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Friday 19 November 2021 – Morning

GCSE (9−1) Chemistry B (Twenty First Century Science)

J258/03 Breadth in Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Chemistry B (inside this document)

You can use:
- an HB pencil
- a scientific or graphical calculator

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

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

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 your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

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Answer **all** the questions.

1 Chlorine is used to make water safe to drink.

(a) How does chlorine make water safe to drink?

.....

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

(b) James has a solution of chlorine in water.

He tests the solution with **blue** litmus paper.

State **two** colour changes that James will see.

1 .....

2 .....
[2]

(c) Mia adds a solution of chlorine to a solution of sodium bromide.

This is the equation for the reaction that happens:

$Cl_2(aq) + 2NaBr(aq) \rightarrow Br_2(aq) + 2NaCl(aq)$

The solution changes colour.

(i) State the colour of the solution at the end of the experiment.

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

(ii) What causes the colour change?

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

(d) Potassium reacts with chlorine. Sodium also reacts with chlorine.

Is the reaction of sodium with chlorine **faster** or **slower** than the reaction of potassium with chlorine?

Faster ☐

Slower ☐

Explain why the rate of reaction is different.

.....

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

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(e) Calcium also reacts with chlorine.
Calcium forms Ca^{2+} ions and chlorine forms Cl^{-} ions.

What is the correct formula of calcium chloride?

Put a (ring) around the correct answer.

$CaCl$ **Ca_2Cl_2** **$CaCl_2$** **$ClCa_2$** **$ClCa$**

[1]

(f) The element astatine, At, is below iodine in Group 7 of the Periodic Table.

Which **two** properties of astatine are correct?

Tick (✓) **two** boxes.

It reacts with Na^{+} ions to form $NaAt_2$. ☐

Its atoms are larger than atoms of iodine. ☐

It is a solid at room temperature. ☐

It is colourless. ☐

It reacts with sodium iodide in solution to give iodine. ☐

[2]

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2 Alex reacts zinc with excess hydrochloric acid.

Fig. 2.1 shows the apparatus Alex uses:

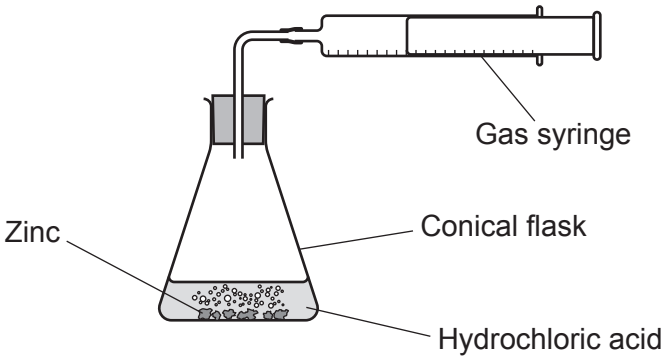

Fig. 2.1

(a) Alex measures the volume of gas made at the start and then again after every minute for 7 minutes.

Fig. 2.2 shows a graph of his results:

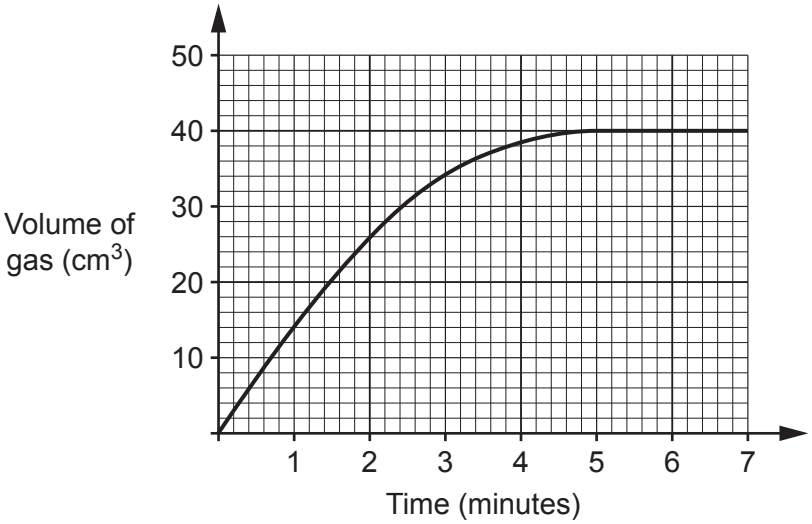

Fig. 2.2

(i) What is the gradient of the curve at 5 minutes?

Gradient = ... cm^3/minute **[1]**

(ii) What happens to the reaction after 5 minutes?

.....

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

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(b) Which value is a correct estimate for the rate at which the reaction starts?

Use **Fig. 2.2**.

Tick (✓) **one** box.

0.08 cm^3 / minute	☐
0.1 cm^3 / minute	☐
10 cm^3 / minute	☐
14 cm^3 / minute	☐
40 cm^3 / minute	☐

[1]

(c) 2.0 g of zinc makes a total of 800 cm^3 of gas.

Calculate the mass of zinc Alex used in his experiment.

Use the total volume of gas produced in **Fig. 2.2**.

Mass of zinc = ... g **[2]**

(d) Alex repeats the experiment with different metals and excess acid.
He wants to compare the rate of reaction for the different metals.

State **two** factors that he should control in these experiments to get valid results.

1 .....

2 .....

[2]

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(e) **Fig. 2.3** shows Alex's results for **zinc**, **magnesium** and **iron**:

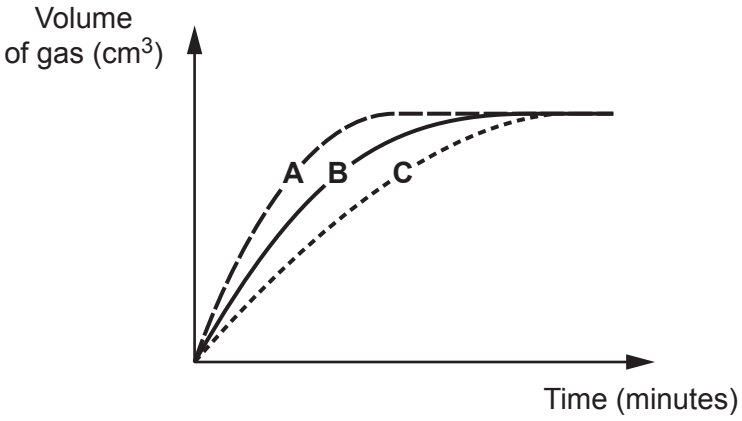

Fig. 2.3

Which metal makes each curve in **Fig. 2.3**?

Curve **A** .....

Curve **B** .....

Curve **C** .....

[2]

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3 In very cold conditions, hand warmers can be used inside gloves. One type of hand warmer uses a chemical reaction to give off heat.

Iron powder inside the hand warmer reacts with oxygen to make iron oxide.
An exothermic reaction starts when the iron powder comes into contact with the air.

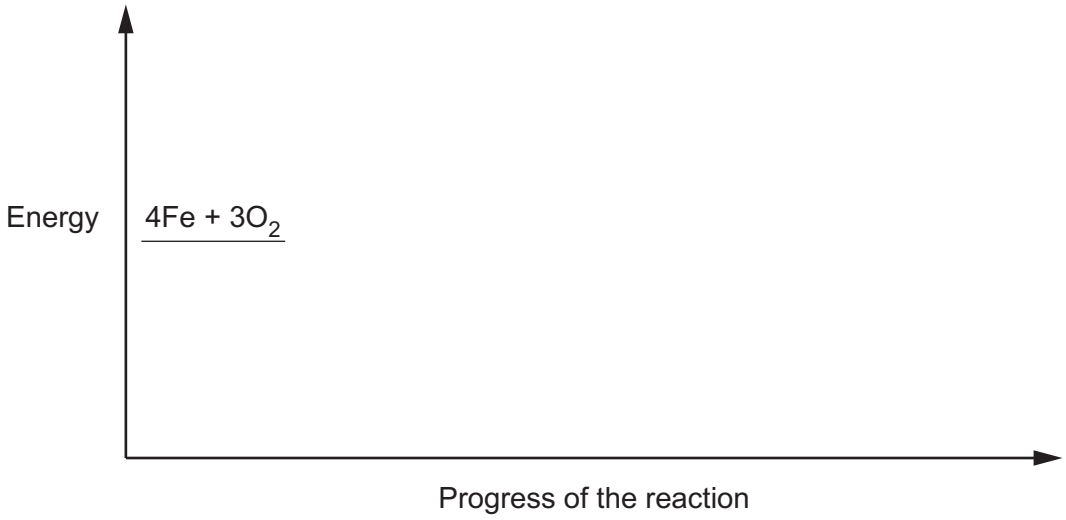
(a) Iron oxide, Fe_2O_3, contains O^{2-} ions.

What other ion does iron oxide, Fe_2O_3, contain?

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

(b) Draw and label the reaction profile for this reaction.

Label the activation energy 'AE'.



[3]

(c) Carbon is used as a catalyst in the hand warmer.

(i) Suggest why a catalyst is added to the hand warmer.

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

(ii) Why does the catalyst have the effect identified in **(c)(i)**?

Use ideas about energy in your answer.

.....

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

(d) The iron is in powdered form.

Explain why this makes the reaction go quickly.

Use ideas about particles in your answer.

.....

.....

..... **[2]**

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4 In the early nineteenth century, a chemist called Dobereiner found some sets of three elements with similar properties.

The table shows an example:

Element	Relative atomic mass
Lithium	6.9
Sodium	23.0
Potassium	39.1

(a) Lithium, sodium and potassium react in a similar way with water.

(i) Balance the symbol equation for the reaction of lithium with water.

..... Li + ... H_2O $\longrightarrow$ ..... LiOH + H_2 **[1]**

(ii) Potassium is more reactive with water than sodium and lithium.

State **two** observations that would prove this.

1 .....

2 .....
[2]

(b) Which property is used to arrange the elements in the modern Periodic Table?

Tick (✓) **one** box.

Atomic number ☐

Mass number ☐

Neutron number ☐

Relative atomic mass ☐

[1]

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(c) Dobereiner called his sets of three elements, 'triads'. He had this idea:

'The relative atomic mass of the middle element is approximately equal to the mean of the other two elements.'

The elements nitrogen, phosphorus and arsenic:
- have similar properties
- are found in Group 5 of the modern Periodic Table.

Are nitrogen, phosphorus and arsenic a Dobereiner 'triad'?

Use the Data Sheet **and** a calculation to help explain your answer.

.....

.....

.....

..... **[2]**

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5 Crude oil contains many compounds that are used as fuels.
The table shows information about some of these compounds:

Name	Formula	Relative formula mass	Melting point (°C)	Boiling point (°C)
Methane	CH_4	16	–182	–162
Pentane	C_5H_{10}	70	–130	36
Nonane	C_9H_{20}	128	–54	151
Dodecane	$C_{12}H_{26}$	170	–10	
Hexadecane	$C_{16}H_{34}$	226	18	287
Icosane	$C_{20}H_{42}$	282	37	343
Benzene	C_6H_6	78	6	80

(a) All the compounds in the table are alkanes, except benzene.

Explain how the formula of benzene shows it is **not** an alkane.

.....

.....

.....

..... **[2]**

(b) **(i)** Name **one** compound from the table which is a solid at 25 °C.

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

(ii) Give **one** reason for your answer to **(b)(i)**.

.....

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

(c) Describe the relationship between melting point and boiling point for the alkanes in the table.

.....

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

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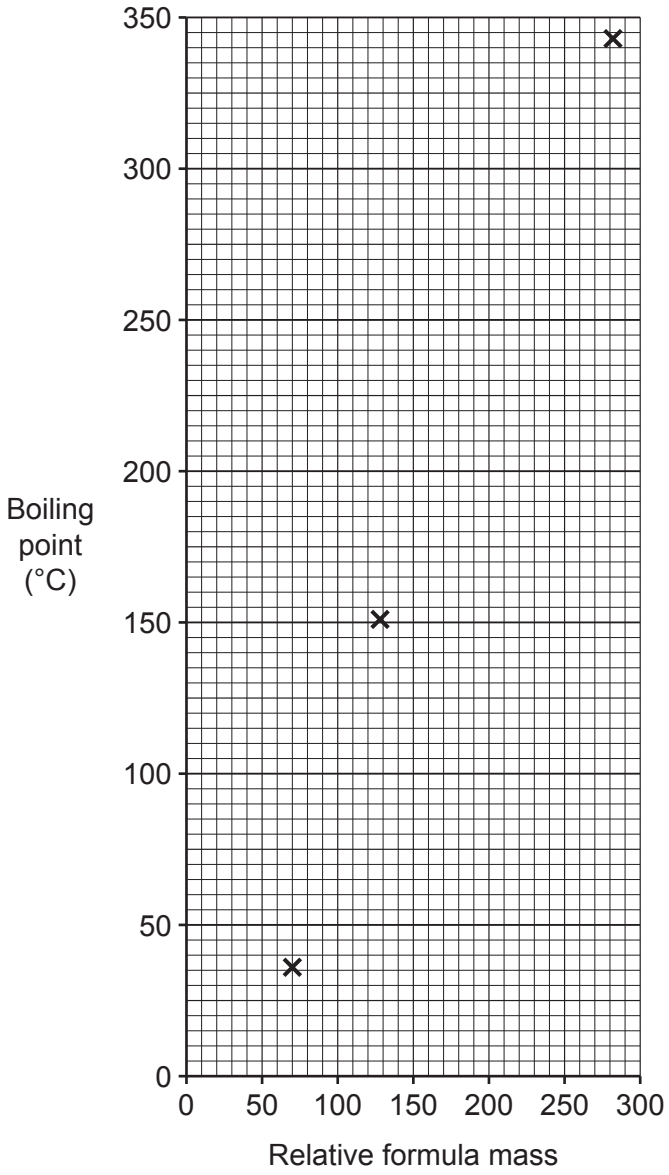
(d) The graph shows the boiling point and relative formula mass for some alkanes.



(i) Hexadecane, $C_{16}H_{34}$, boils at 287 °C.
Plot the point for hexadecane on the graph.

Use data from the table. **[1]**

(ii) Draw a line of best fit. **[1]**

(iii) Estimate the boiling point of dodecane, $C_{12}H_{26}$.

Show your working on the graph.

Boiling point = ... °C **[1]**

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(e) Fractional distillation is used to separate the compounds in crude oil.

Which property of the compounds is used to separate them?

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

(f) **(i)** Describe how carbon monoxide forms when alkanes burn in vehicle engines.

.....

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

(ii) Why is it important to decrease the amount of carbon monoxide entering the air?

.....

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

(iii) The formula of carbon monoxide is CO.
One mole of carbon monoxide contains 6.02×10^{23} molecules.

Calculate the mass of one carbon monoxide molecule.

Use the Data Sheet and the relationship: number of moles = $\frac{\text{mass of substance (g)}}{\text{relative formula mass (g)}}$

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

Mass of one carbon monoxide molecule = ... g **[3]**

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(g) Nitrogen oxides are also formed in vehicle engines.

Describe how nitrogen oxides form in vehicle engines.

.....

.....

.....

..... **[2]**

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6 Scientists use models to describe things that are too small to be seen.

Fig. 6.1 shows a model of an atom:

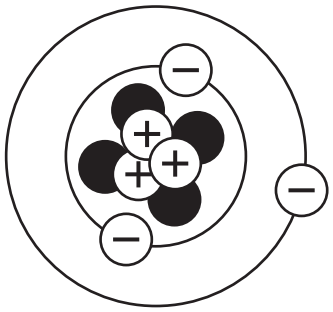

Fig. 6.1

(a) Name the particles represented by black circles in the model.

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

(b) **(i)** Identify the element in **Fig. 6.1**.

Use the Data Sheet.

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

(ii) How was the element in **Fig. 6.1** identified in **(b)(i)**?

.....

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

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(c) **Fig. 6.2** shows a model of a molecule of butane:

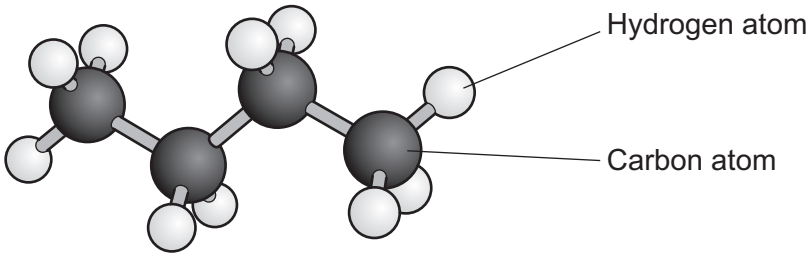

Fig. 6.2

(i) Which **two** features are shown by the model in **Fig. 6.2**?

Tick (✓) **two** boxes.

- The number of electrons in the atoms. ☐
- The 3D shape of the molecule. ☐
- The number of atoms in the molecule. ☐
- The actual size of the atoms. ☐
- The length of the bonds between the atoms. ☐

[2]

(ii) State the **empirical** formula of butane.

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

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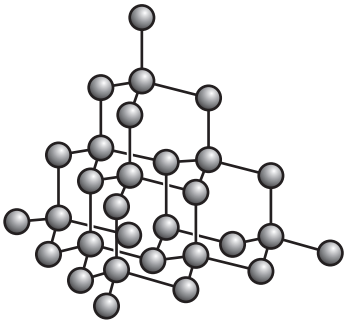
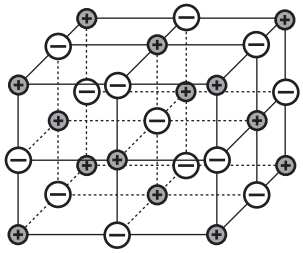
(d) **Fig. 6.3** shows models of four types of giant structure.

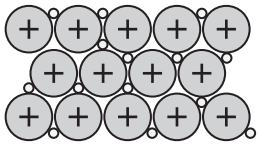
A



B



C



D

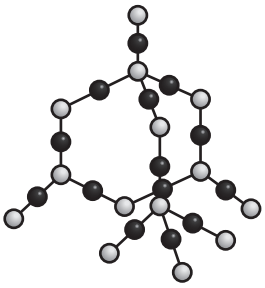


Fig. 6.3

(i) Which **two** structures contain covalent bonds?

Put a ring around the **two** correct answers.

A **B** **C** **D**

[2]

(ii) Which structure only conducts electricity when it is molten?

Put a ring around the **one** correct answer.

A **B** **C** **D**

[1]

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7 Amaya is given some coloured sweets. She removes the food colour from each sweet. Each food colour contains a mixture of dyes.

(a) She uses chromatography to find out the number of dyes in each sweet:

- She draws a pencil line on a piece of filter paper **1 cm** from the bottom.
- She puts spots of food colour from each sweet on the pencil line.
- She places the filter paper in **2 cm** of water in a beaker.
- She waits for the water to rise to near the top of the filter paper.

There is a mistake in Amaya's method.

(i) Identify the mistake in Amaya's method.

.....

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

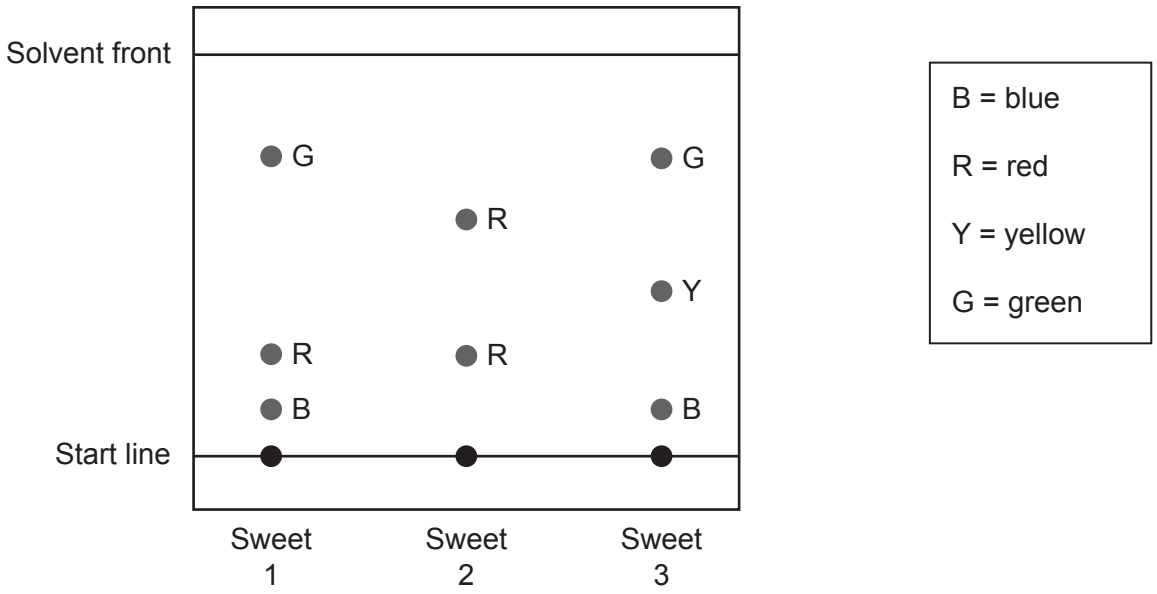
(ii) Why will this mistake stop Amaya from getting useful results?

.....

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

(b) Amaya corrects her method and does the chromatography correctly.

Her results are shown in the chromatogram:



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(i) Amaya says, 'The chromatogram shows that there were a total of four different pure dyes used in the three sweets.'

Explain why this is incorrect.

.....

.....

.....

..... **[2]**

(ii) Which dye is the **most** soluble in water?

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

(iii) Give **one** reason for your answer to **(b)(ii)**.

.....

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

(iv) Calculate the R_f value for the **yellow** dye.

Use the chromatogram and the equation:

$$R_f = \frac{\text{distance travelled by solute}}{\text{distance travelled by solvent front}}$$

R_f value = ... **[2]**

(c) Ali has a mixture of carbon in copper sulfate solution. Carbon is insoluble in water.

Describe a method Ali can use to obtain pure copper sulfate crystals from the mixture.

.....

.....

.....

.....

.....

..... **[3]**

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8 Plastic bags are made of poly(ethene).

(a) **(i)** Poly(ethene) is made by polymerising ethene, C_2H_4.

Draw the structure of the repeating unit of poly(ethene).

[2]

(ii) What **type** of polymer is poly(ethene)?

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

(b) **(i)** Ethene, C_2H_4, is made by cracking molecules such as decane, $C_{10}H_{22}$.
One other product is made in the reaction.

Write a balanced symbol equation for the cracking of decane.

..... **[2]**

(ii) Ethene is an alkene.

Describe a laboratory test for an alkene **and** the expected result for ethene.

Test .....

.....

Result .....

.....
[2]

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(c) **Table 8.1** shows the energy required to make 1000 poly(ethene) bags and transport them to shops:

	Energy per 1000 bags (kJ)
Energy required to make the raw materials	279 000
Energy required in processing the raw materials to make bags	220 000
Energy required to transport the bags	11 000

Table 8.1

(i) Calculate the percentage of the energy in the table required to transport the bags.

Give your answer to **1** decimal place.

Percentage = ... % **[3]**

(ii) Sarah estimates the cost of recycling waste bags into new bags.

Table 8.2 shows her estimates:

	Energy per 1000 bags (kJ)
Processing	220 000
Transport	11 000

Table 8.2

Suggest why Sarah's estimates may be inaccurate.

Use data from **Table 8.1** and **Table 8.2** to support your answer.

.....

.....

..... **[2]**

(d) Poly(ethene) is described as 'non-biodegradable'.

Define '**non-biodegradable**'.

.....

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

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9 Blue copper sulfate crystals turn white when heated:

'blue copper sulfate' $\longrightarrow$ 'white copper sulfate' + water

- Sarah weighs out five different samples of 'blue copper sulfate'.
- She puts each sample in a test tube.
- She heats each test tube.
- She weighs each test tube and its contents after heating.
- She then calculates the mass of 'white copper sulfate'.

(a) The graph shows the results:

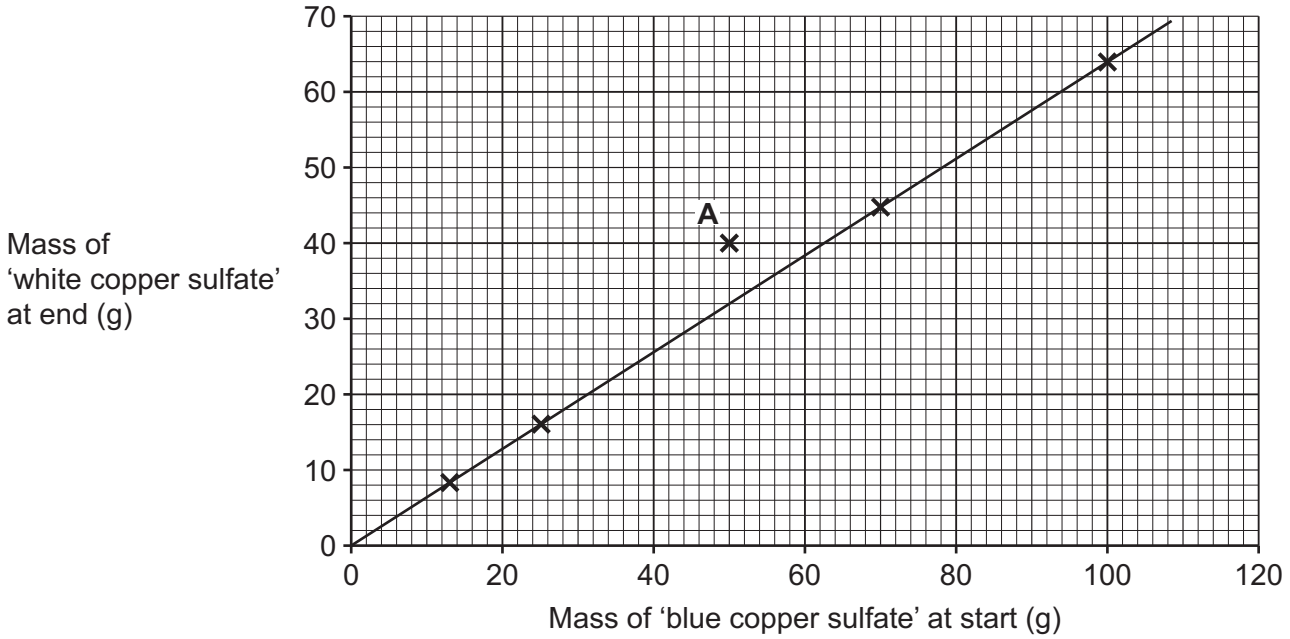

Fig. 9.1

(i) Result **A** does **not** fit the pattern.

Sarah says the test tube was not heated for long enough.

Is Sarah correct? Explain your answer.

.....

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

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(ii) The equation for the line in **Fig. 9.1** is given by y = **m**x + **c**.

Calculate values for **m** and **c**, using **Fig. 9.1**.

m = ...

c = ... g
[3]

(b) **(i)** 25 g of 'blue copper sulfate' gives 16 g of 'white copper sulfate' when heated.

Calculate the number of moles of water that are made.

Use the equation: number of moles = $\frac{\text{mass of substance (g)}}{\text{relative formula mass (g)}}$

Number of moles of water = ... mol **[3]**

(ii) 'Blue copper sulfate' has the formula $CuSO_4 \bullet nH_2O$, where *n* is a whole number.

In one experiment, Sarah makes 2.0 mol of water and 0.4 mol of 'white copper sulfate'.

'White copper sulfate' has the formula $CuSO_4$.

Calculate the value of *n* in 'blue copper sulfate', $CuSO_4 \bullet nH_2O$.

n = ... **[2]**

END OF QUESTION PAPER

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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).

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