OCR
Oxford Cambridge and RSA

Friday 17 May 2024 – 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

H

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 **24** pages.

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

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1 Fertilisers are used to increase the growth of plants.

They are added to soil to provide essential plant nutrient elements.

(a) Nitrogen is one essential plant nutrient element.

Name **two other** essential plant nutrient elements.

1 .....

2 .....
[2]

(b)
(i) State **one** disadvantage of the over-use of synthetic fertilisers.

.....

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

(ii) Suggest why farmers still use synthetic fertilisers despite their disadvantages.

.....

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

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(c) An example of a synthetic fertiliser is ammonium nitrate, NH_4NO_3.

Ammonium nitrate is produced when ammonium hydroxide, NH_4OH, reacts with nitric acid, HNO_3.

$NH_4OH(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq) + H_2O(l)$

The relative formula masses for the reactants and products are shown in the table.

	NH_4OH	**HNO_3**	**NH_4NO_3**	**H_2O**
Relative formula mass	35.0	63.0	80.0	18.0

Calculate the atom economy for the formation of NH_4NO_3.

Use the equation:

$$\text{atom economy} = \frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}} \times 100\%$$

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

Atom economy = ... % **[4]**

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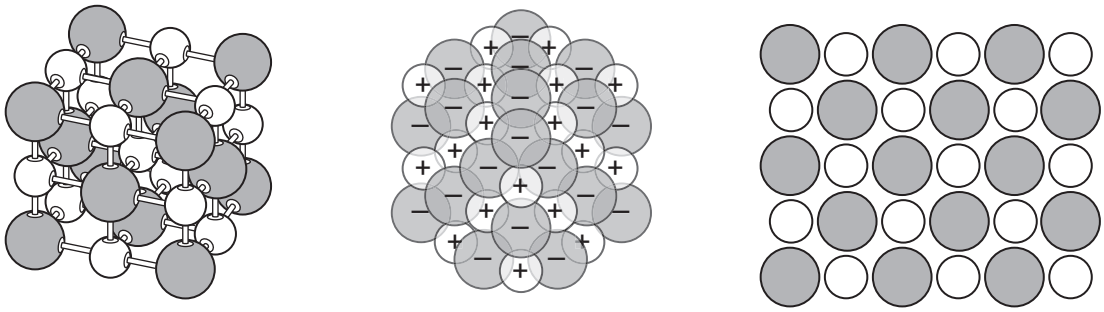
2 Sodium chloride is an ionic compound.

(a) **Fig. 2.1** shows three models of the arrangement of ions in sodium chloride.

Fig. 2.1



Model A **Model B** **Model C**

(i) Describe the attraction between ions in sodium chloride.

.....

.....

.....

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

(ii) Which **two** statements about the limitations of the models in **Fig. 2.1** are **true**?

Tick (✓) **two** boxes.

Model A does **not** show the relative sizes of the ions. ☐

Model C does **not** show the 3-D arrangement of ions. ☐

None of the models show that sodium chloride is a compound containing two elements. ☐

Only one model shows that a chloride ion is an anion. ☐

[2]

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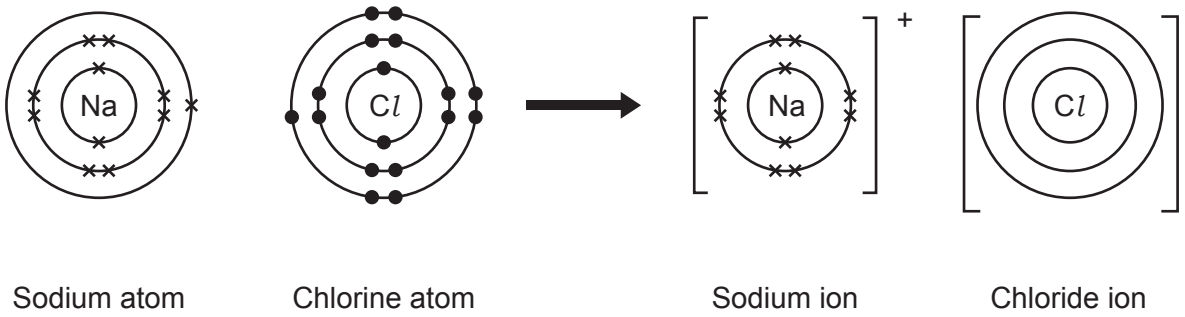
(iii) **Fig. 2.2** shows the dot and cross diagram for sodium chloride.

Complete Fig. 2.2 to show the structure and charge of the chloride ion.

Fig. 2.2



[2]

(b) How does the arrangement of electrons in atoms of sodium and chlorine relate to their group and period in the Periodic Table?

.....

.....

.....

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

(c) An atom of sodium has an atomic number of 11 and a mass number of 23.

State the number of protons, neutrons and electrons in a sodium atom.

Number of protons = ...

Number of neutrons = ...

Number of electrons = ...

[2]

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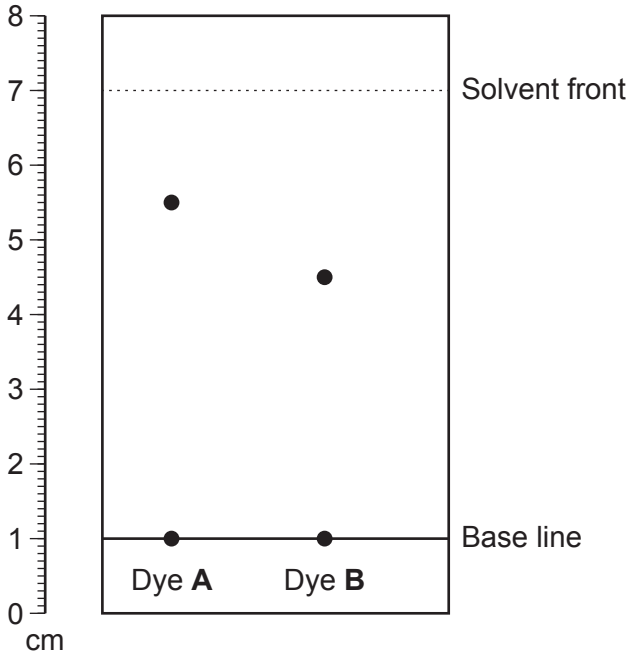
3 A student uses paper chromatography to check the purity of two dyes used to make coloured plastics.

The diagram shows a chromatogram for the two dyes.



(a) Explain why hexane rather than water must be used as the solvent for these dyes.

.....

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

(b) Calculate the Rf value of dye **B**.

Give the answer to an appropriate number of significant figures.

Rf value = ... **[4]**

(c) The student wants to check that there are no colourless substances in the dyes.

What must be sprayed onto the chromatogram so any colourless substances can be seen?

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

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4 Chloride ions, bromide ions and iodide ions are halide ions.

A student tests three solutions, A, B, and C, to find out whether they contain halide ions.

The student adds acidified dilute silver nitrate to the three solutions.

The table below shows their results.

Solution	Observation after adding acidified dilute silver nitrate
A	White precipitate
B	No precipitate
C	Yellow precipitate

(a) What conclusions can the student make about the ions present in each solution?

Solution A .....

.....

Solution B .....

.....

Solution C .....

.....

[3]

(b) Complete the **word** equation and **ionic** equation for the reaction between solutions of silver ions and bromide ions.

You need to:

- add the name and the formula for the product
- add the missing state symbols.

silver ions + bromide ions → .....

Ag^{+}(.....) + Br^{-}(.....) → .....(s)

[3]

(c) Before the tests, silver nitrate solution is acidified by adding a dilute acid.

Explain why dilute hydrochloric acid is **not** a suitable acid to use to acidify the silver nitrate solution.

.....

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

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5 Some metals can be extracted from their ores using electrolysis.

(a) Copper can be extracted from an aqueous solution of copper sulphate using electrolysis with inert electrodes.

The table shows some information about the changes during this electrolysis.

	Cathode	**Anode**
Ions attracted	Cu^{2+}, H^+	SO_4^{2-}, OH^-
Products formed	Copper	Oxygen and water
Half equation	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	

(i) Write the **balanced half** equation for the formation of oxygen gas and water from OH^- ions at the anode.

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

(ii) Why is the formation of copper from copper ions a reduction reaction?

.....

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

(iii) Explain why copper and not hydrogen is formed at the cathode.

.....

.....

.....

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

(iv) Describe **one** observation that can be seen as the electrolysis proceeds.

.....

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

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(b) Aluminium is extracted from aluminium oxide by electrolysis.

Oxygen is also made in this process.

(i) Complete the **balanced symbol** equation for the electrolysis of aluminium oxide.

$$.....Al_2O_3 \rightarrow .....Al + ...O_2$$

[2]

(ii) Which **two** statements explain why the industrial electrolysis of aluminium oxide is very expensive?

Tick (✓) **two** boxes.

A high temperature is needed for the process. ☐

Electrolysis uses a large amount of energy. ☐

Oxygen is a by-product of the reaction. ☐

The demand for aluminium is very high. ☐

The process must be done quickly. ☐

[2]

(iii) Describe a test to identify oxygen.

.....

.....

.....

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

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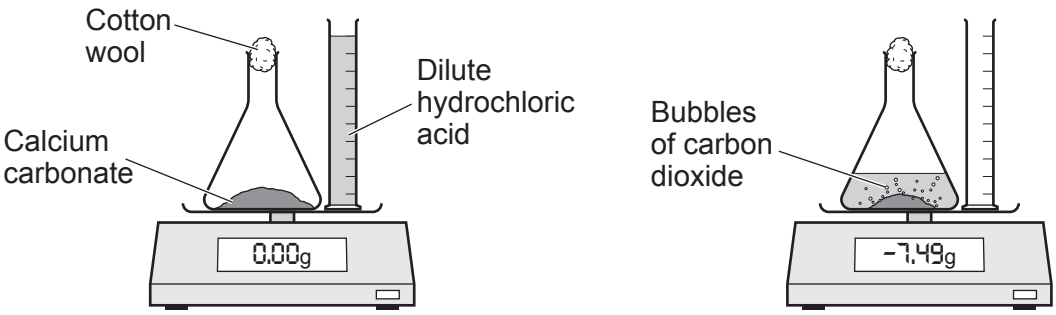
6 A student adds dilute hydrochloric acid to calcium carbonate to form calcium chloride, water and carbon dioxide.

The diagram shows how the student measures the mass before and during the reaction.



Before reaction **During reaction**

(a) The equation for the reaction of calcium carbonate with dilute hydrochloric acid is:

$CaCO_3(s) + 2HCl(aq) \rightarrow \mathbf{X}(aq) + H_2O(l) + CO_2(g)$

(i) Write the chemical formula for **X**.

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

(ii) The mass decreases during the reaction.

Explain why.

.....

.....

.....

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

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(b) 100 cm^3 of dilute hydrochloric acid contains 5.0 g of HCl.

(i) Calculate the number of moles of HCl in 100 cm^3 of dilute hydrochloric acid.

Relative atomic masses (A_r): H = 1.0 Cl = 35.5

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

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

(ii) There are 6.0×10^{23} atoms in one mole of atoms.

How many atoms are in 4 moles of HCl?

Put a ring around the correct option.

1.2×10^{24} **2.4×10^{24}** **4.8×10^{24}** **8×10^{23}**

[1]

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7 Aqueous hydrogen peroxide breaks down slowly to form oxygen gas and water.

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

(a) Manganese dioxide is a catalyst for this reaction.

Which statement explains how manganese dioxide speeds up the reaction?

Tick (✓) **one** box.

It decreases the frequency of particle collisions. ☐

It lowers the activation energy of the reaction. ☐

It lowers the temperature of the reaction. ☐

It provides energy for the reaction. ☐

[1]

(b) Explain why increasing the concentration of the aqueous hydrogen peroxide also speeds up the reaction.

Use ideas about particles.

.....

.....

.....

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

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(c) In one experiment, 0.1 moles of oxygen is collected when hydrogen peroxide decomposes.

Calculate the volume of 0.1 moles of oxygen at room temperature and pressure.

Use the formula: number of moles of gas = $\frac{\text{volume of gas (dm}^3\text{)}}{\text{24 (dm}^3\text{)}}$

Give your answer in cm^3.

Volume of oxygen = ... cm^3 **[3]**

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8 Fossil fuels are used as energy sources.

(a) Natural gas contains an alkane with the formula CH_4.

(i) Name this alkane.

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

(ii) Combustion of natural gas increases the temperature of the surroundings.

Name of the type of reaction that increases the temperature of the surroundings.

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

(iii) Incomplete combustion occurs when not enough oxygen is present.

Name **one** pollutant caused by the incomplete combustion of natural gas.

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

(b) Hydrogen can also be used as an energy source in a fuel cell.

The balanced symbol equation for the reaction in the hydrogen fuel cell is:

$2H_2 + O_2 \rightarrow 2H_2O$

The table shows the bond energies involved in the reaction.

Bond	Bond energy (kJ)
O═O	498
H—H	434
O—H	464

Calculate:
- the energy needed to break bonds in the reactants
- the energy given out when bonds form in the products
- the overall energy change of the reaction.

Energy needed to break bonds in the reactants = ... kJ

Energy given out when bonds form in the products = ... kJ

Overall energy change = ... kJ
[3]

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(c) Hydrogen fuel cells can be used in cars, but many cars use fossil fuels, such as diesel.

The table shows information about hydrogen and diesel.

Fuel	Products formed during complete combustion	Source	Melting point (°C)	Boiling point (°C)	Density at room temperature and pressure (g/cm^3)
Hydrogen	water	water	–259	–253	0.09
Diesel		crude oil	–80 to 0	200 to 350	0.85

(i) Diesel is a hydrocarbon.

Name the products formed during complete combustion of diesel.

.....

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

(ii) Evaluate the impact on the environment of producing and using hydrogen and diesel as fuels.

.....

.....

.....

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

(iii) Explain why the density of hydrogen and diesel are very different.

Use data from the table.

.....

.....

.....

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

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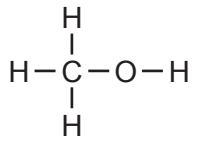
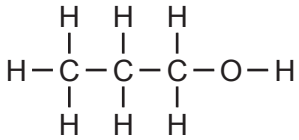
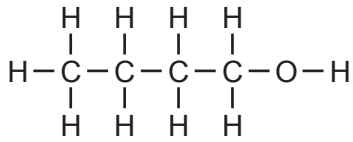
9 The table shows some information about the homologous series of alcohols.

(a) Complete the table by adding the missing name and displayed formula.

Name	Formula	Displayed formula
.....	CH_3OH	
Ethanol	C_2H_5OH	.....
Propanol	C_3H_7OH	
Butanol	C_4H_9OH	

[2]

(b) Alcohols oxidise to form carboxylic acids.

(i) Name the carboxylic acid formed when propanol is oxidised.

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

(ii) Draw the displayed formula of the carboxylic acid formed when propanol is oxidised.

Show all the bonds.

[1]

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10 Black silver oxide powder decomposes when heated to form silver and oxygen gas.

The balanced symbol equation for the reaction is:

$2Ag_2O \rightarrow 4Ag + O_2$

(a) Calculate the theoretical yield of silver made when 250 g of silver oxide completely decomposes.

Relative atomic mass (A_r): O = 16 Ag = 108

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

Theoretical yield = ... g **[4]**

(b) The actual yield of silver in an experiment is 215 g.

Some black silver oxide powder remains visible after the experiment.

Suggest **two** ways the experiment could be changed to increase the actual yield.

1 .....

.....

2 .....

.....

[2]

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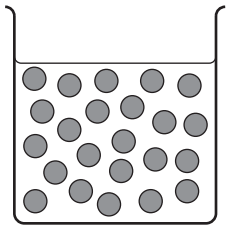
11 A student does some experiments with dilute and concentrated acids.

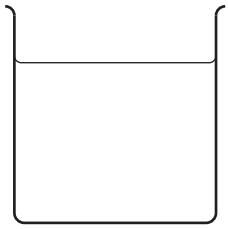
Fig. 11.1 represents the H^+ ions in a concentrated solution of acid.

Fig. 11.1



(a) **Complete Fig. 11.2** to show the H^+ ions in a dilute solution of acid.

Fig. 11.2



[1]

(b)
(i) The student says that all concentrated acids are strong acids and all dilute acids are weak acids.

Explain why they are **incorrect**.

.....

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

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(ii) The student adds a carbonate to three dilute acids, A, B and C, with the same concentration.

They record the pH of each acid and the time taken for each reaction to finish (the reaction time).

The table shows the results.

Acid	pH	Reaction time (s)
A	1	10
B	3	200
C	5	1000

Which acid is the weakest acid?

Explain your answer.

Use:
- data from the table
- ideas about hydrogen ions.

.....

.....

.....

.....

.....

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

(c)
(i) Describe how to use Universal indicator to measure the pH of a solution.

.....

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

(ii) A solution of pH 1 has a hydrogen ion concentration of 0.1 mol / dm^3.

What is the hydrogen ion concentration of a solution of pH 3?

Put a (ring) around the correct option.

1×10^{-1} mol / dm^3 **1×10^{-2} mol / dm^3** **1×10^{-3} mol / dm^3** **1×10^{-4} mol / dm^3**

[1]

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12 Group 7(17) of the Periodic Table contains non-metals called halogens.

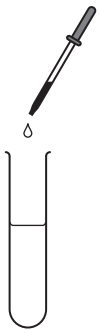
(a) The table shows the properties of three Group 7(17) elements at room temperature and pressure.

Complete the table.

Element	**Colour**	**State at room temperature**
Chlorine	Pale green	.....
Bromine	.....	Liquid
Iodine	Grey	Solid

[2]

(b) A student adds aqueous sodium iodide to aqueous chlorine.



The balanced symbol equation for the reaction is:

$Cl_2(aq) + 2NaI(aq) \rightarrow 2NaCl(aq) + I_2(aq)$

(i) Explain what the student observes when the reaction takes place.

.....

.....

.....

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

(ii) Write an **ionic** equation for the reaction.

Use the symbol equation to help you.

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

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

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

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