Oxford Cambridge and RSA

Monday 19 May 2025 – Morning

GCSE (9–1) Chemistry A (Gateway Science)

J248/03 (Higher Tier)

Time allowed: 1 hour 45 minutes

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

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

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 **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

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

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Section A

You should spend a **maximum** of **30 minutes** on this section.

Write your answer to each question in the box provided.

1 How many covalent bonds can a carbon atom form?

A 2

B 4

C 6

D 8

Your answer ☐ **[1]**

2 What is the ionic equation for neutralisation?

A $H^- + OH^+ \rightarrow H_2O$

B $H^+ + OH^- \rightarrow H_2O$

C $2H_2 + 2O^{2-} \rightarrow 2H_2O$

D $H^+ + O_2 \rightarrow HO_2$

Your answer ☐ **[1]**

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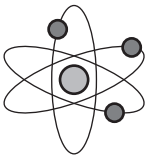
3 Which atomic model was developed by Thomson?

A



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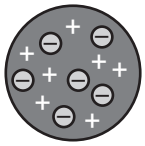

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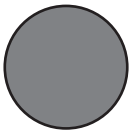

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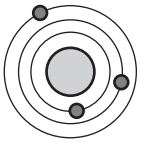


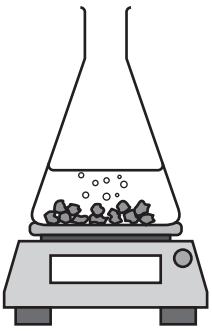
Your answer ☐ **[1]**

4 The diagram shows calcium carbonate, $CaCO_3$, reacting with an acid.

The equation for the reaction is:

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

What happens to the mass displayed on the balance as the reaction progresses?



A Decreases

B Decreases then increases

C Increases

D Stays the same

Your answer ☐ **[1]**

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5 Which ion do solutions of all alkalis contain?

A K^+

B H^+

C OH^-

D SO_4^{2-}

Your answer ☐ **[1]**

6 What is the relative formula mass of butanoic acid, C_3H_7COOH?

Relative atomic mass (A_r): C = 12.0 H = 1.0 O = 16.0

A 29.0

B 44.0

C 88.0

D 120.0

Your answer ☐ **[1]**

7 What type of bonding is found in all polymers?

A Covalent

B Electrostatic

C Ionic

D Metallic

Your answer ☐ **[1]**

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8 Propene has the molecular formula C_3H_6.

What is the **empirical** formula?

A CH_2

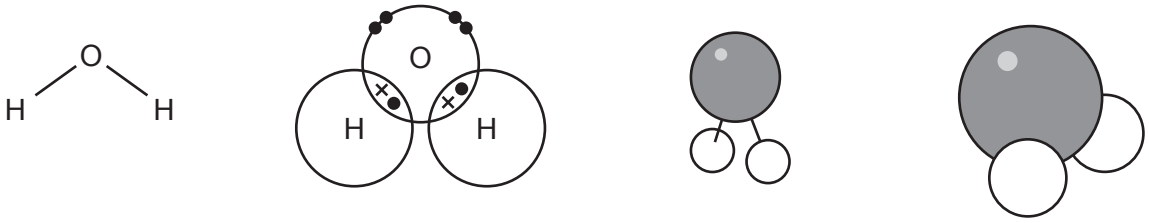
B CH_3

C CH_2CHCH_3

D C_3H_6

Your answer ☐ **[1]**

9 Which statement is true of **all** the diagrams of a water molecule?



A Shows all the atoms

B Shows all the electrons

C Shows the bonds between the atoms

D Shows the movement of the electrons

Your answer ☐ **[1]**

10 Aluminium sulfate contains aluminium ions Al^{3+} and sulfate ions SO_4^{2-}.

What is the formula for aluminium sulfate?

A $AlSO_4$

B $Al(SO_4)_2$

C Al_2SO_4

D $Al_2(SO_4)_3$

Your answer ☐ **[1]**

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11 Where is beryllium found in the Periodic Table?

4 **Be** beryllium 9.0

	Group	Period
A	1	1
B	1	2
C	2	1
D	2	2

Your answer ☐ **[1]**

12 Ethene reacts with bromine to form dibromoethane.

What is the energy change for the reaction?

Energy required to break bonds (kJ / mol)	Energy released from forming bonds (kJ / mol)
2453	2548

A –48 kJ / mol

B –95 kJ / mol

C 95 kJ / mol

D 190 kJ / mol

Your answer ☐ **[1]**

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13 Which of the following reactions does **not** show a neutralisation reaction?

A Magnesium + hydrochloric acid → magnesium chloride + hydrogen

B Magnesium carbonate + hydrochloric acid → magnesium chloride + water + carbon dioxide

C Magnesium hydroxide + hydrochloric acid → magnesium chloride + water

D Magnesium oxide + hydrochloric acid → magnesium chloride + water

Your answer ☐ **[1]**

14 Copper chloride solution is electrolysed.

What is the half equation for the reaction at the **negative electrode (cathode)**?

A $2Cl^- \rightarrow Cl_2 + 2e^-$

B $Cu^{2+} + 2e^- \rightarrow Cu$

C $2H^+ + 2e^- \rightarrow H_2$

D $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

Your answer ☐ **[1]**

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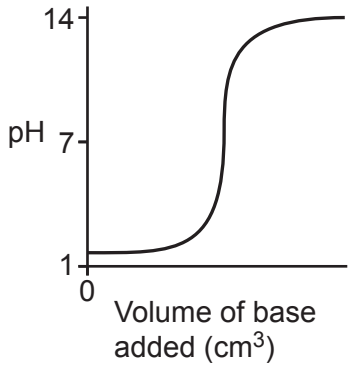
15 Which diagram shows the titration curve when a **weak base** is added to a **strong acid**?

A



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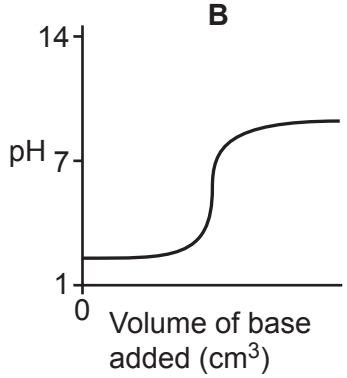

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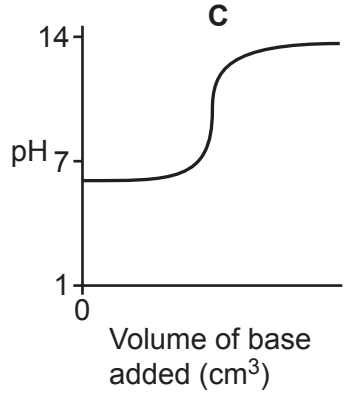

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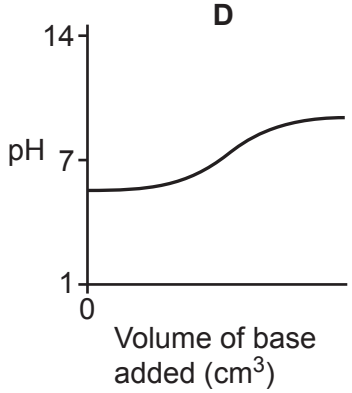

Your answer ☐ **[1]**

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Section B

16 Scientists are developing the use and application of nanoparticles.

(a) The table shows the diameters of four different particles.

Particle	Diameter (nm)
A	97
B	2100
C	11
D	0.73

Which **two** particles are nanoparticles?

..... and .....

Explain your answer.

.....

.....

[2]

(b)
(i) One use of nanoparticles is in medicines.

State **one other** use of nanoparticles.

Explain why they can be used for that purpose.

Use .....

Explanation .....

.....

.....

[2]

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(ii) Some scientists are worried about the risks of using nanoparticles.

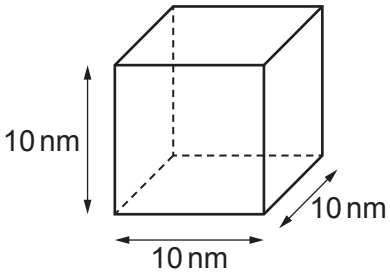
Which statements are risks to humans of using nanoparticles?

Tick (✓) **two** boxes.

- They can block ultraviolet light. ☐
- They can catalyse harmful reactions in the body. ☐
- They can have antibacterial properties. ☐
- They can have toxic effects on the body. ☐
- They have a high surface area to volume ratio. ☐

[2]

(c) A cube-shaped nanoparticle has sides of length 10 nm.



Calculate the surface area to volume ratio of the cube.

Use the equation:

$$\text{Surface area to volume ratio} = \frac{\text{surface area}}{\text{volume}}$$

Surface area to volume ratio = ...**[3]**

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17 This question is about separation techniques.

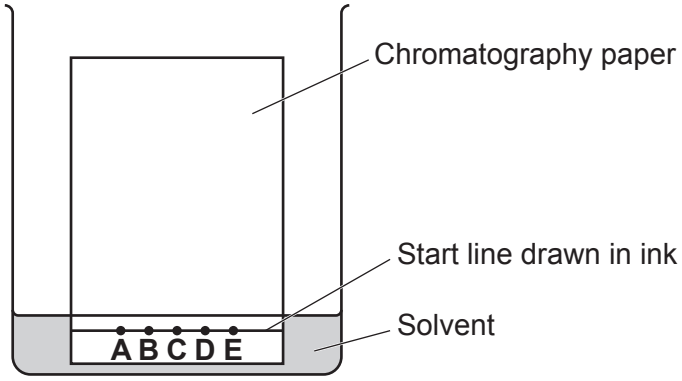
(a) What is meant by a **pure** substance?

.....

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

(b)
(i) A student does a chromatography experiment to separate some dyes.

The diagram shows how they set up their equipment.



The student's experiment will **not** work to separate the dyes.

Suggest **two** changes the student can make so that the experiment will work.

1 .....

2 .....
[2]

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(ii) The student calculates that a dye has an R_f value of 0.67.

The table shows the R_f value of different dyes.

Colour of dye	**R_f value**
Blue	0.15–0.20
Red	0.35–0.40
Pink	0.40–0.80
Yellow	0.75–0.80

Which dye did they use in their experiment?

Explain your answer.

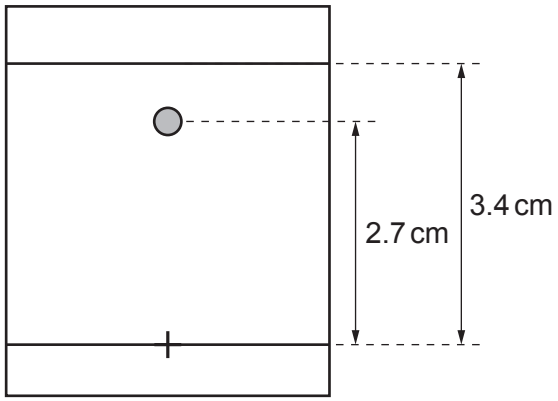
Dye .....

Explanation .....

.....

[2]

(c) The diagram shows a chromatogram for another dye.



Calculate the R_f value of the dye.

Use the equation: $R_f = \frac{\text{distance travelled by the substance}}{\text{distance travelled by the solvent}}$

R_f value = ... **[2]**

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(d) A student separates substance **S** from a mixture of substances **S** and **T**.

The starting mass of the mixture is 9.7 g and they obtain 5.1 g of pure substance **S**.

Calculate the mass of pure substance **S** that could be separated from 15.0 g of the mixture.

Mass of pure substance **S** = ... g **[2]**

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18 A group of students are investigating chemical reactions.

They add magnesium powder to copper sulfate solution.

They predict this will cause an increase in temperature, as they believe the reaction is exothermic.

(a) The students collect the apparatus needed to test their theory.

Describe an experiment the students can do to measure the increase in temperature.

You can include a labelled diagram in your answer.

Optional diagram:

.....

.....

.....

.....

.....

.....

.....

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

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(b) The students do the experiment five times.

The table shows the students' results.

Experiment	Temperature increase (°C)
1	37
2	39
3	53
4	22
5	48

The students' results show that their experiment is **not** repeatable.

Explain why.

.....

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

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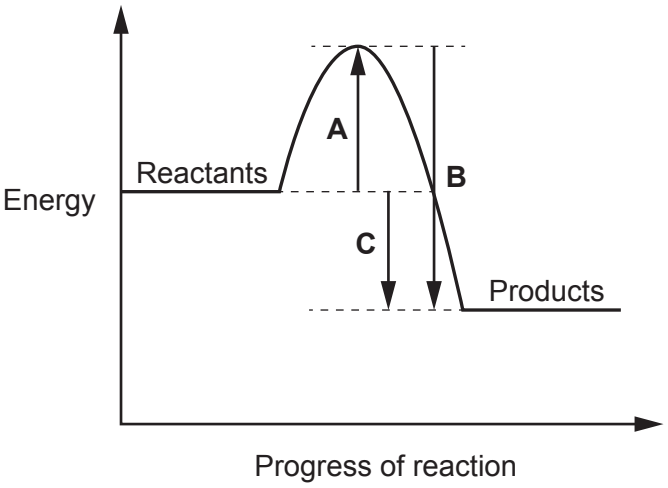
(c) The students draw a reaction profile for the reaction.



(i) Which part of the reaction profile shows the activation energy?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

[1]

(ii) Which part of the reaction profile shows the energy change?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

[1]

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19 Atoms contain three subatomic particles: protons, neutrons and electrons.

(a) The table shows some information about the subatomic particles.

Subatomic particle	Relative mass	Relative charge
Electron	.....	.....
Neutron	1	.....
Proton	1	+1

Complete the table to show the relative mass and relative charge of each subatomic particle. **[3]**

(b) Describe how a lithium atom forms a lithium ion.

.....

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

(c) Lithium exists as two isotopes.

Complete the sentence about isotopes.

Use words from the list.

atom	**electrons**	**element**	**ion**	**neutrons**	**protons**

Isotopes are atoms of the same ..... with the same number of .....

but different numbers of ..... .

[3]

(d) Lithium can bond with fluorine to form lithium fluoride.

Draw the dot and cross diagram to show the bonding in lithium fluoride.

You only need to show the outer shell electrons.

[2]

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(e) A sample of lithium is 11.5 cm wide.

Estimate how many lithium atoms would fit across the width of the sample.

Use your knowledge of the typical radius of atoms in your calculation.

Estimated number of lithium atoms = ... **[3]**

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20* This question is about structure and bonding.

The table shows some information about three different substances.

Substance	Melting point (°C)	Boiling point (°C)	Conducts electricity?
J	734	1435	yes, when molten or in solution
K	–182	–162	no
L	3422	5930	yes

It is also known that substance **L** is malleable.

Identify the type of structure and bonding in each substance.

Explain the properties shown in the table for each substance in terms of the type of structure and bonding.

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

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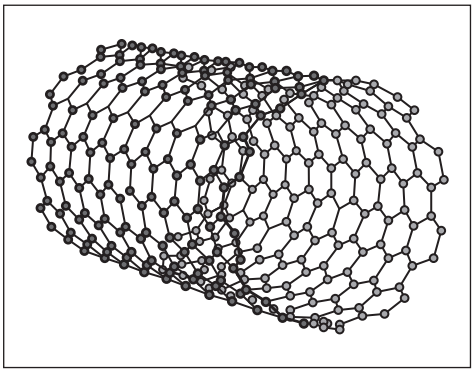
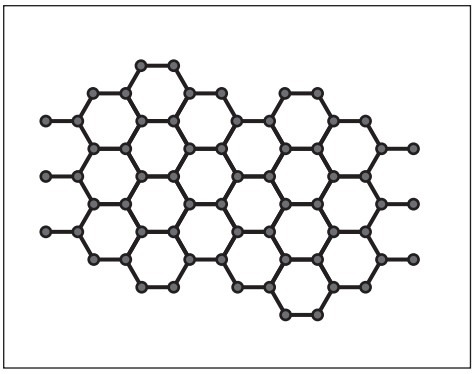
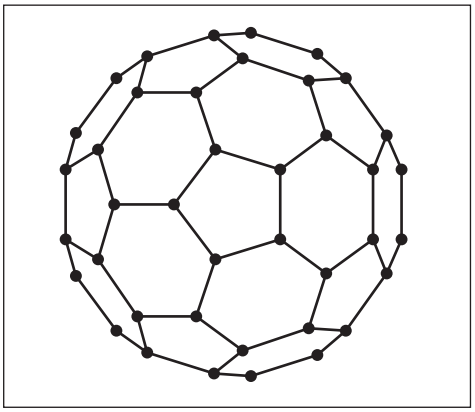
21 This question is about allotropes of carbon.

(a) Draw lines to connect each **allotrope structure** with its correct **name**.

Allotrope structure	**Name**
	Buckminsterfullerene
	Graphene
	Nanotube

[2]

(b) Graphite is used to make electrodes because it conducts electricity and has a high melting point.

(i) Explain why graphite conducts electricity.

.....

.....

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

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(ii) Explain why graphite has a high melting point.

Use ideas about structure and bonding in your answer.

.....

.....

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

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22 A student reacts solid calcium carbonate, $CaCO_3$, with nitric acid, HNO_3.

Calcium nitrate, $Ca(NO_3)_2$, carbon dioxide and water are made.

Calcium nitrate is soluble in water.

(a) Write the **balanced symbol** equation for the reaction.

Include state symbols.

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

(b) The student measures the volume of carbon dioxide every 10 seconds.

Table 22.1 shows the student's results.

Table 22.1

Time (s)	Volume of carbon dioxide (cm^3)
0	0
10	15
20	31
30	
40	45
50	47
60	47

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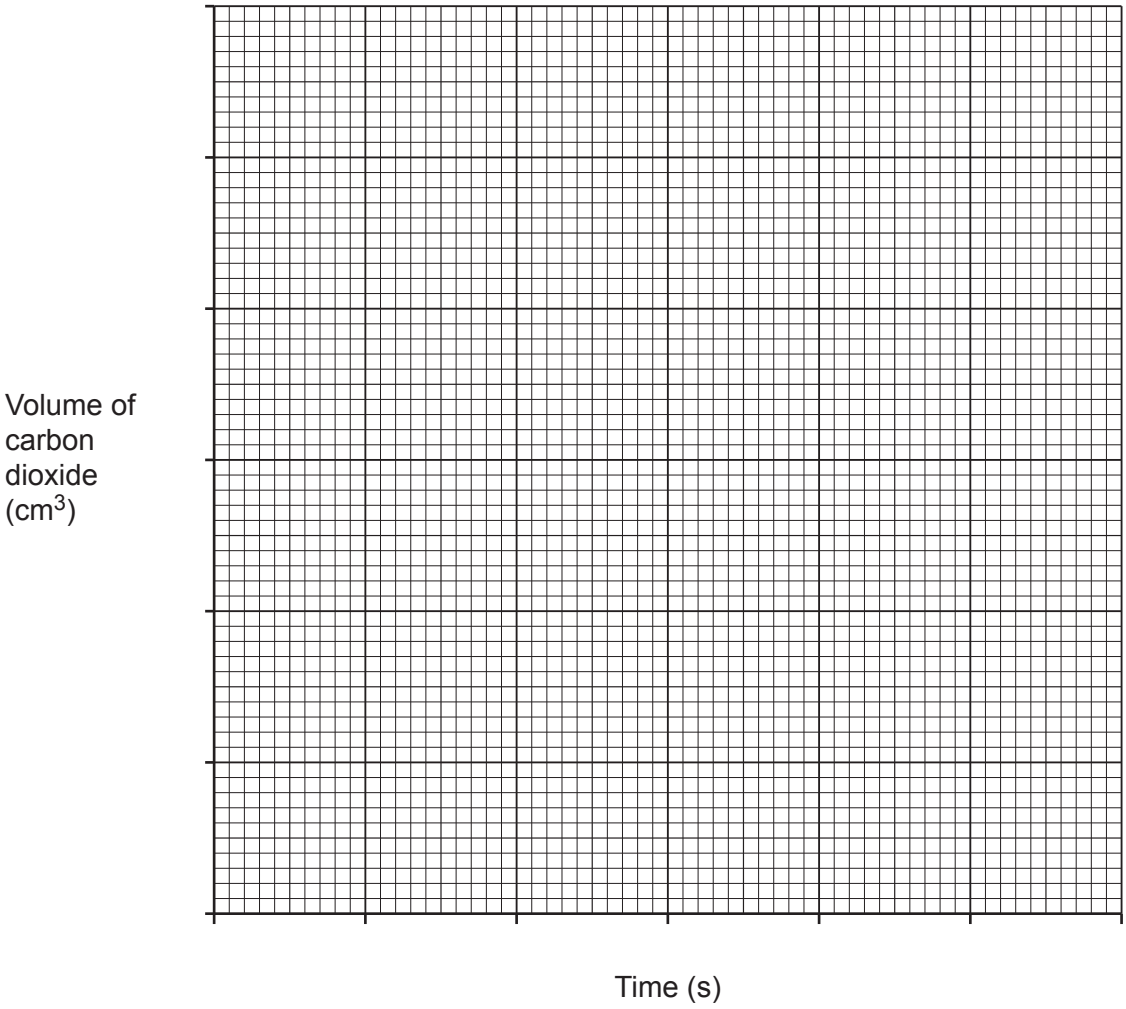
(i) Plot the results on the graph.



[3]

(ii) Draw a curve of best fit. **[1]**

(iii) Use the graph to estimate the volume of carbon dioxide that has been made after 30 seconds.

Volume of carbon dioxide after 30 seconds = ... cm^3 **[1]**

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(c) The student repeats the experiment with a different concentration of nitric acid.

Table 22.2 shows the results of both experiments.

Table 22.2

Time (s)	Volume of carbon dioxide (cm^3)	
	Experiment 1	**Experiment 2**
0	0	0
10	15	21
20	31	39
30		41
40	45	47
50	47	47
60	47	47

Which experiment had the **higher** concentration of acid?

Explain your answer.

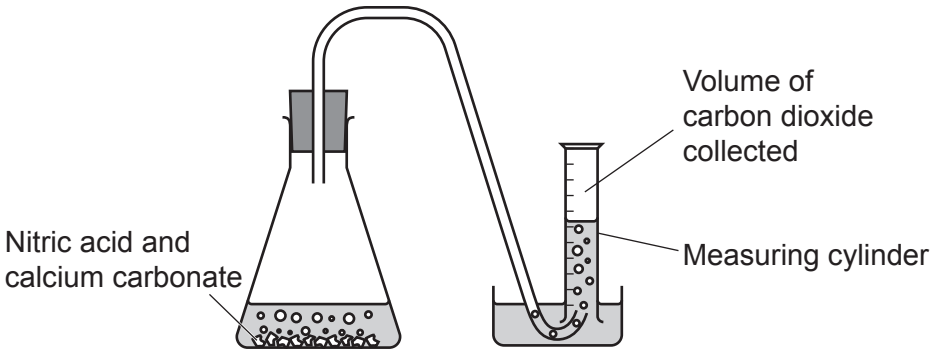
Experiment .....

Explanation .....

.....

[2]

(d) The diagram shows the apparatus the student uses.



Suggest another piece of equipment that could be used to measure the volume of carbon dioxide.

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

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(e) Calcium nitrate, $Ca(NO_3)_2$, can also be made in the reaction between calcium and nitric acid.

$Ca + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2$

60 g of calcium reacts with excess nitric acid.

Calculate the mass of calcium nitrate made.

Relative atomic mass (A_r): Ca = 40.1 N = 14.0 O = 16.0

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

Mass of calcium nitrate made = ... g **[4]**

(f) **Table 22.3** shows the hydrogen ion concentration and the pH for two different acids.

Table 22.3

Acid	**Hydrogen ion concentration (mol/dm^3)**	**pH**
Hydrochloric acid	1.0×10^{-1}	1.0
	.....	2.0
Sulfuric acid	2.0×10^{-1}	.....
	2.0×10^{-3}	2.7

Complete **Table 22.3**. **[2]**

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23 Chromium is a shiny transition metal.

(a) The equation shows the displacement reaction between aluminium and chromium oxide.

$2Al(s) + Cr_2O_3(s) \rightarrow Al_2O_3(s) + 2Cr(s)$

Calculate the mass of chromium oxide needed to make 1 mol of chromium.

Relative atomic mass (A_r): Cr = 52.0 O = 16.0

Mass of chromium oxide = ... g **[3]**

(b) Calculate the mass of **one** atom of chromium.

Relative atomic mass (A_r): Cr = 52.0

Avogadro constant = 6.02×10^{23}

Mass of one atom of chromium = ... g **[2]**

(c) Chromium is used for electroplating.

Chromium atoms lose electrons at the anode.

Chromium ions, Cr^{3+}, gain electrons at the cathode.

Write **balanced** half equations to show the reactions at each electrode.

Anode .....

Cathode .....

[4]

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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