OCR
Oxford Cambridge and RSA

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Friday 19 November 2021 – Morning

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

J260/06 Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

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You must have:
- a ruler (cm/mm)
- the Data Sheet for GCSE (9-1) Combined Science (Chemistry) B (inside this document)

You can use:
- an HB pencil
- a scientific or graphical calculator

J260006

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 **95**.
- 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 **24** pages.

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

Answer **all** the questions.

1 The table shows data about the composition of the Earth's atmosphere 4 billion years ago and today.

	Composition of gases in Earth's atmosphere (%)	
	4 billion years ago	**Today**
Carbon dioxide	20	0.04
Water	50	small
Nitrogen	3	78
Oxygen	0	21
Other gases	.....	small

(a) (i) Complete the table to show the approximate percentage of other gases in the atmosphere 4 billion years ago. **[1]**

(ii) Four billion years ago the Earth was extremely hot.

When the temperature of the Earth cooled to below 100 °C there was a large decrease in the amount of water vapour in the atmosphere.

Describe what happens when hot water vapour cools to below 100 °C.

Use ideas about arrangement and speed of particles in your answer.

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

(b) How and why have the percentages of **carbon dioxide** and **oxygen** in the atmosphere changed over time?

Use data from the table to support your answer.

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

(c) Some rocks are red because they contain iron oxide.

Iron oxide was formed when iron in the rocks reacted with oxygen in the atmosphere.

(i) Complete the **balanced symbol** equation for the reaction which produces iron oxide.

..... Fe + ... O_2 $\rightarrow$ $2Fe_2O_3$

[1]

(ii) Scientists think these red rocks formed 2.3 million years ago.

Suggest why these rocks could **not** form 4 billion years ago.

Use data from the table to support your answer.

.....

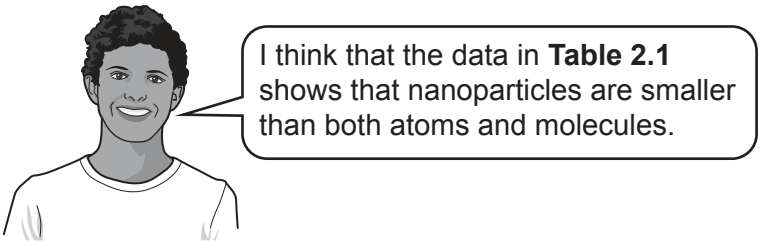
..... **[1]**

2 **Table 2.1** shows data about the sizes of some particles.

Particle	Approximate size (m)
Nanoparticles	between 1×10^{-9} and 1×10^{-7}
Hydrogen atom	1.06×10^{-10}
Oxygen atom	1.56×10^{-10}
Water molecule	2.75×10^{-10}
Carbon atom	1.54×10^{-10}
Polymer molecules	1.00×10^{-6}

Table 2.1

James comments on the data in **Table 2.1**.



(a) Discuss James' comment.

Use **Table 2.1** to support your answer.

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

(b) **Table 2.2** shows information about the particles in some silver powders.

Type of powder	Size of particles (nm)	Surface area to volume ratio
Nanoparticles	50	0.12
Fine powder	5000	0.0012
Coarse powder	10 000	0.0006

Table 2.2

(i) Which type of powder in **Table 2.2** provides the biggest surface area for a given volume of silver?

Give **one** reason for your answer.

Type of powder .....

Reason .....

.....

[1]

(ii) James thinks that the data in **Table 2.2** gives this relationship.

surface area to volume ratio ∝ size of particle

Is James correct?

Yes ☐

No ☐

Explain your answer.

.....

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.....

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[2]

(c) The different ways that nanoparticles are used depends on their properties.

Draw lines to connect each **property** of nanoparticles with the **use** that depends on it.

Property	Use
Atoms arranged in balls	Carry medicines into the body
Atoms arranged in tubes	Catalysts
High surface area to volume ratio	Molecular sieves

[2]

(d) Nanoparticles are used as catalysts.

Which **two** statements explain how a catalyst increases the rate of a reaction?

Tick (✓) **two** boxes.

Catalysts decrease the activation energy of the reaction. ☐

Catalysts increase the energy change of the reaction. ☐

Catalysts increase the kinetic energy of the particles. ☐

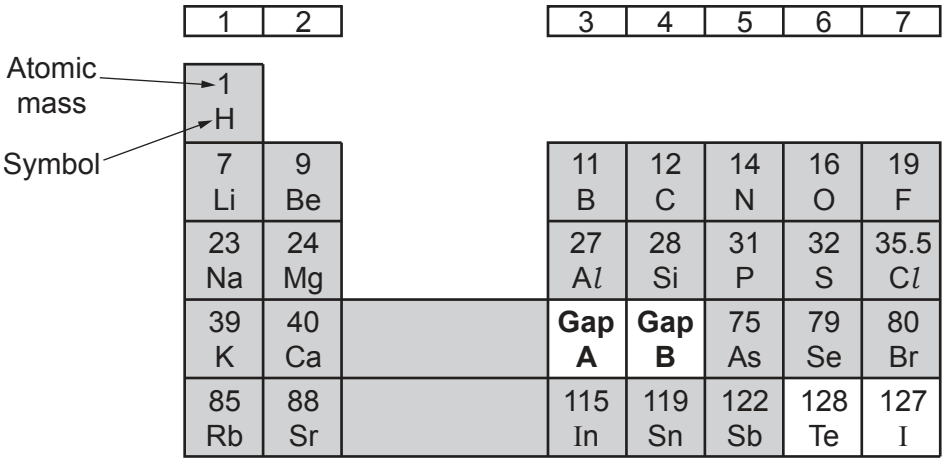
Catalysts increase the temperature. ☐

Catalysts reduce the energy needed to break the bonds in the reactants. ☐

[2]

3 Mendeleev developed an early Periodic Table based on the elements that were known about at the time. He put these elements in order of increasing atomic mass.

Here is part of Mendeleev's table.



1	2		3	4	5	6	7
1 H							
7 Li	9 Be		11 B	12 C	14 N	16 O	19 F
23 Na	24 Mg		27 Al	28 Si	31 P	32 S	35.5 Cl
39 K	40 Ca		**Gap A**	**Gap B**	75 As	79 Se	80 Br
85 Rb	88 Sr		115 In	119 Sn	122 Sb	128 Te	127 I

(a) Mendeleev left gaps in positions **A** and **B** in his table.

(i) How did leaving these gaps help him to arrange the other elements into groups?

Use ideas about properties of elements in your answer.

.....

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

(ii) How did the work of later scientists show that he was correct to leave gaps?

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

(iii) What is unusual about the positions of **Te** and **I**?

.....

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

(b) The modern Periodic Table is organised in order of the atomic number of the elements.

(i) **Fig. 4.1** shows the arrangement of electrons in lithium and fluorine.

Lithium **Fluorine**

Fig. 4.1

How does the arrangement of electrons in **lithium** relate to its atomic number, group and period?

Atomic number .....

.....

Group .....

.....

Period .....

.....

[3]

(ii) Lithium is a metal and fluorine is a non-metal.

Explain how **and** why metals and non-metals form different types of ions.

Use **Fig. 4.1** to support your answer.

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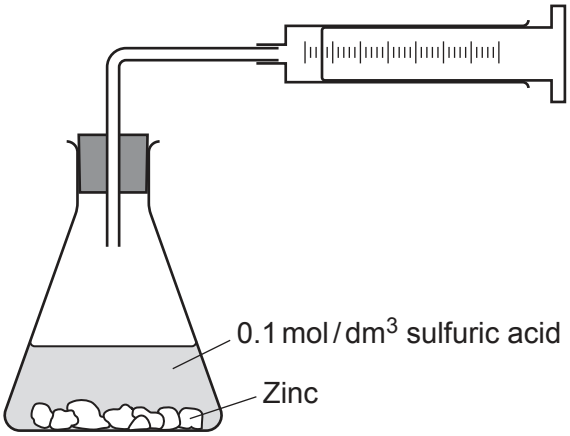
..... **[3]**

4 Sarah investigates the rate of reaction when zinc reacts with dilute sulfuric acid.

She adds small pieces of zinc to 50 cm^3 of 0.1 mol/dm^3 sulfuric acid. She measures the volume of hydrogen gas collected every 30 seconds.



(a) Sarah finds that the reaction is very slow and so she increases the temperature.

(i) Explain why increasing the temperature increases the rate of a reaction.

Use ideas about collisions of particles in your answer.

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

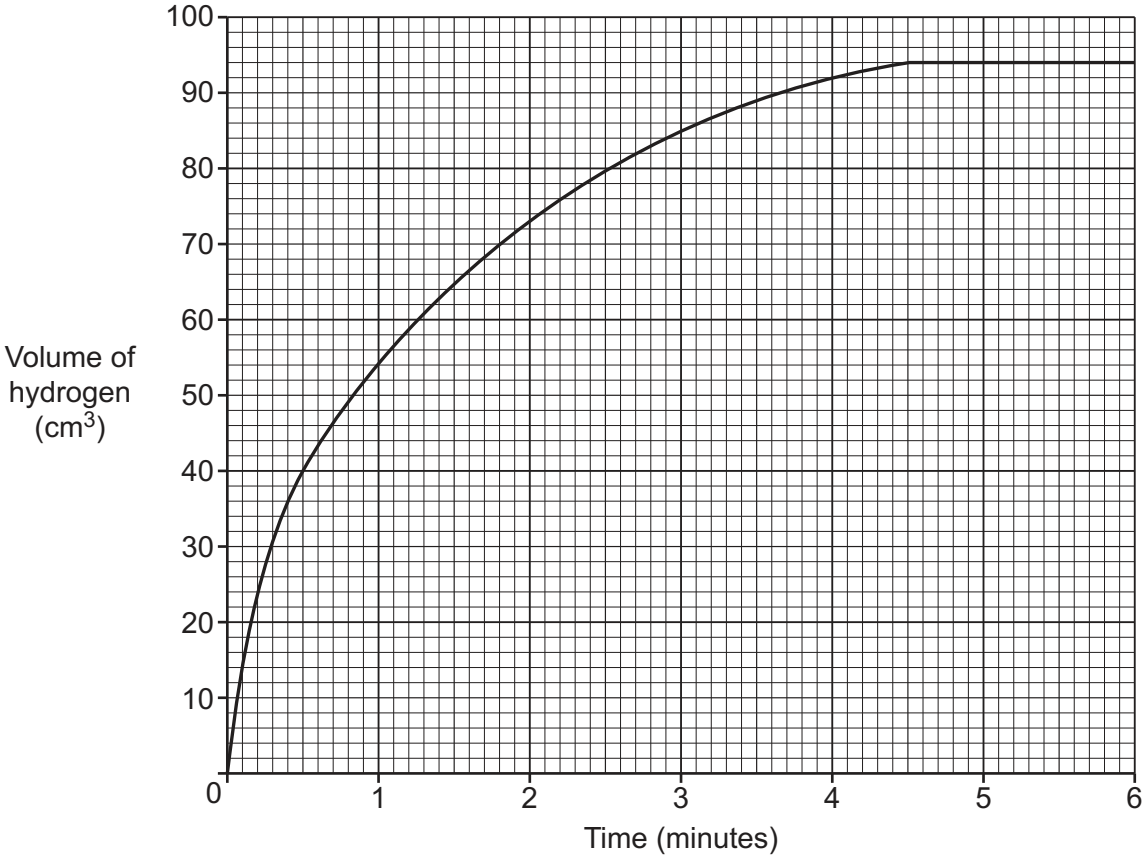
(ii) Give **two** other ways that she could speed up the reaction.

1 .....

2 .....

[1]

(b) Sarah plots a graph from her results.



(i) How long does it take for the reaction to finish?

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

(ii) What volume of hydrogen is given off by the end of the reaction?

..... cm^3 **[1]**

(iii) Calculate the average volume of hydrogen given off **per second**.

..... cm^3/s **[2]**

(iv) Draw a tangent on the graph **and** use it to calculate the **initial rate** of the reaction in **cm^3/s**.

Initial rate = ... cm^3/s **[3]**

(v) Some zinc pieces are left behind when the reaction ends.

Explain how and why the rate of reaction changes during the first **two** minutes of the reaction.

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

5 Carbon dioxide gas in the atmosphere is one cause of the greenhouse effect.

(a) Explain how carbon dioxide causes the greenhouse effect.

Include ideas about radiation from the Sun.

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

(b) Carbon dioxide gas, $CO_2(g)$ dissolves in seawater to form dissolved carbon dioxide, $CO_2(aq)$.

Dissolved carbon dioxide reacts with seawater to form two new ions. The two new ions are soluble.

Equation 1 shows what happens when dissolved carbon dioxide reacts with water.

Equation 1 $CO_2(aq) + H_2O(.....) \rightleftharpoons HCO_3^-(.....) + H^+(.....)$

(i) Complete **equation 1** by adding the missing state symbols. **[2]**

(ii) **Equation 1** shows an equilibrium reaction.

What does the $\rightleftharpoons$ symbol mean?

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

(iii) The pH of seawater is 7.5.

The reaction in **equation 1** causes the pH of seawater to change.

Explain how **and** why the pH changes.

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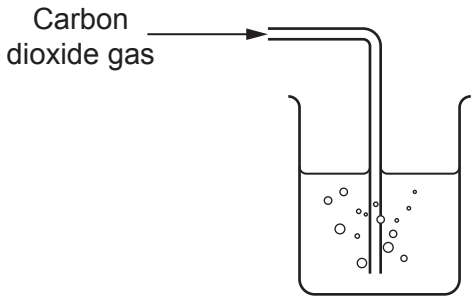
..... **[2]**

(iv) Ling does an experiment. She bubbles carbon dioxide through water.

She uses this apparatus.



Suggest **two** methods for showing that the pH of the water changes.

1 .....

2 .....

[2]

6 **Fig. 6.1** shows the structures of diamond and methane.

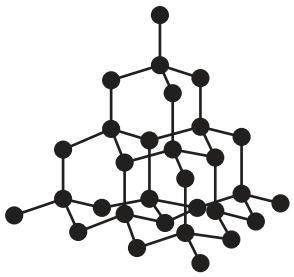
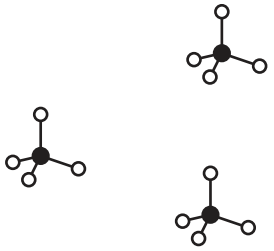
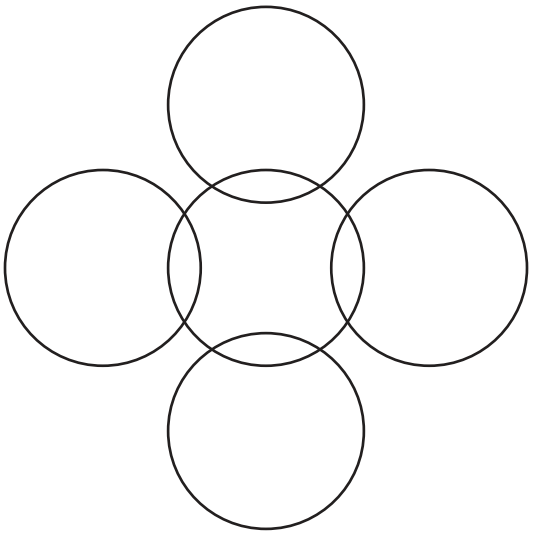
	Diamond	Methane
Diagram of structure		

Fig. 6.1

(a) **(i)** Complete the dot and cross diagram for methane.

Show outer electrons only, and label each atom.



[1]

(ii) Complete the table by giving the type of bonds and type of structure for diamond and methane.

Use **Fig. 6.1**.

	Type of bonds	Type of structure
Diamond		
Methane		

[2]

(iii) Explain why diamond is a solid and methane is a gas at room temperature and pressure.

Use ideas about bonds and attractions between molecules in your answer.

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

(b) Diamond is an allotrope of carbon.

Fig. 6.2 shows the structure of graphite, another allotrope of carbon.

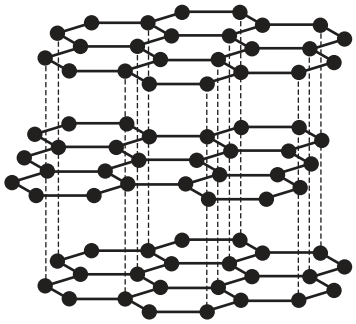

Fig. 6.2

(i) Graphite conducts electricity, but diamond does not.

Explain this statement.

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

(ii) Diamond is a very hard material, but graphite is soft and slippery.

Explain this statement.

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

7* Layla investigates the trend in reactivity of the Group 7 elements, using these solutions:

Chlorine water	Potassium chloride
Iodine water	Potassium iodide
Bromine water	Potassium bromide

Describe what **experiments** she should do, what **observations** she should expect and explain how her observations can be used to **show** the trend in reactivity of the Group 7 elements.

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

8 Aluminium is extracted from aluminium oxide by electrolysis.

(a) Solid aluminium oxide is dissolved in a hot, molten compound called cryolite and then electrolysed.

(i) Explain why solid aluminium oxide cannot be electrolysed.

Use ideas about ions in your answer.

.....

.....

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

(ii) The melting point of pure aluminium oxide is 2072 °C. Aluminium oxide dissolved in cryolite melts at approximately 900 °C.

Explain **one** advantage of electrolysing aluminium oxide dissolved in cryolite instead of pure molten aluminium oxide.

.....

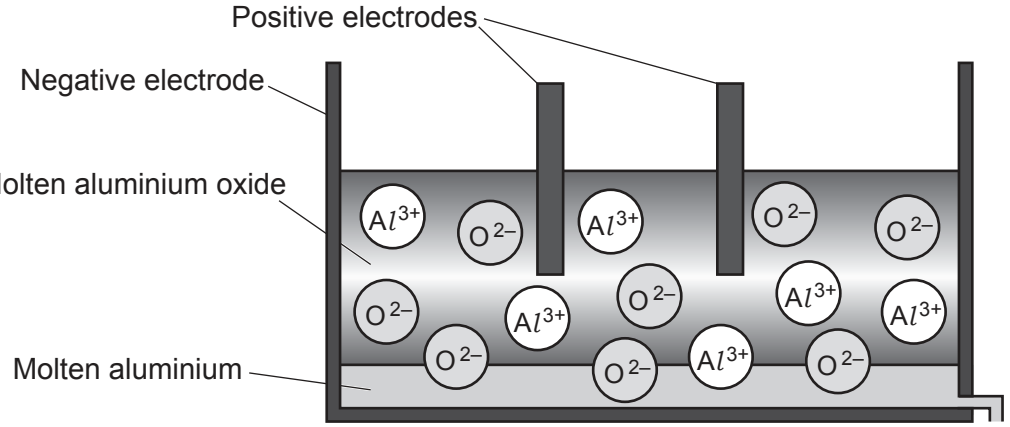
..... **[1]**

(b) The diagram shows the tank used for the electrolysis of aluminium oxide.

Positive electrodes dip into the molten solution of aluminium oxide.

The casing of the tank acts as the negative electrode.

Molten aluminium metal collects at the bottom.



Describe what happens at each electrode during electrolysis of aluminium oxide.

Use ideas about ions and electrons in your answer.

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..... **[4]**

(c) Copper is extracted by heating copper oxide (CuO) with carbon to form copper and carbon dioxide.

(i) Write a **balanced symbol** equation for this reaction.

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

(ii) Explain why copper can be extracted by this method but aluminium cannot.

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

(d) Bioleaching and phytoextraction are new biological methods of extracting metals from waste heaps around old mines.

Bioleaching uses bacteria on waste heaps. The waste heaps need to be first sprayed with dilute acid. The bacteria then produce a dilute solution of metal ions which can be collected.

Phytoextraction uses plants to absorb metal ions from the waste heaps and store them in their leaves. Some plants can even absorb metals which are toxic to other plants and animals.

Traditional methods of extracting metals use electrolysis or heating with carbon.

Give **two** advantages and **one** disadvantage of using biological methods of extracting metals instead of traditional methods.

Advantage 1 .....

.....

Advantage 2 .....

.....

Disadvantage .....

.....

[3]

9 Kareem does a titration to find the concentration of some dilute sulfuric acid.

He uses 25.0 cm^3 of a sodium hydroxide solution with a concentration of 8.0 g/dm^3 and measures the volume of sulfuric acid which reacts exactly with the sodium hydroxide solution.

(a) The table shows Kareem's results for the volume of acid added.

	Rough trial	**Repeat 1**	**Repeat 2**	**Repeat 3**	**Repeat 4**
Burette reading at end	24.2	47.7	24.6	48.7	24.0
Burette reading at start	0.0	24.2	1	24.6	0.6
Volume added	24.2	23.5	23.6	24.1	23.4

(i) Give **two** errors that Kareem has made when recording his results in the table.

1 .....

2 .....

[2]

(ii) Why is the volume of acid added for the repeat readings **less** than that added in the rough trial?

.....

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

(iii) Kareem decided that the most accurate value for the volume of acid added was 23.5 cm^3.

Explain how he calculated this value.

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

(b) Kareem's results show that 25.0 cm^3 of 8.0 g/dm^3 sodium hydroxide solution are neutralised by 23.5 cm^3 of sulfuric acid.

The balanced symbol equation for the reaction is:

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) Calculate the mass of sodium hydroxide in 25.0 cm^3 of the 8.0 g/dm^3 solution.

Use the formula: concentration (g/dm^3) = $\frac{\text{mass (g)}}{\text{volume } (dm^3)}$

Mass = ... g **[3]**

(ii) Show that the number of moles of sulfuric acid reacting with the sodium hydroxide is 0.0025.

Use your answer to **(b)(i)**.

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

[3]

(iii) Calculate the concentration of the sulfuric acid, in **mol / dm^3**.

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

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

Concentration = ... mol/dm^3 **[3]**

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).