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Friday 19 November 2021 – Morning

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

J258/01 Breadth in Chemistry (Foundation 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 **32** pages.

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

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Answer **all** the questions.

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

Table 1.1 shows an example:

Element	Relative atomic mass
Lithium	6.9
Sodium	23.0
Potassium	39.1

Table 1.1

(a) State the Group number of lithium, sodium and potassium in the modern Periodic Table.

Group number ..... **[1]**

(b) Which statements about lithium, sodium and potassium are **true** and which are **false**?

Tick (✓) **one** box in each row.

Statement	True	False
They all react with water.		
Lithium is the most reactive.		
They all react with chlorine.		
They are all metals.		

[2]

(c) **(i)** The elements nitrogen, phosphorus and arsenic have similar properties.

Complete **Table 1.2** by adding the symbols for these three elements.

	Element	Symbol	Relative atomic mass
1	Nitrogen	.....	14.0
2	Phosphorus	.....	31.0
3	Arsenic	.....	74.9

Table 1.2

[1]

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

'The relative atomic mass of element 2 is approximately equal to the mean of the other two elements.'

Do the elements in **Table 1.2** fit Dobereiner's idea?

Yes ☐

No ☐

Use a calculation to help explain your answer.

.....

.....

.....

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

(d) Mendeleev arranged the elements in order of their relative atomic masses.

Mendeleev's work was peer reviewed.

Describe the peer review process.

.....

.....

.....

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

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2 Water evaporates from lakes and oceans. It forms clouds of gaseous water.

In the right conditions the water falls as rain, as shown by the equation:

$H_2O(g) \rightarrow H_2O(l)$

(a) Which **two** processes does this equation show?

Tick (✓) **two** boxes.

Condensation ☐

Chemical change ☐

Evaporation ☐

Physical change ☐

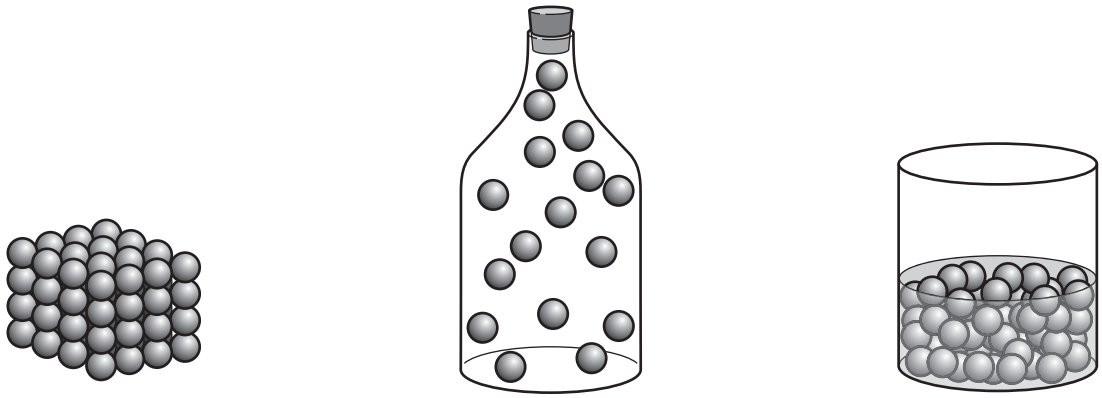
Melting ☐

Combustion ☐

[2]

(b) **Fig. 2.1** represents the three states of matter: **solid**, **liquid** and **gas**.

(i) Write the word for the correct state under each model.



....

[1]

Fig. 2.1

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(ii) **Fig. 2.2** shows a molecule of oxygen, O_2.

O=O

Fig. 2.2

Draw a similar diagram to show a molecule of water, H_2O.

[1]

(c) The table shows the percentage of nitrogen and carbon dioxide in air:

Gas	Percentage (%)
Nitrogen	78
Carbon dioxide	0.04

(i) Calculate how many times more nitrogen there is than carbon dioxide in air.

..... times more nitrogen than carbon dioxide **[2]**

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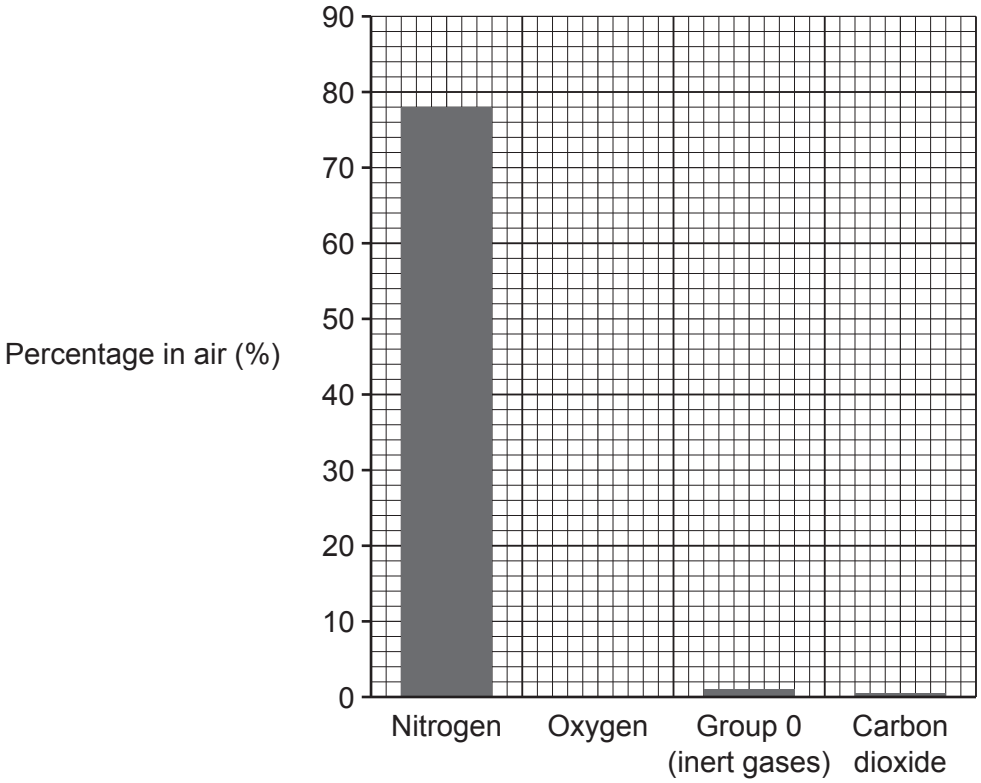
(ii) Oxygen is 21% of air.

Plot the data for oxygen on the bar chart.



[1]

(iii) Draw lines to connect each **gas** with its correct **property**.

Gas	**Property**
	Unreactive.
Group 0 (inert gases)	Relights a glowing splint.
Carbon dioxide	Turns limewater milky.
Oxygen	Turns litmus blue.

[3]

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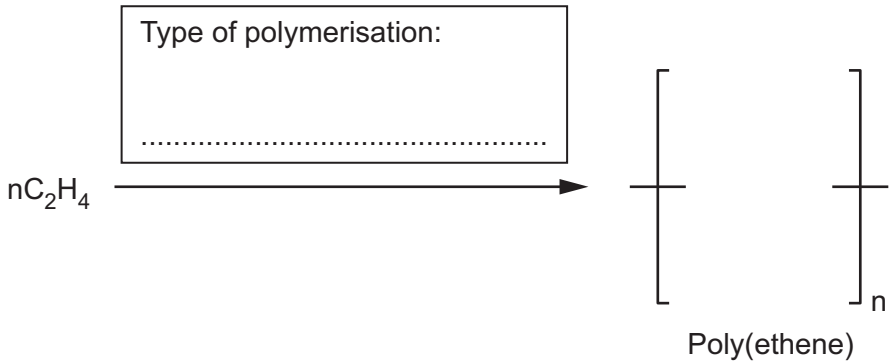
3 Plastic bags are made of poly(ethene).

Poly(ethene) is made by polymerisation of ethene.

(a) Complete the diagram to show the polymerisation of ethene, C_2H_4.



[2]

(b) Ethene, C_2H_4, is made by cracking molecules such as decane, $C_{10}H_{22}$.

Complete the symbol equation for this reaction.

$C_{10}H_{22} \rightarrow C_2H_4$ + ... **[1]**

(c) The table 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 to process the raw materials to make the bags	220 000
Energy required to transport the bags	11 000

(i) Calculate the total energy required **per bag**.

Use data from the table.

Total energy required per bag = ... kJ **[2]**

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(ii) Calculate the percentage of the energy in the table required to make the raw materials for 1000 bags.

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

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

(d) Some plastic materials are described as 'biodegradable'.

What does 'biodegradable' mean?

.....

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

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4 Amaya is given some coloured sweets.

She uses chromatography to find out the number of dyes in each sweet.

(a) **(i)** Amaya starts by drawing a line on a piece of filter paper using ink.

Describe **one** way in which Amaya can improve this part of her method.

.....

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

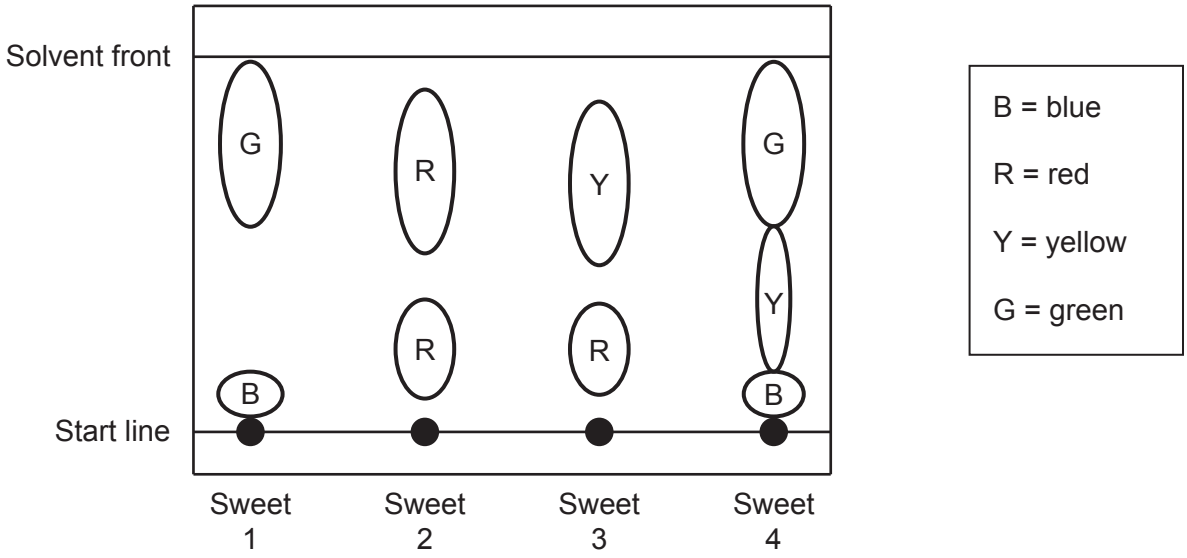
(ii) Give **one** reason for your answer to **(a)(i)**.

.....

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

(b) Sundip repeats the experiment, improving on Amaya's method.

Her results are shown in the chromatogram:



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(i) Each sweet contains a mixture of dyes.

How many different dyes are there in all of the sweets that Sundip has used?

Use the chromatogram.

Total number of different dyes = ... **[1]**

(ii) Which dye is the **least** soluble in the solvent?

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

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

.....

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

(iv) R_f values can be calculated using this equation:

$$R_f = \frac{\text{distance moved by dye}}{\text{distance moved by solvent front}}$$

Which dye has the largest R_f value?

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

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

Complete the list to show the correct order of methods he needs to obtain pure copper sulfate crystals from the mixture.

Use the words.

You can use each word once, more than once, or not at all.

Crystallization **Dissolving** **Distillation** **Heating**

1 .....

2 Filtration

3 .....

4 .....

[3]

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5 Chemists use models to describe things that are too small to be seen.

Fig. 5.1 shows an atomic model proposed by a scientist over 100 years ago:

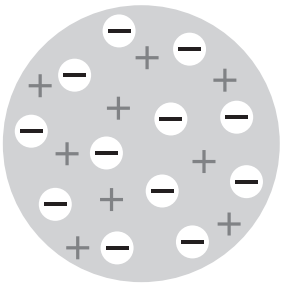

Fig. 5.1

(a) Which scientist suggested the atomic model in **Fig. 5.1**?

Put a (ring) around the correct answer.

Dalton **Thomson** **Rutherford** **Bohr**

[1]

(b) The modern model of the atom is different from the model in **Fig. 5.1**.

Complete the sentences about the modern model of the atom.

Use the words.

You can use each word once, more than once, or not at all.

electrons **ions** **neutrons** **nucleus** **protons**

The centre of the atom is called the ..... .

This is made up of positively charged ..... and

neutral ..... .

The ..... are negatively charged.

In a neutral atom, there are equal numbers of .....

and ..... .

[3]

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(c) **Fig. 5.2** shows a model of an ethanol molecule and a methane molecule:

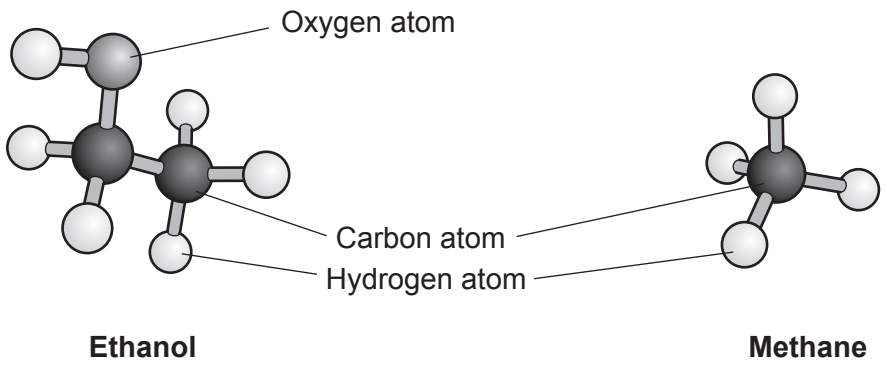

Fig. 5.2

(i) The formula of methane is CH_4.

What is the formula of ethanol?

Use **Fig. 5.2** to help you.

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

(ii) Which **two** statements do the models in **Fig. 5.2** accurately show?

Tick (✓) **two** boxes.

The number of electrons in each atom. ☐

The number of atoms in each molecule. ☐

The 3D shape of each molecule. ☐

The actual size of the atoms. ☐

[2]

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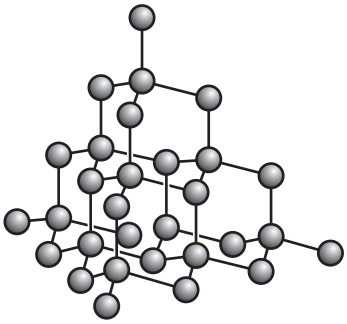
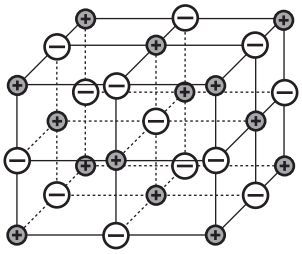
(d) **Fig. 5.3** shows models of four types of giant structure.

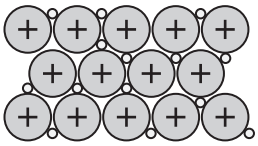
A



B



C



D

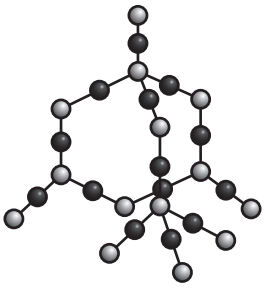


Fig. 5.3

(i) Which **two** structures are compounds?

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

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

[2]

(ii) Which structure conducts electricity when it is solid?

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

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

[1]

(iii) Which **two** structures contain ions?

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

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

[2]

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6 Blue copper sulfate crystals turn white when heated:

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

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

(a) **Fig. 6.1** shows a graph of his results:

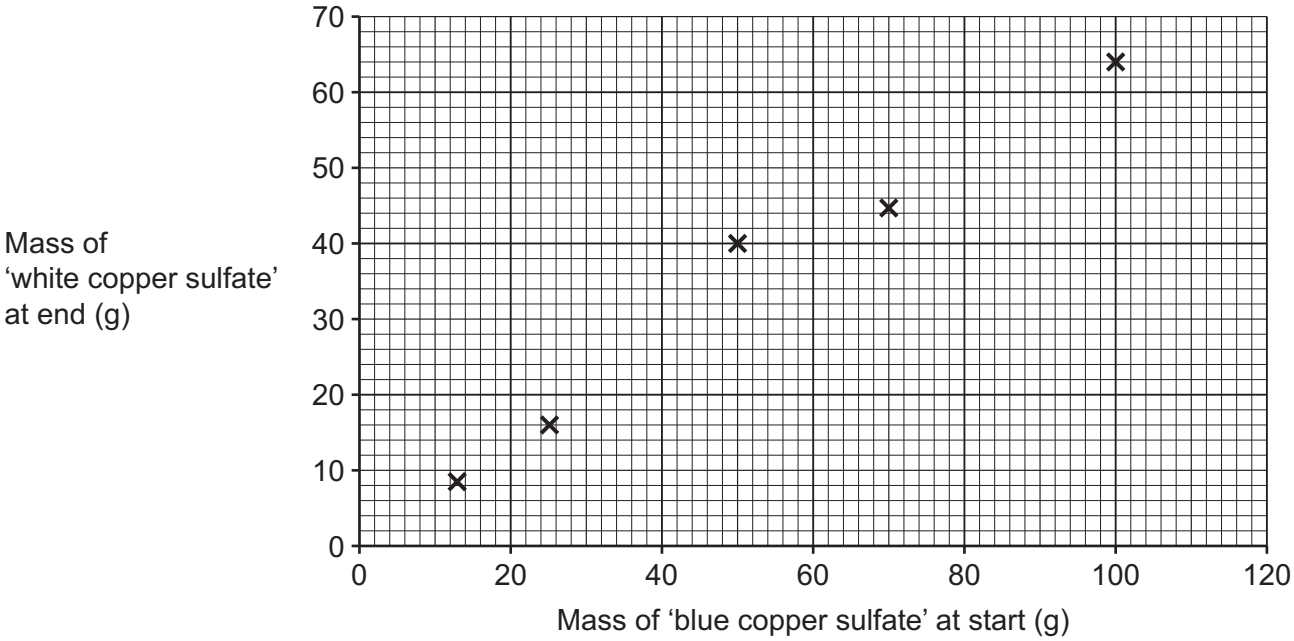

Fig. 6.1

One result does **not** fit the pattern.

(i) Put a ring around the result that does not fit the pattern in **Fig. 6.1**. **[1]**

(ii) Kai thinks he made a mistake when he was heating the 'blue copper sulfate' for this result.

Suggest the mistake Kai made.

.....

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

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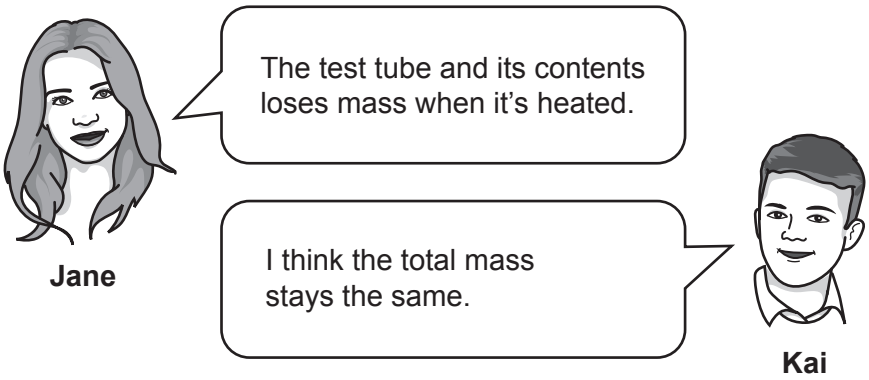
(b) Calculate the mass of 'white copper sulfate' that is made when 2.0 g of 'blue copper sulfate' is heated.

Use the equation: mass of 'white copper sulfate' × 1.5625 = mass of 'blue copper sulfate'

Mass of 'white copper sulfate' = ... g **[3]**

(c) Jane and Kai discuss the results:



Explain why Jane and Kai are **both** correct.

Jane .....

.....

Kai .....

.....

[2]

(d) 100 g of 'blue copper sulfate' gives 64 g of 'white copper sulfate'.

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

Calculate the mass of water that is formed.

Mass of water = ... g **[1]**

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(e) Jane tests whether this reaction is reversible:

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

She adds water to 'white copper sulfate' in a test tube.
The solid turns blue and the test tube gets hot.

(i) Does her observation show that the reaction is reversible?

Yes ☐

No ☐

Explain your answer.

.....

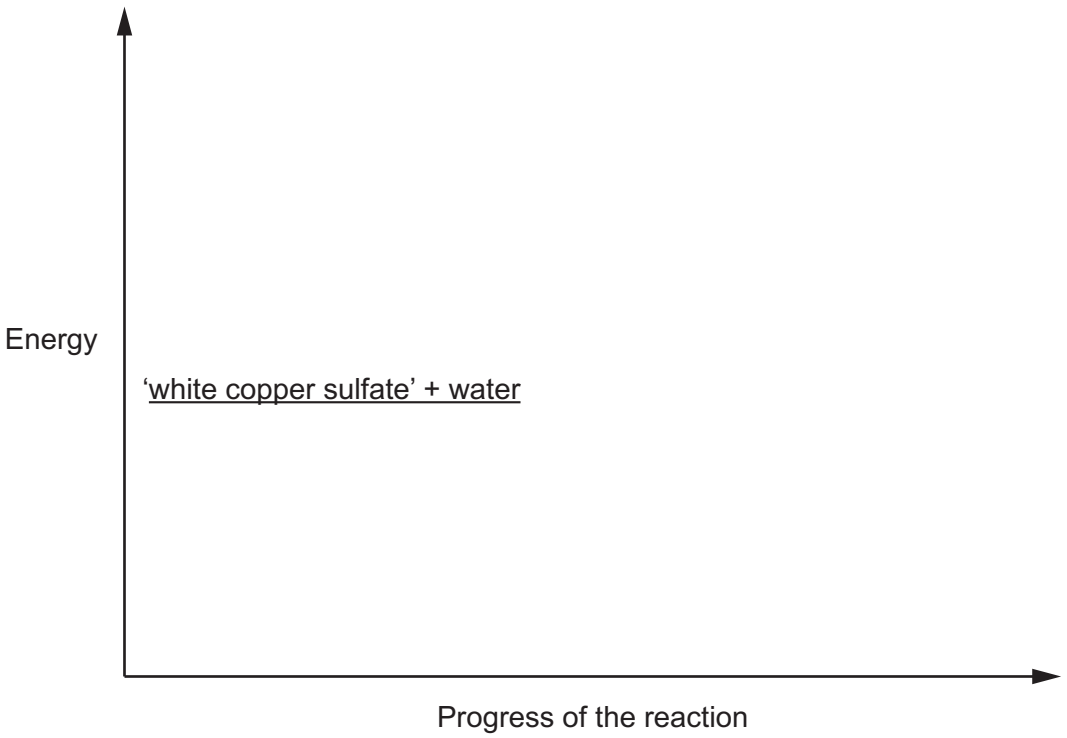
..... **[1]**

(ii) What name is given to a reaction that gives out heat?

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

(iii) Draw **one** line to show the energy level of 'blue copper sulfate' on the reaction profile in **Fig. 6.2**.

Label your line 'blue copper sulfate'.



[1]

Fig. 6.2

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7 Crude oil contains many compounds that are used as fuels.

The table shows some of these compounds:

Name	Formula	Relative formula mass	Boiling point (°C)
Methane	CH_4		–162
Butane	C_4H_{10}	58	–1
Benzene	C_6H_6	78	80
Octane	C_8H_{18}	114	126
Hexadecane	$C_{16}H_{34}$	226	287

(a) Which word describes crude oil?

Put a ring around the correct answer.

Chemical **Compound** **Element** **Mixture**

[1]

(b) **(i)** Name the **two** compounds in the table that are gases at 25 °C.

Compound 1 .....

Compound 2 .....

[1]

(ii) Explain your answer to **(b)(i)**.

.....

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

(c) Calculate the relative formula mass of methane.

Use the Data Sheet.

Relative formula mass = ... **[1]**

(d) Describe the relationship between relative formula mass and boiling point for the compounds in the table.

.....

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

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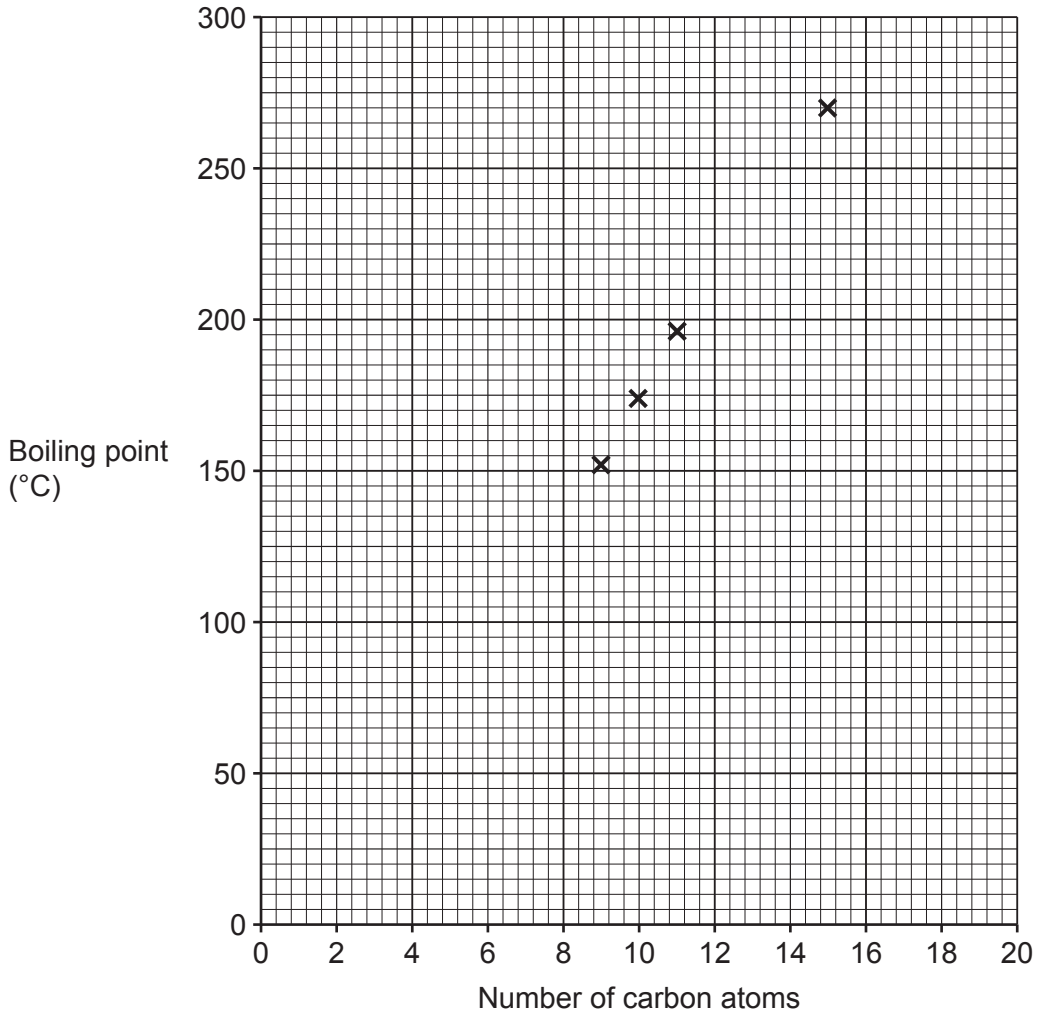
(e) Benzene has six carbon atoms but is **not** an alkane.

Alkanes have the general formula C_nH_{2n+2}.

Give the formula of the alkane with **six** carbon atoms.

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

(f) The graph shows the boiling point and the number of carbon atoms for some alkanes.



(i) Hexadecane has 16 carbon atoms. The boiling point of hexadecane is 287 °C.

Plot the point for hexadecane on the graph. **[1]**

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

(iii) Estimate the boiling point of the alkane with the formula $C_{12}H_{26}$.

Show your working on the graph.

Boiling point = ... °C **[1]**

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

Which property is used to separate compounds in fractional distillation?

Tick (✓) **one** box.

Boiling point ☐

Density ☐

Formula ☐

Melting point ☐

[1]

(h) **(i)** The formula for butane is C_4H_{10}.

Draw the displayed formula for butane.

[1]

(ii) What is the **simplest** ratio of carbon atoms to hydrogen atoms in butane?

Ratio of carbon atoms : hydrogen atoms = ... : ..... **[1]**

(iii) State the empirical formula of butane.

Empirical formula = ... **[1]**

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8 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:

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

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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9 Alex reacts zinc with excess hydrochloric acid.

Fig. 9.1 shows the apparatus Alex uses:

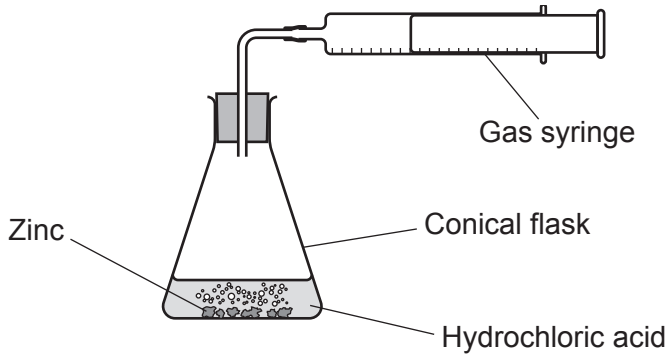

Fig. 9.1

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

Fig. 9.2 shows a graph of his results:

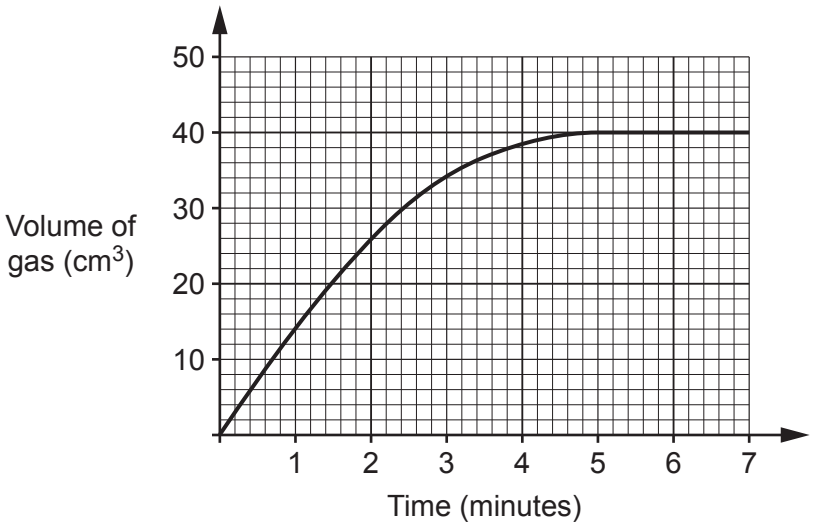

Fig. 9.2

(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. 9.2**.

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. 9.2**.

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. 9.3** shows Alex's results for **zinc**, **magnesium** and **iron**:

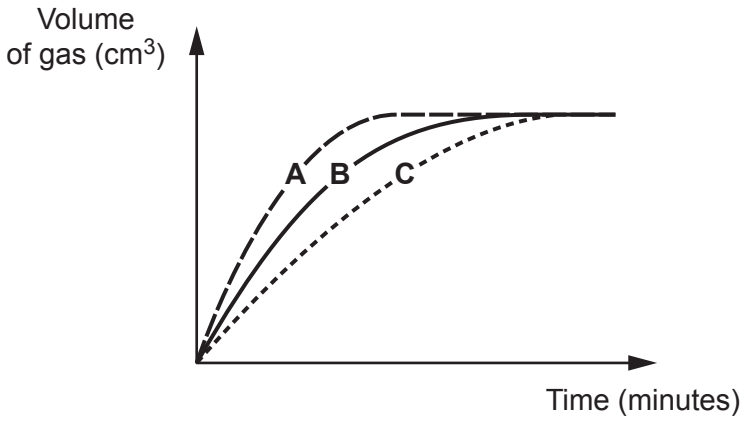

Fig. 9.3

Which metal makes each curve in **Fig. 9.3**?

Curve **A** .....

Curve **B** .....

Curve **C** .....

[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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