Rate of Reaction

Question Paper 1

Level	GCSE (9-1)
Subject	Combined Science: Trilogy - Chemistry
Exam Board	AQA
Topic	5.6 Rate + Extent Chemical Change
Sub-Topic	Rate of Reaction
Difficulty Level	Gold Level
Booklet	Question Paper 1

Time Allowed: **55 minutes**

Score: **/55**

Percentage: **/100**

Grade Boundaries:

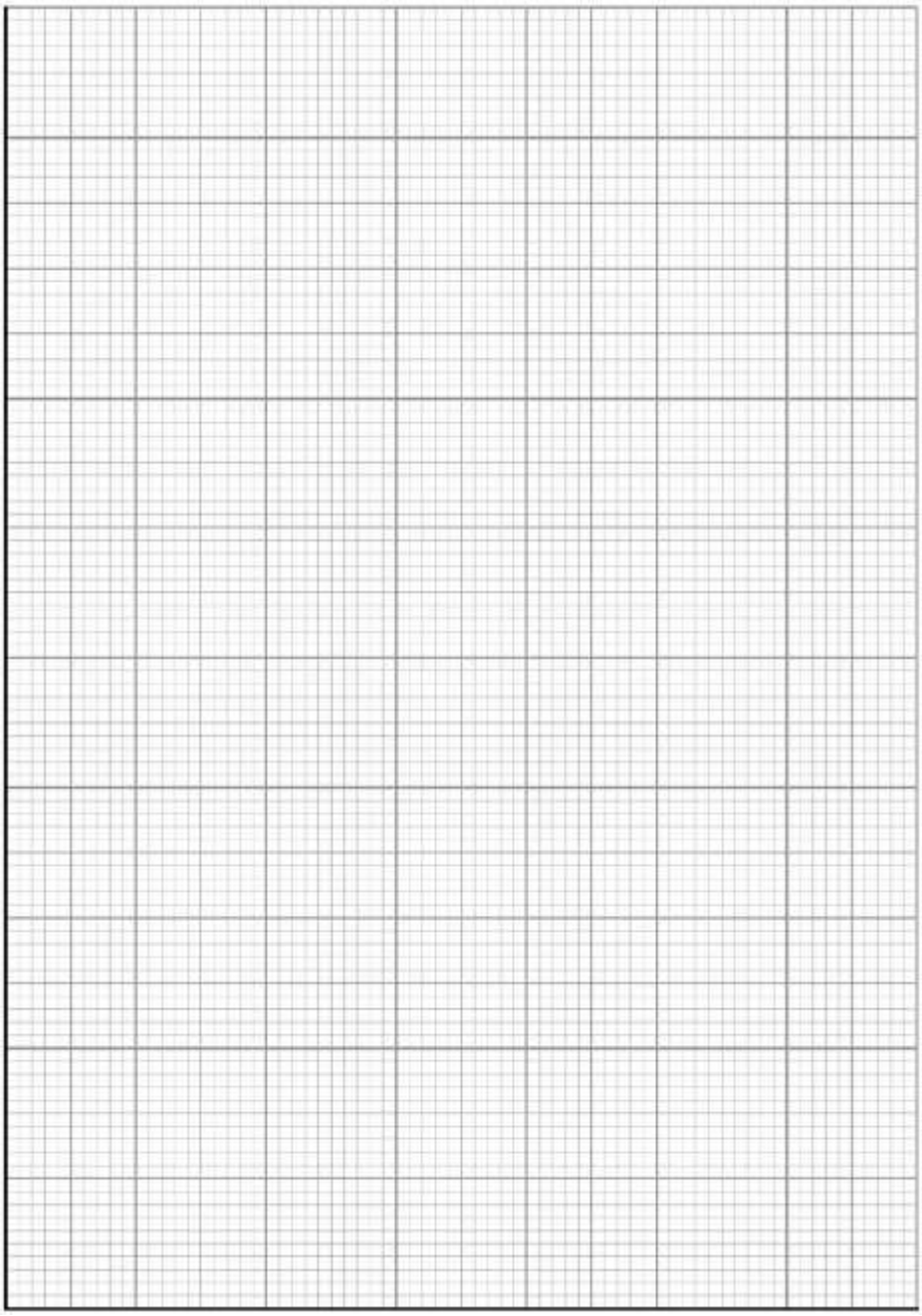
Q1. Ammonium nitrate (NH_4NO_3) is produced by reacting ammonia with nitric acid.

A student measured the mass of ammonium nitrate that dissolves in 100 cm^3 of water at different temperatures.

The table below shows the student's results.

Temperature in °C	0	20	40	60	80	100
Mass of ammonium nitrate in g that dissolves in 100 cm^3 water	119	190	286	321	630	1 024

(a) Use the table above to plot a graph of the solubility of ammonium nitrate on the figure below.



(4)

(b) At 20 °C, 190 g of ammonium nitrate dissolves in 100 cm^3 of water.

Calculate the amount of ammonium nitrate (in moles) that dissolves in 1 dm^3 of water at 20 °C.

Relative atomic masses (A_r): H = 1; N = 14; O = 16

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Amount of dissolved ammonium nitrate = ... mol

(3)

(c) Farmers use ammonium nitrate as a fertiliser.

Farmers want to slow down the rate at which ammonium nitrate fertiliser dissolves in the water in the soil.

Suggest why they spread the fertiliser in the form of small beads instead of a fine powder.

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(2)

(d) Ammonia is needed to make ammonium nitrate.

The reaction used to make ammonia is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

At equilibrium, about 35% of the nitrogen and hydrogen are converted to ammonia at
450 °C and 200 atmospheres pressure.

Explain the effects of increasing the temperature, or increasing the pressure, on the amount of ammonia produced at equilibrium.

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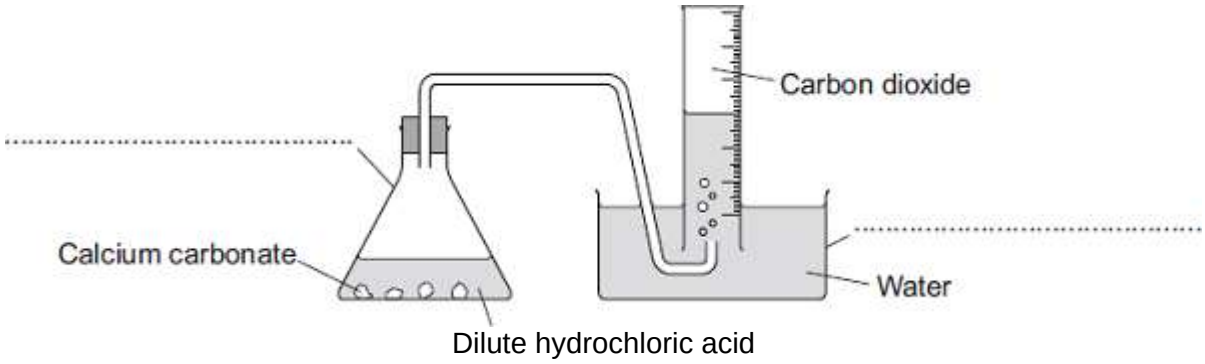
(4)
(Total 13 marks)

Q2. Some students were investigating the rate at which carbon dioxide gas is produced when metal carbonates react with an acid.

One student reacted 1.00 g of calcium carbonate with 50 cm^3, an excess, of dilute hydrochloric acid.

The apparatus used is shown in **Diagram 1**.

Diagram 1



(a) Complete the **two** labels for the apparatus on the diagram.

(2)

(b) The student measured the volume of gas collected every 30 seconds.

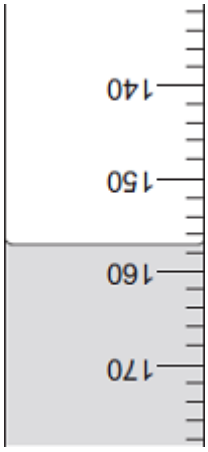
The table shows the student's results.

Time in seconds	**Volume of carbon dioxide collected in cm^3**
30	104

60	
90	198
120	221
150	232
180	238
210	240
240	240

(i) **Diagram 2** shows what the student saw at 60 seconds.

Diagram 2



What is the volume of gas collected?

Volume of gas = ... cm^3

(1)

(ii) Why did the volume of gas stop changing after 210 seconds?

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(1)

(c) Another student placed a conical flask containing 1.00 g of a Group 1 carbonate (M_2CO_3) on a balance.

He then added 50 cm^3, an excess, of dilute hydrochloric acid to the flask and measured the mass of carbon dioxide given off.

The equation for the reaction is:

$$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$$

The final mass of carbon dioxide given off was 0.32 g.

(i) Calculate the amount, in moles, of carbon dioxide in 0.32 g carbon dioxide.

Relative atomic masses (A_r): C = 12; O = 16

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Moles of carbon dioxide = ... moles

(2)

(ii) How many moles of the metal carbonate are needed to make this number of moles of carbon dioxide?

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Moles of metal carbonate = ... moles

(1)

(iii) The mass of metal carbonate used was 1.00 g.

Use this information, and your answer to part **(c) (ii)**, to calculate the relative formula mass (M_r) of the metal carbonate.

If you could not answer part **(c) (ii)**, use 0.00943 as the number of moles of metal carbonate. This is **not** the answer to part **(c) (ii)**.

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Relative formula mass (M_r) of metal carbonate = ...

(1)

(iv) Use your answer to part **(c) (iii)** to calculate the relative atomic mass (A_r) of the metal in the metal carbonate (M_2CO_3) and so identify the Group 1 metal in the

metal carbonate.

If you could not answer part **(c) (iii)**, use 230 as the relative formula mass of the metal carbonate. This is **not** the answer to part **(c) (iii)**.

To gain full marks, you must show your working.

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Relative atomic mass of metal is .....

Identity of metal .....

(3)

(d) Two other students repeated the experiment in part **(c)**.

(i) When the first student did the experiment some acid sprayed out of the flask as the metal carbonate reacted.

Explain the effect this mistake would have on the calculated relative atomic mass of the metal.

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(3)

(ii) The second student used 100 cm^3 of dilute hydrochloric acid instead of 50 cm^3.

Explain the effect, if any, this mistake would have on the calculated relative atomic mass of the metal.

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(3)
(Total 17 marks)

Q3. A company manufactures ethanol (C_2H_5OH).

The reaction for the process is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ per mole}$$

The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.

(a) Explain what is meant by equilibrium.

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(3)

(b) (i) How would increasing the temperature change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(ii) How would increasing the pressure change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(c) A catalyst is added to increase the rate of the reaction.

Explain how adding a catalyst increases the rate of a chemical reaction.

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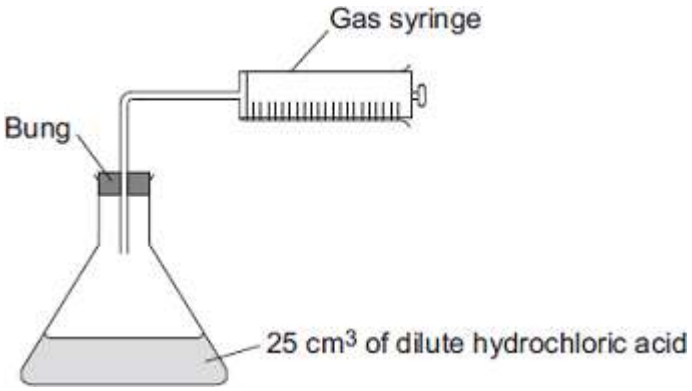
(2)
(Total 9 marks)

Q4.A student investigated the reaction between magnesium metal and dilute hydrochloric acid.

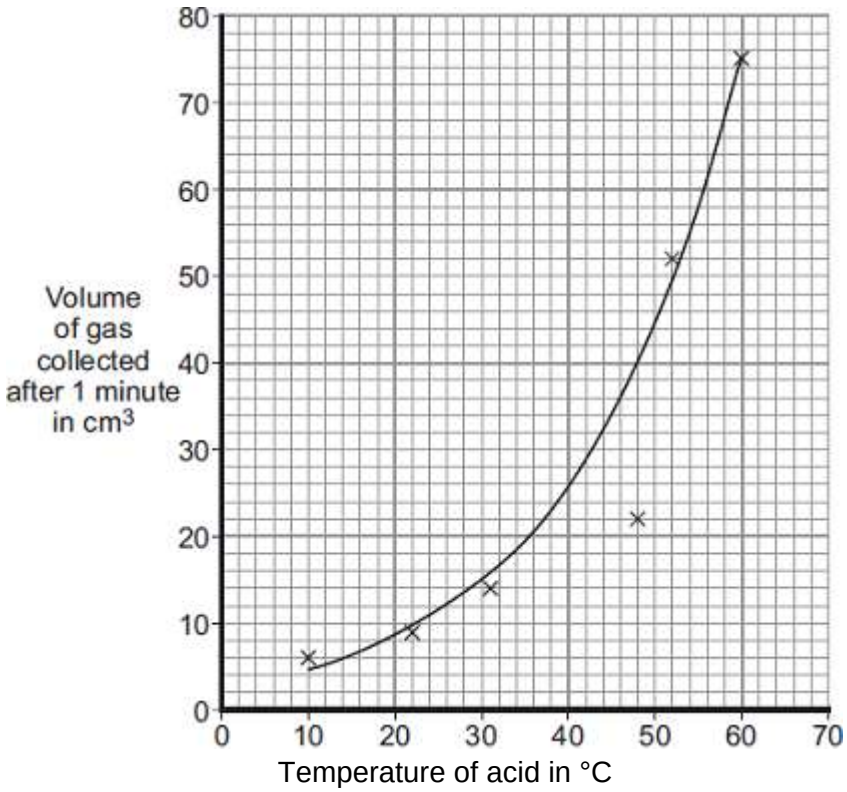
The student placed 25 cm^3 of dilute hydrochloric acid in a conical flask and set up the apparatus as shown in the diagram.



The student:

- took the bung out of the flask and added a single piece of magnesium ribbon 8 cm long
- put the bung back in the flask and started a stopwatch
- recorded the volume of gas collected after 1 minute
- repeated the experiment using different temperatures of acid.

The student plotted his results on a graph.



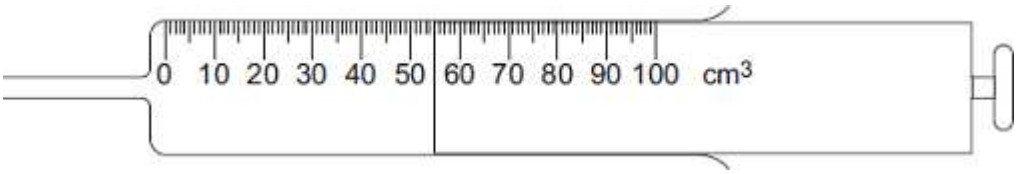
(a) Write the correct state symbols in the equation.

Choose from (s) for solid, (l) for liquid, (g) for gas and (aq) for aqueous.

$Mg\ (....) + 2\ HCl\ (....) \longrightarrow MgCl_2\ (....) + H_2\ (....)$

(2)

(b) The diagram shows a gas syringe after 1 minute.



(i) What volume of gas has been collected in the gas syringe after 1 minute?

Volume = ... cm^3

(1)

(ii) Use the graph to determine the temperature of the acid used in this experiment.

Temperature = ... °C

(1)

(iii) Calculate the average rate of reaction, in cm^3 of hydrogen made per second (cm^3/s), for this experiment.

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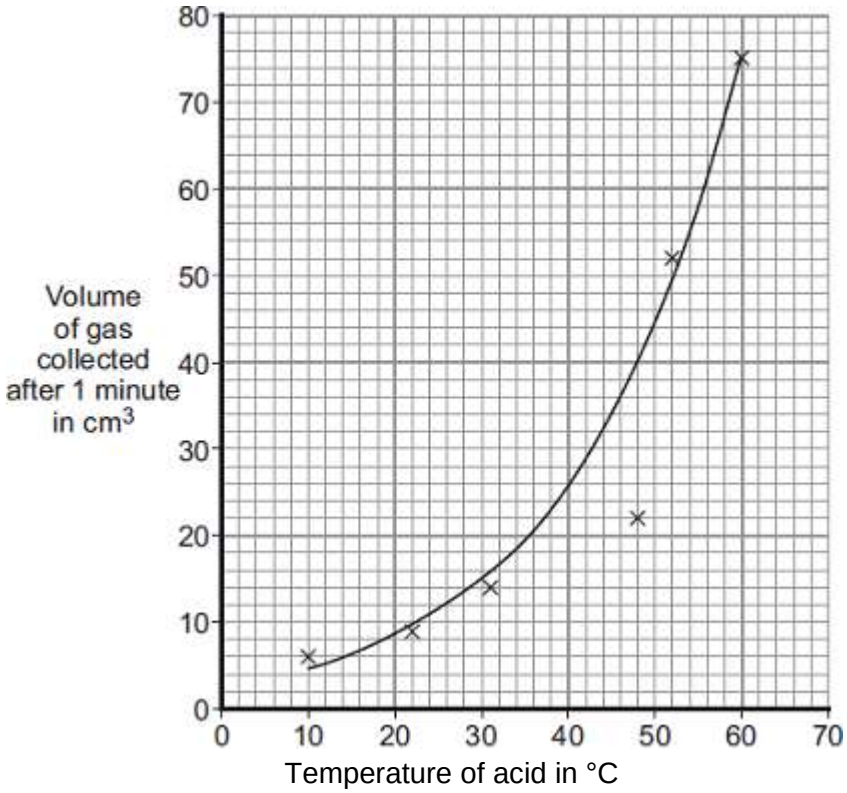
Rate of reaction = ... cm^3/s

(2)

(c) The student's graph has been reprinted to help you answer this question.



One of the results on the graph is anomalous.

(i) Draw a circle on the graph around the anomalous point.

(1)

(ii) Suggest what may have happened to cause this anomalous result.

Explain your answer.

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(2)

(d) Explain how the student could improve the accuracy of the volume of gas recorded at each temperature.

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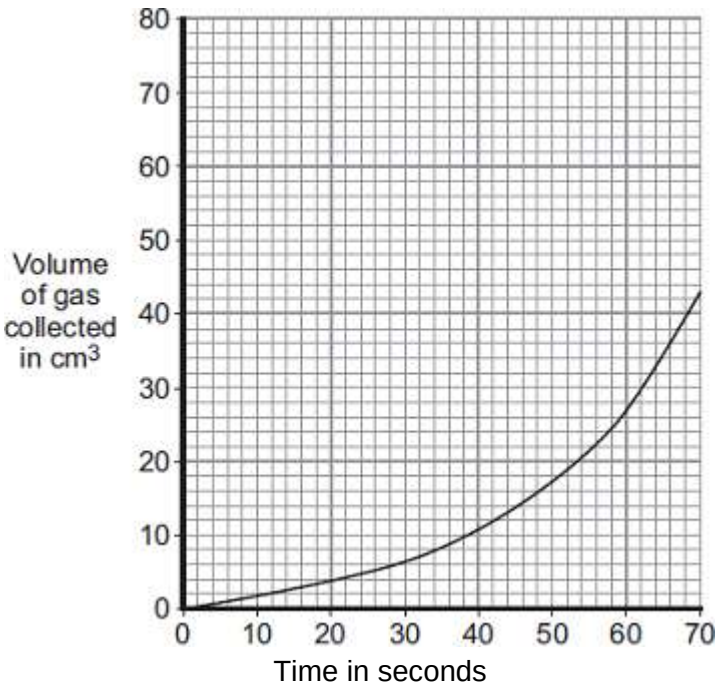
(3)

(e) The student then used the same apparatus to measure the volume of gas produced every 10 seconds at 40 °C.

The student's results are shown on the graph.



The rate at which the gas was produced got faster over the first 60 seconds.

The student's teacher gave two possible explanations of why the reaction got faster.

Explanation 1
There was a layer of magnesium oxide on the surface of the magnesium.
The layer of magnesium oxide prevented the magnesium reacting with the acid.
As the magnesium oxide reacted slowly with the acid, the magnesium was exposed

to the acid and hydrogen gas was produced.

Explanation 2
The reaction is exothermic, and so the temperature of the acid increased during the reaction.

(i) Describe further experimental work the student could do to see if **Explanation 1** is correct.

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(2)

(ii) Describe further experimental work the student could do to see if **Explanation 2** is correct.

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(2)
(Total 16 marks)