

**Tuesday 10 November 2020 – Morning**

**GCSE (9–1) Chemistry A (Gateway Science)**

**J248/03 Paper 3 (Higher Tier)**

**Time allowed: 1 hour 45 minutes**

**You must have:**

- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Chemistry A (inside this document)

**You can use:**

- a scientific or graphical calculator
- an HB pencil



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

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Candidate number

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First name(s)

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Last name

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**INSTRUCTIONS**

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if the answer is wrong.

**INFORMATION**

- The total mark for this paper is **90**.
- The marks for each question are shown in brackets [ ].
- Quality of extended response will be assessed in questions marked with an asterisk (\*).
- This document has **32** pages.

**ADVICE**

- Read each question carefully before you start your answer.

**2**  
**SECTION A**

Answer **all** the questions.

You should spend a maximum of 30 minutes on this section.

**Write your answer to each question in the box provided.**

- 1 The formula of ammonium carbonate is  $(\text{NH}_4)_2\text{CO}_3$ .

What is the relative formula mass of ammonium carbonate?

(A<sub>r</sub>: C = 12, H = 1, N = 14, O = 16)

- A 78
- B 90
- C 96
- D 120

Your answer

[1]

- 2 Which purification technique is used to separate ethanol and water from a mixture?

- A Chromatography
- B Distillation
- C Evaporation
- D Filtration

Your answer

[1]

- 3 Magnesium reacts with chlorine. Magnesium chloride is made.

What is the balanced symbol equation for this reaction?

- A  $\text{Mg} + \text{Cl} \rightarrow \text{MgCl}$
- B  $\text{Mg} + \text{Cl}_2 \rightarrow \text{MgCl}_2$
- C  $2\text{Mg} + \text{Cl}_2 \rightarrow 2\text{MgCl}$
- D  $2\text{Mg} + \text{Cl}_2 \rightarrow \text{Mg}_2\text{Cl}_2$

Your answer

[1]

4 Which Period 3 element is in Group 2?

- A Aluminium
- B Boron
- C Calcium
- D Magnesium

Your answer

[1]

5 Carbon-12 and carbon-14 are isotopes.

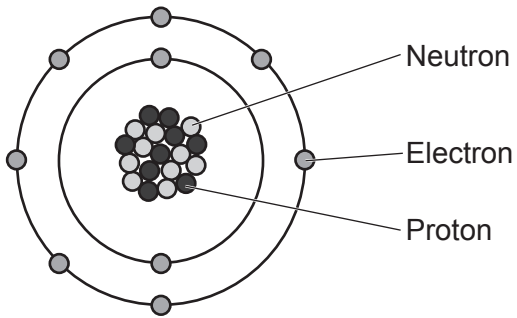
Which statement describes isotopes?

- A Atoms with the same number of protons but a different number of electrons.
- B Atoms with the same number of electrons but a different number of protons.
- C Atoms with the same number of protons but a different number of neutrons.
- D Atoms with the same number of neutrons but a different number of protons.

Your answer

[1]

6 The diagram shows an atom of an element.



What is the name of the element?

- A Boron
- B Beryllium
- C Fluorine
- D Neon

Your answer

[1]

7 The charge on an electron is  $-1.6 \times 10^{-19} \text{C}$ .

What is the charge on a proton?

- A  $-1.6 \times 10^{19} \text{C}$
- B  $-1.6 \times 10^{-19} \text{C}$
- C  $1.6 \times 10^{-19} \text{C}$
- D  $1.6 \times 10^{19} \text{C}$

Your answer

[1]

8 Ammonia has a simple molecular structure.

Which statement explains why ammonia has a low melting point and a low boiling point?

- A The covalent bonds between the atoms are strong.
- B The covalent bonds between the atoms are weak.
- C The intermolecular forces between the molecules are strong.
- D The intermolecular forces between the molecules are weak.

Your answer

[1]

9 Graphite is a form of carbon. Graphite can conduct electricity.

Why can graphite conduct electricity?

- A Delocalised electrons are between layers.
- B The ions can move.
- C Layers have weak intermolecular forces.
- D Strong covalent bonds are between the carbon atoms.

Your answer

[1]

10 Avogadro's constant has a value of  $6.02 \times 10^{23}$ .

What is the number of atoms in 0.5 mol of water?

- A  $2.00 \times 10^{23}$
- B  $3.01 \times 10^{23}$
- C  $6.02 \times 10^{23}$
- D  $9.03 \times 10^{23}$

Your answer

[1]

- 11 Magnesium powder reacts with copper(II) oxide. Magnesium oxide and copper are made.



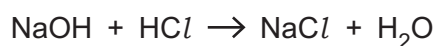
Which substance is the **reducing agent**?

- A Magnesium
- B Copper oxide
- C Magnesium oxide
- D Copper

Your answer

[1]

- 12 Sodium hydroxide reacts with hydrochloric acid. Sodium chloride and water are made.



What mass of sodium hydroxide would be needed to make 46.8 g of sodium chloride?

- A 16 g
- B 32 g
- C 50 g
- D 64 g

Your answer

[1]

- 13 Which equation shows the formation of a Group 2 metal ion?

M represents a Group 2 metal and  $e^-$  represents an electron.

- A  $\text{M} + e^- \rightarrow \text{M}^+$
- B  $\text{M} + 2e^- \rightarrow \text{M}^{2+}$
- C  $\text{M} \rightarrow \text{M}^+ + e^-$
- D  $\text{M} \rightarrow \text{M}^{2+} + 2e^-$

Your answer

[1]

14 The accurate relative atomic mass of aluminium is 26.9815385.

What is this number to 5 significant figures?

- A 26.98153
- B 26.981
- C 26.98154
- D 26.982

Your answer

[1]

15 Phosphoric acid contains phosphate ions,  $\text{PO}_4^{3-}$ .

Phosphoric acid is completely neutralised by sodium hydroxide.

What is the formula of the salt that is made?

- A  $\text{Na}_2\text{PO}_4$
- B  $\text{Na}_3\text{PO}_4$
- C  $\text{Na}(\text{PO}_4)_3$
- D  $\text{Na}_2(\text{PO}_4)_3$

Your answer

[1]

8  
SECTION B

Answer **all** the questions.

16 This question is about structure and bonding.

(a) Look at the two structures, **A** and **B**, in Fig. 16.1.

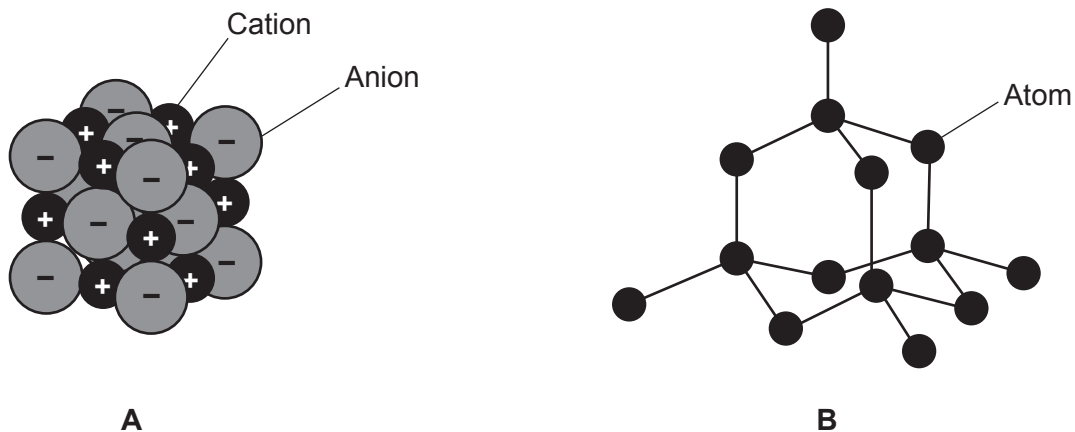


Fig. 16.1

(i) Identify the bonding in structure **A**.

Explain your answer.

Bonding .....

Explanation .....

.....

[2]

(ii) Explain why structure **B** has a high melting point.

.....

.....

..... [2]

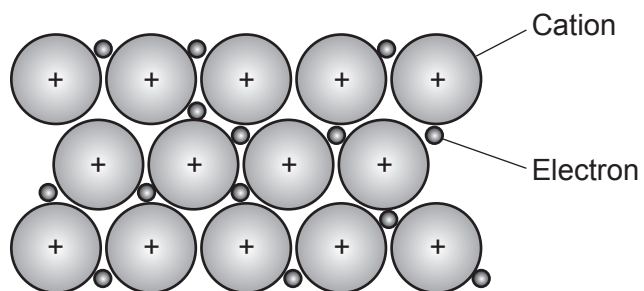
(iii) Explain why structure **B** does **not** conduct electricity.

.....

..... [1]



- (b) Look at the structure of a metal in **Fig. 16.2**. Metals are malleable, which means they can be hammered or pressed into shape without breaking or cracking.



**Fig. 16.2**

Explain why metals are **malleable**.

.....

.....

..... [2]

**10**  
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- 17 Dmitri Mendeleev produced a Periodic Table of elements which is the basis for our modern Periodic Table. He left gaps for elements that had not been discovered yet as shown in **Fig. 17.1**.

I	II	III	IV	V	VI	VII
H						
Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl
K	Ca		Ti	V	Cr	Mn
Cu	Zn			As	Se	Br
Rb	Sr	Y	Zr	Nb	Mo	
Ag	Cd	In	Sn	Sb	Te	I
Ce	Ba	La		Ta	W	
Au	Hg	Ti	Pb	Bi		

**Fig. 17.1**

- (a) Describe **two** ways Mendeleev arranged the elements in his Periodic Table.

1 .....

.....

2 .....

.....

[2]

- (b) Describe how the elements are arranged in the modern Periodic Table.

.....

..... [1]

- (c) Mendeleev left gaps in his Periodic Table for undiscovered elements. He predicted properties of these elements.

**Table 17.1** shows the predicted properties for one of these elements in one of the gaps.

Mendeleev called this element 'eka-silicon'.

<b>Appearance</b>	Grey metal
<b>Melting point (°C)</b>	Over 800
<b>Relative atomic mass</b>	72
<b>Density (g/cm<sup>3</sup>)</b>	5.5

**Table 17.1**

**Table 17.2** shows some of the elements that were discovered after Mendeleev published his Periodic Table.

	<b>Scandium (Sc)</b>	<b>Gallium (Ga)</b>	<b>Germanium (Ge)</b>	<b>Technetium (Tc)</b>
<b>Appearance</b>	Silver-white metal	Silver-blue metal	Grey-white metal	Grey metal
<b>Melting point (°C)</b>	1541	30	947	2157
<b>Relative atomic mass</b>	45.0	69.7	72.6	98.0
<b>Density (g/cm<sup>3</sup>)</b>	3.0	5.9	5.35	11.0

**Table 17.2**

- (i) Which element matches Mendeleev's predictions for 'eka-silicon'?

Tick (✓) **one** box.

Scandium

Gallium

Germanium

Technetium

[1]

(ii) Give **two** reasons for your answer to (c)(i).

1 .....

.....

2 .....

.....

[2]

(d) (i) Mendeleev did not predict the existence of argon, neon, krypton or xenon.

The electron arrangement of argon is 2,8,8.

What does this tell you about the reactivity of argon?

Explain your answer.

.....

.....

..... [2]

(ii) Neon is an element that has isotopes. Two of the isotopes are shown below.



Complete **Table 17.3** to show the number of protons, neutrons and electrons in each neon isotope.

	${}_{10}^{20}\text{Ne}$	${}_{10}^{22}\text{Ne}$
<b>Proton</b>		
<b>Neutron</b>		
<b>Electron</b>		

**Table 17.3**

[3]

14  
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18 A student is investigating chemical reactions that produce heat.

(a) She adds zinc to hydrochloric acid,  $\text{HCl}$ .

Zinc chloride,  $\text{ZnCl}_2$ , and hydrogen gas are made.

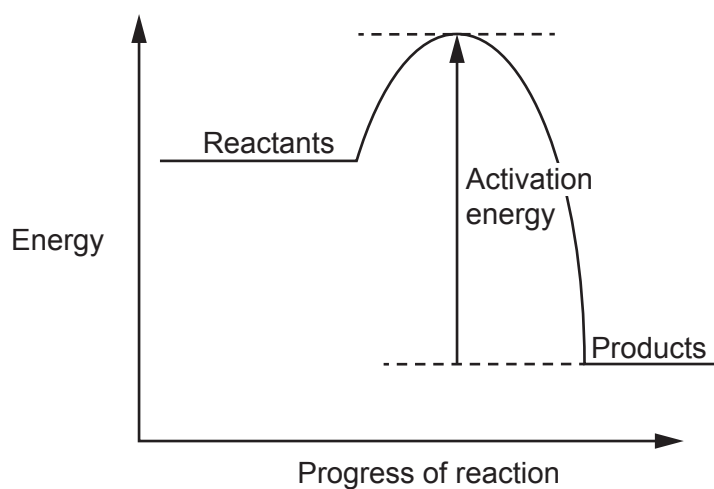
(i) Write the **balanced symbol** equation for this reaction.

..... [2]

(ii) What term is used to describe a reaction that produces heat?

..... [1]

(b) The student draws the reaction profile for this reaction, as shown in **Fig. 18.1**.



**Fig. 18.1**

Explain what is meant by the term **activation energy**.

.....  
 ..... [1]

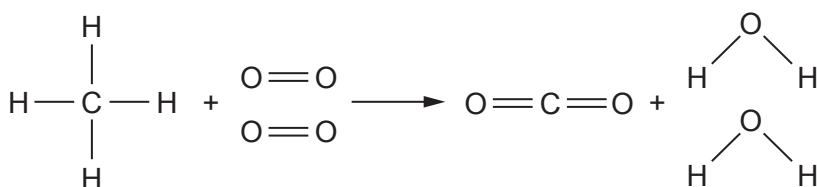
(c) Combustion reactions produce a lot of heat energy.

Bond energies can be used to calculate the energy change in combustion reactions.

Bond	Bond energy (kJ/mol)
C-H	413
O=O	498
C=O	805
O-H	464

Methane is a common fuel used in combustion reactions.

Methane reacts with oxygen. Carbon dioxide and water are made, as shown in **Fig. 18.2**.



**Fig. 18.2**

(i) The reaction of methane with oxygen produces heat.

Explain why.

Use ideas about bond breaking and bond making in your answer.

.....

.....

.....

..... [3]

(ii) Calculate the total energy transferred to break the bonds in the reactants in **Fig. 18.2**.

Total energy transferred = ..... kJ/mol [1]



- (iii) Calculate the total energy transferred to make the bonds in the products in **Fig. 18.2**.

Total energy transferred = ..... kJ/mol **[1]**

- (iv) Use your answers to parts (ii) and (iii) to calculate the energy change for the reaction in **Fig. 18.2**.

Energy change = ..... kJ/mol **[1]**



(b) After testing the soil samples, the farmer finds that the soil in one of his fields is acidic.

Acidic soil can be neutralised by spreading magnesium carbonate,  $\text{MgCO}_3$ , onto the soil.

The farmer uses 25.0 kg of magnesium carbonate.

Calculate the number of moles of magnesium carbonate the farmer uses.

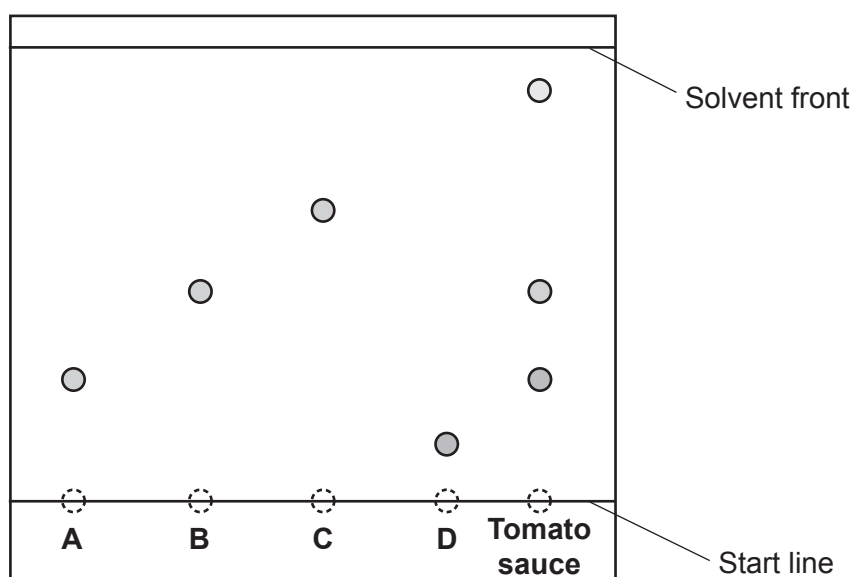
( $A_r$ : C = 12.0; Mg = 24.3; O = 16.0)

Give your answer to **3** significant figures.

Number of moles of magnesium carbonate = ..... [3]

20 A student analyses a sample of tomato sauce using thin-layer chromatography.

The tomato sauce was compared to four known food additives, **A**, **B**, **C** and **D**, as shown in the chromatogram.



(a) (i) Calculate the  $R_f$  value for **C**.

Give your answer to **2** significant figures.

$R_f$  value = ..... [3]

(ii) Which additives are shown to be in the tomato sauce?

Tick (✓) **all the correct** boxes.

**A**

**B**

**C**

**D**

[1]

(iii) Suggest why **D** has **not** travelled as far up the plate as **C**.

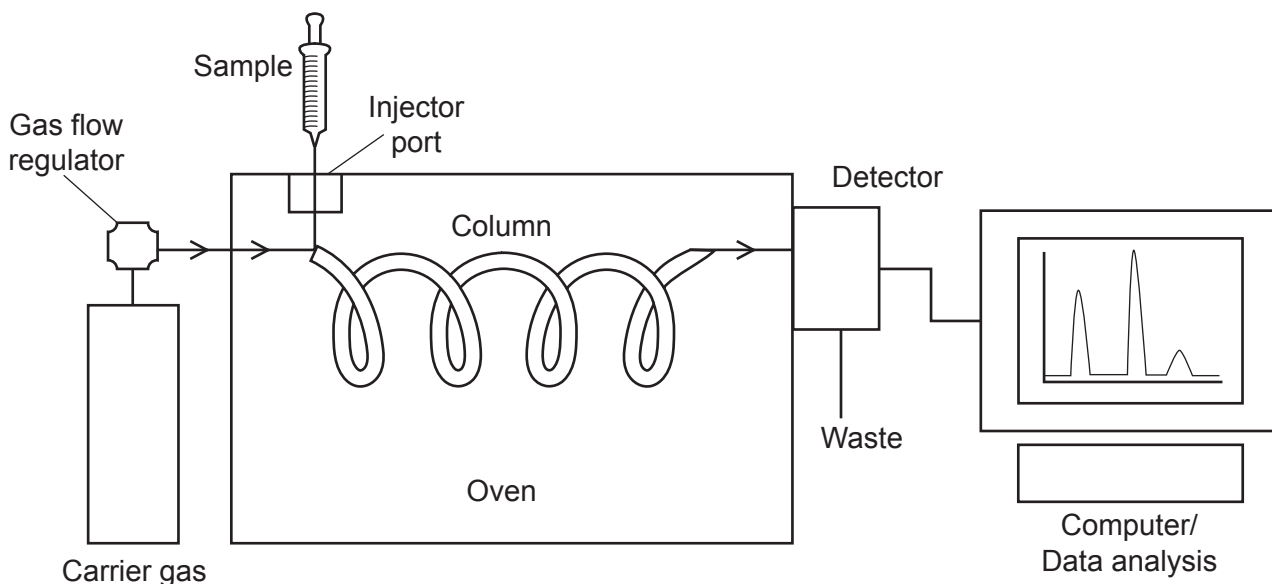
.....

.....

..... [1]

(b) Gas chromatography is another type of chromatography.

The diagram shows the equipment used for gas chromatography.



(i) State **one similarity** and **one difference** between gas chromatography and thin-layer chromatography.

Similarity .....

.....

Difference .....

.....

[2]

(ii) Explain why thin-layer chromatography is used instead of gas chromatography to analyse the tomato sauce.

.....

.....

..... [1]

21 Sodium oxide,  $\text{Na}_2\text{O}$ , is a white solid.

(a) Draw a dot and cross diagram to show the ions in sodium oxide.

[2]

(b) (i) Sodium oxide reacts with water.

An aqueous solution of sodium hydroxide is made.

Write the **balanced symbol equation** for this reaction, including **state symbols**.

..... [3]

(ii) Sodium hydroxide neutralises acids. It is an alkali.

Which ion do solutions of alkalis contain?

..... [1]

(iii) A salt is made when sodium hydroxide neutralises sulfuric acid.

Name this salt.

..... [1]

(iv) A sample of hydrochloric acid has a pH of 1.04.

A student adds water to the hydrochloric acid until the pH is 3.04.

The concentration of hydrogen ions decreases.

Calculate the factor by which the hydrogen ion concentration has decreased.

Decrease in hydrogen ion concentration = ..... [2]

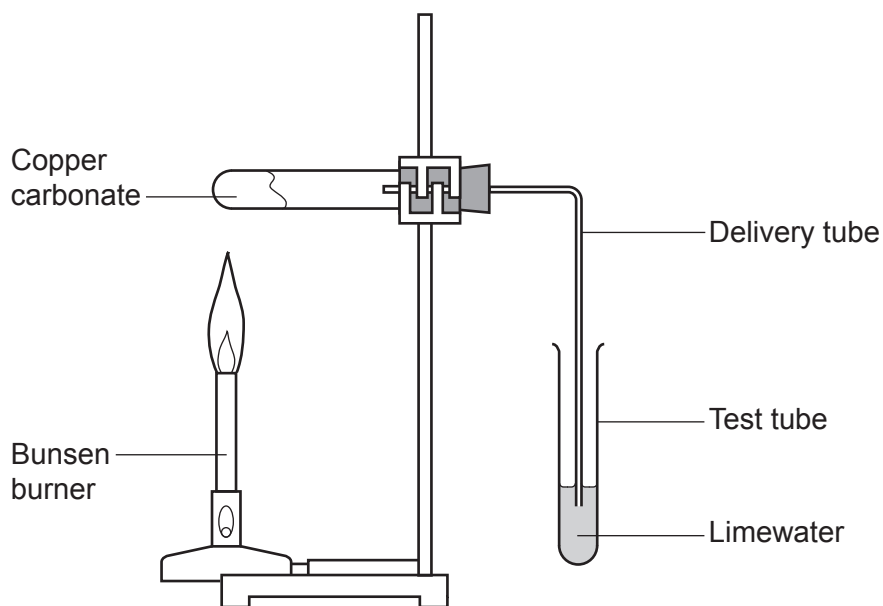
23  
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22 A student investigates the thermal decomposition of copper carbonate.



Here is the set-up of the apparatus she uses.



The student measures the mass of copper carbonate at the start of the experiment. She then measures the mass of copper oxide made.

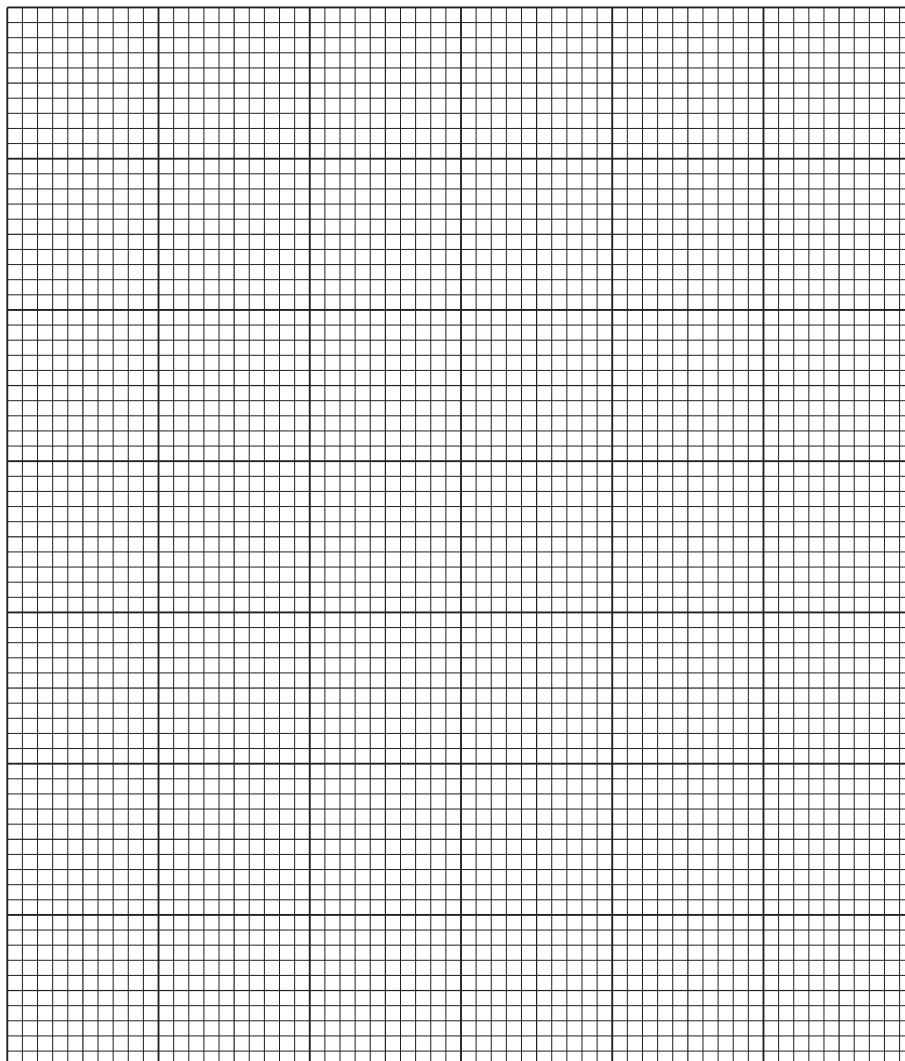
She does the experiment five times using a different mass of copper carbonate each time.

Look at her results.

Mass of copper carbonate (g)	Mass of copper oxide (g)
1.00	0.70
2.00	1.35
3.00	1.95
4.00	2.65
5.00	3.30



- (a) (i) Plot a graph of the student's results and draw a line of best fit.



[4]

- (ii) What is the mass of copper carbonate that needs to be heated to produce 2.50g of copper oxide?

Use your graph in your answer.

Mass of copper carbonate = ..... g [1]

- (iii) The mass of copper oxide made in the reaction is less than the mass of the copper carbonate heated.

Suggest why.

.....  
.....  
..... [1]

- (b) Calcium carbonate thermally decomposes to make calcium oxide and carbon dioxide.



Calculate the mass of calcium carbonate needed to make 209g of calcium oxide.  
( $A_r$ : Ca = 40.1, C = 12.0, O = 16.0)

Give your answer to **3** significant figures.

Mass of calcium carbonate = ..... g [4]

27  
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23 A student investigates the electrolysis of aqueous solutions of ionic compounds.

Aqueous solution	Product at cathode	Product at anode
Copper sulfate	Copper	Oxygen
Zinc bromide	Hydrogen	Bromine
Copper chloride	Copper	Chlorine
Sulfuric acid	Hydrogen	Oxygen

(a) Write the formulae of the **ions** that are present in aqueous copper sulfate solution.

..... [2]

(b) Why is it important that the investigation is done with **inert** electrodes?

.....  
 ..... [1]

(c) Electroplating is used to cover a metal with another metal.

(i) Which aqueous solution would you use to electroplate a metal spoon with copper using a safe method?

Tick (✓) **one** box.

Copper sulfate

Zinc bromide

Copper chloride

Sulfuric acid

[1]

(ii) Give **two** reasons for your answer to (c)(i).

1 .....

.....

2 .....

.....

[2]

- (d) (i) Predict the product made at the anode when sodium sulfate solution is electrolysed.

..... [1]

- (ii) Hydrogen gas is made at the cathode instead of sodium metal.

Explain why.

.....  
.....  
..... [1]

- (iii) Write the **balanced half equation** for the formation of hydrogen gas.

Use  $e^-$  to represent an electron.

..... [2]

- (e) The electrolysis products of ionic compounds can be different in the molten or aqueous states.

Suggest why.

.....  
..... [1]

**END OF QUESTION PAPER**

**ADDITIONAL ANSWER SPACE**

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

A large area of lined paper for writing. It features a vertical solid line on the left side, creating a margin. The rest of the page is filled with horizontal dotted lines, providing space for writing answers.

A page for handwriting practice featuring a vertical margin line on the left and 26 horizontal dotted lines extending across the page.

A large rectangular area with a solid vertical line on the left side and horizontal dotted lines extending across the page, providing a grid for writing answers.



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