Name: Class: Date:

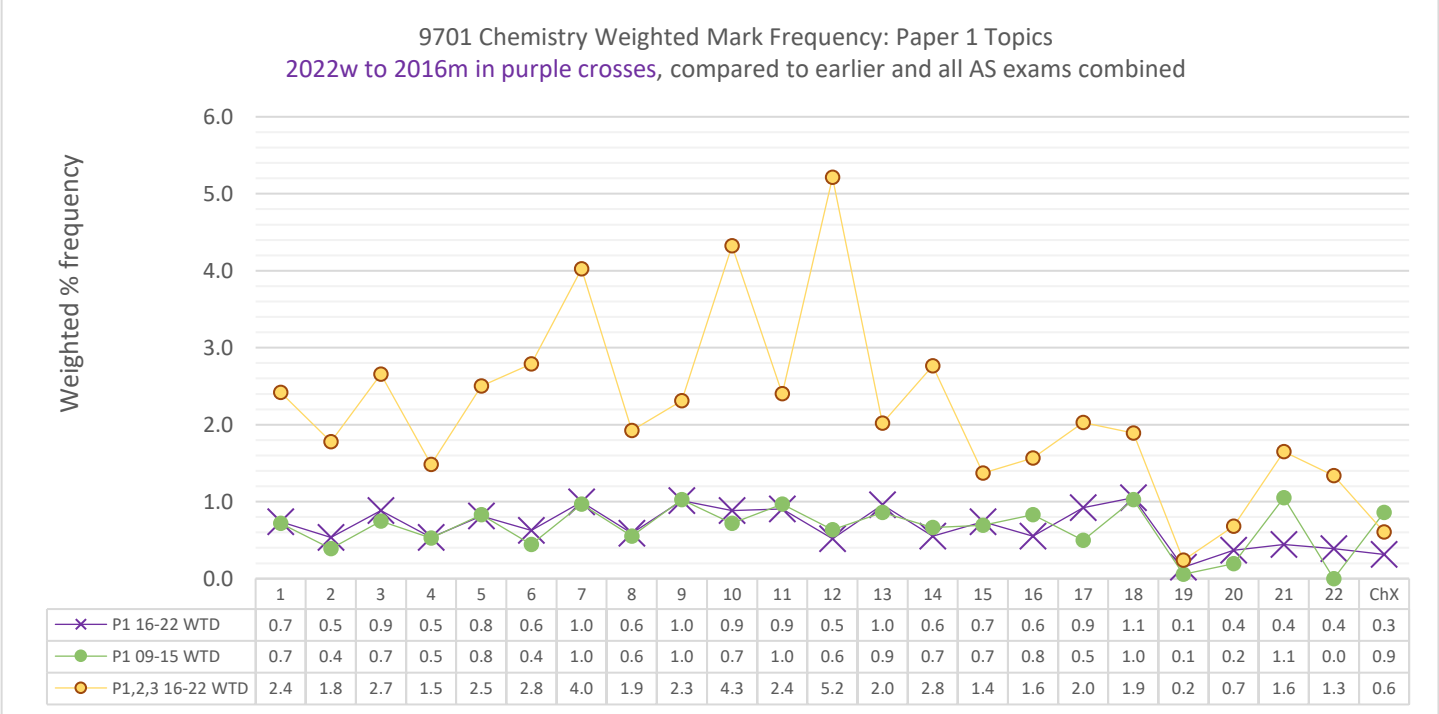
ALvl Chem 5 EQ P1 22w to 09s Paper 1 Chemical energetics 73marks

As you start and work through this worksheet you can tick off your progress to show yourself how much you have done, and what you need to do next. The first task is just to read the first question and should take you less than one minutes to complete.

Paper 1 **Topic 5**

Checklist Tick each task off as you go along

	RANK:	P1 Noob	P1 Novice	P1 Bronze	P1 Silver	P1 Gold	P1[1] Winner	P1 Hero	P1 Legend
		1 Q started	1 Q done	10% of marks	25% of marks	40% of marks	50% of marks	75% of marks	100% of marks
Topic (marks)	73		1	7	18	29	37	55	73
Time @75s/mark (minutes)	91		1	9	23	37	46	68	91



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	ChX
P1 16-22 WTD	0.7	0.5	0.9	0.5	0.8	0.6	1.0	0.6	1.0	0.9	0.9	0.5	1.0	0.6	0.7	0.6	0.9	1.1	0.1	0.4	0.4	0.4	0.3
P1 09-15 WTD	0.7	0.4	0.7	0.5	0.8	0.4	1.0	0.6	1.0	0.7	1.0	0.6	0.9	0.7	0.7	0.8	0.5	1.0	0.1	0.2	1.1	0.0	0.9
P1,2,3 16-22 WTD	2.4	1.8	2.7	1.5	2.5	2.8	4.0	1.9	2.3	4.3	2.4	5.2	2.0	2.8	1.4	1.6	2.0	1.9	0.2	0.7	1.6	1.3	0.6

What the most thoughtful students will get out of their extensive studying will be a capacity to do meaningful brain-based work even under stressful conditions, which is a part of the self-mastery skillset that will continue to deliver value for the whole of their lives. Outstanding grades will also happen, but the most important goal from skillful action in study is being better at any important task, even if circumstances do not feel ideal.

As you are moving through your studies you can learn more about yourself by trying out new ways to manage yourself, and analysing how effective those new techniques were. In this reflective process not only will you get better at working positively and productively to deliver ambitious and successful outcomes, but you will be working towards one aspect of life's highest pursuit, summarised and inscribed on the Temple of Apollo at Delphi: "know thyself".

1. To complete these questions, as important as your answer, is checking your answer against the mark scheme.
2. For each page or group of 10 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.
3. Multiple choice questions, done carefully where you explain and show yourself your thinking using written notes as you move through each question, can be more useful than just Paper 2 for students aiming for a C or B grade. Paper 2 should be the larger focus for students aiming for A and A* grades, however.
4. If you find you get a higher percentage answering short answer questions than multiple choice questions that often means you are NOT using the marking scheme correctly; your correct answer might not be fully complete for all the marks you are awarding. The marks easiest to miss rely on providing the largest amount of detail.

[1] **DO NOT** work on these higher levels of completion in your A2 year unless you have also achieved at least a "**Silver**" (25%) in the same topic in **Paper 2**, which is **MOST** of your **AS grade**, and Paper 3 which is a smaller part of your year but still important.

5 Chemical energetics

5.1 Enthalpy change, ΔH

Learning outcomes

Candidates should be able to:

1 understand that chemical reactions are accompanied by enthalpy changes and these changes can be exothermic (ΔH is negative) or endothermic (ΔH is positive)

2 construct and interpret a reaction pathway diagram, in terms of the enthalpy change of the reaction and of the activation energy

3 define and use the terms:

(a) standard conditions (this syllabus assumes that these are 298 K and 101 kPa) shown by $^{\ominus}$.

(b) enthalpy change with particular reference to: reaction, ΔH_r, formation, ΔH_f, combustion, ΔH_c, neutralisation, ΔH_{neut}

4 understand that energy transfers occur during chemical reactions because of the breaking and making of chemical bonds

5 use bond energies (ΔH positive, i.e. bond breaking) to calculate enthalpy change of reaction, ΔH_r

6 understand that some bond energies are exact and some bond energies are averages

7 calculate enthalpy changes from appropriate experimental results, including the use of the relationships $q = mc\Delta T$ and $\Delta H = -mc\Delta T$

5.2 Hess's Law

Learning outcomes

Candidates should be able to:

1 apply Hess's Law to construct simple energy cycles

2 carry out calculations using cycles and relevant energy terms, including:

(a) determining enthalpy changes that cannot be found by direct experiment

(b) use of bond energy data

Q# 232/ AS Chemistry/2022/w/TZ 1/Paper 1/Q# 9//www.SmashingScience.org :o)

9 The enthalpy changes of formation, $\Delta H_f^{\ominus}$, of both PCl_3 and PCl_5 are exothermic.

PCl_3 reacts with chlorine.

$$PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s) \qquad \Delta H^{\ominus}_{reaction} = -124\ kJ\ mol^{-1}$$

Which pair of statements is correct?

	statement 1	statement 2
A	$\Delta H^{\ominus}_{reaction}$ is less negative than $\Delta H_f^{\ominus}(PCl_5)$.	The Cl_2 bond energy is needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.
B	$\Delta H^{\ominus}_{reaction}$ is more negative than $\Delta H_f^{\ominus}(PCl_5)$.	The Cl_2 bond energy is needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.
C	$\Delta H^{\ominus}_{reaction}$ is less negative than $\Delta H_f^{\ominus}(PCl_5)$.	The Cl_2 bond energy is not needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.
D	$\Delta H^{\ominus}_{reaction}$ is more negative than $\Delta H_f^{\ominus}(PCl_5)$.	The Cl_2 bond energy is not needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.

Q# 233/ AS Chemistry/2022/w/TZ 1/Paper 1/Q# 10//www.SmashingScience.org :o)

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 J cm^{-3} 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}

Q# 234/ AS Chemistry/2022/s/TZ 1/Paper 1/Q# 9//www.SmashingScience.org :o)

9 The equation for an enthalpy change is shown. The enthalpy change is Q.

$$2C(s) + 3H_2(g) + 3.5O_2(g) \xrightarrow{Q} 2CO_2(g) + 3H_2O(l)$$

What is the correct expression to calculate Q?

A $2 \times \Delta H_c^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

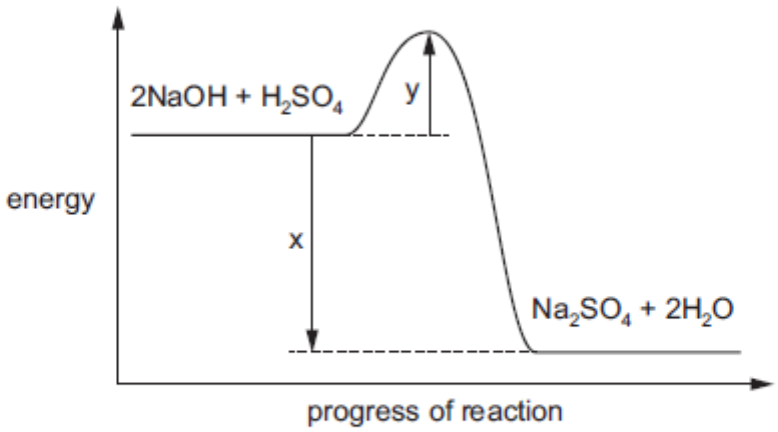
B $3 \times \Delta H_f^{\ominus}[H_2O(g)] + 2 \times \Delta H_c^{\ominus}[CO_2(g)]$

C $2 \times \Delta H_f^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

D $3 \times \Delta H_f^{\ominus}[H_2O(l)] + 2 \times \Delta H_f^{\ominus}[CO_2(g)]$

Q# 235/ AS Chemistry/2022/s/TZ 1/Paper 1/Q# 10//www.SmashingScience.org :o)

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** $\frac{(x-y)}{2}$

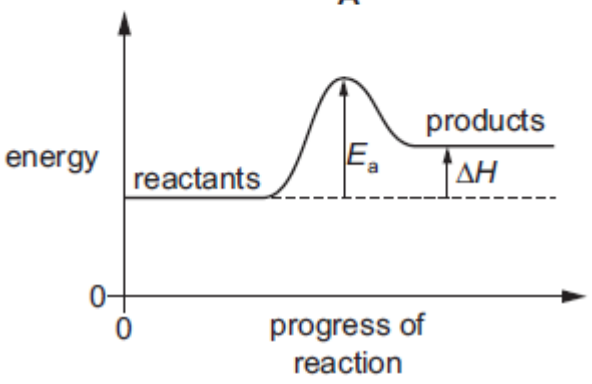
Q# 236/ AS Chemistry/2022/m/TZ 2/Paper 1/Q# 9//www.SmashingScience.org :o)

9 Nitrogen monoxide is an atmospheric pollutant that is formed inside car engines by an endothermic reaction between nitrogen and oxygen.

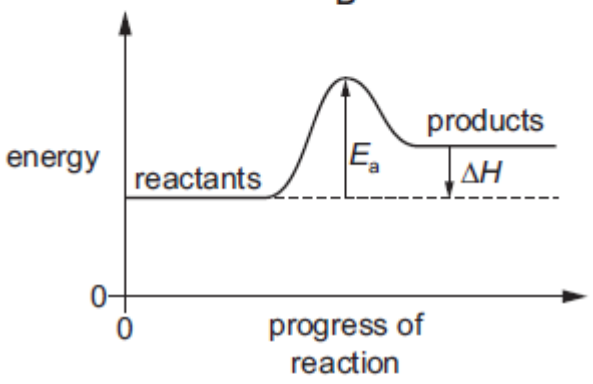
$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

Which diagram correctly represents the energy profile for this reaction?

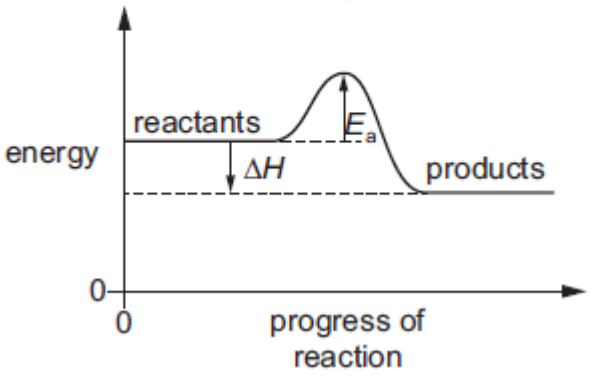
A



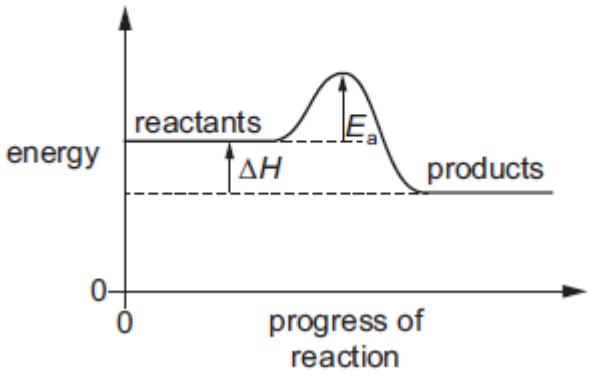
B



C



D



Q# 237/ AS Chemistry/2022/m/TZ 2/Paper 1/Q# 8//www.SmashingScience.org :o)

8 The equation for reaction 1 is shown.

reaction 1 $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$

	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
$C_6H_{12}O_6$	a
C_2H_5OH	b

What is the correct expression for the enthalpy change of reaction 1?

A $a + b$ **B** $a - b$ **C** $a + 2b$ **D** $a - 2b$

Q# 238/ AS Chemistry/2021/w/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 Which equation represents the enthalpy change of atomisation of iodine?

A $\frac{1}{2}I_2(g) \rightarrow I(g)$

B $I_2(g) \rightarrow 2I(g)$

C $\frac{1}{2}I_2(s) \rightarrow I(g)$

D $I_2(s) \rightarrow 2I(g)$

Q# 239/ AS Chemistry/2021/w/TZ 1/Paper 1/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 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 25.0 cm^3 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 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 50.0 cm^3 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

Q# 240/ AS Chemistry/2021/s/TZ 1/Paper 1/Q# 4//www.SmashingScience.org :o)

4 $\Delta H_1^\ominus$ is the standard enthalpy of formation of methane.

$\Delta H_2^\ominus$ is the standard enthalpy of combustion of carbon.

$\Delta H_3^\ominus$ is the standard enthalpy of combustion of hydrogen.

$$CH_4(g) + 2O_2(g) \xrightarrow{\Delta H_c^\ominus} CO_2(g) + 2H_2O(l)$$

Which expression is equivalent to $\Delta H_c^\ominus$?

A $\Delta H_1^\ominus - \Delta H_2^\ominus + \Delta H_3^\ominus$

B $\Delta H_1^\ominus - 2\Delta H_3^\ominus - \Delta H_2^\ominus$

C $\Delta H_2^\ominus - \Delta H_3^\ominus + \Delta H_1^\ominus$

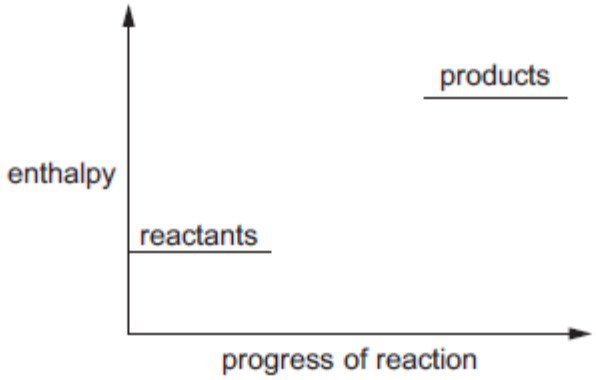
D $\Delta H_2^\ominus + 2\Delta H_3^\ominus - \Delta H_1^\ominus$

Q# 241/ AS Chemistry/2021/s/TZ 1/Paper 1/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?

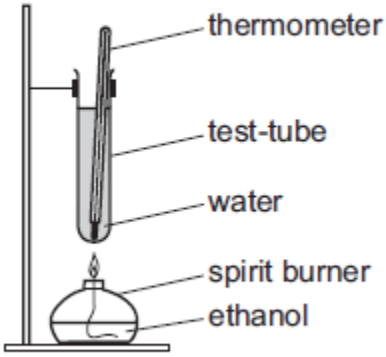
1 $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

2 $H_2(g) \rightarrow 2H(g)$

3 $Cl^-(aq) \rightarrow Cl^-(g) + aq$

Q# 242/ AS Chemistry/2021/m/TZ 2/Paper 1/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 = Wg

mass of ethanol burned = Xg

temperature rise = Y°C

molar mass of ethanol = Zg mol^{-1}

specific heat capacity of water = 4.2 J K^{-1} g^{-1}

Which expression can be used to calculate the enthalpy of combustion of ethanol in kJ mol^{-1}?

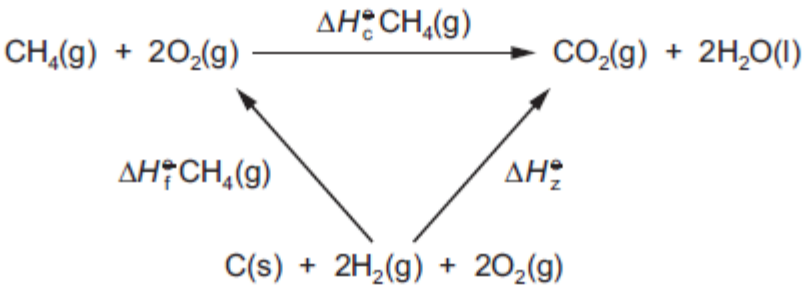
A $\frac{-4.2WYZ}{1000X}$ **B** $\frac{-4.2WYX}{1000Z}$ **C** $\frac{-4.2XYZ}{1000W}$ **D** $\frac{-4.2X(Y+273)Z}{1000W}$

Q# 243/ AS Chemistry/2021/m/TZ 2/Paper 1/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 energy cycle for the combustion of methane is shown.



Which expressions can be used to calculate the energy change, $\Delta H_z^\ominus$?

1 $\Delta H_f^\ominus CH_4(g) + \Delta H_c^\ominus CH_4(g)$

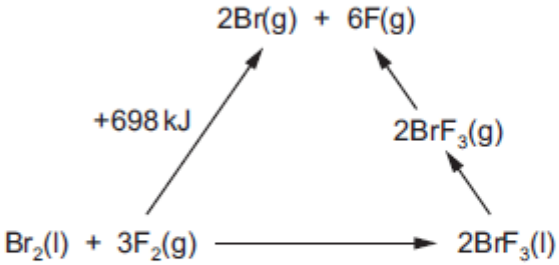
2 $\Delta H_c^\ominus C(s) + 2\Delta H_c^\ominus H_2(g)$

3 $\Delta H_c^\ominus CO(g) + 2\Delta H_c^\ominus H_2(g)$

Q# 244/ AS Chemistry/2020/w/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 An energy cycle is drawn for the following reaction.

$$Br_2(l) + 3F_2(g) \rightarrow 2BrF_3(l)$$



The standard enthalpy of formation of $BrF_3(l)$ = –301 kJ mol^{-1}.

The enthalpy change of $BrF_3(l)$ to $BrF_3(g)$ is +44 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}

Q# 245/ AS Chemistry/2020/w/TZ 1/Paper 1/Q# 6//www.SmashingScience.org :o)

6 Which pair of standard enthalpy changes are numerically equal?

A atomisation of $CH_4(g)$ and formation of $CH_4(g)$

B combustion of $CH_3OH(l)$ and combustion of graphite + 2(combustion of $H_2(g)$)

C combustion of graphite and formation of $CO_2(g)$

D neutralisation of $HCl(aq)$ with $NaOH(aq)$ and formation of $H_2O(l)$

Q# 246/ AS Chemistry/2020/w/TZ 1/Paper 1/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 statements are correct?

1 enthalpy of combustion of H_2 = enthalpy of formation of H_2O

2 enthalpy of formation of H_2 = –(enthalpy of atomisation of H_2)

3 enthalpy of solution of HCl = enthalpy of hydration of H^+ + enthalpy of hydration of Cl^-

Q# 247/ AS Chemistry/2020/w/TZ 1/Paper 1/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 Nitrogen forms a number of oxides. Their enthalpies of formation are given.

$\Delta H_f^{\ominus}[NO(g)] = +90\,kJ\,mol^{-1}$

$\Delta H_f^{\ominus}[N_2O(g)] = +82\,kJ\,mol^{-1}$

$\Delta H_f^{\ominus}[NO_2(g)] = +33\,kJ\,mol^{-1}$

Which statements are correct?

1 If $N_2O(g)$ is oxidised by $O_2(g)$ to $NO_2(g)$, 16 kJ is released per mole of N_2O.

2 The decomposition of $N_2O(g)$ to $N_2(g)$ and $O_2(g)$ is exothermic.

3 The reaction between NO and oxygen is exothermic.

Q# 248/ AS Chemistry/2020/s/TZ 1/Paper 1/Q# 5//www.SmashingScience.org :o)

5 Two reactions are shown.

$$H_2(g) \rightarrow 2H(g)$$

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g)$$

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

Q# 249/ AS Chemistry/2020/m/TZ 2/Paper 1/Q# 4//www.SmashingScience.org :o)

4 The following data are needed for this question.

$$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g) \qquad \Delta H = -38.97\,kJ\,mol^{-1}$$

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g) \qquad \Delta H = -96.59\,kJ\,mol^{-1}$$

On heating, sodium hydrogencarbonate decomposes as shown.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

What is the enthalpy change for this decomposition?

A $-57.62\,kJ\,mol^{-1}$

B $-18.65\,kJ\,mol^{-1}$

C $18.65\,kJ\,mol^{-1}$

D $57.62\,kJ\,mol^{-1}$

Q# 250/ AS Chemistry/2020/m/TZ 2/Paper 1/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.

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

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

Q# 251/ AS Chemistry/2019/w/TZ 1/Paper 1/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.

$$2Na(s) + \tfrac{1}{2}O_2(g) \rightarrow Na_2O(s)$$

Which statement about the reaction is correct?

A $\Delta H^{\ominus}$ for the reaction is equal to twice the bond energy of the Na–O bond.

B $\Delta H^{\ominus}$ 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.

Q# 252/ AS Chemistry/2019/w/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 The following data are needed for this question.

$\Delta H_f^{\ominus}(N_2H_4(l)) = 50.6\,kJ\,mol^{-1}$

$\Delta H_f^{\ominus}(N_2O_4(g)) = 9.2\,kJ\,mol^{-1}$

$\Delta H_f^{\ominus}(H_2O(g)) = -241.8\,kJ\,mol^{-1}$

Hydrazine, $N_2H_4(l)$, reacts with dinitrogen tetraoxide, $N_2O_4(g)$, to form nitrogen gas and water vapour.

$$2N_2H_4(l) + N_2O_4(g) \rightarrow 3N_2(g) + 4H_2O(g)$$

What is the enthalpy change for this reaction?

A $-1077.6\,kJ\,mol^{-1}$

B $-856.8\,kJ\,mol^{-1}$

C $-301.6\,kJ\,mol^{-1}$

D $-182.0\,kJ\,mol^{-1}$

Q# 253/ AS Chemistry/2019/s/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 Two reactions and their enthalpy changes are shown.

$$2C(s) + 2H_2(g) \rightarrow C_2H_4(g) \qquad \Delta H^{\ominus} = +52.2\,kJ\,mol^{-1}$$

$$C_2H_2(g) + H_2(g) \rightarrow C_2H_4(g) \qquad \Delta H^{\ominus} = -175.8\,kJ\,mol^{-1}$$

These data can be used to calculate the enthalpy change for the reaction shown.

$$2C(s) + H_2(g) \rightarrow C_2H_2(g) \qquad \Delta H^{\ominus} = X$$

What is the value of X?

A $-228.0\,kJ\,mol^{-1}$

B $-123.6\,kJ\,mol^{-1}$

C $+123.6\,kJ\,mol^{-1}$

D $+228.0\,kJ\,mol^{-1}$

Q# 254/ AS Chemistry/2019/s/TZ 1/Paper 1/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.

Q# 255/ AS Chemistry/2019/m/TZ 2/Paper 1/Q# 9//www.SmashingScience.org :o)

9 The equation for a chemical reaction is shown. All substances are in their standard states.

$$XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$$

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

Q# 256/ AS Chemistry/2019/m/TZ 2/Paper 1/Q# 8//www.SmashingScience.org :o)

8 The standard enthalpy changes of combustion of carbon, hydrogen and methanol are shown.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H_c^{\ominus} = -394\,kJ\,mol^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H_c^{\ominus} = -286\,kJ\,mol^{-1}$$

$$CH_3OH(l) + 1\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H_c^{\ominus} = -726\,kJ\,mol^{-1}$$

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 $-726 - (-394) - (-286 \times 2)$

Q# 257/ AS Chemistry/2018/w/TZ 1/Paper 1/Q# 6//www.SmashingScience.org :o)

6 A butane burner is used to heat water. The M_r of butane is 58.

- $\Delta H_c^{\ominus}$ of butane is –2877 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

Q# 258/ AS Chemistry/2018/w/TZ 1/Paper 1/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 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.

Q# 259/ AS Chemistry/2018/s/TZ 1/Paper 1/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.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

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	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	–394
$H_2(g)$	–286
$C_4H_{10}(g)$	–2877

A –5883 kJ mol^{-1}

B –129 kJ mol^{-1}

C +129 kJ mol^{-1}

D +2197 kJ mol^{-1}

Q# 260/ AS Chemistry/2018/s/TZ 1/Paper 1/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.

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$$

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, $\Delta H_f^{\ominus}\,Ca(OH)_2(s)$?

1 $\Delta H_f^{\ominus}$ for $H_2O(l)$

2 $\Delta H_f^{\ominus}$ for $H_2(g)$

3 first and second ionisation energies of Ca

Q# 261/ AS Chemistry/2018/m/TZ 2/Paper 1/Q# 9//www.SmashingScience.org :o)

9 Hess' Law and bond energy data can be used to calculate the enthalpy change of a reaction.

Bromoethane, CH_3CH_2Br, can be made by reacting ethene with hydrogen bromide.

$$CH_2{=}CH_2 + HBr \rightarrow CH_3CH_2Br$$

What is the enthalpy change for this reaction?

A $-674\,kJ\,mol^{-1}$

B $-64\,kJ\,mol^{-1}$

C $+186\,kJ\,mol^{-1}$

D $+346\,kJ\,mol^{-1}$

Q# 262/ AS Chemistry/2018/m/TZ 2/Paper 1/Q# 8//www.SmashingScience.org :o)

8 Which equation represents the standard enthalpy change of formation of water?

A $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$

B $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

C $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

D $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

Q# 263/ AS Chemistry/2017/w/TZ 1/Paper 1/Q# 8//

8 Sulfur can be oxidised in two ways.

$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H^{\ominus} = -296.5\,kJ\,mol^{-1}$$

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g) \qquad \Delta H^{\ominus} = -791.4\,kJ\,mol^{-1}$$

Sulfur trioxide can be made from sulfur dioxide and oxygen.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What is the standard enthalpy change for this reaction?

A $-1384.4\,kJ\,mol^{-1}$

B $-989.8\,kJ\,mol^{-1}$

C $-494.9\,kJ\,mol^{-1}$

D $-198.4\,kJ\,mol^{-1}$

Q# 264/ AS Chemistry/2017/w/TZ 1/Paper 1/Q# 11//

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

Q# 265/ AS Chemistry/2017/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 Which expression gives the standard enthalpy change of combustion of methane?

A $\Delta H_f^{\ominus}(CH_4) + \Delta H_f^{\ominus}(CO_2) - 2\Delta H_f^{\ominus}(H_2O)$

B $\Delta H_f^{\ominus}(CO_2) + 2\Delta H_f^{\ominus}(H_2O) + \Delta H_f^{\ominus}(CH_4)$

C $\Delta H_f^{\ominus}(CH_4) + 2\Delta H_f^{\ominus}(H_2O) - \Delta H_f^{\ominus}(CO_2)$

D $\Delta H_f^{\ominus}(CO_2) + 2\Delta H_f^{\ominus}(H_2O) - \Delta H_f^{\ominus}(CH_4)$

Q# 266/ AS Chemistry/2017/s/TZ 1/Paper 1/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.

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

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

Q# 267/ AS Chemistry/2017/m/TZ 2/Paper 1/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.

Q# 268/ AS Chemistry/2017/m/TZ 2/Paper 1/Q# 7//www.SmashingScience.org :o)

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 $-62.7\ kJ\ mol^{-1}$

B $-31.4\ kJ\ mol^{-1}$

C $-15.7\ kJ\ mol^{-1}$

D $-3.14\ kJ\ mol^{-1}$

Q# 269/ AS Chemistry/2016/w/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 An important reaction in the manufacture of nitric acid is the catalytic oxidation of ammonia.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

For every mole of O_2 that reacts in this way, 181.8 kJ of energy are released.

A factory makes 2.50×10^5 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

Q# 270/ AS Chemistry/2016/w/TZ 1/Paper 1/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 For which enthalpy changes is the value of ΔH always negative?

1 combustion

2 hydration

3 solution

Q# 271/ AS Chemistry/2016/w/TZ 1/Paper 1/Q# 15//www.SmashingScience.org :o)

15 At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as $CH_3\bullet$ in the catalytic converter of a motor vehicle.

$$4CH_3\bullet + 7NO_2 \rightarrow 3\tfrac{1}{2}N_2 + 4CO_2 + 6H_2O$$

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 N≡N bond energy is very high
C	exothermic	CO_2 and H_2O have large negative $\Delta H_f^{\ominus}$ values
D	exothermic	double bonds are broken in NO_2

Q# 272/ AS Chemistry/2016/s/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

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}
P–C*l* (in both chlorides)	330
C*l*–C*l*	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 kJ mol^{-1}

D +418 kJ mol^{-1}

Q# 273/ AS Chemistry/2016/m/TZ 2/Paper 1/Q# 5//www.SmashingScience.org :o)

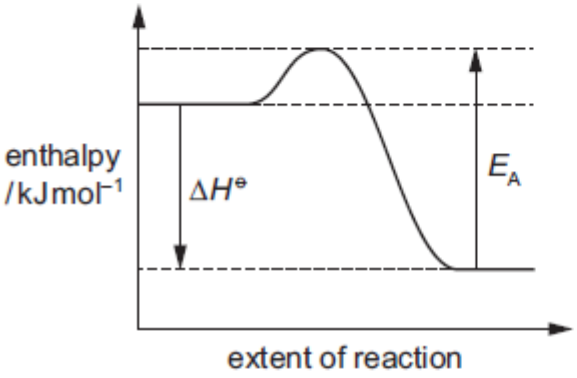
5 Nitric oxide, NO, and bromine vapour react together according to the following equation.

$$2NO(g) + Br_2(g) \rightarrow 2NOBr(g) \qquad \Delta H^{\ominus} = -23\,kJ\,mol^{-1}$$

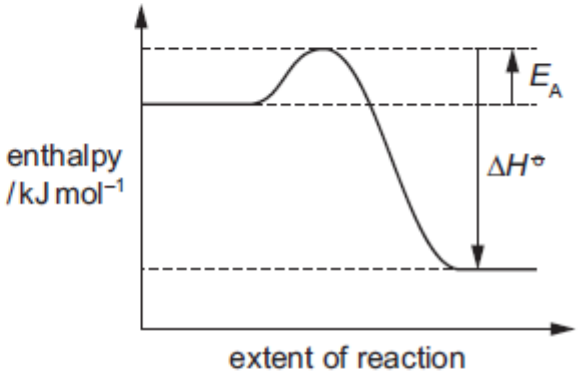
The reaction has an activation energy of $+5.4\,kJ\,mol^{-1}$.

What is the correct reaction pathway diagram for this reaction?

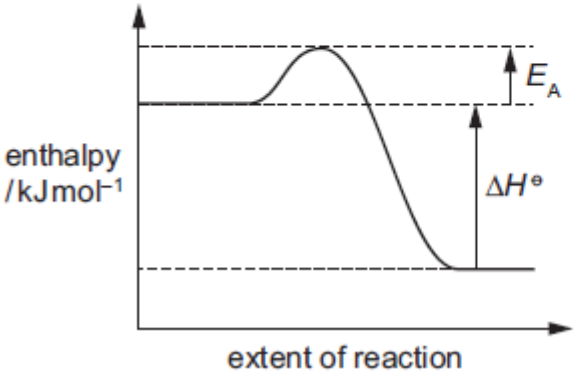
A



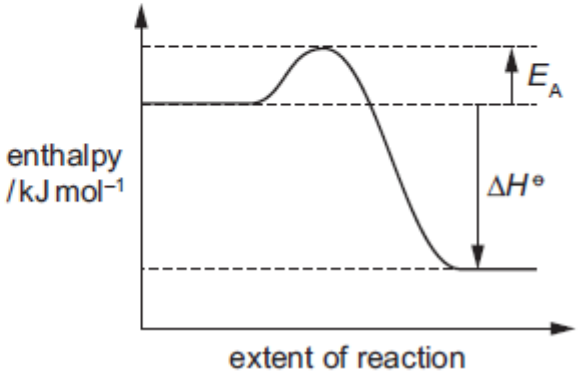
B



C



D

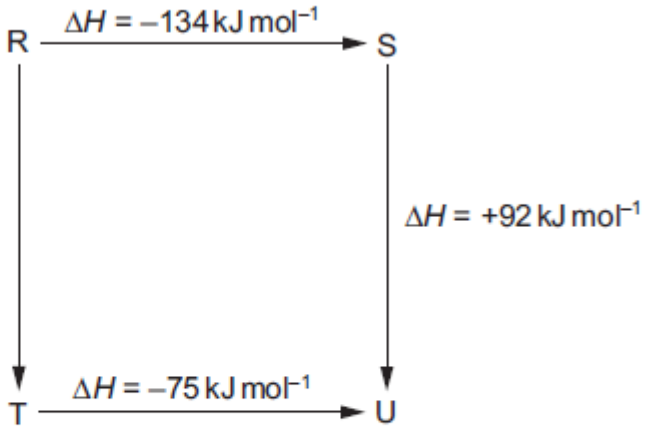


Q# 274/ AS Chemistry/2016/m/TZ 2/Paper 1/Q# 32//www.SmashingScience.org :o)

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 → R is +42 kJ mol^{-1}.

2 The enthalpy change for the transformation T → S is endothermic.

3 The enthalpy change for the transformation R → T is –33 kJ mol^{-1}.

Q# 275/ AS Chemistry/2016/m/TZ 2/Paper 1/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 $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$

B $\frac{1}{2}Cl_2(l) \rightarrow Cl(g)$

C $Cl_2(g) \rightarrow 2Cl(g)$

D $Cl_2(l) \rightarrow 2Cl(g)$

Q# 276/ AS Chemistry/2015/w/TZ 1/Paper 1/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 kJ mol^{-1}

B –970 kJ mol^{-1}

C –352 kJ mol^{-1}

D –24.2 kJ mol^{-1}

Q# 277/ AS Chemistry/2015/w/TZ 1/Paper 1/Q# 6//www.SmashingScience.org :o)

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 S_8, $\Delta H_c^e S_8(s) = -2376 kJ\,mol^{-1}$

energy required to break 1 mole $S_8(s)$ 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** $536\,kJ\,mol^{-1}$

Q# 278/ AS Chemistry/2015/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 The standard enthalpy changes of combustion of glucose and ethanol are given as –2820 and $-1368\,kJ\,mol^{-1}$ respectively.

Glucose, $C_6H_{12}O_6$, can be converted into ethanol.

$$C_6H_{12}O_6(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$$

What is the standard enthalpy change for this reaction?

A $-1452\,kJ\,mol^{-1}$

B $-84\,kJ\,mol^{-1}$

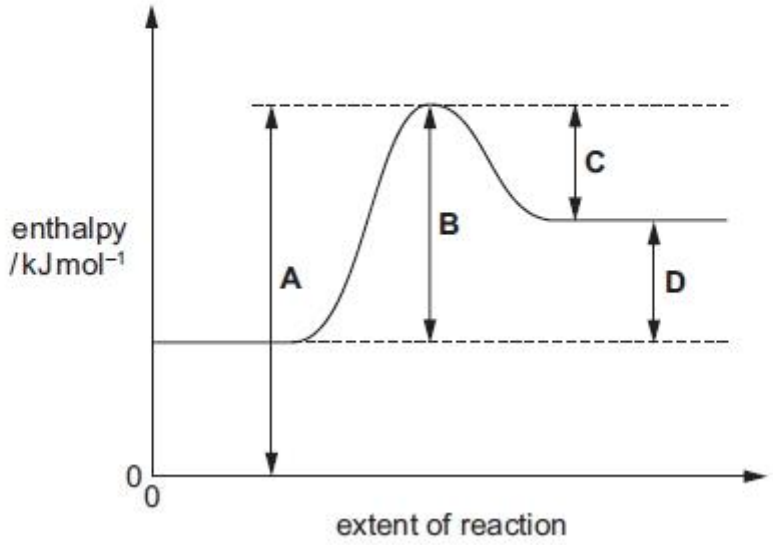
C $+84\,kJ\,mol^{-1}$

D $+1452\,kJ\,mol^{-1}$

Q# 279/ AS Chemistry/2015/s/TZ 1/Paper 1/Q# 11//www.SmashingScience.org :o)

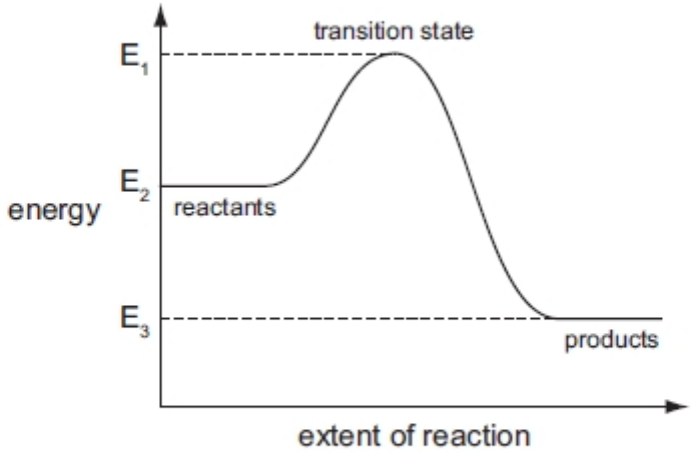
11 The diagram shows a reaction pathway for an endothermic reaction.

Which arrow represents the activation energy for the forward reaction?



Q# 280/ AS Chemistry/2014/w/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

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** $E_3 - E_2$

Q# 281/ AS Chemistry/2014/w/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 In an experiment to calculate the enthalpy change of combustion of a fuel, 1.5 g (0.0326 mol) of the fuel was used to heat 200 g of water. The temperature of the water rose from 25 °C to 55 °C. The specific heat capacity of water is $4.18\,J\,g^{-1}\,K^{-1}$.

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 $-16.7\,kJ\,mol^{-1}$

Q# 282/ AS Chemistry/2014/w/TZ 1/Paper 1/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?

1 $OH\bullet + HBr \rightarrow H_2 + BrO\bullet$

2 $OH\bullet + HBr \rightarrow H_2O + Br\bullet$

3 $H\bullet + HBr \rightarrow H_2 + Br\bullet$

Q# 283/ AS Chemistry/2014/w/TZ 1/Paper 1/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}

Q# 284/ AS Chemistry/2014/w/TZ 1/Paper 1/Q# 11//www.SmashingScience.org :o)

11 For which equation is the enthalpy change correctly described as an enthalpy change of formation?

A $C(g) + O_2(g) \rightarrow CO_2(g)$

B $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

C $2N(g) + 4O(g) \rightarrow N_2O_4(g)$

D $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

Q# 285/ AS Chemistry/2014/s/TZ 1/Paper 1/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 J cm^{-3} K^{-1}.

What is the molar enthalpy change for the reaction?

A –150 kJ mol^{-1}

B –60.0 kJ mol^{-1}

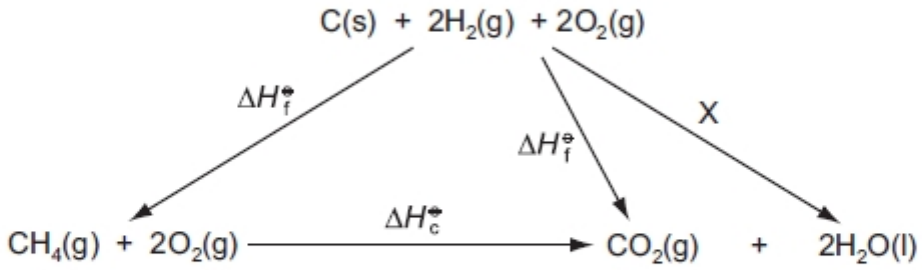
C –30.0 kJ mol^{-1}

D –0.150 kJ mol^{-1}

Q# 286/ AS Chemistry/2014/s/TZ 1/Paper 1/Q# 3//www.SmashingScience.org :o)

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 × the enthalpy of combustion of hydrogen

B +4 × the enthalpy of combustion of hydrogen

C −2 × the enthalpy of formation of water

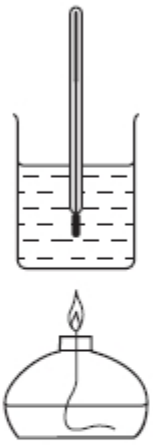
D +2 × the enthalpy of formation of water

Q# 287/ AS Chemistry/2013/w/TZ 1/Paper 1/Q# 11//www.SmashingScience.org :o)

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.



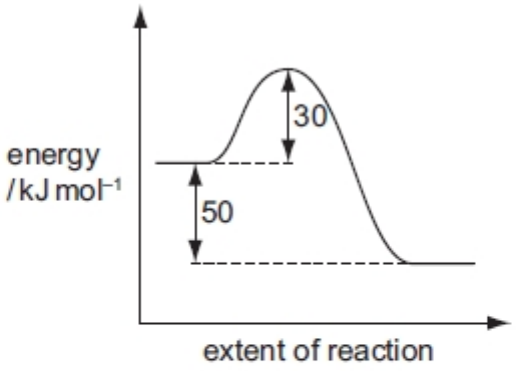
start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

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

Q# 288/ AS Chemistry/2013/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

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 kJ mol^{-1}.

B The enthalpy change for the forward reaction is +30 kJ mol^{-1}.

C The enthalpy change for the forward reaction is +50 kJ mol^{-1}.

D The enthalpy change for the reverse reaction is +30 kJ mol^{-1}.

Q# 289/ AS Chemistry/2013/s/TZ 1/Paper 1/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.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

What is the enthalpy change of combustion of methane?

A –1530 kJ mol^{-1}

B –1184 kJ mol^{-1}

C –770 kJ mol^{-1}

D –688 kJ mol^{-1}

Q# 290/ AS Chemistry/2012/w/TZ 1/Paper 1/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.

$$N_2 + O_2 \rightarrow 2NO \qquad \Delta H = +180\,kJ\,mol^{-1}$$

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

Q# 291/ AS Chemistry/2012/w/TZ 1/Paper 1/Q# 11//www.SmashingScience.org :o)

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 $nXY(g) \rightarrow nX(g) + \frac{n}{2}Y_2(g)$

Q# 292/ AS Chemistry/2012/w/TZ 1/Paper 1/Q# 10//www.SmashingScience.org :o)

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 ($-1560\ kJ\ mol^{-1}$) 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 $-1432\ kJ\ mol^{-1}$

B $-860\ kJ\ mol^{-1}$

C $-430\ kJ\ mol^{-1}$

D $-272\ kJ\ mol^{-1}$

Q# 293/ AS Chemistry/2012/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

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 $-1786\ kJ\ mol^{-1}$.

Using this information, what is the enthalpy change of formation of propanone?

A $-1106\ kJ\ mol^{-1}$

B $-540\ kJ\ mol^{-1}$

C $-254\ kJ\ mol^{-1}$

D $+1106\ kJ\ mol^{-1}$

Q# 294/ AS Chemistry/2012/s/TZ 1/Paper 1/Q# 3//www.SmashingScience.org :o)

3 The equation for a reaction is shown.

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)\ ;\ \Delta H = x\ kJ\ mol^{-1}$$

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

Q# 295/ AS Chemistry/2011/w/TZ 1/Paper 1/Q# 6//www.SmashingScience.org :o)

6 The standard enthalpy change for the reaction

$$2NF_3(g) \rightarrow 2N(g) + 6F(g) \qquad \text{is } \Delta H^{\ominus} = +1668\,kJ$$

What is the bond energy of the N–F bond?

A $-556\,kJ\,mol^{-1}$

B $-278\,kJ\,mol^{-1}$

C $+278\,kJ\,mol^{-1}$

D $+556\,kJ\,mol^{-1}$

Q# 296/ AS Chemistry/2011/w/TZ 1/Paper 1/Q# 19//www.SmashingScience.org :o)

19 Which reaction is endothermic?

A $2HBr \rightarrow H_2 + Br_2$

B $N_2 + 3H_2 \rightarrow 2NH_3$

C $2SO_2 + O_2 \rightarrow 2SO_3$

D $SO_3 + H_2O \rightarrow H_2SO_4$

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9 $50\,cm^3$ of $2.50\,mol\,dm^{-3}$ hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then $50\,cm^3$ 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 $\frac{-(50 \times 4.2 \times 17)}{(0.050 \times 2.5)}\,J\,mol^{-1}$

B $\frac{-(50 \times 4.2 \times 17)}{(0.10 \times 2.5)}\,J\,mol^{-1}$

C $\frac{-(100 \times 4.2 \times 17)}{(0.050 \times 2.5)}\,J\,mol^{-1}$

D $\frac{-(100 \times 4.2 \times 17)}{(50 \times 2.5)}\,J\,mol^{-1}$

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8 The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.

$$2X(g) + 6H(g) \rightarrow X_2H_6(g) \qquad \Delta H = -2775\,kJ\,mol^{-1}$$

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 $+405.0\,kJ\,mol^{-1}$

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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

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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.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for this reaction?

compound	$\Delta H_c^{\ominus}$ / 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 $+2197\,kJ\,mol^{-1}$

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5 Given the following enthalpy changes,

$$I_2(g) + 3Cl_2(g) \rightarrow 2ICl_3(s) \qquad \Delta H^{\ominus} = -214\,kJ\,mol^{-1}$$

$$I_2(s) \rightarrow I_2(g) \qquad \Delta H^{\ominus} = +38\,kJ\,mol^{-1}$$

What is the standard enthalpy change of formation of iodine trichloride, $ICl_3(s)$?

A $+176\,kJ\,mol^{-1}$

B $-88\,kJ\,mol^{-1}$

C $-176\,kJ\,mol^{-1}$

D $-214\,kJ\,mol^{-1}$

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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.

P $Br_2 \rightarrow 2Br$

Q $2Cl \rightarrow Cl_2$

R $CH_3 + Cl \rightarrow CH_3Cl$

S $CH_4 \rightarrow CH_3 + H$

What is the order of enthalpy changes of these reactions from most negative to most positive?

A P → Q → R → S

B Q → R → S → P

C R → Q → P → S

D S → P → Q → R

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6 The first stage in the industrial production of nitric acid from ammonia can be represented by the following equation.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Using the following standard enthalpy change of formation data, what is the value of the standard enthalpy change, $\Delta H^{\ominus}$, for this reaction?

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$NH_3(g)$	–46.1
$NO(g)$	+90.3
$H_2O(g)$	–241.8

A +905.2 kJ mol^{-1}

B –105.4 kJ mol^{-1}

C –905.2 kJ mol^{-1}

D –1274.0 kJ mol^{-1}

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8 Hydrogen peroxide slowly decomposes into water and oxygen. The enthalpy change of reaction can be calculated using standard enthalpies of formation.

$\Delta H_f^{\ominus}$(hydrogen peroxide(l)) = –187.8 kJ mol^{-1}

$\Delta H_f^{\ominus}$(water(l)) = –285.8 kJ mol^{-1}

Using a Hess cycle, what is the enthalpy change of reaction for this decomposition?

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

A +98 kJ mol^{-1}

B –98 kJ mol^{-1}

C –196 kJ mol^{-1}

D –947.2 kJ mol^{-1}

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

A	B	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 $\Delta H^{\ominus}$ represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

1 $C(s) + O_2(g) \rightarrow CO_2(g)$

2 $2C(s) + O_2(g) \rightarrow 2CO(g)$

3 $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

Mark Scheme ALvl Chem 5 EQ P1 22w to 09s Paper 1 Chemical energetics 73marks

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9	C

Q# 233/ AS Chemistry/2022/w/TZ 1/Paper 1/Q# 10//www.SmashingScience.org :o)

10	B

Q# 234/ AS Chemistry/2022/s/TZ 1/Paper 1/Q# 9//www.SmashingScience.org :o)

9	D

Q# 235/ AS Chemistry/2022/s/TZ 1/Paper 1/Q# 10//www.SmashingScience.org :o)

10	C

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9	A

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8	D

Q# 238/ AS Chemistry/2021/w/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8	C

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7	B

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4	D

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32	A

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7	A

Q# 243/ AS Chemistry/2021/m/TZ 2/Paper 1/Q# 32//www.SmashingScience.org :o)

32	B

Q# 244/ AS Chemistry/2020/w/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7	B

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6	C

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32	D

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31	A

Q# 248/ AS Chemistry/2020/s/TZ 1/Paper 1/Q# 5//www.SmashingScience.org :o)

5	C

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4	C

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33	D

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8	D

Q# 252/ AS Chemistry/2019/w/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7	A

Q# 253/ AS Chemistry/2019/s/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8	D

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33	A

Q# 255/ AS Chemistry/2019/m/TZ 2/Paper 1/Q# 9//www.SmashingScience.org :o)

9	D

Q# 256/ AS Chemistry/2019/m/TZ 2/Paper 1/Q# 8//www.SmashingScience.org :o)

8	C

Q# 257/ AS Chemistry/2018/w/TZ 1/Paper 1/Q# 6//www.SmashingScience.org :o)

6	C

Q# 258/ AS Chemistry/2018/w/TZ 1/Paper 1/Q# 33//www.SmashingScience.org :o)

33	B

Q# 259/ AS Chemistry/2018/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 | B

Q# 260/ AS Chemistry/2018/s/TZ 1/Paper 1/Q# 33//www.SmashingScience.org :o)

33 | D

Q# 261/ AS Chemistry/2018/m/TZ 2/Paper 1/Q# 9//www.SmashingScience.org :o)

9 | B

Q# 262/ AS Chemistry/2018/m/TZ 2/Paper 1/Q# 8//www.SmashingScience.org :o)

8 | B

Q# 263/ AS Chemistry/2017/w/TZ 1/Paper 1/Q# 8//

8 | D

Q# 264/ AS Chemistry/2017/w/TZ 1/Paper 1/Q# 11//

11 | C

Q# 265/ AS Chemistry/2017/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 | D

Q# 266/ AS Chemistry/2017/s/TZ 1/Paper 1/Q# 33//www.SmashingScience.org :o)

33 | D

Q# 267/ AS Chemistry/2017/m/TZ 2/Paper 1/Q# 9//www.SmashingScience.org :o)

9 | C

Q# 268/ AS Chemistry/2017/m/TZ 2/Paper 1/Q# 7//www.SmashingScience.org :o)

7 | B

Q# 269/ AS Chemistry/2016/w/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 **C**

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33 **B**

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15 **C**

Q# 272/ AS Chemistry/2016/s/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 **D**

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5 **D**

Q# 274/ AS Chemistry/2016/m/TZ 2/Paper 1/Q# 32//www.SmashingScience.org :o)

32 **D**

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10 **A**

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7 **B**

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6 **D**

Q# 278/ AS Chemistry/2015/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 **B**

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11 **B**

Q# 280/ AS Chemistry/2014/w/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 **A**

Q# 281/ AS Chemistry/2014/w/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 **B**

Q# 282/ AS Chemistry/2014/w/TZ 1/Paper 1/Q# 32//www.SmashingScience.org :o)

32 **C**

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3 **B**

Q# 284/ AS Chemistry/2014/w/TZ 1/Paper 1/Q# 11//www.SmashingScience.org :o)

11 **B**

Q# 285/ AS Chemistry/2014/s/TZ 1/Paper 1/Q# 5//www.SmashingScience.org :o)

5 **B**

Q# 286/ AS Chemistry/2014/s/TZ 1/Paper 1/Q# 3//www.SmashingScience.org :o)

3 **D**

Q# 287/ AS Chemistry/2013/w/TZ 1/Paper 1/Q# 11//www.SmashingScience.org :o)

11 **B**

Q# 288/ AS Chemistry/2013/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 **A**

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12 **D**

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4 **A**

Q# 291/ AS Chemistry/2012/w/TZ 1/Paper 1/Q# 11//www.SmashingScience.org :o)

11 **A**

Q# 292/ AS Chemistry/2012/w/TZ 1/Paper 1/Q# 10//www.SmashingScience.org :o)

10 **C**

Q# 293/ AS Chemistry/2012/s/TZ 1/Paper 1/Q# 7//www.SmashingScience.org :o)

7 C

Q# 294/ AS Chemistry/2012/s/TZ 1/Paper 1/Q# 3//www.SmashingScience.org :o)

3 D

Q# 295/ AS Chemistry/2011/w/TZ 1/Paper 1/Q# 6//www.SmashingScience.org :o)

6 C

Q# 296/ AS Chemistry/2011/w/TZ 1/Paper 1/Q# 19//www.SmashingScience.org :o)

19 A

Q# 297/ AS Chemistry/2011/s/TZ 1/Paper 1/Q# 9//www.SmashingScience.org :o)

9 C

Q# 298/ AS Chemistry/2011/s/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 D

Q# 299/ AS Chemistry/2010/w/TZ 1/Paper 1/Q# 9//www.SmashingScience.org :o)

9 B

Q# 300/ AS Chemistry/2010/w/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 B

Q# 301/ AS Chemistry/2010/s/TZ 1/Paper 1/Q# 5//www.SmashingScience.org :o)

5 B

Q# 302/ AS Chemistry/2010/s/TZ 1/Paper 1/Q# 4//www.SmashingScience.org :o)

4 C

Q# 303/ AS Chemistry/2009/w/TZ 1/Paper 1/Q# 6//www.SmashingScience.org :o)

6 C

Q# 304/ AS Chemistry/2009/s/TZ 1/Paper 1/Q# 8//www.SmashingScience.org :o)

8 C

Q# 305/ AS Chemistry/2009/s/TZ 1/Paper 1/Q# 33//www.SmashingScience.org :o)

33 D