Oxford Cambridge and RSA

Tuesday 11 June 2024 – Morning

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

J258/02 Depth 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:
- a scientific or graphical calculator
- an HB pencil

F

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 page 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 **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

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

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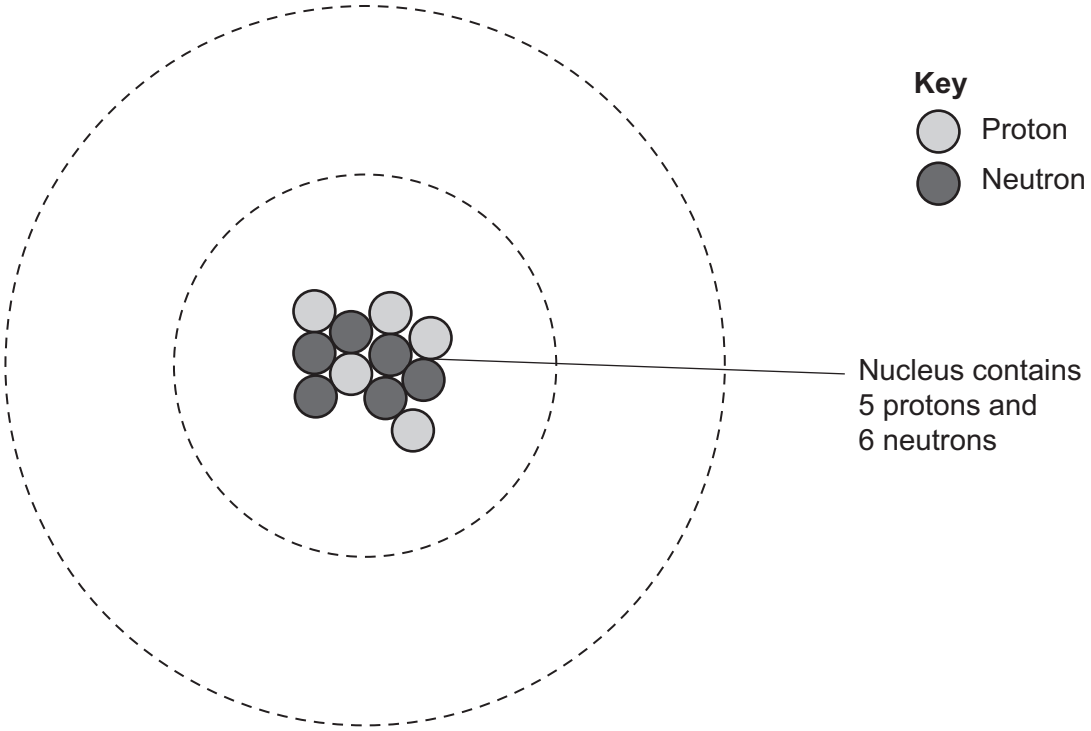
1 A student makes a model of an atom.

(a) The student uses small, coloured beads to represent the protons and neutrons in the nucleus of the model. This is shown in the diagram below.

Complete the diagram to show the correct arrangement of electrons in the atom.

Use **X** to represent each electron.



[2]

(b) Complete the sentences.

Use words from the list.

ions	**negative**	**neutral**	**neutrons**	**positive**	**protons**

Atoms contain a nucleus with a ..... charge.

The atomic number gives the number of ..... in an atom.

[2]

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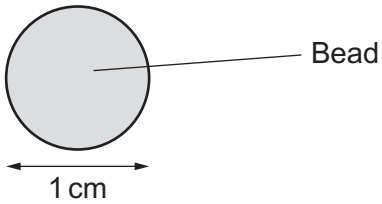
(c) The bead the student uses to represent a proton has a diameter of 1 cm.



The student finds out that an atom is 1×10^5 times larger than a proton.

If they make their model to scale, what is the diameter of the model atom?

Put a ring around the correct option.

100 cm **1000 cm** **10 000 cm** **100 000 cm**

[1]

(d) The student makes models of some other atoms.

The particles in each atom are shown in the table.

Atom	Number of protons	Number of neutrons	Electron arrangement
A	3	4	2.1
B	8	8	2.6
C	12	12	2.8.2

(i) Which atom, **A**, **B** or **C**, has the **highest** mass number?

Explain your answer.

Atom .....

Explanation .....

.....

[2]

(ii) The student uses the table to decide **A** is a metal atom.

The student is correct.

How does the student know?

Tick (✓) **one** box.

Atom **A** has one electron in the outer shell. ☐

Atom **A** has two electrons in the first shell. ☐

Atom **A** has two shells of electrons. ☐

[1]

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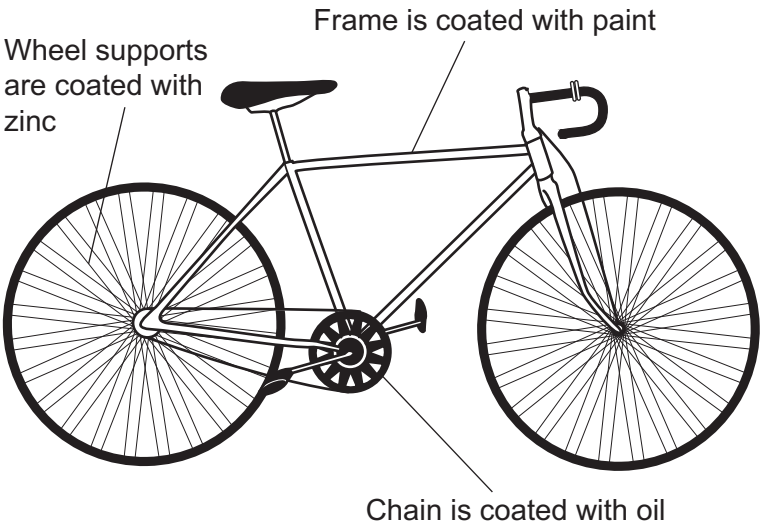
2 The parts used to make a bike contain mainly iron.

The diagram shows the methods to prevent corrosion that are used on some parts of a bike.



(a) Some methods to prevent corrosion work by forming a protective barrier. Some work by sacrificial protection.

Draw lines to connect each **coating** with **how the coating prevents corrosion** on the bike.

Coating	**How the coating prevents corrosion**
Oil	Forms a protective barrier.
Paint	Works by sacrificial protection.
Zinc	

[2]

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(b) Iron to make bikes is extracted from iron oxide.

During the extraction, iron oxide reacts with carbon monoxide to make iron.

When iron corrodes it reacts with oxygen to form iron oxide.

The equations show what happens in these two reactions.

Extraction: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Corrosion: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Explain the difference between oxidation and reduction.

Use examples from the equations in your answer.

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

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3 A scientist works in a laboratory that does research into medicines.

They use distilled water to make different formulations of medicines for testing.

(a) Which statements about formulations are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
Formulations are a mixture of substances.		
Formulations contain elements bonded together to make a single compound.		
The amount of each substance in a formulation is carefully controlled.		

[2]

(b) The scientist uses distilled water for their medicines.

They use simple distillation to distil tap water.

What changes happen during simple distillation?

Tick (✓) **two** boxes.

Condensation ☐

Dissolving ☐

Evaporation ☐

Melting ☐

Precipitation ☐

[2]

(c) Another worker says that tap water is already pure because it has been treated to kill bacteria.

Explain why tap water is **not** a pure substance.

.....

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

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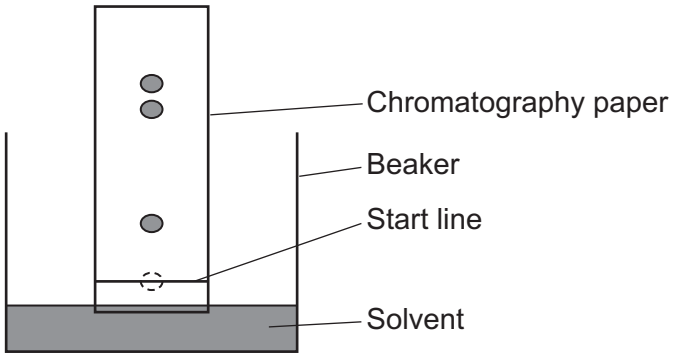
(d) The scientist uses paper chromatography to separate the substances in one of their medicines.

The diagram shows their results.



Complete the sentences to explain why the substances in the medicine separate during chromatography.

Put a (ring) around the correct options.

The substances in the medicine move up because they dissolve in the **start line** / **solvent**.

The chromatography paper acts as the **stationary** / **mobile** phase.

The distance travelled by each substance depends on its **Rf value** / **melting point**.

[2]

(e) The scientist measures the melting point of some of the substances they use to make medicines.

The table below shows their results.

Substance	Melting point (°C)
A	102
B	151–156
C	2032
D	1040–1056

Which **two** substances are pure?

Explain your reasoning.

Pure substances .....

Explanation .....

.....

[2]

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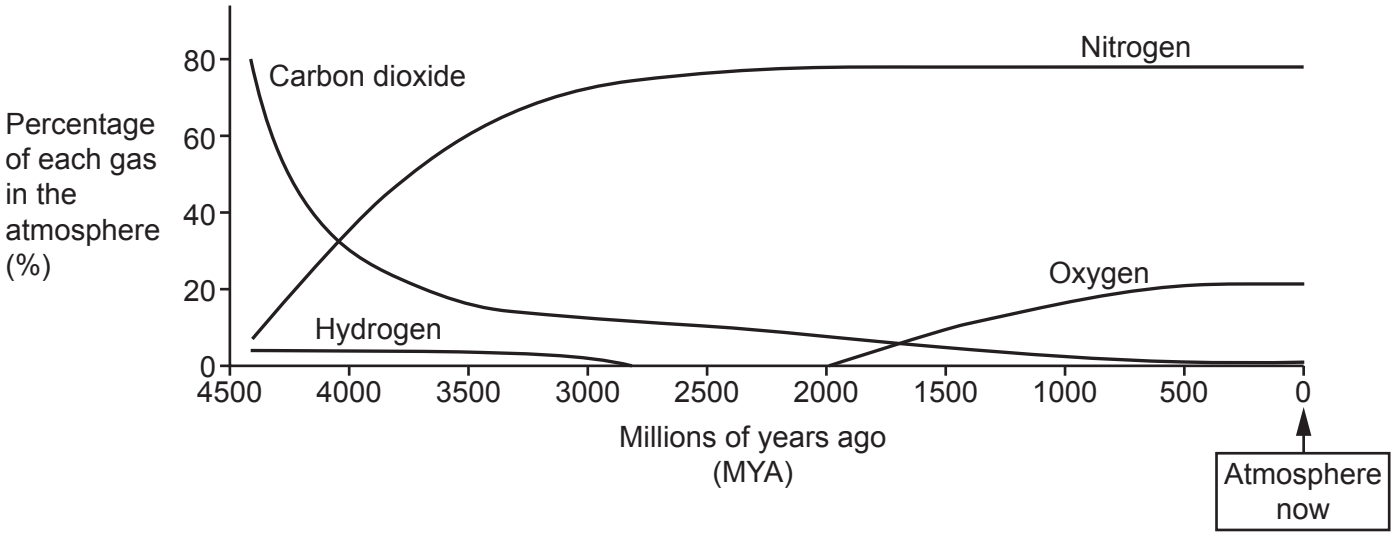
4 The graph shows how the percentages of some gases in the atmosphere have changed from 4400 million years ago (MYA) until now.



(a) Use the graph to predict when living things that photosynthesise first appeared on Earth.

Explain your reasoning.

Living things that photosynthesise appeared ..... MYA.

Explanation .....

.....

.....

.....

[3]

(b) Which statements about the graph are **true**?

Tick (✓) **two** boxes.

All of the hydrogen left the atmosphere over 3000 MYA. ☐

The percentage of carbon dioxide has decreased at the same rate for over 4000 million years. ☐

The percentages of gases in the atmosphere have stayed approximately constant for the last 500 million years. ☐

The percentage of nitrogen in the atmosphere today is similar to the percentage of carbon dioxide in the atmosphere 4400 MYA. ☐

[2]

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(c) Scientists think that the Earth's early atmosphere came from volcanoes.

The table shows the percentage composition of gases from a volcano and in the Earth's atmosphere 4400 MYA.

Gas	**Percentage composition**	
	Volcano gas	**Earth's atmosphere 4400 MYA**
Water vapour	92%	5%
Carbon dioxide	4.6%	80%
Hydrogen	0.5%	4%

(i) Scientists think that water vapour from volcanoes turned into liquid water over 4000 MYA and formed the Earth's oceans.

What does this suggest about the temperature of the Earth at that time?

Explain your reasoning.

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.....

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

(ii) Which of these statements support the idea that the Earth's atmosphere came from volcanoes?

Use the data in the table and the graph.

Tick (✓) **two** boxes.

Hydrogen comes from volcanoes and was in the Earth's atmosphere 4400 MYA. ☐

There was more water vapour in the Earth's atmosphere 4400 MYA than in volcano gas. ☐

The Earth's atmosphere 4400 MYA and volcano gases both contain carbon dioxide. ☐

The percentages of gases in the Earth's atmosphere 4400 MYA are not the same as today. ☐

[2]

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5

(a) Ammonium sulfate is made in an industrial process for use as a fertiliser.

In this process, aqueous ammonium carbonate reacts with **excess** solid calcium sulfate to make aqueous ammonium sulfate and a solid by-product.

ammonium carbonate	+	calcium sulfate	→	ammonium sulfate	+	a by-product
$(NH_4)_2CO_3(aq)$	+	$CaSO_4(s)$	→	$(NH_4)_2SO_4(aq)$	+	$CaCO_3(s)$

(i) Which method can be used to separate aqueous ammonium sulfate from the mixture left at the end of the reaction.

Put a ring around the correct option.

Distillation **Evaporation** **Filtration** **Titration**

[1]

(ii) Explain the difference between what happens to by-products and waste products from industrial processes.

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

(b) Ammonium sulfate can also be made in a laboratory by reacting ammonia with a dilute acid:

ammonia + dilute acid → ammonium sulfate

Which dilute acid reacts with ammonia to make ammonium sulfate?

Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Phosphoric acid ☐

Sulfuric acid ☐

[1]

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(c) Chemicals are usually made in industry in continuous processes.

Chemicals are usually made in the laboratory in batches.

(i) State **one** advantage of using continuous processes in industry.

.....

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

(ii) State **one** advantage of making chemicals in the laboratory in batches.

.....

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

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6

(a)* A student has samples of two solid compounds.

They think that one compound contains copper and that the other compound contains calcium.

They decide to do a flame test on each compound.

They also decide to make a solution of each compound to do a test using dilute sodium hydroxide.

Describe how the student should do their flame test and their test using dilute sodium hydroxide.

State the results they should expect for a copper compound and a calcium compound.

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..... **[6]**

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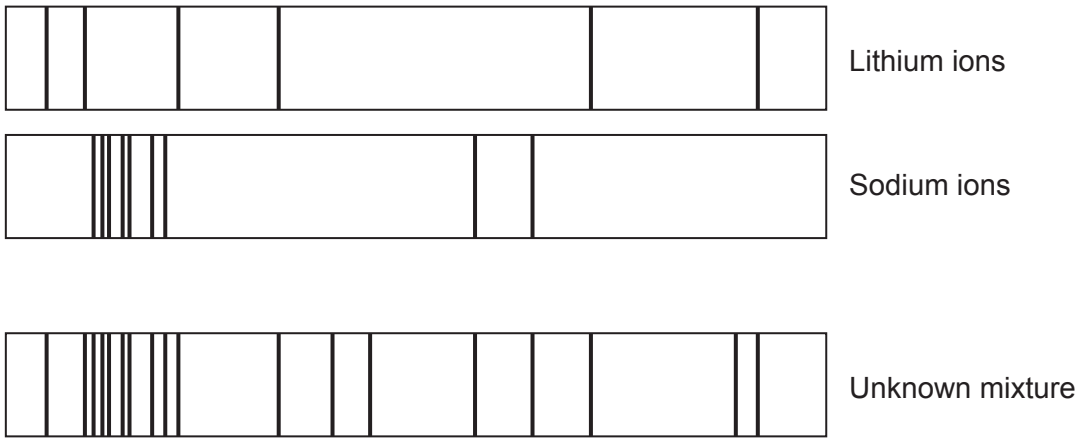
(b) The student uses an emission spectroscopy machine to find out the metal ions in some other compounds.

They test a compound that contains lithium ions and a compound that contains sodium ions.

They then test an unknown mixture.

The diagram shows the results of the emission spectrum for each of the substances they test.



(i) Which statements about the unknown mixture are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
The unknown mixture contains both lithium ions and sodium ions.		
The information in the diagram is not enough to identify all the ions in the unknown mixture.		
The results show that the unknown mixture contains more than five different ions.		

[2]

(ii) Which statement about using tests to identify ions is **true**?

Tick (✓) **one** box.

Emission spectroscopy relies on human judgement of colours. ☐

Emission spectroscopy is more sensitive than chemical tests. ☐

Ions cannot be identified using chemical tests alone. ☐

Reactions used in chemical tests are very slow. ☐

[1]

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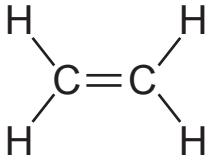
7 Ethene is a monomer used to make poly(ethene).

Fig. 7.1 shows the structure of ethene.

Fig. 7.1



The reaction of ethene to make poly(ethene) is addition polymerisation.

(a) **Draw** the structure of a section of poly(ethene) formed from **three** ethene monomers.

[2]

(b)
(i) 12 000 ethene monomers join together to make a poly(ethene) molecule.

Calculate the number of carbon and hydrogen atoms in this poly(ethene) molecule.

Number of carbon atoms = ...

Number of hydrogen atoms = ...
[2]

(ii) Another poly(ethene) molecule forms when 10 000 ethene monomers join together.

Calculate the relative formula mass of this poly(ethene) molecule.

Use the Periodic Table to help you.

Relative formula mass = ... **[2]**

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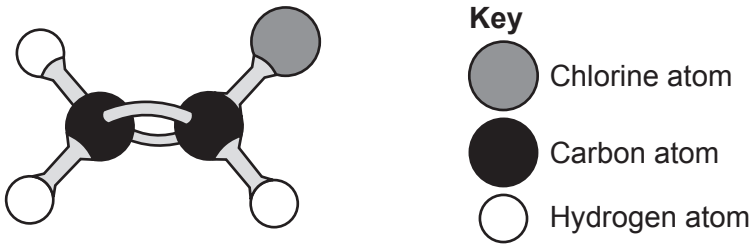
(c) Chloroethene is another monomer that forms an addition polymer.

Fig. 7.2 shows a three-dimensional model of a chloroethene monomer.

Fig. 7.2



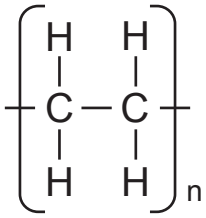
(i) The molecular formula of ethene is C_2H_4.

Write the molecular formula of chloroethene.

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

(ii) **Fig. 7.3** shows the structure of the repeating unit of **poly(ethene)**.

Fig. 7.3



Draw the structure of the repeating unit of **poly(chloroethene)**.

[2]

(d)
(i) Explain why ethene is considered to be an alkene and chloroethene is **not** an alkene.

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

(ii) Use ideas about functional groups to explain why both ethene and chloroethene can form addition polymers.

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

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8* A student does some experiments to find out the order of reactivity of some metals.

They add the same size pieces of five different metals to separate samples of water and record the time taken to make 10 cm^3 gas.

They stop timing after 5 minutes if 10 cm^3 gas have not been made.

They repeat their experiments for some of the metals but this time they use a dilute acid instead of water.

The table shows their results.

Metal	**Time taken to make 10 cm^3 gas (s)**	
	When added to water	**When added to dilute acid**
Calcium	35	did not test
Magnesium	small amount of gas collected after 5 minutes	20
Iron	no gas collected after 5 minutes	190
Zinc	no gas collected after 5 minutes	50
Sodium	15	did not test

Use the information to put the metals in order of reactivity from most reactive to least reactive.

Explain your reasoning.

Include in your answer:

- how you used the information in the table to work out the order of reactivity
- why the student did not test all of the metals with dilute acid.

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..... **[6]**

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9

(a) **Table 9.1** shows the formulae and boiling points of some alkanes.

Table 9.1

Alkane	Formula	Number of carbon atoms in formula	Boiling point (°C)
Pentane	C_5H_{12}	5	36
Hexane	C_6H_{14}	6	69
Octane	C_8H_{18}	8	125
Nonane	C_9H_{20}	9	151

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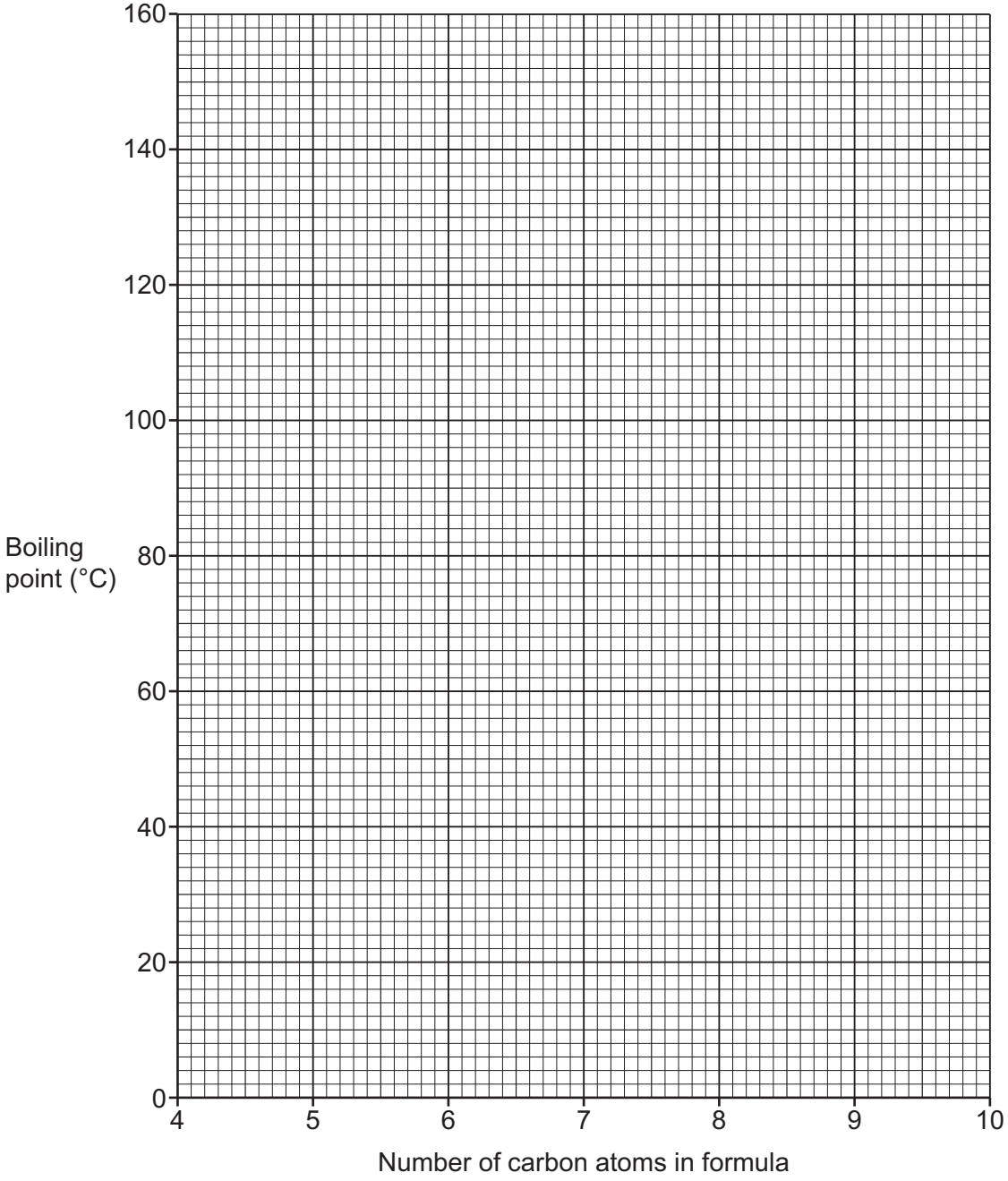
(i) Use the data in **Table 9.1** to complete the graph.

You need to:
- plot the boiling point of each alkane
- draw a line of best fit.



[3]

(ii) Use your graph to predict the boiling point of heptane, C_7H_{16}.

Show your working on the graph.

Boiling point of heptane = ... °C **[2]**

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(b) The empirical formula of an alkane is the simplest ratio of hydrogen atoms to carbon atoms.

Table 9.2 shows the molecular formula and empirical formula of some alkanes.

Complete **Table 9.2** by filling in the empirical formula for butane.

Table 9.2

Alkane	Molecular formula	Empirical formula
Ethane	C_2H_6	CH_3
Propane	C_3H_8	C_3H_8
Butane	C_4H_{10}	.....

[1]

(c) Alkanes come from crude oil.

Why is crude oil important to modern life?

Tick (✓) **two** boxes.

Chemicals in crude oil have different boiling points. ☐

Crude oil contains molecules with single bonds. ☐

Crude oil is a feedstock for the petrochemical industry. ☐

Crude oil is a main source of hydrocarbons. ☐

[2]

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Turn over for the next question

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10 Millions of tonnes of carbon dioxide (CO_2) are added to the air in the UK every year.

Carbon dioxide is produced when fossil fuels are burned in power stations to generate electricity.

(a) Schemes are being developed to remove carbon dioxide from power station waste gases. These schemes add to the cost of electricity.

Explain why it is important to remove carbon dioxide, despite the cost.

Use ideas of risk and benefit.

.....

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

(b) The UK government says that the mass of carbon dioxide added to the air during the year 2020 decreased by 400 million tonnes compared to 1990. This is a decrease of 49%.

Calculate the mass of carbon dioxide added to the air during 1990.

Use the formula: $\text{percentage decrease} = \dfrac{\text{decrease in mass}}{\text{mass added to the air during 1990}} \times 100$

Mass added to the air during 1990 = ... million tonnes **[3]**

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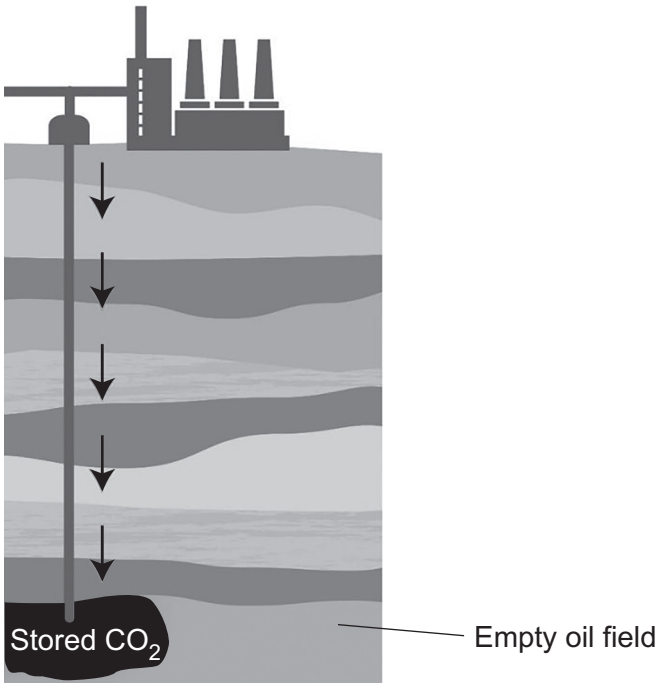
(c) Scientists are developing a new scheme to remove carbon dioxide from the air and store it in empty oil fields.



Scientists make two predictions:

1. Burning fossil fuels in the UK will add 230 million tonnes of carbon dioxide to the air each year.

2. There is enough space in UK oil fields to store all this carbon dioxide for at least the next 100 years.

(i) Which is the best estimate of the amount of carbon dioxide that can be stored in UK oil fields?

Tick (✓) **one** box.

$< 2.3 \times 10^3$ million tonnes ☐

$> 2.3 \times 10^4$ million tonnes ☐

$< 2.3 \times 10^6$ million tonnes ☐

$> 2.3 \times 10^6$ million tonnes ☐

[1]

(ii) The demand for energy for electricity is one factor that affects the amount of fossil fuels we burn.

State **one other** factor that affects the amount of fossil fuels we burn.

.....

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

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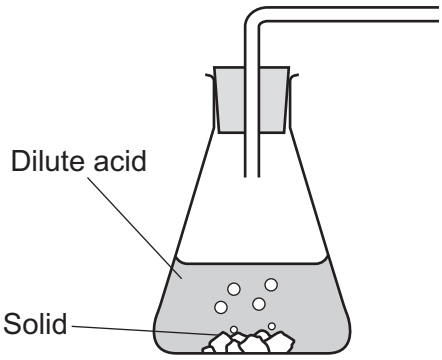
11 A student investigates the rate of reaction when a solid reacts with a dilute acid.

(a) The reaction makes a gas.

The student collects the gas in a measuring cylinder over water.

(i) **Complete** the diagram to show how the student sets up their measuring cylinder to collect the gas over water.

Include labels on your diagram.



[3]

(ii) The student finds it difficult to measure the volume accurately in the measuring cylinder.

Suggest another method they could use to get more accurate readings.

.....

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

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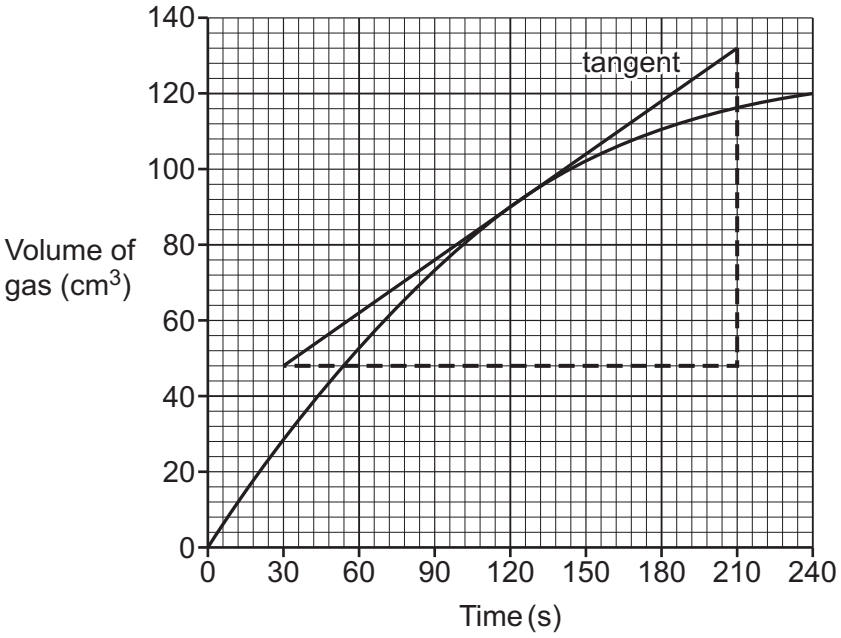
(b) The student plots a graph of their results.

The student draws a tangent to the curve at the point where time = 120 s.



(i) Calculate the gradient of the tangent shown on the graph.

Gradient = ... cm^3/s **[3]**

(ii) What information does your answer to **(i)** give about the reaction?

Tick (✓) **one** box.

The increase in volume and time at 180 s. ☐

The rate of reaction at 120 s. ☐

The time taken to make 90 cm^3 gas. ☐

The volume of gas made in the first minute of the reaction. ☐

[1]

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(c) The student repeats their experiment using different conditions.

The rate of the reaction increases each time.

Draw lines to connect each **change in condition** with its correct **explanation** for the increase in rate.

Change in condition	**Explanation**
Increased concentration of acid	Frequency of particle collision increases because surface area increases.
Increased temperature	Frequency of particle collision increases because particles are closer together.
Smaller pieces of solid	More particle collisions are successful because the energy of the particles increases.

[2]

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

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