AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.6.1.1

Calculating rates of reactions

Past-paper questions

Tier	**Higher**
Question groups	**9**
Available paper years	**2018–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

5.6.1.1 Calculating rates of reactions

Question 01

June 2018 | 8464/C/2H | Original Q5

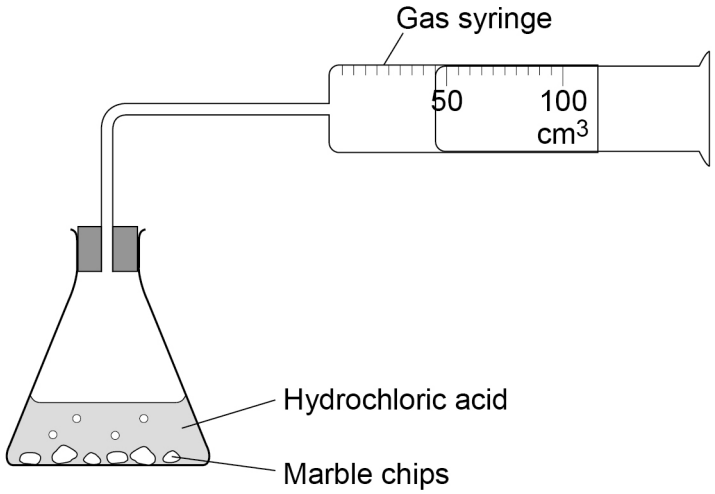
0 5 A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10 g of marble chips into the flask.
2. Add 50 cm^3 of hydrochloric acid, connect the gas syringe and start a timer.
3. Record the volume of gas produced every 10 seconds.

Figure 4 shows the apparatus.

Figure 4



0 5 . 1 Complete the equation for the reaction.

[2 marks]

$CaCO_3$ + ____ HCl → _____

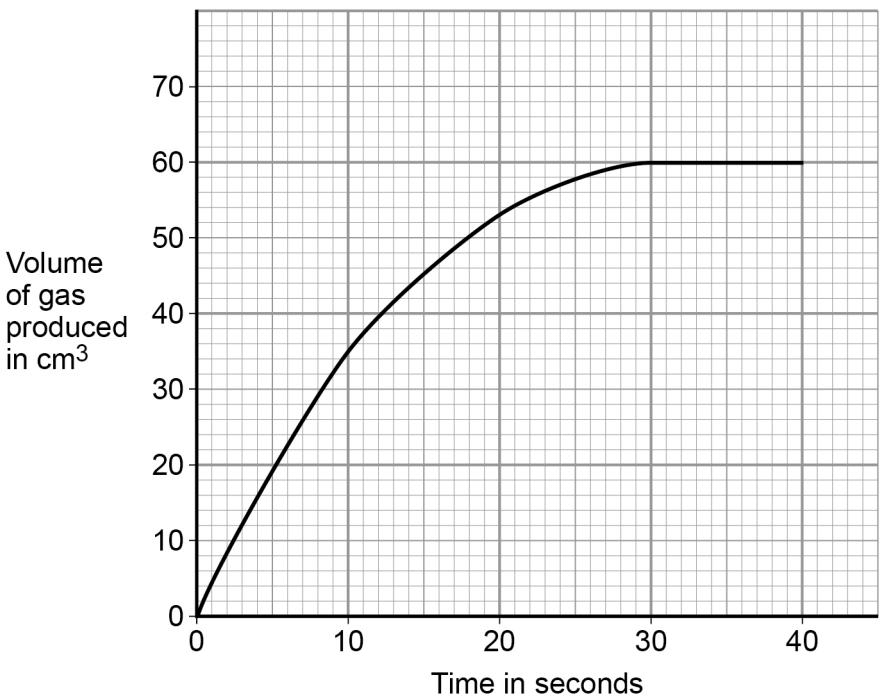
Question 5 continues on the next page

5.6.1.1 Calculating rates of reactions

Question 01 · continued

Figure 5 shows the student's results.

Figure 5



0 5 . 2 Describe the trend shown in **Figure 5**

Use values in your answer.

[3 marks]

5.6.1.1 Calculating rates of reactions

Question 01 · continued

0 5 . 3 Describe how you would use **Figure 5** to find the rate of the reaction at 15 seconds.

You do **not** need to do a calculation.

[2 marks]

0 5 . 4 Give the units for the rate of this reaction.

[1 mark]

Table 3 shows the results of the investigation.

Table 3

Relative size of marble chips	Volume of gas produced in cm^3 after given time in seconds					
	10 s	**20 s**	**30 s**	**40 s**	**50 s**	**60 s**
Small	35	53	60	60	60	60
Medium	21	39	51	58	60	60
Large	14	29	39	48	58	60

0 5 . 5 Give **one** conclusion about how the size of the marble chips affects the rate of the reaction.

[1 mark]

0 5 . 6 Suggest why all three sizes of marble chips produce a maximum volume of 60 cm^3 of gas.

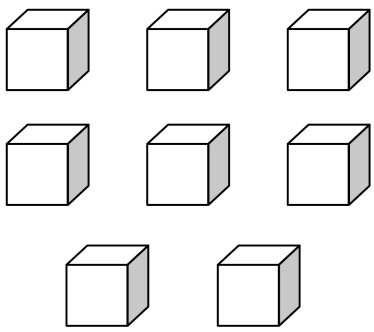
[1 mark]

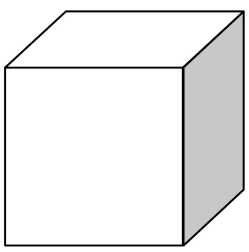
5.6.1.1 Calculating rates of reactions

Question 01 · continued

0 5 . 7 **Figure 6** shows eight small cubes, each 1 cm x 1 cm x 1 cm, and one large cube, 2 cm x 2 cm x 2 cm

Figure 6





Total volume of small cubes = 8 cm^3

Volume of large cube = 8 cm^3

Total surface area of small cubes = 48 cm^2

Calculate the surface area of the large cube.

[2 marks]

Surface area of the large cube = _____ cm^2

0 5 . 8 Explain why the size of the marble chips affects the rate of the reaction.

Give your answer in terms of 'collision theory'.

[2 marks]

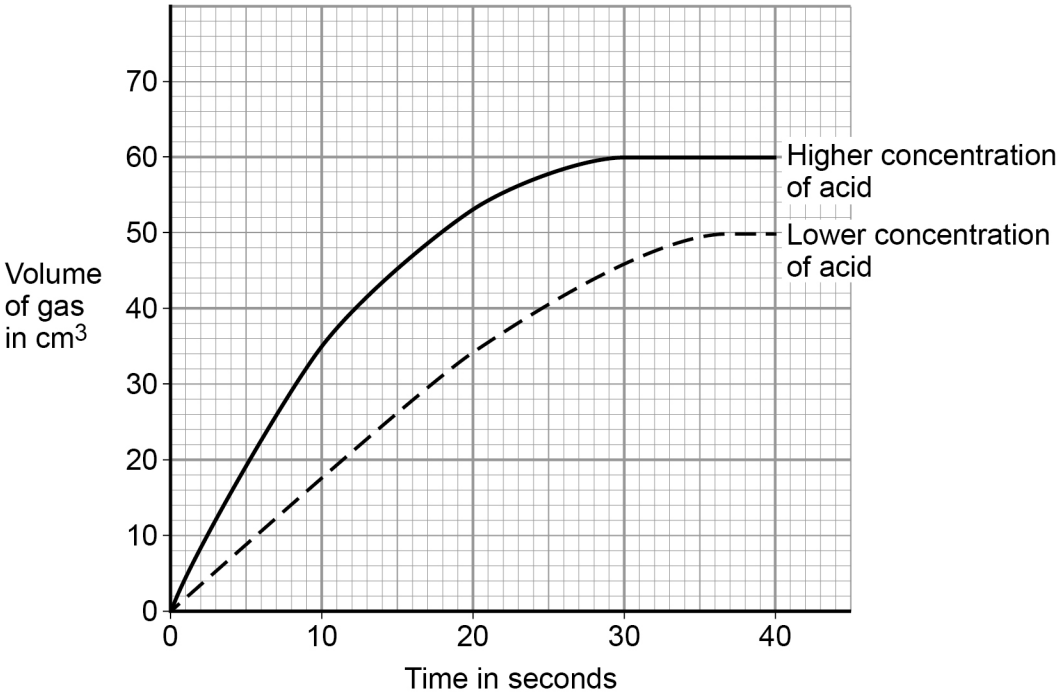
5.6.1.1 Calculating rates of reactions

Question 01 · continued

0 5 . 9 The student repeated the investigation with small marble chips using hydrochloric acid with a lower concentration.

Figure 7 shows the volume of gas produced during the first 40 seconds.

Figure 7



Explain why the results for the lower concentration of acid are different from the results for the higher concentration of acid.

[3 marks]

17

5.6.1.1 Calculating rates of reactions

Question 02

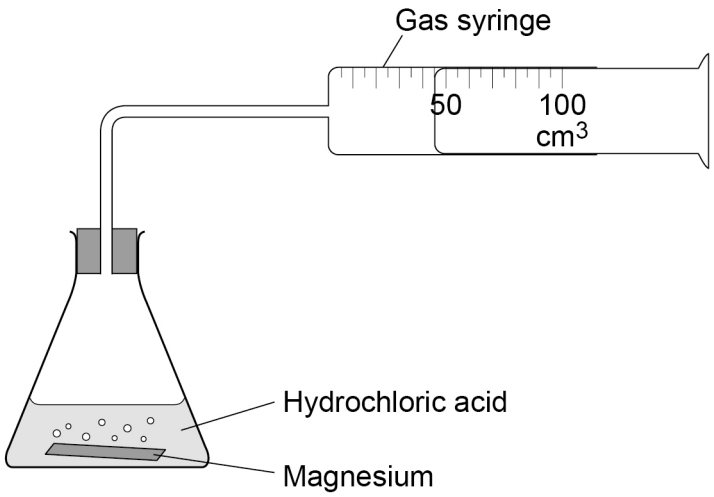
June 2019 | 8464/C/2H | Original Q5

0 5 This question is about magnesium.

A student investigated the rate of the reaction between magnesium and hydrochloric acid.

Figure 2 shows the apparatus.

Figure 2



0 5 . 1 Which is the correct ionic equation for the reaction?

[1 mark]

Tick (✓) **one** box.

$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ ☐

$Mg^{2+} + 2Cl^- \rightarrow MgCl_2$ ☐

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ ☐

$Mg^+ + Cl^- \rightarrow MgCl$ ☐

5.6.1.1 Calculating rates of reactions

Question 02 · continued

0 5 . 2 What happens in the reaction between magnesium and hydrochloric acid?

[1 mark]

Tick (✓) **one** box.

Electron sharing ☐

Electron transfer ☐

Proton transfer ☐

Question 5 continues on the next page

0 5 . 3 **Table 2** shows the student's results.

Table 2

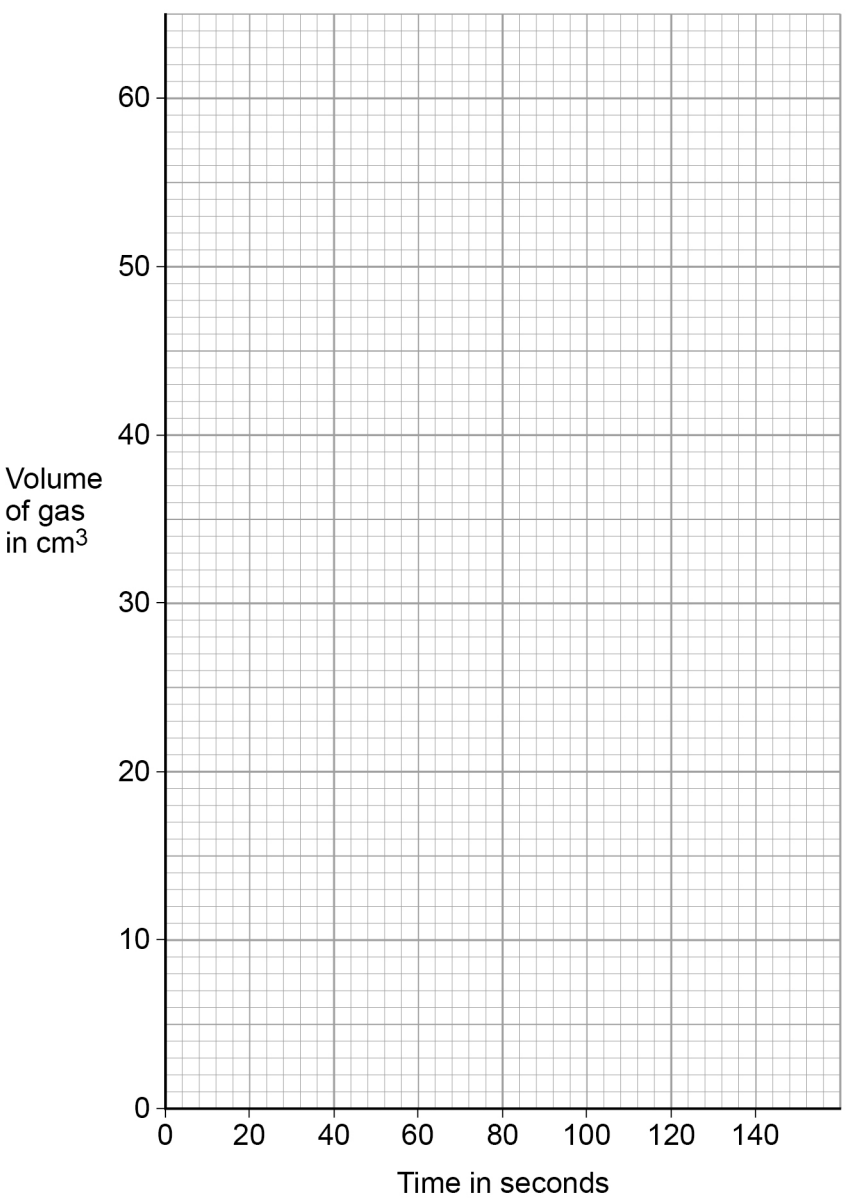
Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm^3	0.0	12.5	36.0	43.5	59.0	60.0	60.0

Plot the data from **Table 2** on **Figure 3**.

Draw a line of best fit.

[3 marks]

Figure 3



5.6.1.1 Calculating rates of reactions

Question 02 · continued

June 2019 | 8464/C/2H | Original Q5

0 5 . 4 Describe the changes in the rate of this reaction.

[3 marks]

0 5 . 5 Explain why the rate of this reaction changes.

Give your answer in terms of collision theory.

[3 marks]

11

5.6.1.1 Calculating rates of reactions

Question 03

November 2020 | 8464/C/2H | Original Q2

0 2 Some students investigated the effect of temperature on the rate of reaction.

0 2 . 1 The students reacted sodium thiosulfate solution with hydrochloric acid.

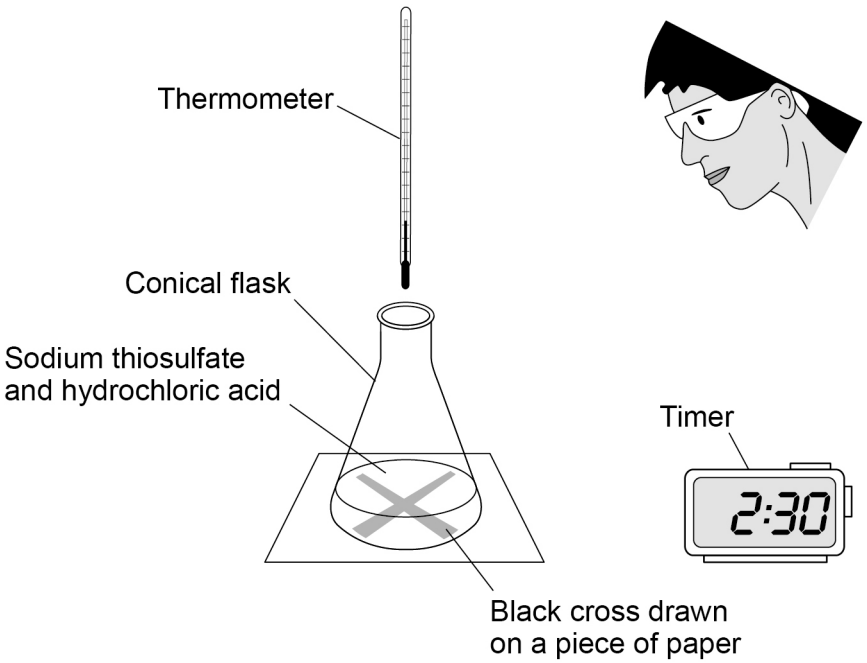
This is the method used.

1. Use a beaker to measure 50 cm^3 of heated sodium thiosulfate solution into a conical flask.
2. Measure the temperature of the room.
3. Put the conical flask on a black cross drawn on a piece of paper.
4. Start a timer.
5. Use the same beaker to measure 10 cm^3 of hydrochloric acid into the conical flask.
6. Stop the timer when the cross is no longer visible.

The students repeated the experiment at a different room temperature.

Figure 1 shows the apparatus.

Figure 1



5.6.1.1 Calculating rates of reactions

Question 03 · continued

The method contains errors and does **not** produce accurate results.

Describe a method the students should use to produce accurate results.

You do **not** need to write about safety precautions.

[6 marks]

Question 2 continues on the next page

5.6.1.1 Calculating rates of reactions

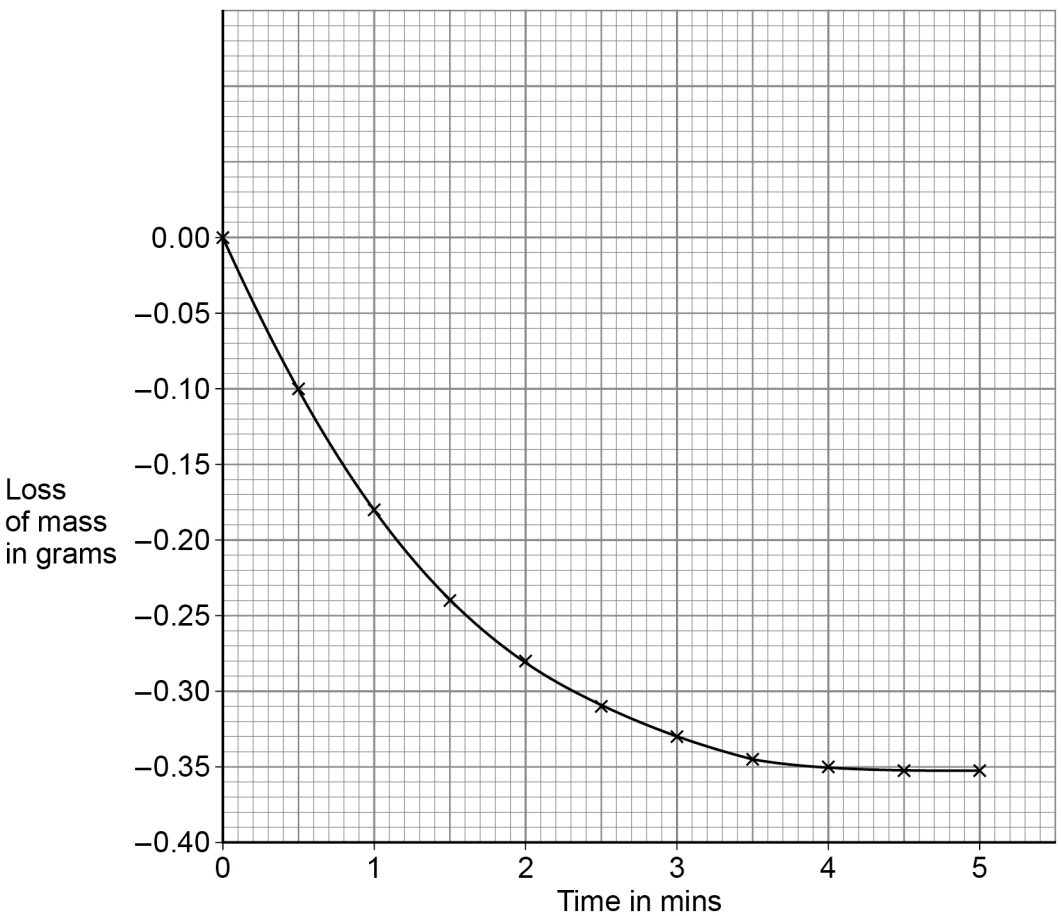
Question 03 · continued

Some students investigated the effect of temperature on the rate of a different reaction.

They recorded the loss of mass from their apparatus at 40 °C

Figure 2 shows the results.

Figure 2



5.6.1.1 Calculating rates of reactions

Question 03 · continued

0 2 . 2 Calculate the mean rate of reaction between 1 minute and 3 minutes at 40 °C

Use **Figure 2** and the equation:

$$\text{Mean rate of reaction} = \frac{\text{change in mass of gas in g}}{\text{time in mins}}$$

[3 marks]

Mean rate of reaction = _____ g/min

0 2 . 3 Draw a curve on **Figure 2** for the results you would expect at a temperature of 50 °C instead of 40 °C

[2 marks]

11

5.6.1.1 Calculating rates of reactions

Question 04

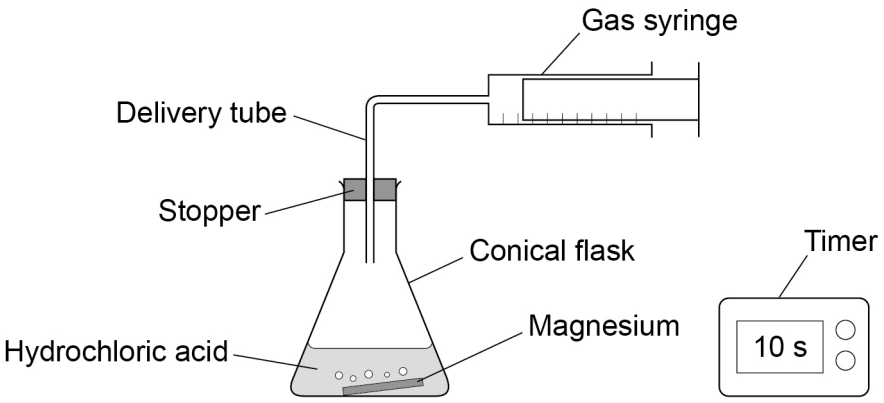
November 2021 | 8464/C/2H | Original Q1

outsid
bo

0 1 A student investigated the reaction between magnesium and excess hydrochloric acid.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Pour 50 cm^3 of hydrochloric acid into a conical flask.

2. Add a piece of magnesium.

3. Insert stopper and delivery tube and start a timer.

4. Collect the gas produced in a gas syringe.

5. Record the volume of gas produced every 20 seconds for 2 minutes.

6. Repeat steps 1 to 5 with higher concentrations of hydrochloric acid.

0 1 . 1 Give the independent variable and **one** control variable in this investigation.

[2 marks]

Independent variable _____

Control variable _____

Question 1 continues on the next page

5.6.1.1 Calculating rates of reactions

Question 04 · continued

Table 1 shows the results from the first experiment using hydrochloric acid with a low concentration.

Table 1

Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm^3	0	48	72	90	97	98	98

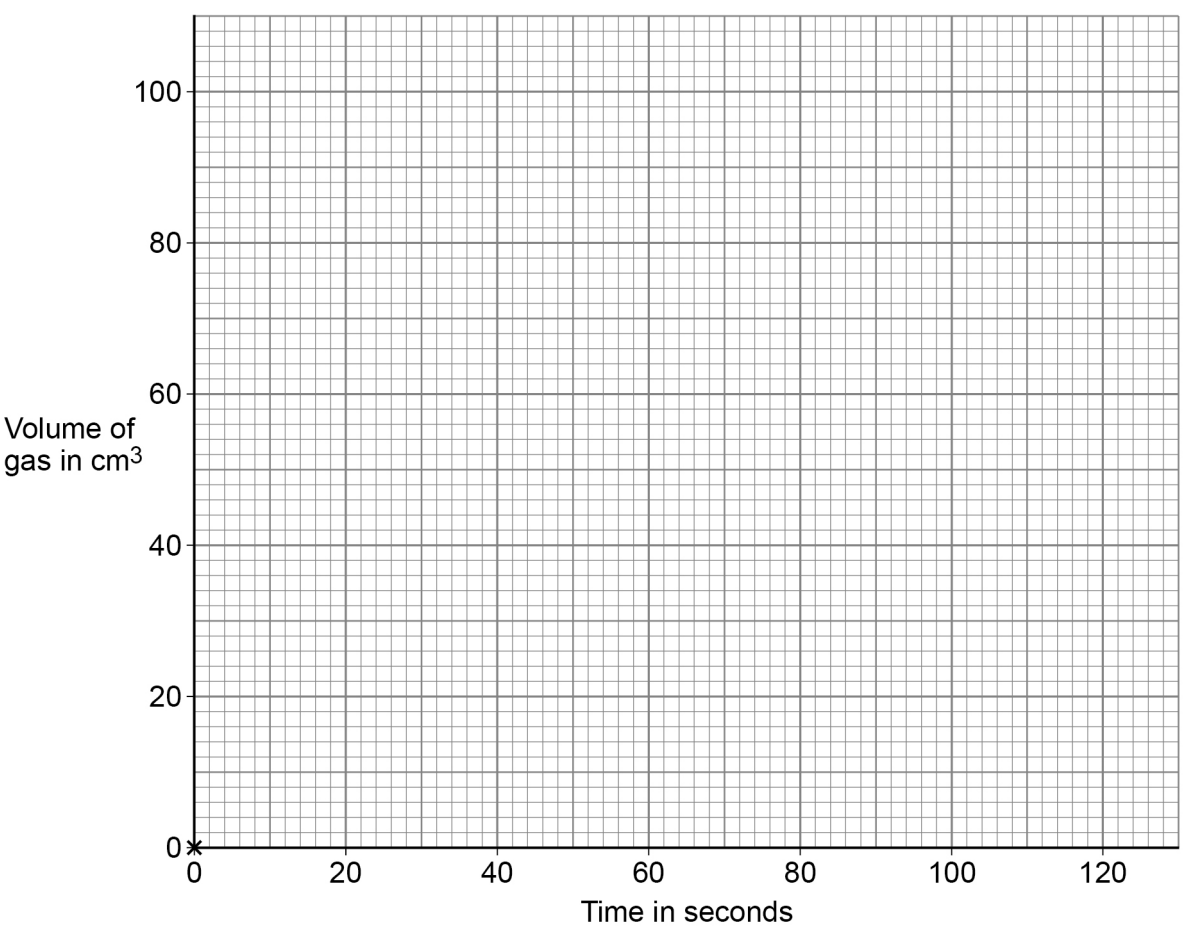
0 1 . 2 Complete **Figure 2**.

You should:

- plot the data from **Table 1** (the point 0,0 has been plotted for you)
- draw a line of best fit.

[3 marks]

Figure 2



5.6.1.1 Calculating rates of reactions

Question 04 · continued

0 1 . 3 How does the **rate** of this reaction change with time?

Use **Table 1**.

[1 mark]

Tick (✓) **one** box.

The rate decreases. ☐

The rate stays the same. ☐

The rate increases. ☐

0 1 . 4 The student repeated the experiment using hydrochloric acid with a higher concentration.

Which statement is correct?

[1 mark]

Tick (✓) **one** box.

The activation energy for the reaction was higher. ☐

The magnesium reacted more quickly. ☐

The reaction finished at the same time. ☐

The total volume of gas collected was smaller. ☐

Question 1 continues on the next page

5.6.1.1 Calculating rates of reactions

Question 04 · continued

0 1 . 5 Temperature also affects the rate of the reaction.

Explain how increasing the temperature affects the **rate** of the reaction.

You should refer to particles and collisions.

[3 marks]

10

5.6.1.1 Calculating rates of reactions

Question 05

0 3 This question is about the reaction between sodium thiosulfate solution and hydrochloric acid.

The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$$

0 3 . 1 The mass of the conical flask and contents was greater at the start of the reaction than at the end.

Explain why.

[2 marks]

Question 3 continues on the next page

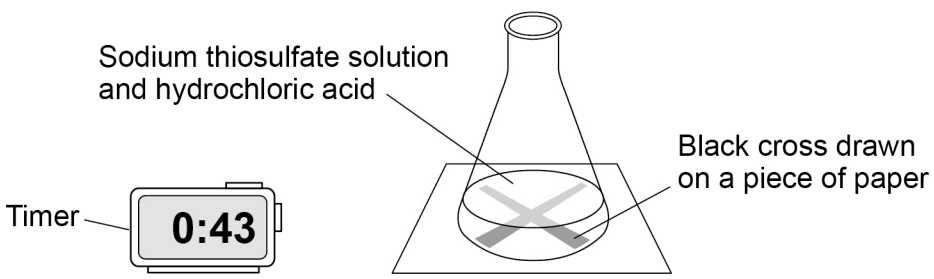
Question 05 · continued

A teacher demonstrated the reaction between sodium thiosulfate solution and hydrochloric acid.

Figure 3 shows the experiment.

The experiment was done in a fume cupboard.

Figure 3



This is the method the teacher used.

1. Pour 50 cm^3 of sodium thiosulfate solution into a conical flask.

2. Put the conical flask on a black cross drawn on a piece of paper.

3. Pour 10 cm^3 of hydrochloric acid into the conical flask and start a timer.

4. Stop the timer when the cross can no longer be seen.

5. Repeat the experiment at different temperatures.

0 3 . 2 What type of variable is time in this reaction?

[1 mark]

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

5.6.1.1 Calculating rates of reactions

Question 05 · continued

0 3 . 3 **Table 1** shows the results.

Table 1

Temperature in °C	Time in seconds
19	82
32	48
45	43
52	15
63	7
73	3

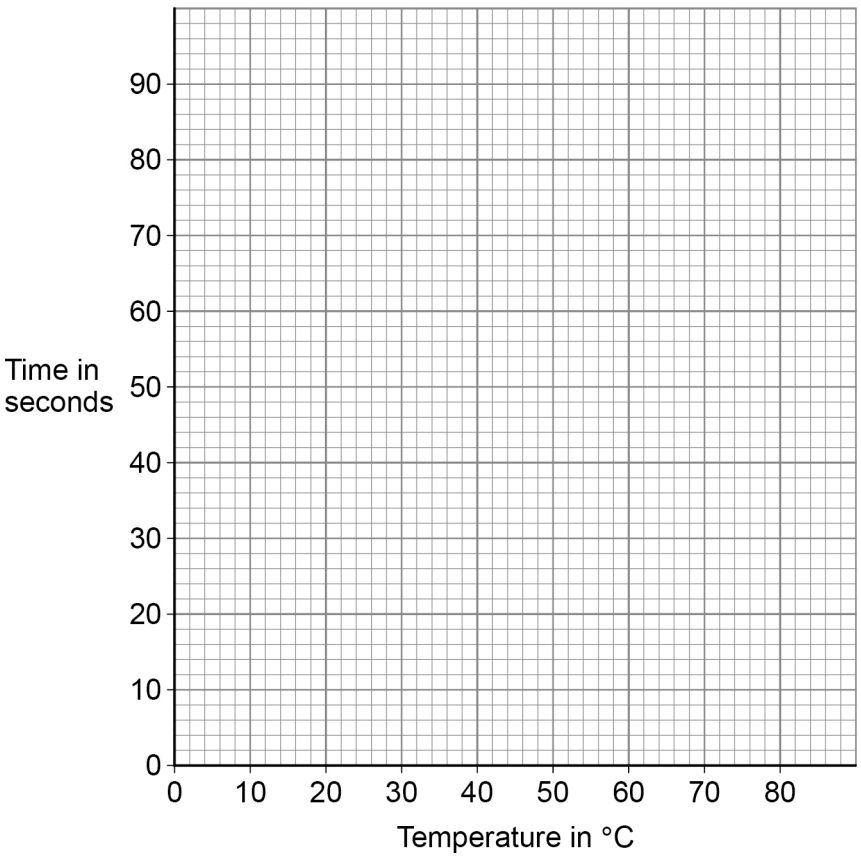
Complete **Figure 4**.

You should:

- plot the data from **Table 1** on **Figure 4**
- draw a line of best fit.

[3 marks]

Figure 4

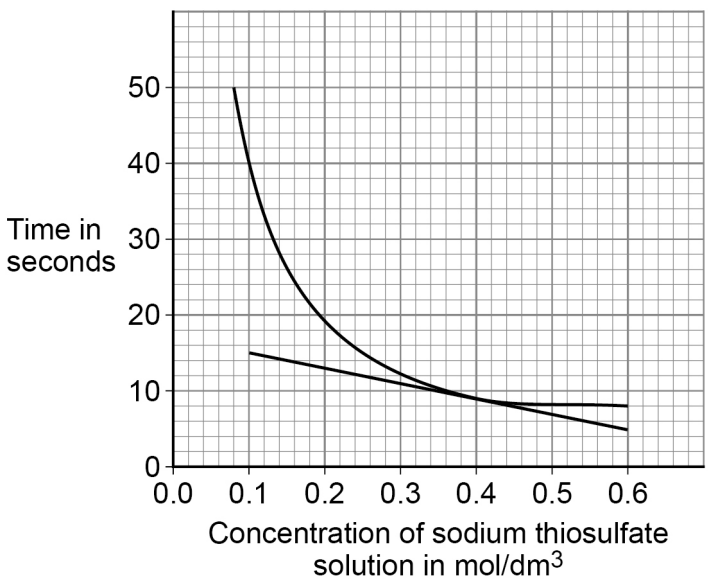


Question 05 · continued

0 3 . 4 A student investigated the effect of concentration of sodium thiosulfate on the time taken for the reaction at room temperature.

Figure 5 shows the results with a tangent drawn at 0.4 mol/dm^3

Figure 5



Calculate the gradient (slope) of the tangent at 0.4 mol/dm^3

Give the unit.

[4 marks]

Gradient = _____

Unit = _____

5.6.1.1 Calculating rates of reactions

Question 05 · continued

0 3 . 5 The student determined the **rate** of the reaction at regular time intervals during an experiment.

Explain why the **rate** decreased during the reaction.

You should give your answer in terms of particles.

[2 marks]

12

Turn over for the next question

5.6.1.1 Calculating rates of reactions

Question 06

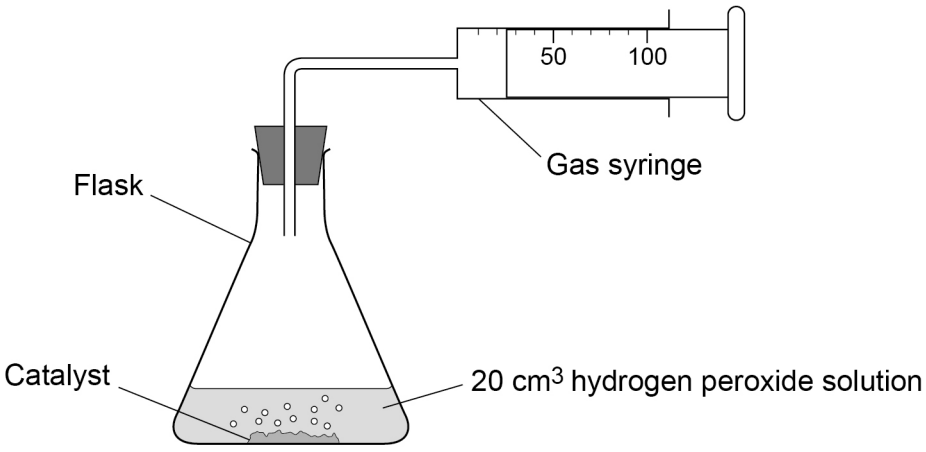
June 2023 | 8464/C/2H | Original Q6

0 6 A student investigated the rate of decomposition of hydrogen peroxide using three different catalysts:

- manganese dioxide
- copper oxide
- zinc oxide.

Figure 2 shows the apparatus.

Figure 2



This is the method used.

1. Measure 20 cm^3 of hydrogen peroxide solution into a flask.

2. Add 0.5 g of manganese dioxide catalyst to the flask.

3. Attach a gas syringe to the flask.

4. Measure the volume of oxygen produced every 30 seconds for 180 seconds.

5. Repeat steps 1 to 4 two more times.

6. Repeat steps 1 to 5 using copper oxide catalyst.

7. Repeat steps 1 to 5 using zinc oxide catalyst.

5.6.1.1 Calculating rates of reactions

Question 06 · continued

0 6 . 1 The equation for the decomposition of hydrogen peroxide is:

$$2\,H_2O_2 \rightarrow 2\,H_2O + O_2$$

Describe a test to identify the gas produced in the reaction.

[2 marks]

Test _____

_____

Result _____

_____

0 6 . 2 Using 10 cm^3 of hydrogen peroxide solution gives less accurate results than using 20 cm^3 of hydrogen peroxide solution of the same concentration.

Explain why.

[2 marks]

_____

_____

_____

_____

0 6 . 3 Suggest **one** possible source of systematic error in the investigation.

[1 mark]

_____

_____

Question 6 continues on the next page

Question 06 · continued

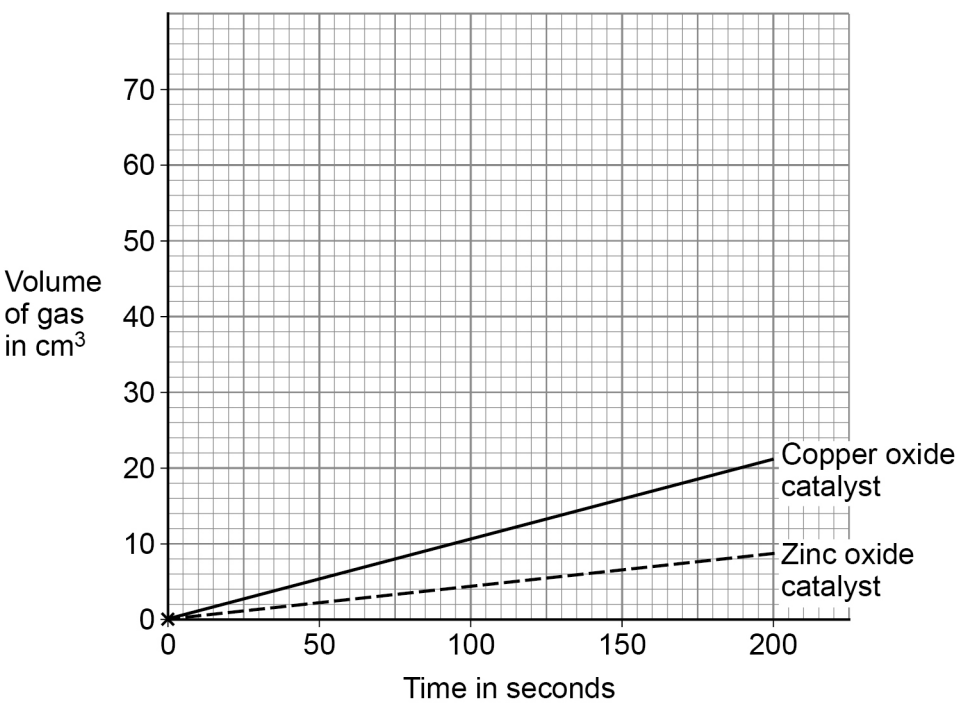
Table 3 shows the results for manganese dioxide catalyst.

Table 3

Time in seconds	0	30	60	90	120	150	180
Volume of gas in cm^3	0	22	38	41	54	58	60

Figure 3 shows a graph of the results with copper oxide catalyst and with zinc oxide catalyst.

Figure 3



0 6 . 4 Complete **Figure 3**.

You should:

- plot the data from **Table 3**
- draw a line of best fit.

The first point has been plotted for you.

[3 marks]

5.6.1.1 Calculating rates of reactions

Question 06 · continued

0 6 . 5 Which catalyst gives the fastest **rate** of reaction?

Give **one** reason for your answer.

Use the completed **Figure 3**.

[2 marks]

Catalyst _____

Reason _____

_____

0 6 . 6 The rate of reaction is **not** dependent on the volume of hydrogen peroxide solution.

Explain why.

[2 marks]

_____

_____

_____

_____

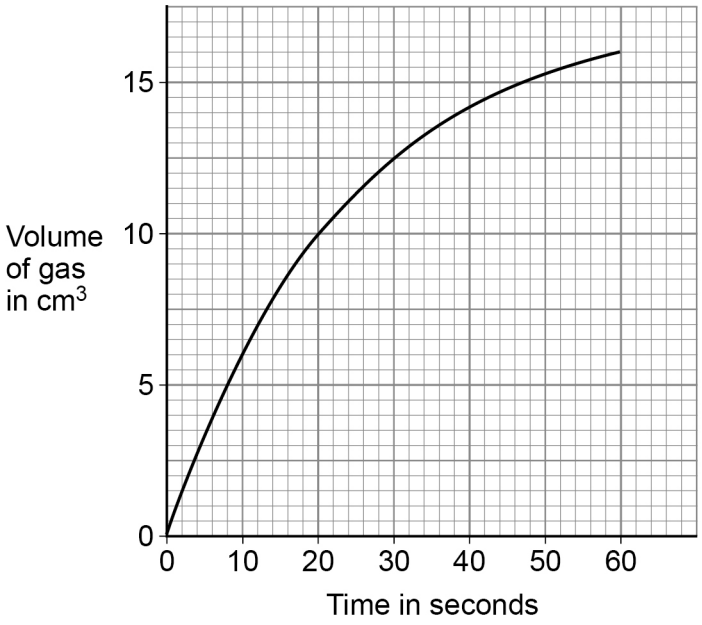
Question 6 continues on the next page

5.6.1.1 Calculating rates of reactions

Question 06 · continued

0 6 . 7 **Figure 4** shows the results from a different investigation.

Figure 4



Determine the rate of reaction at 20 seconds.

Show your working on **Figure 4**.

Give your answer to 3 significant figures.

[5 marks]

Rate (3 significant figures) = _____ cm^3/s

17

5.6.1.1 Calculating rates of reactions

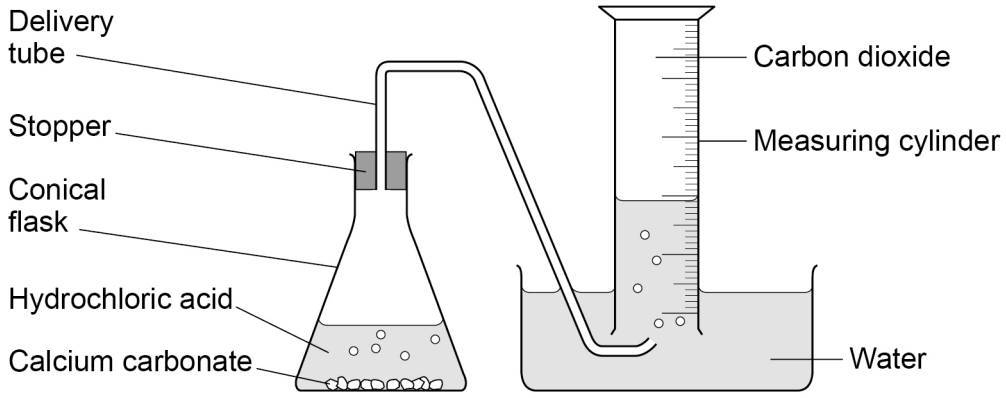
Question 07

0 2 Some factors affect the rates of chemical reactions.

0 2 . 1 A student investigated the effect of changing the particle size of calcium carbonate on the rate of reaction with hydrochloric acid.

Figure 3 shows the apparatus.

Figure 3



Describe a method the student could use to produce valid results.

[6 marks]

5.6.1.1 Calculating rates of reactions

Question 07 · continued

0 2 . 2 The student investigated the effect of increasing the temperature on the rate of a reaction.

Explain the effect of increasing the temperature on the rate of a reaction.

Refer to particles and collisions in your answer.

[3 marks]

5.6.1.1 Calculating rates of reactions

Question 07 · continued

Catalysts affect the rate of reactions.

0 2 . 3 What is meant by a 'catalyst'?

[2 marks]

0 2 . 4 What are catalysts in biological systems called?

[1 mark]

12

5.6.1.1 Calculating rates of reactions

Question 08

June 2024 | 8464/C/2H | Original Q5

0 5 Sulfuric acid is produced by an industrial process.

In the process, sulfur dioxide (SO_2) reacts with oxygen (O_2) to produce sulfur trioxide (SO_3).

The equation for the reversible reaction is:

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$$

The forward reaction releases 198 kJ/mol of energy.

0 5 . 1 What is the amount of energy transferred during the reverse reaction?

[1 mark]

Tick (✓) **one** box.

< 198 kJ/mol ☐

= 198 kJ/mol ☐

> 198 kJ/mol ☐

0 5 . 2 The concentration of oxygen is increased.

What is the effect on the position of the equilibrium?

[1 mark]

Tick (✓) **one** box.

Equilibrium position shifts to the left ☐

Equilibrium position does not change ☐

Equilibrium position shifts to the right ☐

5.6.1.1 Calculating rates of reactions

Question 08 · continued

0 5 . 3 The pressure is decreased.

What is the effect on the position of the equilibrium?

[1 mark]

Tick (✓) **one** box.

Equilibrium position shifts to the left ☐

Equilibrium position does not change ☐

Equilibrium position shifts to the right ☐

0 5 . 4 The temperature is increased.

What is the effect on the position of the equilibrium?

[1 mark]

Tick (✓) **one** box.

Equilibrium position shifts to the left ☐

Equilibrium position does not change ☐

Equilibrium position shifts to the right ☐

0 5 . 5 A catalyst is used in the reaction.

Suggest what effect the catalyst has on the position of the equilibrium.

Give **one** reason for your answer.

[2 marks]

Effect _____

_____

Reason _____

_____

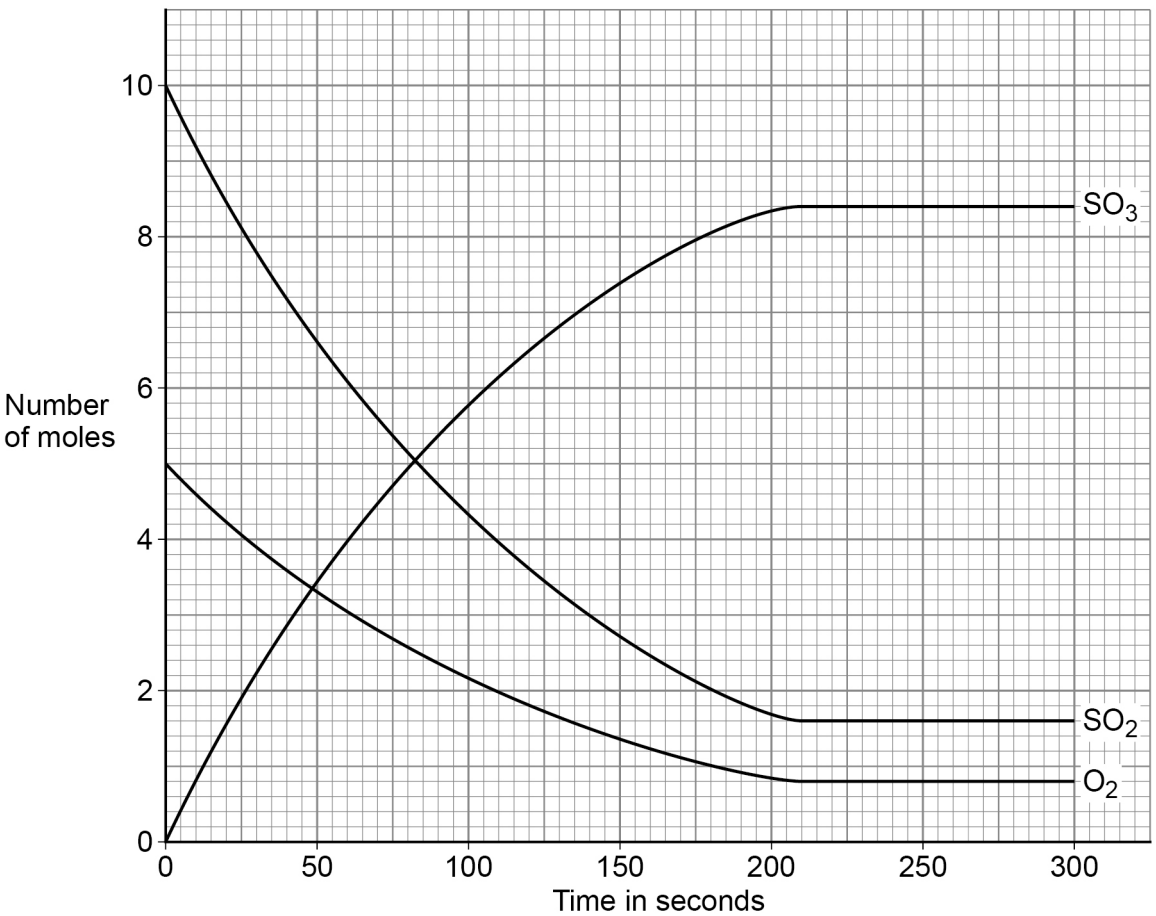
5.6.1.1 Calculating rates of reactions

Question 08 · continued

A scientist measured how the number of moles of sulfur dioxide, oxygen and sulfur trioxide varied with time during the reaction.

Figure 5 shows the results.

Figure 5



5.6.1.1 Calculating rates of reactions

Question 08 · continued

0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time _____ s

Explanation _____

_____

_____

_____

_____

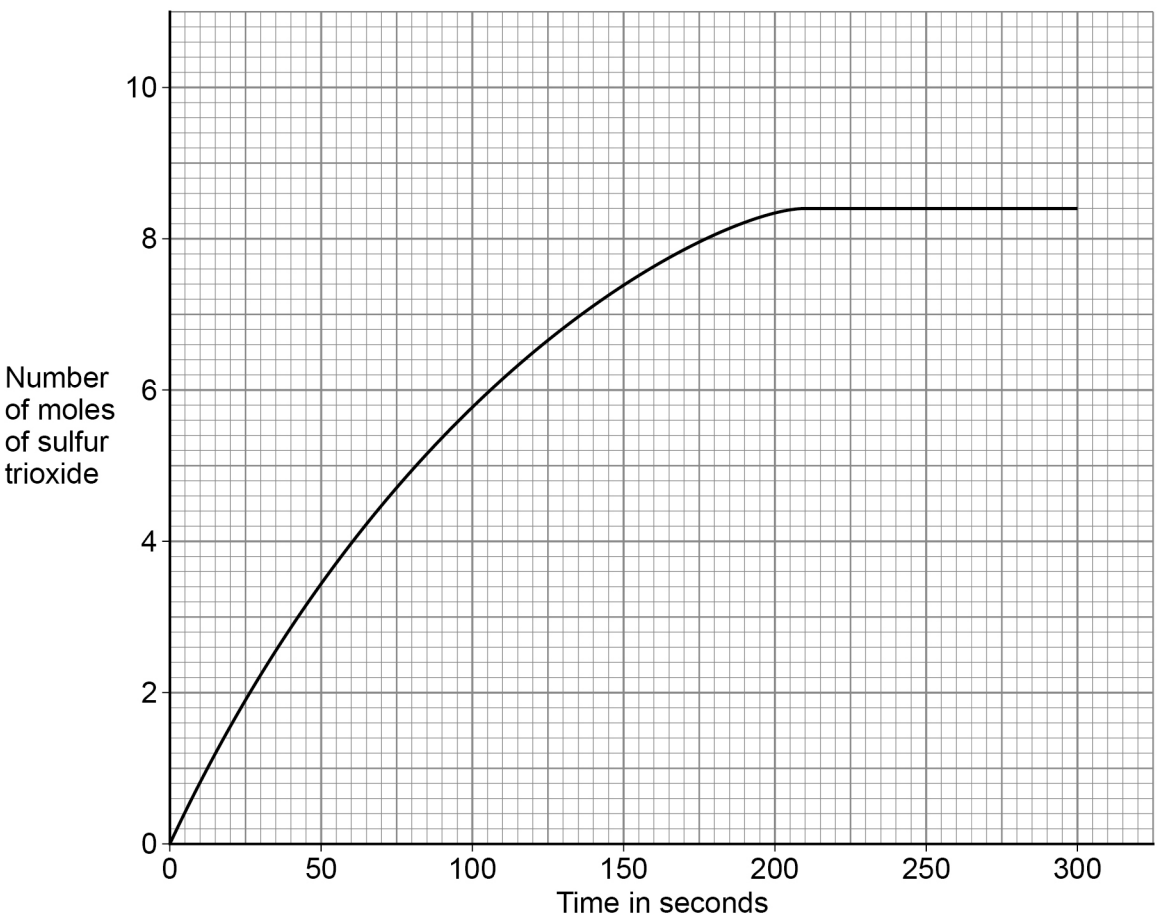
Question 5 continues on the next page

5.6.1.1 Calculating rates of reactions

Question 08 · continued

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

Rate = _____ mol/s

13

5.6.1.1 Calculating rates of reactions

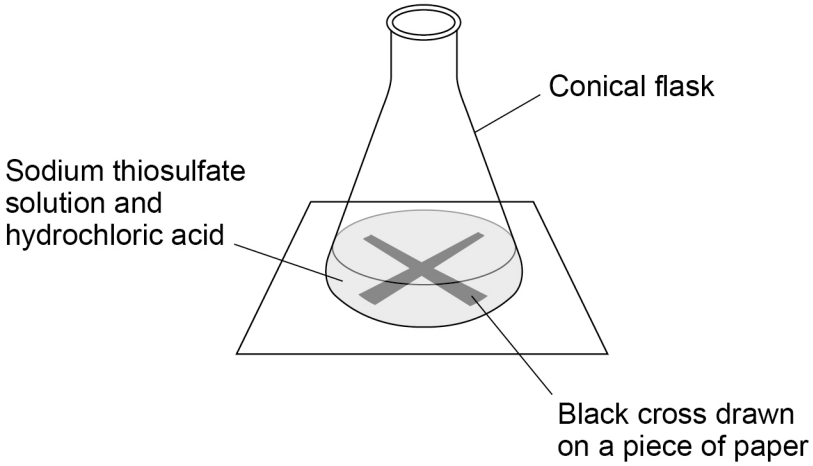
Question 09

0 5 Students investigated the effect of changing the concentration on the rate of chemical reactions.

A student reacted sodium thiosulfate solution with hydrochloric acid.

Figure 3 shows the apparatus.

Figure 3



This is the method used.

1. Measure 50 cm^3 of sodium thiosulfate solution into a conical flask.

2. Put the conical flask on a black cross drawn on a piece of paper.

3. Add 10 cm^3 of hydrochloric acid to the conical flask.

4. Start a timer.

5. Stop the timer when the cross is no longer visible.

6. Record the time taken.

7. Repeat steps 1 to 6 using different concentrations of sodium thiosulfate solution.

5.6.1.1 Calculating rates of reactions

Question 09 · continued

0 5 . 1 What is the dependent variable in this investigation?

[1 mark]

0 5 . 2 The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

The mixture becomes cloudy as the reaction takes place.

Explain why the mixture becomes cloudy.

[2 marks]

0 5 . 3 Explain the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

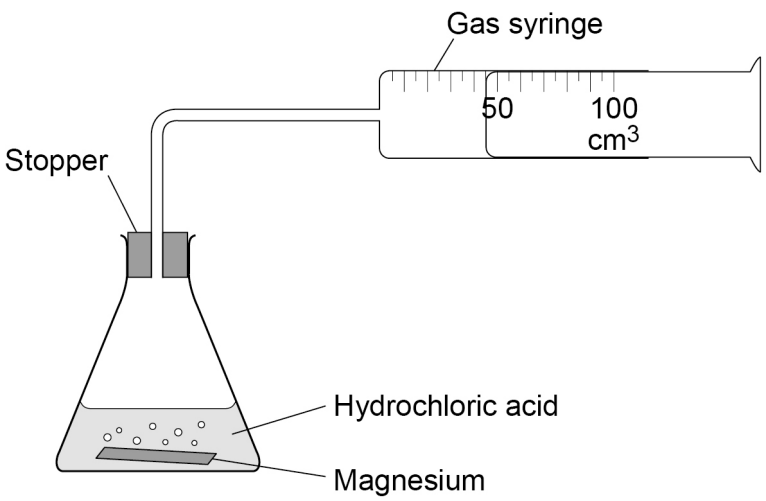
[3 marks]

Question 09 · continued

A different student reacted magnesium with hydrochloric acid.

Figure 4 shows the apparatus.

Figure 4



This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a conical flask.
2. Add 0.1 g of magnesium ribbon to the conical flask.
3. Insert the stopper into the conical flask as quickly as possible.
4. Start a timer.
5. Record the volume of gas collected every 20 seconds for 5 minutes.
6. Repeat steps 1 to 5 using different concentrations of hydrochloric acid.

0 5 . 4 Why is the stopper inserted into the conical flask as quickly as possible in step 3?

[1 mark]

5.6.1.1 Calculating rates of reactions

Question 09 · continued

0 5 . 5 The equation for the reaction of magnesium with hydrochloric acid is:

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

Describe a test for the gas produced in the reaction.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

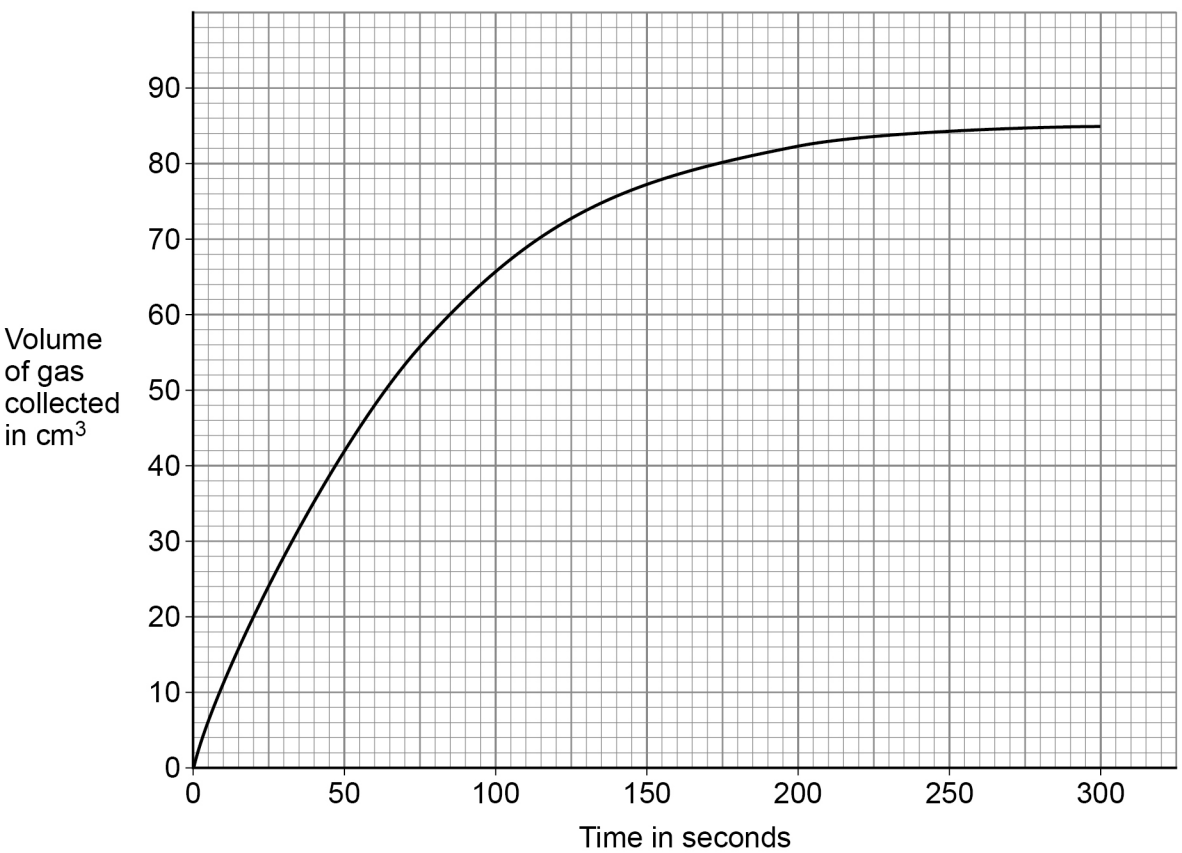
Question 5 continues on the next page

5.6.1.1 Calculating rates of reactions

Question 09 · continued

0 5 . 6 **Figure 5** shows the results for one concentration of hydrochloric acid.

Figure 5



Determine the rate of reaction at 75 seconds.

[4 marks]

Rate = _____ cm^3/s

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