OCR
Oxford Cambridge and RSA

Monday 19 May 2025 – Morning

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

J258/03 Breadth in Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

H

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

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.

1 A student investigates rate of reaction.

(a) The student does three experiments adding limestone to dilute hydrochloric acid.

In all three experiments, the student keeps these the same:

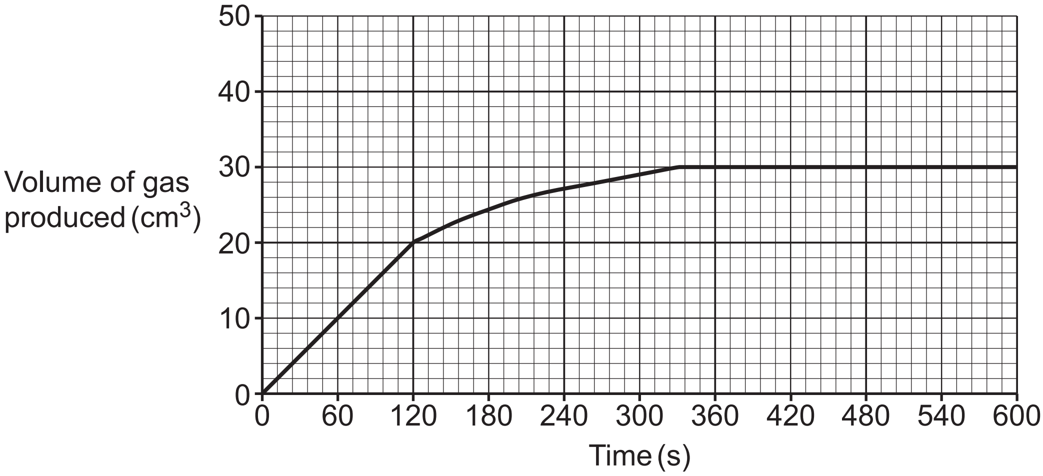
- the mass of limestone
- the volume of acid
- the concentration of acid.

In experiment 1 the student adds **one** large piece of limestone to the acid at 20 °C.

The student measures the volume of gas produced every 30 seconds.

Fig. 1.1 shows the results of experiment 1.

Fig. 1.1



Calculate the rate of reaction during the first 120 seconds.

Use **Fig. 1.1**.

Give your answer to **2** decimal places.

Rate of reaction = ... cm^3/s **[3]**

(b) **Table 1.1** shows the conditions used for all three experiments.

Table 1.1

	Type of limestone	Temperature (°C)
Experiment 1	Large piece	20
Experiment 2	Large piece	40
Experiment 3	Powder	40

(i) Draw a line on **Fig. 1.1** to show the expected results for experiment 2.

Use the information in **Table 1.1** to help you. **[2]**

(ii) Experiment 3 is the **fastest**.

Explain why.

Use the information in **Table 1.1**.

Include ideas about collisions in your answer.

....

....

....

.... **[2]**

(c) A scientist investigates the effect of four metals, **A**, **B**, **C** and **D**, on the rate of reaction to make ethane.

The scientist uses 5.0 g of each metal.

Table 1.2 shows their results.

Table 1.2

Metal	Mass of metal at end of reaction (g)	Time taken to make 10 g of ethane (s)
A	2.5	25
B	0.0	30
C	5.0	40
D	5.0	25

(i) Which metal **A**, **B**, **C** or **D** is the best metal to use as a catalyst in this reaction?

Explain your reasoning.

Use the information in **Table 1.2**.

Metal ....

Explanation ....

....

....
[2]

(ii) Which statements about catalysts are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
A catalyst changes the overall energy change for a reaction.		
A catalyst lowers the activation energy of a reaction.		
A catalyst provides an alternative route for a reaction.		

[2]

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Turn over for the next question

2 Atoms contain protons, neutrons and electrons.

(a) The table shows the relative masses and relative charges of protons, neutrons and electrons.

Complete the table by filling in the blanks.

Particle	Relative mass	Relative charge
....	1	....
....	....	0
Electron	0.0005	–1

[2]

(b) **Fig. 2.1** shows information about fluorine.

Fig. 2.1

9
F
Fluorine
19.00

Find the number of protons, neutrons and electrons in an atom of fluorine.

Protons = ...

Neutrons = ...

Electrons = ...

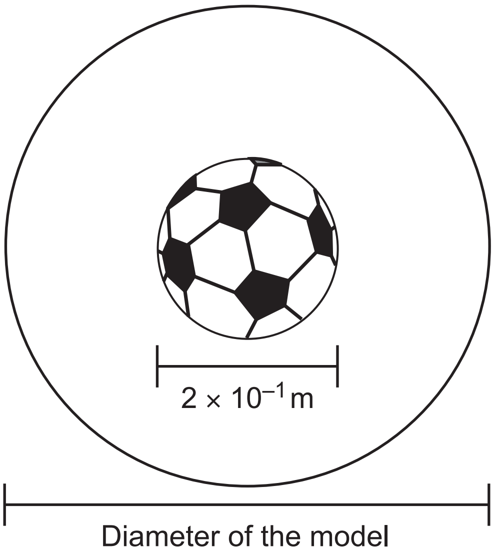
[3]

(c) The size and scale of atoms can be compared to objects in the physical world.

A student builds a model of a hydrogen atom using a football to represent the nucleus.

Fig. 2.2 shows their model.

Fig. 2.2



The diameter of the football is 2×10^{-1} m.

The diameter of a hydrogen atom is 5×10^{4} times bigger than its nucleus.

Calculate the diameter of the model of the hydrogen atom.

Give your answer in **standard form** in **metres**.

Diameter = ... m **[2]**

3

(a) Iron reacts with oxygen in the presence of water to form hydrated iron oxide (rust).

(i) Complete the **balanced symbol** equation for the reaction.

$$4Fe(s) + 3..........(g) \rightarrow .... Fe_2O_3(s)$$

[2]

(ii) This reaction can be called rusting.

What is another name for this reaction?

.... **[1]**

(b) Rusting can be prevented by sacrificial protection.

(i) Explain why zinc can be used as sacrificial protection for iron.

....

....

....

.... **[2]**

(ii) Which **half** equation shows the oxidation of zinc?

Tick (✓) **one** box.

$Zn \rightarrow Zn^{2+} + 2e^-$ ☐

$Zn \rightarrow Zn^{2+} + e^-$ ☐

$Zn^{2+} + e^- \rightarrow Zn$ ☐

$Zn^{2+} + 2e^- \rightarrow Zn$ ☐

[1]

(iii) What is meant by the term reduction?

....

.... **[1]**

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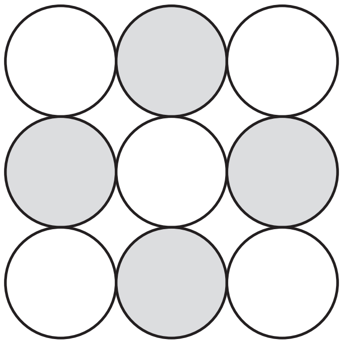
4 Potassium bromide, KBr, is an ionic compound.

Potassium bromide is an example of a giant ionic lattice.

(a) The diagram shows a **2D model** for the arrangement of ions in potassium bromide.



(i) Complete the diagram by writing the correct charge onto each ion.

[2]

(ii) State **one** limitation of the model of potassium bromide shown in the diagram.

....

.... **[1]**

(iii) Which statements about the bonds in potassium bromide are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
A bromine atom gains an electron to form a positive ion.		
A potassium atom loses an electron to form a positive ion.		
Potassium bromide is held together by a sea of delocalised electrons.		
Strong electrostatic forces of attraction hold ions together.		

[3]

(b) The properties of potassium bromide can be explained in terms of the behaviour of its ions.

Draw lines to connect each **property** with its correct **explanation**.

Property	**Explanation**
High melting point	Ions are arranged in a regular lattice
Forms crystals	Ions are free to move
Conducts electricity when molten	Oppositely charged ions are strongly attracted to each other

[2]

5 The Periodic Table arranges the elements into groups.

(a) Group 1 of the Periodic Table contains reactive metals.

(i) Which statement about Group 1 metals is **true**?

Tick (✓) **one** box.

Group 1 metals are hard.	☐
Potassium is the most reactive Group 1 metal.	☐
Reactivity increases down the group.	☐

[1]

(ii) Sodium is a Group 1 metal.

Sodium reacts with water, moist air and chlorine.

Draw lines to connect each **reaction** with its correct **observation**.

Reaction	**Observation**
Heated with chlorine	Burns with a bright yellow flame
Left in moist air	Fizzes
Put in cold water	Forms a white coating

[2]

(iii) Caesium reacts with water to make hydrogen and one other product.

Complete the **word** equation for the reaction.

caesium + water → hydrogen + ... **[1]**

(b) The table shows information about some Group 7 elements.

Element	Melting point (°C)	Boiling point (°C)	State at room temperature
Fluorine	–220	–188	Gas
Chlorine	–102	–35	Gas
Bromine	–7	59	Liquid
Iodine	114	184	Solid

Explain the trend in boiling point of the Group 7 elements.

Use ideas about intermolecular forces.

....

....

....

....

....

.... **[3]**

(c) Chlorine displaces bromine from its compounds.

(i) Describe an experiment to show that this statement is **true**.

Include in your answer:
- the names and physical state of each reactant
- the observation you expect.

....

....

....

.... **[2]**

(ii) Aqueous chlorine is corrosive.

State **one** safety precaution that can be taken when handling aqueous chlorine.

.... **[1]**

6 The Earth, including its atmosphere and its oceans, is made up from elements and compounds in different states.

(a) The particle model can be used to describe the states of these substances and what happens to the particles when they change state.

(i) Water, H_2O, can be present on earth as a solid, liquid or gas.

Explain the changes in the movement and arrangement of particles when water changes from liquid to solid.

....

....

....

....

....

.... **[3]**

(ii) State **one** limitation of the particle model.

....

.... **[1]**

(b) The greenhouse effect is an essential process for maintaining life on earth.

Carbon dioxide and methane cause the greenhouse effect.

(i) Which statements about greenhouse gases are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	**False**
They absorb infrared radiation from the Earth.		
They come only from anthropogenic sources.		
They emit radiation in all directions.		
They prevent all radiation from the Sun passing through the atmosphere.		

[3]

(ii) Increased carbon dioxide and methane cause climate change.

State **two** possible consequences of climate change.

1 ....

....

2 ....

....

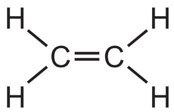
[2]

7 Polymers are long chain molecules.

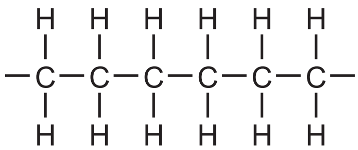
(a) Ethene is a monomer that is used to make an addition polymer.

Fig. 7.1 shows a molecule of ethene.

Fig. 7.1



(i) The table shows the addition polymer formed from ethene.

Addition polymer formed from ethene	**Repeating unit of addition polymer formed from ethene**
	[ ]

Complete the table to show the repeating unit of the addition polymer. **[2]**

(ii) Suggest the name of the addition polymer shown in the table.

.... **[1]**

(b) Describe what happens when an addition polymer forms from its monomers.

....

....

....

.... **[2]**

(c) Some synthetic polymers are condensation polymers.

Which statements about condensation polymers are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
Condensation polymers contain repeating units.		
Condensation polymers form from monomers that contain two functional groups.		
Some condensation polymers are hydrocarbons.		
The polymer is the only product in a condensation polymerisation reaction.		

[3]

8 A student investigates the law of conservation of mass.

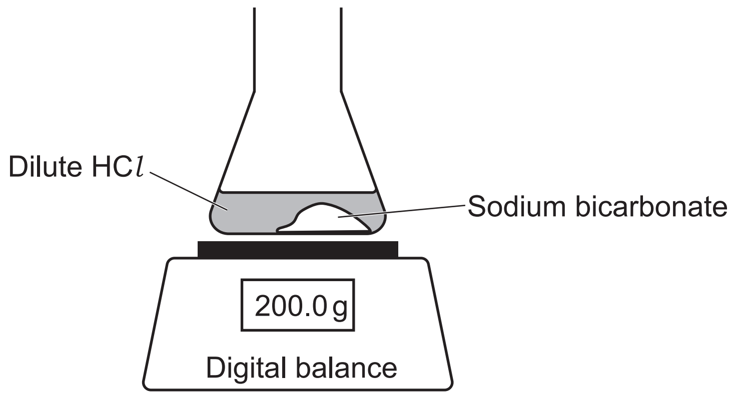
(a) In one experiment, the student reacts sodium bicarbonate with dilute hydrochloric acid.

The equation shows the reaction.

$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

Fig. 8.1 shows the apparatus the student uses at the start of the experiment.

Fig. 8.1



The mass of the flask and contents at the start of the experiment is 200.0 g.

(i) The student uses 40.0 g of dilute hydrochloric acid.
The empty conical flask weighs 150.0 g.

Calculate the number of moles of sodium bicarbonate the student adds to the flask at the start of the reaction.

Number of moles = ... **[4]**

(ii) The student also measures the mass of the flask and contents at the end of the reaction.

The table shows their results.

Mass of flask and contents at **start** of reaction (g)	200.0
Mass of flask and contents at **end** of reaction (g)	194.8

The student says that the law of conservation of mass does **not** apply to this experiment.

Explain why the student thinks this **and** why the student is **not** correct.

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.... **[3]**

(b) In another experiment the student reacts copper oxide with dilute hydrochloric acid.

$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

The mass of the flask and contents at the start of the reaction is 250.0 g.

(i) Predict the mass of the flask and contents at the end of the reaction.

Explain your reasoning.

Mass = ... g

Explanation ....

....

....
[2]

(ii) Complete the sentences to describe the reactants at the end of a reaction.

A reaction ends when one of the reactants is used up.

The reactant that is used up is called the .... reactant.

The reactant that is left over is described as being in ....
[2]

9 Qualitative analysis can be used to identify the elements in compounds.

(a) A student does a flame test on some unknown samples.

The table shows their results.

Sample	**Flame Colour**
A	bright red
B	bright yellow
C	lilac
D	blue-green

(i) Describe the method for using a flame test to identify metal ions.

....

....

....

....

....

.... **[3]**

(ii) The student says:

"Sample D contains **sodium** metal ions."

They are **not** correct.

Explain why.

....

.... **[1]**

(iii) Name the metal ion in Sample D.

....

.... **[1]**

(b) In qualitative analysis, chemists make sure that a sample is **representative**.

Describe the purpose of representative sampling in qualitative analysis.

....

....

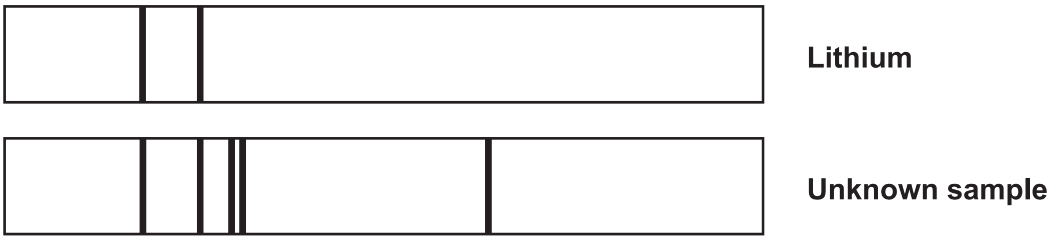
....

.... **[1]**

(c) Emission spectroscopy is an instrumental method of analysis.

Fig. 9.1 shows the spectrum for lithium and the spectrum for an unknown sample.

Fig. 9.1



(i) What conclusions can be made about the ions in the unknown sample?

Explain your reasoning.

Use **Fig. 9.1**.

....

....

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....

.... **[3]**

(ii) State **two** advantages of instrumental methods of analysis rather than flame tests to identify the ions in unknown samples.

1 ....

....

2 ....

.... **[2]**

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10 Acids react with hydroxides and metals to produce salts.

(a) A student uses a titration experiment to investigate the volume of dilute hydrochloric acid that reacts with aqueous sodium hydroxide.

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

$HCl + NaOH \rightarrow$ .... + ...

[2]

(ii) The student uses phenolphthalein indicator.

They complete the titration four times.

The table shows their results.

Titration number	**1**	**2**	**3**	**4**
Volume of acid used in each titration (cm^3)	30.0	28.9	29.1	29.7

The student thinks the data in the table is **not** accurate.

Describe **one** change the student can make to their titration experiment to make the data more accurate.

.... **[1]**

(iii) The salt formed in the reaction is **soluble** in water.

Suggest **one** way to prepare pure dry crystals of the salt produced in the titration.

....

.... **[1]**

(b) Hydrochloric acid is a **strong** acid.

(i) Which **two** statements about strong acids are **true**?

Tick (✓) **two** boxes.

Strong acids contain only covalent bonds. ☐

Strong acids have a pH <7. ☐

Strong acids have OH^- ions. ☐

Strong acids ionise completely. ☐

[1]

(ii) An acid with a pH of 1 has a hydrogen ion concentration of 0.1 mol / dm^3.

What is the pH of a solution with a hydrogen ion concentration of 0.0001 mol / dm^3?

.... **[1]**

(c) A student measures the reaction time when magnesium reacts with two different acids, dilute hydrochloric acid and a dilute weak acid.

The student keeps the same mass of magnesium and the same volume and concentration of acid in each reaction.

They record the time it takes for the magnesium to disappear.

The reaction with dilute hydrochloric acid finishes after 25 seconds.

Predict the reaction time with the dilute weak acid.

Explain your answer using ideas about hydrogen ions.

Reaction time with the dilute weak acid = ... s

Explanation ....

....

....

....
[2]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.