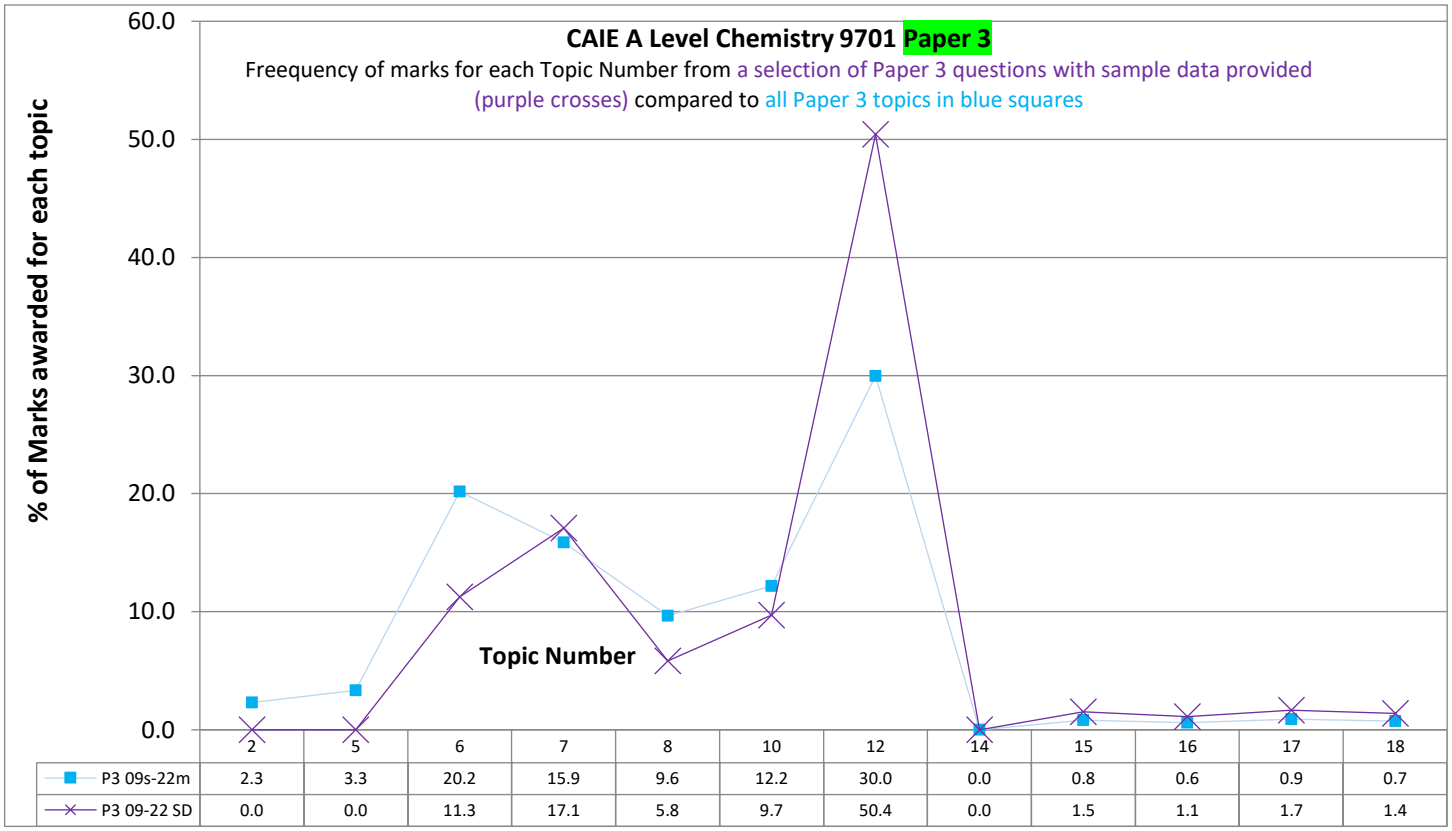
Name: Class: Date:

ALvl Chem 10 EQ P3 22w to 09s Paper 3 SAMPLE DATA Group 2 70marks

- This **booklet cannot replace lab experience** as the best way to prepare for Paper 3, but it can help with understanding some of the theory aspects.
- This booklet contains 399marks worth of Paper 3 questions with SAMPLE DATA provided which allows you to work on the theory parts of the questions outside of a chemistry lab.
- Not all types of experiment are included (as of May 2024), so **this is only partially complete**. This can be seen best in the graphs comparing experiment types rather than topic numbers.
- It is usually better to revise Paper 3 by looking at specific experiment types, rather than by topic. But these booklets may be helpful when learning each topic for the first time.
- 75 seconds have been budgeted for these theory-based questions (same as Paper 2 questions), which roughly privileges the time allocation to the marks derived directly from practical work. The mean average time per mark is 180 seconds in Paper 3, but there are a lot of different ways that this time allocation could be more carefully worked out.

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.

Paper3 Topic 10 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)	70		12	7	18	28	35	53	70
Time @**75s**/mark (minutes)	88		15	9	22	35	44	66	88

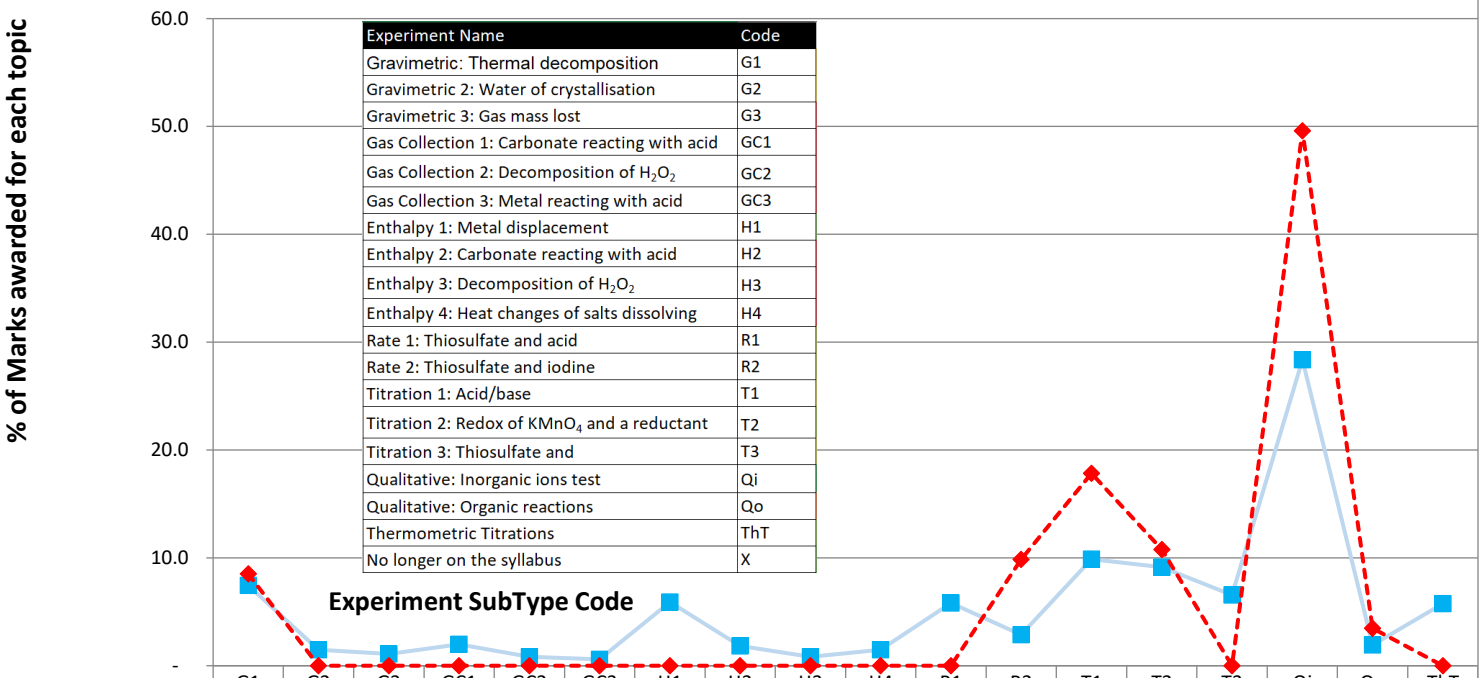


	2	5	6	7	8	10	12	14	15	16	17	18
P3 09s-22m	2.3	3.3	20.2	15.9	9.6	12.2	30.0	0.0	0.8	0.6	0.9	0.7
P3 09-22 SD	0.0	0.0	11.3	17.1	5.8	9.7	50.4	0.0	1.5	1.1	1.7	1.4

[1] **DO NOT** work on these higher levels of completion in your AS year unless you have also achieved at least a "**Gold**" (40%) in the same topic in both **Paper 1** and **Paper 2**, which is **MOST (77%)** of your **AS grade**

CAIE A Level Chemistry 9701 Paper 3

Freequency of marks for each Experiment SubType from m2022 to m2016 blue squares, compared to SAMPLE DATA Section 1 of this workbook in the red diamonds



Experiment Name	Code
Gravimetric: Thermal decomposition	G1
Gravimetric 2: Water of crystallisation	G2
Gravimetric 3: Gas mass lost	G3
Gas Collection 1: Carbonate reacting with acid	GC1
Gas Collection 2: Decomposition of H_2O_2	GC2
Gas Collection 3: Metal reacting with acid	GC3
Enthalpy 1: Metal displacement	H1
Enthalpy 2: Carbonate reacting with acid	H2
Enthalpy 3: Decomposition of H_2O_2	H3
Enthalpy 4: Heat changes of salts dissolving	H4
Rate 1: Thiosulfate and acid	R1
Rate 2: Thiosulfate and iodine	R2
Titration 1: Acid/base	T1
Titration 2: Redox of $KMnO_4$ and a reductant	T2
Titration 3: Thiosulfate and	T3
Qualitative: Inorganic ions test	Qi
Qualitative: Organic reactions	Qo
Thermometric Titrations	ThT
No longer on the syllabus	X

	G1	G2	G3	GC1	GC2	GC3	H1	H2	H3	H4	R1	R2	T1	T2	T3	Qi	Qo	ThT
P3 09s-22w	7.4	1.5	1.1	2.0	0.8	0.6	5.9	1.8	0.8	1.5	5.8	2.9	9.9	9.1	6.6	28.4	1.9	5.7
SAMPLE Data	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	17.8	10.8	0.0	49.6	3.5	0.0

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 10-20 marks, 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.

SAMPLE DATA

Paper ID	Marks	Measured initial mass	Measured final mass	Mass of crucible and lid	Initial mass	Final mass
2022/s/TZ 3/Q2	12	42	41.42	40.76	42.06	41.38
2019/s/TZ 1/Q2	14	42.98	41.52	41.58	42.98	42.24
2017/s/TZ 1/Q2	10	43.60	42.76	40.76	43.51	42.74
2016/s/TZ 4/Q2	14	35.8	41.29	41.58	42.78	42.10

2 In this experiment you will identify the metal, **M**, in a metal carbonate, $\mathbf{M}CO_3$, by thermal decomposition.

$$\mathbf{M}CO_3(s) \rightarrow \mathbf{M}O(s) + CO_2(g)$$

FA 4 is the metal carbonate, $\mathbf{M}CO_3$.

(a) Method

- Weigh the empty crucible with its lid. Record the mass.
- Transfer all the **FA 4** from the container into the crucible.
- Weigh the crucible, lid and **FA 4**. Record the mass.
- Calculate and record the mass of **FA 4** used.
- Place the crucible and contents on a pipe-clay triangle.
- Heat the crucible gently, with the lid on, for approximately 1 minute.
- Heat strongly, with the lid off, for a further 4 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.

During the cooling period, you may wish to begin work on Question 3.

- When the crucible has cooled, weigh the crucible with its lid and contents. Record the mass.
- Heat strongly, with the lid off, for a further 2 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.
- When the crucible has cooled, reweigh the crucible with its lid and contents. Record the mass.
- Calculate and record the total loss of mass and the mass of residue obtained.
- This residue is **FA 5**.

Keep FA 5 for use in 2(d).

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Calculate the amount, in mol, of carbon dioxide given off in your experiment.

amount of CO_2 = ... mol [1]

(ii) Calculate the relative formula mass, M_r, of **M**CO_3.

M_r of **M**CO_3 = ... [1]

(iii) From your results, deduce the identity of **M**.
Show your reasoning.

M is = ... [1]

(c) A student carries out the same procedure, using the same mass of solid. However, the student uses the basic carbonate, **M**CO_3•**M**$(OH)_2$, instead of the pure carbonate, **M**CO_3.

When the metal hydroxide part of the basic carbonate decomposes, metal oxide and steam are produced. The metal carbonate part decomposes in the usual way.

State how the loss of mass from the student's solid compares with the loss of mass you obtained when you carried out your experiment. Explain your reasoning.

.....

..... [2]

(d) Use a spatula to transfer a small quantity of your cold residue, **FA 5**, into a test-tube.
Add about a 1 cm depth of dilute hydrochloric acid to the **FA 5** in the test-tube.

Record what you observe.

.....

.....

State whether or not the thermal decomposition of **M**CO_3 is complete.

Justify your answer based on your observations.

.....

.....

.....
[2]

[Total: 12]

SAMPLE DATA

Paper ID	Marks	Measured initial mass	Measured final mass	Mass of crucible and lid	Initial mass	Final mass
2022/s/TZ 3/Q2	12	42	41.42	40.76	42.06	41.38
2019/s/TZ 1/Q2	14	42.98	41.52	41.58	42.98	42.24
2017/s/TZ 1/Q2	10	43.60	42.76	40.76	43.51	42.74
2016/s/TZ 4/Q2	14	35.8	41.29	41.58	42.78	42.10

2 When hydrated copper hydroxycarbonate, $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$ is heated, it decomposes as shown.

$$CuCO_3.Cu(OH)_2.\mathbf{y}H_2O(s) \rightarrow 2CuO(s) + CO_2(g) + (1 + \mathbf{y})H_2O(g)$$

In this experiment, you will heat hydrated copper hydroxycarbonate to decompose it. You will use your results to investigate the value of **y**.

FB 4 is hydrated copper hydroxycarbonate, $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$.

(a) Method

- Weigh the crucible with its lid and record the mass.
- Add all the **FB 4** from the container into the crucible.
- Weigh the crucible and lid with **FB 4** and record the mass.
- Place the crucible and contents on the pipe-clay triangle.
- Heat the crucible and contents gently for approximately two minutes with the lid on.
- Use tongs to remove the lid and heat strongly for approximately three minutes.
- Replace the lid and leave the crucible and residue to cool for several minutes.

While the crucible is cooling, you may wish to begin work on Question 3.

- When the crucible is cool, reweigh it with its lid and contents. Record the mass.
- Calculate and record the mass of **FB 4** and the mass of residue obtained.

Results

I	
II	
III	
IV	

State the observations made while the decomposition of **FB 4** was taking place.

.....

.....

[4]

(b) Calculations

(i) Calculate the number of moles of copper oxide, CuO, obtained as residue.

moles of CuO obtained = ... mol [1]

(ii) Use your results to calculate the relative formula mass, M_r, of hydrated copper hydroxycarbonate, $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$.

M_r of $CuCO_3.Cu(OH)_2.\mathbf{y}H_2O$ = ... [2]

(iii) Use the Periodic Table to calculate the relative formula mass of $CuCO_3.Cu(OH)_2$.

M_r of $CuCO_3.Cu(OH)_2$ = ...

Use your answer to **(ii)** and this M_r to comment on the value of **y** in the formula of hydrated copper hydroxycarbonate.

.....

.....

[2]

(c) State **one** way to improve the accuracy of the experiment, using the same mass of **FB 4**.

.....

..... [1]

[Total: 10]

SAMPLE DATA

Paper ID	Marks	Measured initial mass	Measured final mass	Mass of crucible and lid	Initial mass	Final mass
2022/s/TZ 3/Q2	12	42	41.42	40.76	42.06	41.38
2019/s/TZ 1/Q2	14	42.98	41.52	41.58	42.98	42.24
2017/s/TZ 1/Q2	10	43.60	42.76	40.76	43.51	42.74
2016/s/TZ 4/Q2	14	35.8	41.29	41.58	42.78	42.10

2 In **Question 1** you measured the volume of carbon dioxide produced by a metal carbonate, $\mathbf{M}CO_3$, in order to identify **M**. In **Question 2** you will identify another Group 2 metal, **Q**, by using a gravimetric method.

When Group 2 carbonates are heated they decompose.

$$\mathbf{Q}CO_3(s) \rightarrow \mathbf{Q}O(s) + CO_2(g)$$

FA 3 is the metal carbonate, $\mathbf{Q}CO_3$.

(a) Method

- Weigh the crucible with its lid and record the mass.
- Add between 1.30 g and 1.50 g of **FA 3** into the crucible. Record the mass of crucible, lid and **FA 3**.
- Place the crucible on the pipe-clay triangle on the tripod. Put the lid on the crucible and heat gently for approximately 1 minute.
- Use tongs to remove the lid and heat the crucible strongly for approximately 5 minutes. Replace the lid and then leave to cool.
- While the crucible is cooling, begin work on **Question 3**.
- When cool, reweigh the crucible with its lid and contents. Record the mass.
- Calculate and record the mass of **FA 3** placed in the crucible.
- Calculate and record the mass of residue left after heating.

Keep the crucible and its contents for use in Question 3(b).

Results

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the number of moles of carbon dioxide produced during heating of **FA 3**.

moles CO_2 = ... mol [1]

(ii) Use the mass of **FA 3** in **(a)** and your answer to **(b)(i)** to calculate the relative atomic mass, A_r, of **Q** and hence identify **Q**. You should assume complete decomposition of **Q**CO_3.

A_r of **Q** is .....

Q is .....
[4]

(c) Explain why the lid was placed on the crucible when the residue was left to cool.

.....

..... [1]

(d) In order to decompose Group 2 carbonates, the solid must be heated strongly. In this experiment **Q**CO_3 was heated for a few minutes.

(i) Suggest an improvement to the method used that would ensure that decomposition was complete.

.....

..... [1]

(ii) Suggest a chemical test to determine whether the decomposition of **Q**CO_3 was complete. State the expected observation if the decomposition was incomplete.

Do not carry out this test.

.....

..... [1]

(e) (i) In your calculation in **(b)** you used the mass of **Q**CO_3 and assumed that it was all decomposed during the heating.

Explain what effect incomplete decomposition would have on the calculated value of the A_r of **Q**.

.....

.....

..... [1]

(ii) A student suggested that you could use the mass of the residue, **Q**O, rather than the mass of **Q**CO_3 in a calculation to identify **Q**.

Explain why this method of calculating the A_r of **Q** is valid.

.....

..... [1]

[Total: 14]

G1 Gravimetric Thermal Decomposition **Q# 21/** AS Chemistry/2017/s/TZ 1/Paper 3/ :o) www.SmashingScience.com

SAMPLE DATA

Paper ID	Marks	Measured initial mass	Measured final mass	Mass of crucible and lid	Initial mass	Final mass
2022/s/TZ 3/Q2	12	42	41.42	40.76	42.06	41.38
2019/s/TZ 1/Q2	14	42.98	41.52	41.58	42.98	42.24
2017/s/TZ 1/Q2	10	43.60	42.76	40.76	43.51	42.74
2016/s/TZ 4/Q2	14	35.8	41.29	41.58	42.78	42.10

2 Malachite is a basic form of copper carbonate in which copper hydroxide is also present. The accepted chemical formula of malachite is $CuCO_3.Cu(OH)_2.H_2O$.

When malachite is heated, it decomposes as shown.

$$CuCO_3.Cu(OH)_2.H_2O(s) \rightarrow 2CuO(s) + CO_2(g) + 2H_2O(g)$$

In this experiment, you will heat malachite to decompose it and use your results to obtain evidence about the accepted formula of malachite.

FA 5 is malachite, $CuCO_3.Cu(OH)_2.H_2O$.

(a) Method

Read through the method before starting any practical work.
In the space below prepare a **single** table for your results of **Experiments 1** and **2**.

Experiment 1

- Weigh a crucible with its lid and record the mass.
- Add between 2.5 g and 3.0 g of **FA 5** to the crucible. Weigh the crucible with **FA 5** and lid and record the mass.
- Place the crucible on the pipe-clay triangle.
- Heat the crucible and contents gently for about two minutes, with the lid on.
- Remove the lid and continue heating gently for about three minutes.
- Replace the lid and leave the crucible and residue to cool for at least five minutes. Then reweigh the crucible and contents with the lid on. Record the mass.
- **While the crucible is cooling, you may wish to begin work on Question 3.**
- Calculate and record the mass of **FA 5** used and the mass of residue obtained.
- State the observation(s) you made while the reaction was taking place.

.....

.....

Experiment 2

Repeat the method used in **Experiment 1**, using between 1.5 g and 2.0 g of **FA 5** in the second crucible.

Results

I	
II	
III	
IV	
V	
VI	

[6]

(b) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Use your results from **Experiment 1** to calculate the number of moles of copper oxide, CuO, obtained as residue.
Use the Periodic Table on page 12 for any data you may require.

moles of CuO obtained in **Experiment 1** = ... mol

(ii) Use your answer to **(i)**, the equation on page 4 and the mass of **FA 5** you used in **Experiment 1**, to calculate the relative formula mass, M_r, of malachite.

M_r of malachite (from **Experiment 1**) = ...

(iii) Use your results from **Experiment 2** to calculate another value for the relative formula mass, M_r, of malachite.

M_r of malachite (from **Experiment 2**) = ...

(iv) Use data from the Periodic Table to calculate the relative formula mass, M_r, of malachite from its accepted formula, $CuCO_3.Cu(OH)_2.H_2O$.

M_r of malachite (from formula) = ...

(v) If the relative formula mass of malachite obtained from **either** of your experiments is within 2.5% of the answer in **(iv)**, this is good evidence that the accepted formula, $CuCO_3.Cu(OH)_2.H_2O$, is correct.

Show by calculation whether either of your experiments supports the accepted formula.

[5]

(c) (i) State **one** way of improving the accuracy of the experimental method, using the same masses of **FA 5**.
Explain the benefit of your improvement.

.....

.....

.....

.....

(ii) Explain why you would expect **Experiment 1** to be more accurate than **Experiment 2**.

.....

.....

.....

[3]

[Total: 14]

G1 Gravimetric Thermal Decomposition **Q# 22/** AS Chemistry/2016/s/TZ 4/Paper 3/ :o) www.SmashingScience.com

SAMPLE DATA

Paper ID	Marks	Measured initial mass	Measured final mass	Mass of crucible and lid	Initial mass	Final mass
2022/s/TZ 3/Q2	12	42	41.42	40.76	42.06	41.38
2019/s/TZ 1/Q2	14	42.98	41.52	41.58	42.98	42.24
2017/s/TZ 1/Q2	10	43.60	42.76	40.76	43.51	42.74
2016/s/TZ 4/Q2	14	35.8	41.29	41.58	42.78	42.10

2 Some metal carbonates cannot be obtained in a pure state. For example magnesium carbonate exists in a 'basic' form, in which magnesium hydroxide is also present.

One possible chemical formula of basic magnesium carbonate is $MgCO_3.Mg(OH)_2.2H_2O$.

When basic magnesium carbonate is heated, if the possible formula were correct, it would decompose as shown below.

$$MgCO_3.Mg(OH)_2.2H_2O(s) \rightarrow 2MgO(s) + CO_2(g) + 3H_2O(g)$$

In this experiment, you will decompose basic magnesium carbonate by heating it, and you will use your results to determine whether this possible formula is correct.

FB 4 is basic magnesium carbonate.

(a) Method

Read through the method before starting any practical work and prepare a table for your results in the space below.

- Weigh a crucible with its lid and record the mass.
- Add 1.1-1.3 g of **FB 4** to the crucible. Weigh the crucible and lid with **FB 4** and record the mass.
- Place the crucible on the pipe-clay triangle and remove the lid.
- Heat the crucible and contents **gently** for about one minute.
- Then heat the crucible and contents strongly for about four minutes.
- Replace the lid and allow the crucible to cool for at least five minutes.
- **While the crucible is cooling, you may wish to begin work on Question 3.**
- Re-weigh the crucible and contents with lid. Record the mass.
- Calculate, and record, the mass of **FB 4** used and the mass of residue obtained.

I	
II	
III	
IV	
V	

[5]

(b) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Use your results to calculate the number of moles of magnesium oxide, MgO, obtained as residue.

moles of MgO obtained = ... mol

(ii) Use your answer to **(i)**, with the equation on page 4 and the mass of **FB 4** you used, to calculate the relative formula mass, M_r, of basic magnesium carbonate.

M_r of basic magnesium carbonate (from experiment) = ...

(iii) Use data from the Periodic Table to calculate the relative formula mass, M_r, of basic magnesium carbonate from its possible formula, $MgCO_3.Mg(OH)_2.2H_2O$.

M_r of basic magnesium carbonate (from formula) = ...

(iv) If the relative formula mass of basic magnesium carbonate obtained from your experiment is within 2.5% of the answer in **(iii)**, this is good evidence that the possible formula, $MgCO_3.Mg(OH)_2.2H_2O$, is correct.
Does your experiment support the possible formula? Give a reason for your answer.

.....

.....

[5]

(c) Evaluation

(i) State **one** way in which the accuracy of the experimental procedure could have been improved using the same mass of **FB 4**.
Explain your answer.

.....

.....

.....

.....

.....

(ii) A student carried out the experiment twice using different masses of **FB 4**. He used the mean mass of **FB 4** and the mean mass of magnesium oxide obtained to calculate the relative formula mass of basic magnesium carbonate.

Instead of doing this, he could have calculated the relative formula mass of basic magnesium carbonate from his two experiments separately.

Suggest **one** advantage of carrying out separate calculations for each experiment.

.....

.....

.....

.....

(iii) State the error when making **one** reading on your balance.

error = ... g

Calculate the maximum percentage error in the mass of **FB 4** used.

percentage error = ... %
[4]

[Total: 14]

Q# 18/ AS Chemistry/2022/s/TZ 3/Paper 3/ :o) www.SmashingScience.com

2(a)	**I** Unambiguous headings and units for four weighings and entered in the space provided: • (mass of) crucible, lid (empty) • (mass of) crucible, lid and **FA 4** (or 'contents before heating') • (mass of) crucible, lid and **FA 5** / residue / contents after first heating • (mass of) crucible, lid and **FA 5** / residue / contents after second heating Units: / g or (g) or gram(me)s or in grams	5
	II Readings are appropriately recorded: • all weighings recorded to same number of decimal places (two or more) • mass of **FA 4** is within the range 0.80–1.80 g *(from weighings)* • fourth weighing is within +0.02 and –0.05 g of third weighing	
	III Correct subtractions to give: • mass of **FA 4** • mass of **FA 5** • mass loss	
	For assessment of accuracy marks: calculate supervisor's mass ratio (to 2 d.p.) = $\frac{\text{mass FA 4}}{\text{mass FA 5 (residue)}}$ Write this value in a ring on each script. Calculate the 25% and 10% ranges correct to 2 dp. Calculate the candidate's mass ratio (to 2 dp) = $\frac{\text{mass FA 4}}{\text{mass FA 5 (residue)}}$ Award accuracy marks as shown below.	
	Award **IV** if δ is within 25% of supervisor **AND** ratio > 1.00 Award **V** if δ is within 10% of supervisor **AND** ratio > 1.00	
2(b)(i)	Correctly calculated amount of CO_2 = $\frac{\text{mass loss}}{44}$ mol **AND** answer to 2–4 significant figures	1

2(b)(ii)	Correctly uses M_r of **FA 4** = $\frac{\text{mass of FA 4 used}}{\text{(b)(i)}}$ **AND** answer to 2–4 sf	1
2(b)(iii)	A_r of metal = **(b)(ii)** – 60 **AND** Group 2 metal correctly deduced from A_r *Be if A_r is in range 0 – 12.1: Mg for A_r 12.2 – 32.2: Ca for A_r 32.2 - 63.8: Sr for A_r 63.9 – 112.4: Ba for A_r 112.5 – 250* (Other metals forming white carbonates with formula MCO_3 are acceptable provided the A_r is close to the value given in the periodic table.)	1
2(c)	**M1**: student's mass loss is lower **AND** M_r H_2O < M_r CO_2 (or values given) **M2**: using Mg as example % loss from $Mg(OH)_2$ = $\left(\frac{18}{58.3}\right)$ × 100 % loss from $MgCO_3$ = $\left(\frac{44}{84.3}\right)$ × 100 (which is greater than % for $Mg(OH)_2$)	2
2(d)	**EITHER** **M1**: solid dissolves **OR** colourless solution formed **M2**: decomposition is complete **AND** reason: no gas / no CO_2 / no fizzing produced (when acid added) **OR** **M1**: effervescence (owtte) **OR** gas / CO_2 gives white ppt with limewater **M2**: decomposition is not complete **AND** reason: carbonate reacts / fizzes / gives out CO_2 with acid / oxide does not fizz with acid	2

Q# 19/ AS Chemistry/2019/s/TZ 2/Paper 3/ :o) www.SmashingScience.com

2(a)	**I: Table / list of data**, to include values and correct headings and units: • Mass of crucible (and lid) • Mass of crucible, (lid) + **FB 4** (or 'contents before heating') • Mass of crucible, (lid) + residue / CuO / contents after heating • Mass of **FB 4** (used) • Mass of residue / CuO (obtained)	1

	Accuracy (Q) marks in 2(a) • To assess accuracy, check the masses of FB 4 used and of CuO obtained by the supervisor and by the candidate. • Work out the ratio $^{\text{mass of FB4}}/_{\text{mass of CuO}}$ for the supervisor (to 2 d.p.) • Work out ratio (mass FB 4: mass CuO) for the candidate (2 d.p.) • Calculate δ, the difference between these two ratios.	
	Award II and III **if δ ⩽ 0.05**	**1**
	Award III **if 0.05 < δ ⩽ 0.10**	**1**
	IV: Observations made during heating (Solid changes from) green / turquoise / cyan / blue-green to black *(both colours required)* or black solid / residue (formed)	**1**
2(b)(i)	**Correctly calculated no. of moles of CuO** • No. of moles CuO = $^{\text{mass of residue}}/_{79.5}$ • Answer must be correct and expressed to 2, 3 or 4 sig. fig.	**1**

2(b)(ii)	**Correct use of mole ratio 1 : 2** • No. of moles of FB 4 = $^{\text{answer (i)}}/_{2}$	**1**
	Correctly uses n to calculate M_r of copper hydroxycarbonate, • M_r = $^{\text{mass of FB 4 used}}/_{\text{no. of moles of FB 4}}$ • Answer (for M_r) must be expressed to 2, 3 or 4 sig. fig. • Some working must be shown to access the second mark	**1**
2(b)(iii)	M_r = 221	**1**
	Appropriate **comment** on the value of y • If answer **2(b)(ii)** is less than 221, candidate should state that y is negative, so the experiment has been inaccurate • If answer **2(b)(ii)** is between 213 and 229, then (within experimental error) there is no water of crystallisation • If answer **2(b)(ii)** is greater than 221, candidate should calculate the value of y **and** state that it should be an integer	**1**
2(c)	Heat to constant mass (or description of procedure)	**1**

Q# 20/ Thermal Decomposition Mark Scheme and Confidential Instructions
AS Chemistry/2019/s/TZ 1/Paper 3/ :o) www.SmashingScience.com

2(a)	**I** Correct headings and units shown. Mass of crucible (+ lid) (Use of lid must be consistent) Mass of crucible (+ lid) + FA 3 Mass of crucible (+ lid) + residue / contents after heating Mass of FA 3 (used) Mass of residue	**1**
	II All balance readings to same dp **and** recorded mass QCO_3 between 1.30 g and 1.50 g AND Mass QCO_3 and residue correctly calculated	**1**
	Award **III** and **IV** if δ ⩽ 0.10	**1**
	Award **IV** if δ ⩽ 0.20 Do not allow any Q marks if mass of residue ⩾ mass of FA 3.	**1**
2(b)(i)	Correctly calculates moles = candidate's mass lost / 44 **and** answer to 2 – 4 sf	**1**

2(b)(ii)	Correct use of $M_r = \frac{\textit{candidate's mass of } QCO_3}{\textbf{(b)(i)}}$	**1**
	Use of 60	**1**
	Use of 3 – 4 sf for *Mr* and correct A_r If no subtraction at step 2 then step 3 cannot be awarded. Identification of Q as Group 2 metal with nearest A_r Do not allow ecf if no evidence to support conclusion.	**1**
	Be ⩽ 16.65; 16.65 ⩽ Mg ⩽ 32.10; 32.10 ⩽ Ca ⩽ 63.85; 63.85 ⩽ Sr ⩽ 112.45; 112.45 ⩽ Ba	**1**

2(c)	So that water vapour / carbon dioxide (from air) not absorbed.	1
2(d)(i)	Heat to constant mass.	1
2(d)(ii)	Add an acid **and** it will fizz / bubble / effervesce **or** Add named acid **and** pass gas through limewater which turns milky / cloudy white / chalky / forms white ppt	1
2(e)(i)	(Mass lost too low →) **moles CO_2 too low** (→ moles QCO_3 (or residue) too low → M_r too high →) **A_r too high**	1
2(e)(ii)	Method is valid since 1 mol QCO_3 gives 1 mol QO. **OR** moles QO : CO_2 = 1 : 1	1

Q# 21/ AS Chemistry/2017/s/TZ 1/Paper 3/ :o) www.SmashingScience.com

2(a)	**I: Table of data**, to include: • Unit "covering" all weighings, or given for each weighing • No repeat headings *(i.e. not two lists of weighings)* • Appropriate headings for the three weighings: Mass of crucible and lid Mass of crucible, lid and **FA 5** (or "contents before heating") Mass of crucible, lid and residue / CuO / contents after heating	1
	II: Weighings recorded • Six weighings recorded in the space provided. • All weighings recorded to same number of decimal places (one or more) • Label/heading to indicate which is Expt 1 and Expt 2	1
	III: Both masses of FA 5 and residue, correctly subtracted • Masses of **FA 5** used recorded on page 4, correctly subtracted • Masses of **FA 5** used were between 2.5 – 3.0 g and 1.5 – 2.0 g • Masses of residue recorded on page 4, correctly subtracted	1
	For assessment of accuracy, examiner must check and correct (if necessary) the masses of **FA 5** used and of CuO obtained by the supervisor and by the candidate for Experiment 1. • Examiner works out the ratio $^{\text{mass of FA5}}/_{\text{mass of CuO}}$ for the supervisor (2 dp) • Examiner works out the ratio (mass **FA 5**: mass CuO) for the candidate (2 dp) • Examiner calculates δ the difference between these two ratios. **Award IV and V if $\delta \leqslant 0.08$** **Award IV if $0.08 < \delta \leqslant 0.15$**	2
	VI: Observations made during heating Solid goes black / black residue (formed) or reference to blue/green flame	1
2(b)(i)	• No of moles CuO = $^{\text{mass of residue}}/_{79.5}$ • Answer must be correct and expressed to 3 or 4 sig fig	1
2(b)(ii)	• No of moles of **FA 5** = $^{\text{answer (i)}}/_{2}$ • M_r = $^{\text{mass of FA 5 used}}/_{\text{no of moles of FA 5}}$	1
2(b)(iii)	M_r = $^{\text{mass of FA5 used in Expt 2} \times 79.5 \times 2}/_{\text{mass of residue (CuO)}}$	1
2(b)(iv)	M_r of **FA 5** calculated from A_r values = 239	1
2(b)(v)	Candidate should • correctly calculate the 2.5% of M_r in **(iv)** = 5.98 / 6.0, **and** • make a correct statement about the accuracy of the accepted formula, based on their result(s). or correctly calculate % difference for their result(s) from M_r in **(iv) and** correct comment	1
2(c)(i)	• heat (crucible and residue) to constant mass • heat more gently for longer period • cool in a desiccator	1
	• to ensure that decomposition (of **FA 5**) is complete or to ensure that <u>all</u> the residue is CuO • to prevent escape of dust / smoke / solid (during heating)	1
2(c)(ii)	Larger masses have lower <u>percentage</u> error in weighing	1
	Total:	**14**

Q# 22/ AS Chemistry/2016/s/TZ 4/Paper 3/ :o) www.SmashingScience.com

2 (a)	**I** Appropriate headings **and** units for the three balance readings • (Mass of) crucible (and lid) • (Mass of) crucible, (lid) and **FB 4** (or "contents before heating") • (Mass of) crucible, (lid) and residue / MgO / contents after heating / **FB 4** after heating • Unit covering **all** balance readings and subtracted values if shown: / g, (g), in g **or** g (for each heading)	1	

	II Masses recorded • Mass of **FB 4** used was claimed to be between 1.1–1.3 g • **All** balance readings recorded to same number of decimal places *(at least one dp)*	1	
	III Mass of **FB 4** and of residue • Mass of **FB 4** used, correctly subtracted • Mass of residue, correctly subtracted	1	
	IV and **V** • Use corrected values • Examiner used corrected values and works out the ratio $\frac{\text{mass of FB 4}}{\text{mass of MgO}}$ to 1 dp for the candidate Accuracy marks are awarded as shown. Award **IV** if ratio between 1.4–2.5 Award **V** if ratio between 1.7–2.3	2	[5]
(b) (i)	Correctly calculates n(MgO) • $\frac{\text{mass of residue}}{40.3}$ • *Answer must be expressed to 2, 3 or 4 significant figures*	1	
(ii)	Correct use of **(i)** and mass of **FB 4** • n(**FB 4**) = $\frac{\text{answer (i)}}{2}$ • $M_r = \frac{\text{mass of FB 4 used}}{\text{no of moles of FB 4}}$ • *An answer for M_r must be quoted to 2 or more significant figures*	1	
(iii)	M_r calculated from A_r values in Periodic Table = 178.6	1	
(iv)	Correct expression shown $\frac{2.5}{100} \times M_r$ in **(iii)** (= 4.5, 4.47, 4.465) **or** expresses % difference of the two M_r values $= \frac{\lvert \text{(iii)} - \text{(ii)} \rvert}{\text{(iii)}} \times 100$ **or (iii)** $\times \frac{97.5}{100}$ / **(iii)** $\times \frac{102.5}{100}$ to give range (= 174(.1) – 183(.1))	1	
	Makes a correct statement (support / does not support / yes / no) about the accuracy of the possible formula, explained by whether the experimental M_r value is close to the answer in **(iii)**. *Numbers must be quoted or reference made to **(ii)** and **(iii)***	1	[5]

(c) (i)	Improvement Heat (crucible and residue) to constant mass *Accept a description of the procedure for the mark* **or** heat more strongly / to a higher temperature **or** heat for longer so more is decomposed If a **1 dp** balance is used allow use a balance weighing to more dp **and** to reduce % error (in weighing) / give more precise mass	1	
(ii)	Conclusion To find out whether the two experiments are reliable / consistent / concordant **or** If the experiments do not agree then carry out a 3rd / another expt **or** If one experiment was inaccurate because it gave a poor M_r value it can be ignored	1	
(iii)	Error is 0.005 g or 0.01 g *(if 2 dp balance was used)* *(If a 3 dp balance was used, error is 0.0005 or 0.001 g)* *(If a 1 dp balance was used, error is 0.05 or 0.1 g)*	1	
	% = 100 × 2 × error / mass of **FB 4** *Accept correct expression **or** correct answer to 2, 3 or 4 significant figures*	1	[4]
Question 2			**[14]**