OCR
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Friday 27 May 2022 – 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.

Answer **all** the questions.

1 Mia investigates the rate of reaction when zinc reacts with dilute sulfuric acid.
She adds zinc pieces to dilute sulfuric acid at room temperature.

Fig. 1.1 shows the apparatus she uses:

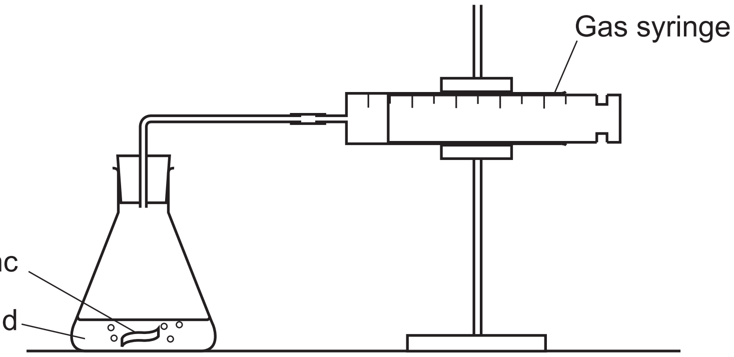


Fig. 1.1

(a) Complete the symbol equation for the reaction.

Include a **state symbol**.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + \ldots\ldots\ldots\ldots$$

[2]

(b) Mia measures the volume of gas in the gas syringe every two minutes.

Fig. 1.2 shows a graph of her results:

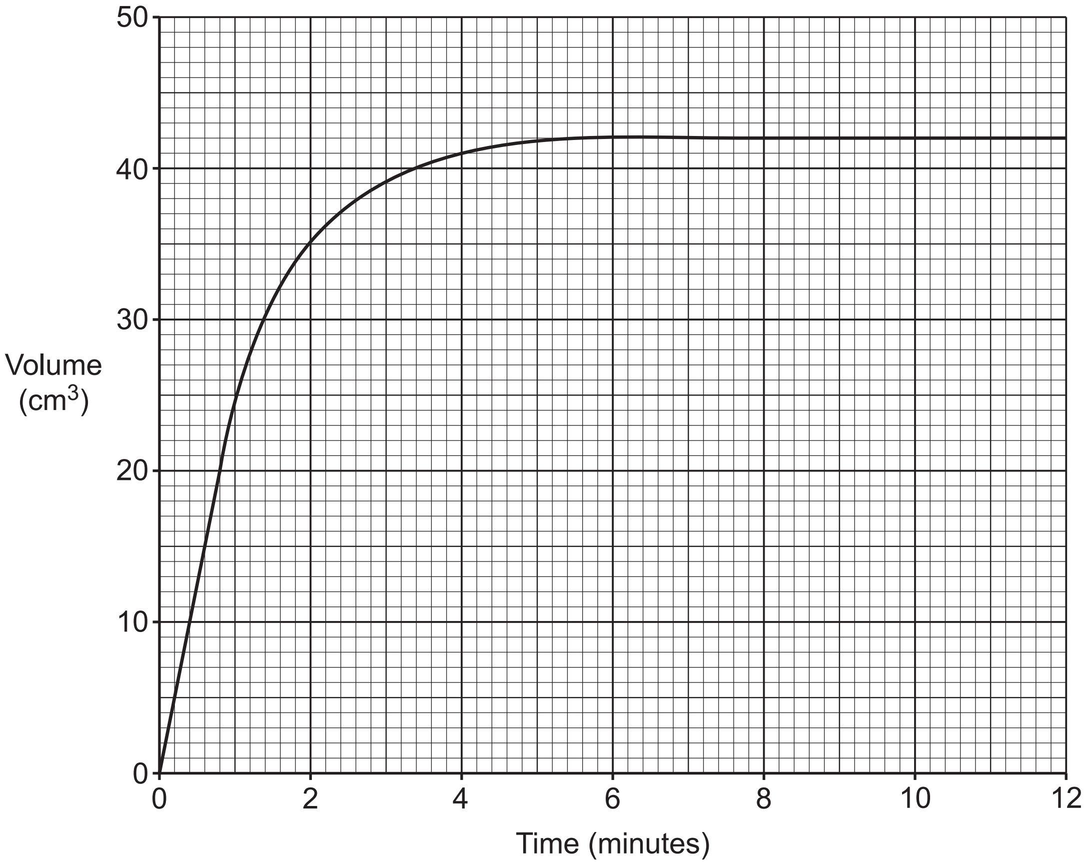


Fig. 1.2

(i) Calculate the rate of reaction during the first minute, using **Fig. 1.2**.

Give your answer in cm^3/s.

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

(ii) Explain why the mass of the flask and its contents decreases during the reaction.

....

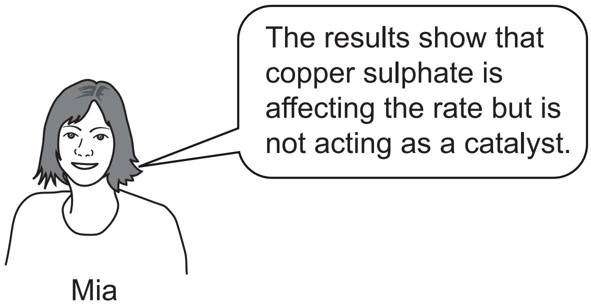
.... **[1]**

(c) Mia repeats the experiment at the same temperature.
She adds a few drops of blue copper sulfate.

Her results show that:

- more gas is produced in the first minute, than in the first experiment.
- the blue colour changes to colourless during the reaction.

Mia makes a statement about the results:



How do the results support Mia's statement?

Explain your answer.

....

....

....

....

....

.... **[3]**

(d) Mia repeats the experiment at a **higher** temperature.

Which statements explain why the reaction is faster at a higher temperature?

Tick (✓) **two** boxes.

The particles move faster. ☐

There are more frequent collisions. ☐

The yield is higher at a higher temperature. ☐

The particles are closer together. ☐

The zinc breaks down into smaller pieces. ☐

[2]

2 The table shows some properties of metals, polymers and clay ceramics:

Type of material	Effect of force on material	Electrical conductivity	Hardness
Metals	malleable	good	hard
Polymers	flexible	poor	soft
Clay ceramics	snaps	....	....

(a) Complete the table by adding the two missing properties of clay ceramics. **[2]**

(b) Layla has three different water jugs.
The jugs are made from aluminium, poly(ethene) and pottery (clay ceramic).

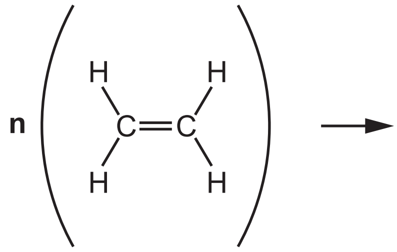
Draw lines to connect each **material** with its correct **property**.

Material	**Property of jug**
	Softens easily when heated.
Aluminium	
	Goes out of shape if dropped.
Poly(ethene)	
	Breaks if dropped.
Pottery	
	Rusts quickly.

[3]

(c) Poly(ethene) is made from ethene.

Complete the equation by drawing the structure of the repeating unit of poly(ethene).



Ethene **Poly(ethene)**

[1]

(d) Genes are made from the natural polymer DNA.

Which monomers make DNA?

Tick (✓) **one** box.

Cellulose ☐

Nucleotides ☐

Sugars ☐

Unsaturated hydrocarbons ☐

[1]

3 The Earth's early atmosphere contained mostly carbon dioxide and water vapour.

(a) As the Earth cooled, the oceans formed. Water vapour condensed from gas to liquid.

The particle model can explain properties of gases and liquids.

Which statement is correct?

Tick (✓) **one** box.

Liquids are difficult to squash because the particles are tightly packed. ☐

Gases have pressure because gas particles rarely collide with each other. ☐

Liquids expand when heated because atoms expand when heated. ☐

Gases are easy to squash because gas atoms get smaller when squashed. ☐

[1]

(b) The particle model assumes molecules of water and carbon dioxide are inelastic spheres. This is a limitation of the particle model.

Water changes state at 100 °C. Carbon dioxide changes state at –79 °C.

Which statement explains another limitation of the particle model in relation to changes of state?
Tick (✓) **one** box.

In real life, all molecules are the same size. ☐

In real life, the molecules of water and carbon dioxide attract each other. ☐

In real life, molecules become smaller during evaporation. ☐

In real life, evaporation happens when bonds are broken in molecules. ☐

[1]

(c) Gradually, plants began to grow on Earth.
Explain how this affected the composition of the atmosphere.

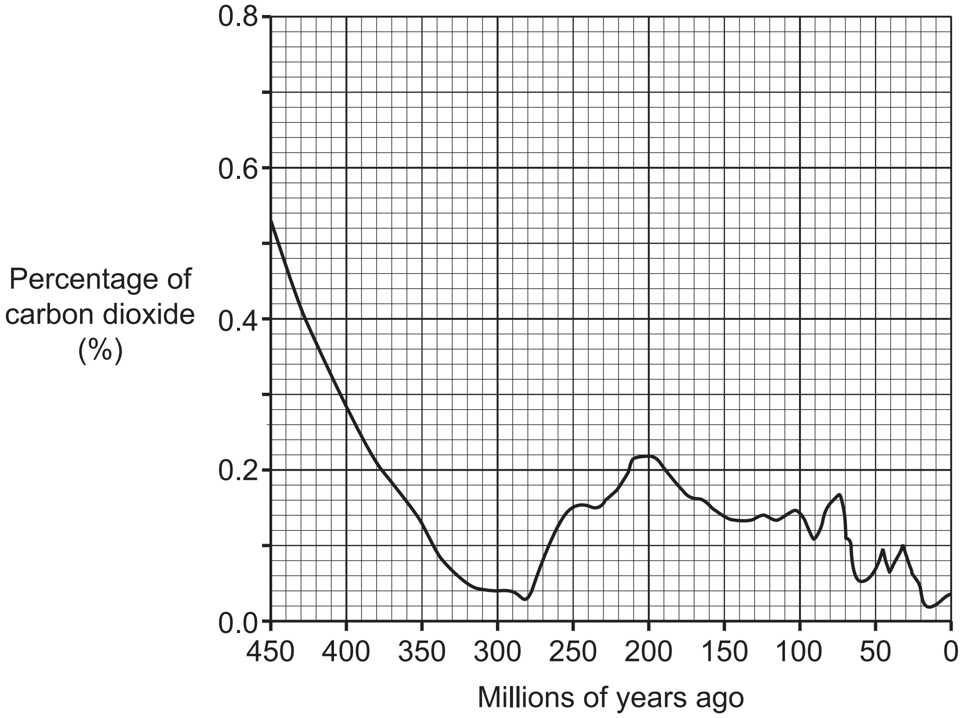
....

....

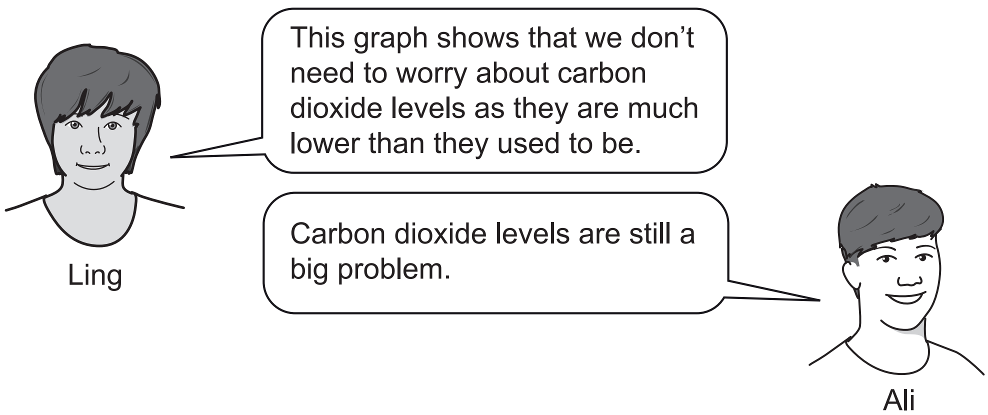
....

.... **[2]**

(d) The graph shows how the percentage of carbon dioxide in the atmosphere has changed over time:



Ling and Ali discuss the graph:



Explain why Ling is wrong and Ali is correct.

Ling ....

....

Ali ....

....

[2]

4 When hydrogen burns, energy is transferred to the surroundings.

(a) What word describes a reaction that releases energy to the surroundings?

.... **[1]**

(b) The equation for the reaction is:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

Complete **Fig. 4.1** to show the reaction profile for this reaction.
Include on **Fig. 4.1**:

- the formulae of the reactants and products
- a label for the activation energy.

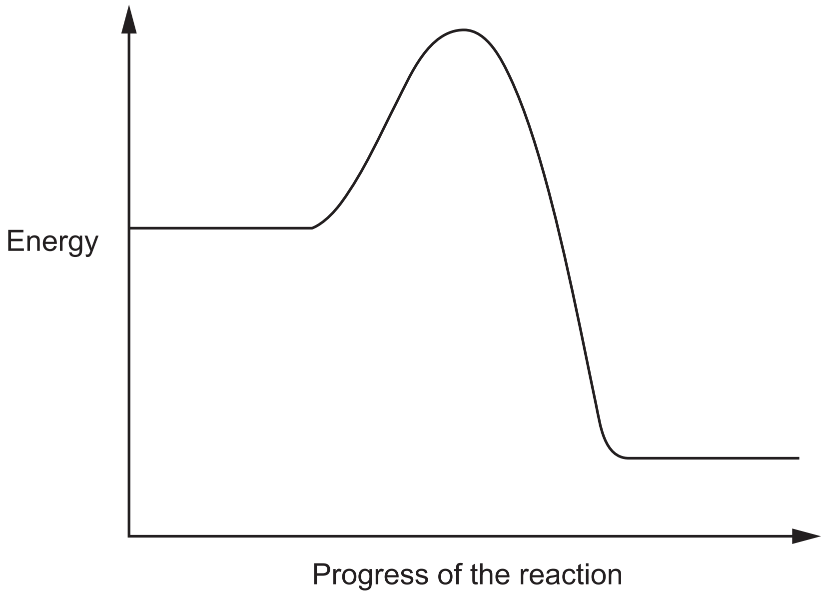


Fig. 4.1

[2]

(c) Which statement describes the activation energy?

Tick (✓) **one** box.

The energy absorbed by the reaction. ☐

The energy given out by the reaction. ☐

The energy needed for a reaction to occur. ☐

The temperature needed to start the reaction. ☐

[1]

(d) **Fig. 4.2** shows what happens when 2 moles of hydrogen burn:

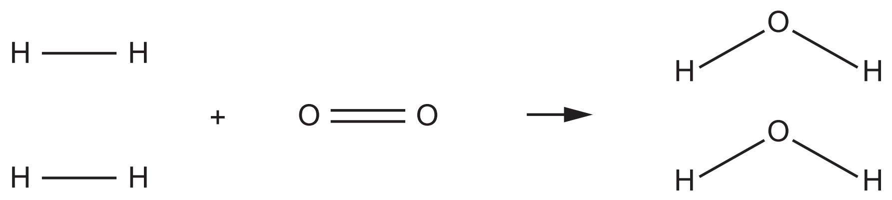


Fig. 4.2

Calculate the energy given out when 2 moles of hydrogen burn.

Use data from the table.

Bond	**Energy (kJ/mol)**
O–H	464
O=O	498
H–H	436

Bonds broken = ... kJ/mol

Bonds made = ... kJ/mol

Energy given out = ... kJ/mol
[3]

5 Iodine is a halogen. It is an element in Group 17 (7) of the Periodic Table.

(a) Which property shows iodine is a non-metal?

Tick (✓) **one** box.

It is a shiny grey solid. ☐

It does not conduct electricity. ☐

It is unreactive. ☐

Its density is higher than water. ☐

[1]

(b) $1.00\,cm^3$ of iodine has a mass of 4.93 g.

Calculate the volume of 1.00 mol of I_2.

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

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

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

(c) Sodium iodide solution reacts with chlorine. This is a symbol equation for the reaction:

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

(i) What would you **see** when this reaction happens?

....

.... **[1]**

(ii) What information does this reaction show about the reactivity of the halogens?

....

.... **[1]**

(d) An isotope of iodine has a mass number of 127.

How many neutrons and electrons does an atom of this isotope have?

Use the Data Sheet.

Number of neutrons = ...

Number of electrons = ...
[2]

(e) Phosphorus reacts with iodine to form a compound.

The compound contains 7.5% by mass of phosphorus. The rest of the compound is iodine.

Determine the formula of the compound.

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

Formula = ... **[3]**

6 In industry, crude oil fractions can be cracked to make alkenes.

(a) Which statement explains why crude oil fractions are cracked?

Tick (✓) **one** box.

Alkenes dissolve in water. ☐

Cracking separates the crude oil fractions. ☐

Crude oil is a mixture of alkenes. ☐

To make useful short chain molecules. ☐

[1]

(b) Bromine reacts with ethene.

Fig. 6.1 shows the fully displayed formula of ethene:

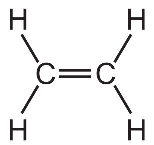


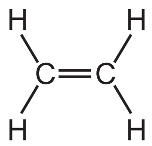
Fig. 6.1

Draw the fully displayed formula of the product made when bromine reacts with ethene.

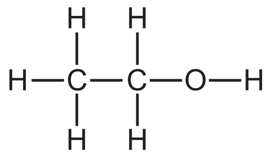
[1]

(c) (i) The reactions of organic compounds depend on their functional groups.

Put a ring around the functional groups present in ethene and ethanol in **Fig. 6.2**.



Ethene



Ethanol

Fig. 6.2

[2]

(ii) A carboxylic acid can be made by oxidising ethanol.

Name the carboxylic acid made by oxidising ethanol.

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

(iii) Draw the fully displayed formula of the carboxylic acid made by oxidising ethanol.

[1]

(d) Ethanol boils at 78 °C. Ethene boils at –104 °C.

Which statement explains why the boiling points are different?

Tick (✓) **one** box.

An ethanol molecule has more carbon atoms than an ethene molecule. ☐

Ethanol is soluble in water but ethene is not. ☐

The covalent bonds in ethanol are stronger than those in ethene. ☐

The intermolecular forces in ethanol are stronger than those in ethene. ☐

[1]

7 **(a)** Iron ore contains iron oxide. Iron can be made from iron ore.
This is a symbol equation for the reaction:

$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

(i) Complete the half equation to show what happens to iron in this reaction.

Fe^{3+} + ... e^- $\rightarrow$ …………..

[1]

(ii) Explain, in terms of electrons, why Fe^{3+} is reduced in the half equation in **(a)(i)**.

....

.... **[1]**

(b) Calculate the percentage by mass of iron present in iron oxide, Fe_2O_3.

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

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

(c) Iron can be made into steel. The main disadvantage of steel is that it rusts.

Explain **one** method of preventing steel from rusting.

....

....

....

.... **[2]**

(d) Used steel is collected and recycled.
Recycling used steel has advantages and disadvantages.

Suggest one **advantage** and one **disadvantage** of recycling used steel.

Advantage ....

....

Disadvantage ....

....

[2]

8 Magnesium reacts with iron sulfide. This is a symbol equation for the reaction:

$Mg + FeS \rightarrow Fe + MgS$

(a) What information does this reaction give about the reactivity of magnesium?

....

.... **[1]**

(b) Magnesium sulfide, MgS is an ionic compound which contains the ions Mg^{2+} and S^{2-}.

Explain why magnesium sulfide has a high melting point.

....

....

....

.... **[2]**

(c) Complete **Fig. 8.1** to show the 'dot and cross' diagrams for an Mg^{2+} ion and an S^{2-} ion.

Show **all** the electrons.

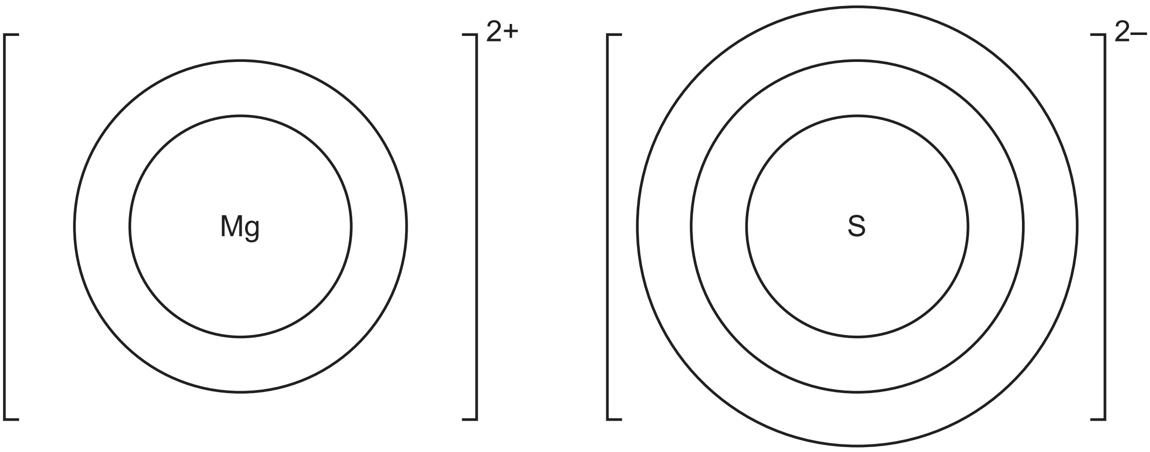


Fig. 8.1

[2]

9 Alex adds the **same** volume of dilute sulfuric acid to different samples of zinc carbonate. The reaction fizzes.

(a) Name the gas that causes the fizzing.

.... **[1]**

(b) **Table 9.1** shows Alex's results:

Experiment	Mass of zinc carbonate (g)	Concentration of acid (mol/dm^3)	Type of zinc carbonate	Time to stop fizzing (minutes)	Relative average rates
1	2.0	1.0	lumps	10	1
2	2.0	1.0	powder	4	

Table 9.1

(i) Explain why the rates of **Experiment 1** and **Experiment 2** are different in **Table 9.1**.

Use ideas about particles in your answer.

....

....

....

.... **[2]**

(ii) Relative average rate is the number of times faster one reaction is compared to another.

Calculate the relative average rate of **Experiment 2**, compared to **Experiment 1**.

Relative average rate = ... **[2]**

(c) Alex does two more experiments, **Experiment 3** and **Experiment 4**.

The results are shown in **Table 9.2**.

Experiment	Mass of zinc carbonate (g)	Concentration of acid (mol/dm^3)	Type of zinc carbonate	Time to stop fizzing (minutes)	Relative average rates
1	2.0	1.0	lumps	10	1
2	2.0	1.0	powder	4	
3	4.0	1.0	lumps	....	
4	2.0	2.0	lumps	....	

Table 9.2

Complete **Table 9.2** by predicting the time taken for the reactions to stop fizzing. **[2]**

10 Nina is given some diluted drain cleaner called 'Drainclear'. 'Drainclear' contains sodium hydroxide.

Nina titrates 25.0 cm^3 of diluted 'Drainclear' with dilute hydrochloric acid and an indicator.

(a) Nina uses a burette to measure out the dilute hydrochloric acid in the titration.

Nina wants to minimise errors in her method.

Describe **one** thing she should do when taking burette readings.

....

.... **[1]**

(b) The table shows Nina's results:

	Rough	**Titration 1**	**Titration 2**	**Titration 3**
2nd reading (cm^3)	14.05	20.55	10.60	22.05
1st reading (cm^3)	3.00	10.05	0.05	11.60
Volume (cm^3)	11.05	10.50	10.55	10.45
Mean (cm^3)		10.50		

Explain why Nina's results are repeatable but **not** reproducible.

....

....

....

.... **[2]**

(c) In her titration, Nina used 25.0 cm^3 of diluted 'Drainclear' with 0.20 mol / dm^3 hydrochloric acid. A symbol equation for the reaction is:

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

Calculate the concentration of sodium hydroxide, NaOH, in the diluted 'Drainclear'.

Use the equation: $\text{concentration (mol/dm}^3) = \dfrac{\text{number of moles of solute}}{\text{volume (dm}^3)}$

Use Nina's mean result of 10.50 cm^3.

Concentration of sodium hydroxide = ... mol / dm^3 **[3]**

(d) Nina says:

'I would have preferred my titration result to be larger than 10.50 cm^3.
This would reduce the percentage uncertainty in my titration result.'

Explain how Nina could get a larger titration result without changing her apparatus.

....

....

....

.... **[2]**

11 Aluminium and chlorine can be made by electrolysis.

(a) Aluminium is made by the electrolysis of molten aluminium oxide.

(i) At which electrode is aluminium formed?

.... **[1]**

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

....

.... **[1]**

(b) Some elements are extracted using electrolysis.

(i) Explain why hydrogen, **not** sodium, is made at the negative electrode when sodium chloride solution is electrolysed.

....

.... **[1]**

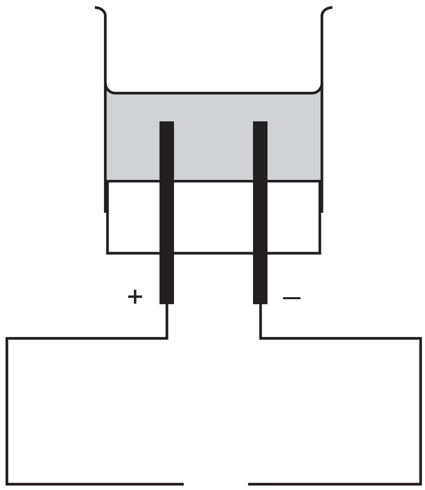
(ii) Write the half equation for the formation of hydrogen at the negative electrode.

.... **[2]**

(c) Kareem electrolyses sodium chloride solution. Hydrogen gas and chlorine gas are made.

Describe what Kareem needs to do to measure the volumes of hydrogen gas and chlorine gas made.

You may add to the diagram to help explain your answer. The diagram is **not** complete.



....

....

....

.... **[2]**

12 Eve has some copper sulfate crystals. The formula of copper sulfate is $CuSO_4$.

(a) Eve says, 'Copper sulfate is a mixture of several elements. It is not a pure substance.'

Explain why Eve is wrong.

....

....

....

.... **[2]**

(b) Eve dissolves the copper sulfate crystals in water.
She does two tests on the copper sulfate solution.

(i) In **test 1** she adds sodium hydroxide solution to the solution of copper sulfate.
She sees a blue precipitate of copper hydroxide.

Write a **word** equation for the formation of copper hydroxide.

.... **[1]**

(ii) In **test 2** she adds acidified barium chloride solution to the solution of copper sulfate.
She sees a white precipitate of barium sulfate.

Write an **ionic** equation for the formation of the white precipitate.

.... **[2]**

END OF QUESTION PAPER

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).