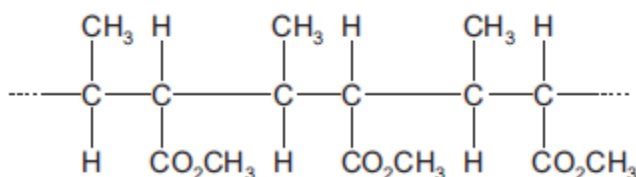


Topic **Chem 18 Q# 1141**/ AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 The diagram shows part of the structure of polymer X.

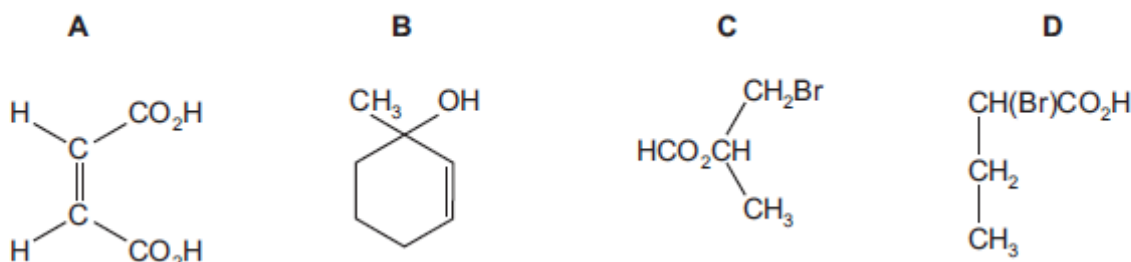


Which reagents react with polymer X?

- 1 aqueous sulfuric acid
- 2 aqueous sodium hydroxide
- 3 sodium



29 Which compound is chiral and reacts with Na_2CO_3 to give CO_2 ?

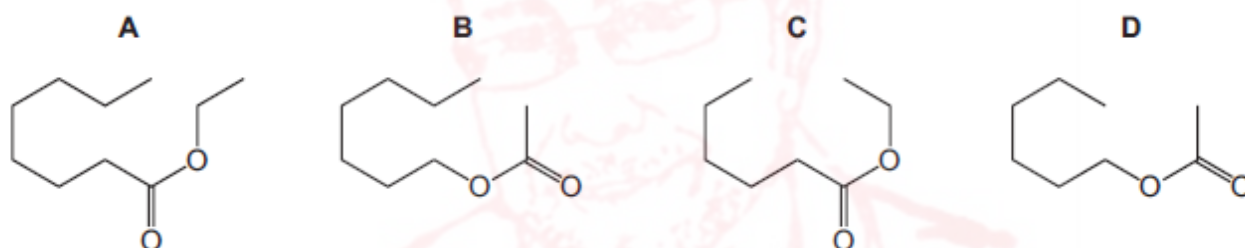


30 Which reaction produces an organic anion with a good yield?

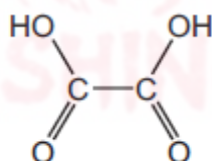
- A** heating ethanenitrile under reflux with dilute sodium hydroxide
- B** heating ethanenitrile under reflux with dilute sulfuric acid
- C** heating ethane with sodium metal
- D** heating ethanol under reflux with dilute sodium hydroxide

26 When compound X is heated under reflux with aqueous sodium hydroxide solution two products are formed: sodium ethanoate and hexan-1-ol.

What is compound X?



22 The diagram shows the structure of ethanedioic acid.



Ethanedioic acid reacts with ethanol in the presence of a few drops of concentrated sulfuric acid to form a diester. The molecular formula of the diester is $\text{C}_6\text{H}_{10}\text{O}_4$.

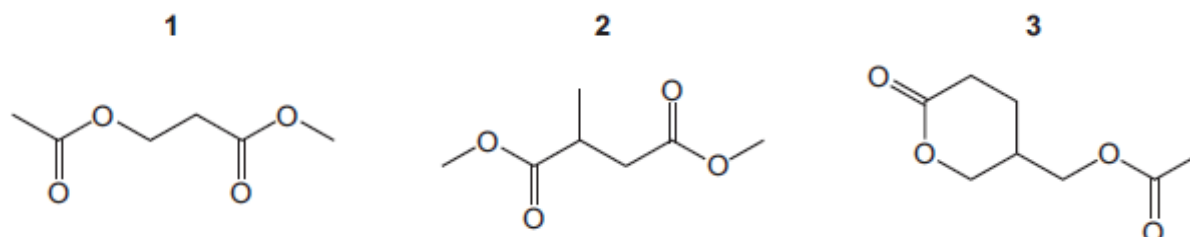
What is the structural formula of the diester?

- A** $\text{CH}_3\text{CH}_2\text{CO}_2\text{CO}_2\text{CH}_2\text{CH}_3$
- B** $\text{CH}_3\text{CH}_2\text{OCOCO}_2\text{CH}_2\text{CH}_3$
- C** $\text{CH}_3\text{CH}_2\text{O}_2\text{CO}_2\text{CCH}_2\text{CH}_3$
- D** $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{OCOCH}_3$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

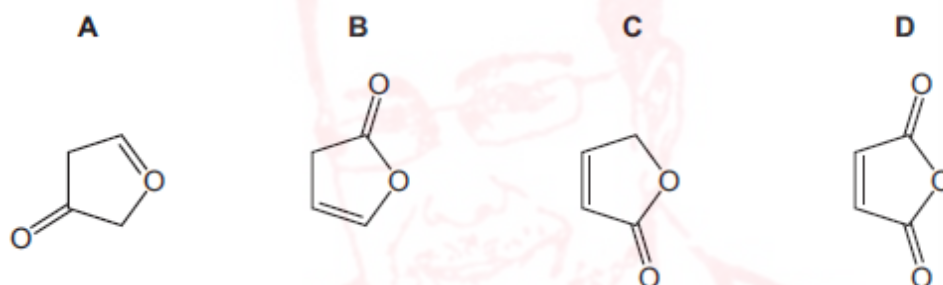
40 Which compounds produce three **different** organic products when hydrolysed?



Topic **Chem 18 Q# 1147/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 When $\text{CH}_2(\text{OH})\text{CH}=\text{CHCO}_2\text{H}$ is warmed with a little concentrated sulfuric acid, a cyclic compound is formed.

What is the skeletal formula of the cyclic compound?



Topic **Chem 18 Q# 1148/** AS Chemistry/2019/w/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 Tartaric acid, $\text{HO}_2\text{CCH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H}$, is found in many plants.

A sample of tartaric acid reacts with an excess of LiAlH_4 to form the organic product J.

What happens when $\text{NaOH}(\text{aq})$ is added to separate samples of tartaric acid and J?

- A** Both tartaric acid and J react.
- B** Only tartaric acid reacts.
- C** Only J reacts.
- D** Neither tartaric acid nor J react.

Topic **Chem 18 Q# 1149/** AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



40 Carboxylic acids react with alcohols to produce esters.

Carboxylic acid X forms **one** ester only with molecular formula $C_5H_{10}O_2$.

What could X be?

- 1 ethanoic acid
- 2 propanoic acid
- 3 butanoic acid

Topic **Chem 18 Q# 1150**/ AS Chemistry/2019/s/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Carboxylic acids can be made by several different reactions.

Which statements are correct?

- 1 The acid hydrolysis of CH_3CH_2CN will make ethanoic acid.
- 2 The oxidation of $CH_3CH_2CH_2CH_2OH$ will make butanoic acid.
- 3 The oxidation of CH_3CH_2CHO will make propanoic acid.

Topic **Chem 18 Q# 1151**/ AS Chemistry/2019/m/TZ 2/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Carboxylic acids can be prepared from alcohols, nitriles or esters.

Which statements are correct?

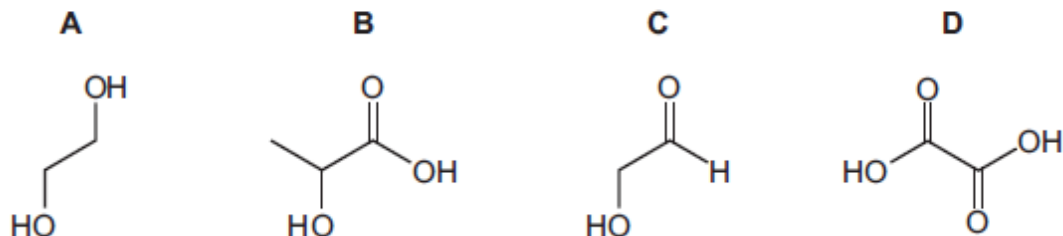
- 1 Both primary and secondary alcohols can be oxidised to carboxylic acids.
- 2 Carboxylic acids can be made from nitriles by hydrolysis.
- 3 Ethyl propanoate gives propanoic acid when reacted with hydrochloric acid.



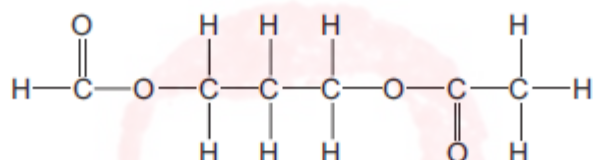
29 1 mole of each of the following four compounds is reacted separately with:

- an excess of sodium
- an excess of sodium carbonate.

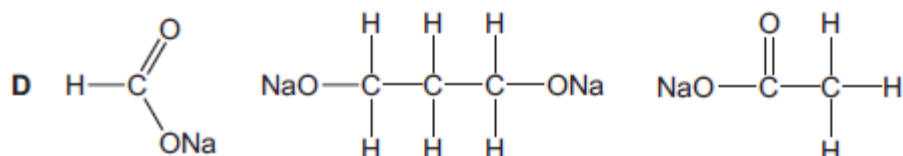
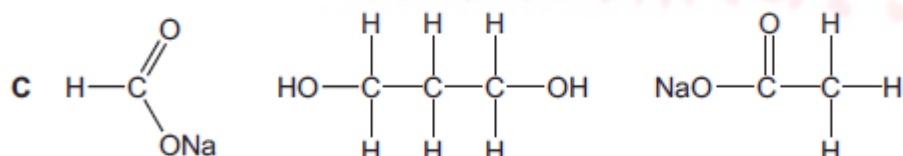
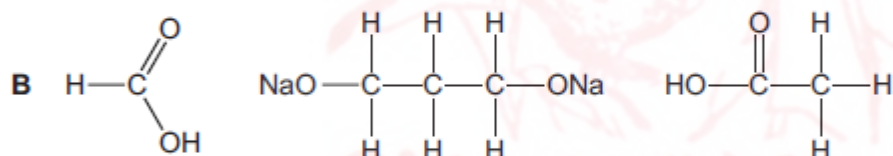
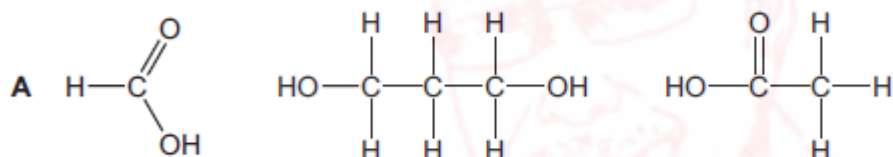
Which compound produces the same volume of gas with each of the **two** reagents?



29 The diester shown can be hydrolysed by heating with an excess of aqueous sodium hydroxide.



What would the products of this reaction be?



28 Ethanedioic acid, $\text{HO}_2\text{CCO}_2\text{H}$, is reduced using an excess of lithium aluminium hydride, LiAlH_4 .

What is the organic product of the reaction?

- A ethanol
- B ethane-1,2-diol
- C ethanedial, OHCCHO
- D methane

26 Sodium reacts with 1 mol of compound Y to produce 1 mol of $\text{H}_2(\text{g})$.

Which compound could Y be?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- B $(\text{CH}_3)_3\text{COH}$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$
- D $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$

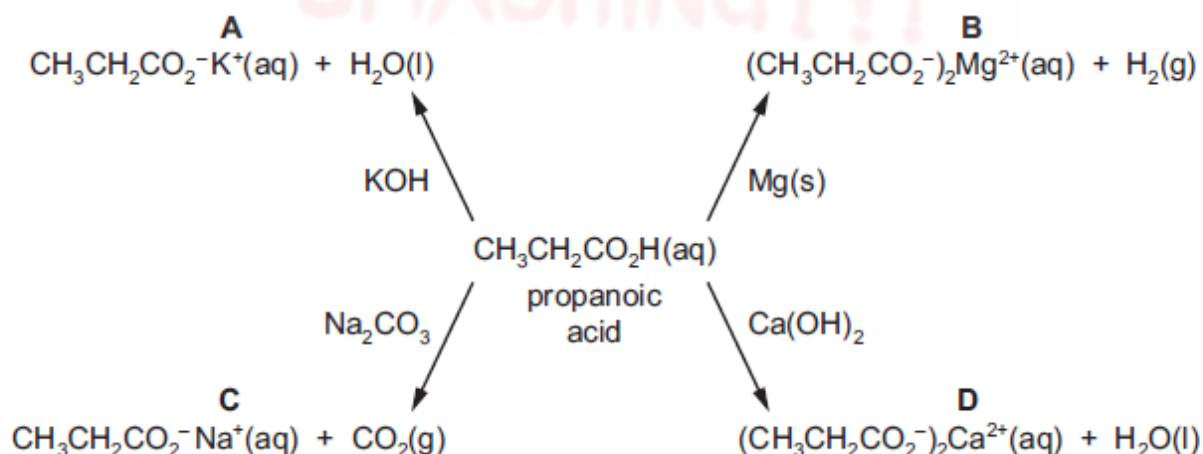
24 An organic molecule W contains 3 carbon atoms. It requires 4.5 molecules of oxygen for complete combustion.

What could W be?

- A propane
- B propanoic acid
- C propanone
- D propan-1-ol

29 Four reactions of propanoic acid to form salts and other products are shown.

Which reaction does **not** show the formulae of **all** the correct products?



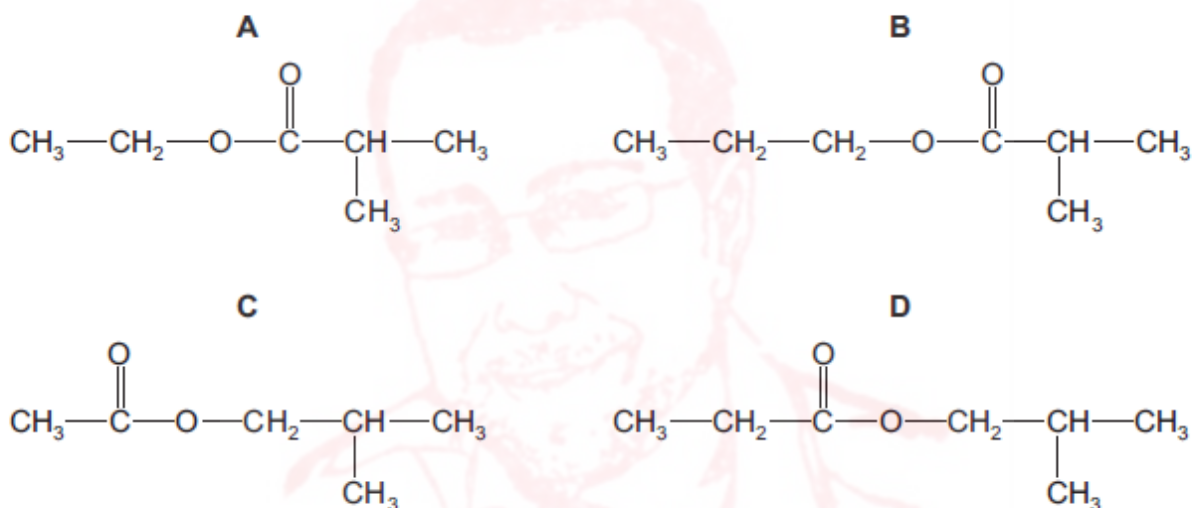
28 Which reagent could be used to carry out the following reaction?



- A a solution containing acidified dichromate(VI) ions
- B a solution containing dilute, acidified manganate(VII) ions
- C a solution containing hot, concentrated, acidified manganate(VII) ions
- D concentrated sulfuric acid

27 Ethyl propanoate is refluxed with aqueous sodium hydroxide. The alcohol produced is then reacted with methyl propanoic acid to make a second ester.

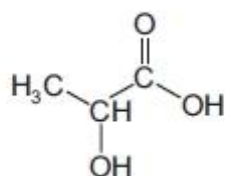
What is the structural formula of this second ester?



The responses **A** to **D** should be selected on the basis of

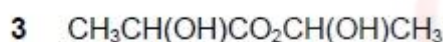
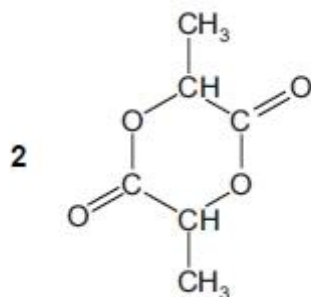
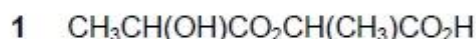
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 The structure of lactic acid is shown.



lactic acid

Which esters might form when lactic acid is heated?



Topic **Chem 18 Q# 1161**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Alcohols, aldehydes and nitriles can each be converted into carboxylic acids.

Which descriptions of their conversions into carboxylic acids are correct?

	alcohols	aldehydes	nitriles
A	hydrolysis	hydrolysis	hydrolysis
B	hydrolysis	hydrolysis	oxidation
C	oxidation	oxidation	hydrolysis
D	oxidation	oxidation	oxidation

Topic **Chem 18 Q# 1162**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 Ethanedioic acid has the formula $\text{HO}_2\text{CCO}_2\text{H}$.

What is the formula of aluminium ethanedioate?



Topic **Chem 18 Q# 1163**/ AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 30//

30 A sample of the ester $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_3$ is hydrolysed. The product mixture is then treated with hot, acidified KMnO_4 .

What are the final carbon-containing products?

- A $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ only
B $\text{CH}_3\text{CO}_2\text{H} + \text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
C $\text{CH}_3\text{CO}_2\text{H} + \text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$
D $\text{CH}_3\text{CH}_2\text{OH} + \text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$

28 At room temperature, propanoic acid was reacted to produce sodium propanoate. No gas was produced during the reaction.

What could the propanoic acid have reacted with?

- A** $\text{NaHCO}_3(\text{aq})$ **B** $\text{NaOH}(\text{aq})$ **C** $\text{Na}_2\text{CO}_3(\text{aq})$ **D** $\text{Na}_2\text{SO}_4(\text{aq})$

Topic **Chem 18 Q# 1165/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

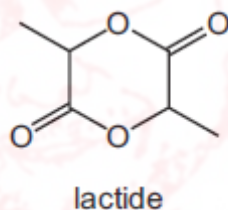
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Which statements about ethanol and ethanoic acid are correct?

- 1** Both react with a suitable reagent to form an ester.
- 2** Both react with sodium.
- 3** Both are soluble in water.

Topic **Chem 18 Q# 1166/** AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 Lactide is an intermediate in the manufacture of a synthetic fibre.



Which compound, on heating with an acid catalyst, can produce lactide?

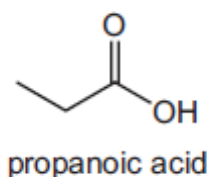
- A** hydroxyethanoic acid
B 2-hydroxybutanoic acid
C 2-hydroxypropanoic acid
D 3-hydroxypropanoic acid

Topic **Chem 18 Q# 1167/** AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 40 Propanoic acid occurs naturally as a result of the bacterial fermentation of milk and is partly responsible for the flavour of Swiss cheese.

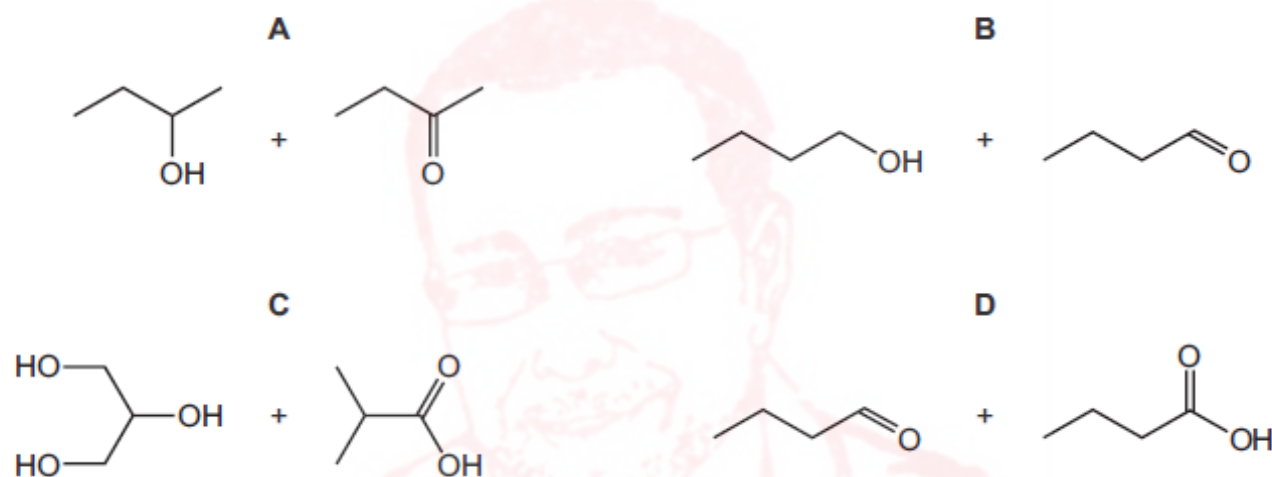


Which starting materials can be used to produce propanoic acid?

- 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- 2 $\text{CH}_3\text{CH}_2\text{CHO}$
- 3 $\text{CH}_3\text{CH}_2\text{CN}$

Topic **Chem 18 Q# 1168**/ AS Chemistry/2017/m/TZ 2/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

- 30 Which two compounds can react together to produce an ester?

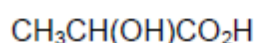
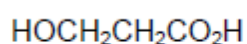
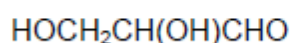
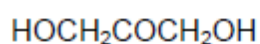


Topic **Chem 18 Q# 1169**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

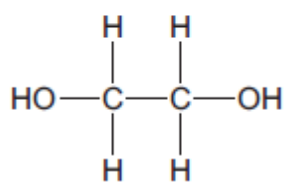
- 39 Several structural isomers of $\text{C}_3\text{H}_6\text{O}_3$ are listed below.



Which statements about these structural isomers are correct?

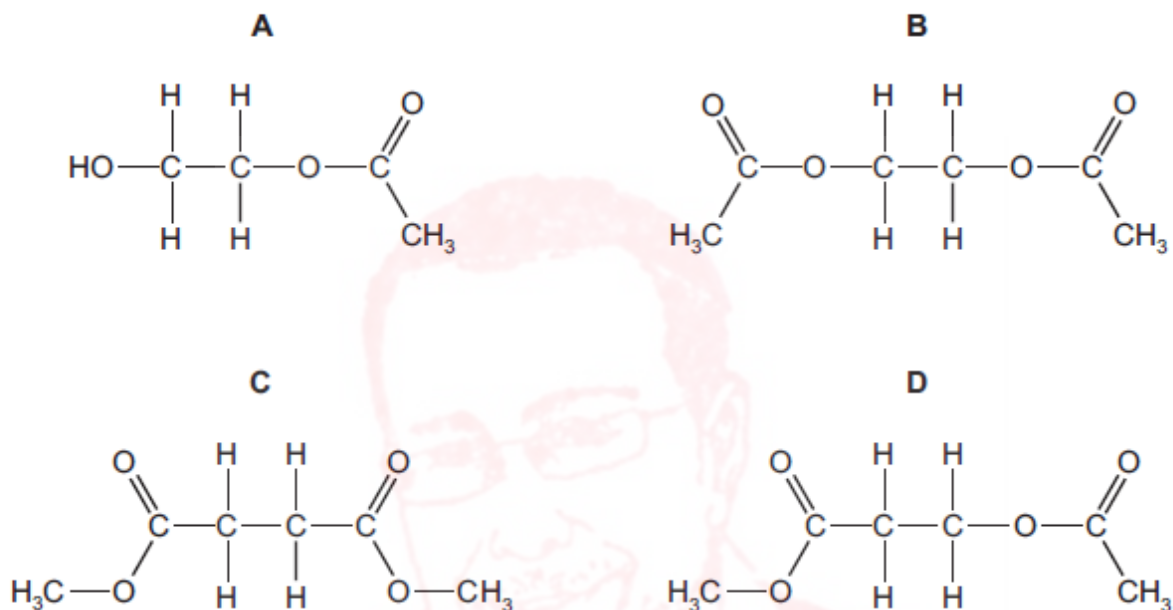
- 1 One mole of each reacts with two moles of sodium.
- 2 Only one of the isomers contains a tertiary alcohol group.
- 3 They all contain a primary alcohol group.

- 30** A solvent, **X**, used in printing inks has a molecular formula $C_6H_{10}O_4$. It may be made by reacting ethane-1,2-diol with ethanoic acid in the presence of an acid catalyst.



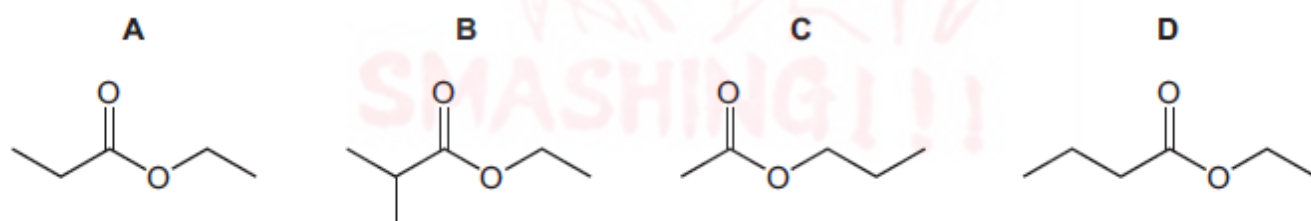
ethane-1,2-diol

What is the structure of solvent **X**?



Topic **Chem 18 Q# 1171**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

- 29** Which formula represents an ester that will form propanoic acid on hydrolysis with dilute sulfuric acid?



Topic **Chem 18 Q# 1172**/ AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

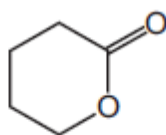
- 29** The ester $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$ was hydrolysed under acidic conditions.

What are the organic products of this hydrolysis?

- A** butanoic acid and 2-methylpropan-1-ol
B butanoic acid and 2-methylpropan-2-ol
C butan-1-ol and 2-methylpropanoic acid
D propanoic acid and 2-methylpropan-1-ol



27 Cyclic esters are also known as lactones. *Delta* lactone is used as a solvent and in the manufacture of polyesters.

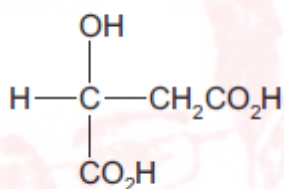


delta lactone

From which compound could *delta* lactone be made by a single reaction?

- A $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$
- B $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$
- C $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- D $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$

26 Malic acid is found in apples.

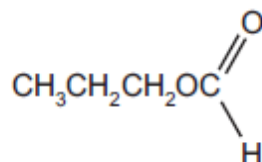


malic acid

Which reagent will react with all three -OH groups present in the malic acid molecule?

- A ethanol in the presence of concentrated sulfuric acid
- B potassium hydroxide
- C sodium
- D sodium carbonate

21 The structural formula of compound **X** is shown below.



compound **X**

What is the name of compound **X** and how does its boiling point compare with that of butanoic acid?

	name of X	boiling point of X
A	methyl propanoate	higher than butanoic acid
B	methyl propanoate	lower than butanoic acid
C	propyl methanoate	higher than butanoic acid
D	propyl methanoate	lower than butanoic acid

Topic **Chem 18 Q# 1176/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 39** An unknown organic compound **Z** reacts with sodium to give a combustible gas as one product. **Z** does **not** give a yellow precipitate with alkaline aqueous iodine.

What is a possible identity of **Z**?

- 1 ethanoic acid
- 2 pentan-3-ol
- 3 propan-1-ol

Topic **Chem 18 Q# 1177/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 37** Which reagents, when used in an excess, can be used to make sodium lactate, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{Na}$, from lactic acid, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$?

- 1 Na
- 2 NaHCO_3
- 3 NaOH

30 Which row of the table is correct?

	increasing number of carbon atoms $\longrightarrow$			
A	ethyl methanoate	methyl propanoate	pentyl pentanoate	propyl butanoate
B	ethyl methanoate	methyl propanoate	propyl butanoate	pentyl pentanoate
C	methyl propanoate	propyl butanoate	ethyl methanoate	pentyl pentanoate
D	propyl butanoate	ethyl methanoate	pentyl pentanoate	methyl propanoate

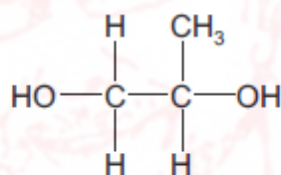
Topic **Chem 18 Q# 1179/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 Which mixture could be used to produce propyl methanoate?

- A** $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ and CH_3OH
- B** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ and HCO_2H
- C** $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ and HCO_2H
- D** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$ and CH_3OH

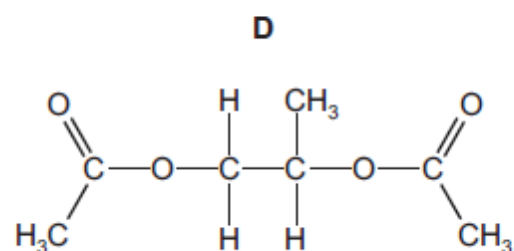
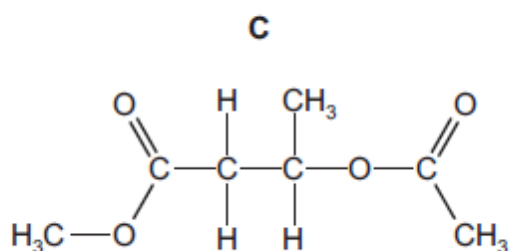
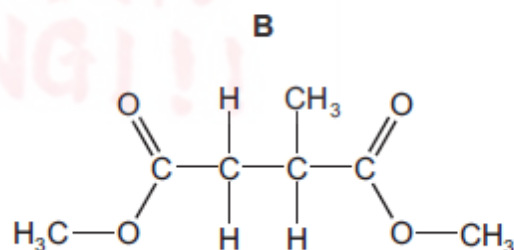
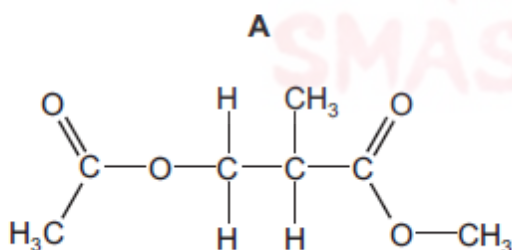
Topic **Chem 18 Q# 1180/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 The fragrance compounds of perfumes are often dissolved in solvent **Y**, which has a molecular formula $\text{C}_7\text{H}_{12}\text{O}_4$. It is made by reacting propane-1,2-diol with ethanoic acid in the presence of an acid catalyst.



propane-1,2-diol

What is the structure of solvent **Y**?



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Which reactions result in the formation of propanoic acid?

- 1 $\text{CH}_3\text{CH}_2\text{CO}_2\text{Na}$ with dilute $\text{H}_2\text{SO}_4(\text{aq})$
- 2 $\text{CH}_3\text{CH}=\text{CHCH}_3$ with hot, concentrated $\text{H}^+ / \text{MnO}_4^-(\text{aq})$
- 3 $\text{CH}_3\text{CH}_2\text{OH}$ with $\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}(\text{aq})$

Topic **Chem 18 Q# 1182/** AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 An oxidising agent that can oxidise ethanal to ethanoic acid, or to ethanoate ions, will also oxidise methanoic acid, HCO_2H , to carbon dioxide and water.

Which reagents, on heating, will react differently with HCO_2H and $\text{CH}_3\text{CO}_2\text{H}$?

- 1 $\text{Na}_2\text{CO}_3(\text{aq})$
- 2 Fehling's reagent
- 3 dilute acidified KMnO_4

Topic **Chem 18 Q# 1183/** AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

30 Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

- A $\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)_2$
- B $\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}(\text{CH}_3)\text{CO}_2\text{CH}_2\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$

Topic **Chem 18 Q# 1184/** AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 How many isomeric esters have the molecular formula $\text{C}_4\text{H}_8\text{O}_2$?

- A 2
- B 3
- C 4
- D 5

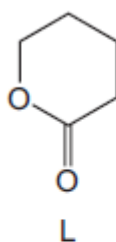
Topic **Chem 18 Q# 1185/** AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



40 5-hydroxypentanoic acid is readily converted into the cyclic compound L.



Which statements about this reaction are correct?

- 1 Acidified sodium dichromate(VI) is used as a reagent.
- 2 A water molecule is produced in the reaction.
- 3 The reaction is catalysed by concentrated H_2SO_4 .

Topic **Chem 18 Q# 1186**/ AS Chemistry/2015/s/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 An organic compound, X, will react with calcium metal to produce a salt with the empirical formula $\text{CaC}_4\text{H}_4\text{O}_4$.

What could be the identity of X?

- 1 ethanoic acid
- 2 butanedioic acid
- 3 2-methylpropanedioic acid

Topic **Chem 18 Q# 1187**/ AS Chemistry/2014/w/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

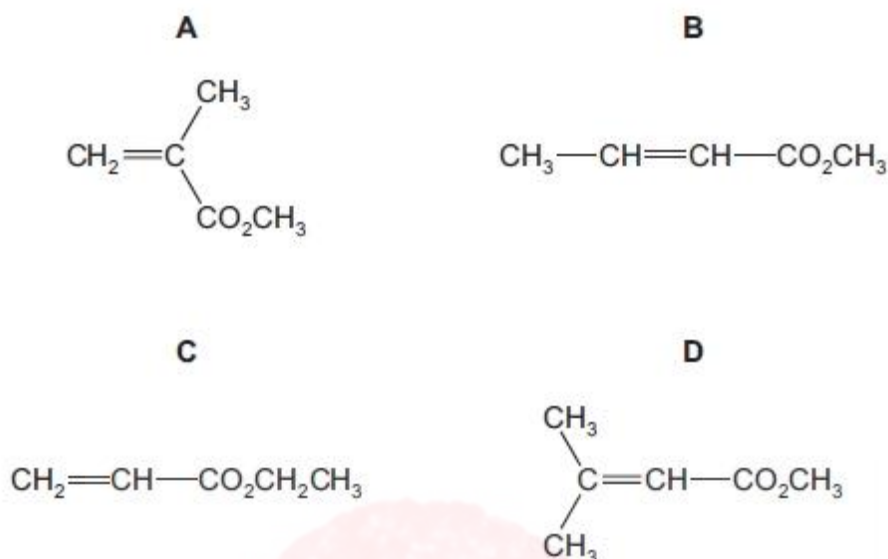
28 The ester $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$ is responsible for the aroma of apples.

When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?

- A CH_2O B CH_4O C $\text{C}_2\text{H}_4\text{O}$ D $\text{C}_3\text{H}_6\text{O}_2$

27 Methyl methacrylate is the monomer used to make *Perspex*.

Which diagram correctly shows methyl methacrylate?



Topic **Chem 18 Q# 1189**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Use of the Data Booklet is relevant to this question.

In an organic synthesis, a 62% yield of product is achieved.

Which conversions are consistent with this information?

- 1** 74.00g of butan-2-ol → 44.64g of butanone
- 2** 74.00g of butan-1-ol → 54.56g of butanoic acid
- 3** 74.00g of 2-methylpropan-1-ol → 54.56g of 2-methylpropanoic acid

Topic **Chem 18 Q# 1190**/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

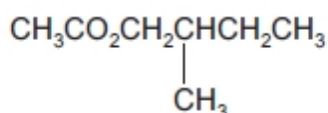
38 The molecule responsible for the pineapple flavour used in sweets is $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_3$.

Which statements about this molecule are correct?

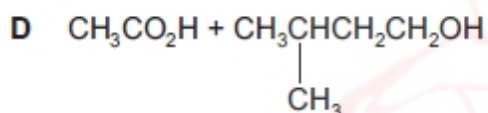
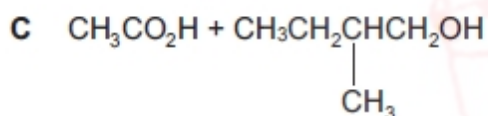
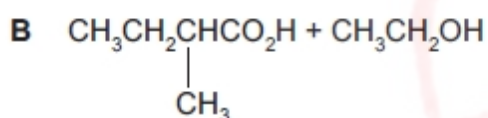
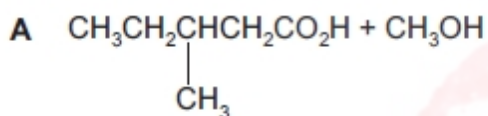
- 1 The name of this compound is ethyl butanoate.
- 2 This compound is a structural isomer of hexanoic acid.
- 3 When this compound is heated with aqueous sodium hydroxide, the products are butan-1-ol and sodium ethanoate.

Topic Chem 18 Q# 1191/ AS Chemistry/2014/s/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

22 An ester with an odour of banana has the following formula.

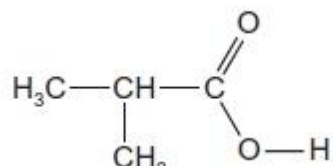
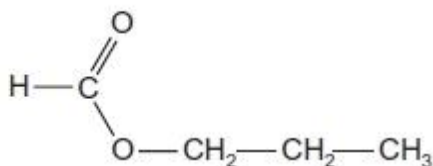
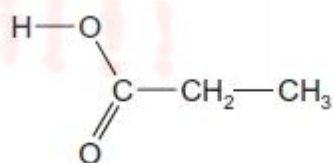
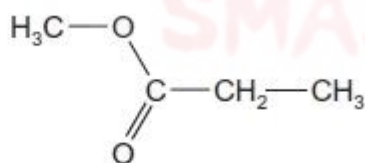


Which pair of reactants, under suitable conditions, will produce this ester?



Topic Chem 18 Q# 1192/ AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 How many of the compounds shown will react with aqueous sodium hydroxide to form the sodium salt of a carboxylic acid?



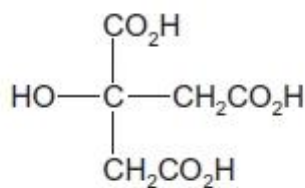
A 1

B 2

C 3

D 4

26 How many moles of hydrogen, H_2 , are evolved when an excess of sodium metal is added to one mole of citric acid?



citric acid

- A** 1 **B** 2 **C** 3 **D** 4

6 An experiment is set up to measure the rate of hydrolysis of ethyl ethanoate.



The hydrolysis is found to be slow in neutral aqueous solution but it proceeds at a measurable rate when the solution is acidified with hydrochloric acid.

What is the function of the hydrochloric acid?

- A** to dissolve the ethyl ethanoate
- B** to ensure that the reaction reaches equilibrium
- C** to increase the reaction rate by catalytic action
- D** to suppress ionisation of the ethanoic acid formed

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Which reagents, when used in an excess, can be used to make sodium lactate, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{Na}$, from lactic acid, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$?

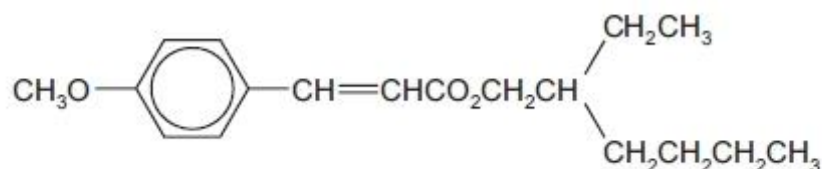
- 1** Na
- 2** NaHCO_3
- 3** NaOH

The responses **A** to **D** should be selected on the basis of

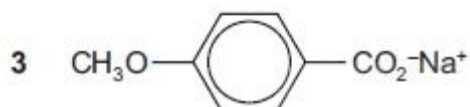
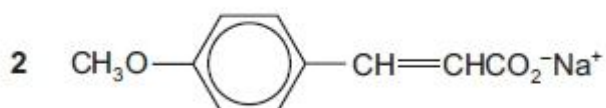
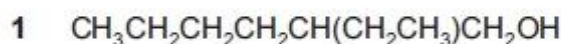
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



39 A sun protection cream contains the following ester as its active ingredient.

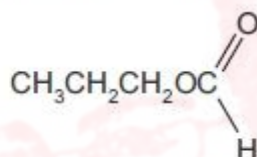


Which substances are present in the products of its hydrolysis by aqueous sodium hydroxide?



Topic **Chem 18 Q# 1197**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

28 The structural formula of a compound X is shown below.



What is the name of compound X and how does its boiling point compare with that of butanoic acid?

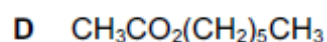
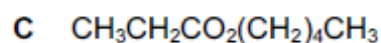
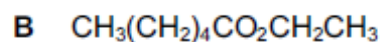
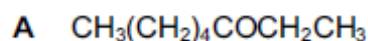
	name of X	boiling point of X
A	methyl propanoate	higher
B	methyl propanoate	lower
C	propyl methanoate	higher
D	propyl methanoate	lower

Topic **Chem 18 Q# 1198**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

30 Compound X, $\text{C}_6\text{H}_{12}\text{O}$, is oxidised by acidified sodium dichromate(VI) to compound Y.

Compound Y reacts with ethanol in the presence of a little concentrated sulfuric acid to give liquid Z.

What is the formula of Z?



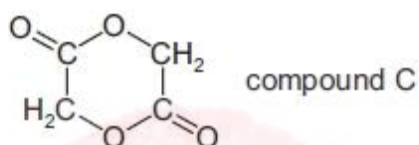
27 Which reagent reacts with ethanol and also reacts with ethanoic acid?

- A acidified potassium dichromate(VI)
- B sodium
- C sodium carbonate
- D sodium hydroxide

24 How many isomeric esters have the molecular formula $C_4H_8O_2$?

- A 2
- B 3
- C 4
- D 5

23 Compound C is used in textile and leather processing.



Which starting material(s), on gentle heating with a few drops of concentrated sulfuric acid, generates compound C?

- A CH_3COOH only
- B $HOCH_2COOH$ only
- C CH_3COOCH_2COOH only
- D CH_3COOH mixed with $HOCH_2COOH$

22 Use of the Data Booklet is relevant to this question.

A sample of ethyl propanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

Out of the total mass of products obtained, what is the percentage by mass of each product?

- A 32.4 % and 67.6 %
- B 38.3 % and 61.7 %
- C 42.3 % and 57.7 %
- D 50.0 % and 50.0 %

21 An organic compound **J** reacts with sodium to produce an organic ion with a charge of -3 . **J** reacts with $NaOH(aq)$ to produce an organic ion with a charge of -1 .

What could be the structural formula of **J**?

- A $HO_2CCH(OH)CH_2CO_2H$
- B $HO_2CCH(OH)CH_2CHO$
- C $HOCH_2CH(OH)CH_2CO_2H$
- D $HOCH_2COCH_2CHO$

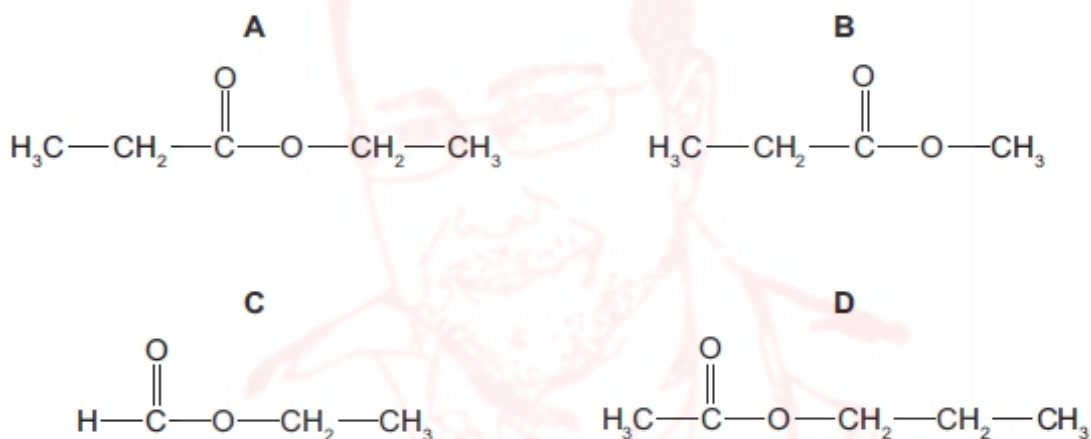
30 Which pair of substances could react to give the ester $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$?

- A ethanol and ethanoic acid
- B methanol and ethanoic acid
- C methanol and propanoic acid
- D propan-1-ol and methanoic acid

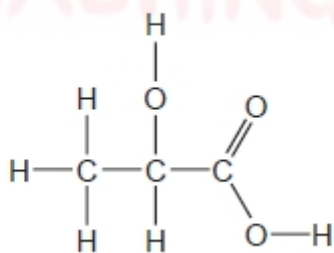
22 In the general formula of which class of compound, is the ratio of hydrogen atoms to carbon atoms the highest?

- A alcohols
- B aldehydes
- C carboxylic acids
- D halogenoalkanes

27 Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?



26 Lactic acid occurs naturally, for example in sour milk.



lactic acid

What is a property of lactic acid?

- A It decolourises aqueous bromine rapidly.
- B It is insoluble in water.
- C It reduces Fehling's reagent.
- D Two molecules react with each other in the presence of a strong acid.



22 A compound Y has all of the properties below.

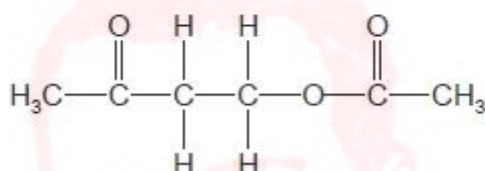
- It is a liquid at 25 °C.
- It mixes completely with water.
- It reacts with aqueous sodium hydroxide.

What could Y be?

- A** ethanoic acid
B ethanol
C ethene
D ethyl ethanoate

Topic **Chem 18 Q# 1209**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



What is the molecular formula of compound X?

- A** $C_2H_6O_2$ **B** $C_2H_6O_3$ **C** C_4H_8O **D** $C_4H_8O_2$

Topic **Chem 18 Q# 1210**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 34//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 When organic refuse decomposes in water carboxylic acids are formed. The water becomes acidic and aquatic life is destroyed.

Which additives are suitable to remove this acid pollution?

- 1** calcium carbonate
2 calcium hydroxide
3 potassium nitrate

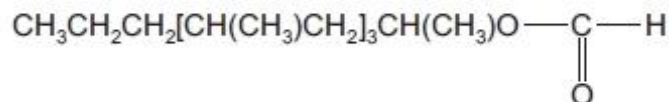
Topic **Chem 18 Q# 1211**/ AS Chemistry/2010/s/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

25 Which compound is a product of the hydrolysis of $CH_3CO_2C_3H_7$ by boiling aqueous sodium hydroxide?

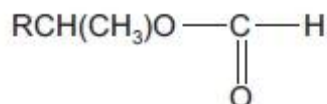
- A** CH_3OH **B** C_3H_7OH **C** $C_3H_7CO_2H$ **D** $C_3H_7CO_2^- Na^+$



- 30** The acarid mite releases *lardolure* to attract other mites to a host. This chemical can be destroyed by hydrolysis with acid.



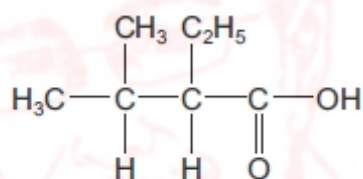
A simplified formula for *lardolure* may be written as follows.



What are the products of its hydrolysis?

- A** $\text{RCH}(\text{CH}_3)\text{CO}_2\text{H} + \text{CH}_3\text{OH}$
- B** $\text{RCH}(\text{CH}_3)\text{CO}_2\text{H} + \text{HCO}_2\text{H}$
- C** $\text{RCH}(\text{CH}_3)\text{OH} + \text{CO}_2$
- D** $\text{RCH}(\text{CH}_3)\text{OH} + \text{HCO}_2\text{H}$

- 29** The characteristic odour of rum is attributed to the compound 2-ethyl-3-methylbutanoic acid.



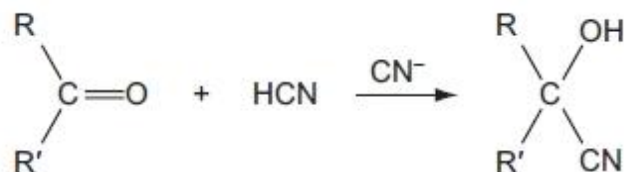
2-ethyl-3-methylbutanoic acid

Which compound will produce 2-ethyl-3-methylbutanoic acid by heating under reflux with alcoholic sodium cyanide and subsequent acid hydrolysis of the reaction product?

- A** $\text{CH}_3-\overset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CH}_2-\text{CHBr}-\text{CH}_3$
- B** $\text{CH}_3-\overset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CHBr}-\text{CH}_2-\text{CH}_3$
- C** $\text{CH}_3-\overset{\text{CH}_3}{\underset{|}{\text{CH}}}-\overset{\text{C}_2\text{H}_5}{\underset{|}{\text{CH}}}-\text{CH}_2\text{Br}$
- D** $\text{CH}_3-\overset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CH}_2-\overset{\text{CH}_2\text{Br}}{\underset{|}{\text{CH}}}-\text{CH}_3$



28 Cyanohydrins can be made from carbonyl compounds by generating CN^- ions from HCN in the presence of a weak base.



In a similar reaction, $^-\text{CH}_2\text{CO}_2\text{CH}_3$ ions are generated from $\text{CH}_3\text{CO}_2\text{CH}_3$ by strong bases.

Which compound can be made from an aldehyde and $\text{CH}_3\text{CO}_2\text{CH}_3$ in the presence of a strong base?

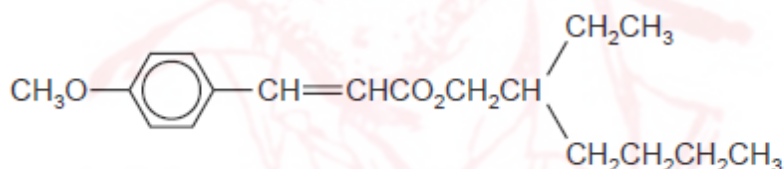
- A** $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{CH}_3$
- B** $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
- C** $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CO}_2\text{CH}_3$
- D** $(\text{CH}_3)_2\text{C}(\text{OH})\text{CH}_2\text{CO}_2\text{CH}_3$

Topic **Chem 18 Q# 1215**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 A sun protection cream contains the following ester as its active ingredient.



What are the products of its partial or total hydrolysis by aqueous sodium hydroxide?

- 1** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_2\text{CH}_3)\text{CH}_2\text{OH}$
- 2** $\text{CH}_3\text{O}-\text{C}_6\text{H}_4-\text{CH}=\text{CHCO}_2^- \text{Na}^+$
- 3** $\text{CH}_3\text{O}-\text{C}_6\text{H}_4-\text{CO}_2^- \text{Na}^+$

30 A compound **Y** has the following properties.

- It is a liquid at room temperature and atmospheric pressure.
- It does not mix completely with water.
- It does not decolourise acidified potassium manganate(VII).

What could **Y** be?

- A** ethane
- B** ethanoic acid
- C** ethanol
- D** ethyl ethanoate

Topic **Chem 18 Q# 1217**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 Which ester is formed when the alcohol $\text{CH}_3\text{CH}_2\text{OH}$ is reacted with $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$?

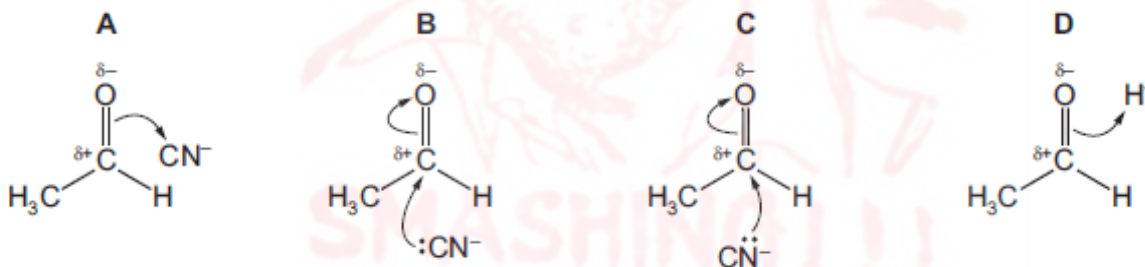
- A** ethyl propanoate
- B** ethyl butanoate
- C** propyl ethanoate
- D** butyl ethanoate

Topic **Chem 19 Q# 1218**/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q#

34//www.SmashingScience.org :o)

34 Ethanal reacts with hydrogen cyanide in the presence of KCN to produce a hydroxynitrile.

What is the first step in the mechanism of this reaction?



Topic **Chem 19 Q# 1219**/ AS Chemistry/2021/w/TZ 1/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

26 $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$ reacts with hydrogen cyanide to form an organic product called a cyanohydrin.

Which statement is correct?

- A** The cyanohydrin product has one chiral centre.
- B** The cyanohydrin product is formed by electrophilic addition.
- C** The cyanohydrin product is formed via an intermediate which contains a C–OH group.
- D** The formation of the cyanohydrin product requires the use of cyanide ions as a catalyst.



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 In which different forms does nitrogen exist in compounds?

- 1 bonded by a triple covalent bond
- 2 as part of a cation
- 3 in an oxidation state of +5

Topic **Chem 19 Q# 1221**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 19//www.SmashingScience.org :o)

19 One molecule of ammonia reacts with one molecule of ethyl methanoate, $\text{HCO}_2\text{C}_2\text{H}_5$, to produce one molecule of methanamide, HCONH_2 , and only one other molecule, X.

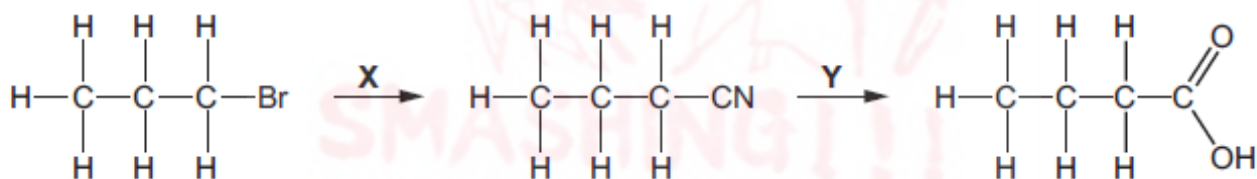
One molecule of methanamide decomposes on heating strongly to produce one molecule of ammonia and only one other molecule, Y.

What could be the identities of X and Y?

	X	Y
A	ethanoic acid	carbon monoxide
B	ethanoic acid	hydrogen cyanide
C	ethanol	carbon monoxide
D	ethanol	hydrogen cyanide

Topic **Chem 19 Q# 1222**/ AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

26 X and Y are the reagents required to convert 1-bromopropane into butanoic acid.

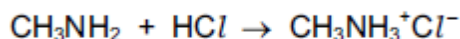


What are the correct identities of X and Y?

	X	Y
A	NH_3	HCl(aq)
B	KCN in $\text{C}_2\text{H}_5\text{OH}$	NaOH(aq)
C	KCN in $\text{C}_2\text{H}_5\text{OH}$	HCl(aq)
D	HCN	NaOH(aq)

19 Methylamine, CH_3NH_2 , has very similar chemical properties to ammonia, NH_3 .

Methylamine reacts with hydrogen chloride to form a white crystalline salt, methylammonium chloride.



A sample of methylammonium chloride is heated with aqueous sodium hydroxide.

What are the products?

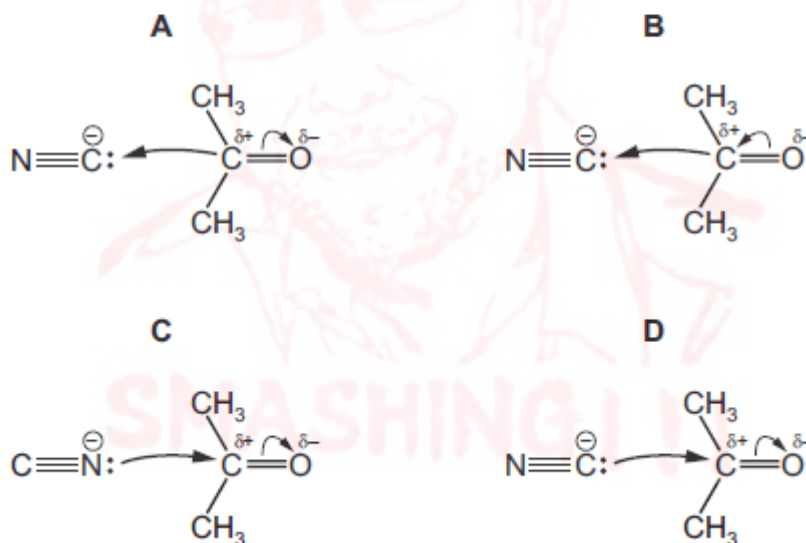
- A ammonia, sodium chloride and water
- B ammonia, sodium hydrogencarbonate and sodium chloride
- C methylamine, hydrogen chloride and water
- D methylamine, sodium chloride and water

Topic **Chem 19 Q# 1224**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

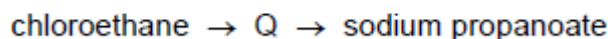
26 Propanone reacts with an aqueous mixture of HCN and NaCN by a nucleophilic addition mechanism.

The first stage of the mechanism involves attack by cyanide ions.

Which diagram correctly represents this?



24 Chloroethane can be used to make sodium propanoate.

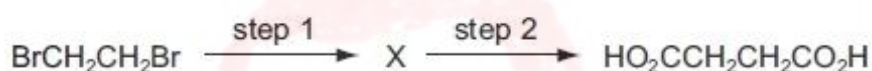


The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide to give sodium propanoate.

Which reagent would produce the intermediate, Q, from chloroethane?

- A concentrated ammonia solution
- B dilute sulfuric acid
- C hydrogen cyanide in water
- D potassium cyanide in ethanol

21 Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.



Which reagents could be used for this synthesis?

	step 1	step 2
A	HCN(g)	HCl(aq)
B	HCO ₂ Na(aq)	HCl(aq)
C	KCN(aq / alcoholic)	H ₂ SO ₄ (aq)
D	NaOH(aq)	K ₂ Cr ₂ O ₇ /H ₂ SO ₄ (aq)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

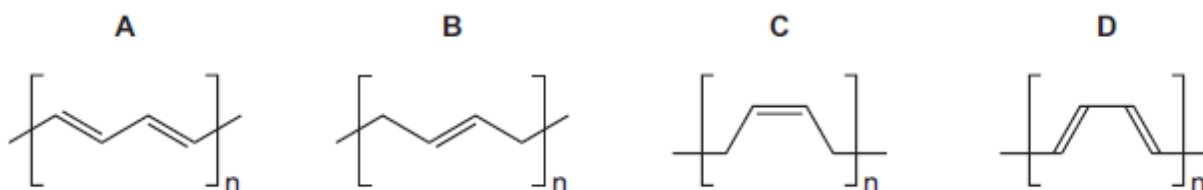
39 How can the rate of reaction between ethanal and aqueous hydrogen cyanide be increased?

- 1 by irradiation with ultraviolet light
- 2 by a rise in temperature
- 3 by the addition of a small quantity of aqueous sodium cyanide



- 39** The monomer buta-1,3-diene can undergo addition polymerisation in various ways. Two of the polymers that can be made are called *cis*-poly(buta-1,3-diene) and *trans*-poly(buta-1,3-diene). In these names *cis* and *trans* have their usual meanings.

What is the structure of the repeat unit of *cis*-poly(buta-1,3-diene)?



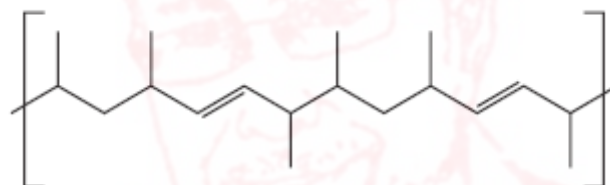
Topic Chem 20 Q# 1229/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 5//www.SmashingScience.org :o)

- 5** In which structure are three atoms bonded together in a straight line?

- A poly(ethene), $\text{-(CH}_2\text{CH}_2\text{)}_n$
 B propane, C_3H_8
 C silicon tetrachloride, SiCl_4
 D sulfur hexafluoride, SF_6

Topic Chem 20 Q# 1230/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

- 39** The diagram shows a section of an addition polymer formed from two different monomers.

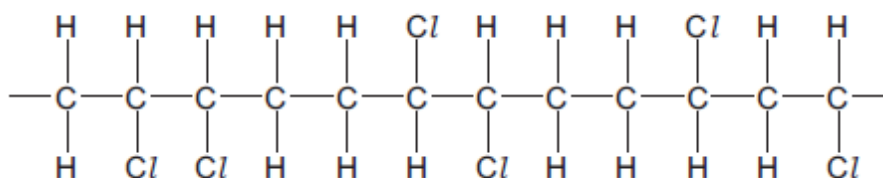


One of the monomers is propene.

What is the other monomer?



37 A molecule of a polymer contains the sequence shown.



Which monomer could produce this polymer by addition polymerisation?

- A $\text{CHCl}=\text{CHCl}$
- B $\text{CH}_2=\text{CHCl}$
- C $\text{CH}_3\text{CCl}=\text{CHCl}$
- D $\text{CH}_3\text{CCl}=\text{CH}_2$

22 Which statement is correct when referring to the complete combustion of PVC?

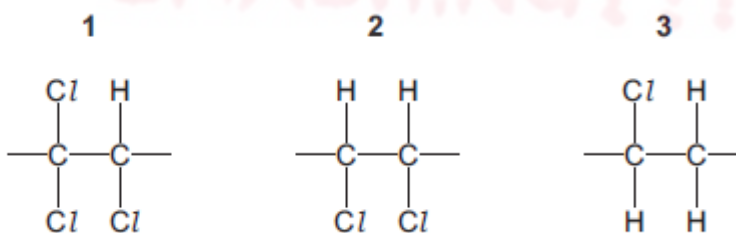
- A A gas is made which contributes to global warming.
- B Carbon dioxide and water are the only products.
- C If water is used to clean the exhaust gases, the water becomes alkaline.
- D There is no need to treat the exhaust gases as the products are non-hazardous.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 A mixture of the three isomers of $\text{C}_2\text{H}_2\text{Cl}_2$ is polymerised.

Which sequences will be seen within the polymer chains?

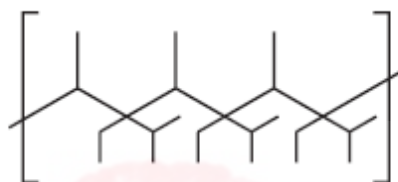


24 Poly(propene) is an addition polymer.

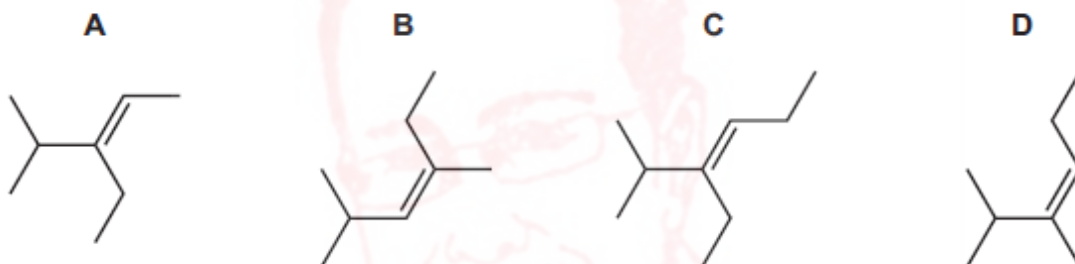
What are the C–C–C bond angles along its polymer chain?

- A** They are all 109°.
- B** Half of them are 109° and half are 120°.
- C** Half of them are 90° and half are 180°.
- D** They are all 120°.

24 A section of a polymer chain is shown.



What is the correct monomer?



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which statements about poly(alkene)s are correct?

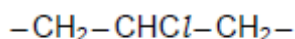
- 1** Poly(alkene)s do not react with Br₂(aq) in the dark.
- 2** Disposal of poly(alkene)s by combustion can produce harmful products.
- 3** Poly(alkene)s do not readily biodegrade.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Polymer Z contains the length of polymer chain shown below.

This short length of chain is found many times within the chains of polymer Z, although it is **not** the repeat unit.



What could be the name of polymer Z?

- 1 poly(2-chloropropene)
- 2 poly(chloroethene)
- 3 PVC

Topic **Chem 20 Q# 1238**/ AS Chemistry/2018/m/TZ 2/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Poly(ethene) and PVC are examples of addition polymers.

Which statements are correct?

- 1 On combustion, PVC can produce carbon monoxide, carbon dioxide and hydrogen chloride.
- 2 When poly(ethene) is buried in a landfill site, it will not significantly biodegrade.
- 3 The empirical formula of an addition polymer is the same as that of the monomer.

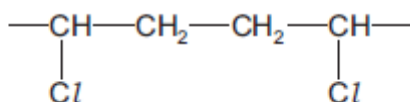
Topic **Chem 20 Q# 1239**/ AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 3//

3 In which structure are three atoms bonded together in a straight line?

- A poly(ethene), $-(\text{CH}_2\text{CH}_2)_n-$
- B propane, C_3H_8
- C silicon tetrachloride, SiCl_4
- D sulfur hexafluoride, SF_6

Topic **Chem 20 Q# 1240**/ AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 23//

23 A section of an addition polymer chain is shown.

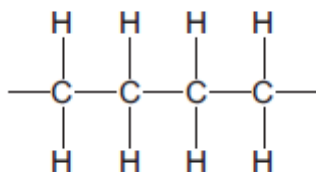


Which monomer could be used to make this polymer?

- A $\text{CH}_2\text{CHCH}_2\text{Cl}$
- B CH_2CHCl
- C CH_3CHCHCl
- D $\text{CHClCHCH}_2\text{CH}_2\text{Cl}$



23 The diagram shows a short length of an addition polymer chain.



The polymer has a relative molecular mass of approximately 10 000.

Approximately how many monomer units are joined together in each polymer molecule?

- A** 180 **B** 360 **C** 625 **D** 710

24 Polymerisation of ethene gives poly(ethene).

How does the bonding between carbon atoms in poly(ethene) compare with that in ethene?

- A** longer and stronger in poly(ethene)
B longer and weaker in poly(ethene)
C shorter and stronger in poly(ethene)
D shorter and weaker in poly(ethene)

22 PVC is difficult to dispose of. Two possible methods are burying it in landfill sites and disposal by combustion.

Which row of the table is correct?

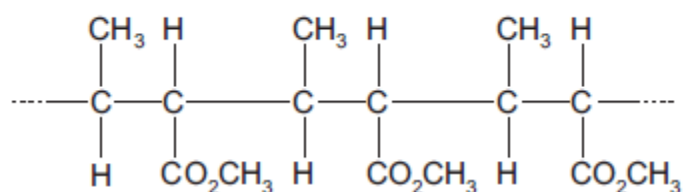
	rate of biodegradation of PVC in landfill sites	gases produced when PVC combusts
A	fast	CO ₂ , H ₂ O, HCl
B	fast	CO ₂ , H ₂ O, Cl ₂
C	slow	CO ₂ , H ₂ O, Cl ₂
D	slow	CO ₂ , H ₂ O, HCl

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



40 The diagram shows the structure of an addition polymer, X.



Which reagents react with polymer X?

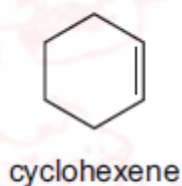
- 1 aqueous sulfuric acid
- 2 aqueous sodium hydroxide
- 3 sodium

Topic **Chem 20 Q# 1245**/ AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

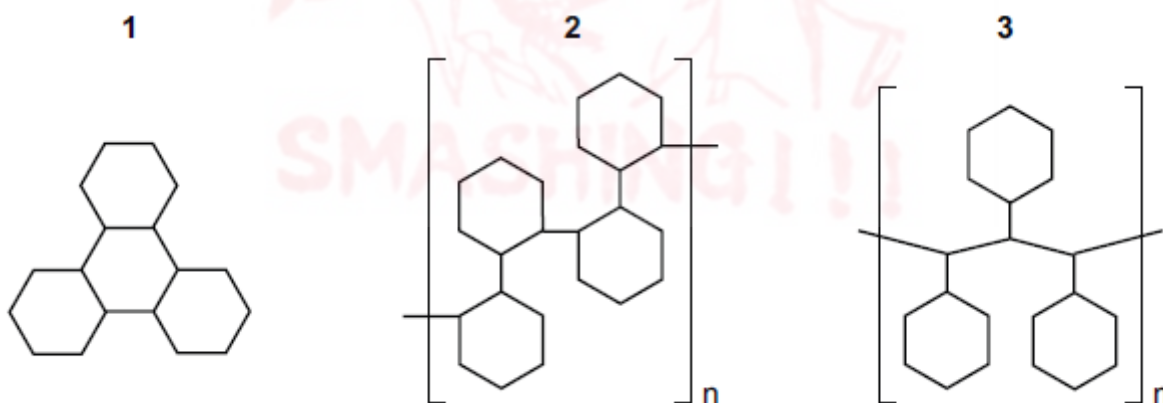
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 The diagram shows the structure of cyclohexene.



Which structures could be formed by addition reactions with cyclohexene as the only reactant?

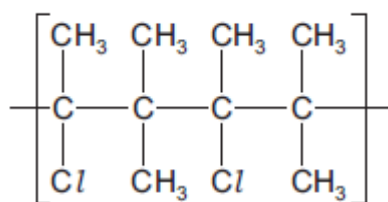


Topic **Chem 20 Q# 1246**/ AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Which statement about poly(chloroethene) is correct?

- A The polymer can be cracked to produce chlorinated alkenes.
- B The polymer has harmless combustion products.
- C The polymer is readily biodegradable when buried.
- D The repeat unit of the polymer has an M_r of 97.

22 A section showing two repeat units of an addition polymer is shown.



What is the identity of the monomer that produced this polymer?

- A 2-chloro-3-methylbutane
- B 2-chloro-3-methylbut-2-ene
- C 2-chloropent-2-ene
- D 2,4-dichloro-3,3,4,5-tetramethylhexane

Topic **Chem 20 Q# 1248**/ AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

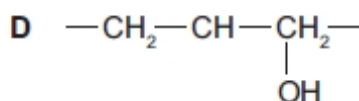
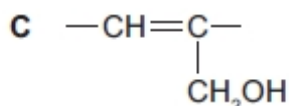
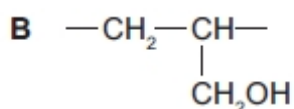
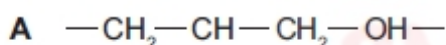
30 Which types of bond breakage and bond formation occur in the addition polymerisation of alkenes?

	bond breakage	bond formation
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

Topic **Chem 20 Q# 1249**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Synthetic resins, plasticisers and many other chemicals can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $\text{CH}_2=\text{CHCH}_2\text{OH}$.

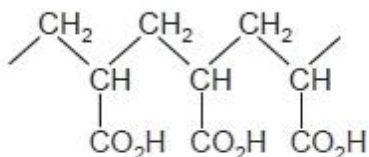
Which structure represents the repeat unit in poly(prop-2-en-1-ol)?



30 Which statement does **not** correctly describe the polymer PVC?

- A** Combustion of PVC waste produces a highly acidic gas.
- B** PVC molecules are saturated.
- C** The empirical formula of PVC is the same as the empirical formula of its monomer.
- D** The repeat unit of PVC is -(CHClCHCl)- .

20 One of the characteristics of addition polymerisation is that the empirical formulae of the polymer and of its monomer are the same. The absorbent material in babies' disposable nappies is made from the addition polymer shown.



From which monomer could this addition polymer be obtained?

- A** $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$
- B** $\text{HOCH}_2\text{CH}_2\text{CO}_2\text{H}$
- C** $\text{H}_2\text{C}=\text{CHCO}_2\text{H}$
- D** $\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$

26 In many countries plastic waste is collected separately and sorted. Some of this is incinerated to provide heat for power stations.

Why is pvc, polyvinylchloride, removed from any waste that is to be incinerated?

- A** It destroys the ozone layer.
- B** It does not burn easily.
- C** It is easily biodegradable.
- D** Its combustion products are harmful.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31 A monomer undergoes addition polymerisation. A 1 mol sample of the monomer is completely polymerised.

How many moles of polymer might, theoretically, be formed?

- 1 1
2 10^{-6}
3 $\frac{1}{6.02 \times 10^{23}}$

Topic Chem 20 Q# 1254/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

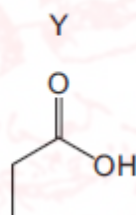
- 23 Polymerisation of chloroethene gives PVC.

How does the carbon-carbon bond in PVC compare with that in chloroethene?

- A longer and stronger
B longer and weaker
C shorter and stronger
D shorter and weaker

Topic Chem 21 Q# 1255/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

- 38 Which compounds can be used to make Y in a single-step reaction?

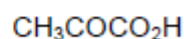
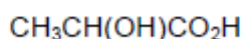
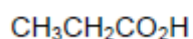


- 1 propanenitrile
2 ethanenitrile
3 propyl ethanoate
4 ethyl propanoate

- A 1 and 3 B 1 and 4 C 2 and 3 D 2 and 4

Topic Chem 21 Q# 1256/ AS Chemistry/2022/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

- 31 Three colourless liquids with the following formulae are contained in separate unlabelled bottles.



Which two tests, carried out on separate samples of each liquid, will successfully identify each liquid?

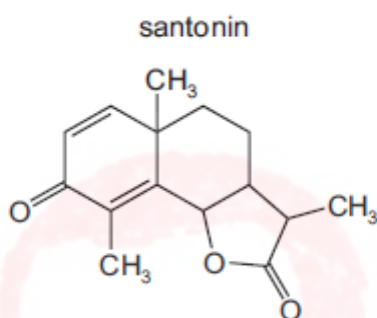
	test 1	test 2
A	NaHCO_3	2,4-DNPH reagent
B	NaHCO_3	Tollens' reagent
C	warm acidified dichromate	2,4-DNPH reagent
D	warm acidified dichromate	Tollens' reagent

- 30** Compound R can be formed from 1-bromopropane using a nucleophilic substitution reaction followed by an oxidation reaction.

What is the identity of R?

- A** propanoic acid
- B** propanone
- C** propylamine
- D** propyl ethanoate

- 29** The structure of santonin is shown.



Santonin is first treated with warm dilute H_2SO_4 . The product of this reaction is treated with cold dilute acidified KMnO_4 . A final product, Q, is obtained.

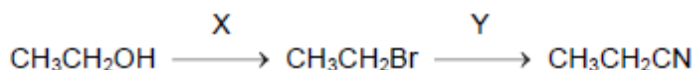
How many atoms of hydrogen in each molecule of product Q will react with sodium metal?

- A** 2
- B** 4
- C** 5
- D** 6

- 28** Which pair of reagents react together in a redox reaction?

- A** $\text{CH}_3\text{CHCH}_2 + \text{Br}_2$
- B** $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} + \text{concentrated } \text{H}_3\text{PO}_4$
- C** $\text{CH}_3\text{COCH}_3 + \text{HCN}$
- D** $\text{HCO}_2\text{C}_2\text{H}_5 + \text{dilute } \text{H}_2\text{SO}_4$

- 26** Ethanol can be used to make propanenitrile in two steps.



What types of reaction are X and Y?

	X	Y
A	free-radical substitution	electrophilic substitution
B	free-radical substitution	nucleophilic substitution
C	nucleophilic substitution	nucleophilic substitution
D	nucleophilic substitution	electrophilic substitution



38 Compound Y is heated with a mild oxidising agent. One of the products of the reaction reacts with hydrogen cyanide forming 2-hydroxybutanenitrile.

What is compound Y?

- A butan-1-ol
- B butan-2-ol
- C propan-1-ol
- D propan-2-ol

30 Butanoic acid is prepared from 1-bromopropane.

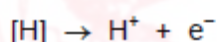
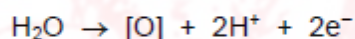
This synthesis requires a sequence of two reactions.

Which compound is prepared in the first stage of the synthesis?

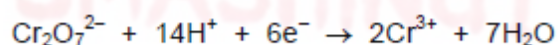
- A 1-aminopropane
- B propan-1-ol
- C butanal
- D butanenitrile

25 When an organic compound is oxidised, any oxygen atom gained by the organic molecule is considered to be from a water molecule also producing $2\text{H}^+ + 2\text{e}^-$. Any hydrogen atom lost may be considered to be lost as $\text{H}^+ + \text{e}^-$.

These changes can be represented by the following two equations.



Compound X is oxidised by heating under reflux with hot, acidified potassium dichromate(VI) for one hour. The half-equation for the reduction reaction is shown.



Under these conditions, one mole of potassium dichromate(VI) oxidises three moles of X.

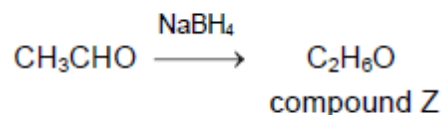
What could X be?

- A propanal
- B propan-1-ol
- C propan-1,2-diol
- D propan-1,3-diol

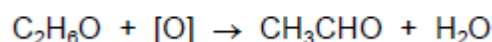
27 In this question you can assume that ^1H and ^3H have the same chemical properties.

A sample of ethanal contains only one isotope of hydrogen, ^1H .

It is reduced to compound Z, $\text{C}_2\text{H}_6\text{O}$, in a nucleophilic addition reaction using NaBH_4 . All the hydrogen atoms in the NaBH_4 are the ^3H isotope.



Compound Z is then oxidised back to ethanal and water.



Which statement about the final mixture of products is correct?

- A Both ethanal and water contain ^3H atoms.
- B Ethanal is the only product containing ^3H atoms.
- C Neither ethanal nor water contain ^3H atoms.
- D Water is the only product containing ^3H atoms.

Topic **Chem 21 Q# 1265/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 24//www.SmashingScience.org :o)

24 A student converts 1-iodopropane, $\text{C}_3\text{H}_7\text{I}$, into butanoic acid, $\text{C}_3\text{H}_7\text{CO}_2\text{H}$, by a two-stage chemical synthesis.

In the **first** of the two stages, which reagent is reacted with 1-iodopropane?

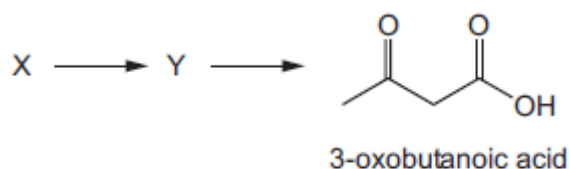
- A aqueous sodium hydroxide
- B ethanolic ammonia
- C ethanolic potassium cyanide
- D ethanolic sodium hydroxide

Topic **Chem 21 Q# 1266/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

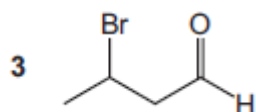
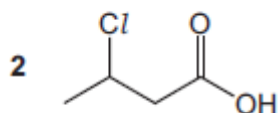
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 3-oxobutanoic acid can be synthesised in a two-step process.



What could be the structure of X?



Topic **Chem 21 Q# 1267**/ AS Chemistry/2017/w/TZ 1/Paper 1/Exam Q# 29//

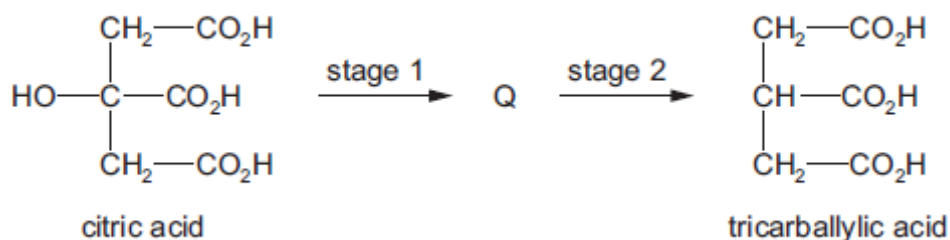
29 Ethene is reacted with steam in the presence of concentrated H_3PO_4 . The product of this reaction is added to acidified potassium dichromate(VI) and heated under reflux for one hour. The final organic product is collected and labelled X.

But-2-ene is treated with hot, concentrated, acidified potassium manganate(VII). The final organic product is collected and labelled Y.

Which statement is correct?

- A One molecule of X has more carbon atoms than one molecule of Y.
- B One molecule of Y has more carbon atoms than one molecule of X.
- C X and Y have different functional groups.
- D X is the same compound as Y.

25 Citric acid can be converted into tricarballic acid in two stages. An intermediate, Q, is formed.



Which reagents are needed for each stage?

	stage 1	stage 2
A	concentrated H ₂ SO ₄	H ₂ (g) and Ni
B	concentrated H ₂ SO ₄	LiAlH ₄
C	LiAlH ₄	H ₂ SO ₄ (aq)
D	NaOH(aq)	H ₂ (g) and Ni

Topic **Chem 21 Q# 1269**/ AS Chemistry/2017/s/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

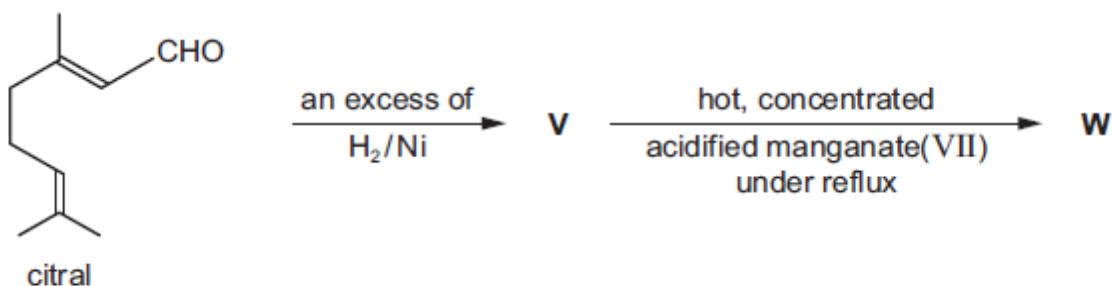
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

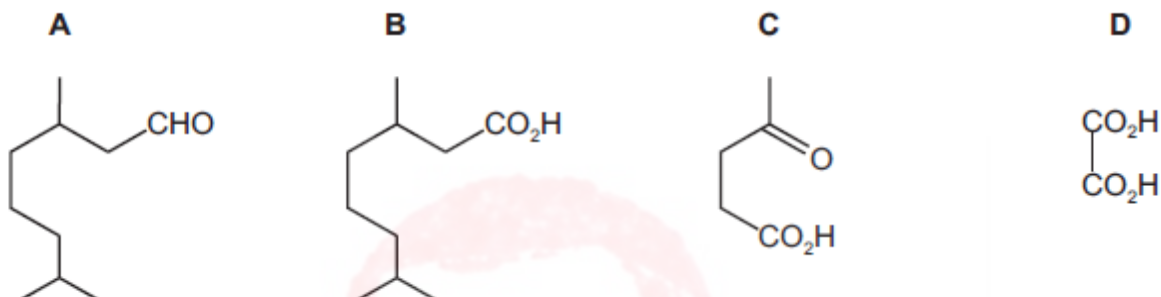
39 For which reactions are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

30 Citral is found in lemongrass oil. It can react to give compound **W**.



What could compound **W** be?



25 Diols in which both hydroxy groups are bonded to the same carbon can spontaneously eliminate a molecule of water to produce a carbonyl compound.

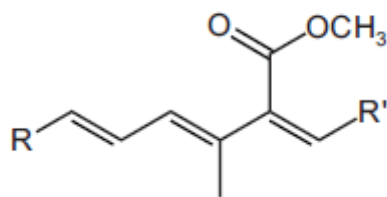
Which compound, after complete hydrolysis, gives a positive reaction with Tollens' reagent?

- A 1,1-dibromobutane
- B 1,2-dibromobutane
- C 1,3-dibromobutane
- D 2,2-dibromobutane

28 Which reaction would **not** give ethanoic acid?

- A heating ethanenitrile under reflux with dilute sodium hydroxide
- B heating ethanenitrile under reflux with dilute sulfuric acid
- C heating ethanal under reflux with acidified sodium dichromate(VI)
- D heating ethanol under reflux with acidified sodium dichromate(VI)

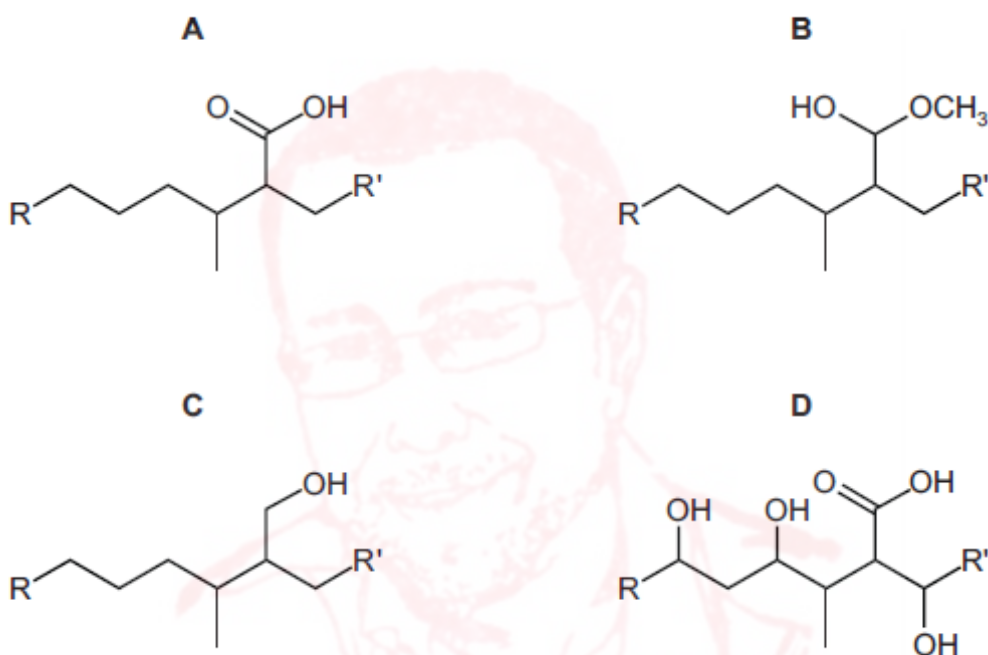
23 Part of the structure of a fungicide, strobilurin, is shown. R and R' are inert groups.



strobilurin

In this reaction, strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

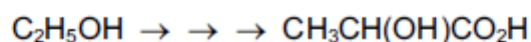


Topic **Chem 21 Q# 1274/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Several steps are involved in the synthesis of 2-hydroxypropanoic acid from ethanol.

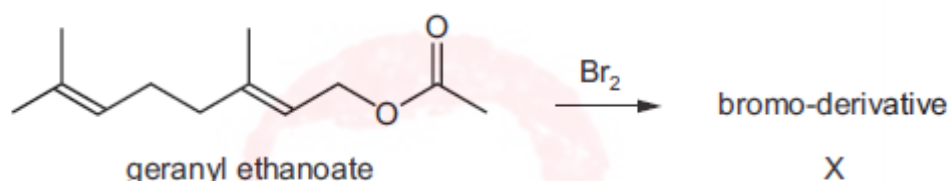


Which statements concerning this synthesis are correct?

- 1 The chain length can be increased during a step involving reaction between HCN and an aldehyde.
- 2 The carboxyl group can be made by hydrolysis of a nitrile by boiling with NaOH(aq) and then acidifying.
- 3 The ethanol should be first oxidised by heating it under reflux with an excess of acidified potassium dichromate(VI).

Topic **Chem 21 Q# 1275/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

30 Geranyl ethanoate is present in ginger and cocoa, and is used in shampoos and soaps as a perfume. It reacts with an excess of bromine in an organic solvent to give X, a bromo-derivative.



Including geranyl ethanoate, how many cis-trans isomers are there of geranyl ethanoate, and how many chiral centres are there in X?

	cis-trans isomers	chiral centres in X
A	2	3
B	2	4
C	4	3
D	4	4

Topic **Chem 21 Q# 1276/** AS Chemistry/2016/s/TZ 1/Paper 1/Exam Q# 22//www.SmashingScience.org :o)

22 Which pair of reagents will take part in a redox reaction?

- A $\text{CH}_3\text{CHCH}_2 + \text{Br}_2$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} + \text{concentrated H}_3\text{PO}_4$
- C $\text{CH}_3\text{COCH}_3 + \text{HCN}$
- D $\text{HCO}_2\text{C}_2\text{H}_5 + \text{dilute H}_2\text{SO}_4$

Topic **Chem 21 Q# 1277/** AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses A to D should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Compound **X** has the molecular formula $C_3H_8O_3$.

Heating **X** under reflux with acidified $K_2Cr_2O_7$ forms HO_2CCOCO_2H .

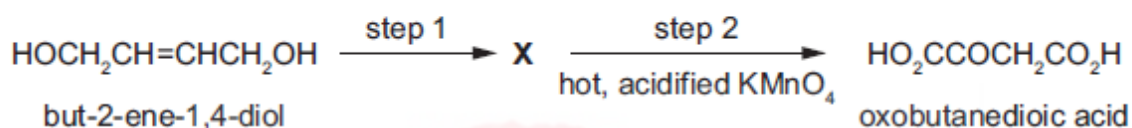
Reacting **X** with $NaBH_4$ forms $HOCH_2CH(OH)CH_2OH$.

What is a possible structural formula for **X**?

- 1 $HOCH_2CH_2CO_2H$
- 2 $HOCH_2CH(OH)CHO$
- 3 $HOCH_2COCH_2OH$

Topic **Chem 21 Q# 1278**/ AS Chemistry/2016/m/TZ 2/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

23 But-2-ene-1,4-diol is converted in two steps through an intermediate **X** into oxobutanedioic acid.



What could be the reagent for step 1 and what is the intermediate **X**?

	reagent for step 1	X
A	cold, acidified $KMnO_4$	$HOCH_2CH_2CH(OH)CH_2OH$
B	hot, acidified $K_2Cr_2O_7$	$HO_2CCH=CHCO_2H$
C	steam and concentrated H_2SO_4	$HOCH_2CH(OH)CH_2CH_2OH$
D	warm, acidified $K_2Cr_2O_7$	$OHCCH(OH)CH_2CHO$

Topic **Chem 21 Q# 1279**/ AS Chemistry/2015/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

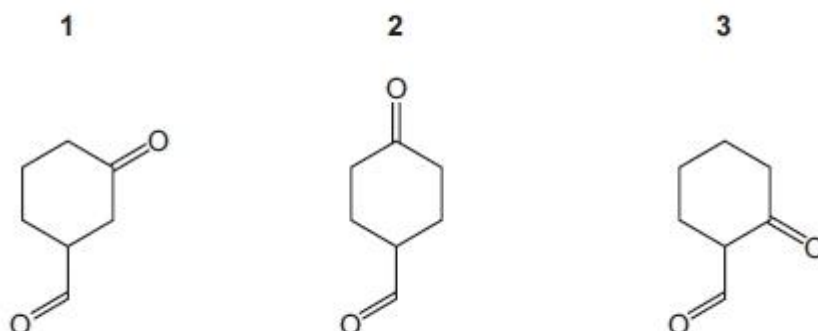
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 Each of the compounds below is treated separately with excess $NaBH_4$. The product of each reaction is then heated with excess concentrated H_2SO_4 .

In each case, one or more products are formed with molecular formula C_7H_{10} .

Which compounds give **only one** final product with the molecular formula C_7H_{10} ?



27 Butan-2-ol can be made by reducing X with H_2/Ni .

Butan-2-ol can be dehydrated to form Y and Z which are structural isomers of each other.

Which row is correct?

	X is	<i>cis-trans</i> isomerism is shown by
A	an aldehyde	both Y and Z
B	an aldehyde	only one of Y and Z
C	a ketone	both Y and Z
D	a ketone	only one of Y and Z

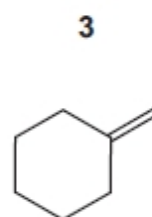
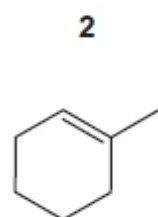
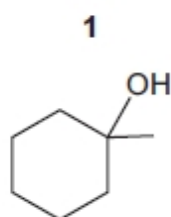
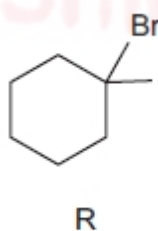
25 If the starting material is iodoethane, which sequence of reactions will produce propanoic acid as the main final product in good yield?

- A** add $NaOH(aq)$, isolate the organic product, add acidified $K_2Cr_2O_7$ and boil under reflux
- B** add $NaOH(aq)$, isolate the organic product, add $H_2SO_4(aq)$ and boil under reflux
- C** heat with HCN in ethanol, isolate the organic product, add $H_2SO_4(aq)$ and boil under reflux
- D** heat with KCN in ethanol, isolate the organic product, add $H_2SO_4(aq)$ and boil under reflux

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Which compounds will react with HBr to give the compound R?



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 For which mixtures of reagents are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

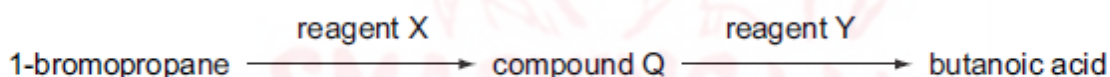
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Which pairs of reagents will take part in a redox reaction?

- 1 CH_3COCH_3 + Tollens' reagent
- 2 $\text{CH}_3\text{CH}_2\text{CHO}$ + Fehling's reagent
- 3 $\text{CH}_3\text{CH}=\text{CH}_2$ + Br_2

30 Butanoic acid can be produced from 1-bromopropane using reagents X and Y as shown below.



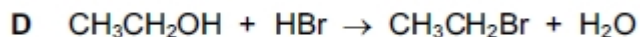
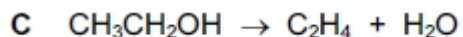
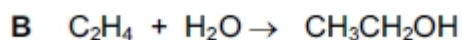
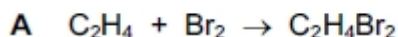
What could be reagents X and Y?

	X	Y
A	KCN in ethanol	HCl(aq)
B	KCN in ethanol	NaOH(aq)
C	NH_3 in ethanol	HCl(aq)
D	NaOH(aq)	$\text{H}^+/\text{Cr}_2\text{O}_7^{2-}(\text{aq})$



20 Many organic reactions need to be heated before reaction occurs, but some do not require heating.

Which reaction occurs quickly at room temperature?



Topic **Chem 21 Q# 1287/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 The compounds below are treated with hydrogen cyanide.

Which compounds react and produce a molecule containing a chiral centre?

1 butanal

2 pentan-3-one

3 2-chlorobutane

Topic **Chem 21 Q# 1288/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Which reactions can be used to make an alcohol in the laboratory?

1 hydrolysis of a bromoalkane with NaOH(aq)

2 reduction of a ketone with NaBH_4

3 reduction of an aldehyde with NaBH_4

Topic **Chem 21 Q# 1289/** AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



- 38 An organic compound **Y**, molecular formula $C_6H_{14}O$, may be oxidised to compound **Z**, molecular formula $C_6H_{12}O_2$.

What could be the structural formula of **Y**?

- 1 $CH_3CH_2CH(CH_2OH)CH_2CH_3$
- 2 $(CH_3)_3CCH_2CH_2OH$
- 3 $CH_3CH_2CH(CH_3)CH_2CH_2OH$

Topic **Chem 21 Q# 1290**/ AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

- 28 In which reaction is the organic compound oxidised?

- A $CH_3CH_2OH + \text{concentrated } H_3PO_4$
- B $CH_3CH_2CH_2CHO + \text{Tollens' reagent}$
- C $CH_3COCH_3 + \text{2,4-dinitrophenylhydrazine reagent}$
- D $CH_3CN + \text{dilute } H_2SO_4$

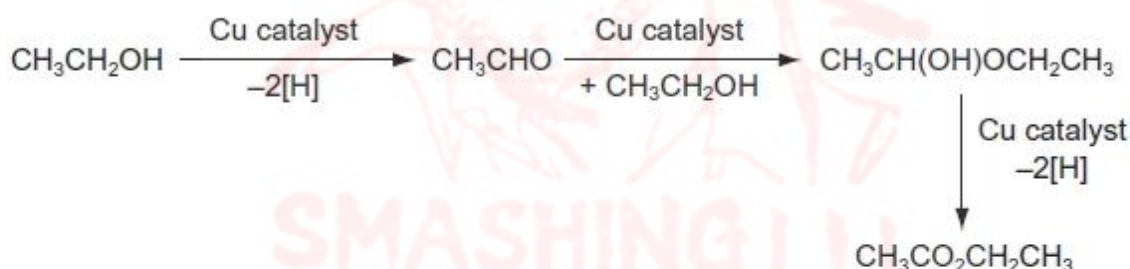
Topic **Chem 21 Q# 1291**/ AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

- 21 Which reaction will give the best yield of 1-chloropropane?

- A chlorine gas with propene gas in the dark
- B propan-1-ol with dilute $NaCl(aq)$
- C propan-1-ol with PCl_5
- D propene with dilute $HCl(aq)$

Topic **Chem 21 Q# 1292**/ AS Chemistry/2013/w/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

- 20 A new industrial preparation of ethyl ethanoate has been developed using cheap sources of ethanol.

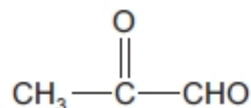


Which process is involved at some stage in this reaction sequence?

- A electrophilic addition
- B nucleophilic addition
- C nucleophilic substitution
- D reduction



27 Burnt sugar has a characteristic smell caused partly by the following compound.



This compound contains two functional groups.

Which reagent will react with **only one** of the functional groups?

- A** acidified potassium dichromate(VI)
- B** 2,4-dinitrophenylhydrazine
- C** hydrogen cyanide
- D** sodium hydroxide

Topic **Chem 21 Q# 1294**/ AS Chemistry/2013/s/TZ 1/Paper 1/Exam Q# 21//www.SmashingScience.org :o)

21 Lactic acid (2-hydroxypropanoic acid), $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$, is found in sour milk.

Which reaction could occur with lactic acid?

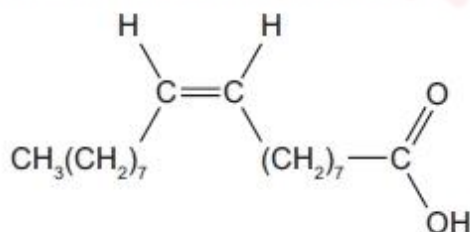
- A** $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{CH}(\text{OCH}_3)\text{CO}_2\text{H} + \text{H}_2\text{O}$
- B** $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{HCO}_2\text{H} \rightarrow \text{CH}_3\text{CH}(\text{O}_2\text{CH})\text{CO}_2\text{H} + \text{H}_2\text{O}$
- C** $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{NaHCO}_3 \rightarrow \text{CH}_3\text{CH}(\text{ONa})\text{CO}_2\text{H} + \text{H}_2\text{O} + \text{CO}_2$
- D** $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{Cl}_2 \rightarrow \text{CH}_3\text{CH}(\text{Cl})\text{CO}_2\text{H} + \text{HOCl}$

Topic **Chem 21 Q# 1295**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 Oleic acid is found in olive oil. It has the following formula.



Which reagents will give a positive result with oleic acid?

- 1** aqueous bromine
- 2** acidified potassium dichromate(VI)
- 3** Fehling's reagent



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Which reagents react with butanone, $\text{C}_2\text{H}_5\text{COCH}_3$?

- 1 Tollens' reagent
- 2 sodium borohydride
- 3 2,4-dinitrophenylhydrazine reagent

Topic **Chem 21 Q# 1297**/ AS Chemistry/2012/w/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20°C)?

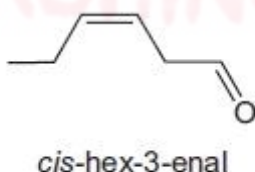
- A $\text{CH}_3\text{OH} + \text{PCl}_5 \rightarrow \text{CH}_3\text{Cl} + \text{POCl}_3 + \text{HCl}$
- B $\text{CH}_3\text{CH}_2\text{Br} + \text{KCN} \rightarrow \text{CH}_3\text{CH}_2\text{CN} + \text{KBr}$
- C $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$
- D $\text{CH}_3\text{CH}_2\text{CN} + 2\text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{CO}_2\text{H} + \text{NH}_3$

Topic **Chem 21 Q# 1298**/ AS Chemistry/2012/s/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

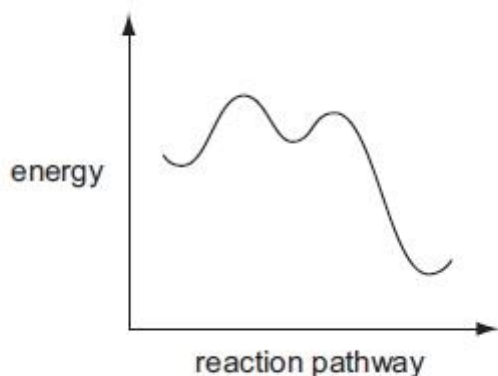
39 The compound *cis*-hex-3-enal is responsible for the characteristic smell of cut grass. The human nose is particularly sensitive to this compound, being able to detect 0.25 parts per billion in air.



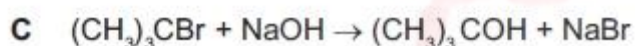
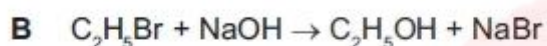
Which reagents will react with *cis*-hex-3-enal?

- 1 sodium
- 2 sodium borohydride
- 3 Fehling's reagent

28 A reaction pathway diagram is shown.



Which reaction does **not** have such a profile?

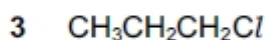
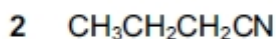
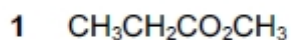


Topic **Chem 21 Q# 1300**/ AS Chemistry/2011/w/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

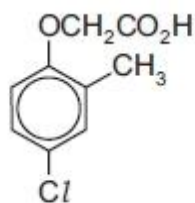
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

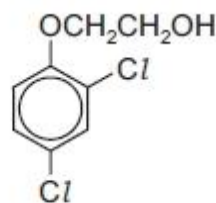
39 On acid hydrolysis, which compounds produce propanoic acid?



23 Y and Z are two widely-used selective weed killers.



Y



Z

Which reagent will distinguish Y from Z?

- A acidified $\text{AgNO}_3(\text{aq})$
- B Fehling's solution
- C Na
- D $\text{Na}_2\text{CO}_3(\text{aq})$

Topic **Chem 21 Q# 1302**/ AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

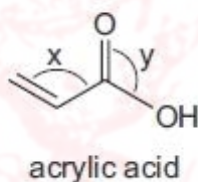
30 The functional group in a primary alcohol is $-\text{CH}_2\text{OH}$.

Which reagent reacts with a primary alcohol, under suitable conditions, to give an organic product with the same number of oxygen atoms as the alcohol?

- A Al_2O_3
- B $\text{CH}_3\text{CO}_2\text{H}$
- C HBr
- D Na

Topic **Chem 21 Q# 1303**/ AS Chemistry/2011/s/TZ 1/Paper 1/Exam Q# 20//www.SmashingScience.org :o)

20 Acrylic acid is produced from propene, a gaseous product of oil refineries.



Which statement about acrylic acid is **not** correct?

- A Both bond angles x and y are approximately 120° .
- B It decolourises aqueous bromine.
- C It gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.
- D It reacts with an alcohol to give an ester.

Topic **Chem 21 Q# 1304**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 39//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 39 An organic compound decolourises aqueous bromine and reacts with sodium to produce hydrogen.

Which molecular formula could represent this compound?

- 1 C_3H_6O
- 2 $C_3H_4O_2$
- 3 C_3H_8O

Topic **Chem 21 Q# 1305**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 38//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 38 Glyceraldehyde, $HOCH_2CH(OH)CHO$, is formed during photosynthesis, and contains a chiral carbon atom.

Which reagents will react with glyceraldehyde to produce an organic product **without** a chiral carbon atom?

- 1 warmed acidified $K_2Cr_2O_7$
- 2 $NaBH_4$
- 3 Tollens' reagent

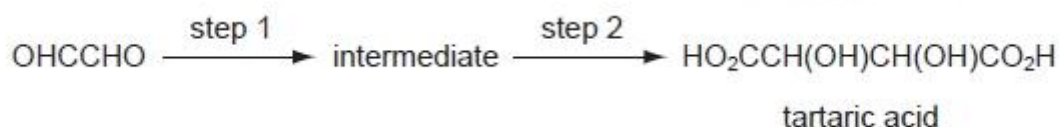
Topic **Chem 21 Q# 1306**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

- 27 Which compound would undergo nucleophilic addition?

- A bromoethane, C_2H_5Br
- B ethanal, CH_3CHO
- C ethane, C_2H_6
- D ethene, C_2H_4

Topic **Chem 21 Q# 1307**/ AS Chemistry/2010/w/TZ 1/Paper 1/Exam Q# 23//www.SmashingScience.org :o)

- 23 Tartaric acid is present in some wines. It may be synthesised in the laboratory in two steps.



Which reagents could be used for this synthesis?

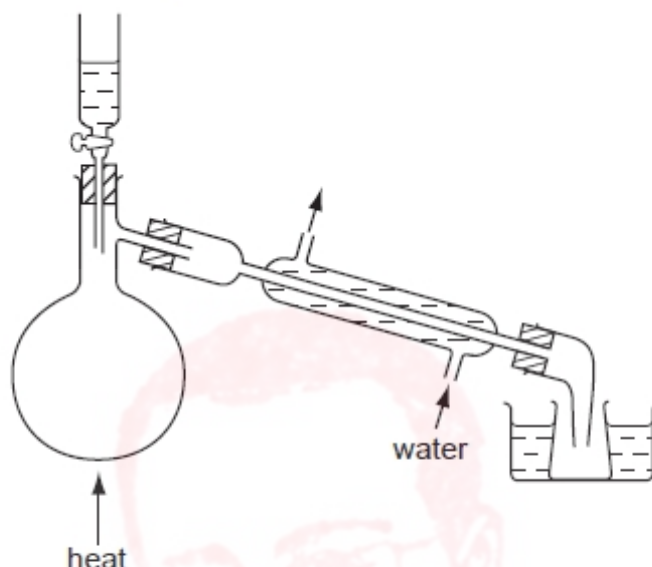
	step 1	step 2
A	$HCl(aq)$	$HCN(g)$
B	$HCN, NaCN(aq/alcoholic)$	$H_2SO_4(aq)$
C	$H_2SO_4(aq)$	$K_2Cr_2O_7 / H_2SO_4(aq)$
D	$KCN(aq/alcoholic)$	$K_2Cr_2O_7 / H_2SO_4(aq)$



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

40 The diagram shows some laboratory apparatus.



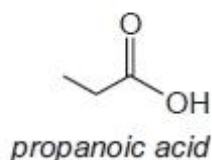
Which preparations could this apparatus be used for?

- 1** bromoethane, from ethanol, sodium bromide and concentrated sulfuric acid
- 2** ethanal, from ethanol, sodium dichromate(VI) and sulfuric acid
- 3** 1,2-dibromoethane, from bromine and ethene

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

37 Propanoic acid occurs naturally as a result of the bacterial fermentation of milk, and is partly responsible for the flavour of Swiss cheese.



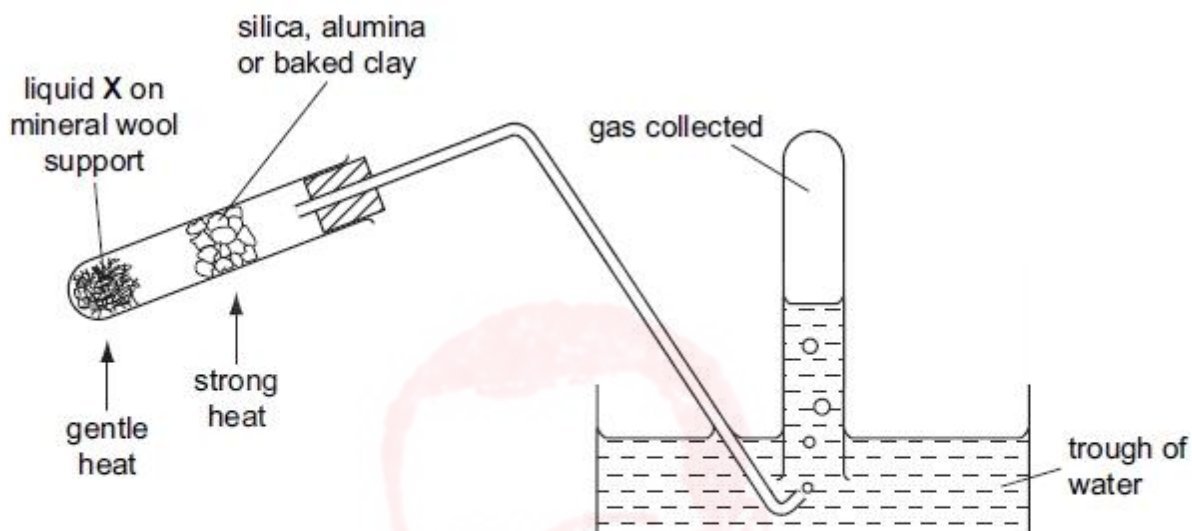
Which starting materials could be used to synthesise propanoic acid?

- 1** $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- 2** $\text{CH}_3\text{CH}_2\text{CN}$
- 3** $\text{CH}_3\text{CH}_2\text{CHO}$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

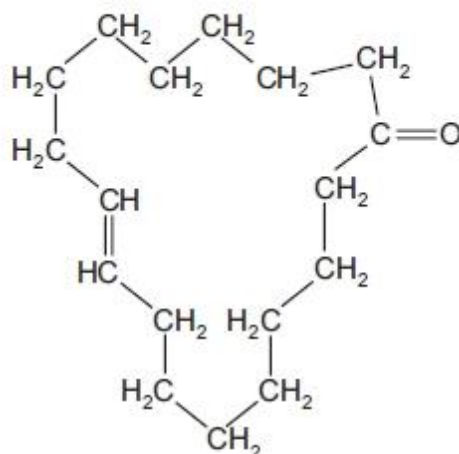
39 The diagram shows an experiment.



Which processes could be demonstrated by using the above apparatus?

- 1** the oxidation of ethanol (the liquid **X**)
- 2** the dehydration of ethanol (the liquid **X**)
- 3** the cracking of paraffin (the liquid **X**)

- 27** The naturally-occurring molecule civetone is found in a gland of the African civet cat and has been used in perfumery.

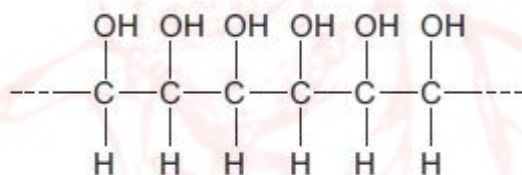


civetone

With which reagent will civetone **not** react?

- A 2,4-dinitrophenylhydrazine reagent
- B Fehling's reagent
- C hydrogen bromide
- D sodium tetrahydridoborate(III) (sodium borohydride)

- 23** The following diagram represents the structure of a possible polymer.



By which method might this polymer be made?

- A polymerise ethene followed by hydration
- B polymerise ethene followed by oxidation with cold acidified KMnO₄
- C polymerise 1,2-dichloroethene followed by hydrolysis
- D polymerise 1,2-dichloroethene followed by oxidation with cold acidified KMnO₄

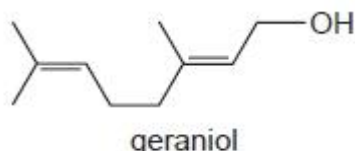
- 6** In which reaction does the carbon-containing product have a smaller bond angle than the organic reactant?
- A bromoethane refluxed with ethanolic sodium hydroxide
 - B complete combustion of methane in air
 - C methane and an excess of chlorine under ultraviolet light
 - D polymerisation of ethene



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 38** Geraniol is one of several compounds produced by the scent glands of honey bees to help them mark nectar-bearing flowers and locate the entrances to their hives.

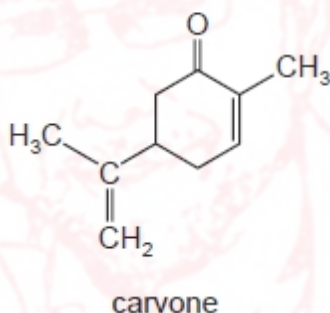


Which reactions will geraniol undergo?

- 1** reaction with hot concentrated acidic KMnO_4 to give propanone
- 2** addition of halogens
- 3** reaction with aqueous NaHCO_3 to give CO_2

Topic **Chem 21 Q# 1315**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 28//www.SmashingScience.org :o)

- 28** Carvone gives the characteristic flavour to caraway and spearmint.



Prolonged heating of carvone with hot concentrated acidified potassium manganate(VII) produces carbon dioxide and a compound **X**.

X contains nine carbon atoms and reacts with 2,4-dinitrophenylhydrazine reagent.

What is the maximum number of molecules of 2,4-dinitrophenylhydrazine that will react with one molecule of **X**?

- A** 1 **B** 2 **C** 3 **D** 4

Topic **Chem 21 Q# 1316**/ AS Chemistry/2009/s/TZ 1/Paper 1/Exam Q# 25//www.SmashingScience.org :o)

- 25** Which reaction would **not** give propene as one product?

- A** adding an excess of concentrated sulfuric acid to propan-1-ol
- B** adding warm aqueous sodium hydroxide to 2-bromopropane
- C** adding warm ethanolic sodium hydroxide to 1-bromopropane
- D** passing propan-2-ol vapour over heated aluminium oxide

- 40 In the mass spectrum of a compound, Z, the relative abundances of the M and M+1 peaks are in the ratio 13:1.

What is compound Z?

- A butyl butanoate
- B hexan-3-one
- C 2,2,3-trimethylhexane
- D 3,3-dimethylpentan-1-ol

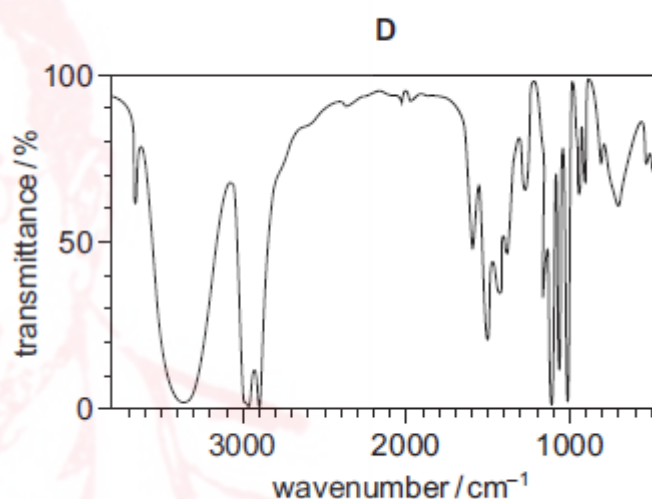
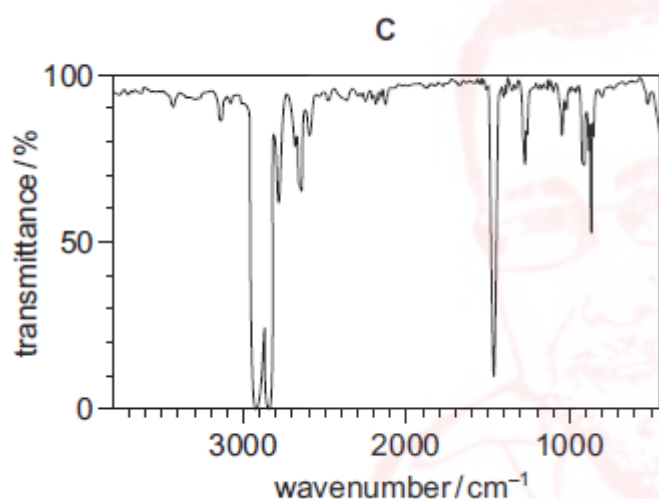
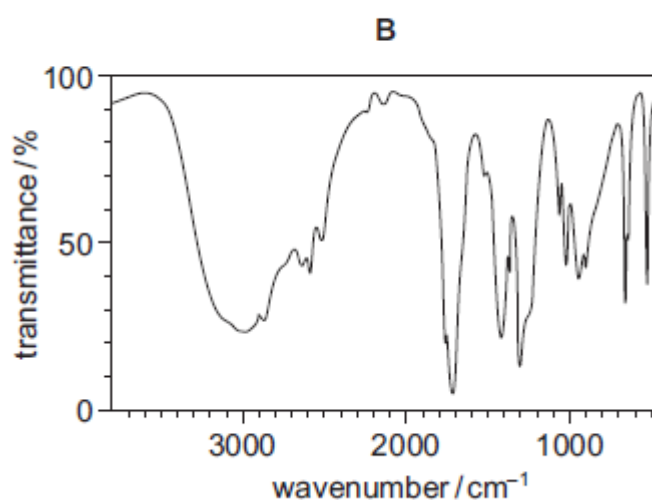
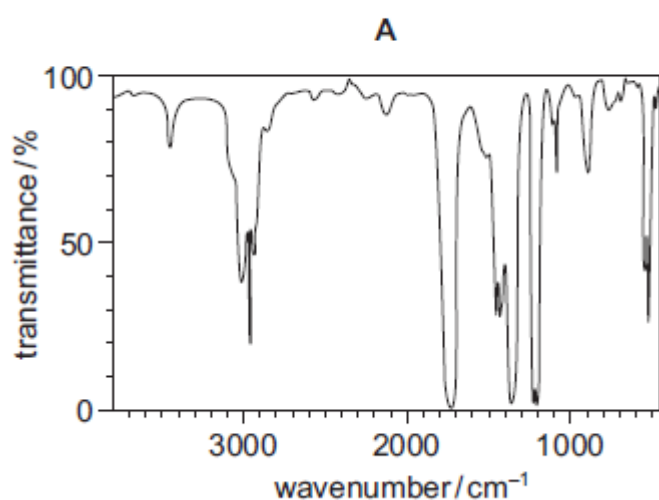
Topic Chem 22 Q# 1318/ AS Chemistry/2022/s/TZ 1/Paper 1/Exam Q# 40//www.SmashingScience.org :o)

- 40 A scientist chooses either infrared spectroscopy or mass spectrometry to find a particular piece of information.

In which row has the **best** choice been made?

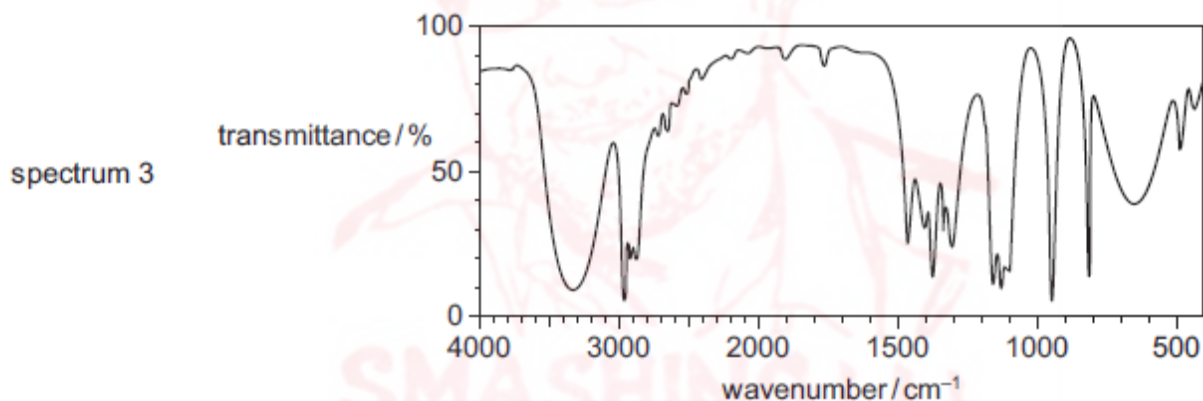
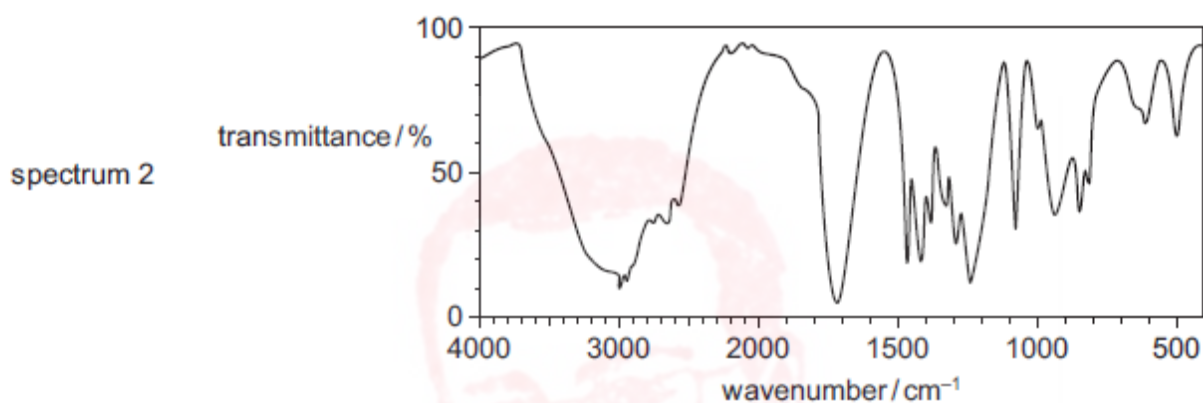
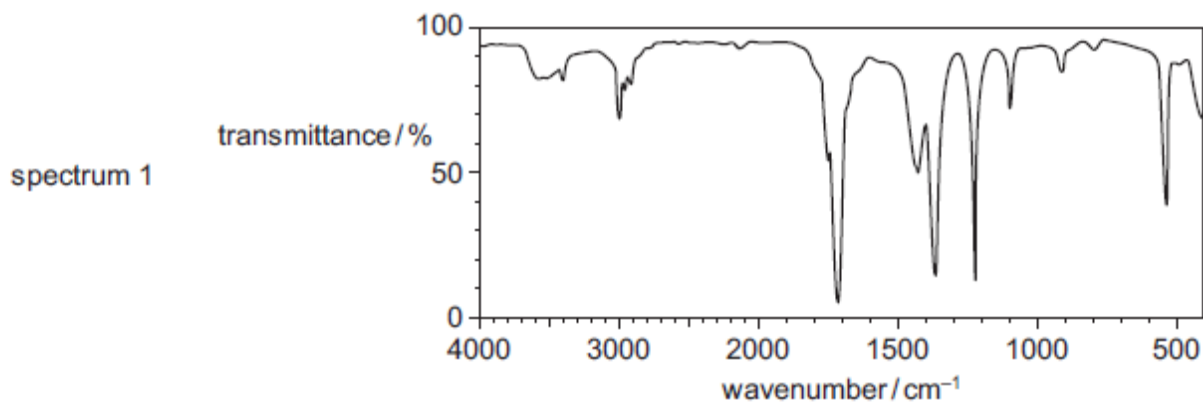
	target information	analytic method used
A	identities of functional groups in an organic compound	infrared spectroscopy
B	identities of functional groups in an organic compound	mass spectrometry
C	values of successive ionisation energies of Na	infrared spectroscopy
D	values of successive ionisation energies of Na	mass spectrometry

40 Which diagram shows the infrared spectrum of a compound that contains both a C=O and an O–H group?



bond	functional group containing the bond	characteristic infrared absorption range (in wavenumbers) / cm ⁻¹
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–3100
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

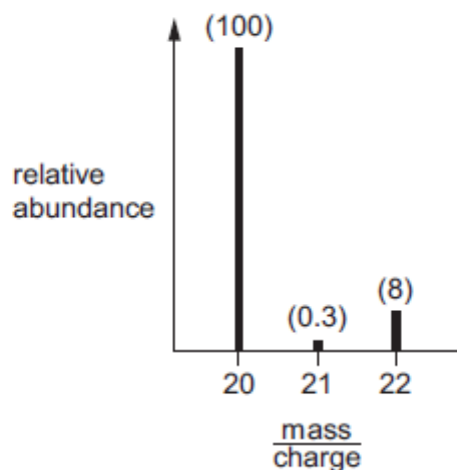
30 The infra-red spectra of three organic compounds are shown.



What could the three compounds be?

	spectrum 1	spectrum 2	spectrum 3
A	propanoic acid	propanone	propan-2-ol
B	propanone	propanoic acid	propan-2-ol
C	propanone	propan-2-ol	propanoic acid
D	propan-2-ol	propanoic acid	propanone

- 1** The mass spectrum of a sample of neon is shown. The relative abundance of each peak is written in brackets above it.

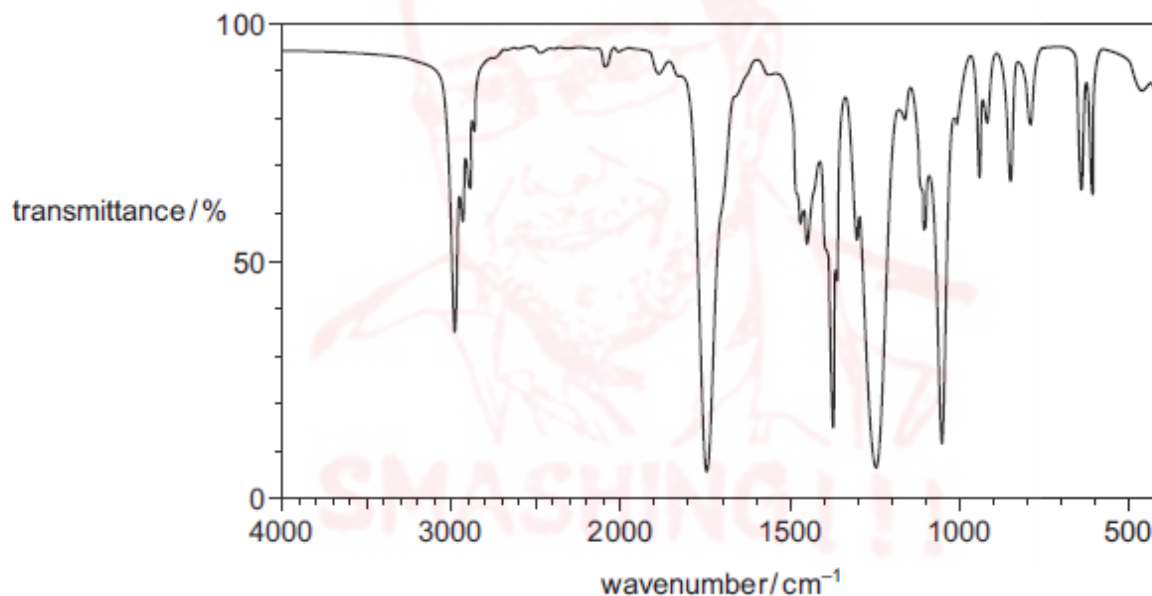


What is the relative atomic mass, A_r , of this sample of neon?

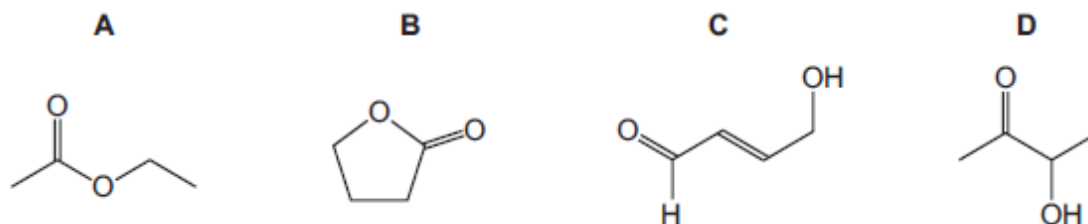
- A** 20.15 **B** 20.20 **C** 21.00 **D** 21.82

Topic **Chem 22 Q# 1322**/ AS Chemistry/2021/s/TZ 1/Paper 1/Exam Q# 26//www.SmashingScience.org :o)

- 26** Compound X has the empirical formula C_2H_4O . Its infra-red spectrum is shown.



What could be the skeletal formula of compound X?



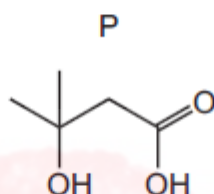
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

38 An excess of P reacts with Q, in the presence of concentrated sulfuric acid, to form R.

Effervescence is seen when a piece of sodium is added to pure R.

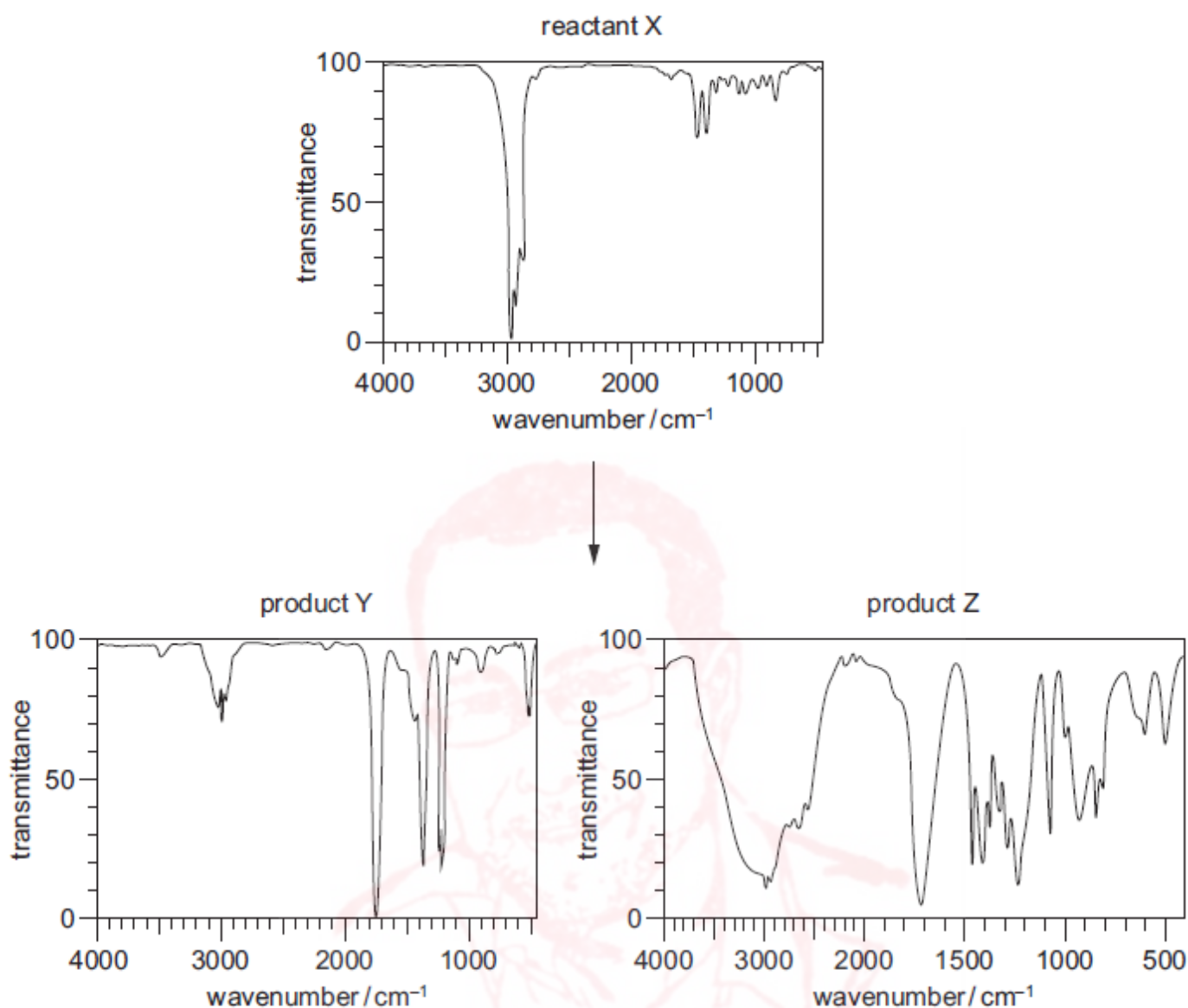
The structure of P is shown.



Which organic compounds could be compound Q?

- 1
CCC(=O)O
- 2
CCO
- 3
CC(=O)C

30 When reactant X is treated with a suitable reagent, products Y and Z are formed. Infrared spectra of X, Y and Z are shown.



Which row could be correct?

	X	Y	Z
A	2,3-dimethylpent-2-ene	propanone	butanone
B	2-methylpent-2-ene	propanone	propanoic acid
C	pent-2-ene	ethanoic acid	propanoic acid
D	propyl propanoate	propan-1-ol	propanoic acid

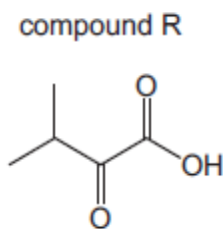
Topic **Chem 22 Q# 1325/** AS Chemistry/2020/w/TZ 1/Paper 1/Exam Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



37 The structure of compound R is shown.

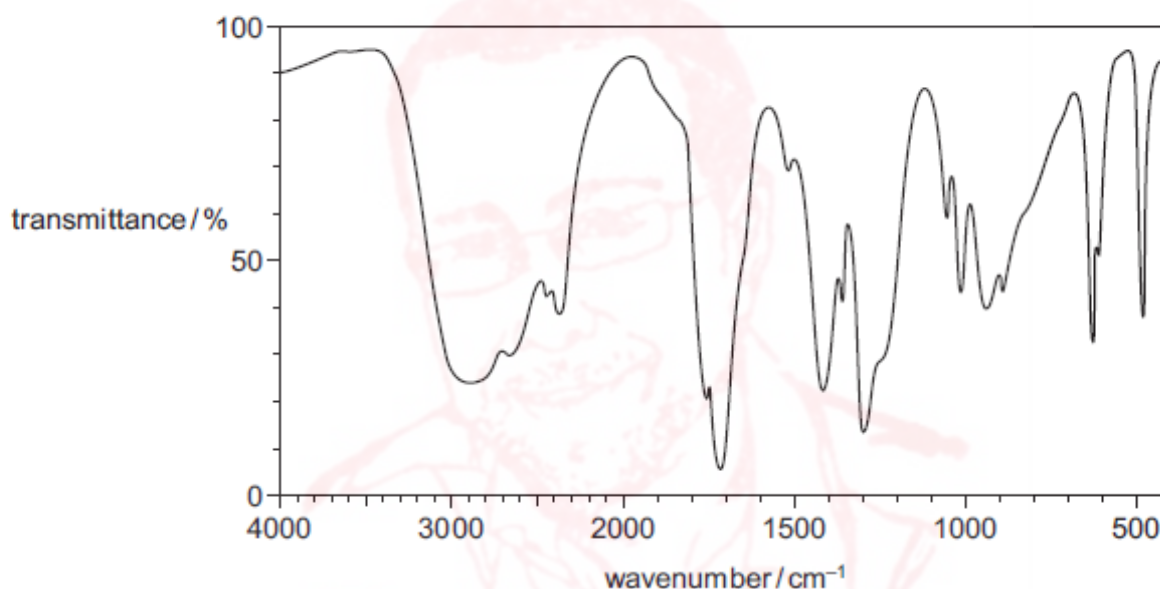


Which statements about compound R are correct?

- 1 It has an M_r of 116.
- 2 It contains two groups that show strong absorptions between 1640 and 1740 cm^{-1} in its infrared spectrum.
- 3 Its only infrared absorption between 2500 and 3000 cm^{-1} is sharp and strong.

Topic **Chem 22 Q# 1326**/ AS Chemistry/2020/s/TZ 1/Paper 1/Exam Q# 29//www.SmashingScience.org :o)

29 Compound X has the infra-red spectrum shown.



What could be the identity of compound X?

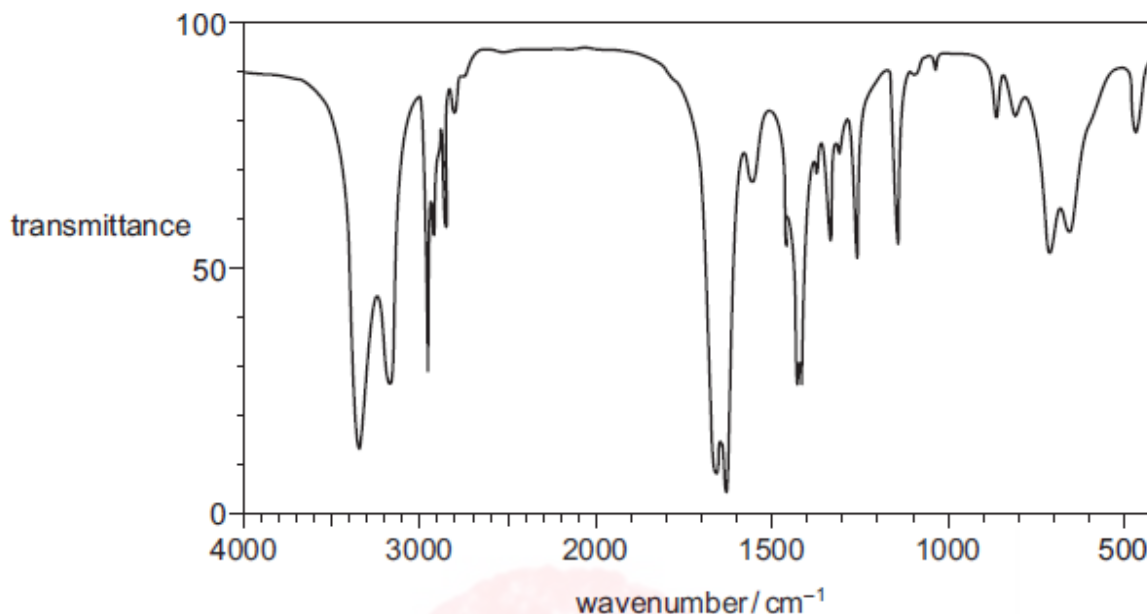
- A ethanoic acid
- B ethanol
- C ethylethanoate
- D propanone

Topic **Chem 22 Q# 1327**/ AS Chemistry/2020/m/TZ 2/Paper 1/Exam Q# 27//www.SmashingScience.org :o)

27 Which reaction would produce propanoic acid as one of its products?

- A heating $(\text{CH}_3)_2\text{C}=\text{CHCH}_2\text{CH}_3$ with concentrated, acidified KMnO_4
- B heating $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_2\text{CH}_3$ with NaOH(aq)
- C heating $\text{CH}_3\text{CH}_2\text{OH}$ with acidified $\text{K}_2\text{Cr}_2\text{O}_7$ under reflux
- D reacting CH_3CHO with HCN then heating the organic product with $\text{H}_2\text{SO}_4\text{(aq)}$

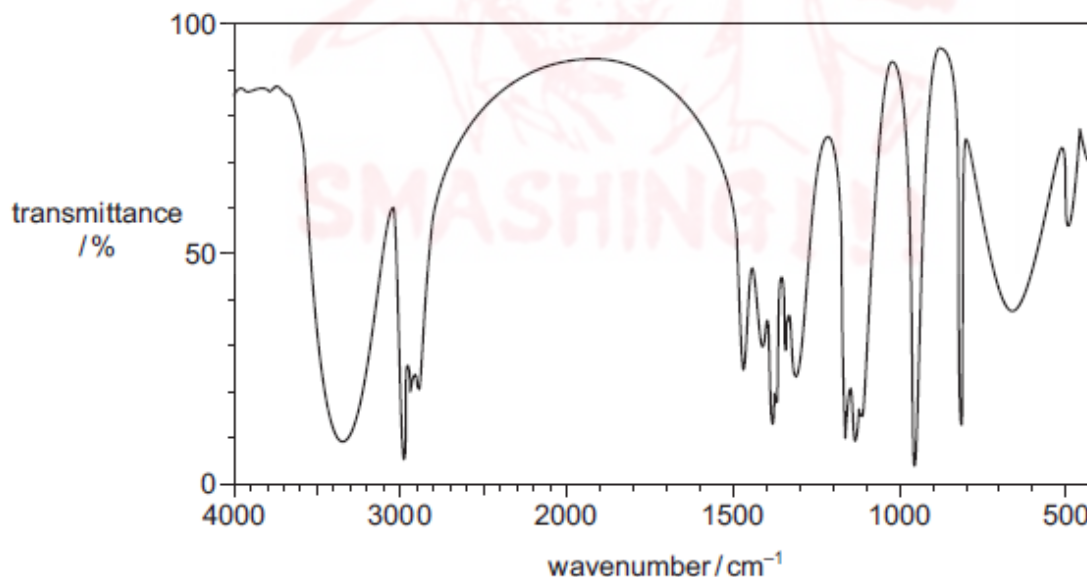
23 The infrared spectrum shown was obtained from a compound J.



Which statement about J is correct?

- A Both C=O and C≡N are present.
- B Neither C=O nor C≡N are present.
- C C=O is present but not C≡N.
- D C≡N is present but not C=O.

30 The infra-red spectrum of compound P is shown.

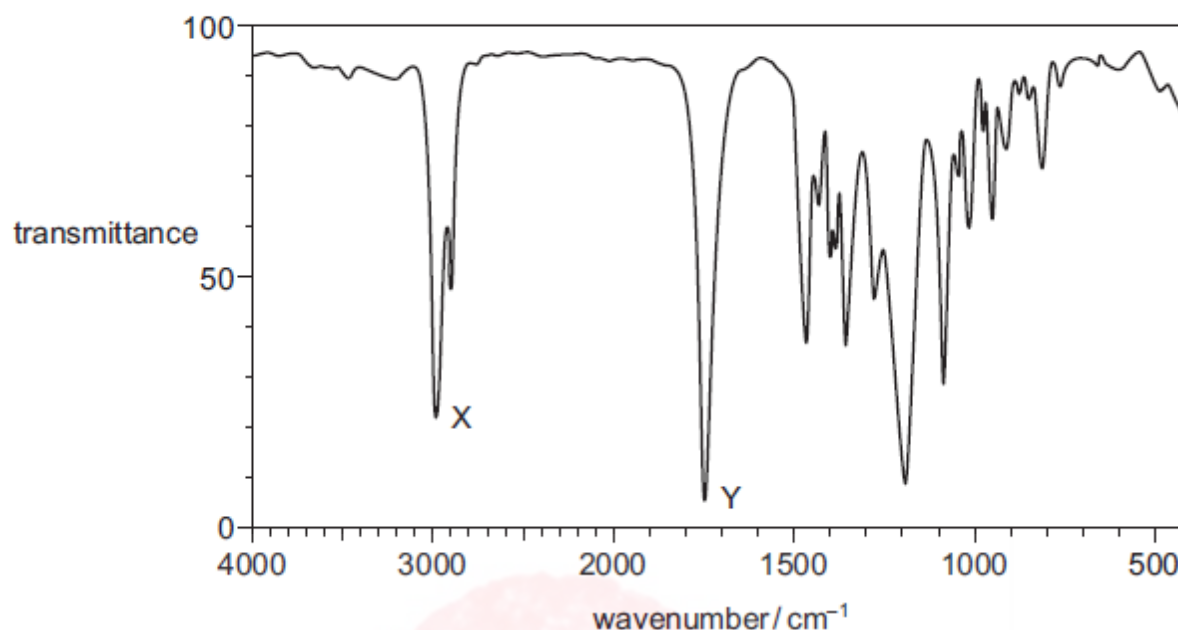


What could be compound P?

- A methyl ethanoate
- B propanal
- C propanoic acid
- D propan-2-ol



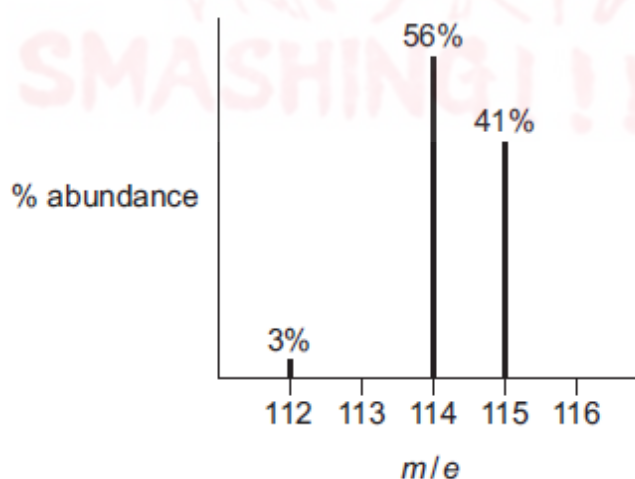
24 The infra-red spectrum of a substance with empirical formula C_2H_4O is shown.



Which bonds are responsible for peak X and peak Y?

	peak X	peak Y
A	C–H	C=C
B	C–H	C=O
C	O–H	C=C
D	O–H	C=O

2 A sample of element X is analysed using mass spectrometry. The mass spectrum obtained is shown.



What is the relative atomic mass of this sample of element X?

- A** 113.7 **B** 114.0 **C** 114.2 **D** 114.4

30 An infra-red spectrum shows a broad peak at 3000 cm^{-1} and a strong peak at 1710 cm^{-1} .

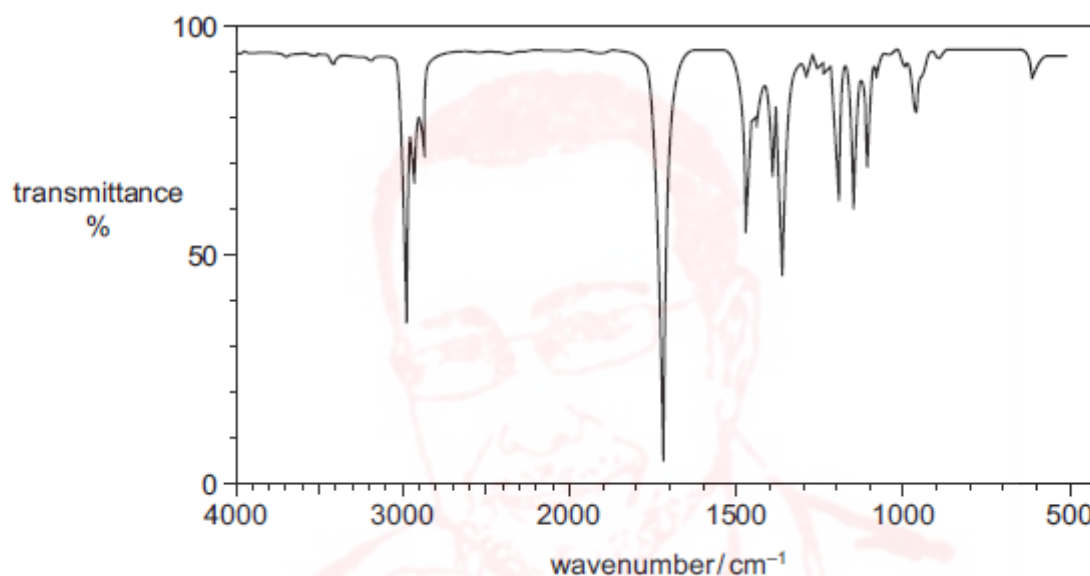
Which substance could have produced this spectrum?

- A methyl propanoate
- B propan-2-ol
- C propanoic acid
- D propanone

Topic **Chem 22 Q# 1333/** AS Chemistry/2018/w/TZ 1/Paper 1/Exam Q# 30//www.SmashingScience.org :o)

30 J is a branched-chain alcohol, $\text{C}_5\text{H}_{12}\text{O}$. J is heated under reflux with an excess of $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ until no further reaction occurs. An organic compound K is formed in good yield.

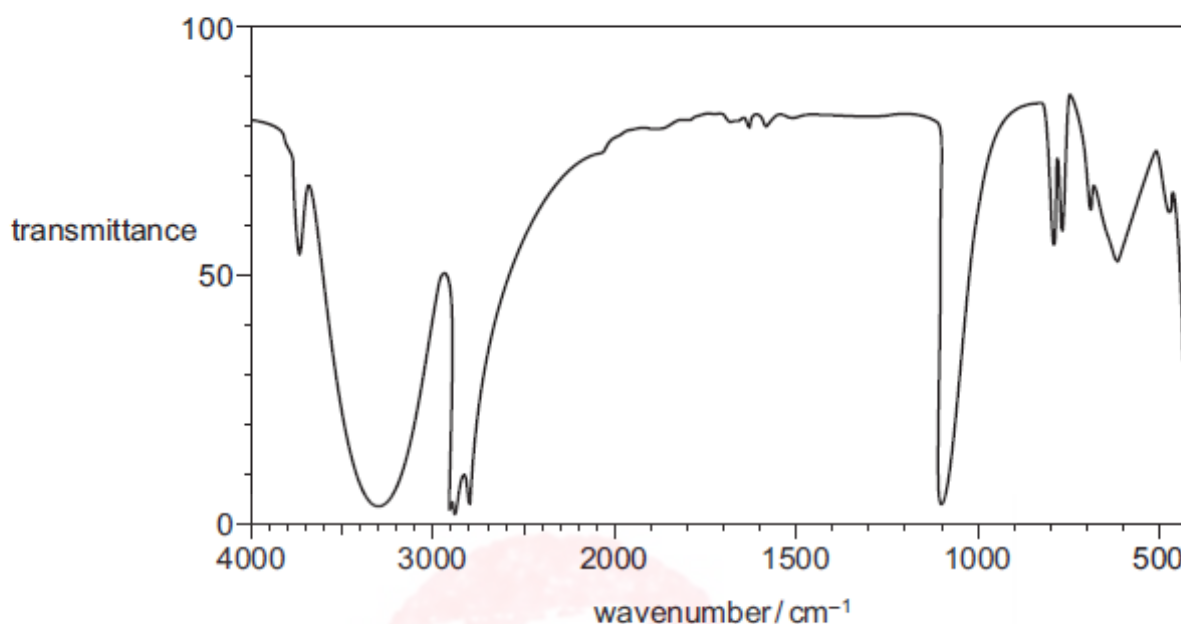
The infra-red spectrum of K is shown.



What are the structures of the branched-chain alcohol J and compound K?

	J	K
A	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CHO}$
B	$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
C	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{OH})\text{CH}_3$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{COCH}_3$
D	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$

30 Compound X contains three carbon atoms. Part of a simplified infra-red spectrum of compound X is shown.



Which compound could be X?

- A $\text{CH}_3\text{CH}_2\text{CHO}$
- B $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- D $\text{CH}_3\text{CO}_2\text{CH}_3$

30 How many **structural** isomers with the molecular formula $\text{C}_4\text{H}_{10}\text{O}$ give infra-red absorptions both at approximately 1200 cm^{-1} and at approximately 3400 cm^{-1} ?

- A 2
- B 4
- C 6
- D 7

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31 Beams of charged particles are deflected by an electric field. In identical conditions the angle of deflection of a particle is proportional to its charge / mass ratio.

In an experiment, protons are deflected by an angle of $+15^\circ$. In another experiment under identical conditions, particle Y is deflected by an angle of -5° .

What could be the composition of particle Y?

	protons	neutrons	electrons
1	1	2	2
2	3	3	5
3	4	5	1

Topic **Chem 22 Q# 1337**/ AS Chemistry/2016/w/TZ 1/Paper 1/Exam Q# 31//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31 A sample of boron contains aluminium as the only impurity. A mass spectrum of the mixture shows three lines corresponding to three ions, X^+ , Y^+ and Z^+ .

ion	X^+	Y^+	Z^+
m/e	10	11	27
percentage abundance	15.52	74.48	10.00

Which statements are correct?

- There are more electrons in Z^+ than in X^+ .
- The A_r of boron in the sample is 10.83 to four significant figures.
- There are more protons in Y^+ than in X^+ .

Paper 1 Mark Scheme

Q# 1/ Chem 1 AS/2022/w/TZ 1/P1/Exam Q# 4// :o)

4 | D

Q# 2/ Chem 1 AS/2022/w/TZ 1/P1/Exam Q# 3// :o)

4 | D

Q# 3/ Chem 3 AS/2022/s/TZ 1/P1/Exam Q# 2// :o)

2 | B

Q# 4/ Chem 1 AS/2022/s/TZ 1/P1/Exam Q# 1// :o)

1 | B

Q# 5/ Chem 1 AS/2022/m/TZ 2/P1/Exam Q# 2// :o)

2 | A

Q# 6/ Chem 1 AS/2022/m/TZ 2/P1/Exam Q# 1// :o)

1 | A

Q# 7/ Chem 1 AS/2021/w/TZ 1/P1/Exam Q# 4// :o)

4 | B

Q# 8/ Chem 1 AS/2021/w/TZ 1/P1/Exam Q# 3// :o)

3 | A

Q# 9/ Chem AS/2021/s/TZ 1/P1/Exam Q# 7// :o)

7 | C

Q# 10/ Chem 1 AS/2021/s/TZ 1/P1/Exam Q# 2// :o)

2 | C

Q# 11/ Chem 1 AS/2021/m/TZ 2/P1/Exam Q# 2// :o)

2 | D

Q# 12/ Chem 1 AS/2021/m/TZ 2/P1/Exam Q# 1// :o)

1 | A

Q# 13/ Chem 1 AS/2020/w/TZ 1/P1/Exam Q# 3// :o)

3 | C

Q# 14/ Chem 1 AS/2020/w/TZ 1/P1/Exam Q# 1// :o)

1 | C

Q# 15/ Chem 1 AS/2020/s/TZ 1/P1/Exam Q# 10// :o)

10 | A

Q# 16/ Chem 1 AS/2020/m/TZ 2/P1/Exam Q# 1// :o)

1 | A

Q# 17/ Chem 1 AS/2019/w/TZ 1/P1/Exam Q# 32// :o)

32 | D

Q# 18/ Chem 1 AS/2019/w/TZ 1/P1/Exam Q# 31// :o)

31 | A

Q# 19/ Chem 1 AS/2019/s/TZ 1/P1/Exam Q# 31// :o)

31 | B

Q# 20/ Chem 1 AS/2019/m/TZ 2/P1/Exam Q# 32// :o)

32 | A

Q# 21/ Chem 1 AS/2019/m/TZ 2/P1/Exam Q# 3// :o)

3 | D

Q# 22/ Chem 1 AS/2018/w/TZ 1/P1/Exam Q# 31// :o)

31 | A

Q# 23/ Chem 1 AS/2018/w/TZ 1/P1/Exam Q# 1// :o)

1 | D

Q# 24/ Chem 1 AS/2018/s/TZ 1/P1/Exam Q# 10// :o)

10 | D

Q# 25/ Chem 1 AS/2018/s/TZ 1/P1/Exam Q# 1// :o)

1 | A

Q# 26/ Chem 1 AS/2018/m/TZ 2/P1/Exam Q# 4// :o)

4 | C

Q# 27/ Chem 1 AS/2018/m/TZ 2/P1/Exam Q# 3// :o)

3 | C

Q# 28/ Chem 1 AS/2018/m/TZ 2/P1/Exam Q# 2// :o)

2 | A

Q# 29/ Chem 1 AS/2017/w/TZ 1/P1/Exam Q# 2// :o)

2 | A

Q# 30/ Chem 1 AS/2017/s/TZ 1/P1/Exam Q# 4// :o)

4 | C

Q# 31/ Chem 1 AS/2017/s/TZ 1/P1/Exam Q# 12// :o)

12 | A

Q# 32/ Chem 1 AS/2017/m/TZ 2/P1/Exam Q# 1// :o)

1 | C

Q# 33/ Chem 1 AS/2016/w/TZ 1/P1/Exam Q# 5// :o)

5 | C

Q# 34/ Chem 1 AS/2016/w/TZ 1/P1/Exam Q# 4// :o)

4 | B

Q# 35/ Chem 1 AS/2016/w/TZ 1/P1/Exam Q# 13// :o)

13 | C

Q# 36/ Chem 1 AS/2016/s/TZ 1/P1/Exam Q# 4// :o)

4 | A

Q# 37/ Chem 1 AS/2016/s/TZ 1/P1/Exam Q# 31// :o)

31 | A

Q# 38/ Chem 1 AS/2016/m/TZ 2/P1/Exam Q# 4// :o)

4 | D

Q# 39/ Chem 1 AS/2016/m/TZ 2/P1/Exam Q# 3// :o)

3 | D

Q# 40/ Chem 1 AS/2016/m/TZ 2/P1/Exam Q# 2// :o)

2 | D

Q# 41/ Chem 1 AS/2015/w/TZ 1/P1/Exam Q# 31// :o)

31 | C

Q# 42/ Chem 1 AS/2015/w/TZ 1/P1/Exam Q# 1// :o)

1 | C

Q# 43/ Chem 1 AS/2015/s/TZ 1/P1/Exam Q# 31// :o)

31 | A

Q# 44/ Chem 1 AS/2014/w/TZ 1/P1/Exam Q# 31// :o)

31 | A

Q# 45/ Chem 1 AS/2014/s/TZ 1/P1/Exam Q# 1// :o)

1 | B

Q# 46/ Chem 1 AS/2013/w/TZ 1/P1/Exam Q# 4// :o)

4 | C

Q# 47/ Chem 1 AS/2013/w/TZ 1/P1/Exam Q# 31// :o)

31 | A

Q# 48/ Chem 1 AS/2013/s/TZ 1/P1/Exam Q# 5// :o)

5 | D

Q# 49/ Chem 1 AS/2013/s/TZ 1/P1/Exam Q# 31// :o)

31 | D



Q# 50/ Chem 1 AS/2012/w/TZ 1/P1/Exam Q# 9// :o)

9 A

Q# 51/ Chem 1 AS/2012/w/TZ 1/P1/Exam Q# 32// :o)

32 A

Q# 52/ Chem 1 AS/2012/w/TZ 1/P1/Exam Q# 2// :o)

2 C

Q# 53/ Chem 1 AS/2012/w/TZ 1/P1/Exam Q# 13// :o)

13 A

Q# 54/ Chem 1 AS/2012/s/TZ 1/P1/Exam Q# 4// :o)

4 B

Q# 55/ Chem 1 AS/2012/s/TZ 1/P1/Exam Q# 32// :o)

32 B

Q# 56/ Chem 1 AS/2011/w/TZ 1/P1/Exam Q# 3// :o)

3 D

Q# 57/ Chem 1 AS/2011/s/TZ 1/P1/Exam Q# 1// :o)

1 B

Q# 58/ Chem 1 AS/2010/w/TZ 1/P1/Exam Q# 6// :o)

6 D

Q# 59/ Chem 1 AS/2010/w/TZ 1/P1/Exam Q# 3// :o)

3 B

Q# 60/ Chem 1 AS/2010/w/TZ 1/P1/Exam Q# 2// :o)

2 B

Q# 61/ Chem 1 AS/2010/s/TZ 1/P1/Exam Q# 1// :o)

1 C

Q# 62/ Chem 1 AS/2009/w/TZ 1/P1/Exam Q# 1// :o)

1 B

Q# 63/ Chem 1 AS/2009/s/TZ 1/P1/Exam Q# 4// :o)

4 D

Q# 64/ Chem 1 AS/2009/s/TZ 1/P1/Exam Q# 31// :o)

31 D

Q# 65/ Chem 1 AS/2009/s/TZ 1/P1/Exam Q# 3// :o)

3 C

Q# 66/ Chem 1 AS/2009/s/TZ 1/P1/Exam Q# 12// :o)

12 D

Q# 67/ Chem 2 AS/2022/w/TZ 1/P1/Exam Q# 2// :o)

2 C

Q# 68/ Chem 2 AS/2022/w/TZ 1/P1/Exam Q# 1// :o)

1 A

Q# 69/ Chem 2 AS/2022/s/TZ 1/P1/Exam Q# 4// :o)

4 D

Q# 70/ Chem 2 AS/2022/s/TZ 1/P1/Exam Q# 16// :o)

16 C

Q# 71/ Chem 2 AS/2022/m/TZ 2/P1/Exam Q# 3// :o)

3 C

Q# 72/ Chem 2 AS/2022/m/TZ 2/P1/Exam Q# 14// :o)

14 D

Q# 73/ Chem 2 AS/2021/w/TZ 1/P1/Exam Q# 2// :o)

2 C

Q# 74/ Chem 2 AS/2021/m/TZ 2/P1/Exam Q# 4// :o)

4 B

Q# 75/ Chem 2 AS/2021/m/TZ 2/P1/Exam Q# 3// :o)

3 A

Q# 76/ Chem 2 AS/2020/w/TZ 1/P1/Exam Q# 2// :o)

2 B

Q# 77/ Chem 2 AS/2020/s/TZ 1/P1/Exam Q# 13// :o)

13 D

Q# 78/ Chem 2 AS/2020/s/TZ 1/P1/Exam Q# 11// :o)

11 C

Q# 79/ Chem 2 AS/2020/m/TZ 2/P1/Exam Q# 7// :o)

7 B

Q# 80/ Chem 2 AS/2019/w/TZ 1/P1/Exam Q# 2// :o)

2 C

Q# 81/ Chem 2 AS/2019/s/TZ 1/P1/Exam Q# 3// :o)

3 C

Q# 82/ Chem 2 AS/2019/s/TZ 1/P1/Exam Q# 12// :o)

12 D

Q# 83/ Chem 2 AS/2019/m/TZ 2/P1/Exam Q# 2// :o)

2 A

Q# 84/ Chem 2 AS/2018/w/TZ 1/P1/Exam Q# 3// :o)

3 A

Q# 85/ Chem 2 AS/2018/s/TZ 1/P1/Exam Q# 3// :o)

3 C

Q# 86/ Chem 2 AS/2018/m/TZ 2/P1/Exam Q# 5// :o)

5 C

Q# 87/ Chem 2 AS/2018/m/TZ 2/P1/Exam Q# 31// :o)

31 D

Q# 88/ Chem 2 AS/2017/w/TZ 1/P1/Exam Q# 32// :o)

32 B

Q# 89/ Chem 2 AS/2017/w/TZ 1/P1/Exam Q# 16// :o)

16 D

Q# 90/ Chem 2 AS/2017/w/TZ 1/P1/Exam Q# 1// :o)

1 A

Q# 91/ Chem 2 AS/2017/s/TZ 1/P1/Exam Q# 3// :o)

3 A

Q# 92/ Chem 2 AS/2017/s/TZ 1/P1/Exam Q# 2// :o)

2 D

Q# 93/ Chem 2 AS/2017/m/TZ 2/P1/Exam Q# 2// :o)

2 B

Q# 94/ Chem 2 AS/2016/w/TZ 1/P1/Exam Q# 12// :o)

12 D

Q# 95/ Chem 2 AS/2016/s/TZ 1/P1/Exam Q# 3// :o)

3 C

Q# 96/ Chem 2 AS/2015/w/TZ 1/P1/Exam Q# 3// :o)

3 B

Q# 97/ Chem 2 AS/2014/w/TZ 1/P1/Exam Q# 6// :o)

6 A

Q# 98/ Chem 2 AS/2013/w/TZ 1/P1/Exam Q# 8// :o)

8 D



Q# 99/ Chem 2 AS/2013/w/TZ 1/P1/Exam Q# 10// :o)
10 | D

Q# 100/ Chem 2 AS/2012/w/TZ 1/P1/Exam Q# 17// :o)
17 | D

Q# 101/ Chem 2 AS/2012/s/TZ 1/P1/Exam Q# 14// :o)
14 | B

Q# 102/ Chem 2 AS/2011/s/TZ 1/P1/Exam Q# 33// :o)
33 | D

Q# 103/ Chem 2 AS/2010/w/TZ 1/P1/Exam Q# 5// :o)
5 | A

Q# 104/ Chem 2 AS/2010/w/TZ 1/P1/Exam Q# 12// :o)
12 | C

Q# 105/ Chem 2 AS/2010/s/TZ 1/P1/Exam Q# 9// :o)
9 | C

Q# 106/ Chem 2 AS/2010/s/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 107/ Chem 2 AS/2009/w/TZ 1/P1/Exam Q# 2// :o)
2 | D

Q# 108/ Chem 2 AS/2009/s/TZ 1/P1/Exam Q# 2// :o)
2 | D

Q# 109/ Chem 2 AS/2009/s/TZ 1/P1/Exam Q# 1// :o)
1 | D

Q# 110/ Chem 3 AS/2022/w/TZ 1/P1/Exam Q# 6// :o)
6 | B

Q# 111/ Chem 3 AS/2022/w/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 112/ Chem 3 AS/2022/s/TZ 1/P1/Exam Q# 8// :o)
8 | A

Q# 113/ Chem 3 AS/2022/m/TZ 2/P1/Exam Q# 7// :o)
7 | C

Q# 114/ Chem 3 AS/2022/m/TZ 2/P1/Exam Q# 6// :o)
6 | B

Q# 115/ Chem 3 AS/2022/m/TZ 2/P1/Exam Q# 5// :o)
5 | B

Q# 116/ Chem 3 AS/2022/m/TZ 2/P1/Exam Q# 4// :o)
4 | D

Q# 117/ Chem 3 AS/2022/m/TZ 2/P1/Exam Q# 25// :o)
25 | D

Q# 118/ Chem 3 AS/2021/w/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 119/ Chem 3 AS/2021/w/TZ 1/P1/Exam Q# 35// :o)
35 | D

Q# 120/ Chem 3 AS/2021/w/TZ 1/P1/Exam Q# 34// :o)
34 | B

Q# 121/ Chem 3 AS/2021/w/TZ 1/P1/Exam Q# 18// :o)
18 | A

Q# 122/ Chem 3 AS/2021/s/TZ 1/P1/Exam Q# 34// :o)
34 | B

Q# 123/ Chem 3 AS/2021/s/TZ 1/P1/Exam Q# 3// :o)
3 | B

Q# 124/ Chem 3 AS/2021/m/TZ 2/P1/Exam Q# 5// :o)
5 | C

Q# 125/ Chem 3 AS/2021/m/TZ 2/P1/Exam Q# 34// :o)
34 | A

Q# 126/ Chem 3 AS/2020/w/TZ 1/P1/Exam Q# 5// :o)
5 | B

Q# 127/ Chem 3 AS/2020/w/TZ 1/P1/Exam Q# 4// :o)
4 | A

Q# 128/ Chem 3 AS/2020/s/TZ 1/P1/Exam Q# 32// :o)
32 | A

Q# 129/ Chem 3 AS/2020/s/TZ 1/P1/Exam Q# 19// :o)
19 | A

Q# 130/ Chem 3 AS/2020/m/TZ 2/P1/Exam Q# 8// :o)
8 | C

Q# 131/ Chem 3 AS/2020/m/TZ 2/P1/Exam Q# 32// :o)
32 | A

Q# 132/ Chem 3 AS/2020/m/TZ 2/P1/Exam Q# 3// :o)
3 | A

Q# 133/ Chem 3 AS/2019/w/TZ 1/P1/Exam Q# 4// :o)
4 | B

Q# 134/ Chem 3 AS/2019/w/TZ 1/P1/Exam Q# 3// :o)
3 | D

Q# 135/ Chem 3 AS/2019/s/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 136/ Chem 3 AS/2019/s/TZ 1/P1/Exam Q# 4// :o)
4 | A

Q# 137/ Chem 3 AS/2019/s/TZ 1/P1/Exam Q# 32// :o)
32 | D

Q# 138/ Chem 3 AS/2019/m/TZ 2/P1/Exam Q# 5// :o)
5 | B

Q# 139/ Chem 3 AS/2019/m/TZ 2/P1/Exam Q# 4// :o)
4 | C

Q# 140/ Chem 3 AS/2019/m/TZ 2/P1/Exam Q# 36// :o)
36 | A

Q# 141/ Chem 3 AS/2018/w/TZ 1/P1/Exam Q# 32// :o)
32 | D

Q# 142/ Chem 3 AS/2018/s/TZ 1/P1/Exam Q# 6// :o)
6 | A

Q# 143/ Chem 3 AS/2018/s/TZ 1/P1/Exam Q# 5// :o)
5 | D

Q# 144/ Chem 3 AS/2018/s/TZ 1/P1/Exam Q# 2// :o)
2 | D

Q# 145/ Chem 3 AS/2018/m/TZ 2/P1/Exam Q# 1// :o)
1 | D

Q# 146/ Chem 3 AS/2017/s/TZ 1/P1/Exam Q# 5// :o)
5 | B

Q# 147/ Chem 3 AS/2017/s/TZ 1/P1/Exam Q# 1// :o)
1 | C



Q# 148/ Chem 3 AS/2017/m/TZ 2/P1/Exam Q# 5// :o)

5 | C

Q# 149/ Chem 3 AS/2017/m/TZ 2/P1/Exam Q# 4// :o)

4 | C

Q# 150/ Chem 3 AS/2016/w/TZ 1/P1/Exam Q# 6// :o)

6 | A

Q# 151/ Chem 3 AS/2016/w/TZ 1/P1/Exam Q# 32// :o)

32 | A

Q# 152/ Chem 3 AS/2016/s/TZ 1/P1/Exam Q# 7// :o)

7 | C

Q# 153/ Chem 3 AS/2016/s/TZ 1/P1/Exam Q# 5// :o)

5 | C

Q# 154/ Chem 3 AS/2016/s/TZ 1/P1/Exam Q# 2// :o)

2 | B

Q# 155/ Chem 3 AS/2016/m/TZ 2/P1/Exam Q# 6// :o)

6 | C

Q# 156/ Chem 3 AS/2016/m/TZ 2/P1/Exam Q# 31// :o)

31 | B

Q# 157/ Chem 3 AS/2016/m/TZ 2/P1/Exam Q# 15// :o)

15 | A

Q# 158/ Chem 3 AS/2015/w/TZ 1/P1/Exam Q# 4// :o)

4 | A

Q# 159/ Chem 3 AS/2015/s/TZ 1/P1/Exam Q# 32// :o)

32 | D

Q# 160/ Chem 3 AS/2014/w/TZ 1/P1/Exam Q# 5// :o)

5 | B

Q# 161/ Chem 3 AS/2014/s/TZ 1/P1/Exam Q# 6// :o)

6 | C

Q# 162/ Chem 3 AS/2014/s/TZ 1/P1/Exam Q# 32// :o)

32 | D

Q# 163/ Chem 3 AS/2014/s/TZ 1/P1/Exam Q# 31// :o)

31 | C

Q# 164/ Chem 3 AS/2014/s/TZ 1/P1/Exam Q# 14// :o)

14 | B

Q# 165/ Chem 3 AS/2013/w/TZ 1/P1/Exam Q# 35// :o)

35 | A

Q# 166/ Chem 3 AS/2013/w/TZ 1/P1/Exam Q# 32// :o)

32 | C

Q# 167/ Chem 3 AS/2013/s/TZ 1/P1/Exam Q# 33// :o)

33 | B

Q# 168/ Chem 3 AS/2013/s/TZ 1/P1/Exam Q# 32// :o)

32 | B

Q# 169/ Chem 3 AS/2012/w/TZ 1/P1/Exam Q# 31// :o)

31 | B

Q# 170/ Chem 3 AS/2012/w/TZ 1/P1/Exam Q# 3// :o)

3 | D

Q# 171/ Chem 3 AS/2012/w/TZ 1/P1/Exam Q# 12// :o)

12 | B

Q# 172/ Chem 3 AS/2012/s/TZ 1/P1/Exam Q# 33// :o)

33 | D

Q# 173/ Chem 3 AS/2012/s/TZ 1/P1/Exam Q# 1// :o)

1 | A

Q# 174/ Chem 3 AS/2011/w/TZ 1/P1/Exam Q# 4// :o)

4 | C

Q# 175/ Chem 3 AS/2011/w/TZ 1/P1/Exam Q# 32// :o)

32 | D

Q# 176/ Chem 3 AS/2011/w/TZ 1/P1/Exam Q# 13// :o)

13 | A

Q# 177/ Chem 3 AS/2011/s/TZ 1/P1/Exam Q# 32// :o)

32 | B

Q# 178/ Chem 3 AS/2011/s/TZ 1/P1/Exam Q# 11// :o)

11 | C

Q# 179/ Chem 3 AS/2010/w/TZ 1/P1/Exam Q# 7// :o)

7 | C

Q# 180/ Chem 3 AS/2010/w/TZ 1/P1/Exam Q# 33// :o)

33 | A

Q# 181/ Chem 3 AS/2009/w/TZ 1/P1/Exam Q# 5// :o)

5 | B

Q# 182/ Chem 3 AS/2009/w/TZ 1/P1/Exam Q# 4// :o)

4 | C

Q# 183/ Chem 3 AS/2009/w/TZ 1/P1/Exam Q# 32// :o)

32 | B

Q# 184/ Chem 3 AS/2009/s/TZ 1/P1/Exam Q# 5// :o)

5 | C

Q# 185/ Chem 4 AS/2022/w/TZ 1/P1/Exam Q# 7// :o)

7 | A

Q# 186/ Chem 4 AS/2022/s/TZ 1/P1/Exam Q# 7// :o)

7 | A

Q# 187/ Chem 4 AS/2021/w/TZ 1/P1/Exam Q# 6// :o)

6 | D

Q# 188/ Chem 4 AS/2021/w/TZ 1/P1/Exam Q# 33// :o)

33 | A

Q# 189/ Chem 4 AS/2021/s/TZ 1/P1/Exam Q# 8// :o)

8 | A

Q# 190/ Chem 4 AS/2021/m/TZ 2/P1/Exam Q# 6// :o)

6 | D

Q# 191/ Chem 4 AS/2021/m/TZ 2/P1/Exam Q# 33// :o)

33 | C

Q# 192/ Chem 4 AS/2020/s/TZ 1/P1/Exam Q# 9// :o)

9 | D

Q# 193/ Chem 4 AS/2020/s/TZ 1/P1/Exam Q# 4// :o)

4 | D

Q# 194/ Chem 4 AS/2020/s/TZ 1/P1/Exam Q# 33// :o)

33 | D

Q# 195/ Chem 4 AS/2020/m/TZ 2/P1/Exam Q# 9// :o)

9 | B

Q# 196/ Chem 4 AS/2019/s/TZ 1/P1/Exam Q# 7// :o)

7 | B

Q# 197/ Chem 4 AS/2019/s/TZ 1/P1/Exam Q# 6// :o)

6 | A

Q# 198/ Chem 4 AS/2019/m/TZ 2/P1/Exam Q# 7// :o)

7 | B

Q# 199/ Chem 4 AS/2019/m/TZ 2/P1/Exam Q# 6// :o)

6 | B



Q# 200/ Chem 4 AS/2018/w/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 201/ Chem 4 AS/2018/w/TZ 1/P1/Exam Q# 2// :o)
2 | A

Q# 202/ Chem 4 AS/2018/s/TZ 1/P1/Exam Q# 32// :o)
32 | B

Q# 203/ Chem 4 AS/2018/m/TZ 2/P1/Exam Q# 7// :o)
7 | C

Q# 204/ Chem 4 AS/2017/w/TZ 1/P1/Exam Q# 5// :o)
5 | B

Q# 205/ Chem 4 AS/2017/w/TZ 1/P1/Exam Q# 4// :o)
4 | C

Q# 206/ Chem 4 AS/2017/m/TZ 2/P1/Exam Q# 6// :o)
6 | B

Q# 207/ Chem 4 AS/2017/m/TZ 2/P1/Exam Q# 32// :o)
32 | D

Q# 208/ Chem 4 AS/2016/w/TZ 1/P1/Exam Q# 7// :o)
7 | D

Q# 209/ Chem 4 AS/2016/w/TZ 1/P1/Exam Q# 2// :o)
2 | D

Q# 210/ Chem 4 AS/2016/s/TZ 1/P1/Exam Q# 32// :o)
32 | A

Q# 211/ Chem 4 AS/2016/m/TZ 2/P1/Exam Q# 9// :o)
9 | C

Q# 212/ Chem 4 AS/2016/m/TZ 2/P1/Exam Q# 8// :o)
8 | A

Q# 213/ Chem 4 AS/2016/m/TZ 2/P1/Exam Q# 7// :o)
7 | C

Q# 214/ Chem 4 AS/2015/w/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 215/ Chem 4 AS/2015/s/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 216/ Chem 4 AS/2014/w/TZ 1/P1/Exam Q# 4// :o)
4 | A

Q# 217/ Chem 4 AS/2014/w/TZ 1/P1/Exam Q# 34// :o)
34 | C

Q# 218/ Chem 4 AS/2014/s/TZ 1/P1/Exam Q# 4// :o)
4 | D

Q# 219/ Chem 4 AS/2014/s/TZ 1/P1/Exam Q# 2// :o)
2 | B

Q# 220/ Chem 4 AS/2013/s/TZ 1/P1/Exam Q# 9// :o)
9 | A

Q# 221/ Chem 4 AS/2013/s/TZ 1/P1/Exam Q# 10// :o)
10 | C

Q# 222/ Chem 4 AS/2012/w/TZ 1/P1/Exam Q# 8// :o)
8 | C

Q# 223/ Chem 4 AS/2012/w/TZ 1/P1/Exam Q# 6// :o)
6 | D

Q# 224/ Chem 4 AS/2012/s/TZ 1/P1/Exam Q# 8// :o)
8 | B

Q# 225/ Chem 4 AS/2012/s/TZ 1/P1/Exam Q# 6// :o)
6 | B

Q# 226/ Chem 4 AS/2012/s/TZ 1/P1/Exam Q# 31// :o)
31 | B

Q# 227/ Chem 4 AS/2011/w/TZ 1/P1/Exam Q# 5// :o)
5 | B

Q# 228/ Chem 4 AS/2011/s/TZ 1/P1/Exam Q# 10// :o)
10 | C

Q# 229/ Chem 4 AS/2010/s/TZ 1/P1/Exam Q# 31// :o)
31 | B

Q# 230/ Chem 4 AS/2010/s/TZ 1/P1/Exam Q# 3// :o)
3 | C

Q# 231/ Chem 4 AS/2009/s/TZ 1/P1/Exam Q# 7// :o)
7 | C

Q# 232/ Chem 4 AS/2009/s/TZ 1/P1/Exam Q# 32// :o)
32 | A

Q# 233/ Chem 5 AS/2022/w/TZ 1/P1/Exam Q# 9// :o)
9 | C

Q# 234/ Chem 5 AS/2022/w/TZ 1/P1/Exam Q# 10// :o)
10 | B

Q# 235/ Chem 5 AS/2022/s/TZ 1/P1/Exam Q# 9// :o)
9 | D

Q# 236/ Chem 5 AS/2022/s/TZ 1/P1/Exam Q# 10// :o)
10 | C

Q# 237/ Chem 5 AS/2022/m/TZ 2/P1/Exam Q# 9// :o)
9 | A

Q# 238/ Chem 5 AS/2022/m/TZ 2/P1/Exam Q# 8// :o)
8 | D

Q# 239/ Chem 5 AS/2021/w/TZ 1/P1/Exam Q# 8// :o)
8 | C

Q# 240/ Chem 5 AS/2021/w/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 241/ Chem 5 AS/2021/s/TZ 1/P1/Exam Q# 4// :o)
4 | D

Q# 242/ Chem 5 AS/2021/s/TZ 1/P1/Exam Q# 32// :o)
32 | A

Q# 243/ Chem 5 AS/2021/m/TZ 2/P1/Exam Q# 7// :o)
7 | A

Q# 244/ Chem 5 AS/2021/m/TZ 2/P1/Exam Q# 32// :o)
32 | B

Q# 245/ Chem 5 AS/2020/w/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 246/ Chem 5 AS/2020/w/TZ 1/P1/Exam Q# 6// :o)
6 | C

Q# 247/ Chem 5 AS/2020/w/TZ 1/P1/Exam Q# 32// :o)
32 | D

Q# 248/ Chem 5 AS/2020/w/TZ 1/P1/Exam Q# 31// :o)
31 | A

Q# 249/ Chem 5 AS/2020/s/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 250/ Chem 5 AS/2020/m/TZ 2/P1/Exam Q# 4// :o)
4 | C



Q# 251/ Chem 5 AS/2020/m/TZ 2/P1/Exam Q# 33// :o)
33 | D

Q# 252/ Chem 5 AS/2019/w/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 253/ Chem 5 AS/2019/w/TZ 1/P1/Exam Q# 7// :o)
7 | A

Q# 254/ Chem 5 AS/2019/s/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 255/ Chem 5 AS/2019/s/TZ 1/P1/Exam Q# 33// :o)
33 | A

Q# 256/ Chem 5 AS/2019/m/TZ 2/P1/Exam Q# 9// :o)
9 | D

Q# 257/ Chem 5 AS/2019/m/TZ 2/P1/Exam Q# 8// :o)
8 | C

Q# 258/ Chem 5 AS/2018/w/TZ 1/P1/Exam Q# 6// :o)
6 | C

Q# 259/ Chem 5 AS/2018/w/TZ 1/P1/Exam Q# 33// :o)
33 | B

Q# 260/ Chem 5 AS/2018/s/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 261/ Chem 5 AS/2018/s/TZ 1/P1/Exam Q# 33// :o)
33 | D

Q# 262/ Chem 5 AS/2018/m/TZ 2/P1/Exam Q# 9// :o)
9 | B

Q# 263/ Chem 5 AS/2018/m/TZ 2/P1/Exam Q# 8// :o)
8 | B

Q# 264/ Chem 5 AS/2017/w/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 265/ Chem 5 AS/2017/w/TZ 1/P1/Exam Q# 11// :o)
11 | C

Q# 266/ Chem 5 AS/2017/s/TZ 1/P1/Exam Q# 7// :o)
7 | D

Q# 267/ Chem 5 AS/2017/s/TZ 1/P1/Exam Q# 33// :o)
33 | D

Q# 268/ Chem 5 AS/2017/m/TZ 2/P1/Exam Q# 9// :o)
9 | C

Q# 269/ Chem 5 AS/2017/m/TZ 2/P1/Exam Q# 7// :o)
7 | B

Q# 270/ Chem 5 AS/2016/w/TZ 1/P1/Exam Q# 8// :o)
8 | C

Q# 271/ Chem 5 AS/2016/w/TZ 1/P1/Exam Q# 33// :o)
33 | B

Q# 272/ Chem 5 AS/2016/w/TZ 1/P1/Exam Q# 15// :o)
15 | C

Q# 273/ Chem 5 AS/2016/s/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 274/ Chem 5 AS/2016/m/TZ 2/P1/Exam Q# 5// :o)
5 | D

Q# 275/ Chem 5 AS/2016/m/TZ 2/P1/Exam Q# 32// :o)
32 | D

Q# 276/ Chem 5 AS/2016/m/TZ 2/P1/Exam Q# 10// :o)
10 | A

Q# 277/ Chem 5 AS/2015/w/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 278/ Chem 5 AS/2015/w/TZ 1/P1/Exam Q# 6// :o)
6 | D

Q# 279/ Chem 5 AS/2015/s/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 280/ Chem 5 AS/2015/s/TZ 1/P1/Exam Q# 11// :o)
11 | B

Q# 281/ Chem 5 AS/2014/w/TZ 1/P1/Exam Q# 8// :o)
8 | A

Q# 282/ Chem 5 AS/2014/w/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 283/ Chem 5 AS/2014/w/TZ 1/P1/Exam Q# 32// :o)
32 | C

Q# 284/ Chem 5 AS/2014/w/TZ 1/P1/Exam Q# 3// :o)
3 | B

Q# 285/ Chem 5 AS/2014/s/TZ 1/P1/Exam Q# 5// :o)
5 | B

Q# 286/ Chem 5 AS/2014/s/TZ 1/P1/Exam Q# 3// :o)
3 | D

Q# 287/ Chem 5 AS/2013/w/TZ 1/P1/Exam Q# 11// :o)
11 | B

Q# 288/ Chem 5 AS/2013/s/TZ 1/P1/Exam Q# 7// :o)
7 | A

Q# 289/ Chem 5 AS/2013/s/TZ 1/P1/Exam Q# 12// :o)
12 | D

Q# 290/ Chem 5 AS/2012/w/TZ 1/P1/Exam Q# 4// :o)
4 | A

Q# 291/ Chem 5 AS/2012/w/TZ 1/P1/Exam Q# 11// :o)
11 | A

Q# 292/ Chem 5 AS/2012/w/TZ 1/P1/Exam Q# 10// :o)
10 | C

Q# 293/ Chem 5 AS/2012/s/TZ 1/P1/Exam Q# 7// :o)
7 | C

Q# 294/ Chem 5 AS/2012/s/TZ 1/P1/Exam Q# 3// :o)
3 | D

Q# 295/ Chem 5 AS/2011/w/TZ 1/P1/Exam Q# 6// :o)
6 | C

Q# 296/ Chem 5 AS/2011/w/TZ 1/P1/Exam Q# 19// :o)
19 | A

Q# 297/ Chem 5 AS/2011/s/TZ 1/P1/Exam Q# 9// :o)
9 | C

Q# 298/ Chem 5 AS/2011/s/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 299/ Chem 5 AS/2010/w/TZ 1/P1/Exam Q# 9// :o)
9 | B

Q# 300/ Chem 5 AS/2010/w/TZ 1/P1/Exam Q# 8// :o)
8 | B

Q# 301/ Chem 5 AS/2010/s/TZ 1/P1/Exam Q# 5// :o)
5 | B



Q# 302/ Chem 5 AS/2010/s/TZ 1/P1/Exam Q# 4// :o)
4 C

Q# 303/ Chem 5 AS/2009/w/TZ 1/P1/Exam Q# 6// :o)
6 C

Q# 304/ Chem 5 AS/2009/s/TZ 1/P1/Exam Q# 8// :o)
8 C

Q# 305/ Chem 5 AS/2009/s/TZ 1/P1/Exam Q# 33// :o)
33 D

Q# 306/ Chem 6 AS/2022/w/TZ 1/P1/Exam Q# 12// :o)
12 B

Q# 307/ Chem 6 AS/2022/w/TZ 1/P1/Exam Q# 11// :o)
11 C

Q# 308/ Chem 6 AS/2022/s/TZ 1/P1/Exam Q# 17// :o)
17 A

Q# 309/ Chem 6 AS/2022/s/TZ 1/P1/Exam Q# 12// :o)
12 C

Q# 310/ Chem 6 AS/2022/s/TZ 1/P1/Exam Q# 11// :o)
11 B

Q# 311/ Chem 6 AS/2022/m/TZ 2/P1/Exam Q# 10// :o)
10 A

Q# 312/ Chem 6 AS/2021/w/TZ 1/P1/Exam Q# 9// :o)
9 C

Q# 313/ Chem 6 AS/2021/s/TZ 1/P1/Exam Q# 9// :o)
9 D

Q# 314/ Chem 6 AS/2021/m/TZ 2/P1/Exam Q# 8// :o)
8 C

Q# 315/ Chem 6 AS/2020/w/TZ 1/P1/Exam Q# 9// :o)
9 B

Q# 316/ Chem 6 AS/2020/w/TZ 1/P1/Exam Q# 8// :o)
8 A

Q# 317/ Chem 6 AS/2020/s/TZ 1/P1/Exam Q# 8// :o)
8 B

Q# 318/ Chem 6 AS/2020/s/TZ 1/P1/Exam Q# 2// :o)
2 C

Q# 319/ Chem 6 AS/2020/m/TZ 2/P1/Exam Q# 5// :o)
5 D

Q# 320/ Chem 6 AS/2020/m/TZ 2/P1/Exam Q# 10// :o)
10 D

Q# 321/ Chem 6 AS/2019/w/TZ 1/P1/Exam Q# 9// :o)
9 D

Q# 322/ Chem 6 AS/2019/w/TZ 1/P1/Exam Q# 6// :o)
6 A

Q# 323/ Chem 6 AS/2019/s/TZ 1/P1/Exam Q# 9// :o)
9 B

Q# 324/ Chem 6 AS/2019/m/TZ 2/P1/Exam Q# 33// :o)
33 D

Q# 325/ Chem 6 AS/2019/m/TZ 2/P1/Exam Q# 10// :o)
10 B

Q# 326/ Chem 6 AS/2018/w/TZ 1/P1/Exam Q# 8// :o)
8 C

Q# 327/ Chem 6 AS/2018/w/TZ 1/P1/Exam Q# 7// :o)
7 B

Q# 328/ Chem 6 AS/2018/s/TZ 1/P1/Exam Q# 14// :o)
14 D

Q# 329/ Chem 6 AS/2018/m/TZ 2/P1/Exam Q# 10// :o)
10 D

Q# 330/ Chem 6 AS/2017/w/TZ 1/P1/Exam Q# 6// :o)
6 A

Q# 331/ Chem 6 AS/2017/w/TZ 1/P1/Exam Q# 33// :o)
33 A

Q# 332/ Chem 6 AS/2017/s/TZ 1/P1/Exam Q# 9// :o)
9 B

Q# 333/ Chem 6 AS/2017/s/TZ 1/P1/Exam Q# 17// :o)
17 A

Q# 334/ Chem 6 AS/2017/m/TZ 2/P1/Exam Q# 36// :o)
36 A

Q# 335/ Chem 6 AS/2017/m/TZ 2/P1/Exam Q# 33// :o)
33 B

Q# 336/ Chem 6 AS/2016/w/TZ 1/P1/Exam Q# 9// :o)
9 A

Q# 337/ Chem 6 AS/2016/w/TZ 1/P1/Exam Q# 3// :o)
3 D

Q# 338/ Chem 6 AS/2016/s/TZ 1/P1/Exam Q# 33// :o)
33 C

Q# 339/ Chem 6 AS/2016/m/TZ 2/P1/Exam Q# 1// :o)
1 A

Q# 340/ Chem 6 AS/2015/w/TZ 1/P1/Exam Q# 33// :o)
33 B

Q# 341/ Chem 6 AS/2015/s/TZ 1/P1/Exam Q# 4// :o)
4 B

Q# 342/ Chem 6 AS/2014/w/TZ 1/P1/Exam Q# 2// :o)
2 D

Q# 343/ Chem 6 AS/2013/w/TZ 1/P1/Exam Q# 3// :o)
3 B

Q# 344/ Chem 6 AS/2013/w/TZ 1/P1/Exam Q# 2// :o)
2 A

Q# 345/ Chem 6 AS/2013/w/TZ 1/P1/Exam Q# 16// :o)
16 C

Q# 346/ Chem 6 AS/2013/s/TZ 1/P1/Exam Q# 11// :o)
11 B

Q# 347/ Chem 6 AS/2012/w/TZ 1/P1/Exam Q# 1// :o)
1 B

Q# 348/ Chem 6 AS/2012/s/TZ 1/P1/Exam Q# 10// :o)
10 D

Q# 349/ Chem 6 AS/2011/w/TZ 1/P1/Exam Q# 2// :o)
2 C

Q# 350/ Chem 6 AS/2011/s/TZ 1/P1/Exam Q# 2// :o)
2 A

Q# 351/ Chem 6 AS/2010/w/TZ 1/P1/Exam Q# 4// :o)
4 D

Q# 352/ Chem 6 AS/2010/s/TZ 1/P1/Exam Q# 6// :o)
6 D



Q# 353/ Chem 6 AS/2010/s/TZ 1/P1/Exam Q# 33// :o)

33 | B

Q# 354/ Chem 6 AS/2010/s/TZ 1/P1/Exam Q# 32// :o)

32 | D

Q# 355/ Chem 6 AS/2009/w/TZ 1/P1/Exam Q# 7// :o)

7 | D

Q# 356/ Chem 7 AS/2022/w/TZ 1/P1/Exam Q# 14// :o)

14 | A

Q# 357/ Chem 7 AS/2022/w/TZ 1/P1/Exam Q# 13// :o)

13 | B

Q# 358/ Chem 7 AS/2022/s/TZ 1/P1/Exam Q# 14// :o)

14 | B

Q# 359/ Chem 7 AS/2022/s/TZ 1/P1/Exam Q# 13// :o)

13 | D

Q# 360/ Chem 7 AS/2022/m/TZ 2/P1/Exam Q# 13// :o)

13 | B

Q# 361/ Chem 7 AS/2022/m/TZ 2/P1/Exam Q# 12// :o)

12 | A

Q# 362/ Chem 7 AS/2021/w/TZ 1/P1/Exam Q# 32// :o)

32 | D

Q# 363/ Chem 7 AS/2021/w/TZ 1/P1/Exam Q# 10// :o)

10 | B

Q# 364/ Chem 7 AS/2021/s/TZ 1/P1/Exam Q# 31// :o)

31 | A

Q# 365/ Chem 7 AS/2021/m/TZ 2/P1/Exam Q# 9// :o)

9 | B

Q# 366/ Chem 7 AS/2021/m/TZ 2/P1/Exam Q# 31// :o)

31 | B

Q# 367/ Chem 7 AS/2020/w/TZ 1/P1/Exam Q# 34// :o)

34 | D

Q# 368/ Chem 7 AS/2020/w/TZ 1/P1/Exam Q# 33// :o)

33 | A

Q# 369/ Chem 7 AS/2020/w/TZ 1/P1/Exam Q# 10// :o)

10 | C

Q# 370/ Chem 7 AS/2020/s/TZ 1/P1/Exam Q# 7// :o)

7 | B

Q# 371/ Chem 7 AS/2020/s/TZ 1/P1/Exam Q# 34// :o)

34 | A

Q# 372/ Chem 7 AS/2020/s/TZ 1/P1/Exam Q# 1// :o)

1 | A

Q# 373/ Chem 7 AS/2020/m/TZ 2/P1/Exam Q# 6// :o)

6 | A

Q# 374/ Chem 7 AS/2020/m/TZ 2/P1/Exam Q# 15// :o)

15 | B

Q# 375/ Chem 7 AS/2020/m/TZ 2/P1/Exam Q# 11// :o)

11 | B

Q# 376/ Chem 7 AS/2019/w/TZ 1/P1/Exam Q# 34// :o)

34 | B

Q# 377/ Chem 7 AS/2019/w/TZ 1/P1/Exam Q# 18// :o)

18 | A

Q# 378/ Chem 7 AS/2019/w/TZ 1/P1/Exam Q# 11// :o)

11 | A

Q# 379/ Chem 7 AS/2019/w/TZ 1/P1/Exam Q# 10// :o)

10 | C

Q# 380/ Chem 7 AS/2019/s/TZ 1/P1/Exam Q# 11// :o)

11 | D

Q# 381/ Chem 7 AS/2019/s/TZ 1/P1/Exam Q# 10// :o)

10 | C

Q# 382/ Chem 7 AS/2019/m/TZ 2/P1/Exam Q# 11// :o)

11 | C

Q# 383/ Chem 7 AS/2018/w/TZ 1/P1/Exam Q# 9// :o)

9 | D

Q# 384/ Chem 7 AS/2018/w/TZ 1/P1/Exam Q# 10// :o)

10 | D

Q# 385/ Chem 7 AS/2018/s/TZ 1/P1/Exam Q# 9// :o)

9 | B

Q# 386/ Chem 7 AS/2018/s/TZ 1/P1/Exam Q# 8// :o)

8 | A

Q# 387/ Chem 7 AS/2018/s/TZ 1/P1/Exam Q# 34// :o)

34 | C

Q# 388/ Chem 7 AS/2018/s/TZ 1/P1/Exam Q# 31// :o)

31 | D

Q# 389/ Chem 7 AS/2018/s/TZ 1/P1/Exam Q# 15// :o)

15 | B

Q# 390/ Chem 7 AS/2018/m/TZ 2/P1/Exam Q# 6// :o)

6 | D

Q# 391/ Chem 7 AS/2018/m/TZ 2/P1/Exam Q# 34// :o)

34 | D

Q# 392/ Chem 7 AS/2018/m/TZ 2/P1/Exam Q# 33// :o)

33 | B

Q# 393/ Chem 7 AS/2018/m/TZ 2/P1/Exam Q# 12// :o)

12 | B

Q# 394/ Chem 7 AS/2018/m/TZ 2/P1/Exam Q# 11// :o)

11 | C

Q# 395/ Chem 7 AS/2017/w/TZ 1/P1/Exam Q# 9// :o)

9 | D

Q# 396/ Chem 7 AS/2017/w/TZ 1/P1/Exam Q# 34// :o)

34 | D

Q# 397/ Chem 7 AS/2017/s/TZ 1/P1/Exam Q# 10// :o)

10 | C

Q# 398/ Chem 7 AS/2017/m/TZ 2/P1/Exam Q# 8// :o)

8 | A

Q# 399/ Chem 7 AS/2017/m/TZ 2/P1/Exam Q# 34// :o)

34 | B

Q# 400/ Chem 7 AS/2017/m/TZ 2/P1/Exam Q# 3// :o)

3 | D



Q# 401/ Chem 7 AS/2017/m/TZ 2/P1/Exam Q# 11// :o)
11 | D

Q# 402/ Chem 7 AS/2016/w/TZ 1/P1/Exam Q# 34// :o)
34 | D

Q# 403/ Chem 7 AS/2016/w/TZ 1/P1/Exam Q# 10// :o)
10 | A

Q# 404/ Chem 7 AS/2016/s/TZ 1/P1/Exam Q# 9// :o)
9 | D

Q# 405/ Chem 7 AS/2016/s/TZ 1/P1/Exam Q# 6// :o)
6 | D

Q# 406/ Chem 7 AS/2016/s/TZ 1/P1/Exam Q# 17// :o)
17 | B

Q# 407/ Chem 7 AS/2016/s/TZ 1/P1/Exam Q# 10// :o)
10 | D

Q# 408/ Chem 7 AS/2016/m/TZ 2/P1/Exam Q# 33// :o)
33 | B

Q# 409/ Chem 7 AS/2016/m/TZ 2/P1/Exam Q# 11// :o)
11 | C

Q# 410/ Chem 7 AS/2015/w/TZ 1/P1/Exam Q# 2// :o)
2 | A

Q# 411/ Chem 7 AS/2015/w/TZ 1/P1/Exam Q# 11// :o)
11 | C

Q# 412/ Chem 7 AS/2015/w/TZ 1/P1/Exam Q# 10// :o)
10 | B

Q# 413/ Chem 7 AS/2015/s/TZ 1/P1/Exam Q# 9// :o)
9 | A

Q# 414/ Chem 7 AS/2015/s/TZ 1/P1/Exam Q# 8// :o)
8 | C

Q# 415/ Chem 7 AS/2015/s/TZ 1/P1/Exam Q# 6// :o)
6 | B

Q# 416/ Chem 7 AS/2014/w/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 417/ Chem 7 AS/2014/s/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 418/ Chem 7 AS/2014/s/TZ 1/P1/Exam Q# 34// :o)
34 | B

Q# 419/ Chem 7 AS/2014/s/TZ 1/P1/Exam Q# 33// :o)
33 | D

Q# 420/ Chem 7 AS/2014/s/TZ 1/P1/Exam Q# 18// :o)
18 | B

Q# 421/ Chem 7 AS/2014/s/TZ 1/P1/Exam Q# 10// :o)
10 | C

Q# 422/ Chem 7 AS/2013/w/TZ 1/P1/Exam Q# 9// :o)
9 | A

Q# 423/ Chem 7 AS/2013/w/TZ 1/P1/Exam Q# 34// :o)
34 | A

Q# 424/ Chem 7 AS/2013/w/TZ 1/P1/Exam Q# 33// :o)
31 | A

Q# 425/ Chem 7 AS/2013/w/TZ 1/P1/Exam Q# 18// :o)
18 | C

Q# 426/ Chem 7 AS/2013/s/TZ 1/P1/Exam Q# 18// :o)
18 | A

Q# 427/ Chem 7 AS/2012/w/TZ 1/P1/Exam Q# 35// :o)
35 | D

Q# 428/ Chem 7 AS/2012/s/TZ 1/P1/Exam Q# 9// :o)
9 | B

Q# 429/ Chem 7 AS/2012/s/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 430/ Chem 7 AS/2012/s/TZ 1/P1/Exam Q# 2// :o)
2 | D

Q# 431/ Chem 7 AS/2011/w/TZ 1/P1/Exam Q# 9// :o)
9 | D

Q# 432/ Chem 7 AS/2011/w/TZ 1/P1/Exam Q# 8// :o)
8 | A

Q# 433/ Chem 7 AS/2011/w/TZ 1/P1/Exam Q# 10// :o)
10 | D

Q# 434/ Chem 7 AS/2011/s/TZ 1/P1/Exam Q# 7// :o)
7 | B

Q# 435/ Chem 7 AS/2010/w/TZ 1/P1/Exam Q# 31// :o)
31 | A

Q# 436/ Chem 7 AS/2010/w/TZ 1/P1/Exam Q# 10// :o)
10 | B

Q# 437/ Chem 7 AS/2010/s/TZ 1/P1/Exam Q# 7// :o)
7 | A

Q# 438/ Chem 7 AS/2010/s/TZ 1/P1/Exam Q# 15// :o)
15 | A

Q# 439/ Chem 7 AS/2010/s/TZ 1/P1/Exam Q# 11// :o)
11 | A

Q# 440/ Chem 7 AS/2010/s/TZ 1/P1/Exam Q# 10// :o)
10 | D

Q# 441/ Chem 7 AS/2009/w/TZ 1/P1/Exam Q# 9// :o)
9 | A

Q# 442/ Chem 7 AS/2009/w/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 443/ Chem 7 AS/2009/w/TZ 1/P1/Exam Q# 33// :o)
33 | C

Q# 444/ Chem 7 AS/2009/w/TZ 1/P1/Exam Q# 17// :o)
17 | A

Q# 445/ Chem 8 AS/2022/w/TZ 1/P1/Exam Q# 16// :o)
16 | A

Q# 446/ Chem 8 AS/2022/w/TZ 1/P1/Exam Q# 15// :o)
15 | A

Q# 447/ Chem 8 AS/2022/s/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 448/ Chem 8 AS/2022/m/TZ 2/P1/Exam Q# 16// :o)
16 | B

Q# 449/ Chem 8 AS/2022/m/TZ 2/P1/Exam Q# 15// :o)
15 | A

Q# 450/ Chem 8 AS/2022/m/TZ 2/P1/Exam Q# 11// :o)
11 | C

Q# 451/ Chem 8 AS/2021/w/TZ 1/P1/Exam Q# 31// :o)
31 | A

Q# 452/ Chem 8 AS/2021/w/TZ 1/P1/Exam Q# 11// :o)
11 | D

Q# 453/ Chem 8 AS/2021/s/TZ 1/P1/Exam Q# 5// :o)
5 | B



Q# 454/ Chem 8 AS/2021/s/TZ 1/P1/Exam Q# 11// :o)
11 | C

Q# 455/ Chem 8 AS/2021/m/TZ 2/P1/Exam Q# 11// :o)
11 | D

Q# 456/ Chem 8 AS/2021/m/TZ 2/P1/Exam Q# 10// :o)
10 | C

Q# 457/ Chem 8 AS/2020/w/TZ 1/P1/Exam Q# 11// :o)
11 | C

Q# 458/ Chem 8 AS/2020/s/TZ 1/P1/Exam Q# 6// :o)
6 | C

Q# 459/ Chem 8 AS/2020/m/TZ 2/P1/Exam Q# 34// :o)
34 | B

Q# 460/ Chem 8 AS/2019/w/TZ 1/P1/Exam Q# 1// :o)
1 | C

Q# 461/ Chem 8 AS/2019/s/TZ 1/P1/Exam Q# 1// :o)
1 | B

Q# 462/ Chem 8 AS/2019/m/TZ 2/P1/Exam Q# 34// :o)
34 | B

Q# 463/ Chem 8 AS/2019/m/TZ 2/P1/Exam Q# 1// :o)
1 | B

Q# 464/ Chem 8 AS/2018/w/TZ 1/P1/Exam Q# 34// :o)
34 | C

Q# 465/ Chem 8 AS/2018/w/TZ 1/P1/Exam Q# 11// :o)
11 | C

Q# 466/ Chem 8 AS/2018/s/TZ 1/P1/Exam Q# 4// :o)
4 | C

Q# 467/ Chem 8 AS/2018/s/TZ 1/P1/Exam Q# 11// :o)
11 | B

Q# 468/ Chem 8 AS/2017/w/TZ 1/P1/Exam Q# 7// :o)
7 | D

Q# 469/ Chem 8 AS/2017/w/TZ 1/P1/Exam Q# 10// :o)
10 | C

Q# 470/ Chem 8 AS/2017/s/TZ 1/P1/Exam Q# 34// :o)
34 | A

Q# 471/ Chem 8 AS/2017/s/TZ 1/P1/Exam Q# 11// :o)
11 | B

Q# 472/ Chem 8 AS/2017/m/TZ 2/P1/Exam Q# 10// :o)
10 | B

Q# 473/ Chem 8 AS/2016/w/TZ 1/P1/Exam Q# 11// :o)
11 | C

Q# 474/ Chem 8 AS/2016/w/TZ 1/P1/Exam Q# 1// :o)
1 | C

Q# 475/ Chem 8 AS/2016/s/TZ 1/P1/Exam Q# 37// :o)
37 | B

Q# 476/ Chem 8 AS/2016/m/TZ 2/P1/Exam Q# 34// :o)
34 | C

Q# 477/ Chem 8 AS/2015/w/TZ 1/P1/Exam Q# 34// :o)
34 | D

Q# 478/ Chem 8 AS/2015/s/TZ 1/P1/Exam Q# 34// :o)
34 | D

Q# 479/ Chem 8 AS/2015/s/TZ 1/P1/Exam Q# 1// :o)
1 | D

Q# 480/ Chem 8 AS/2014/w/TZ 1/P1/Exam Q# 33// :o)
33 | B

Q# 481/ Chem 8 AS/2014/w/TZ 1/P1/Exam Q# 1// :o)
1 | A

Q# 482/ Chem 8 AS/2014/s/TZ 1/P1/Exam Q# 8// :o)
8 | A

Q# 483/ Chem 8 AS/2014/s/TZ 1/P1/Exam Q# 11// :o)
11 | C

Q# 484/ Chem 8 AS/2013/w/TZ 1/P1/Exam Q# 6// :o)
6 | D

Q# 485/ Chem 8 AS/2013/s/TZ 1/P1/Exam Q# 8// :o)
8 | D

Q# 486/ Chem 8 AS/2011/w/TZ 1/P1/Exam Q# 11// :o)
11 | A

Q# 487/ Chem 8 AS/2011/s/TZ 1/P1/Exam Q# 6// :o)
6 | A

Q# 488/ Chem 8 AS/2011/s/TZ 1/P1/Exam Q# 4// :o)
4 | C

Q# 489/ Chem 8 AS/2011/s/TZ 1/P1/Exam Q# 12// :o)
12 | B

Q# 490/ Chem 8 AS/2010/w/TZ 1/P1/Exam Q# 32// :o)
32 | C

Q# 491/ Chem 8 AS/2010/s/TZ 1/P1/Exam Q# 12// :o)
12 | D

Q# 492/ Chem 8 AS/2009/w/TZ 1/P1/Exam Q# 34// :o)
34 | B

Q# 493/ Chem 8 AS/2009/w/TZ 1/P1/Exam Q# 11// :o)
11 | A

Q# 494/ Chem 8 AS/2009/w/TZ 1/P1/Exam Q# 10// :o)
10 | C

Q# 495/ Chem 8 AS/2009/s/TZ 1/P1/Exam Q# 10// :o)
10 | B

Q# 496/ Chem 9 AS/2022/w/TZ 1/P1/Exam Q# 25// :o)
25 | D

Q# 497/ Chem 9 AS/2022/w/TZ 1/P1/Exam Q# 19// :o)
19 | A

Q# 498/ Chem 9 AS/2022/w/TZ 1/P1/Exam Q# 18// :o)
18 | B

Q# 499/ Chem 9 AS/2022/w/TZ 1/P1/Exam Q# 17// :o)
17 | C

Q# 500/ Chem 9 AS/2022/s/TZ 1/P1/Exam Q# 6// :o)
6 | C

Q# 501/ Chem 9 AS/2022/s/TZ 1/P1/Exam Q# 23// :o)
23 | D

Q# 502/ Chem 9 AS/2022/s/TZ 1/P1/Exam Q# 19// :o)
19 | A

Q# 503/ Chem 9 AS/2022/s/TZ 1/P1/Exam Q# 18// :o)
18 | C



Q# 504/ Chem 9 AS/2022/m/TZ 2/P1/Exam Q# 19// :o)
19 | D

Q# 505/ Chem 9 AS/2022/m/TZ 2/P1/Exam Q# 18// :o)
18 | C

Q# 506/ Chem 9 AS/2022/m/TZ 2/P1/Exam Q# 17// :o)
17 | A

Q# 507/ Chem 9 AS/2021/w/TZ 1/P1/Exam Q# 13// :o)
13 | C

Q# 508/ Chem 9 AS/2021/w/TZ 1/P1/Exam Q# 12// :o)
12 | D

Q# 509/ Chem 9 AS/2021/s/TZ 1/P1/Exam Q# 35// :o)
35 | D

Q# 510/ Chem 9 AS/2021/s/TZ 1/P1/Exam Q# 19// :o)
19 | D

Q# 511/ Chem 9 AS/2021/s/TZ 1/P1/Exam Q# 12// :o)
12 | B

Q# 512/ Chem 9 AS/2021/m/TZ 2/P1/Exam Q# 35// :o)
35 | D

Q# 513/ Chem 9 AS/2021/m/TZ 2/P1/Exam Q# 13// :o)
13 | C

Q# 514/ Chem 9 AS/2021/m/TZ 2/P1/Exam Q# 12// :o)
12 | B

Q# 515/ Chem 9 AS/2020/w/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 516/ Chem 9 AS/2020/w/TZ 1/P1/Exam Q# 35// :o)
35 | B

Q# 517/ Chem 9 AS/2020/w/TZ 1/P1/Exam Q# 12// :o)
12 | B

Q# 518/ Chem 9 AS/2020/s/TZ 1/P1/Exam Q# 16// :o)
16 | D

Q# 519/ Chem 9 AS/2020/s/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 520/ Chem 9 AS/2020/m/TZ 2/P1/Exam Q# 36// :o)
36 | B

Q# 521/ Chem 9 AS/2020/m/TZ 2/P1/Exam Q# 31// :o)
31 | C

Q# 522/ Chem 9 AS/2020/m/TZ 2/P1/Exam Q# 16// :o)
16 | D

Q# 523/ Chem 9 AS/2020/m/TZ 2/P1/Exam Q# 12// :o)
12 | D

Q# 524/ Chem 9 AS/2019/w/TZ 1/P1/Exam Q# 13// :o)
13 | D

Q# 525/ Chem 9 AS/2019/w/TZ 1/P1/Exam Q# 12// :o)
12 | A

Q# 526/ Chem 9 AS/2019/s/TZ 1/P1/Exam Q# 35// :o)
35 | D

Q# 527/ Chem 9 AS/2019/s/TZ 1/P1/Exam Q# 13// :o)
13 | C

Q# 528/ Chem 9 AS/2019/m/TZ 2/P1/Exam Q# 13// :o)
13 | B

Q# 529/ Chem 9 AS/2019/m/TZ 2/P1/Exam Q# 12// :o)
12 | A

Q# 530/ Chem 9 AS/2018/w/TZ 1/P1/Exam Q# 14// :o)
14 | B

Q# 531/ Chem 9 AS/2018/w/TZ 1/P1/Exam Q# 13// :o)
13 | C

Q# 532/ Chem 9 AS/2018/w/TZ 1/P1/Exam Q# 12// :o)
12 | C

Q# 533/ Chem 9 AS/2018/s/TZ 1/P1/Exam Q# 13// :o)
13 | C

Q# 534/ Chem 9 AS/2018/s/TZ 1/P1/Exam Q# 12// :o)
12 | D

Q# 535/ Chem 9 AS/2018/m/TZ 2/P1/Exam Q# 14// :o)
14 | B

Q# 536/ Chem 9 AS/2018/m/TZ 2/P1/Exam Q# 13// :o)
13 | A

Q# 537/ Chem 9 AS/2017/w/TZ 1/P1/Exam Q# 13// :o)
13 | A

Q# 538/ Chem 9 AS/2017/w/TZ 1/P1/Exam Q# 12// :o)
12 | A

Q# 539/ Chem 9 AS/2017/s/TZ 1/P1/Exam Q# 35// :o)
35 | D

Q# 540/ Chem 9 AS/2017/s/TZ 1/P1/Exam Q# 13// :o)
13 | B

Q# 541/ Chem 9 AS/2017/m/TZ 2/P1/Exam Q# 35// :o)
35 | A

Q# 542/ Chem 9 AS/2017/m/TZ 2/P1/Exam Q# 31// :o)
31 | D

Q# 543/ Chem 9 AS/2017/m/TZ 2/P1/Exam Q# 15// :o)
15 | C

Q# 544/ Chem 9 AS/2017/m/TZ 2/P1/Exam Q# 12// :o)
12 | C

Q# 545/ Chem 9 AS/2016/s/TZ 1/P1/Exam Q# 34// :o)
34 | A

Q# 546/ Chem 9 AS/2016/s/TZ 1/P1/Exam Q# 12// :o)
12 | A

Q# 547/ Chem 9 AS/2016/m/TZ 2/P1/Exam Q# 13// :o)
13 | C

Q# 548/ Chem 9 AS/2016/m/TZ 2/P1/Exam Q# 12// :o)
12 | D

Q# 549/ Chem 9 AS/2015/w/TZ 1/P1/Exam Q# 32// :o)
32 | B

Q# 550/ Chem 9 AS/2015/w/TZ 1/P1/Exam Q# 16// :o)
16 | D



Q# 551/ Chem 9 AS/2015/w/TZ 1/P1/Exam Q# 15// :o)
15 D

Q# 552/ Chem 9 AS/2015/w/TZ 1/P1/Exam Q# 14// :o)
14 A

Q# 553/ Chem 9 AS/2015/s/TZ 1/P1/Exam Q# 3// :o)
3 A

Q# 554/ Chem 9 AS/2015/s/TZ 1/P1/Exam Q# 15// :o)
15 C

Q# 555/ Chem 9 AS/2015/s/TZ 1/P1/Exam Q# 14// :o)
14 B

Q# 556/ Chem 9 AS/2014/w/TZ 1/P1/Exam Q# 19// :o)
19 D

Q# 557/ Chem 9 AS/2014/w/TZ 1/P1/Exam Q# 18// :o)
18 C

Q# 558/ Chem 9 AS/2014/w/TZ 1/P1/Exam Q# 14// :o)
14 C

Q# 559/ Chem 9 AS/2014/w/TZ 1/P1/Exam Q# 13// :o)
13 D

Q# 560/ Chem 9 AS/2014/w/TZ 1/P1/Exam Q# 12// :o)
12 B

Q# 561/ Chem 9 AS/2014/s/TZ 1/P1/Exam Q# 19// :o)
19 B

Q# 562/ Chem 9 AS/2014/s/TZ 1/P1/Exam Q# 16// :o)
16 C

Q# 563/ Chem 9 AS/2014/s/TZ 1/P1/Exam Q# 15// :o)
15 B

Q# 564/ Chem 9 AS/2013/w/TZ 1/P1/Exam Q# 19// :o)
19 D

Q# 565/ Chem 9 AS/2013/s/TZ 1/P1/Exam Q# 4// :o)
4 A

Q# 566/ Chem 9 AS/2013/s/TZ 1/P1/Exam Q# 34// :o)
34 A

Q# 567/ Chem 9 AS/2013/s/TZ 1/P1/Exam Q# 2// :o)
2 C

Q# 568/ Chem 9 AS/2012/w/TZ 1/P1/Exam Q# 36// :o)
36 B

Q# 569/ Chem 9 AS/2012/w/TZ 1/P1/Exam Q# 19// :o)
19 A

Q# 570/ Chem 9 AS/2012/w/TZ 1/P1/Exam Q# 18// :o)
18 C

Q# 571/ Chem 9 AS/2012/s/TZ 1/P1/Exam Q# 15// :o)
15 A

Q# 572/ Chem 9 AS/2011/w/TZ 1/P1/Exam Q# 18// :o)
18 C

Q# 573/ Chem 9 AS/2011/w/TZ 1/P1/Exam Q# 1// :o)
1 B

Q# 574/ Chem 9 AS/2011/s/TZ 1/P1/Exam Q# 5// :o)
5 D

Q# 575/ Chem 9 AS/2011/s/TZ 1/P1/Exam Q# 35// :o)
35 A

Q# 576/ Chem 9 AS/2011/s/TZ 1/P1/Exam Q# 34// :o)
34 B

Q# 577/ Chem 9 AS/2011/s/TZ 1/P1/Exam Q# 13// :o)
13 C

Q# 578/ Chem 9 AS/2010/w/TZ 1/P1/Exam Q# 13// :o)
13 A

Q# 579/ Chem 9 AS/2010/s/TZ 1/P1/Exam Q# 2// :o)
2 A

Q# 580/ Chem 9 AS/2010/s/TZ 1/P1/Exam Q# 19// :o)
19 A

Q# 581/ Chem 9 AS/2010/s/TZ 1/P1/Exam Q# 18// :o)
18 D

Q# 582/ Chem 9 AS/2010/s/TZ 1/P1/Exam Q# 16// :o)
16 C

Q# 583/ Chem 9 AS/2009/w/TZ 1/P1/Exam Q# 14// :o)
14 D

Q# 584/ Chem 9 AS/2009/w/TZ 1/P1/Exam Q# 13// :o)
13 C

Q# 585/ Chem 9 AS/2009/w/TZ 1/P1/Exam Q# 12// :o)
12 D

Q# 586/ Chem 10 AS/2022/w/TZ 1/P1/Exam Q# 8// :o)
8 D

Q# 587/ Chem 10 AS/2022/w/TZ 1/P1/Exam Q# 20// :o)
20 D

Q# 588/ Chem 10 AS/2022/s/TZ 1/P1/Exam Q# 3// :o)
3 A

Q# 589/ Chem 10 AS/2022/s/TZ 1/P1/Exam Q# 21// :o)
21 B

Q# 590/ Chem 10 AS/2022/s/TZ 1/P1/Exam Q# 20// :o)
20 C

Q# 591/ Chem 10 AS/2022/m/TZ 2/P1/Exam Q# 21// :o)
21 D

Q# 592/ Chem 10 AS/2022/m/TZ 2/P1/Exam Q# 20// :o)
20 B

Q# 593/ Chem 10 AS/2021/w/TZ 1/P1/Exam Q# 36// :o)
36 C

Q# 594/ Chem 10 AS/2021/w/TZ 1/P1/Exam Q# 15// :o)
15 A

Q# 595/ Chem 10 AS/2021/w/TZ 1/P1/Exam Q# 14// :o)
14 C

Q# 596/ Chem 10 AS/2021/s/TZ 1/P1/Exam Q# 36// :o)
36 A

Q# 597/ Chem 10 AS/2021/s/TZ 1/P1/Exam Q# 15// :o)
15 A

Q# 598/ Chem 10 AS/2021/s/TZ 1/P1/Exam Q# 14// :o)
14 A

Q# 599/ Chem 10 AS/2021/m/TZ 2/P1/Exam Q# 15// :o)
15 B

Q# 600/ Chem 10 AS/2021/m/TZ 2/P1/Exam Q# 14// :o)
14 D

Q# 601/ Chem 10 AS/2020/w/TZ 1/P1/Exam Q# 19// :o)
19 C



Q# 602/ Chem 10 AS/2020/w/TZ 1/P1/Exam Q# 18// :o)
18 | D

Q# 603/ Chem 10 AS/2020/w/TZ 1/P1/Exam Q# 15// :o)
15 | C

Q# 604/ Chem 10 AS/2020/w/TZ 1/P1/Exam Q# 13// :o)
13 | B

Q# 605/ Chem 10 AS/2020/s/TZ 1/P1/Exam Q# 17// :o)
17 | C

Q# 606/ Chem 10 AS/2020/s/TZ 1/P1/Exam Q# 14// :o)
14 | A

Q# 607/ Chem 10 AS/2020/m/TZ 2/P1/Exam Q# 17// :o)
17 | C

Q# 608/ Chem 10 AS/2020/m/TZ 2/P1/Exam Q# 13// :o)
13 | A

Q# 609/ Chem 10 AS/2019/w/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 610/ Chem 10 AS/2019/w/TZ 1/P1/Exam Q# 14// :o)
14 | B

Q# 611/ Chem 10 AS/2019/s/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 612/ Chem 10 AS/2019/s/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 613/ Chem 10 AS/2019/s/TZ 1/P1/Exam Q# 14// :o)
14 | A

Q# 614/ Chem 10 AS/2019/m/TZ 2/P1/Exam Q# 16// :o)
16 | B

Q# 615/ Chem 10 AS/2019/m/TZ 2/P1/Exam Q# 15// :o)
15 | A

Q# 616/ Chem 10 AS/2019/m/TZ 2/P1/Exam Q# 14// :o)
14 | A

Q# 617/ Chem 10 AS/2018/w/TZ 1/P1/Exam Q# 4// :o)
4 | C

Q# 618/ Chem 10 AS/2018/w/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 619/ Chem 10 AS/2018/w/TZ 1/P1/Exam Q# 35// :o)
35 | A

Q# 620/ Chem 10 AS/2018/w/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 621/ Chem 10 AS/2018/s/TZ 1/P1/Exam Q# 18// :o)
18 | D

Q# 622/ Chem 10 AS/2018/m/TZ 2/P1/Exam Q# 15// :o)
15 | B

Q# 623/ Chem 10 AS/2017/w/TZ 1/P1/Exam Q# 35// :o)
35 | B

Q# 624/ Chem 10 AS/2017/w/TZ 1/P1/Exam Q# 15// :o)
15 | C

Q# 625/ Chem 10 AS/2017/s/TZ 1/P1/Exam Q# 15// :o)
15 | C

Q# 626/ Chem 10 AS/2017/s/TZ 1/P1/Exam Q# 14// :o)
14 | A

Q# 627/ Chem 10 AS/2017/m/TZ 2/P1/Exam Q# 18// :o)
18 | D

Q# 628/ Chem 10 AS/2017/m/TZ 2/P1/Exam Q# 14// :o)
14 | A

Q# 629/ Chem 10 AS/2016/w/TZ 1/P1/Exam Q# 18// :o)
18 | D

Q# 630/ Chem 10 AS/2016/w/TZ 1/P1/Exam Q# 16// :o)
16 | D

Q# 631/ Chem 10 AS/2016/s/TZ 1/P1/Exam Q# 14// :o)
14 | A

Q# 632/ Chem 10 AS/2016/m/TZ 2/P1/Exam Q# 36// :o)
36 | D

Q# 633/ Chem 10 AS/2016/m/TZ 2/P1/Exam Q# 18// :o)
18 | B

Q# 634/ Chem 10 AS/2015/w/TZ 1/P1/Exam Q# 35// :o)
35 | B

Q# 635/ Chem 10 AS/2015/w/TZ 1/P1/Exam Q# 13// :o)
13 | A

Q# 636/ Chem 10 AS/2015/w/TZ 1/P1/Exam Q# 12// :o)
12 | A

Q# 637/ Chem 10 AS/2015/s/TZ 1/P1/Exam Q# 36// :o)
36 | D

Q# 638/ Chem 10 AS/2015/s/TZ 1/P1/Exam Q# 19// :o)
19 | C

Q# 639/ Chem 10 AS/2015/s/TZ 1/P1/Exam Q# 13// :o)
13 | D

Q# 640/ Chem 10 AS/2014/w/TZ 1/P1/Exam Q# 36// :o)
36 | B

Q# 641/ Chem 10 AS/2014/s/TZ 1/P1/Exam Q# 17// :o)
17 | A

Q# 642/ Chem 10 AS/2014/s/TZ 1/P1/Exam Q# 13// :o)
13 | C

Q# 643/ Chem 10 AS/2013/w/TZ 1/P1/Exam Q# 14// :o)
14 | B

Q# 644/ Chem 10 AS/2013/w/TZ 1/P1/Exam Q# 13// :o)
13 | A

Q# 645/ Chem 10 AS/2013/s/TZ 1/P1/Exam Q# 16// :o)
16 | D

Q# 646/ Chem 10 AS/2013/s/TZ 1/P1/Exam Q# 13// :o)
13 | C

Q# 647/ Chem 10 AS/2012/w/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 648/ Chem 10 AS/2012/w/TZ 1/P1/Exam Q# 14// :o)
13 | A

Q# 649/ Chem 10 AS/2012/s/TZ 1/P1/Exam Q# 13// :o)
13 | C

Q# 650/ Chem 10 AS/2011/w/TZ 1/P1/Exam Q# 15// :o)
15 | B

Q# 651/ Chem 10 AS/2011/w/TZ 1/P1/Exam Q# 14// :o)
14 | B



Q# 652/ Chem 10 AS/2011/s/TZ 1/P1/Exam Q# 14// :o)

14 D

Q# 653/ Chem 10 AS/2010/w/TZ 1/P1/Exam Q# 34// :o)

34 D

Q# 654/ Chem 10 AS/2010/w/TZ 1/P1/Exam Q# 19// :o)

19 C

Q# 655/ Chem 10 AS/2010/w/TZ 1/P1/Exam Q# 14// :o)

14 D

Q# 656/ Chem 10 AS/2010/s/TZ 1/P1/Exam Q# 17// :o)

17 B

Q# 657/ Chem 10 AS/2009/w/TZ 1/P1/Exam Q# 3// :o)

1 B

Q# 658/ Chem 10 AS/2009/s/TZ 1/P1/Exam Q# 13// :o)

13 B

Q# 659/ Chem 10 AS/2009/s/TZ 1/P1/Exam Q# 11// :o)

11 C

Q# 660/ Chem 11 AS/2022/w/TZ 1/P1/Exam Q# 22// :o)

22 B

Q# 661/ Chem 11 AS/2022/w/TZ 1/P1/Exam Q# 21// :o)

21 C

Q# 662/ Chem 11 AS/2022/s/TZ 1/P1/Exam Q# 22// :o)

22 D

Q# 663/ Chem 11 AS/2022/m/TZ 2/P1/Exam Q# 23// :o)

23 B

Q# 664/ Chem 11 AS/2022/m/TZ 2/P1/Exam Q# 22// :o)

22 D

Q# 665/ Chem 11 AS/2021/w/TZ 1/P1/Exam Q# 17// :o)

17 D

Q# 666/ Chem 11 AS/2021/w/TZ 1/P1/Exam Q# 16// :o)

16 D

Q# 667/ Chem 11 AS/2021/s/TZ 1/P1/Exam Q# 17// :o)

17 D

Q# 668/ Chem 11 AS/2021/s/TZ 1/P1/Exam Q# 16// :o)

16 C

Q# 669/ Chem 11 AS/2021/m/TZ 2/P1/Exam Q# 17// :o)

17 A

Q# 670/ Chem 11 AS/2021/m/TZ 2/P1/Exam Q# 16// :o)

16 A

Q# 671/ Chem 11 AS/2020/w/TZ 1/P1/Exam Q# 16// :o)

16 C

Q# 672/ Chem 11 AS/2020/w/TZ 1/P1/Exam Q# 14// :o)

14 A

Q# 673/ Chem 11 AS/2020/s/TZ 1/P1/Exam Q# 36// :o)

36 B

Q# 674/ Chem 11 AS/2020/s/TZ 1/P1/Exam Q# 18// :o)

18 D

Q# 675/ Chem 11 AS/2020/s/TZ 1/P1/Exam Q# 12// :o)

12 D

Q# 676/ Chem 11 AS/2020/m/TZ 2/P1/Exam Q# 35// :o)

35 D

Q# 677/ Chem 11 AS/2020/m/TZ 2/P1/Exam Q# 18// :o)

18 A

Q# 678/ Chem 11 AS/2020/m/TZ 2/P1/Exam Q# 14// :o)

14 C

Q# 679/ Chem 11 AS/2019/w/TZ 1/P1/Exam Q# 35// :o)

35 C

Q# 680/ Chem 11 AS/2019/w/TZ 1/P1/Exam Q# 17// :o)

17 A

Q# 681/ Chem 11 AS/2019/w/TZ 1/P1/Exam Q# 16// :o)

16 C

Q# 682/ Chem 11 AS/2019/s/TZ 1/P1/Exam Q# 17// :o)

17 D

Q# 683/ Chem 11 AS/2019/s/TZ 1/P1/Exam Q# 16// :o)

16 C

Q# 684/ Chem 11 AS/2019/m/TZ 2/P1/Exam Q# 18// :o)

18 A

Q# 685/ Chem 11 AS/2019/m/TZ 2/P1/Exam Q# 17// :o)

17 D

Q# 686/ Chem 11 AS/2018/w/TZ 1/P1/Exam Q# 17// :o)

17 D

Q# 687/ Chem 11 AS/2018/w/TZ 1/P1/Exam Q# 16// :o)

16 A

Q# 688/ Chem 11 AS/2018/s/TZ 1/P1/Exam Q# 35// :o)

35 D

Q# 689/ Chem 11 AS/2018/s/TZ 1/P1/Exam Q# 19// :o)

19 D

Q# 690/ Chem 11 AS/2018/s/TZ 1/P1/Exam Q# 16// :o)

16 D

Q# 691/ Chem 11 AS/2018/m/TZ 2/P1/Exam Q# 35// :o)

35 D

Q# 692/ Chem 11 AS/2018/m/TZ 2/P1/Exam Q# 17// :o)

17 B

Q# 693/ Chem 11 AS/2018/m/TZ 2/P1/Exam Q# 16// :o)

16 D

Q# 694/ Chem 11 AS/2017/w/TZ 1/P1/Exam Q# 19// :o)

19 B

Q# 695/ Chem 11 AS/2017/w/TZ 1/P1/Exam Q# 18// :o)

18 C

Q# 696/ Chem 11 AS/2017/w/TZ 1/P1/Exam Q# 17// :o)

17 D

Q# 697/ Chem 11 AS/2017/s/TZ 1/P1/Exam Q# 8// :o)

8 C

Q# 698/ Chem 11 AS/2017/s/TZ 1/P1/Exam Q# 19// :o)

19 A



Q# 699/ Chem 11 AS/2017/s/TZ 1/P1/Exam Q# 18// :o)

18 | C

Q# 700/ Chem 11 AS/2017/m/TZ 2/P1/Exam Q# 17// :o)

17 | A

Q# 701/ Chem 11 AS/2017/m/TZ 2/P1/Exam Q# 16// :o)

16 | C

Q# 702/ Chem 11 AS/2016/w/TZ 1/P1/Exam Q# 19// :o)

19 | B

Q# 703/ Chem 11 AS/2016/w/TZ 1/P1/Exam Q# 14// :o)

14 | D

Q# 704/ Chem 11 AS/2016/s/TZ 1/P1/Exam Q# 35// :o)

35 | D

Q# 705/ Chem 11 AS/2016/s/TZ 1/P1/Exam Q# 15// :o)

15 | C

Q# 706/ Chem 11 AS/2016/m/TZ 2/P1/Exam Q# 19// :o)

19 | A

Q# 707/ Chem 11 AS/2016/m/TZ 2/P1/Exam Q# 16// :o)

16 | B

Q# 708/ Chem 11 AS/2016/m/TZ 2/P1/Exam Q# 14// :o)

14 | D

Q# 709/ Chem 11 AS/2015/w/TZ 1/P1/Exam Q# 18// :o)

18 | A

Q# 710/ Chem 11 AS/2015/w/TZ 1/P1/Exam Q# 17// :o)

17 | B

Q# 711/ Chem 11 AS/2015/s/TZ 1/P1/Exam Q# 17// :o)

17 | D

Q# 712/ Chem 11 AS/2015/s/TZ 1/P1/Exam Q# 16// :o)

16 | A

Q# 713/ Chem 11 AS/2014/w/TZ 1/P1/Exam Q# 35// :o)

35 | B

Q# 714/ Chem 11 AS/2014/w/TZ 1/P1/Exam Q# 17// :o)

17 | C

Q# 715/ Chem 11 AS/2014/w/TZ 1/P1/Exam Q# 16// :o)

16 | A

Q# 716/ Chem 11 AS/2014/s/TZ 1/P1/Exam Q# 36// :o)

36 | C

Q# 717/ Chem 11 AS/2014/s/TZ 1/P1/Exam Q# 12// :o)

12 | D

Q# 718/ Chem 11 AS/2013/s/TZ 1/P1/Exam Q# 36// :o)

36 | B

Q# 719/ Chem 11 AS/2013/s/TZ 1/P1/Exam Q# 17// :o)

17 | A

Q# 720/ Chem 11 AS/2013/s/TZ 1/P1/Exam Q# 15// :o)

15 | A

Q# 721/ Chem 11 AS/2013/s/TZ 1/P1/Exam Q# 14// :o)

14 | D

Q# 722/ Chem 11 AS/2013/s/TZ 1/P1/Exam Q# 1// :o)

1 | C

Q# 723/ Chem 11 AS/2012/w/TZ 1/P1/Exam Q# 34// :o)

34 | D

Q# 724/ Chem 11 AS/2012/s/TZ 1/P1/Exam Q# 35// :o)

35 | A

Q# 725/ Chem 11 AS/2012/s/TZ 1/P1/Exam Q# 18// :o)

18 | C

Q# 726/ Chem 11 AS/2012/s/TZ 1/P1/Exam Q# 17// :o)

17 | D

Q# 727/ Chem 11 AS/2012/s/TZ 1/P1/Exam Q# 16// :o)

16 | C

Q# 728/ Chem 11 AS/2011/w/TZ 1/P1/Exam Q# 7// :o)

7 | C

Q# 729/ Chem 11 AS/2011/w/TZ 1/P1/Exam Q# 35// :o)

35 | B

Q# 730/ Chem 11 AS/2011/w/TZ 1/P1/Exam Q# 17// :o)

17 | C

Q# 731/ Chem 11 AS/2011/s/TZ 1/P1/Exam Q# 36// :o)

36 | D

Q# 732/ Chem 11 AS/2011/s/TZ 1/P1/Exam Q# 16// :o)

16 | D

Q# 733/ Chem 11 AS/2011/s/TZ 1/P1/Exam Q# 15// :o)

15 | B

Q# 734/ Chem 11 AS/2010/w/TZ 1/P1/Exam Q# 35// :o)

35 | A

Q# 735/ Chem 11 AS/2010/w/TZ 1/P1/Exam Q# 17// :o)

17 | A

Q# 736/ Chem 11 AS/2010/w/TZ 1/P1/Exam Q# 16// :o)

16 | D

Q# 737/ Chem 11 AS/2010/s/TZ 1/P1/Exam Q# 14// :o)

14 | A

Q# 738/ Chem 11 AS/2010/s/TZ 1/P1/Exam Q# 13// :o)

13 | A

Q# 739/ Chem 11 AS/2009/w/TZ 1/P1/Exam Q# 36// :o)

36 | D

Q# 740/ Chem 11 AS/2009/w/TZ 1/P1/Exam Q# 15// :o)

15 | B

Q# 741/ Chem 11 AS/2009/s/TZ 1/P1/Exam Q# 36// :o)

36 | C

Q# 742/ Chem 11 AS/2009/s/TZ 1/P1/Exam Q# 16// :o)

16 | D

Q# 743/ Chem 11 AS/2009/s/TZ 1/P1/Exam Q# 15// :o)

15 | A

Q# 744/ Chem 12 AS/2022/w/TZ 1/P1/Exam Q# 23// :o)

23 | C

Q# 745/ Chem 12 AS/2022/s/TZ 1/P1/Exam Q# 29// :o)

29 | B

Q# 746/ Chem 12 AS/2022/s/TZ 1/P1/Exam Q# 25// :o)

26 | C

Q# 747/ Chem 12 AS/2022/m/TZ 2/P1/Exam Q# 24// :o)

24 | C

Q# 748/ Chem 12 AS/2021/s/TZ 1/P1/Exam Q# 18// :o)

18 | C

Q# 749/ Chem 12 AS/2021/s/TZ 1/P1/Exam Q# 13// :o)

13 | B



Q# 750/ Chem 12 AS/2021/s/TZ 1/P1/Exam Q# 10// :o)
10 | D

Q# 751/ Chem 12 AS/2021/m/TZ 2/P1/Exam Q# 36// :o)
36 | C

Q# 752/ Chem 12 AS/2021/m/TZ 2/P1/Exam Q# 19// :o)
19 | D

Q# 753/ Chem 12 AS/2021/m/TZ 2/P1/Exam Q# 18// :o)
18 | C

Q# 754/ Chem 12 AS/2020/w/TZ 1/P1/Exam Q# 17// :o)
17 | D

Q# 755/ Chem 12 AS/2020/m/TZ 2/P1/Exam Q# 19// :o)
19 | C

Q# 756/ Chem 12 AS/2019/w/TZ 1/P1/Exam Q# 36// :o)
36 | D

Q# 757/ Chem 12 AS/2019/w/TZ 1/P1/Exam Q# 19// :o)
19 | D

Q# 758/ Chem 12 AS/2019/s/TZ 1/P1/Exam Q# 19// :o)
19 | B

Q# 759/ Chem 12 AS/2019/s/TZ 1/P1/Exam Q# 18// :o)
18 | C

Q# 760/ Chem 12 AS/2019/m/TZ 2/P1/Exam Q# 19// :o)
19 | D

Q# 761/ Chem 12 AS/2018/w/TZ 1/P1/Exam Q# 19// :o)
19 | D

Q# 762/ Chem 12 AS/2018/w/TZ 1/P1/Exam Q# 18// :o)
18 | D

Q# 763/ Chem 12 AS/2018/s/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 764/ Chem 12 AS/2018/s/TZ 1/P1/Exam Q# 17// :o)
17 | A

Q# 765/ Chem 12 AS/2018/m/TZ 2/P1/Exam Q# 18// :o)
18 | D

Q# 766/ Chem 12 AS/2017/w/TZ 1/P1/Exam Q# 36// :o)
36 | C

Q# 767/ Chem 12 AS/2017/s/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 768/ Chem 12 AS/2017/m/TZ 2/P1/Exam Q# 13// :o)
13 | C

Q# 769/ Chem 12 AS/2016/w/TZ 1/P1/Exam Q# 17// :o)
17 | B

Q# 770/ Chem 12 AS/2016/s/TZ 1/P1/Exam Q# 18// :o)
18 | C

Q# 771/ Chem 12 AS/2016/m/TZ 2/P1/Exam Q# 17// :o)
17 | A

Q# 772/ Chem 12 AS/2015/w/TZ 1/P1/Exam Q# 19// :o)
19 | A

Q# 773/ Chem 12 AS/2015/s/TZ 1/P1/Exam Q# 18// :o)
18 | A

Q# 774/ Chem 12 AS/2014/s/TZ 1/P1/Exam Q# 35// :o)
35 | A

Q# 775/ Chem 12 AS/2013/w/TZ 1/P1/Exam Q# 17// :o)
17 | D

Q# 776/ Chem 12 AS/2012/w/TZ 1/P1/Exam Q# 25// :o)
25 | D

Q# 777/ Chem 12 AS/2012/w/TZ 1/P1/Exam Q# 16// :o)
16 | A

Q# 778/ Chem 12 AS/2012/s/TZ 1/P1/Exam Q# 5// :o)
5 | C

Q# 779/ Chem 12 AS/2012/s/TZ 1/P1/Exam Q# 34// :o)
34 | B

Q# 780/ Chem 12 AS/2012/s/TZ 1/P1/Exam Q# 19// :o)
19 | C

Q# 781/ Chem 12 AS/2011/w/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 782/ Chem 12 AS/2011/w/TZ 1/P1/Exam Q# 34// :o)
34 | A

Q# 783/ Chem 12 AS/2011/s/TZ 1/P1/Exam Q# 37// :o)
37 | B

Q# 784/ Chem 12 AS/2011/s/TZ 1/P1/Exam Q# 18// :o)
18 | C

Q# 785/ Chem 12 AS/2010/w/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 786/ Chem 12 AS/2010/w/TZ 1/P1/Exam Q# 30// :o)
30 | D

Q# 787/ Chem 12 AS/2010/w/TZ 1/P1/Exam Q# 15// :o)
15 | D

Q# 788/ Chem 12 AS/2010/s/TZ 1/P1/Exam Q# 35// :o)
35 | C

Q# 789/ Chem 12 AS/2009/w/TZ 1/P1/Exam Q# 35// :o)
35 | C

Q# 790/ Chem 12 AS/2009/w/TZ 1/P1/Exam Q# 19// :o)
19 | A

Q# 791/ Chem 12 AS/2009/w/TZ 1/P1/Exam Q# 18// :o)
18 | A

Q# 792/ Chem 12 AS/2009/s/TZ 1/P1/Exam Q# 34// :o)
34 | D

Q# 793/ Chem 12 AS/2009/s/TZ 1/P1/Exam Q# 18// :o)
18 | C

Q# 794/ Chem 12 AS/2009/s/TZ 1/P1/Exam Q# 17// :o)
17 | D

Q# 795/ Chem 13 AS/2022/w/TZ 1/P1/Exam Q# 35// :o)
35 | C

Q# 796/ Chem 13 AS/2022/w/TZ 1/P1/Exam Q# 27// :o)
27 | B

Q# 797/ Chem 13 AS/2022/w/TZ 1/P1/Exam Q# 24// :o)
24 | D

Q# 798/ Chem 13 AS/2022/s/TZ 1/P1/Exam Q# 33// :o)
33 | A

Q# 799/ Chem 13 AS/2022/s/TZ 1/P1/Exam Q# 24// :o)
24 | D



Q# 800/ Chem 13 AS/2022/m/TZ 2/P1/Exam Q# 39// :o)

39 | C

Q# 801/ Chem 13 AS/2022/m/TZ 2/P1/Exam Q# 36// :o)

36 | A

Q# 802/ Chem 13 AS/2022/m/TZ 2/P1/Exam Q# 26// :o)

26 | C

Q# 803/ Chem 13 AS/2021/s/TZ 1/P1/Exam Q# 6// :o)

6 | B

Q# 804/ Chem 13 AS/2021/s/TZ 1/P1/Exam Q# 23// :o)

23 | C

Q# 805/ Chem 13 AS/2021/s/TZ 1/P1/Exam Q# 22// :o)

23 | C

Q# 806/ Chem 13 AS/2021/s/TZ 1/P1/Exam Q# 1// :o)

1 | C

Q# 807/ Chem 13 AS/2021/m/TZ 2/P1/Exam Q# 20// :o)

20 | D

Q# 808/ Chem 13 AS/2020/w/TZ 1/P1/Exam Q# 38// :o)

38 | C

Q# 809/ Chem 13 AS/2020/w/TZ 1/P1/Exam Q# 30// :o)

30 | A

Q# 810/ Chem 13 AS/2020/w/TZ 1/P1/Exam Q# 20// :o)

20 | D

Q# 811/ Chem 13 AS/2020/s/TZ 1/P1/Exam Q# 31// :o)

31 | B

Q# 812/ Chem 13 AS/2020/s/TZ 1/P1/Exam Q# 3// :o)

3 | B

Q# 813/ Chem 13 AS/2020/s/TZ 1/P1/Exam Q# 28// :o)

28 | D

Q# 814/ Chem 13 AS/2020/s/TZ 1/P1/Exam Q# 21// :o)

21 | C

Q# 815/ Chem 13 AS/2020/m/TZ 2/P1/Exam Q# 30// :o)

30 | D

Q# 816/ Chem 13 AS/2020/m/TZ 2/P1/Exam Q# 25// :o)

25 | D

Q# 817/ Chem 13 AS/2020/m/TZ 2/P1/Exam Q# 20// :o)

20 | B

Q# 818/ Chem 13 AS/2020/m/TZ 2/P1/Exam Q# 2// :o)

2 | D

Q# 819/ Chem 13 AS/2019/w/TZ 1/P1/Exam Q# 5// :o)

5 | C

Q# 820/ Chem 13 AS/2019/w/TZ 1/P1/Exam Q# 37// :o)

37 | B

Q# 821/ Chem 13 AS/2019/s/TZ 1/P1/Exam Q# 30// :o)

29 | A

Q# 822/ Chem 13 AS/2019/s/TZ 1/P1/Exam Q# 25// :o)

25 | D

Q# 823/ Chem 13 AS/2019/s/TZ 1/P1/Exam Q# 21// :o)

21 | A

Q# 824/ Chem 13 AS/2019/s/TZ 1/P1/Exam Q# 20// :o)

20 | D

Q# 825/ Chem 13 AS/2019/m/TZ 2/P1/Exam Q# 31// :o)

31 | C

Q# 826/ Chem 13 AS/2019/m/TZ 2/P1/Exam Q# 21// :o)

21 | A

Q# 827/ Chem 13 AS/2019/m/TZ 2/P1/Exam Q# 20// :o)

20 | C

Q# 828/ Chem 13 AS/2018/w/TZ 1/P1/Exam Q# 22// :o)

22 | C

Q# 829/ Chem 13 AS/2018/w/TZ 1/P1/Exam Q# 21// :o)

21 | A

Q# 830/ Chem 13 AS/2018/s/TZ 1/P1/Exam Q# 21// :o)

21 | B

Q# 831/ Chem 13 AS/2018/s/TZ 1/P1/Exam Q# 20// :o)

20 | B

Q# 832/ Chem 13 AS/2018/m/TZ 2/P1/Exam Q# 20// :o)

20 | D

Q# 833/ Chem 13 AS/2017/w/TZ 1/P1/Exam Q# 37// :o)

37 | B

Q# 834/ Chem 13 AS/2017/w/TZ 1/P1/Exam Q# 21// :o)

21 | A

Q# 835/ Chem 13 AS/2017/w/TZ 1/P1/Exam Q# 20// :o)

20 | C

Q# 836/ Chem 13 AS/2017/s/TZ 1/P1/Exam Q# 6// :o)

6 | A

Q# 837/ Chem 13 AS/2017/s/TZ 1/P1/Exam Q# 37// :o)

37 | B

Q# 838/ Chem 13 AS/2017/s/TZ 1/P1/Exam Q# 21// :o)

21 | D

Q# 839/ Chem 13 AS/2017/s/TZ 1/P1/Exam Q# 16// :o)

16 | C

Q# 840/ Chem 13 AS/2017/m/TZ 2/P1/Exam Q# 21// :o)

21 | D

Q# 841/ Chem 13 AS/2016/w/TZ 1/P1/Exam Q# 36// :o)

36 | B

Q# 842/ Chem 13 AS/2016/w/TZ 1/P1/Exam Q# 21// :o)

21 | A

Q# 843/ Chem 13 AS/2016/w/TZ 1/P1/Exam Q# 20// :o)

20 | B

Q# 844/ Chem 13 AS/2016/s/TZ 1/P1/Exam Q# 20// :o)

20 | D

Q# 845/ Chem 13 AS/2016/s/TZ 1/P1/Exam Q# 19// :o)

19 | C

Q# 846/ Chem 13 AS/2016/m/TZ 2/P1/Exam Q# 21// :o)

21 | B

Q# 847/ Chem 13 AS/2015/w/TZ 1/P1/Exam Q# 9// :o)

9 | B



Q# 848/ Chem 13 AS/2015/w/TZ 1/P1/Exam Q# 29// :o)
29 B

Q# 849/ Chem 13 AS/2015/w/TZ 1/P1/Exam Q# 22// :o)
22 D

Q# 850/ Chem 13 AS/2015/w/TZ 1/P1/Exam Q# 21// :o)
21 C

Q# 851/ Chem 13 AS/2015/s/TZ 1/P1/Exam Q# 37// :o)
37 C

Q# 852/ Chem 13 AS/2015/s/TZ 1/P1/Exam Q# 29// :o)
29 B

Q# 853/ Chem 13 AS/2015/s/TZ 1/P1/Exam Q# 28// :o)
28 A

Q# 854/ Chem 13 AS/2015/s/TZ 1/P1/Exam Q# 10// :o)
10 A

Q# 855/ Chem 13 AS/2014/w/TZ 1/P1/Exam Q# 26// :o)
26 C

Q# 856/ Chem 13 AS/2014/w/TZ 1/P1/Exam Q# 21// :o)
21 D

Q# 857/ Chem 13 AS/2014/s/TZ 1/P1/Exam Q# 9// :o)
9 D

Q# 858/ Chem 13 AS/2014/s/TZ 1/P1/Exam Q# 24// :o)
24 C

Q# 859/ Chem 13 AS/2013/w/TZ 1/P1/Exam Q# 23// :o)
23 B

Q# 860/ Chem 13 AS/2013/s/TZ 1/P1/Exam Q# 30// :o)
30 B

Q# 861/ Chem 13 AS/2013/s/TZ 1/P1/Exam Q# 20// :o)
20 B

Q# 862/ Chem 13 AS/2013/s/TZ 1/P1/Exam Q# 19// :o)
19 C

Q# 863/ Chem 13 AS/2012/w/TZ 1/P1/Exam Q# 22// :o)
22 C

Q# 864/ Chem 13 AS/2012/w/TZ 1/P1/Exam Q# 21// :o)
21 D

Q# 865/ Chem 13 AS/2012/w/TZ 1/P1/Exam Q# 20// :o)
20 D

Q# 866/ Chem 13 AS/2012/s/TZ 1/P1/Exam Q# 37// :o)
37 B

Q# 867/ Chem 13 AS/2011/s/TZ 1/P1/Exam Q# 24// :o)
24 B

Q# 868/ Chem 13 AS/2010/w/TZ 1/P1/Exam Q# 29// :o)
29 C

Q# 869/ Chem 13 AS/2010/s/TZ 1/P1/Exam Q# 38// :o)
38 C

Q# 870/ Chem 13 AS/2010/s/TZ 1/P1/Exam Q# 30// :o)
30 D

Q# 871/ Chem 13 AS/2010/s/TZ 1/P1/Exam Q# 20// :o)
20 C

Q# 872/ Chem 13 AS/2009/w/TZ 1/P1/Exam Q# 22// :o)
22 A

Q# 873/ Chem 13 AS/2009/w/TZ 1/P1/Exam Q# 21// :o)
21 A

Q# 874/ Chem 13 AS/2009/w/TZ 1/P1/Exam Q# 20// :o)
20 D

Q# 875/ Chem 13 AS/2009/s/TZ 1/P1/Exam Q# 20// :o)
20 C

Q# 876/ Chem 13 AS/2009/s/TZ 1/P1/Exam Q# 19// :o)
19 D

Q# 877/ Chem 14 AS/2022/s/TZ 1/P1/Exam Q# 30// :o)
30 A

Q# 878/ Chem 14 AS/2022/m/TZ 2/P1/Exam Q# 28// :o)
28 A

Q# 879/ Chem 14 AS/2022/m/TZ 2/P1/Exam Q# 27// :o)
27 C

Q# 880/ Chem 14 AS/2021/w/TZ 1/P1/Exam Q# 38// :o)
38 D

Q# 881/ Chem 14 AS/2021/w/TZ 1/P1/Exam Q# 37// :o)
37 B

Q# 882/ Chem 14 AS/2021/w/TZ 1/P1/Exam Q# 21// :o)
21 B

Q# 883/ Chem 14 AS/2021/s/TZ 1/P1/Exam Q# 33// :o)
33 D

Q# 884/ Chem 14 AS/2021/s/TZ 1/P1/Exam Q# 29// :o)
29 C

Q# 885/ Chem 14 AS/2021/s/TZ 1/P1/Exam Q# 21// :o)
21 B

Q# 886/ Chem 14 AS/2021/m/TZ 2/P1/Exam Q# 22// :o)
22 D

Q# 887/ Chem 14 AS/2020/w/TZ 1/P1/Exam Q# 21// :o)
21 D

Q# 888/ Chem 14 AS/2020/s/TZ 1/P1/Exam Q# 35// :o)
35 C

Q# 889/ Chem 14 AS/2020/s/TZ 1/P1/Exam Q# 22// :o)
22 C

Q# 890/ Chem 14 AS/2020/m/TZ 2/P1/Exam Q# 40// :o)
40 A

Q# 891/ Chem 14 AS/2019/w/TZ 1/P1/Exam Q# 27// :o)
27 A

Q# 892/ Chem 14 AS/2019/w/TZ 1/P1/Exam Q# 22// :o)
22 D

Q# 893/ Chem 14 AS/2019/w/TZ 1/P1/Exam Q# 21// :o)
21 C

Q# 894/ Chem 14 AS/2019/w/TZ 1/P1/Exam Q# 20// :o)
20 A

Q# 895/ Chem 14 AS/2019/s/TZ 1/P1/Exam Q# 22// :o)
22 B

Q# 896/ Chem 14 AS/2019/m/TZ 2/P1/Exam Q# 22// :o)
22 B

Q# 897/ Chem 14 AS/2018/w/TZ 1/P1/Exam Q# 37// :o)
37 B

Q# 898/ Chem 14 AS/2018/s/TZ 1/P1/Exam Q# 38// :o)
38 C



Q# 899/ Chem 14 AS/2018/m/TZ 2/P1/Exam Q# 22// :o)

22 | A

Q# 900/ Chem 14 AS/2017/w/TZ 1/P1/Exam Q# 22// :o)

22 | A

Q# 901/ Chem 14 AS/2017/s/TZ 1/P1/Exam Q# 22// :o)

22 | B

Q# 902/ Chem 14 AS/2017/m/TZ 2/P1/Exam Q# 37// :o)

37 | A

Q# 903/ Chem 14 AS/2017/m/TZ 2/P1/Exam Q# 23// :o)

23 | C

Q# 904/ Chem 14 AS/2017/m/TZ 2/P1/Exam Q# 20// :o)

20 | D

Q# 905/ Chem 14 AS/2016/w/TZ 1/P1/Exam Q# 37// :o)

37 | A

Q# 906/ Chem 14 AS/2016/s/TZ 1/P1/Exam Q# 23// :o)

23 | B

Q# 907/ Chem 14 AS/2015/w/TZ 1/P1/Exam Q# 23// :o)

23 | B

Q# 908/ Chem 14 AS/2015/s/TZ 1/P1/Exam Q# 23// :o)

23 | A

Q# 909/ Chem 14 AS/2015/s/TZ 1/P1/Exam Q# 22// :o)

22 | A

Q# 910/ Chem 14 AS/2014/w/TZ 1/P1/Exam Q# 30// :o)

30 | B

Q# 911/ Chem 14 AS/2014/w/TZ 1/P1/Exam Q# 29// :o)

29 | D

Q# 912/ Chem 14 AS/2014/w/TZ 1/P1/Exam Q# 20// :o)

20 | A

Q# 913/ Chem 14 AS/2014/s/TZ 1/P1/Exam Q# 27// :o)

27 | D

Q# 914/ Chem 14 AS/2014/s/TZ 1/P1/Exam Q# 26// :o)

26 | A

Q# 915/ Chem 14 AS/2013/w/TZ 1/P1/Exam Q# 7// :o)

7 | B

Q# 916/ Chem 14 AS/2013/s/TZ 1/P1/Exam Q# 37// :o)

37 | C

Q# 917/ Chem 14 AS/2013/s/TZ 1/P1/Exam Q# 25// :o)

25 | A

Q# 918/ Chem 14 AS/2013/s/TZ 1/P1/Exam Q# 22// :o)

22 | D

Q# 919/ Chem 14 AS/2012/w/TZ 1/P1/Exam Q# 37// :o)

37 | D

Q# 920/ Chem 14 AS/2012/w/TZ 1/P1/Exam Q# 23// :o)

23 | C

Q# 921/ Chem 14 AS/2011/w/TZ 1/P1/Exam Q# 29// :o)

29 | D

Q# 922/ Chem 14 AS/2011/w/TZ 1/P1/Exam Q# 27// :o)

27 | D

Q# 923/ Chem 14 AS/2011/w/TZ 1/P1/Exam Q# 26// :o)

26 | D

Q# 924/ Chem 14 AS/2011/s/TZ 1/P1/Exam Q# 38// :o)

38 | C

Q# 925/ Chem 14 AS/2010/w/TZ 1/P1/Exam Q# 25// :o)

25 | D

Q# 926/ Chem 14 AS/2010/s/TZ 1/P1/Exam Q# 21// :o)

21 | C

Q# 927/ Chem 14 AS/2009/w/TZ 1/P1/Exam Q# 26// :o)

26 | B

Q# 928/ Chem 14 AS/2009/w/TZ 1/P1/Exam Q# 25// :o)

25 | D

Q# 929/ Chem 14 AS/2009/w/TZ 1/P1/Exam Q# 24// :o)

24 | A

Q# 930/ Chem 14 AS/2009/s/TZ 1/P1/Exam Q# 37// :o)

37 | B

Q# 931/ Chem 15 AS/2022/w/TZ 1/P1/Exam Q# 37// :o)

37 | D

Q# 932/ Chem 15 AS/2022/s/TZ 1/P1/Exam Q# 32// :o)

32 | C

Q# 933/ Chem 15 AS/2022/s/TZ 1/P1/Exam Q# 31// :o)

31 | C

Q# 934/ Chem 15 AS/2022/m/TZ 2/P1/Exam Q# 30// :o)

30 | A

Q# 935/ Chem 15 AS/2022/m/TZ 2/P1/Exam Q# 29// :o)

29 | B

Q# 936/ Chem 15 AS/2021/w/TZ 1/P1/Exam Q# 23// :o)

23 | B

Q# 937/ Chem 15 AS/2021/w/TZ 1/P1/Exam Q# 22// :o)

22 | D

Q# 938/ Chem 15 AS/2021/s/TZ 1/P1/Exam Q# 37// :o)

37 | A

Q# 939/ Chem 15 AS/2021/s/TZ 1/P1/Exam Q# 20// :o)

20 | A

Q# 940/ Chem 15 AS/2021/m/TZ 2/P1/Exam Q# 37// :o)

37 | B

Q# 941/ Chem 15 AS/2021/m/TZ 2/P1/Exam Q# 25// :o)

25 | A

Q# 942/ Chem 15 AS/2020/w/TZ 1/P1/Exam Q# 25// :o)

25 | D

Q# 943/ Chem 15 AS/2020/w/TZ 1/P1/Exam Q# 23// :o)

23 | D

Q# 944/ Chem 15 AS/2020/s/TZ 1/P1/Exam Q# 27// :o)

27 | B

Q# 945/ Chem 15 AS/2020/s/TZ 1/P1/Exam Q# 23// :o)

23 | B

Q# 946/ Chem 15 AS/2020/m/TZ 2/P1/Exam Q# 21// :o)

21 | B

Q# 947/ Chem 15 AS/2019/w/TZ 1/P1/Exam Q# 24// :o)

24 | B



Q# 948/ Chem 15 AS/2019/w/TZ 1/P1/Exam Q# 23// :o)
23 | C

Q# 949/ Chem 15 AS/2019/s/TZ 1/P1/Exam Q# 23// :o)
23 | D

Q# 950/ Chem 15 AS/2019/m/TZ 2/P1/Exam Q# 24// :o)
24 | B

Q# 951/ Chem 15 AS/2019/m/TZ 2/P1/Exam Q# 23// :o)
23 | C

Q# 952/ Chem 15 AS/2018/w/TZ 1/P1/Exam Q# 38// :o)
38 | C

Q# 953/ Chem 15 AS/2018/w/TZ 1/P1/Exam Q# 25// :o)
25 | B

Q# 954/ Chem 15 AS/2018/w/TZ 1/P1/Exam Q# 23// :o)
23 | B

Q# 955/ Chem 15 AS/2018/w/TZ 1/P1/Exam Q# 20// :o)
20 | B

Q# 956/ Chem 15 AS/2018/s/TZ 1/P1/Exam Q# 22// :o)
22 | A

Q# 957/ Chem 15 AS/2018/m/TZ 2/P1/Exam Q# 38// :o)
38 | B

Q# 958/ Chem 15 AS/2018/m/TZ 2/P1/Exam Q# 27// :o)
27 | B

Q# 959/ Chem 15 AS/2018/m/TZ 2/P1/Exam Q# 21// :o)
21 | A

Q# 960/ Chem 15 AS/2017/w/TZ 1/P1/Exam Q# 38// :o)
38 | D

Q# 961/ Chem 15 AS/2017/w/TZ 1/P1/Exam Q# 31// :o)
31 | B

Q# 962/ Chem 15 AS/2017/w/TZ 1/P1/Exam Q# 24// :o)
24 | B

Q# 963/ Chem 15 AS/2017/s/TZ 1/P1/Exam Q# 38// :o)
38 | D

Q# 964/ Chem 15 AS/2017/m/TZ 2/P1/Exam Q# 38// :o)
38 | C

Q# 965/ Chem 15 AS/2017/m/TZ 2/P1/Exam Q# 22// :o)
22 | A

Q# 966/ Chem 15 AS/2016/w/TZ 1/P1/Exam Q# 38// :o)
38 | C

Q# 967/ Chem 15 AS/2016/s/TZ 1/P1/Exam Q# 36// :o)
36 | A

Q# 968/ Chem 15 AS/2016/s/TZ 1/P1/Exam Q# 25// :o)
25 | B

Q# 969/ Chem 15 AS/2016/m/TZ 2/P1/Exam Q# 25// :o)
25 | B

Q# 970/ Chem 15 AS/2016/m/TZ 2/P1/Exam Q# 24// :o)
24 | D

Q# 971/ Chem 15 AS/2015/w/TZ 1/P1/Exam Q# 24// :o)
24 | C

Q# 972/ Chem 15 AS/2015/s/TZ 1/P1/Exam Q# 26// :o)
26 | C

Q# 973/ Chem 15 AS/2015/s/TZ 1/P1/Exam Q# 25// :o)
25 | D

Q# 974/ Chem 15 AS/2015/s/TZ 1/P1/Exam Q# 24// :o)
24 | D

Q# 975/ Chem 15 AS/2014/w/TZ 1/P1/Exam Q# 40// :o)
40 | D

Q# 976/ Chem 15 AS/2014/w/TZ 1/P1/Exam Q# 38// :o)
38 | D

Q# 977/ Chem 15 AS/2014/w/TZ 1/P1/Exam Q# 25// :o)
25 | D

Q# 978/ Chem 15 AS/2014/w/TZ 1/P1/Exam Q# 22// :o)
21 | D

Q# 979/ Chem 15 AS/2014/s/TZ 1/P1/Exam Q# 23// :o)
23 | B

Q# 980/ Chem 15 AS/2013/w/TZ 1/P1/Exam Q# 37// :o)
37 | B

Q# 981/ Chem 15 AS/2013/w/TZ 1/P1/Exam Q# 24// :o)
24 | A

Q# 982/ Chem 15 AS/2013/s/TZ 1/P1/Exam Q# 24// :o)
24 | A

Q# 983/ Chem 15 AS/2013/s/TZ 1/P1/Exam Q# 23// :o)
23 | D

Q# 984/ Chem 15 AS/2012/s/TZ 1/P1/Exam Q# 40// :o)
40 | D

Q# 985/ Chem 15 AS/2012/s/TZ 1/P1/Exam Q# 27// :o)
27 | D

Q# 986/ Chem 15 AS/2011/w/TZ 1/P1/Exam Q# 40// :o)
40 | C

Q# 987/ Chem 15 AS/2011/w/TZ 1/P1/Exam Q# 24// :o)
24 | A

Q# 988/ Chem 15 AS/2011/s/TZ 1/P1/Exam Q# 39// :o)
39 | A

Q# 989/ Chem 15 AS/2011/s/TZ 1/P1/Exam Q# 22// :o)
22 | A

Q# 990/ Chem 15 AS/2010/w/TZ 1/P1/Exam Q# 28// :o)
28 | C

Q# 991/ Chem 15 AS/2010/s/TZ 1/P1/Exam Q# 39// :o)
39 | A

Q# 992/ Chem 15 AS/2010/s/TZ 1/P1/Exam Q# 28// :o)
28 | D

Q# 993/ Chem 15 AS/2009/w/TZ 1/P1/Exam Q# 37// :o)
37 | A

Q# 994/ Chem 15 AS/2009/s/TZ 1/P1/Exam Q# 24// :o)
24 | D

Q# 995/ Chem 15 AS/2009/s/TZ 1/P1/Exam Q# 21// :o)
21 | B

Q# 996/ Chem 16 AS/2022/w/TZ 1/P1/Exam Q# 26// :o)
26 | B



Q# 997/ Chem 16 AS/2022/s/TZ 1/P1/Exam Q# 34// :o)
34 | D

Q# 998/ Chem 16 AS/2022/m/TZ 2/P1/Exam Q# 31// :o)
31 | C

Q# 999/ Chem 16 AS/2021/w/TZ 1/P1/Exam Q# 40// :o)
40 | A

Q# 1000/ Chem 16 AS/2021/w/TZ 1/P1/Exam Q# 20// :o)
20 | A

Q# 1001/ Chem 16 AS/2021/m/TZ 2/P1/Exam Q# 24// :o)
24 | D

Q# 1002/ Chem 16 AS/2021/m/TZ 2/P1/Exam Q# 21// :o)
21 | C

Q# 1003/ Chem 16 AS/2020/w/TZ 1/P1/Exam Q# 39// :o)
39 | A

Q# 1004/ Chem 16 AS/2020/w/TZ 1/P1/Exam Q# 26// :o)
26 | B

Q# 1005/ Chem 16 AS/2020/s/TZ 1/P1/Exam Q# 25// :o)
25 | C

Q# 1006/ Chem 16 AS/2020/m/TZ 2/P1/Exam Q# 38// :o)
38 | C

Q# 1007/ Chem 16 AS/2020/m/TZ 2/P1/Exam Q# 29// :o)
29 | B

Q# 1008/ Chem 16 AS/2020/m/TZ 2/P1/Exam Q# 26// :o)
26 | C

Q# 1009/ Chem 16 AS/2019/w/TZ 1/P1/Exam Q# 38// :o)
38 | B

Q# 1010/ Chem 16 AS/2019/w/TZ 1/P1/Exam Q# 26// :o)
26 | A

Q# 1011/ Chem 16 AS/2019/w/TZ 1/P1/Exam Q# 25// :o)
25 | C

Q# 1012/ Chem 16 AS/2019/s/TZ 1/P1/Exam Q# 26// :o)
26 | C

Q# 1013/ Chem 16 AS/2019/m/TZ 2/P1/Exam Q# 37// :o)
37 | D

Q# 1014/ Chem 16 AS/2019/m/TZ 2/P1/Exam Q# 26// :o)
26 | D

Q# 1015/ Chem 16 AS/2019/m/TZ 2/P1/Exam Q# 25// :o)
25 | A

Q# 1016/ Chem 16 AS/2018/s/TZ 1/P1/Exam Q# 24// :o)
24 | A

Q# 1017/ Chem 16 AS/2018/s/TZ 1/P1/Exam Q# 23// :o)
23 | B

Q# 1018/ Chem 16 AS/2018/m/TZ 2/P1/Exam Q# 25// :o)
25 | A

Q# 1019/ Chem 16 AS/2018/m/TZ 2/P1/Exam Q# 24// :o)
24 | C

Q# 1020/ Chem 16 AS/2017/s/TZ 1/P1/Exam Q# 28// :o)
28 | C

Q# 1021/ Chem 16 AS/2017/s/TZ 1/P1/Exam Q# 27// :o)
27 | A

Q# 1022/ Chem 16 AS/2017/m/TZ 2/P1/Exam Q# 27// :o)
27 | D

Q# 1023/ Chem 16 AS/2017/m/TZ 2/P1/Exam Q# 26// :o)
26 | C

Q# 1024/ Chem 16 AS/2016/w/TZ 1/P1/Exam Q# 25// :o)
25 | C

Q# 1025/ Chem 16 AS/2016/m/TZ 2/P1/Exam Q# 26// :o)
26 | D

Q# 1026/ Chem 16 AS/2015/w/TZ 1/P1/Exam Q# 26// :o)
26 | A

Q# 1027/ Chem 16 AS/2015/s/TZ 1/P1/Exam Q# 27// :o)
27 | B

Q# 1028/ Chem 16 AS/2014/w/TZ 1/P1/Exam Q# 9// :o)
9 | C

Q# 1029/ Chem 16 AS/2014/w/TZ 1/P1/Exam Q# 24// :o)
24 | C

Q# 1030/ Chem 16 AS/2014/w/TZ 1/P1/Exam Q# 23// :o)
23 | C

Q# 1031/ Chem 16 AS/2014/s/TZ 1/P1/Exam Q# 39// :o)
39 | A

Q# 1032/ Chem 16 AS/2014/s/TZ 1/P1/Exam Q# 28// :o)
28 | C

Q# 1033/ Chem 16 AS/2014/s/TZ 1/P1/Exam Q# 21// :o)
21 | B

Q# 1034/ Chem 16 AS/2013/w/TZ 1/P1/Exam Q# 27// :o)
27 | C

Q# 1035/ Chem 16 AS/2013/w/TZ 1/P1/Exam Q# 25// :o)
25 | B

Q# 1036/ Chem 16 AS/2013/w/TZ 1/P1/Exam Q# 22// :o)
22 | C

Q# 1037/ Chem 16 AS/2013/s/TZ 1/P1/Exam Q# 26// :o)
26 | C

Q# 1038/ Chem 16 AS/2012/w/TZ 1/P1/Exam Q# 38// :o)
38 | B

Q# 1039/ Chem 16 AS/2012/w/TZ 1/P1/Exam Q# 24// :o)
24 | C

Q# 1040/ Chem 16 AS/2012/s/TZ 1/P1/Exam Q# 38// :o)
38 | A

Q# 1041/ Chem 16 AS/2012/s/TZ 1/P1/Exam Q# 20// :o)
20 | D

Q# 1042/ Chem 16 AS/2012/s/TZ 1/P1/Exam Q# 12// :o)
12 | C

Q# 1043/ Chem 16 AS/2011/w/TZ 1/P1/Exam Q# 28// :o)
28 | C

Q# 1044/ Chem 16 AS/2011/w/TZ 1/P1/Exam Q# 25// :o)
25 | C



Q# 1045/ Chem 16 AS/2011/w/TZ 1/P1/Exam Q# 20// :o)
20 | C

Q# 1046/ Chem 16 AS/2011/s/TZ 1/P1/Exam Q# 40// :o)
40 | A

Q# 1047/ Chem 16 AS/2011/s/TZ 1/P1/Exam Q# 31// :o)
31 | D

Q# 1048/ Chem 16 AS/2011/s/TZ 1/P1/Exam Q# 25// :o)
25 | B

Q# 1049/ Chem 16 AS/2011/s/TZ 1/P1/Exam Q# 23// :o)
23 | B

Q# 1050/ Chem 16 AS/2011/s/TZ 1/P1/Exam Q# 19// :o)
19 | C

Q# 1051/ Chem 16 AS/2010/w/TZ 1/P1/Exam Q# 37// :o)
37 | D

Q# 1052/ Chem 16 AS/2010/w/TZ 1/P1/Exam Q# 24// :o)
24 | B

Q# 1053/ Chem 16 AS/2010/s/TZ 1/P1/Exam Q# 29// :o)
29 | B

Q# 1054/ Chem 16 AS/2010/s/TZ 1/P1/Exam Q# 22// :o)
22 | B

Q# 1055/ Chem 16 AS/2009/s/TZ 1/P1/Exam Q# 29// :o)
29 | D

Q# 1056/ Chem 17 AS/2022/w/TZ 1/P1/Exam Q# 33// :o)
33 | A

Q# 1057/ Chem 17 AS/2022/s/TZ 1/P1/Exam Q# 36// :o)
36 | D

Q# 1058/ Chem 17 AS/2022/s/TZ 1/P1/Exam Q# 35// :o)
35 | B

Q# 1059/ Chem 17 AS/2022/m/TZ 2/P1/Exam Q# 33// :o)
33 | D

Q# 1060/ Chem 17 AS/2021/w/TZ 1/P1/Exam Q# 27// :o)
27 | A

Q# 1061/ Chem 17 AS/2021/w/TZ 1/P1/Exam Q# 25// :o)
25 | A

Q# 1062/ Chem 17 AS/2021/s/TZ 1/P1/Exam Q# 39// :o)
39 | D

Q# 1063/ Chem 17 AS/2021/s/TZ 1/P1/Exam Q# 38// :o)
38 | B

Q# 1064/ Chem 17 AS/2021/s/TZ 1/P1/Exam Q# 28// :o)
28 | B

Q# 1065/ Chem 17 AS/2021/m/TZ 2/P1/Exam Q# 39// :o)
40 | B

Q# 1066/ Chem 17 AS/2021/m/TZ 2/P1/Exam Q# 28// :o)
28 | D

Q# 1067/ Chem 17 AS/2021/m/TZ 2/P1/Exam Q# 26// :o)
26 | C

Q# 1068/ Chem 17 AS/2020/w/TZ 1/P1/Exam Q# 28// :o)
28 | A

Q# 1069/ Chem 17 AS/2020/w/TZ 1/P1/Exam Q# 27// :o)
27 | C

Q# 1070/ Chem 17 AS/2020/s/TZ 1/P1/Exam Q# 38// :o)
38 | B

Q# 1071/ Chem 17 AS/2020/s/TZ 1/P1/Exam Q# 37// :o)
37 | C

Q# 1072/ Chem 17 AS/2020/s/TZ 1/P1/Exam Q# 20// :o)
20 | A

Q# 1073/ Chem 17 AS/2020/m/TZ 2/P1/Exam Q# 37// :o)
37 | A

Q# 1074/ Chem 17 AS/2020/m/TZ 2/P1/Exam Q# 28// :o)
28 | D

Q# 1075/ Chem 17 AS/2019/w/TZ 1/P1/Exam Q# 39// :o)
39 | A

Q# 1076/ Chem 17 AS/2019/s/TZ 1/P1/Exam Q# 38// :o)
38 | B

Q# 1077/ Chem 17 AS/2019/s/TZ 1/P1/Exam Q# 29// :o)
29 | A

Q# 1078/ Chem 17 AS/2019/s/TZ 1/P1/Exam Q# 28// :o)
28 | A

Q# 1079/ Chem 17 AS/2019/s/TZ 1/P1/Exam Q# 27// :o)
27 | A

Q# 1080/ Chem 17 AS/2019/m/TZ 2/P1/Exam Q# 39// :o)
39 | A

Q# 1081/ Chem 17 AS/2019/m/TZ 2/P1/Exam Q# 28// :o)
28 | D

Q# 1082/ Chem 17 AS/2019/m/TZ 2/P1/Exam Q# 27// :o)
27 | C

Q# 1083/ Chem 17 AS/2018/w/TZ 1/P1/Exam Q# 40// :o)
40 | B

Q# 1084/ Chem 17 AS/2018/w/TZ 1/P1/Exam Q# 27// :o)
27 | A

Q# 1085/ Chem 17 AS/2018/s/TZ 1/P1/Exam Q# 40// :o)
40 | A

Q# 1086/ Chem 17 AS/2018/s/TZ 1/P1/Exam Q# 26// :o)
26 | B

Q# 1087/ Chem 17 AS/2018/s/TZ 1/P1/Exam Q# 25// :o)
25 | C

Q# 1088/ Chem 17 AS/2018/m/TZ 2/P1/Exam Q# 39// :o)
39 | A

Q# 1089/ Chem 17 AS/2018/m/TZ 2/P1/Exam Q# 26// :o)
26 | A

Q# 1090/ Chem 17 AS/2018/m/TZ 2/P1/Exam Q# 23// :o)
23 | A

Q# 1091/ Chem 17 AS/2017/w/TZ 1/P1/Exam Q# 40// :o)
40 | A

Q# 1092/ Chem 17 AS/2017/w/TZ 1/P1/Exam Q# 39// :o)
39 | C



Q# 1093/ Chem 17 AS/2017/w/TZ 1/P1/Exam Q# 27// :o)
27 | C

Q# 1094/ Chem 17 AS/2017/w/TZ 1/P1/Exam Q# 26// :o)
26 | B

Q# 1095/ Chem 17 AS/2017/s/TZ 1/P1/Exam Q# 29// :o)
29 | A

Q# 1096/ Chem 17 AS/2017/s/TZ 1/P1/Exam Q# 25// :o)
25 | D

Q# 1097/ Chem 17 AS/2017/s/TZ 1/P1/Exam Q# 20// :o)
20 | B

Q# 1098/ Chem 17 AS/2017/m/TZ 2/P1/Exam Q# 39// :o)
39 | A

Q# 1099/ Chem 17 AS/2017/m/TZ 2/P1/Exam Q# 29// :o)
29 | B

Q# 1100/ Chem 17 AS/2017/m/TZ 2/P1/Exam Q# 28// :o)
28 | D

Q# 1101/ Chem 17 AS/2016/w/TZ 1/P1/Exam Q# 40// :o)
40 | B

Q# 1102/ Chem 17 AS/2016/w/TZ 1/P1/Exam Q# 27// :o)
27 | B

Q# 1103/ Chem 17 AS/2016/s/TZ 1/P1/Exam Q# 28// :o)
28 | B

Q# 1104/ Chem 17 AS/2016/s/TZ 1/P1/Exam Q# 24// :o)
24 | A

Q# 1105/ Chem 17 AS/2016/m/TZ 2/P1/Exam Q# 20// :o)
20 | D

Q# 1106/ Chem 17 AS/2015/w/TZ 1/P1/Exam Q# 28// :o)
28 | B

Q# 1107/ Chem 17 AS/2015/s/TZ 1/P1/Exam Q# 20// :o)
20 | C

Q# 1108/ Chem 17 AS/2014/w/TZ 1/P1/Exam Q# 37// :o)
37 | B

Q# 1109/ Chem 17 AS/2014/s/TZ 1/P1/Exam Q# 25// :o)
25 | D

Q# 1110/ Chem 17 AS/2013/s/TZ 1/P1/Exam Q# 38// :o)
38 | B

Q# 1111/ Chem 17 AS/2012/w/TZ 1/P1/Exam Q# 28// :o)
28 | C

Q# 1112/ Chem 17 AS/2012/s/TZ 1/P1/Exam Q# 26// :o)
26 | C

Q# 1113/ Chem 17 AS/2012/s/TZ 1/P1/Exam Q# 25// :o)
25 | A

Q# 1114/ Chem 17 AS/2011/w/TZ 1/P1/Exam Q# 38// :o)
38 | B

Q# 1115/ Chem 17 AS/2011/w/TZ 1/P1/Exam Q# 37// :o)
37 | B

Q# 1116/ Chem 17 AS/2011/w/TZ 1/P1/Exam Q# 33// :o)
33 | B

Q# 1117/ Chem 17 AS/2011/s/TZ 1/P1/Exam Q# 29// :o)
29 | B

Q# 1118/ Chem 17 AS/2011/s/TZ 1/P1/Exam Q# 28// :o)
28 | B

Q# 1119/ Chem 17 AS/2011/s/TZ 1/P1/Exam Q# 26// :o)
26 | D

Q# 1120/ Chem 17 AS/2010/s/TZ 1/P1/Exam Q# 24// :o)
24 | C

Q# 1121/ Chem 17 AS/2010/s/TZ 1/P1/Exam Q# 23// :o)
23 | D

Q# 1122/ Chem 17 AS/2009/w/TZ 1/P1/Exam Q# 40// :o)
40 | C

Q# 1123/ Chem 17 AS/2009/s/TZ 1/P1/Exam Q# 26// :o)
26 | A

Q# 1124/ Chem 18 AS/2022/w/TZ 1/P1/Exam Q# 36// :o)
36 | D

Q# 1125/ Chem 18 AS/2022/w/TZ 1/P1/Exam Q# 32// :o)
32 | A

Q# 1126/ Chem 18 AS/2022/s/TZ 1/P1/Exam Q# 38// :o)
37 | B

Q# 1127/ Chem 18 AS/2022/s/TZ 1/P1/Exam Q# 37// :o)
37 | B

Q# 1128/ Chem 18 AS/2022/s/TZ 1/P1/Exam Q# 28// :o)
26 | C

Q# 1129/ Chem 18 AS/2022/s/TZ 1/P1/Exam Q# 27// :o)
26 | C

Q# 1130/ Chem 18 AS/2022/m/TZ 2/P1/Exam Q# 35// :o)
35 | A

Q# 1131/ Chem 18 AS/2022/m/TZ 2/P1/Exam Q# 34// :o)
34 | C

Q# 1132/ Chem 18 AS/2022/m/TZ 2/P1/Exam Q# 32// :o)
32 | A

Q# 1133/ Chem 18 AS/2021/w/TZ 1/P1/Exam Q# 29// :o)
29 | B

Q# 1134/ Chem 18 AS/2021/w/TZ 1/P1/Exam Q# 28// :o)
28 | C

Q# 1135/ Chem 18 AS/2021/w/TZ 1/P1/Exam Q# 24// :o)
24 | C

Q# 1136/ Chem 18 AS/2021/s/TZ 1/P1/Exam Q# 27// :o)
27 | C

Q# 1137/ Chem 18 AS/2021/s/TZ 1/P1/Exam Q# 24// :o)
24 | D

Q# 1138/ Chem 18 AS/2021/m/TZ 2/P1/Exam Q# 40// :o)
40 | B

Q# 1139/ Chem 18 AS/2021/m/TZ 2/P1/Exam Q# 29// :o)
29 | C

Q# 1140/ Chem 18 AS/2021/m/TZ 2/P1/Exam Q# 23// :o)
23 | A



Q# 1141/ Chem 18 AS/2020/w/TZ 1/P1/Exam Q# 40// :o)

40 | B

Q# 1142/ Chem 18 AS/2020/w/TZ 1/P1/Exam Q# 29// :o)

29 | D

Q# 1143/ Chem 18 AS/2020/s/TZ 1/P1/Exam Q# 30// :o)

30 | A

Q# 1144/ Chem 18 AS/2020/s/TZ 1/P1/Exam Q# 26// :o)

26 | D

Q# 1145/ Chem 18 AS/2020/m/TZ 2/P1/Exam Q# 22// :o)

22 | B

Q# 1146/ Chem 18 AS/2019/w/TZ 1/P1/Exam Q# 40// :o)

40 | D

Q# 1147/ Chem 18 AS/2019/w/TZ 1/P1/Exam Q# 29// :o)

29 | C

Q# 1148/ Chem 18 AS/2019/w/TZ 1/P1/Exam Q# 28// :o)

28 | B

Q# 1149/ Chem 18 AS/2019/s/TZ 1/P1/Exam Q# 40// :o)

40 | C

Q# 1150/ Chem 18 AS/2019/s/TZ 1/P1/Exam Q# 39// :o)

39 | C

Q# 1151/ Chem 18 AS/2019/m/TZ 2/P1/Exam Q# 40// :o)

40 | C

Q# 1152/ Chem 18 AS/2019/m/TZ 2/P1/Exam Q# 29// :o)

29 | D

Q# 1153/ Chem 18 AS/2018/w/TZ 1/P1/Exam Q# 29// :o)

29 | C

Q# 1154/ Chem 18 AS/2018/w/TZ 1/P1/Exam Q# 28// :o)

28 | B

Q# 1155/ Chem 18 AS/2018/w/TZ 1/P1/Exam Q# 26// :o)

26 | D

Q# 1156/ Chem 18 AS/2018/w/TZ 1/P1/Exam Q# 24// :o)

24 | D

Q# 1157/ Chem 18 AS/2018/s/TZ 1/P1/Exam Q# 29// :o)

29 | C

Q# 1158/ Chem 18 AS/2018/s/TZ 1/P1/Exam Q# 28// :o)

28 | A

Q# 1159/ Chem 18 AS/2018/s/TZ 1/P1/Exam Q# 27// :o)

27 | A

Q# 1160/ Chem 18 AS/2018/m/TZ 2/P1/Exam Q# 40// :o)

40 | B

Q# 1161/ Chem 18 AS/2018/m/TZ 2/P1/Exam Q# 29// :o)

29 | C

Q# 1162/ Chem 18 AS/2018/m/TZ 2/P1/Exam Q# 28// :o)

28 | D

Q# 1163/ Chem 18 AS/2017/w/TZ 1/P1/Exam Q# 30// :o)

30 | C

Q# 1164/ Chem 18 AS/2017/w/TZ 1/P1/Exam Q# 28// :o)

28 | B

Q# 1165/ Chem 18 AS/2017/s/TZ 1/P1/Exam Q# 40// :o)

40 | A

Q# 1166/ Chem 18 AS/2017/s/TZ 1/P1/Exam Q# 24// :o)

24 | C

Q# 1167/ Chem 18 AS/2017/m/TZ 2/P1/Exam Q# 40// :o)

40 | A

Q# 1168/ Chem 18 AS/2017/m/TZ 2/P1/Exam Q# 30// :o)

30 | C

Q# 1169/ Chem 18 AS/2016/w/TZ 1/P1/Exam Q# 39// :o)

39 | D

Q# 1170/ Chem 18 AS/2016/w/TZ 1/P1/Exam Q# 30// :o)

30 | B

Q# 1171/ Chem 18 AS/2016/w/TZ 1/P1/Exam Q# 29// :o)

29 | A

Q# 1172/ Chem 18 AS/2016/s/TZ 1/P1/Exam Q# 29// :o)

29 | A

Q# 1173/ Chem 18 AS/2016/s/TZ 1/P1/Exam Q# 27// :o)

27 | B

Q# 1174/ Chem 18 AS/2016/s/TZ 1/P1/Exam Q# 26// :o)

26 | C

Q# 1175/ Chem 18 AS/2016/s/TZ 1/P1/Exam Q# 21// :o)

21 | D

Q# 1176/ Chem 18 AS/2016/m/TZ 2/P1/Exam Q# 39// :o)

39 | A

Q# 1177/ Chem 18 AS/2016/m/TZ 2/P1/Exam Q# 37// :o)

37 | C

Q# 1178/ Chem 18 AS/2016/m/TZ 2/P1/Exam Q# 30// :o)

30 | B

Q# 1179/ Chem 18 AS/2016/m/TZ 2/P1/Exam Q# 28// :o)

28 | C

Q# 1180/ Chem 18 AS/2016/m/TZ 2/P1/Exam Q# 27// :o)

27 | D

Q# 1181/ Chem 18 AS/2015/w/TZ 1/P1/Exam Q# 39// :o)

39 | D

Q# 1182/ Chem 18 AS/2015/w/TZ 1/P1/Exam Q# 37// :o)

37 | C

Q# 1183/ Chem 18 AS/2015/w/TZ 1/P1/Exam Q# 30// :o)

30 | B

Q# 1184/ Chem 18 AS/2015/w/TZ 1/P1/Exam Q# 20// :o)

20 | C

Q# 1185/ Chem 18 AS/2015/s/TZ 1/P1/Exam Q# 40// :o)

40 | C

Q# 1186/ Chem 18 AS/2015/s/TZ 1/P1/Exam Q# 38// :o)

38 | C

Q# 1187/ Chem 18 AS/2014/w/TZ 1/P1/Exam Q# 28// :o)

28 | C

Q# 1188/ Chem 18 AS/2014/w/TZ 1/P1/Exam Q# 27// :o)

27 | A

Q# 1189/ Chem 18 AS/2014/s/TZ 1/P1/Exam Q# 40// :o)

40 | A



Q# 1190/ Chem 18 AS/2014/s/TZ 1/P1/Exam Q# 38// :o)
38 B

Q# 1191/ Chem 18 AS/2014/s/TZ 1/P1/Exam Q# 22// :o)
22 C

Q# 1192/ Chem 18 AS/2013/w/TZ 1/P1/Exam Q# 29// :o)
29 D

Q# 1193/ Chem 18 AS/2013/w/TZ 1/P1/Exam Q# 26// :o)
26 B

Q# 1194/ Chem 18 AS/2013/s/TZ 1/P1/Exam Q# 6// :o)
6 C

Q# 1195/ Chem 18 AS/2013/s/TZ 1/P1/Exam Q# 40// :o)
40 C

Q# 1196/ Chem 18 AS/2013/s/TZ 1/P1/Exam Q# 39// :o)
39 B

Q# 1197/ Chem 18 AS/2013/s/TZ 1/P1/Exam Q# 28// :o)
28 D

Q# 1198/ Chem 18 AS/2012/w/TZ 1/P1/Exam Q# 30// :o)
30 B

Q# 1199/ Chem 18 AS/2012/w/TZ 1/P1/Exam Q# 27// :o)
27 B

Q# 1200/ Chem 18 AS/2012/s/TZ 1/P1/Exam Q# 24// :o)
24 C

Q# 1201/ Chem 18 AS/2012/s/TZ 1/P1/Exam Q# 23// :o)
23 B

Q# 1202/ Chem 18 AS/2012/s/TZ 1/P1/Exam Q# 22// :o)
22 A

Q# 1203/ Chem 18 AS/2012/s/TZ 1/P1/Exam Q# 21// :o)
21 C

Q# 1204/ Chem 18 AS/2011/w/TZ 1/P1/Exam Q# 30// :o)
30 C

Q# 1205/ Chem 18 AS/2011/w/TZ 1/P1/Exam Q# 22// :o)
22 A

Q# 1206/ Chem 18 AS/2011/s/TZ 1/P1/Exam Q# 27// :o)
27 D

Q# 1207/ Chem 18 AS/2010/w/TZ 1/P1/Exam Q# 26// :o)
26 D

Q# 1208/ Chem 18 AS/2010/w/TZ 1/P1/Exam Q# 22// :o)
22 A

Q# 1209/ Chem 18 AS/2010/w/TZ 1/P1/Exam Q# 21// :o)
21 D

Q# 1210/ Chem 18 AS/2010/s/TZ 1/P1/Exam Q# 34// :o)
34 B

Q# 1211/ Chem 18 AS/2010/s/TZ 1/P1/Exam Q# 25// :o)
25 B

Q# 1212/ Chem 18 AS/2009/w/TZ 1/P1/Exam Q# 30// :o)
30 D

Q# 1213/ Chem 18 AS/2009/w/TZ 1/P1/Exam Q# 29// :o)
29 B

Q# 1214/ Chem 18 AS/2009/w/TZ 1/P1/Exam Q# 28// :o)
28 C

Q# 1215/ Chem 18 AS/2009/s/TZ 1/P1/Exam Q# 40// :o)
40 B

Q# 1216/ Chem 18 AS/2009/s/TZ 1/P1/Exam Q# 30// :o)
30 D

Q# 1217/ Chem 18 AS/2009/s/TZ 1/P1/Exam Q# 27// :o)
27 B

Q# 1218/ Chem 19 AS/2022/w/TZ 1/P1/Exam Q# 34// :o)
34 B

Q# 1219/ Chem 19 AS/2021/w/TZ 1/P1/Exam Q# 26// :o)
26 D

Q# 1220/ Chem 19 AS/2018/m/TZ 2/P1/Exam Q# 36// :o)
36 A

Q# 1221/ Chem 19 AS/2018/m/TZ 2/P1/Exam Q# 19// :o)
19 C

Q# 1222/ Chem 19 AS/2017/s/TZ 1/P1/Exam Q# 26// :o)
26 C

Q# 1223/ Chem 19 AS/2017/m/TZ 2/P1/Exam Q# 19// :o)
19 D

Q# 1224/ Chem 19 AS/2016/w/TZ 1/P1/Exam Q# 26// :o)
26 D

Q# 1225/ Chem 19 AS/2016/w/TZ 1/P1/Exam Q# 24// :o)
24 D

Q# 1226/ Chem 19 AS/2011/s/TZ 1/P1/Exam Q# 21// :o)
21 C

Q# 1227/ Chem 19 AS/2009/s/TZ 1/P1/Exam Q# 39// :o)
39 C

Q# 1228/ Chem 20 AS/2022/w/TZ 1/P1/Exam Q# 39// :o)
39 C

Q# 1229/ Chem 20 AS/2022/s/TZ 1/P1/Exam Q# 5// :o)
5 D

Q# 1230/ Chem 20 AS/2022/s/TZ 1/P1/Exam Q# 39// :o)
39 D

Q# 1231/ Chem 20 AS/2022/m/TZ 2/P1/Exam Q# 37// :o)
37 B

Q# 1232/ Chem 20 AS/2020/w/TZ 1/P1/Exam Q# 22// :o)
22 A

Q# 1233/ Chem 20 AS/2020/s/TZ 1/P1/Exam Q# 40// :o)
40 A

Q# 1234/ Chem 20 AS/2020/s/TZ 1/P1/Exam Q# 24// :o)
24 A

Q# 1235/ Chem 20 AS/2020/m/TZ 2/P1/Exam Q# 24// :o)
24 A

Q# 1236/ Chem 20 AS/2019/s/TZ 1/P1/Exam Q# 37// :o)
37 A

Q# 1237/ Chem 20 AS/2018/s/TZ 1/P1/Exam Q# 37// :o)
37 C

Q# 1238/ Chem 20 AS/2018/m/TZ 2/P1/Exam Q# 37// :o)
37 A

Q# 1239/ Chem 20 AS/2017/w/TZ 1/P1/Exam Q# 3// :o)
3 D



Q# 1240/ Chem 20 AS/2017/w/TZ 1/P1/Exam Q# 23// :o)

23 | B

Q# 1241/ Chem 20 AS/2017/s/TZ 1/P1/Exam Q# 23// :o)

23 | B

Q# 1242/ Chem 20 AS/2017/m/TZ 2/P1/Exam Q# 24// :o)

24 | B

Q# 1243/ Chem 20 AS/2016/w/TZ 1/P1/Exam Q# 22// :o)

22 | D

Q# 1244/ Chem 20 AS/2016/s/TZ 1/P1/Exam Q# 40// :o)

40 | B

Q# 1245/ Chem 20 AS/2016/s/TZ 1/P1/Exam Q# 38// :o)

38 | B

Q# 1246/ Chem 20 AS/2016/m/TZ 2/P1/Exam Q# 29// :o)

29 | A

Q# 1247/ Chem 20 AS/2016/m/TZ 2/P1/Exam Q# 22// :o)

22 | B

Q# 1248/ Chem 20 AS/2013/w/TZ 1/P1/Exam Q# 30// :o)

30 | A

Q# 1249/ Chem 20 AS/2013/s/TZ 1/P1/Exam Q# 29// :o)

29 | B

Q# 1250/ Chem 20 AS/2012/s/TZ 1/P1/Exam Q# 30// :o)

30 | D

Q# 1251/ Chem 20 AS/2010/w/TZ 1/P1/Exam Q# 20// :o)

20 | C

Q# 1252/ Chem 20 AS/2010/s/TZ 1/P1/Exam Q# 26// :o)

26 | D

Q# 1253/ Chem 20 AS/2009/w/TZ 1/P1/Exam Q# 31// :o)

31 | C

Q# 1254/ Chem 20 AS/2009/s/TZ 1/P1/Exam Q# 23// :o)

23 | B

Q# 1255/ Chem 21 AS/2022/w/TZ 1/P1/Exam Q# 38// :o)

38 | B

Q# 1256/ Chem 21 AS/2022/w/TZ 1/P1/Exam Q# 31// :o)

31 | C

Q# 1257/ Chem 21 AS/2022/w/TZ 1/P1/Exam Q# 30// :o)

30 | A

Q# 1258/ Chem 21 AS/2022/w/TZ 1/P1/Exam Q# 29// :o)

29 | D

Q# 1259/ Chem 21 AS/2022/w/TZ 1/P1/Exam Q# 28// :o)

28 | A

Q# 1260/ Chem 21 AS/2022/s/TZ 1/P1/Exam Q# 26// :o)

26 | C

Q# 1261/ Chem 21 AS/2022/m/TZ 2/P1/Exam Q# 38// :o)

38 | C

Q# 1262/ Chem 21 AS/2021/s/TZ 1/P1/Exam Q# 30// :o)

30 | D

Q# 1263/ Chem 21 AS/2021/s/TZ 1/P1/Exam Q# 25// :o)

25 | A

Q# 1264/ Chem 21 AS/2021/m/TZ 2/P1/Exam Q# 27// :o)

27 | A

Q# 1265/ Chem 21 AS/2020/w/TZ 1/P1/Exam Q# 24// :o)

24 | C

Q# 1266/ Chem 21 AS/2018/w/TZ 1/P1/Exam Q# 39// :o)

39 | A

Q# 1267/ Chem 21 AS/2017/w/TZ 1/P1/Exam Q# 29// :o)

29 | D

Q# 1268/ Chem 21 AS/2017/w/TZ 1/P1/Exam Q# 25// :o)

25 | A

Q# 1269/ Chem 21 AS/2017/s/TZ 1/P1/Exam Q# 39// :o)

39 | B

Q# 1270/ Chem 21 AS/2017/s/TZ 1/P1/Exam Q# 30// :o)

30 | B

Q# 1271/ Chem 21 AS/2017/m/TZ 2/P1/Exam Q# 25// :o)

25 | A

Q# 1272/ Chem 21 AS/2016/w/TZ 1/P1/Exam Q# 28// :o)

28 | A

Q# 1273/ Chem 21 AS/2016/w/TZ 1/P1/Exam Q# 23// :o)

23 | A

Q# 1274/ Chem 21 AS/2016/s/TZ 1/P1/Exam Q# 39// :o)

39 | B

Q# 1275/ Chem 21 AS/2016/s/TZ 1/P1/Exam Q# 30// :o)

30 | A

Q# 1276/ Chem 21 AS/2016/s/TZ 1/P1/Exam Q# 22// :o)

22 | A

Q# 1277/ Chem 21 AS/2016/m/TZ 2/P1/Exam Q# 40// :o)

40 | C

Q# 1278/ Chem 21 AS/2016/m/TZ 2/P1/Exam Q# 23// :o)

23 | C

Q# 1279/ Chem 21 AS/2015/w/TZ 1/P1/Exam Q# 38// :o)

38 | C

Q# 1280/ Chem 21 AS/2015/w/TZ 1/P1/Exam Q# 27// :o)

27 | D

Q# 1281/ Chem 21 AS/2015/w/TZ 1/P1/Exam Q# 25// :o)

25 | D

Q# 1282/ Chem 21 AS/2015/s/TZ 1/P1/Exam Q# 39// :o)

39 | A

Q# 1283/ Chem 21 AS/2014/w/TZ 1/P1/Exam Q# 39// :o)

39 | B

Q# 1284/ Chem 21 AS/2014/s/TZ 1/P1/Exam Q# 37// :o)

37 | C

Q# 1285/ Chem 21 AS/2014/s/TZ 1/P1/Exam Q# 30// :o)

30 | A

Q# 1286/ Chem 21 AS/2014/s/TZ 1/P1/Exam Q# 20// :o)

20 | A

Q# 1287/ Chem 21 AS/2013/w/TZ 1/P1/Exam Q# 40// :o)

40 | D

Q# 1288/ Chem 21 AS/2013/w/TZ 1/P1/Exam Q# 39// :o)

39 | A



Q# 1289/ Chem 21 AS/2013/w/TZ 1/P1/Exam Q# 38// :o)
38 A

Q# 1290/ Chem 21 AS/2013/w/TZ 1/P1/Exam Q# 28// :o)
28 B

Q# 1291/ Chem 21 AS/2013/w/TZ 1/P1/Exam Q# 21// :o)
21 C

Q# 1292/ Chem 21 AS/2013/w/TZ 1/P1/Exam Q# 20// :o)
20 B

Q# 1293/ Chem 21 AS/2013/s/TZ 1/P1/Exam Q# 27// :o)
27 A

Q# 1294/ Chem 21 AS/2013/s/TZ 1/P1/Exam Q# 21// :o)
21 B

Q# 1295/ Chem 21 AS/2012/w/TZ 1/P1/Exam Q# 40// :o)
40 D

Q# 1296/ Chem 21 AS/2012/w/TZ 1/P1/Exam Q# 39// :o)
39 C

Q# 1297/ Chem 21 AS/2012/w/TZ 1/P1/Exam Q# 29// :o)
29 A

Q# 1298/ Chem 21 AS/2012/s/TZ 1/P1/Exam Q# 39// :o)
39 C

Q# 1299/ Chem 21 AS/2012/s/TZ 1/P1/Exam Q# 28// :o)
28 B

Q# 1300/ Chem 21 AS/2011/w/TZ 1/P1/Exam Q# 39// :o)
39 D

Q# 1301/ Chem 21 AS/2011/w/TZ 1/P1/Exam Q# 23// :o)
23 D

Q# 1302/ Chem 21 AS/2011/s/TZ 1/P1/Exam Q# 30// :o)
30 D

Q# 1303/ Chem 21 AS/2011/s/TZ 1/P1/Exam Q# 20// :o)
20 C

Q# 1304/ Chem 21 AS/2010/w/TZ 1/P1/Exam Q# 39// :o)
39 B

Q# 1305/ Chem 21 AS/2010/w/TZ 1/P1/Exam Q# 38// :o)
38 B

Q# 1306/ Chem 21 AS/2010/w/TZ 1/P1/Exam Q# 27// :o)
27 B

Q# 1307/ Chem 21 AS/2010/w/TZ 1/P1/Exam Q# 23// :o)
23 B

Q# 1308/ Chem 21 AS/2010/s/TZ 1/P1/Exam Q# 40// :o)
40 B

Q# 1309/ Chem 21 AS/2010/s/TZ 1/P1/Exam Q# 37// :o)
37 A

Q# 1310/ Chem 21 AS/2009/w/TZ 1/P1/Exam Q# 39// :o)
39 C

Q# 1311/ Chem 21 AS/2009/w/TZ 1/P1/Exam Q# 27// :o)
27 B

Q# 1312/ Chem 21 AS/2009/w/TZ 1/P1/Exam Q# 23// :o)
23 C

Q# 1313/ Chem 21 AS/2009/s/TZ 1/P1/Exam Q# 6// :o)
6 D

Q# 1314/ Chem 21 AS/2009/s/TZ 1/P1/Exam Q# 38// :o)
38 B

Q# 1315/ Chem 21 AS/2009/s/TZ 1/P1/Exam Q# 28// :o)
28 C

Q# 1316/ Chem 21 AS/2009/s/TZ 1/P1/Exam Q# 25// :o)
25 B

Q# 1317/ Chem 22 AS/2022/w/TZ 1/P1/Exam Q# 40// :o)
40 D

Q# 1318/ Chem 22 AS/2022/s/TZ 1/P1/Exam Q# 40// :o)
40 A

Q# 1319/ Chem 22 AS/2022/m/TZ 2/P1/Exam Q# 40// :o)
40 B

Q# 1320/ Chem 22 AS/2021/w/TZ 1/P1/Exam Q# 30// :o)
30 B

Q# 1321/ Chem 22 AS/2021/w/TZ 1/P1/Exam Q# 1// :o)
1 A

Q# 1322/ Chem 22 AS/2021/s/TZ 1/P1/Exam Q# 26// :o)
26 A

Q# 1323/ Chem 22 AS/2021/m/TZ 2/P1/Exam Q# 38// :o)
38 B

Q# 1324/ Chem 22 AS/2021/m/TZ 2/P1/Exam Q# 30// :o)
30 B

Q# 1325/ Chem 22 AS/2020/w/TZ 1/P1/Exam Q# 37// :o)
37 B

Q# 1326/ Chem 22 AS/2020/s/TZ 1/P1/Exam Q# 29// :o)
29 A

Q# 1327/ Chem 22 AS/2020/m/TZ 2/P1/Exam Q# 27// :o)
27 A

Q# 1328/ Chem 22 AS/2020/m/TZ 2/P1/Exam Q# 23// :o)
23 C

Q# 1329/ Chem 22 AS/2019/w/TZ 1/P1/Exam Q# 30// :o)
30 D

Q# 1330/ Chem 22 AS/2019/s/TZ 1/P1/Exam Q# 24// :o)
24 B

Q# 1331/ Chem 22 AS/2019/s/TZ 1/P1/Exam Q# 2// :o)
2 D

Q# 1332/ Chem 22 AS/2019/m/TZ 2/P1/Exam Q# 30// :o)
30 C

Q# 1333/ Chem 22 AS/2018/w/TZ 1/P1/Exam Q# 30// :o)
30 C

Q# 1334/ Chem 22 AS/2018/s/TZ 1/P1/Exam Q# 30// :o)
30 C

Q# 1335/ Chem 22 AS/2018/m/TZ 2/P1/Exam Q# 30// :o)
30 B

Q# 1336/ Chem 22 AS/2017/s/TZ 1/P1/Exam Q# 31// :o)
31 B

Q# 1337/ Chem 22 AS/2016/w/TZ 1/P1/Exam Q# 31// :o)
31 B



Learning to Learn

Reading to Learn Effectively

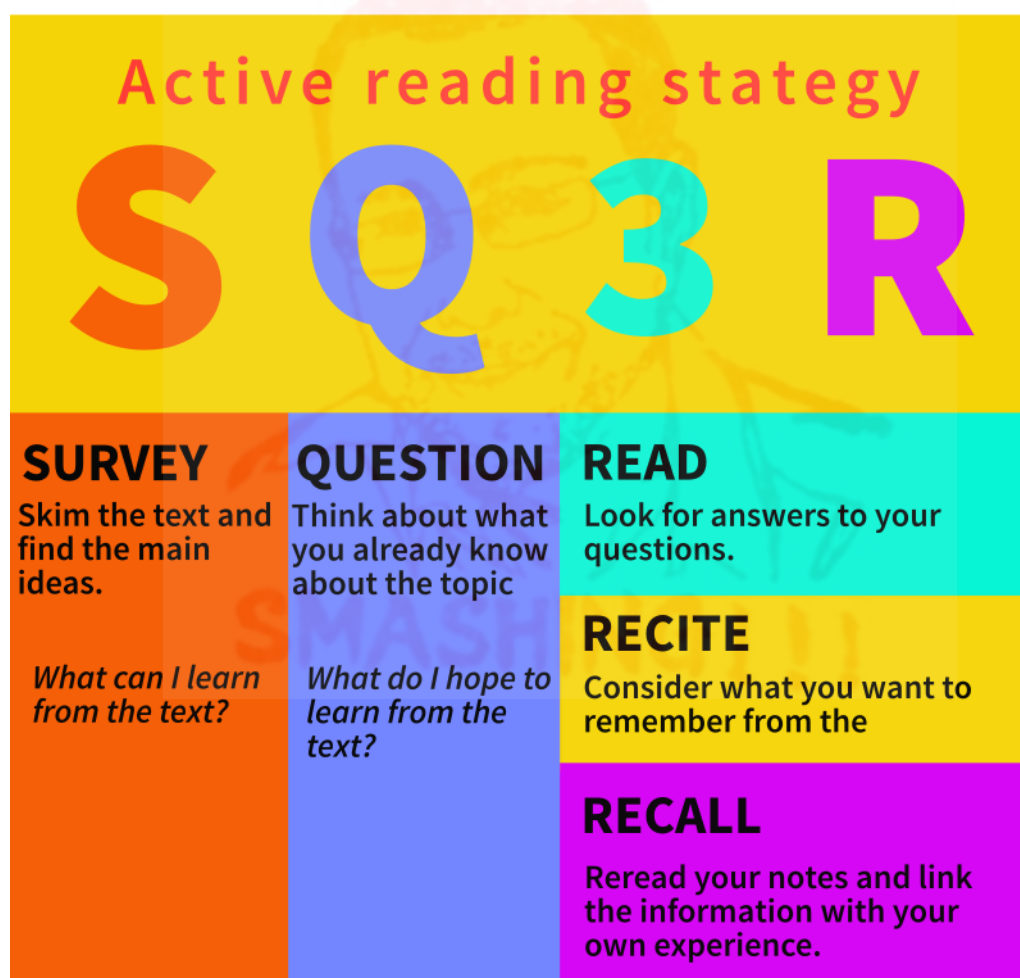
Critical Reading Techniques

1. [Critical reading techniques](#)
2. [Use an efficient approach](#)
3. [Active reading](#)
4. [How to take notes](#)
5. [Critically processing what you read](#)
6. [Coping with difficult content](#)

Active reading simply means reading something with a determination to understand and evaluate it for its relevance to your needs.

Only reading and re-reading the material isn't an effective way to understand and learn. Actively and critically engaging with the content can save you time. Most OU study books and websites include in-text questions and self-assessed questions. Use these as built-in cues to make your study active.⁹

Active Reading Advice –Core ideas



⁹ <https://help.open.ac.uk/active-reading>
www.SmashingScience.org



Active Reading Advice - Extension

From: <https://mcgraw.princeton.edu/sites/mcgraw/files/media/active-reading-strategies.pdf>



328 Frist Campus Center
Princeton University, Princeton, NJ

Active Reading Strategies

Choose the strategies that work best for you or that best suit your purpose.

- **Ask yourself pre-reading questions.** For example: What is the topic, and what do you already know about it? Why has the instructor assigned this reading at this point in the semester?
- **Identify and define any unfamiliar terms.**
- **Bracket the main idea or thesis of the reading, and put an asterisk next to it.** Pay particular attention to the introduction or opening paragraphs to locate this information.
- **Put down your highlighter. Make marginal notes or comments instead.** Every time you feel the urge to highlight something, write instead. You can summarize the text, ask questions, give assent, protest vehemently. You can also write down key words to help you recall where important points are discussed. Above all, strive to enter into a dialogue with the author.
- **Write questions in the margins, and then answer the questions in a reading journal or on a separate piece of paper.** If you're reading a textbook, try changing all the titles, subtitles, sections and paragraph headings into questions. For example, the section heading "The Gas Laws of Boyle, Charles, and Avogadro" might become "What are the gas laws of Boyle, Charles, and Avogadro?"
- **Make outlines, flow charts, or diagrams that help you to map and to understand ideas visually.** See the reverse side for examples.
- **Read each paragraph carefully and then determine "what it says" and "what it does." Answer "what it says" in only one sentence.** Represent the main idea of the paragraph in your own words. To answer "what it does," describe the paragraph's purpose within the text, such as "provides evidence for the author's first main reason" or "introduces an opposing view."
- **Write a summary of an essay or chapter in your own words.** Do this in less than a page. Capture the essential ideas and perhaps one or two key examples. This approach offers a great way to be sure that you know what the reading really says or is about.
- **Write your own exam question based on the reading.**
- **Teach what you have learned to someone else!** Research clearly shows that teaching is one of the most effective ways to learn. If you try to explain aloud what you have been studying, (1) you'll transfer the information from short-term to long-term memory, and (2) you'll quickly discover what you understand — and what you don't.

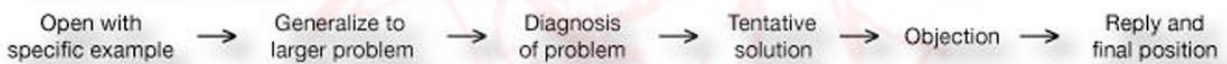
See other side of page for sample diagrams →



Sample diagrams:



Sketch of a reading's argumentative structure:



SMASHING!!!

Learning with your Textbook using Active Learning and Active Reading

The easiest to recommend textbook regardless of format is <https://www.chemguideforcie.co.uk/>

It is free and delivers enough content even for even a quite good A*, which is more than most A Level Chemistry textbooks for the CAIE syllabus offer. However, it is not that easy to print it out, so whatever **printed textbook** that CAIE recommends that is for the 2016 syllabus or later would be the way to go (newer would be better, but not by much).

Hopefully you have already started to notice certain patterns in all textbooks, like the way they are set out and structured. Normally one idea or concept (which are defined by the syllabus points) is covered in a section which gets its own heading, and these sections usually follow the order of the syllabus. In this way a larger syllabus topic is broken down into smaller parts

Usually there are also **questions to test your understanding of the content**, either after the section, or at the end of the chapter. These questions are not at all as carefully thought out or complex as exam questions but writing out the answers to them is still an effective way to get a longer lasting learning impact (more efficient) from the time invested. They are better than exam questions in the respect that they are answerable with just the information from that section you have just finished. Exam questions have been mapped to the syllabus topic in this and other workbooks, and to a Smashing!!! standard, but it is not always clear for Paper 2 and 3 which parts you should be able to answer when there are still important ideas within the topic that you have not yet started. You can however use Paper 1 questions, but this is less straightforward so not for all students.

Working through these questions in the textbook and making systematic notes is a part of a process known as **Active Learning**¹⁰. Solving past exam questions is another way to learn by activity. Also effective is teaching another student who is struggling with a particular part of the course.

Active Reading¹¹ requires you to really think about what you are reading and make notes, underline and reflect on the ideas in front of you. It is highly effective at making what you read understandable later on (part of the reading for meaning skill). The instructions in the next table will help you learn how to actively read, some or many will be things you already do, so concentrate on trying out the things you are not yet doing.

A common misconception, especially in lower levels of academic success, that the faster you read, the smarter you are. Scanning for key information across pages is a vital skill that gets more useful at university. But by the far the strongest way to read the most complex types of literature is systematically with a deeply intellectually engaged process and by being profoundly open and vulnerable to changing your mind in the biggest and best ways. All of this takes care and especially time. It is also a skill, so you can get better at it. If you really like reading, or big ideas, or would like to spend more time with either or both check out:

<https://www.smashingscience.org/periodic-table-of-literature>

Important points to note about the textbook

Sometimes there are differences between details in a textbook and in an exam mark scheme. Usually, the mark scheme would be the best version to learn (textbooks often have several mistakes in them, mark schemes almost never have any errors of any kind; so if there is a conflict, always assume the mark scheme is correct). The very best version would be one that includes details of both the mark scheme, which should be prioritised and then add whatever details the textbook also thinks is important.

¹⁰ <https://teachingcommons.stanford.edu/resources/learning-resources/promoting-active-learning> & <https://www.smartsparrow.com/what-is-active-learning/>

¹¹ <https://help.open.ac.uk/active-reading>
www.SmashingScience.org



Activity	What you should do	Why it helps	When you should do it
1. Translation (If English is an additional language)	Translate ALL new words, especially the ones in bold , ideally next to the text. Use the glossary at the back to help you. If English is an additional language, instead of translating a word into your first language, explain the word in English in a way that you understand.	The most important words to translate are the non-scientific words you already know in your first language. If you sat the English as a Second Language iGCSE prioritising your English language learning earlier will benefit all aspects all of your AS Levels.	As you are reading.
2. Underlining	Underline, bold , CAPITAL LETTERS, highlight circle put a *star or symbol 😊 next to the biggest new ideas. But remember, if you highlight everything, you've actually highlighted nothing 😞.	This is where Active Reading and Active Learning begins, but it should not be where it ends. Students who are more capable sometimes do less well because they chose to annotate the textbook instead of their notes. Whatever you do in the textbook is building on work your brain knows is not its own, so it is less interested in it. That also makes it easier and therefore more appealing, but it is much less effective use of time.	As you are reading.
3. Answers to questions in the textbook	Write the title of the section, date, textbook page number, then answer the question in a way that allows you to use these answers as notes months or even years from now. Therefore, use complete sentences, include as much detail as is needed in your answer for it to make sense. Include all of the working for the calculation. Answer all of these questions either with your main class notes, or a specific notebook.	Remember you are aiming to learn the idea, not just reproduce mark scheme, so your work should reflect that intention. For each question's answer you are essentially summarising the question and the idea in your answer, which is a creative, analytical and reflective process; all of these higher order thinking skills in one activity is a very powerful way to systematically actively learn using the textbook.	As you are reading.
4. Answers to worked examples	Answer the worked examples whenever you get to them. Cover up the explanation with a piece of paper so you can only see the question. Include your working, with clearly labelled numbers and equations. After you have written out your answer then check to see if you understood the calculation.	You are building not only the skill to get the right answer, but also the skill to deliver an answer in an exam that gets all of the marks, including the hardest marks for details that most students who know the answer lack the exam technique to include.	As you are reading.
5. Create an introduction mind map of key points and essential aspects	Create a mind map of the topic as you learn it. Include essential diagrams, equations, keywords and connections as you come across them. Try to be creative, visual and colourful. Make sure whatever you write is in your own words. You can tape securely sticky notes to add to areas that need more space. This can be the first page in your notes. It will grow as you are encounter new ideas.	You will be using, exploring and growing your creativity, analysis skills, your visual understanding of the topic as well as your ability to summarise large amounts of information into a small space. You are unlikely to do this well for Topic 1. But by Topic 37 you will be an expert at this highly specialised and efficient way to study using a written source.	As you are reading.
6. Create summary sentences of textbook sections	You can create condensed sentences with the essential points as you go for each section. You could write all of them for a chapter together on the same page, clearly indicating the pages each sentence relates to (and the date).	Another way of thinking about it is: what's the least useful or least important 90% content in a section?	As you are reading.

Activity	What you should do	Why it helps	When you should do it
7. Read ahead and write out questions to ask in class	Read ahead in the topic you are studying in class and write out questions about the material you have encountered that it's not well or fully explained by the textbook. Ask these questions at the end of class, or after class if the lesson has not answered them.	Asking good, insightful questions is an important skill to improve. Don't ask these questions before the content has been taught – the best value of the activity lies in your carefully listening throughout the whole lesson to make sure the question was not answered; often it will have been. You are aiming to learn better in the scheduled time. This is a highly effective way give yourself extra incentive to pay extra attention.	As you are reading.
8. Read and practice past exam questions	Carefully select parts of exam questions you can answer from what you have already learnt about the topic. Paper 1 questions usually are the most compartmentalised and focus on individual syllabus points, so they tend to be the best questions to try when you are still studying the topic. You might be able to answer some questions on the topic you are currently learning in Papers 2 and 3, or at least can read through them and look for the parts that you can do.	Learning a topic with and knowledge of they kinds of questions you will be asked can help you understand the relevance of what you are learning and centre it on practical skills and understanding that will soon be essentially to gaining a good grade. It can also help you to create questions in your mind about things you have yet to see, so that you are curious to find out the answer.	As you are reading.
9. Add to your Cornell Notetaking Notes from class	Add any details you are missing in your class notes on a section in a way that allows you to see what came from a textbook (e.g. by highlighting that text, or different colour only used for content from the textbook).	You will have to read and understand all of your notes and the textbook content before you decide to add and write out these additional details. You are far more likely to check if this content really isn't in your notes, making you compare and contrast the content of both much more thoughtfully, again using and growing your thinking skills for this topic.	After you have studied the textbook's section in class.
10. Add to your Cornell Notetaking Cue column	Cover up you Cornell cue column for a section you have studied both in class and from the textbook. Does this cue column have everything it should, or are there details, keywords or questions you now know that are missing? Add to your cue column in your Cornell Notes any additional details, keywords or questions that you have.	If you covered up the notes section of the page, answering these questions should allow you revise the whole page simply by answering the questions you have written out and thinking about a few core ideas (much more efficient revision, for instance before you start practicing past exam questions).	After you have studied the textbook's section in class.
11. Add to your Cornell Notetaking Summary sections	Read carefully what you have already written in the cue column and the summary section of your notes. What additional sentence could you add to make it better? Write it in a specific colour so you can easily and quickly see this most sophisticated and important (to you) sentence that can lead you back to your thinking when it was written after finishing your lessons and your notes of the whole topic.	Another way of thinking about it is: what's the least useful or least important 80-90% content here?	After you have studied the textbook's section in class.

Activity	What you should do	Why it helps	When you should do it
12. Create a summary mind map	Using the introductory mind map create a summary map that summarises everything in a logical and well presented and well set out ways.	A great quick revision strategy is to write out a mind map for the entire topic on a blank piece of paper, from memory. Then to check it with a mind map like this one, and look for the things you missed out, you now know what to concentrate on.	After you have finished the textbook chapter in class, but before the topic test.
13. Practice Paper 2 past exam questions	Concentrate on answering Paper 2 exam questions. Use these questions to explore how the knowledge you have encountered is examined, and what parts of the syllabus are important enough to be worth creating exam questions and marks for.	These are the most important exam question to get good at. If you can answer them well, then usually Paper 1 questions on the same topic will also be answered to at least the same standard, often slightly higher. But if you cannot answer Paper 2 questions then it doesn't matter if you are good at Paper 1 questions.	After you have finished the textbook chapter in class, but before the topic test.
14. Practice Paper 3 past exam questions	Most topics are not covered in Paper 3, but those that are it is particularly important to try out the questions that have Sample Data answers from SmashingScience. Explore whatever content is included about experiments from the textbook for these questions.	By far the best practice for this practical exam paper will be done in the lab, actually doing similar experiments. But when you do not have lab access, for instance outside of lesson time, you can still revise Paper 3 questions and include the information from the textbook to help.	After you have finished the textbook chapter in class, but before the topic test.
15. Add to your Cornell Notes any final essential textbook details you missed	Add whatever details into your notes that your past exam question practice highlights that was in the textbook but that you missed, both when you were studying it in class and when you were reading it. Try to think about how you could in the next Topic spot and learn these kinds of subtle and easy to miss ideas that deliver the harder marks earlier. This is the highest level of reflection, using data and systems to deliver the easiest to miss improvements that only the best students can make.	The tricky marks and the slippery explanations (especially that 2 nd or 3 rd mark) often follow patterns that can make it much easier to spot once you have thought not about the answer, or even the question, but those underlying patterns examiners use to make content more complex (so that it is an AS question instead of an iGCSE question). Sometimes those patterns are addressed in a textbook, when you miss them in one textbook chapter, you should try to be more deliberate and thoughtful to see them in the next topic.	As you are practicing the past exam questions.
16. Write out your own Top Tips	Write out any new tough marks or details that you have overlooked and try to think of a rule or piece of advice, to yourself and others, about how to effectively build an exam habit so you don't drop a mark from that kind of problem or puzzle again.	Ultimately, you are not aiming to deliver into your life a library of facts, but an active and growing library of learning systems. You are building a way of incrementally grow your problem solving ability to achieve important life goals through pattern recognition, diligent perseverance and creative reflection.	Any time after you've finished the topic, but before the CAIE exam.

Exercise: Exam Technique Top Tips for Smashing!!! your Exams

Actively read through these top tips. **Task:** What order are they in?

Task: Rank them, with 1 as most important to exam success (doing it correctly will deliver the most marks, failing to do it well will result in the most amount of marks last) and 25 as the least important.

For exercises like this one, it is often best to start at both ends, with the most and least important ideas, and then work into the middle where it is harder to differentiate.

Task: Add these ideas to your “Exercise: My Notes about the Paper 1 To-Do Checklist”

ID/ rank	Idea	Why it matters
TT 1	Adding to your answers at the end	For most students. The harder explain questions, or other multi-mark questions often will require details that may not be the first ones you include. After you have given the question roughly the right amount of time per mark, MOVE ON to the next part of the exam. Return later if you have made the time to do so, after you have checked through the exam and add whatever else you can think might be relevant AND correct. If you are not sure if it's relevant, but you are sure that it is correct, then add it anyways, but only if you have the time!
TT 2	Annotating your multiple-choice questions	For ALL students! Although the examiner will not see you question paper for multiple choice questions, you should still make notes on the question paper itself. This will help you break the question down, which will often require you to have one idea that follows another, if this is written down inside the question you are more likely to see these other steps. Also important, at the end you can see your own thinking when you check through your exam at the end, which will make checking your work easier and more effective
TT 3	Annotating your questions	For ALL students! You should be writing out what you know about the compounds and ideas as you are reading the question. Underline numbers, these are usually only ever given to you because they are necessary in a calculation. For questions involving unknowns, try to write what substance X is if that is possible (e.g. if X has 3 protons, it is a form of Li). This way you break down a larger problem in to more manageable parts helping you see more clearly the answer.
TT 4	Checking your exam paper	For most students try to allow at least 10% of the exam time to check your exam paper at the end. As you move through the paper, you should have already marked the hardest questions with a star or other symbol, these should be checked the most carefully. For the most able students who are aiming for a good A* you ought to have about 20 to 30% of the time left at the end for checking which will allow you to thoroughly check all of the exam and locate every mark. This is especially important for the hardest multi-mark questions, identify where in your answer do you think you have delivered enough details for each mark. For students who struggle you may need to ignore the later parts of a tough topic (spend least time on the hardest marks) so you can spend most time checking the easier questions to make sure that you catch and correct the silly mistakes which could deny you the higher grade.
TT 5	Chemical equations	For most students. Always try to include at least one balanced chemical equation with state symbols , even if you feel you have just explained the same thing in words, because you may have missed something out or not explained properly the idea that you had in your mind which the chemical equation will provide evidence to the examiner that will allow you to get the mark. It is an example of REDUNDENCY (or a FAIL-SAFE).
TT 6	Crossing out answers	Never cross out an answer until you have provided an alternative. So draw a box around what you intend to replace, then write your new answer, THEN write a neat cross through that box. Your crossed-out work should always be readable to the examiner. If it contradicts your new work, it will not be considered, but if it helps to clarify your new answer, than it ought to be considered by the examiner. For instance, in a recent exam students were expected to describe a difference and explain it; many students simply explained the difference, without saying if the value would be larger or smaller, one student suggested that it would be smaller in their crossed out work, but only different in their final answer, but they had shown they understood how it would be different and got the mark.
TT 7	Diagrams	For ALL students! A picture is worth a 1000 words. A good LABELLED diagram, even if there is no blank space for a diagram, can sometimes be acceptable and can help give a fuller answer to allow you to pick up the hardest marks or prevent silly mistakes where you have accidentally not included enough information. Another example of REDUNDENCY .

ID/ rank	Idea	Why it matters
TT 8	Drawing graphs	In pencil!!! If you make a mistake in the real exam in pen it your answer may not be clear enough for you to be awarded really easy marks, you cannot ask for another exam paper, so mistakes that are made in pen are permanent! For ALL students!
TT 9	Eliminating the wrong answers in multiple choice questions	For ALL students! Usually two of the 4 answers are more easily seen as incorrect. Finding these two will give you a 50/50 chance of getting the right answer with less understanding, so even though you don't fully understand the question, you have at least managed to increase your odds of guessing correctly. If you can't easily and quickly find these 2 answers, mark the question, make a guess IN PENCIL, then move on, this question is obviously a difficult question therefore.
TT 10	Exam Questions	For ALL students! Almost none of the marks are awarded for answering actual questions (you will almost never see a question mark?!?!). What are commonly referred to as exam questions, are in fact commands: calculate this, or explain that or state how etc. This is to reduce confusion so that you know exactly what is expected from the language of the command (which is why the command terms exist and why they are so important to properly understand!!!).
TT 11	FAIL SAFE or REDUNDENCY	For most students. If you really want to make sure you pick up every single mark you should be aiming to include additional information in a slightly different format, including labelled diagrams and balanced chemical equations with state symbols. This level of attention to detail means that if your first attempt at the hardest marks in the exam paper fails to deliver the complete answer, it fails into a safe position, because you have a backup plan. This is an essential idea in engineering and research science.
TT 12	Give some properties/ etc.	For the most able students. Give about 40 to 100% more properties or conditions than there are marks: irrelevant answers, or incomplete answers will not go against you, so to ensure you include all of the details that the examiner requires you need to be very cautious. Answers acceptable one year may not be acceptable in another exam session, they are not incorrect, just not enough to get a mark. This is essential for a candidate to hope for a good A*!!! For the least able students. Make sure that you are at least giving as many answers as there are marks, if you are not sure, give your best guess, never leave an answer blank! Remember though that an incorrect answer plus a correct answer normally will mean the correct answer does not get the mark.
TT 13	Give <u>x</u> # properties/ conditions/etc.	For ALL Students! Give exactly and only x number of properties, any more will either not be marked, so if one of your answers is irrelevant, and you are supposed to give 3 answers, but you give 4 and the 4th is correct, you could lose the mark. If one of the answers is wrong, then you will most likely lose the mark. They do not reward candidates who try to use ambiguity to increase their score, and in fact actively penalise it.
TT 14	Name	For most students. Give the name, in English, for the chemical compound, ion or element. Only the name is acceptable, and if you misspell it, especially if it is a negative ion, like chloride, you will not be awarded the mark. Do not give the chemical formula as well: it will not give you an extra mark, but if it is incorrect, it could negate the mark the name you gave would have gotten.
TT 15	Plurals	For ALL students! If a question requires more than one answer, it will have ALWAYS indicated this with the use of plurals. If only one answer is needed than again, the statement will indicate this grammatically. PAY ATTENTION TO THIS!!!
TT 16	Showing your working in calculations	For ALL students! The space given for your working for a calculation should not be considered as 'rough paper' or include incomplete numbers or ideas. The space for your response should be considered as a place for you to communicate with the examiner what you are doing, and especially thinking, in each step. Label your numbers! Write out the equation you are using, e.g. $PV=nRT$, even if there is never directly a mark of that, it will help the examiner award method marks. Sometimes the final answer is only worth one mark, and the other marks can only be achieved with carefully laid out working. Another important reason for good, systematic working, even for easy questions that involve more than one step is that they allow you at the end of the exam to check your thinking quickly, efficiently and effectively. A logical, neatly and clearly presented, step-by-step approach to writing out your thinking for every question, including calculations, is also excellent exam technique.
TT 17	Spelling	For ALL students! It is only really in the naming of a specific process or a species (atom, ion, radical, compound, element etc) that spelling is vital. Otherwise, anything that is spelt well enough for the word to be clear and the meaning to be understood is acceptable. Your

ID/ rank	Idea	Why it matters
		written response is the usual evidence the exam board uses to award you credit for correct and complete scientific ideas, but they have ways to give credit to students with conditions that limit their writing ability. This includes dyslexia is used by the exam board to measure your level of understanding, but there are other ways to show you understand. Some students with certain disabilities may not be able to write, but they could still get an A* in this subject if they could shown, e.g. through speech, that they are able to understand the ideas in the mark scheme.
TT 18	State or identify	For ALL Students! In this case you can use either the chemical formula or the full English name of the compound, ion or element. If you give the formula and the name and one of them is incorrect, you will often lose the mark, so you are better off only identifying the substance by the way you are most confident in. For instance, if you say that it is "Bromine (Br)" when it is in fact Br ₂ , you could lose the mark. Or "Bromine (Br ⁻)" when the answer is the bromide ion.
TT 19	State symbols	For all students. You usually do not get an extra mark for including these, but will often lose a mark which requires other details if you have not included them. Always include these whenever you are stating or identifying a substance, so H ₂ O(g), or Cl ₂ (aq) include far more sometimes vital details than writing "water" or "chlorine". This is another example of a FAIL SAFE .
TT 20	The order you answer questions	For ALL students! This should be organised at the start of the exam. Take 2 minutes to skim through the exam paper and find the hardest questions and the easiest ones. The hardest questions should be answered last, these are the least efficient use of your time (in terms of marks achieved versus time spent). The easiest questions are the most efficient use of your time, unless you have run out of time and are forced to leave them unanswered, or poorly answered. DON'T ANSWER EXAM QUESTIONS IN THE ORDER THEY APPEAR ON THE EXAM PAPER!!!
TT 21	Time management in exams	For ALL students! You should know how long you have for each mark (normally it is around 1 mark a minute). You should also have a watch that you are familiar with that is not a smart watch or a smart band. A simple, cheap classic Casio watch would be best, and you can use this same watch throughout your academic career making sure to replace the battery before every exam session. Some questions you should be able to make time up on, others will take considerably longer, for those harder questions, stop after about 1 minute a mark and return to them at the end to ensure the easiest marks have been answered fully and carefully.
TT 22	Understanding the distracter answer in a multiple-choice question	For the most able students. After you have eliminated the 2 easily incorrect answers there will be two very similar answers that will differ in a fundamental way, hopefully, that will allow you to find the correct answer. Sometimes, however, neither will be easily identified as correct, so you will need to find the most incorrect answer and chose the other one. These questions tend to be the hardest marks in the exam.
TT 23	Units	For ALL students! Always include units in your answer! Often, they will not be enough to allow you to get a mark, but if they are not there you will lose a mark.
TT 24	Writing in the mathematics formula booklets	For ALL maths students. Nothing to do with chemistry, but I find it really unnecessary. DO NOT TO THIS! At best rough work which should have been included in your answer booklet, then neatly crossed out, will not be seen by an examiner, so you could very pointlessly drop marks. At worst the handwriting is yours in this booklet, so you could be accused of writing the answers in there before the exam and therefore cheating. It is CAIE policy (and all exam boards, actually) that everything a candidate does in the exam is sent to them, which is again related to exam security which they take extremely seriously. Most likely however, the booklets are just thrown away for no good reason which is a waste of paper.
TT 25	Wrong answer + Right Answer	= No marks! If you are unsure go with your best guess, but don't give two answers if only one answer is acceptable. For ALL Students!

The Cornell Note-Taking System

Background science – your brain is an organ

As important as remembering important things is forgetting everything else. Your brain does both. Learning well is like programming a computer, using specific ways to best interact with this mysterious organ so that you can remember information and connect ideas in new ways, so you can solve new problems like an exam question you have never tried before.

Most details of most seconds, minutes and hours of anyone's life are not needed and are deleted (forgotten). But if you have ever fallen off a bike or had an accident your brain stops deleting everything and instead stores as much of the information as it is able. Time slows down and your memory feels almost photographic. **Some things are therefore more memorable than others.** The trick with learning is to present information and skills to your brain in just the right way so that it stores these memories longer term.

It is designed to only remember the things that it is programmed to think are important. It's programming comes from culture, but some is also hard-wired into the system itself, like our shared interest in learning a language when we are babies, or our ability to process visual images better or our ability to control our body temperature. This hard wiring is created by our genes, which we inherit from our parents. Our genes were created and adapted to survive and reproduce tens of thousands of years ago living lives that are totally alien to even the most extreme high school environment.

Current understanding of the human brain is extremely basic, no-one knows what the smallest part, or atom, of an idea might be in terms of brain cells. But we do know that **brain cells make connections**, and we think that those connections are where the mind, and memory, is created. We also know that the brain is more likely to make connections, and therefore memories, from events we are emotionally attached to, like an accident or a totally awesome movie. If we feel more emotions about something our brain is adding meaning to the memory, and it is much more likely to be stored longer term.

If you keep returning to the same idea over time, but you make your brain think about it differently,

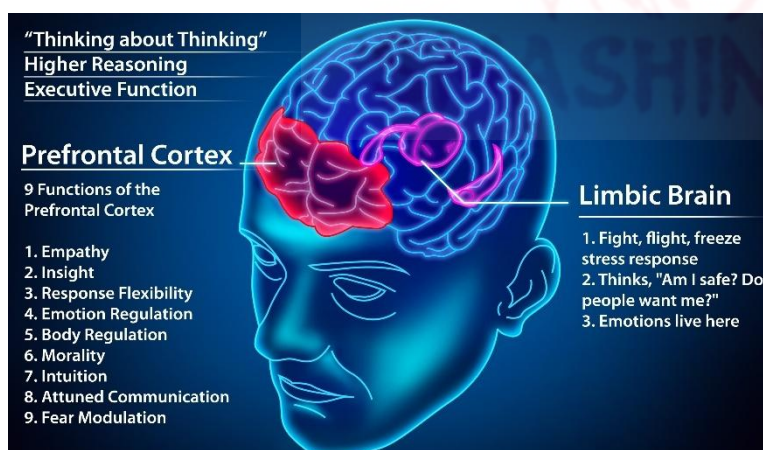


Figure 2 The business end of the organ. The human brain is special not for its size, whale brains are bigger, but for its uniquely complex **prefrontal cortex** which does much of the best thinking, it also delivers the higher order thinking skills you will need to plan and deliver the revision needed to crush your exams.

The **limbic brain** adds emotional weight to your ideas, it powerfully moderates your thinking and adds a difficult to describe property that can be simplified to as **"meaning"** to thoughts and memories.

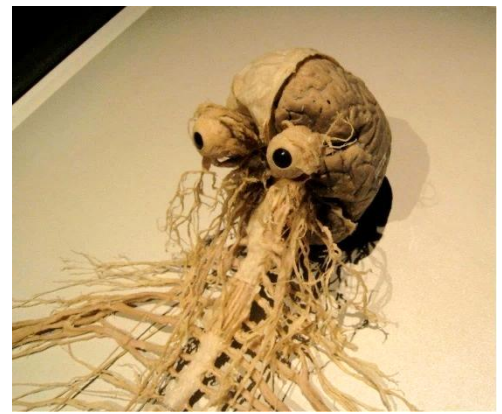


Figure 1 It's what's on the inside that counts! This organ is where almost all of your mind comes from. Other factors like adrenalin, a powerful fast-acting hormone from glands in the body, outside the brain, also shape your thinking.

for instance by **taking notes using your own words**, or **making a summary**, or **writing out key questions** raised by that idea, you are making your brain to make **new connections** to make this new kind of thinking happen. Not only will the brain be better able to use new ideas in a new situation, like in an exam, but these connections also make the memory more stable. If the brain really thinks something is important, like something that hurt you or where you live, it will store these essential bits of information into what can be called long-term memory.

The goal of learning is not only to make as many interesting and important connections within the brain as possible, but also to **put as much key**

information into the long-term storage area as possible. The goal of education, especially in the better universities is not fill a student's brain with specific facts and ideas, or to test how intelligent someone was born, but **to train a student's brain with valuable skills and techniques to learn faster**, better and longer.

Learning how to learn better is the most valuable and important thing you will take away from any period of education. Luckily, you are not the first person to have ever been taught. There are thousands of years of history and tens of thousands of years of culture that you can use to your advantage. Some systems of learning work better than others. The **world's best universities** have done a great deal of research into these different systems and skills involved in learning e.g.:

<https://english.gse.pku.edu.cn/newsandevents/news/index.htm> (Peeking University);
<https://www.ucl.ac.uk/ioe/research> ; <https://www.gse.harvard.edu/ideas> ; <https://web.edu.hku.hk/knowledge-exchange> (Hong Kong University) ; <https://nus.edu.sg/cfg/students> (National Uni of Singapore) ;
<https://ed.stanford.edu/faculty/overview> ; https://www.ioe.tsinghua.edu.cn/en/Education/Summer_School.htm ;
<https://www.educ.cam.ac.uk/research/impact/> (Cambridge); [Institute Of Education What Works Clearinghouse](#) (USA); <https://as.cornell.edu/education/education-innovation> ;

The Cornell Notetaking System

In the 1940s a professor of law at **Cornell University** called Walter Paulk realised his students, who were supposed to be some of the best of their generation, weren't that good and he wondered what they could do to learn better. He invented the Cornell Notetaking system, which is widely considered to be the best way to learn difficult things faster for almost any subject at both the High School and University level.

Notetaking is not about storing information that you need to relearn before the exams, rather it is like creating structured save points on your journey to understanding a syllabus point. The notes you have made have created connections in your brain that are reactivated when you see your notes again. Your notes are a visual key or code that transports your mind not to one part of the idea, but rather to all of the connections you had to make when the notes were created. You are retrieving the whole box of memories, skills and connections, instead of a single piece of the bigger topic.

These notes are therefore a way to neatly store away not facts, but how all of those facts interconnect (understanding) in an orderly way through an organised process that uses what we know about the brain as a biological, evolved organ.

A key feature of this system is making your brain think about priority, order and relationships that make a lessons worth of ideas at different times. Even more effective thinking about the same idea in a creative way after several nights of good sleep. The Cornell Notetaking system includes all of these most effective learning strategies.

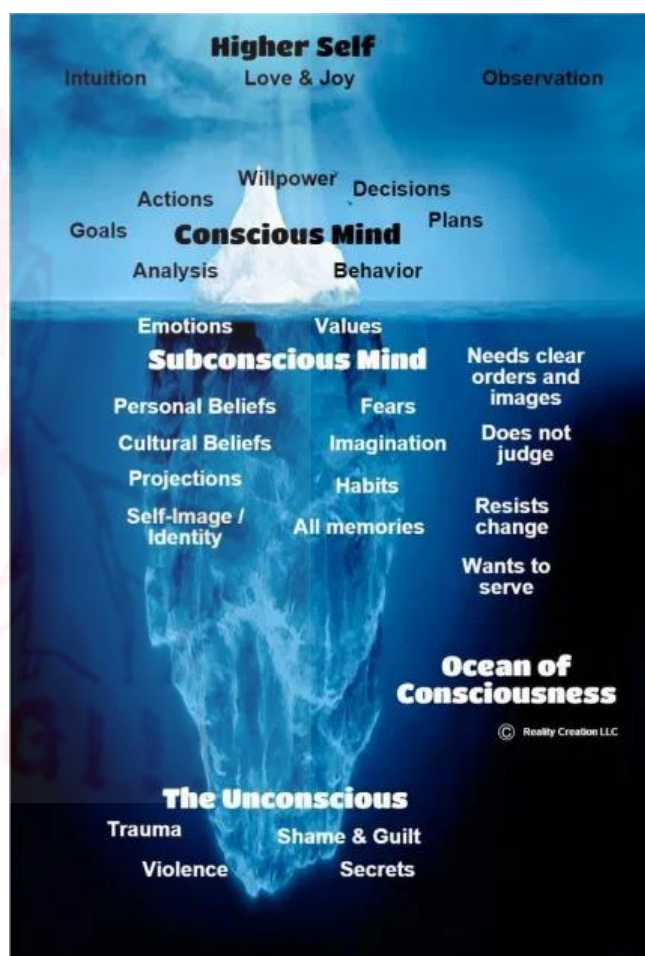
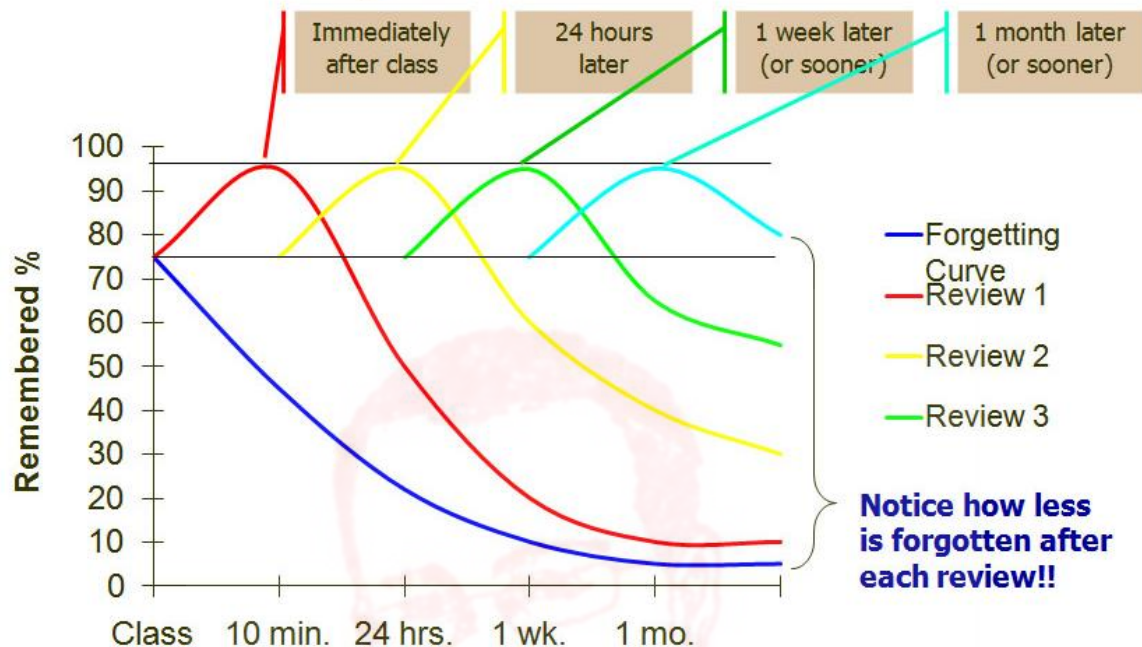


Figure 3: The mind is a small part of the brain. But the conscious mind is a smaller part of the whole mind. Most of the mind involves aspects of the self that are hard to understand and even harder to change, but with enough work it is possible for anyone to nurture and grow the habits of an outstanding student. These larger changes take time, hard work and especially a commitment to try new things.

The forgetting curve

Learning how and when the brain deletes and removes information is another essential aspect to becoming more effective at learning new things. This idea is integral to understanding the effectiveness of the Cornell Notetaking system.

Overcoming the Curve

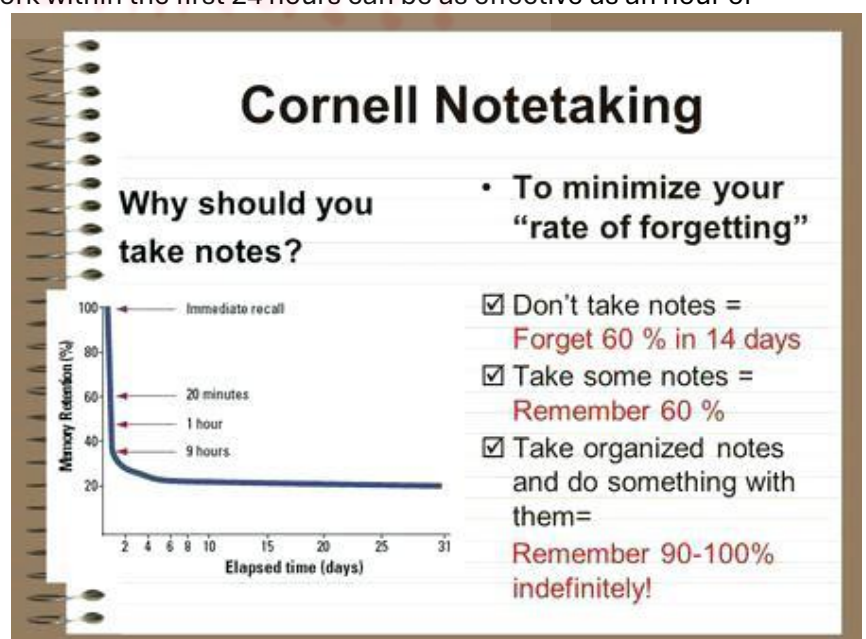


How might the data for these graphs be gathered? A physicist might say any graph without error bars ought to be classed as art rather than anything like rigorous analysis. As the central science, a chemist would have a more open mind. For a more scientific perspective on the “Forgetting Curve”:

<https://psychology.stackexchange.com/questions/8377/how-are-these-review-forgetting-curve-calculated>

The quicker you return to a lesson to review it, the less time you will need to gently nudge it into your long-term memory, so 5 minutes of work within the first 24 hours can be as effective as an hour of study a month later. Remember, your brain does not understand what you are trying to do, but if you try to work with it, and help it along, remind it that this stuff matters to you (and it), it will be more likely respond in the way that you want and learn what you need it to.

Effective learning is essentially effective brain programming, and the Cornell Notetaking System is a highly efficient (more learning in less study time) way to insert new ideas, skills and understanding into your long term memory.



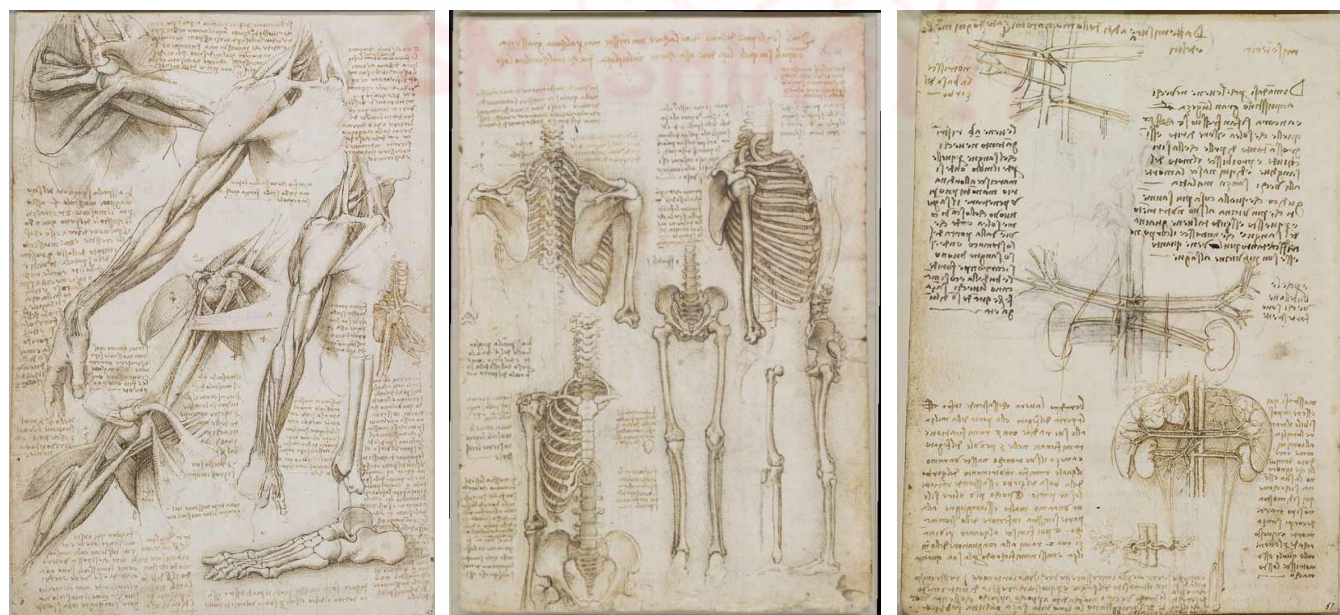
Cornell Notetaking – What to do and Why it Helps

Notetaking has been an essential skill that the most important and prominent minds throughout history have used to record, explore and expand their thinking. Perhaps the most famous notes were those of Leonardo da Vinci, which shows how he interconnected his then advanced ideas on science and the human body with his mastery of visual art and profound insights into design.



Leonardo da Vinci's notes in the *Codex Leicester*, above, and sketches from his anatomical sketches, below, held in the Royal Collection. For a boss-level free book in .pdf format on DaVinci's anatomical sketches:

<https://www.rct.uk/collection/publications/leonardo-da-vinci-anatomist>



For more resources on notes and why they matter at iGCSE and AS/A2 levels and beyond, including exemplar notes from students and a PowerPoint presentation exploring the value of notetaking skills see

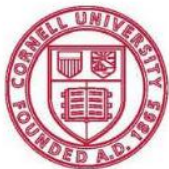
www.SmashingScience.org

www.SmashingScience.org

Patrick Brannac

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The Cornell Note-taking System

$2\frac{1}{2}"$	$6"$
Cue Column	Note-taking Column
1. Record: During the lecture, use the note-taking column to record the lecture using telegraphic sentences. 2. Questions: As soon after class as possible, formulate questions based on the notes in the right-hand column. Writing questions helps to clarify meanings, reveal relationships, establish continuity, and strengthen memory. Also, the writing of questions sets up a perfect stage for exam-studying later. 3. Recite: Cover the note-taking column with a sheet of paper. Then, looking at the questions or cue-words in the question and cue column only, say aloud, in your own words, the answers to the questions, facts, or ideas indicated by the cue-words. 4. Reflect: Reflect on the material by asking yourself questions, for example: "What's the significance of these facts? What principle are they based on? How can I apply them? How do they fit in with what I already know? What's beyond them?" 5. Review: Spend at least ten minutes every week reviewing all your previous notes. If you do, you'll retain a great deal for current use, as well as, for the exam.	
$2"$	Summary After class, use this space at the bottom of each page to summarize the notes on that page.

<https://lsc.cornell.edu/how-to-study/taking-notes/cornell-note-taking-system/>



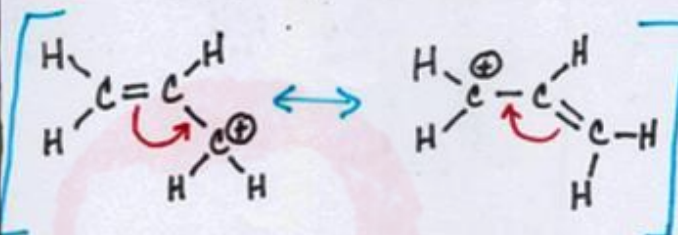
TITLE	NOTES	KEYWORDS	SUMMARY
①	②	③	④

Order to complete notes, start with the title (#1). The last section (#4) is done after at least one full night's sleep.

What is the difference between resonance structures & true structures?

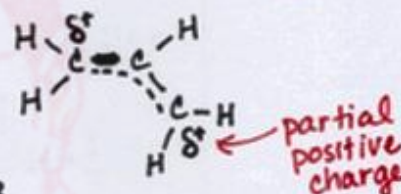
Why does charge delocalization stabilize a molecule?

Resonance Hybrid: True structure of molecule represented by a set of resonance structures

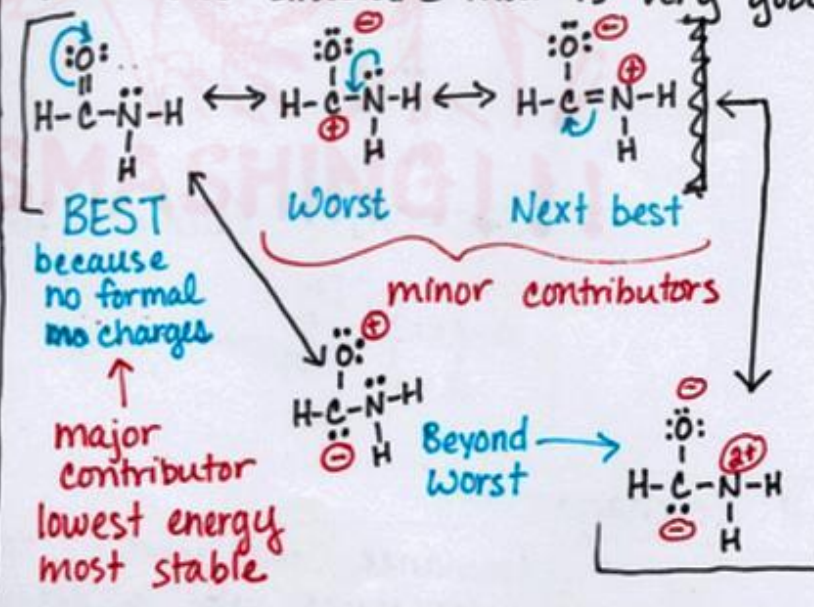


"True Structure"

Positive charge is delocalized over carbon 1 & 3



Some sets of resonance structures have one structure that is very good.



Resonance structures are used to represent true structure of molecule. The more resonance structures you can draw, the more stable the molecule due to delocalization of e^- .

CUES

(reduce & recall)

AIM

reduce notes to essential ideas to practice recall

WRITE SOON AFTER CLASS

Step 1.

Review NOTES

column + pull out:

- key words
- key concepts
- authors
- dates
- facts

Step 2.

Formulate questions

based on your

NOTES e.g. what are Pascale's 4 principles of complexity theory?

Step 3.

Write these cues and questions in this column alongside the corresponding NOTES

DATE

MODULE/CLASS

TOPIC

NOTES (record)

AIM

record as many key points as possible

TAKE DURING CLASS

What do I write here?

- key words and ideas
- important dates / people / places
- diagrams / charts
- formulas
- examples / case studies
- critique - strengths / limitations

Top tips

- use bullet points instead of full sentences
- use symbols and abbreviations
- leave a line between ideas
- don't mindlessly copy from the slider or textbook - write in your own words where possible
- use a method that works for you. Take notes in a format that you understand so you can make sense of them later.

SUMMARY (reflect & review)

AIM

review the main ideas + reflect on their importance

WRITTEN AFTER CLASS

Briefly summarise the main points from your notes. This section is useful when searching for info later.

Think about:

- why is this info important?
- what conclusions can I draw?

2.5"

CORNELL NOTE TAKING

CUE COLUMN

This section is to be completed after the lesson/lecture, and should include key words or phrases as well as vocabulary, people or case studies you may need to research, and potential exam questions.

I guess you could say this column is for the

WHAT'S
WHO'S
WHEN'S and
WHERE'S

6"

Name, Date, Subject, Topic...

NOTE TAKING COLUMN

This section of your page is dedicated to lesson time and in class note taking. You might want to include:

- Main points and lesson objectives
- Diagrams, graph sketches, drawings or charts
- Bullet points/numbered processes
- Concise sentences
- Shorthand symbols/paraphrases/abbreviations

Also, try to leave lines between points so you can go back in and add any brief notes you may have missed. This extra space will also give you a sense of clarity.

You don't have to use a ruled line version- try one with a blank note taking section to experiment with mindmaps, tables or whatever takes your fancy - make it personal to you.

You might say this column is for the

WHY'S and
HOW'S

with some of these guys thrown in.

ALSO
If you really run out of space, add a post-it, but do try to summarise on just one page!

SUMMARY SECTION

2"

This section should be written last, after class. It should also only really contain a basic, condensed summary of your notes in the Cue column, and important details of your main notes. It is used to quickly find & digest info later.

Topic:	Name:	Date:
	Class:	Period:

<u>Step 2:</u> Cues (Reduce) When: During class but after the lecture, activity or discussion What: Reduce learning to the essential facts & ideas How (make lists): • Facts • Key ideas • Important words • Pivotal phrases • Questions Why: Students can not recall everything and need to filter out the most important ideas, concepts and questions.	<u>Step 1:</u> Notes (Record) When: During class lecture, discussion or activity What: Record as many facts and ideas from the lesson as possible How: • Bullets, phrases and pictures • Avoid sentences and paragraphs • develop abbreviations and symbols • leave space between points to add information later Why: Students need to record the learning in a method that is meaningful to them before they can do anything with it.
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<u>Step 3:</u> Summary (Reflect & Review)
When: At the end of class, after class for homework or as a warmup at the start of the next class What: Synthesis that reviews and summarizes the main ideas from the lesson How (in complete sentences, answer questions such as the following): • "Why is this information important?" • "What conclusions can I make from this information?" • "How can this information be applied?" Why: Summarizing and reviewing information after it is learned is one of the best research based strategies for ensuring long term retention of any content or skill.

Exercise: Learning and Understanding the Five R's of the Cornell Notetaking

Use the table of ideas in the section “**Learning with your Textbook using Active Learning and Active Reading**” to actively read the living heck out of the descriptions of what highly effective Cornell Notetaking looks like, and the explanations about why it works so well that follow.

On a piece of paper marked out with the Cornell Notetaking sections, write out as much of these details, instructions and explanations about the Cornell Notetaking System as you can remember, write them in the most effective place, using as much details as you can remember. Then re-read these descriptions and explanations here and add to your notes the things you think are important, but that you missed.

Extension activity: You can create an A3 version (or larger) with all of the details, an A4 version with the most important, and A5 and A6 versions which progressively include stronger and more succinct summaries.

Regularly and Systematically Reflecting to Make Progress Deliberate: At the start of every term, try to recreate this page summarising and listing key points of the Cornell Notetaking from memory, then check with the one you created last term. Also, read again the notes in this workbook and think about what you tried that works best, what you could improve, either by upgrading something you are already doing, or by trying something new to you. Add these additions and changes to improve and update the working version of your own most important ideas on effective Cornell Notetaking. Keep this version with you at the start and try to implement the new ideas as early and as often as possible into you class notes.

The Five R's of the Cornell Notetaking – Summary

1. **Record** – Your notes (ideally in your own words), written in class, with as much detail as you have time to include, written in the largest, main space.
2. **Reduce** – Extract keywords, chemical symbols, structures, diagrams and equations, create questions which your notes may or may not answer, done after the main part of the lesson, or after the lesson on the same day.
3. **Recite** – Cover your notes, read out loud your cue column, then your notes. Maybe even record your performance.
4. **Reflect** – Create 1 or 2 summary sentences that includes only the most essential and important ideas from that lesson.
5. **Review** – Return to your notes, build on and add to them. Reread your summaries regularly, especially before solving past exam paper questions on the topic.

Learning and Understanding the Five R's of the Cornell Notetaking

1. **RECORD the ideas of the lesson by handwriting them in the large right-hand section.**
 - a) Writing them out combines the thinking that uses the part of your brain associated with the idea, and with the part of the brain with the incredibly complex fine motor hand skills that creates handwriting; typing uses fewer muscles, so less brain action, so less effective. The best notes are those that you have created yourself, even if you have only altered the word order; the more you have to think, the deeper the idea goes into the brain.
 - b) This should be done in the lesson.
 - c) These notes should be as complete as possible.
 - d) Try to leave large spaces, at least 30% for future notes to be added later.
 - e) Use a variety of colours. A single pen with 4 colours is extremely valuable to professional notetaking. Try to think of a system to highlight increasingly important terms, e.g. black, least important, blue, green then red, most important keywords, with red **CAPITALS BOLD UNDERLINED** the most important you have seen this whole week. You will need to think slightly more as you are writing them, comparing new information with what you have already written on this page, and if its extremely important, other pages elsewhere. Your notes will also look much more appealing and easier to use when you are under stress preparing for an important test. Great notes are a kind gift to your future self. When you ever see your bad notes that are poorly presented, which are hard to read and all of a single colour without any formatting or attempts to help you see what matters most, is a great moment to decide to buy a 4 colour pen and start using it!
 - f) If English is not your first language, include translations here.
2. **REDUCE the sentences from your notes into just a few keywords and ideas into the much smaller cue column.**
 - a) This helps **crosslink the parts of your brain** that creates **handwriting** with the parts of your brain responsible for **creative, analytical and critical thought**, which helps to use and grow your higher order thinking skills on this subtopic, and in general. Your brain is required to see different ideas and rank their importance, so has to compare them with each other and the idea in general. The thinking it is required to do this actually creates new physical connections inside your brain.
 - b) This should be done some time, either minutes or hours, after your notes were made and on the same day (before you sleep).
 - c) If these notes are done really well you will be able to put a blank page over your main notes and from just reading the cue column on the left you will be able to recall not only keywords, but the whole idea, which makes revision much more effective and faster to do.
 - d) Try to leave large spaces, at least 30%, for future notes to be added later.
 - e) If English is not your first language, include key translations here.
3. **RECITE, or read out loud the words in the recall column.**
 - a) **Speaking out these keywords** and essential ideas combines the thinking parts of the brain needed for these ideas with another incredibly complex region of the brain involved with the throat, mouth, tongue and lips that produces spoken language and speech. It might feel like this doesn't make a difference, but it really does.
 - b) **This is especially useful for English as an additional language learners.**
 - c) Cover first your main notes and just read the cue column.
 - d) Describe diagrams with words.
 - e) Try to record your performance, especially for the harder topics. This can improve your confidence in public speaking, which is a key life skill. You edit these together and have your own personal podcast of your voice and your notes about key topics. The process of creating these files will also introduce you to an entirely new skillset connected to content generation.
 - f) This can be done really quickly and without much effort several times before your topic test or exam, but ideally only once per session, with sleep between each session, which helps consolidate and reinforce learning in extremely effective ways.



- g) Your notes will be at their most advanced state and useful when you have finished the topic in class, read through the textbook and completed all of the exercises associated with the chapter suggested in this workbook and are preparing for the end of topic test or an exam. They will hopefully include a great deal of updates, and upgrades, that are also easy and quick to identify.

Reading these notes calmly and deliberately, thinking about what you are saying, just before the exam will pull together all of the hard work you have done at different times and in different ways activating all of the memories you have worked so hard and so carefully to create.

- h) Listening to your notes could be an interesting and strongly different new way to revise in the future, find out if it works for you!

4. REFLECT on the ideas and the connections needed to understand the concept by creating summary sentences.

- a) By creating just 1 or 2 summary sentences you will be making your brain go through the whole lesson's worth of ideas again, but this time after it has been allowed to sleep, which causes important changes to its abilities and allows it to remember better. You will also have to think critically and logically to remove as much as possible to allow the central ideas to remain complete, and leaving out everything that might be important, but not essential. Writing interlinks these higher order thinking skills with the complex physical action of writing, helping embed these ideas even further into your long-term memory.
- b) When reflecting, try to organise the information in a new way. So create a reverse time order for a process, or if your notes go from small to large in your notes, do the reverse order in your summary.
- c) You need to do this after you have slept well, ideally about a week after the lesson.
- d) When done well, another revision strategy would be to put a paper across the top 80% of your notes and only read these summary sections. Then on that paper write out whatever is important but missing from the summary. Check with your cue section and then your notes to see if there is anything really important that you would have liked to include and then write out as succinctly as possible onto a strip of paper. Tape those new notes to the summary section to use later.
- e) Try to leave large spaces, at least 30% for future notes to be added later.

5. REVIEW your notes immediately and regularly using past exam paper questions. Add to them whenever you notice something important missing.

- a) The best way to test your understanding of your notes is past exam papers, which is why this Workbook exists. Almost all of the most effective and deepest learning will be done with past exam questions, both answering them, and especially checking those answers carefully with the mark schemes. The most successful students at the most selective universities are all experts at exam technique and exam questions. They are also incredibly well organised because the kinds of things that are in this Workbook are part of their everyday high school life, in their tutor time, and their lessons. But anyone can learn these key organisation, notetaking and exam skills.
- b) **Trying to answer a question on your own is the best way to really test yourself.** Guess if you have to, but the more you write, the better your guessing skills will get (which eventually, with a lot of structured growth, becomes what is known as "Professional Judgement", which is how engineers, for instance build a new kind of aeroplane). Also, the more invested you are in trying to find the answer, by writing as much as you know, the more interested you will be to know the actual correct and complete answer.
- c) Finding questions that you can't quite answer on your own when you are solving past exam questions will give you the most valuable study aid there is: a practical curiosity to find out.
- d) After you have got as much written down as you can using only your memory, check your notes for questions you think need more than you are able to remember. In a different colour pen, add to your answer using information in your notes.
- e) After completing about 10 to 20 mark's worth of questions (or a page or two from this Workbook), check your answers with the mark scheme. You should be able to easily tell which answers you were able to remember on your own, and what parts you got from your notes because they are



written in a different colour pen. In a third colour, ideally red, add additional details until your answer includes all of the points needed to get all of the marks in the mark scheme.

- f) **The details you remembered without help** are least important to getting the next grade: you already know them and have shown that you can deliver them in the right context.
- g) **The details you needed your notes** for are the most important for you getting the higher grade. You have already started the work to learn these and can use them effectively when they are in front of you. You just need to remember them better. These are usually the easiest but most important and most valuable details to learn for the next test. You can write these on cue cards or flashcards to help you remember them better, for instance.
- h) **The details you could not remember and did not include from your notes, but were in the mark scheme** have two categories. Both of these levels represent the hardest parts of the syllabus to you.
 - i. If the detail was in your notes, but you did not include it, where was it?
 - ii. Was it in your main notes, the cue column, or the summary section at the bottom?
 - iii. How can you highlight this detail?
 - iv. Usually given that you missed it, even with your notes in front of you, it means you should give it an increased level of priority, so either promote it by writing it out into the cue column from the main notes section or even adding it the summary section (the most important part).
- i) **If the details from the mark scheme you missed were not in your notes**, where they in the textbook?
 - i. Tracking down these details is your curiosity in action, and this is the most powerful way to learn.
 - ii. If you find these kinds of details are often in the textbook, but not your notes after you have finished learning a topic in class then you need to fill in these gaps.
 - iii. **The easiest way** to do this is to use a textbook find out what you are missing and add it afterwards to each topic.
 - iv. **The most effective way** to do this is to try to find out why you are missing out on these key facts in your notes and solve the problem, either by making better notes in class, if that is where the problem is coming from.
 - v. Or, if you are getting everything written down in class, but there are still key things missing, then after each class add to your notes using the relevant sections of your textbook.
- j) **After every topic test, look back on your notetaking method** and make improvements to address whatever issues you have encountered. If you need more space, miss every other or every third line out. If your notes in class are too messy to easily read, rewrite them after class but on the same day after you made them (an extremely powerful technique, but usually not as effective for most students as solving past exam questions).

Using the Cornell Notetaking System for Topics you have not Studied in Class

You can also use the Cornell Notetaking system to make notes from chapters you have not studied in class. To study well doing that you should be rewriting the ideas found in the textbook into your own words, the more you change what was written the stronger the learning effect. If you are going to cover this topic anyways in class, this kind of activity often is not a particularly effective or efficient use of study time.

Some students will race ahead and do work on topics much later in the AS syllabus, including into the A2 syllabus, sometimes without really looking into the past exam questions for the topics they already feel they have completed. This is often not the best use of time to get the highest quality A* Vital understanding that is needed to make sense of this more advanced material is often missing



leading to silly misunderstandings which are hard to unlearn. It is far better instead to become a true expert on the topic you are studying, and any you have studied, with past exam paper questions especially, and then working on and exploring every other active learning technique presented in these workbooks.

If after running out of all things to do from these Paper 1, 2 and 3 workbooks for all topics you have so far covered in class you still have extra time to use, instead of skipping ahead in the syllabus, work towards the kinds of extracurricular activities that the best universities use to make offers to students with otherwise identical academic achievements. More information can be found here: <https://www.smashingscience.org/uni-guidance>

Effective Note-Taking Tips and Examples

Develop a code system of note-marking to indicate questions, comments, important points, for example:

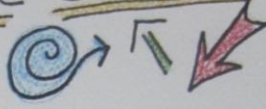
- a) Mark unfamiliar vocabulary & unclear ideas in unique ways, such as with a star or asterisk.
Highlight vocabulary terms and important people.
- b) Circle ideas that are still unclear.
- c) Make sure you can understand what you have written and if needed, make corrections.
Use drawings, arrows or other organizers to help you see concepts and relationships between them.
- d) If you don't understand an idea, leave a large blank space and ask your teacher, or investigate it in your textbook. Update your notes with what you found out.
- e) Use accepted **abbreviations** and **symbols** wherever you are comfortable
e.g.
 - i. s/ for some: s/thing, s/where
 - ii. Positive: +ve, +vely, Negative: -ve, -vely
 - iii. H^+ for proton, e^- for electron
 - iv. $\downarrow$ for less, smaller or decreasing; $\uparrow$ for more, increasing or bigger
 - v. And is & or +
 - vi. Equalities and relationships: $\approx$ approx.; $\neq$ not the same; $=$ exactly the same; $x < y$ x is less or $x > y$ x is more.
 - vii. Take particular care when writing chemical symbols and include state symbols whenever possible when you know them, so bromine is $Br_2(l)$ not Br!
 - viii. Always pay attention to bonding when ordering atoms in structures, so for methanol write $HO-CH_3$ instead of $OH-CH_3$ etc.
 - ix. If your notetaking style really favours abbreviations and you find you use a larger number, make sure that you have a key page in your notes explaining what your abbreviations mean.
 - x. At the start of every term, spend 15 minutes to analyse your notes only for abbreviations. Do they still make sense? Do they make it harder, easier or no impact to understand your notes? Often for most students most abbreviations usually create more problems than they solve.
 - xi. **NEVER use any abbreviations except chemical elements in exam questions, either when you are practicing or in the exams!**

For a more detailed and involved exploration and explanation of notetaking download document attached to this QR code (30 pages):

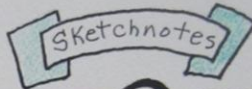


Sketchnote Basics

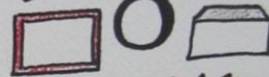
1. Arrows



2. Banners



3. Containers



4. Frames



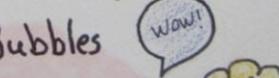
5. Icons



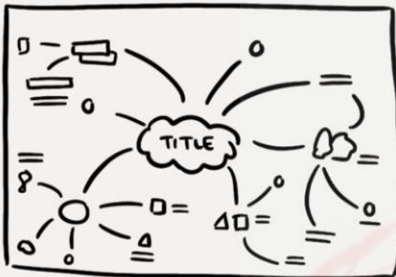
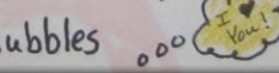
6. People



7. Speech Bubbles



8. Thought Bubbles



MIND MAP

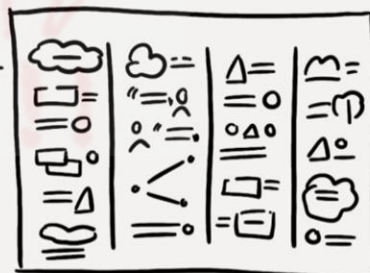
FOLLOW A PATH (WORKS BEST FOR STORIES)



WORK IN COLUMNS - IT'S LESS INTIMIDATING IF YOU BREAK THE PAGE



USE DISCRETE BOXES



OR



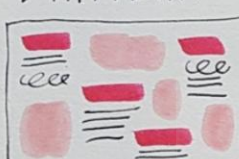
JUST WORK TO FILL THE PAGE & HIGHLIGHT AS YOU GO.

DRAW YOUR NOTES!

INTRO TO VISUAL NOTE-TAKING
by Ink Factory Studio

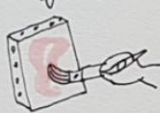
VISUAL HIERARCHY

- SCALE
- CONTRAST
- COLOR
- PATTERN



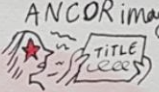
TOOLS

- Pick the "CANVA" first
- pens brushes
- digital



WARM UP EXERCISES

- lines & circles
- circles & squares
- draw the TITLE & an ANCHOR image



COLORS

- CONTRAST
- SATURATION
- One COLOR for ONE INFORMATION or SPEAKER
- 1 DARK
- 1 LIGHT
- 1 MEDIUM



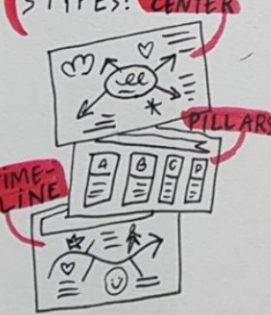
HAND WRITING

- LETTERING more elaborate
- WRITE IN UPPERCASE
- DRAW BLOCK LETTERS



COMPOSITION

3 TYPES: CENTER



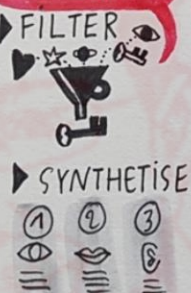
VISUAL LANGUAGE

- ICONS LIBRARY
- SIMPLE! NOT A MASTER-PIECE



ACTIVE LISTENING

- FILTER
- SYNTHETISE



PRACTISE & IMPROVE

- CHECKLIST to set up for SUCCESS
- ASK FOR FEEDBACK



CONCLUSION

- It takes TIME & PRACTISE



Sketchnote Tips

Carol Anne McGuire

Lettering	Bullets	Frames	Connectors	Shadows	People
Print (easy to read)					
High Low	○ =	Cloud	→	Cloud	People
SKINNY FAT	□ =	Speech bubble	→	Person	Person
ALL CAPS	◇ =	Star	→	Person	Person
Small Caps	* =	HELLO!	→	Person	Person
Kinder	B =	HELLO	→	Person	Person
FANCY		HELLO	→	Person	Person
Fast		HELLO	→	Person	Person
Reverse		WOW	→	Person	Person
BLOCK		ANGRY!	→	Person	Person
3D		SLAY	→	Person	Person
DASH		ELECTRONIC	→	Person	Person
Script		BANNER	→	Person	Person

How To Illustrate Your Notes

By Revise or Die

YOU CAN DO IT!

YES. I CAN DO IT!

IT'S ALL ABOUT PIC N' MIX Y'KNOW

① CHOOSE YOUR 'BAG'... (TYPE OF NOTES)

MINDMAP? POSTER? THE CORNELL METHOD?
THE OUTLINING METHOD? THE CHARTING METHOD?



② CHOOSE YOUR 'SCOOP'... (FONTS/TOOLS/COLOURS)



{ THERE are SO **MANY** kinds
(O)F **FONTS** to choose **FROM**
to find inspo go to dafont.com!



PENS

BIRD

FINELINER

PENCILS

GEL

FELT TIP

HIGHLIGHTER

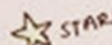
Colours - if you're feeling really snazzy, choose a colour palette for your work! Here's some suggested ones I use...



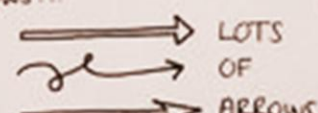
③ CHOOSE YOUR 'SWEETS'... (TWIDDLY BITS)



DASHED LINES



ARROWS...

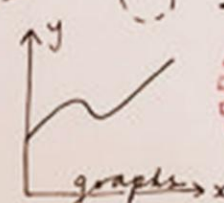


LOTS OF ARROWS

①
②
③
STEP-BY-STEP!
HA!



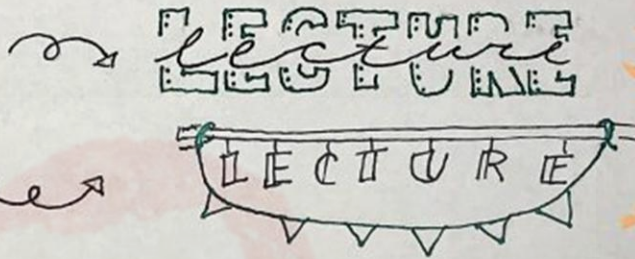
LITTLE DRAWINGS OF WHO YOU'RE STUDYING



+ anything specific to the subject - don't be afraid to draw it!

how to Illustrate — — YOUR NOTES

1. Start your page with the **TITLE** of the **CLASS** you took notes in!

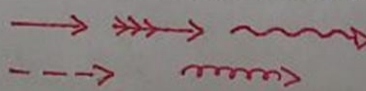
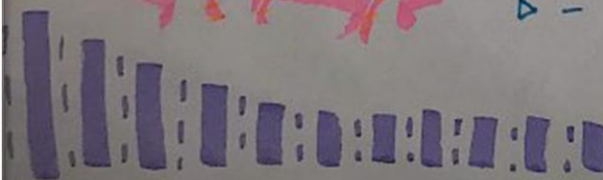


2. Then you can add **HEADERS** or the **MAIN TOPICS** of the subject!



3. There are many ways to customize your actual **NOTES!**

- WRITE *in* different **WAYS** to spice up notes!
- use various **shapes** to amplify specific words
- use doodles for little embellishments
- HIGHLIGHT key phrases!
- use bullets!
- ... and lots of arrows!



how i write outlines // take notes

ROMAN NUMERAL METHOD: (outline)

required format by my bio teacher

- I usually jot notes down in the margins
- I usually highlight key points/definitions/things the teacher goes over
- I. Main Topic
 - A. Section Name (pg. #)
 1. Important facts, concepts, examples, etc.
 2. and so on...
 - B. Section Name (pg. #)
 1. Important fact/concept/etc.
 - a. Expansion/going into details
 2. Important fact/concept/etc.
 - a. Expansion, details, more examples, etc.
 - II. Main Topic and so on...

EXAMPLE

- I. Energy and the Cell
 - A. Cells transform energy as they perform work (pg. 80)
 1. Energy is the capacity to cause change or to perform work. The 2 types of energy are kinetic and potential.
 - a. Kinetic energy is the energy of motion. Moving objects transfer motion to other matter. Heat is a type of kinetic energy associated with the random movement of atoms/electrons.
 - b. Potential energy is energy that is a result of its location or structure. Chemical energy is the potential energy available for release in a chemical reaction.

MY USUAL OUTLINE METHOD:

[Section #] Section Name

→ summary from textbook

Heading

{MAIN IDEA}

- info (important dates/ events/ people/ concepts/etc.)

SUBHEADING

- info
- event
- ↳ effect

- info (Ex) examples

I usually write the headings and subheadings in a different color

EXAMPLE

[Section 1] The Road to World War I

→ 1914, summer: Crisis in the Balkans led to conflict when a Serbian terrorist assassinated Archduke Francis Ferdinand...

Causes of the War

{MAIN IDEA} Nationalism, militarism, and a system of alliances contributed to the start of World War I.

- system of nation-states that were formed led to competition

NATIONALISM AND ALLIANCES

- Europe's greatest powers were divided into 2 alliances: the Triple Alliance (1882) AND the Triple Entente (1907)

- Germany
- Austria-Hungary
- Italy

- France
- Great Britain
- Russia



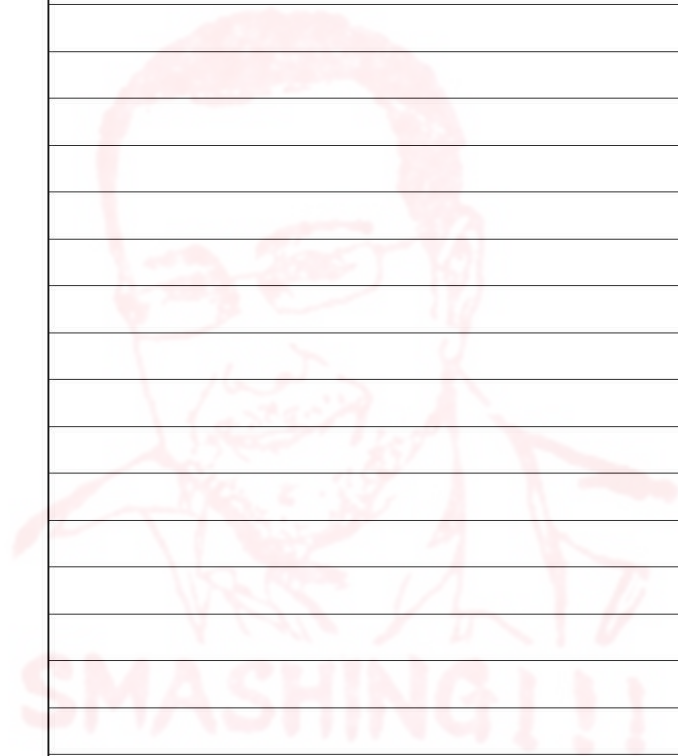
Trying Out the Cornell Notetaking System

[illegible]

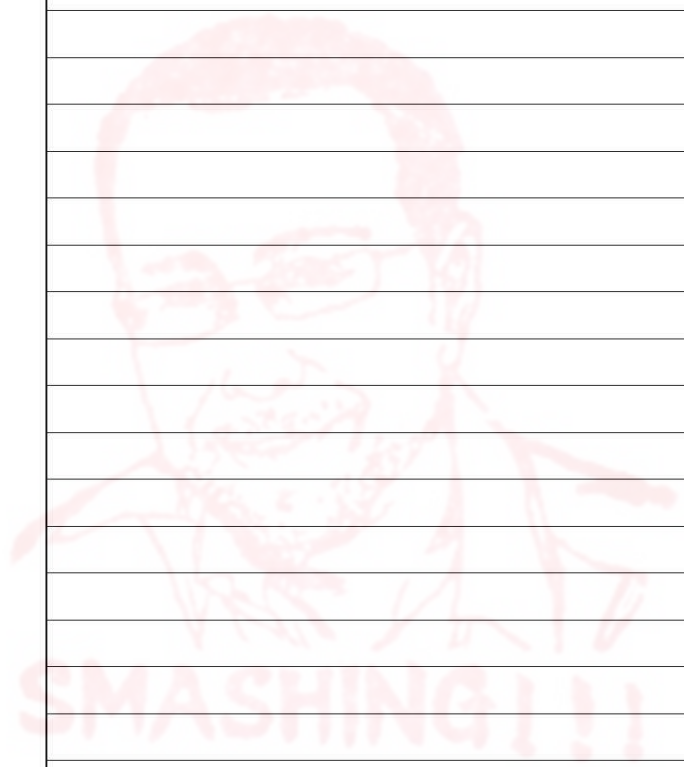
Summary Section- Do this a week later and write, in your own words, only one or two sentences that sums up the important points on this page



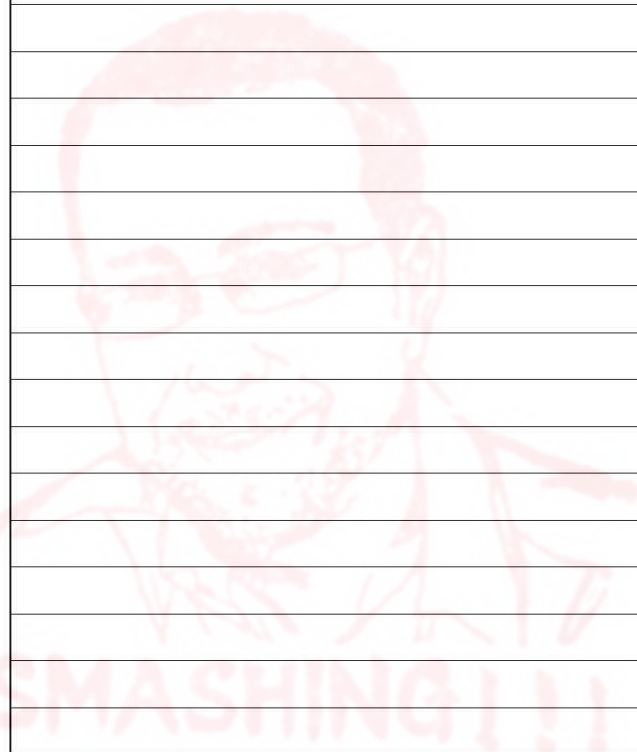
Date:



Date:



Date:



SMASHING!!!

CAIE 9701 Chemistry A Level Syllabus Data and Materials

Command Words Used in AS Chemistry Exams

Cambridge International AS & A Level Chemistry 9701 syllabus for 2025, 2026 and 2027. Details of the assessment

Command words

Command words and their meanings help candidates know what is expected from them in the exam. The table below includes command words used in the assessment for this syllabus. The use of the command word will relate to the subject context.

Command word	What it means
Analyse	examine in detail to show meaning, identify elements and the relationship between them
Calculate	work out from given facts, figures or information
Compare	identify/comment on similarities and/or differences
Consider	review and respond to given information
Contrast	identify/comment on differences
Deduce	conclude from available information
Define	give precise meaning
Demonstrate	show how or give an example
Describe	state the points of a topic / give characteristics and main features
Determine	establish an answer using the information available
Discuss	write about issue(s) or topic(s) in depth in a structured way
Evaluate	judge or calculate the quality, importance, amount, or value of something
Examine	investigate closely, in detail
Explain	set out purposes or reasons / make the relationships between things evident / provide why and/or how and support with relevant evidence
Give	produce an answer from a given source or recall/memory
Identify	name/select/recognise
Justify	support a case with evidence/argument
Predict	suggest what may happen based on available information
Show (that)	provide structured evidence that leads to a given result
Sketch	make a simple drawing showing the key features
State	express in clear terms
Suggest	apply knowledge and understanding to situations where there are a range of valid responses in order to make proposals / put forward considerations



2016 Data Booklet

The Data Booklet was used for all **Paper 1, 2 and 4** exams until and including **winter 2021**.

Two Data Booklets cover the time period of this Workbook, one for exams after 2009 and the other for exam safter 2016. Only the data booklet for 2016 is given here, but for exam questions for years 2009 to 2015 care should be taken checking the mark schemes, sometimes constants change from one edition of a Data Booklet to another, so **answers to calculations using data from an unintended Data Booklet might be a little out** as a result. If unsure, check out the earlier data booklet for questions 2015 and before (Google: "2009 data booklet 9701").

A quick and easy rule: if the question is from 2009-2015 and your calculation is a small amount out, try to do a similar question from 2016 and later. If the answer is exactly right, the problem is the data booklet, if not, and you cannot see or understand the error, concentrate on questions from 2016 and later.

Contents: Tables of Chemical Data

	Page no.
1 Important values, constants and standards	3
2 Ionisation energies (1 st , 2 nd , 3 rd and 4 th) of selected elements in kJ mol ⁻¹	4
3 Bond energies	5
4 Standard electrode potential and redox potentials, $E^\ominus$ at 298K (25 °C)	7
5 Atomic and ionic radii	10
6 Typical proton (¹ H) chemical shift values (δ) relative to TMS = 0	12
7 Typical carbon (¹³ C) chemical shift values (δ) relative to TMS = 0	13
8 Characteristic infra-red absorption frequencies for some selected bonds	14
9 The orientating effect of groups in aromatic substitution reactions	15
10 Names, structures and abbreviations of some amino acids	16
11 The Periodic Table of Elements	17

1 Important values, constants and standards

molar gas constant	$R = 8.31 \text{ JK}^{-1} \text{ mol}^{-1}$
the Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
the Avogadro constant	$L = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ Js}$
speed of light in a vacuum	$c = 3.00 \times 10^8 \text{ ms}^{-1}$
rest mass of proton, ${}^1_1\text{H}$	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of neutron, ${}^1_0\text{n}$	$m_n = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron, ${}^0_{-1}\text{e}$	$m_e = 9.11 \times 10^{-31} \text{ kg}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ under room conditions (where s.t.p. is expressed as 101 kPa, approximately, and 273 K [0 °C])
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K [25 °C])
specific heat capacity of water	$= 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ ($= 4.18 \text{ J g}^{-1} \text{ K}^{-1}$)



2 Ionisation energies (1st, 2nd, 3rd and 4th) of selected elements, in kJ mol^{-1}

	Proton number	First	Second	Third	Fourth
H	1	1310	–	–	–
He	2	2370	5250	–	–
Li	3	519	7300	11800	–
Be	4	900	1760	14800	21000
B	5	799	2420	3660	25000
C	6	1090	2350	4610	6220
N	7	1400	2860	4590	7480
O	8	1310	3390	5320	7450
F	9	1680	3370	6040	8410
Ne	10	2080	3950	6150	9290
Na	11	494	4560	6940	9540
Mg	12	736	1450	7740	10500
Al	13	577	1820	2740	11600
Si	14	786	1580	3230	4360
P	15	1060	1900	2920	4960
S	16	1000	2260	3390	4540
Cl	17	1260	2300	3850	5150
Ar	18	1520	2660	3950	5770
K	19	418	3070	4600	5860
Ca	20	590	1150	4940	6480
Sc	21	632	1240	2390	7110
Ti	22	661	1310	2720	4170
V	23	648	1370	2870	4600
Cr	24	653	1590	2990	4770
Mn	25	716	1510	3250	5190
Fe	26	762	1560	2960	5400
Co	27	757	1640	3230	5100
Ni	28	736	1750	3390	5400
Cu	29	745	1960	3350	5690
Zn	30	908	1730	3828	5980
Ga	31	577	1980	2960	6190
Br	35	1140	2080	3460	4850
Rb	37	403	2632	3900	5080
Sr	38	548	1060	4120	5440
Ag	47	731	2074	3361	5000
I	53	1010	1840	3000	4030
Cs	55	376	2420	3300	4400
Ba	56	502	966	3390	4700

3 Bond Energies

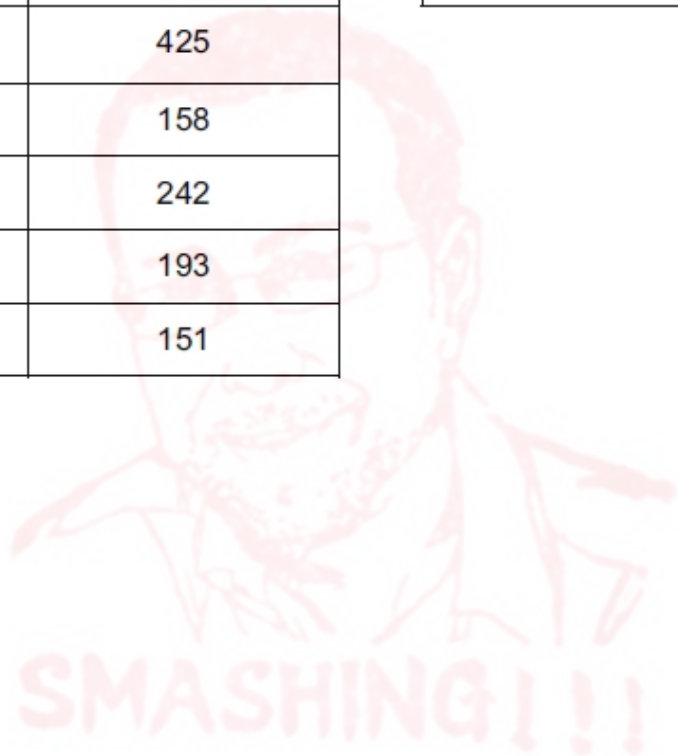
3(a) Bond energies in diatomic molecules (these are exact values)

Homonuclear

Bond	Energy / kJ mol^{-1}
H—H	436
D—D	442
N≡N	944
O=O	496
P≡P	485
S=S	425
F—F	158
Cl—Cl	242
Br—Br	193
I—I	151

Heteronuclear

Bond	Energy / kJ mol^{-1}
H—F	562
H—Cl	431
H—Br	366
H—I	299
C≡O	1077



3(b) Bond energies in polyatomic molecules (these are average values)

Homonuclear

Bond	Energy / kJ mol^{-1}
C—C	350
C=C	610
C≡C	840
C $\cdots$ C (benzene)	520
N—N	160
N=N	410
O—O	150
Si—Si	225
P—P	200
S—S	265

Heteronuclear

Bond	Energy / kJ mol^{-1}
C—H	410
C—Cl	340
C—Br	280
C—I	240
C—N	305
C=N	610
C≡N	890
C—O	360
C=O	740
C=O in CO_2	805
N—H	390
N—Cl	310
O—H	460
Si—Cl	360
Si—H	320
Si—O (in $\text{SiO}_2(\text{s})$)	460
Si=O (in $\text{SiO}_2(\text{g})$)	640
P—H	320
P—Cl	330
P—O	340
P=O	540
S—H	340
S—Cl	250
S—O	360
S=O	500

4 Standard electrode potential and redox potentials, $E^\ominus$ at 298 K (25°C)

For ease of reference, two tables are given:

- (a) an extended list in alphabetical order;
- (b) a shorter list in decreasing order of magnitude, i.e. a redox series.

(a) $E^\ominus$ in alphabetical order

Electrode reaction	$E^\ominus / V$
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Al^{3+} + 3e^- \rightleftharpoons Al$	-1.66
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	-2.90
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	-2.87
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$2HOCl + 2H^+ + 2e^- \rightleftharpoons Cl_2 + 2H_2O$	+1.64
$ClO^- + H_2O + 2e^- \rightleftharpoons Cl^- + 2OH^-$	+0.89
$Co^{2+} + 2e^- \rightleftharpoons Co$	-0.28
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+1.82
$[Co(NH_3)_6]^{2+} + 2e^- \rightleftharpoons Co + 6NH_3$	-0.43
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	-0.91
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	-0.74
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	-0.41
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$Cu^+ + e^- \rightleftharpoons Cu$	+0.52
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+0.15
$[Cu(NH_3)_4]^{2+} + 2e^- \rightleftharpoons Cu + 4NH_3$	-0.05
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	-0.04
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$[Fe(CN)_6]^{3-} + e^- \rightleftharpoons [Fe(CN)_6]^{4-}$	+0.36
$Fe(OH)_3 + e^- \rightleftharpoons Fe(OH)_2 + OH^-$	-0.56
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	-0.83
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$K^+ + e^- \rightleftharpoons K$	-2.92
$Li^+ + e^- \rightleftharpoons Li$	-3.04
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.38
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	-1.18
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$	+1.49
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+1.23
$MnO_4^- + e^- \rightleftharpoons MnO_4^{2-}$	+0.56
$MnO_4^- + 4H^+ + 3e^- \rightleftharpoons MnO_2 + 2H_2O$	+1.67
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$NO_3^- + 3H^+ + 2e^- \rightleftharpoons HNO_2 + H_2O$	+0.94
$NO_3^- + 10H^+ + 8e^- \rightleftharpoons NH_4^+ + 3H_2O$	+0.87

Electrode reaction	$E^\ominus/V$
$\text{Na}^+ + \text{e}^- \rightleftharpoons \text{Na}$	-2.71
$\text{Ni}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ni}$	-0.25
$[\text{Ni}(\text{NH}_3)_6]^{2+} + 2\text{e}^- \rightleftharpoons \text{Ni} + 6\text{NH}_3$	-0.51
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1.77
$\text{HO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons 3\text{OH}^-$	+0.88
$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1.23
$\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightleftharpoons 4\text{OH}^-$	+0.40
$\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2$	+0.68
$\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{HO}_2^- + \text{OH}^-$	-0.08
$\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}$	-0.13
$\text{Pb}^{4+} + 2\text{e}^- \rightleftharpoons \text{Pb}^{2+}$	+1.69
$\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Pb}^{2+} + 2\text{H}_2\text{O}$	+1.47
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{SO}_2 + 2\text{H}_2\text{O}$	+0.17
$\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \rightleftharpoons 2\text{SO}_4^{2-}$	+2.01
$\text{S}_4\text{O}_6^{2-} + 2\text{e}^- \rightleftharpoons 2\text{S}_2\text{O}_3^{2-}$	+0.09
$\text{Sn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sn}$	-0.14
$\text{Sn}^{4+} + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}$	+0.15
$\text{V}^{2+} + 2\text{e}^- \rightleftharpoons \text{V}$	-1.20
$\text{V}^{3+} + \text{e}^- \rightleftharpoons \text{V}^{2+}$	-0.26
$\text{VO}^{2+} + 2\text{H}^+ + \text{e}^- \rightleftharpoons \text{V}^{3+} + \text{H}_2\text{O}$	+0.34
$\text{VO}_2^+ + 2\text{H}^+ + \text{e}^- \rightleftharpoons \text{VO}^{2+} + \text{H}_2\text{O}$	+1.00
$\text{VO}_3^- + 4\text{H}^+ + \text{e}^- \rightleftharpoons \text{VO}^{2+} + 2\text{H}_2\text{O}$	+1.00
$\text{Zn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn}$	-0.76

All ionic states refer to aqueous ions but other state symbols have been omitted.

(b) $E^\ominus$ in decreasing order of oxidising power

(a selection only – see also the extended alphabetical list on the previous pages)

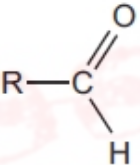
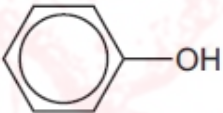
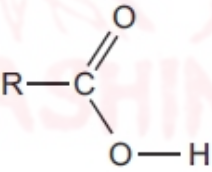
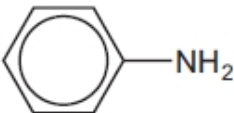
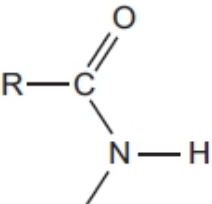
Electrode reaction	$E^\ominus / V$
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$	+2.01
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.47
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$ClO^- + H_2O + 2e^- \rightleftharpoons Cl^- + 2OH^-$	+0.89
$NO_3^- + 10H^+ + 8e^- \rightleftharpoons NH_4^+ + 3H_2O$	+0.87
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	-0.14
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	-0.76
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	-0.83
$V^{2+} + 2e^- \rightleftharpoons V$	-1.20
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.38
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	-2.87
$K^+ + e^- \rightleftharpoons K$	-2.92

5 Atomic and ionic radii

(a)	Period 1	atomic / nm		ionic / nm	
	single covalent	H	0.037	H ⁻	0.208
	van der Waals	He	0.140		
(b)	Period 2	atomic / nm		ionic / nm	
	metallic	Li	0.152	Li ⁺	0.060
		Be	0.112	Be ²⁺	0.031
	single covalent	B	0.080	B ³⁺	0.020
		C	0.077	C ⁴⁺	0.015 C ⁴⁻ 0.260
		N	0.074		N ³⁻ 0.171
		O	0.073		O ²⁻ 0.140
		F	0.072		F ⁻ 0.136
	van der Waals	Ne	0.160		
(c)	Period 3	atomic / nm		ionic / nm	
	metallic	Na	0.186	Na ⁺	0.095
		Mg	0.160	Mg ²⁺	0.065
		Al	0.143	Al ³⁺	0.050
	single covalent	Si	0.117	Si ⁴⁺	0.041 Si ⁴⁻ 0.271
		P	0.110		P ³⁻ 0.212
		S	0.104		S ²⁻ 0.184
		Cl	0.099		Cl ⁻ 0.181
	van der Waals	Ar	0.190		
(d)	Group 2	atomic / nm		ionic / nm	
	metallic	Be	0.112	Be ²⁺	0.031
		Mg	0.160	Mg ²⁺	0.065
		Ca	0.197	Ca ²⁺	0.099
		Sr	0.215	Sr ²⁺	0.113
		Ba	0.217	Ba ²⁺	0.135
		Ra	0.220	Ra ²⁺	0.140

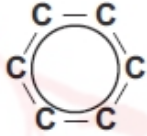
(e) Group 14	atomic / nm		ionic / nm	
single covalent	C	0.077		
	Si	0.117	Si ⁴⁺	0.041
	Ge	0.122	Ge ²⁺	0.093
metallic	Sn	0.162	Sn ²⁺	0.112
	Pb	0.175	Pb ²⁺	0.120
(f) Group 17	atomic / nm		ionic / nm	
single covalent	F	0.072	F ⁻	0.136
	Cl	0.099	Cl ⁻	0.181
	Br	0.114	Br ⁻	0.195
	I	0.133	I ⁻	0.216
	At	0.140		
(g) First row transition elements	atomic / nm		ionic / nm	
metallic	Sc	0.164		Sc ³⁺ 0.081
	Ti	0.146	Ti ²⁺ 0.090	Ti ³⁺ 0.067
	V	0.135	V ²⁺ 0.079	V ³⁺ 0.064
	Cr	0.129	Cr ²⁺ 0.073	Cr ³⁺ 0.062
	Mn	0.132	Mn ²⁺ 0.067	Mn ³⁺ 0.062
	Fe	0.126	Fe ²⁺ 0.061	Fe ³⁺ 0.055
	Co	0.125	Co ²⁺ 0.078	Co ³⁺ 0.053
	Ni	0.124	Ni ²⁺ 0.070	Ni ³⁺ 0.056
	Cu	0.128	Cu ²⁺ 0.073	
	Zn	0.135	Zn ²⁺ 0.075	

6 Typical proton (^1H) chemical shift values (δ) relative to TMS = 0

type of proton	environment of proton	example structures	chemical shift range (δ)
C-H	alkane	$-\text{CH}_3$, $-\text{CH}_2-$, $>\text{CH}-$	0.9–1.7
	alkyl next to C=O	$\text{CH}_3-\text{C}=\text{O}$, $-\text{CH}_2-\text{C}=\text{O}$, $>\text{CH}-\text{C}=\text{O}$	2.2–3.0
	alkyl next to aromatic ring	CH_3-Ar , $-\text{CH}_2-\text{Ar}$, $>\text{CH}-\text{Ar}$	2.3–3.0
	alkyl next to electronegative atom	CH_3-O , $-\text{CH}_2-\text{O}$, $-\text{CH}_2-\text{Cl}$, $>\text{CH}-\text{Br}$	3.2–4.0
	attached to alkyne	$\equiv\text{C}-\text{H}$	1.8–3.1
	attached to alkene	$=\text{CH}_2$, $=\text{CH}-$	4.5–6.0
	attached to aromatic ring		6.0–9.0
	aldehyde		9.3–10.5
O-H (see note below)	alcohol	$\text{RO}-\text{H}$	0.5–6.0
	phenol		4.5–7.0
	carboxylic acid		9.0–13.0
N-H (see note below)	alkyl amine	$\text{R}-\text{NH}-$	1.0–5.0
	aryl amine		3.0–6.0
	amide		5.0–12.0

Note: δ values for $-\text{O}-\text{H}$ and $-\text{N}-\text{H}$ protons can vary depending on solvent and concentration

7 Typical carbon (^{13}C) chemical shift values (δ) relative to TMS = 0

hybridisation of the carbon atom	environment of carbon atom	example structures	chemical shift range (δ)
sp^3	alkyl	CH_3- , $-\text{CH}_2-$, $-\text{CH}<$, $>\text{C}<$	0–50
sp^3	next to alkene/arene	$-\text{C}-\text{C}=\text{C}$, $-\text{C}-$ 	10–40
sp^3	next to carbonyl/carboxyl	$-\text{C}-\text{COR}$, $-\text{C}-\text{CO}_2\text{R}$	25–50
sp^3	next to nitrogen	$-\text{C}-\text{NH}_2$, $-\text{C}-\text{NR}_2$, $-\text{C}-\text{NHCO}$	30–65
sp^3	next to chlorine ($-\text{CH}_2\text{-Br}$ and $-\text{CH}_2\text{-I}$ are in the same range as alkyl)	$-\text{C}-\text{Cl}$	30–60
sp^3	next to oxygen	$-\text{C}-\text{OH}$, $-\text{C}-\text{O}-\text{CO}-$	50–70
sp^2	alkene or arene	$>\text{C}=\text{C}<$, 	110–160
sp^2	carboxyl	$\text{R}-\text{CO}_2\text{H}$, $\text{R}-\text{CO}_2\text{R}$	160–185
sp^2	carbonyl	$\text{R}-\text{CHO}$, $\text{R}-\text{CO}-\text{R}$	190–220
sp	alkyne	$\text{R}-\text{C}\equiv\text{C}-$	65–85
sp	nitrile	$\text{R}-\text{C}\equiv\text{N}$	100–125

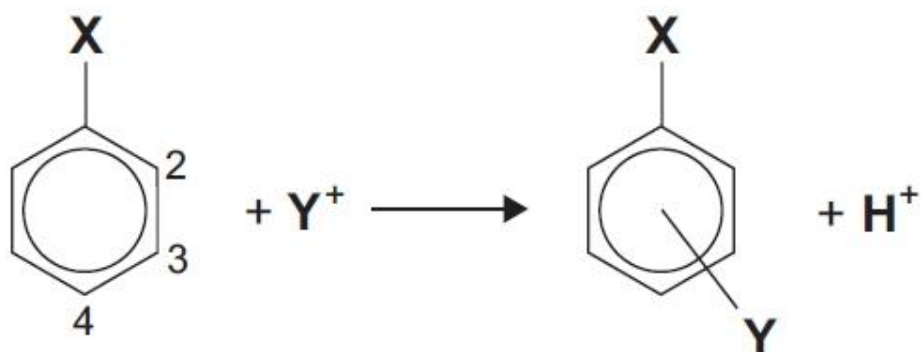
8 Characteristic infra-red absorption frequencies for some selected bonds

bond	functional groups containing the bond	absorption range (in wavenumbers) /cm ⁻¹	appearance of peak (s = strong, w = weak)
C–O	alcohols, ethers, esters	1040–1300	s
C=C	aromatic compounds, alkenes	1500–1680	w unless conjugated
C=O	amides, ketones and aldehydes, carboxylic acids, esters	1640–1690 1670–1740 1680–1730 1710–1750	s s s s
C≡C	alkynes	2150–2250	w unless conjugated
C≡N	nitriles	2200–2250	w
C–H	alkanes, CH ₂ –H alkenes/arenes, =C–H	2850–2950 3000–3100	s w
N–H	amines, amides	3300–3500	w
O–H	carboxylic acids, RCO ₂ –H H-bonded alcohol, RO–H free alcohol, RO–H	2500–3000 3200–3600 3580–3650	s and very broad s s and sharp

SMASHING!!!

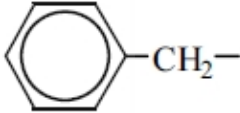
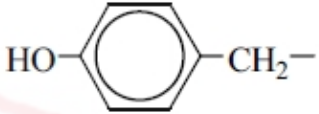
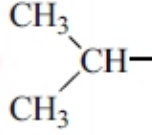
9 The orientating effect of groups in aromatic substitution reactions.

The position of the incoming group, Y, is determined by the nature of the group, X, already bonded to the ring, and not by the nature of the incoming group Y.



X- groups that direct the incoming Y group to the 2- or 4- positions	X- groups that direct the incoming Y group to the 3- position
-NH ₂ , -NHR or -NR ₂	-NO ₂
-OH or -OR	-NH ₃ ⁺
-NHCOR	-CN
-CH ₃ , -alkyl	-CHO, -COR
-Cl	-CO ₂ H, -CO ₂ R

10 Names, structures and abbreviations of some amino acids

name	3-letter abbreviation	1-letter symbol	structure of side chain R- in $\begin{array}{c} \text{NH}_2 \\ \\ \text{R}-\text{CH} \\ \\ \text{CO}_2\text{H} \end{array}$
alanine	Ala	A	CH_3-
aspartic acid	Asp	D	HO_2CCH_2-
cysteine	Cys	C	HSCH_2-
glutamic acid	Glu	E	$\text{HO}_2\text{CCH}_2\text{CH}_2-$
glycine	Gly	G	$\text{H}-$
lysine	Lys	K	$\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{CH}_2-$
phenylalanine	Phe	F	
serine	Ser	S	HOCH_2-
tyrosine	Tyr	Y	
valine	Val	V	

Important Values, Constants and Standards (2022 and after)

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 $\text{J g}^{-1} \text{ K}^{-1}$)

The Periodic Table of Elements

Group																			
1	2	Key												13	14	15	16	17	18
		1 H hydrogen 1.0																	
		atomic number atomic symbol name relative atomic mass																	
3 Li lithium 6.9	4 Be beryllium 9.0																		
11 Na sodium 23.0	12 Mg magnesium 24.3	3 Li lithium 6.9	4 Be beryllium 9.0	5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2	13 Al aluminum 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9				
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8		
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium —	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3		
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids		72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium —	85 At astatine —	86 Rn radon —	
87 Fr francium —	88 Ra radium —	89–103 actinoids		104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	117 Ts tennessine —	118 Og oganeson —	
lanthanoids																			
57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium —	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0					
actinoids																			
89 Ac actinium —	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —					

