

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 cm³ 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.

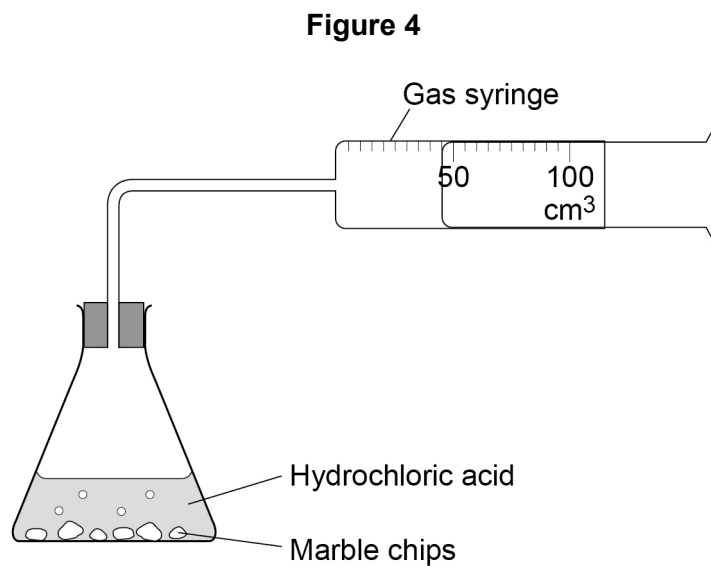
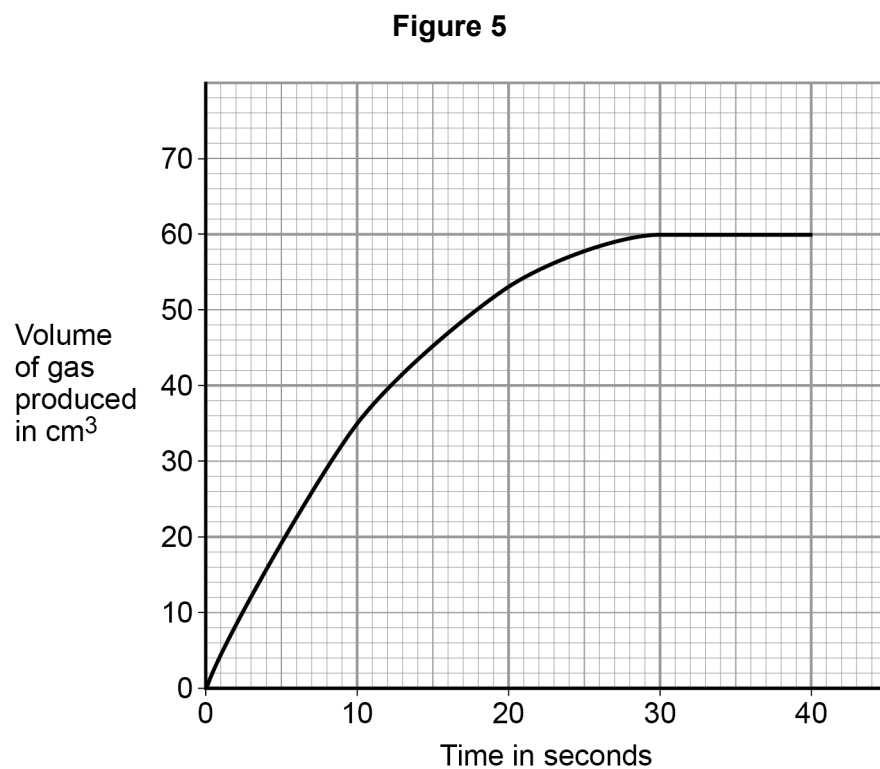


Figure 5 shows the student's results.



1.1

Describe the trend shown in **Figure 5**

Use values in your answer.

[3 marks]

1.2

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]

1.3

Give the units for the rate of this reaction.

[1 mark]

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

1.4

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

[1 mark]

1.5

Explain why the size of the marble chips affects the rate of the reaction.

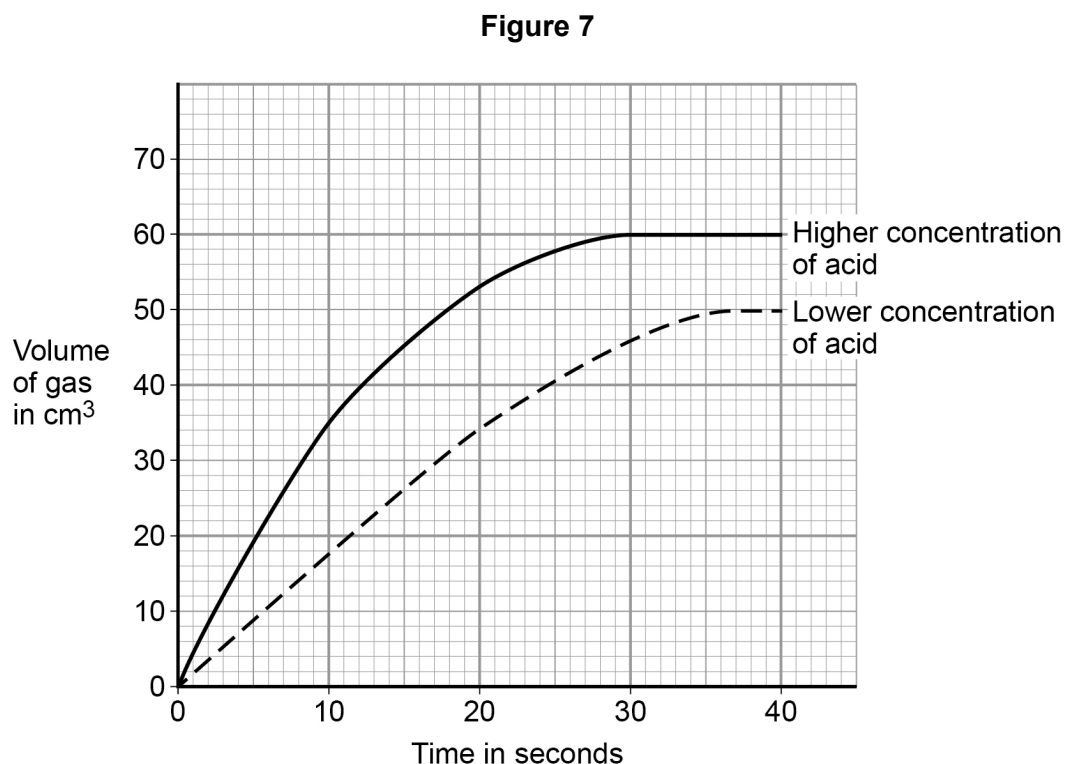
Give your answer in terms of 'collision theory'.

[2 marks]

1.6

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.



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

[3 marks]

Sodium thiosulfate solution reacts with dilute hydrochloric acid.

The solution becomes cloudy as the reaction takes place.

2.1

Plan an investigation to show how the concentration of the sodium thiosulfate solution affects the rate of the reaction with dilute hydrochloric acid.

Your plan should give valid results.

[6 marks]

3.1

Table 5 shows the student's results for hydrochloric acid at 30 °C**Table 5**

Time in seconds	Loss of mass in grams
0	0.00
20	0.26
40	0.48
60	0.67
80	0.82
100	0.91
120	0.96
140	0.99

Plot the data from **Table 5** on **Figure 6**.

Draw a line of best fit.

[3 marks]

Figure 6

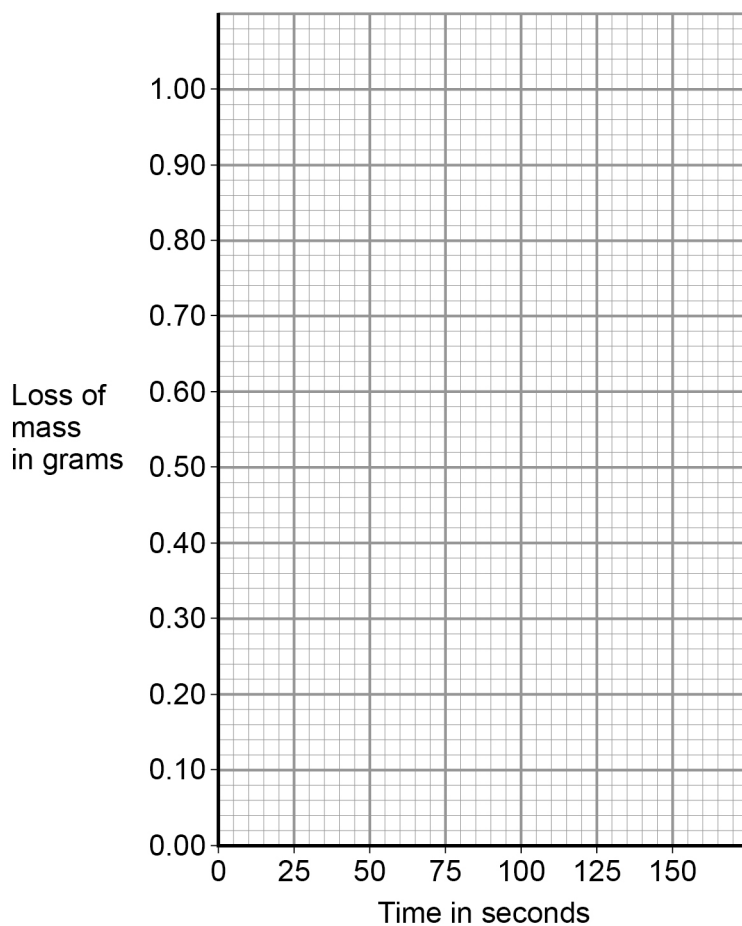
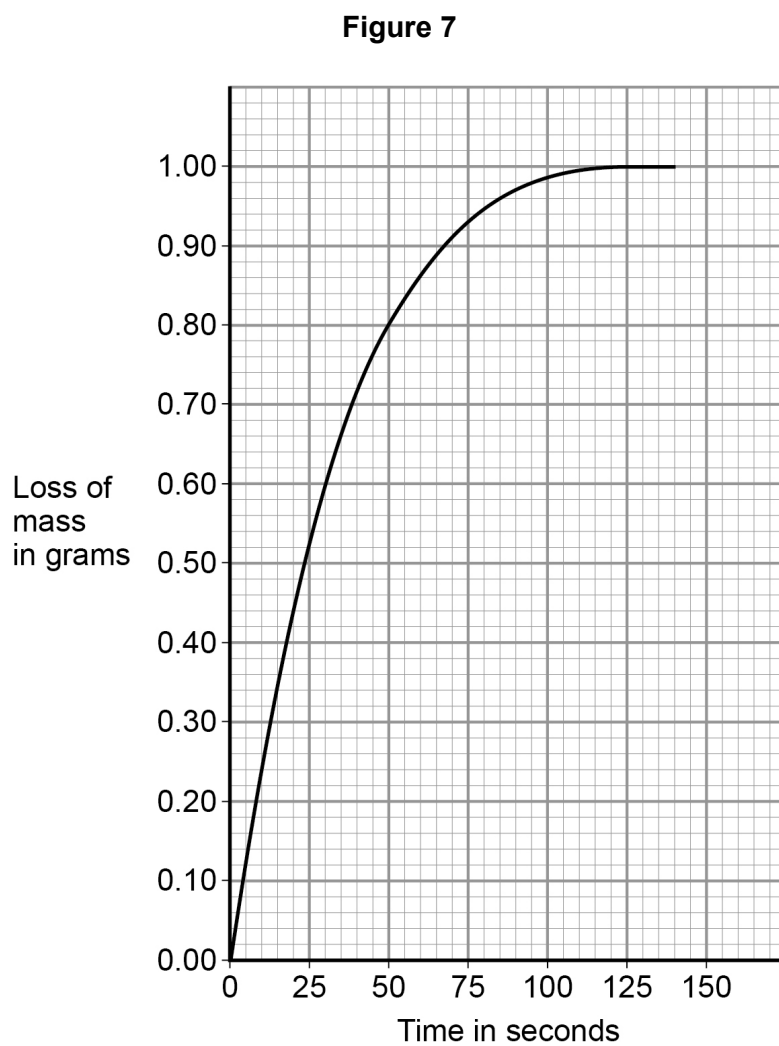


Figure 7 shows the student's results for hydrochloric acid at 50 °C



3.2

Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

Rate of reaction = _____ g/s

4.1

Methanol is broken down in the body during digestion.

What type of substance acts as a catalyst in this process?

[1 mark]

Tick **one** box.

Amino acid

☐

Enzyme

☐

Ester

☐

Nucleotide

☐

A catalyst is used in the reaction to produce methanol from carbon monoxide and hydrogen.

4.2

Explain how a catalyst increases the rate of a reaction.

[2 marks]

5.1

Hydrogen reacts with oxygen.

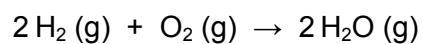
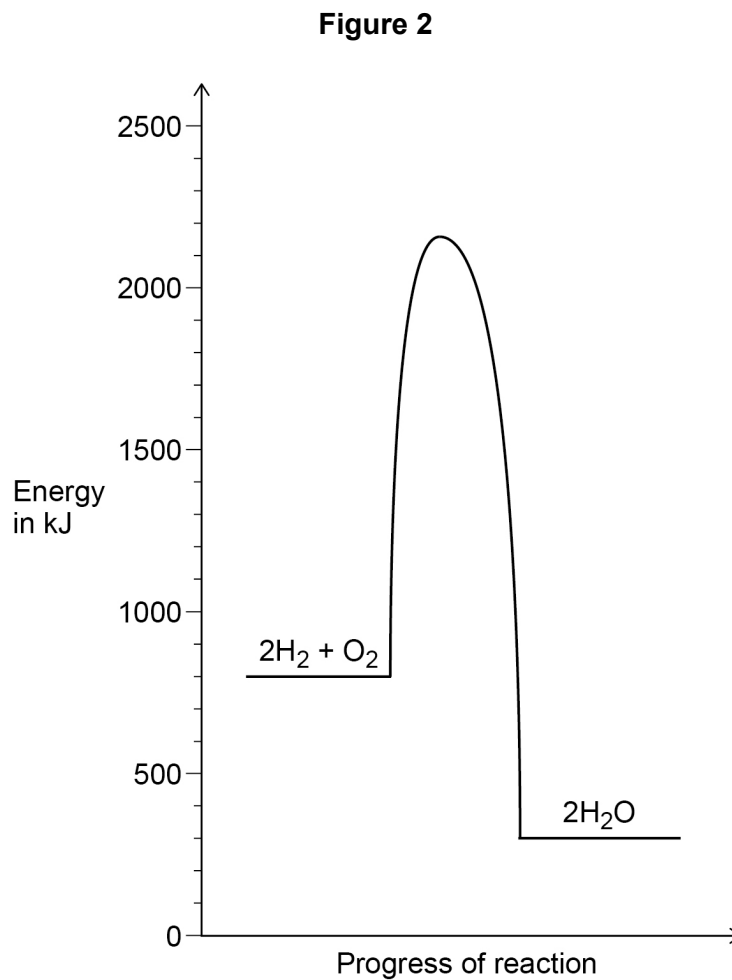


Figure 2 shows the relative energies of the reactants and products at a certain temperature.

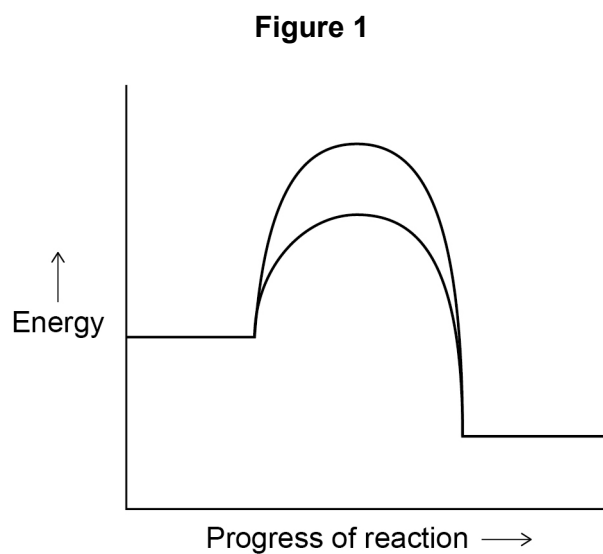


Label the activation energy on **Figure 2**.

[1 mark]

Copper is used as a catalyst.

Figure 1 shows reaction profiles for a reaction with and without a catalyst.



6.1

How do the reaction profiles show that using a catalyst does **not** affect the overall energy change for the reaction?

[1 mark]

Tick (✓) **one** box.

Both reaction profiles show exothermic reactions.

☐

Both reaction profiles start at the same energy level and end at the same energy level.

☐

Both reaction profiles show the activation energy.

☐

The activation energy for the uncatalysed reaction is much lower than for the catalysed reaction.

☐

7.1

Table 2 shows the student's results.

Table 2

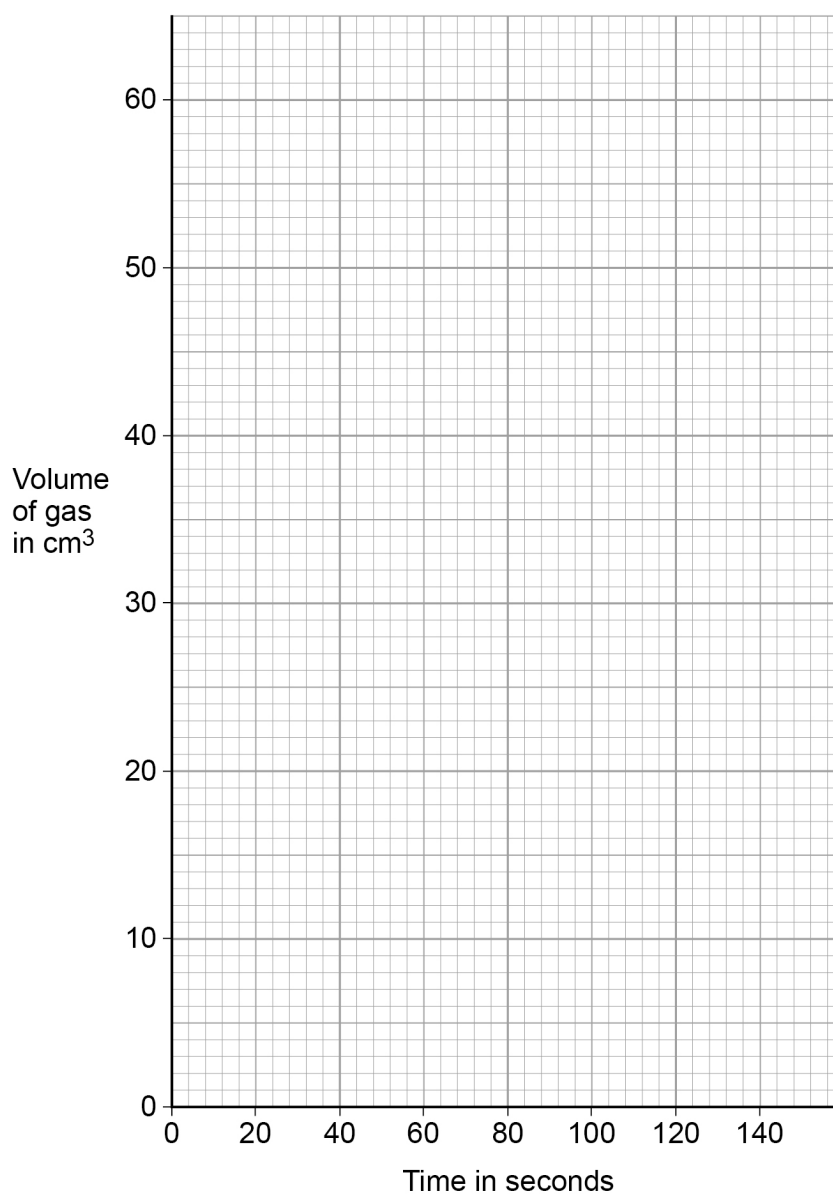
Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm ³	0.0	12.5	36.0	43.5	59.0	60.0	60.0

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

Draw a line of best fit.

[3 marks]

Figure 3



7.2

Describe the changes in the rate of this reaction.

[3 marks]

7.3

Explain why the rate of this reaction changes.

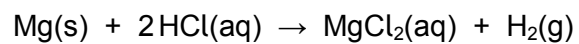
Give your answer in terms of collision theory.

[3 marks]

This question is about rate of reaction.

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

The equation for the reaction is:



The student determined the rate of production of hydrogen gas.

8.1

What **two** pieces of measuring apparatus could the student use to find the rate of production of hydrogen gas?

[2 marks]

1 _____

2 _____

Table 2 shows the results of the investigation.

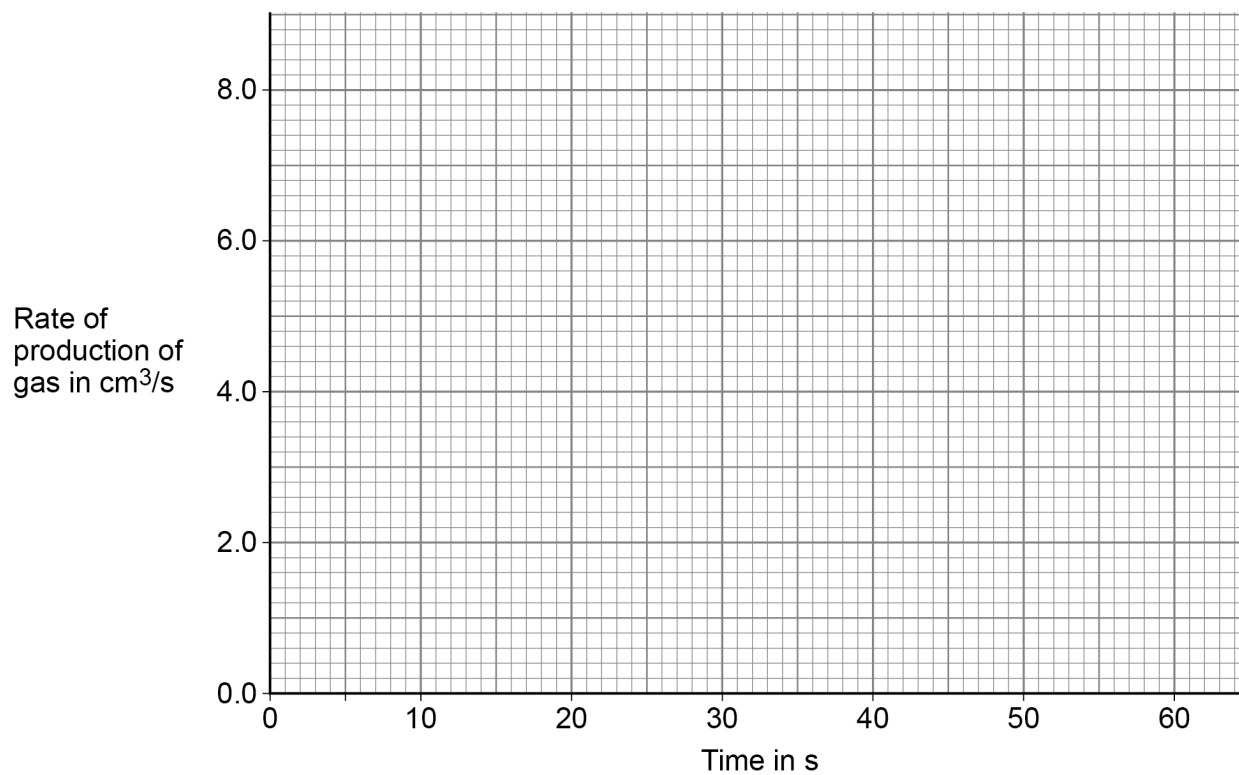
Table 2

Time in s	Rate of production of gas in cm ³ /s
10	6.9
20	3.9
30	2.0
40	0.9
50	0.3
60	0.0

8.2

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

You should draw a line of best fit.

[3 marks]**Figure 3**

8.3

Give **three** conclusions that can be drawn about the rate of reaction between magnesium and dilute hydrochloric acid in this investigation.

Use data from **Figure 3** and **Table 2**.

[3 marks]

1 _____

2 _____

3 _____

8.4

The student repeated the investigation using dilute hydrochloric acid at a higher temperature.

All the other variables were kept the same.

Which **two** statements are correct?

[2 marks]

Tick (✓) **two** boxes.

More bubbles were produced in the first 10 seconds.

☐

The activation energy for the reaction was higher.

☐

The magnesium was used up more quickly.

☐

The reaction finished at the same time.

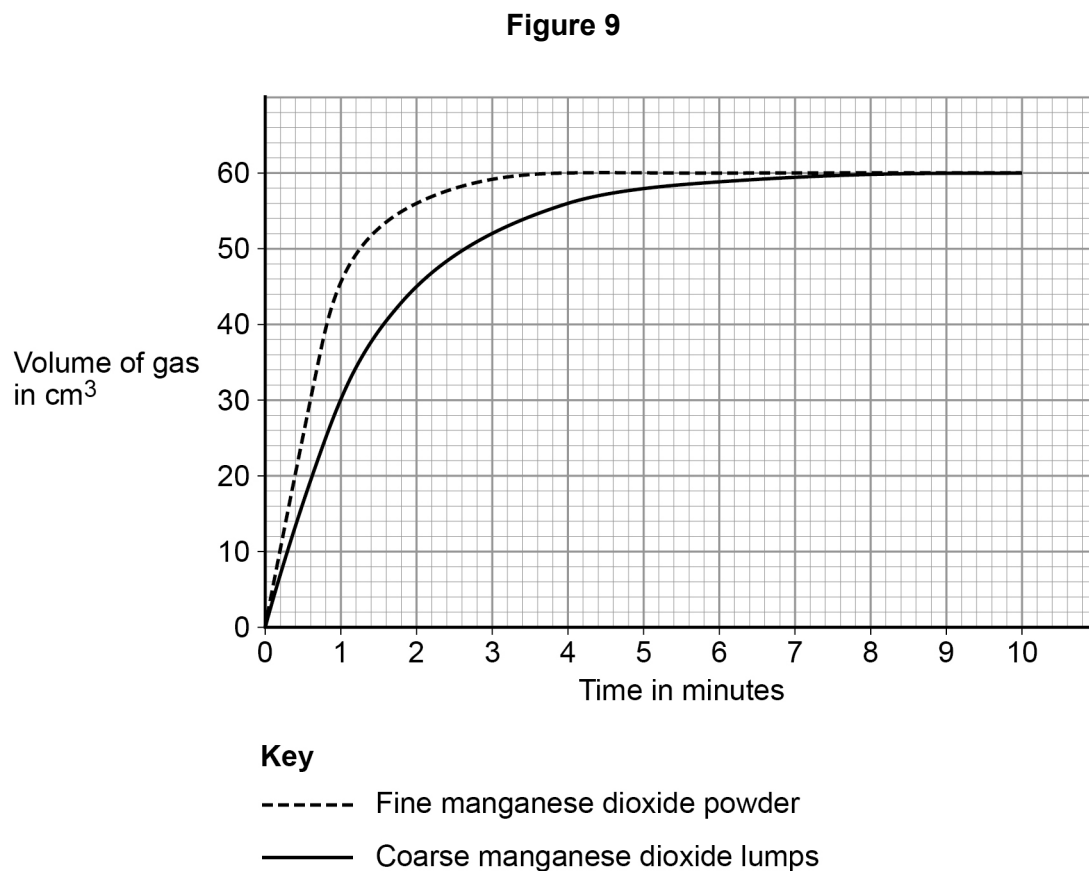
☐

The total volume of gas collected was greater.

☐

Student **B** used a method which gave valid results.

Figure 9 shows student **B**'s results.



9.1

Determine the mean rate of reaction in cm^3/s between 2 and 4 minutes for coarse manganese dioxide lumps.

Give your answer to 2 significant figures.

Use data from **Figure 9**.

[3 marks]

Mean rate of reaction = _____ cm^3/s

9.2

Student **B** repeated the experiment with coarse lumps of manganese dioxide.

Student **B** used the same volume of 0.2 mol/dm^3 hydrogen peroxide instead of 0.3 mol/dm^3 hydrogen peroxide.

Sketch on **Figure 9** the curve you would expect to see.

Assume that the reaction is complete after 9 minutes.

[2 marks]

9.3

The rate of reaction is different when manganese dioxide is used as a fine powder rather than coarse lumps.

Explain why.

You should answer in terms of collision theory.

[2 marks]

This question is about acids, alkalis and bases.

A student reacted zinc oxide powder with hydrochloric acid to produce zinc chloride solution.

10.1

Give **one** way that the student could speed up the reaction between zinc oxide powder and hydrochloric acid.

[1 mark]

11.1

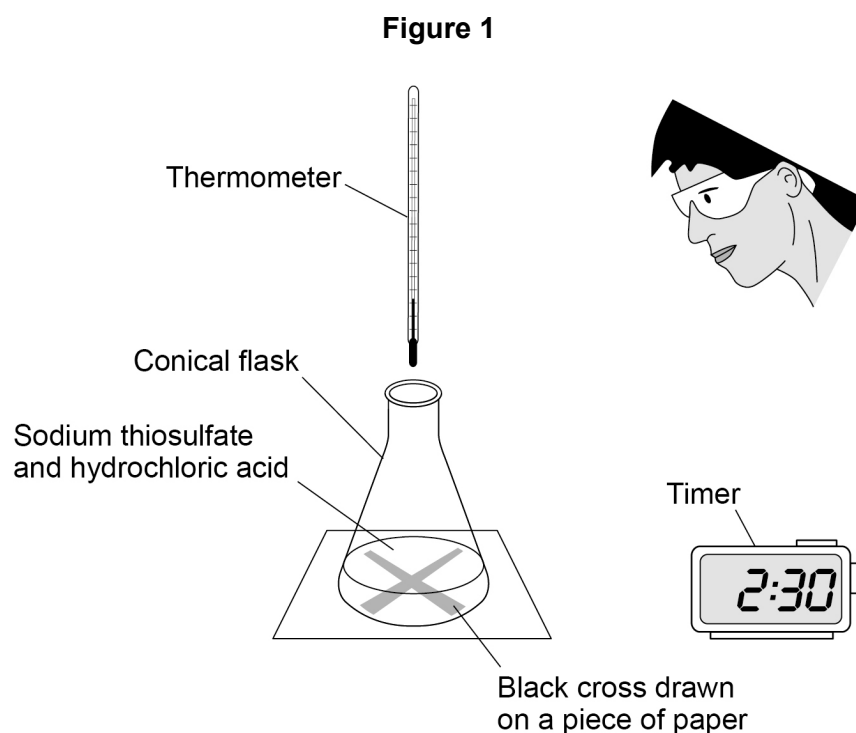
The students reacted sodium thiosulfate solution with hydrochloric acid.

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.

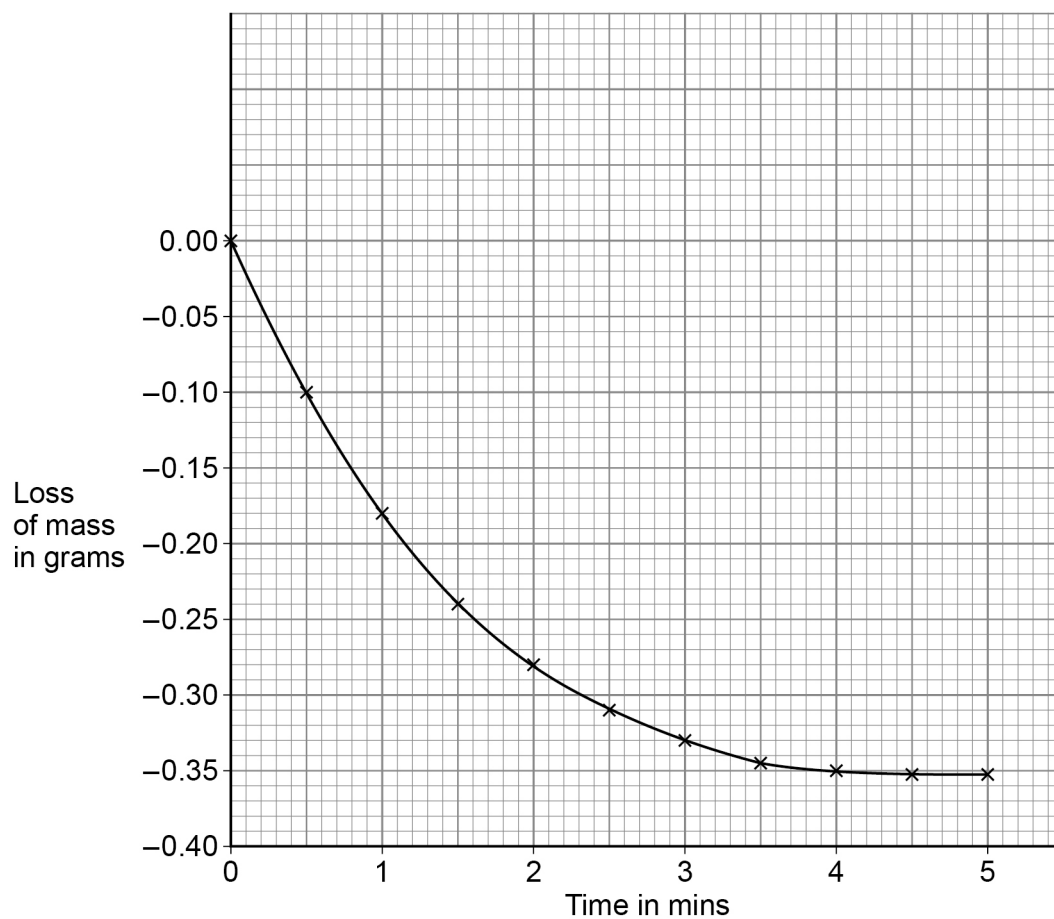


Some students investigated the effect of temperature on the rate of a different reaction.

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

Figure 2 shows the results.

Figure 2



11.2

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

11.3

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

[2 marks]

12.1

The displacement reaction between aluminium and iron oxide has a high activation energy.

What is meant by 'activation energy'?

[1 mark]

This question is about carboxylic acids.

Carboxylic acids belong to a homologous series.

Table 3 shows information about the first three carboxylic acids in this homologous series.

Table 3

	Formula	pH of a 0.01 mol/dm ³ solution
ethanoic acid		2.91
propanoic acid	CH ₃ COOH	3.39
	CH ₃ CH ₂ COOH	3.44

13.1

The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm³ methanoic acid
- 0.01 mol/dm³ ethanoic acid.

The rate of the reaction with methanoic acid is greater than the rate of the reaction with ethanoic acid.

Explain why.

You should refer to ions in your answer.

Use **Table 3**.

[3 marks]

This question is about the rate of the reaction between hydrochloric acid and calcium carbonate.

A student investigated the effect of changing the size of calcium carbonate lumps on the rate of this reaction.

This is the method used.

1. Pour 40 cm³ of hydrochloric acid into a conical flask.
2. Add 10.0 g of small calcium carbonate lumps to the conical flask.
3. Attach a gas syringe to the conical flask.
4. Measure the volume of gas produced every 30 seconds for 180 seconds.
5. Repeat steps 1 to 4 using 10.0 g of large calcium carbonate lumps.

The student calculated the number of moles of gas from each volume of gas measured.

Table 4 shows the student's results for large calcium carbonate lumps.

Table 4

Time in seconds	Number of moles of gas
0	0.0000
30	0.0011
60	0.0020
90	0.0028
120	0.0034
150	0.0038
180	0.0040

The student plotted the results for small calcium carbonate lumps on **Figure 4**.

14.1

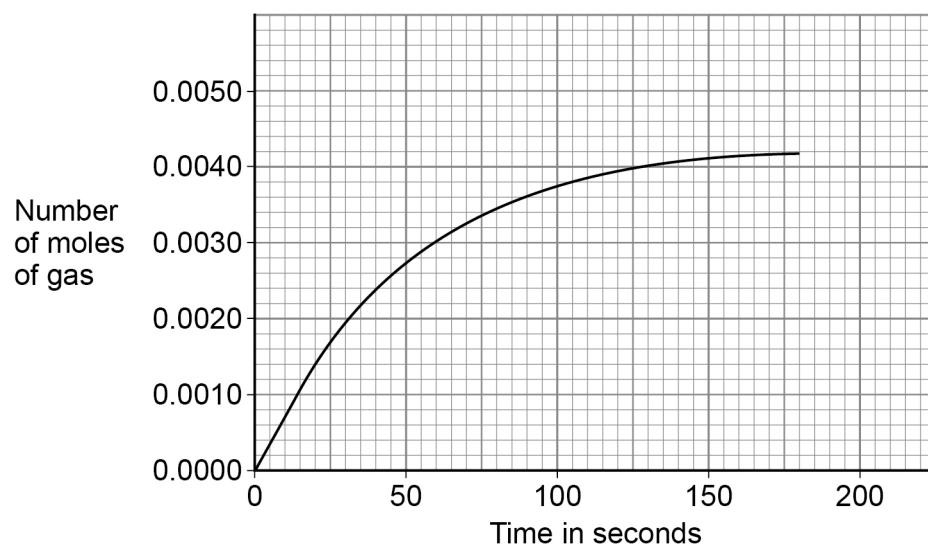
Complete **Figure 4**.

You should:

- plot the data for large calcium carbonate lumps from **Table 4**
- draw a line of best fit.

[3 marks]

Figure 4



14.2

Determine the mean rate of reaction for **small** calcium carbonate lumps between 20 seconds and 105 seconds.

Give the unit.

Use **Figure 4**.

[4 marks]

Mean rate of reaction = _____ Unit _____

14.3

The student concluded that the large calcium carbonate lumps reacted more slowly than the small calcium carbonate lumps.

How do the student's results show that this conclusion is correct?

[1 mark]

15.1

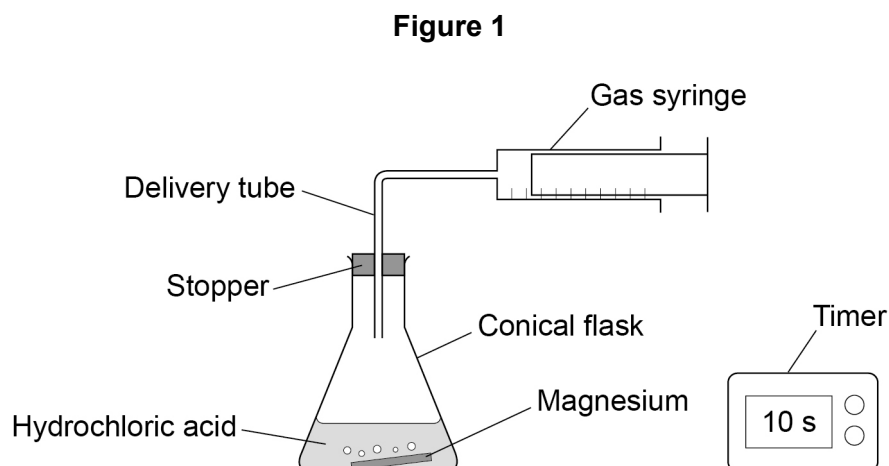
Suggest why a mixture of methane and oxygen does **not** react at room temperature.

Answer in terms of particles.

[2 marks]

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

Figure 1 shows the apparatus.



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.

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

Table 1

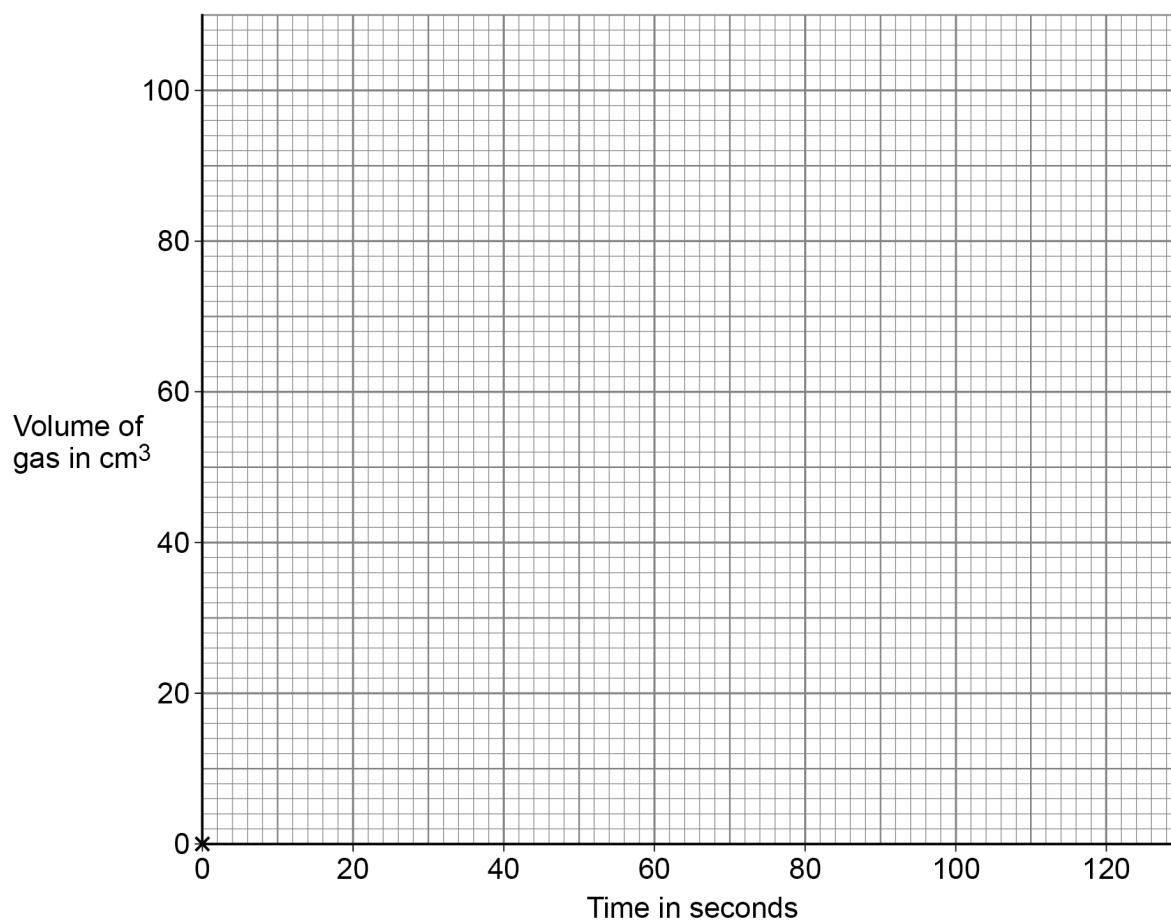
Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm ³	0	48	72	90	97	98	98

16.1

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**

16.2

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.

☐

16.3

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.

☐

16.4

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]

17.1

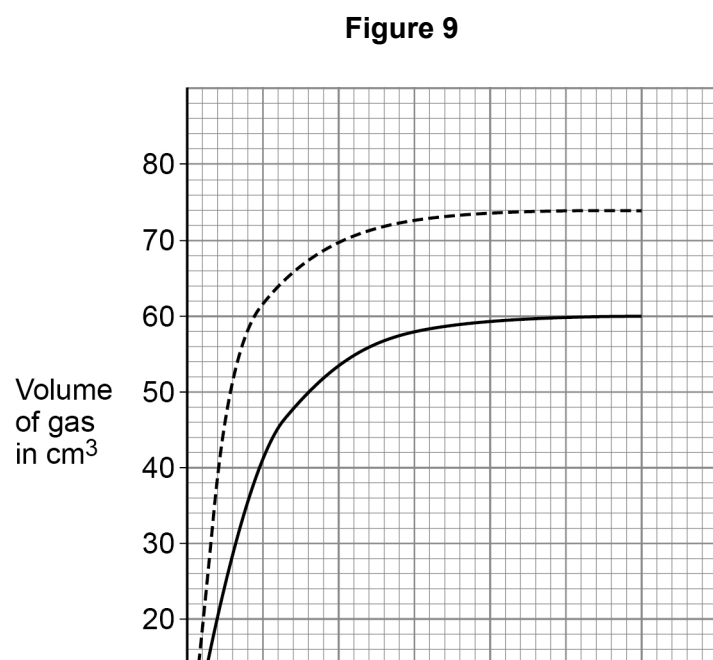
A catalyst is used in the reaction.

Explain how a catalyst increases the rate of a reaction.

[2 marks]

The student corrected the error.

Figure 9 shows the student's results.



18.1

Explain why the lines of best fit on **Figure 9** become horizontal.

[2 marks]

18.2

How does **Figure 9** show that zinc powder reacts more slowly with 0.05 mol/dm^3 sulfuric acid than with 0.10 mol/dm^3 sulfuric acid?

[1 mark]

18.3

Determine the rate of the reaction for 0.05 mol/dm^3 sulfuric acid at 80 seconds.

Show your working on **Figure 9**.

Give your answer to 2 significant figures.

[5 marks]

Rate of reaction (2 significant figures) = _____ cm^3/s

19.1

Describe how magnesium can be used to distinguish between a strong acid and a weak acid of the same concentration.

[2 marks]

20.1

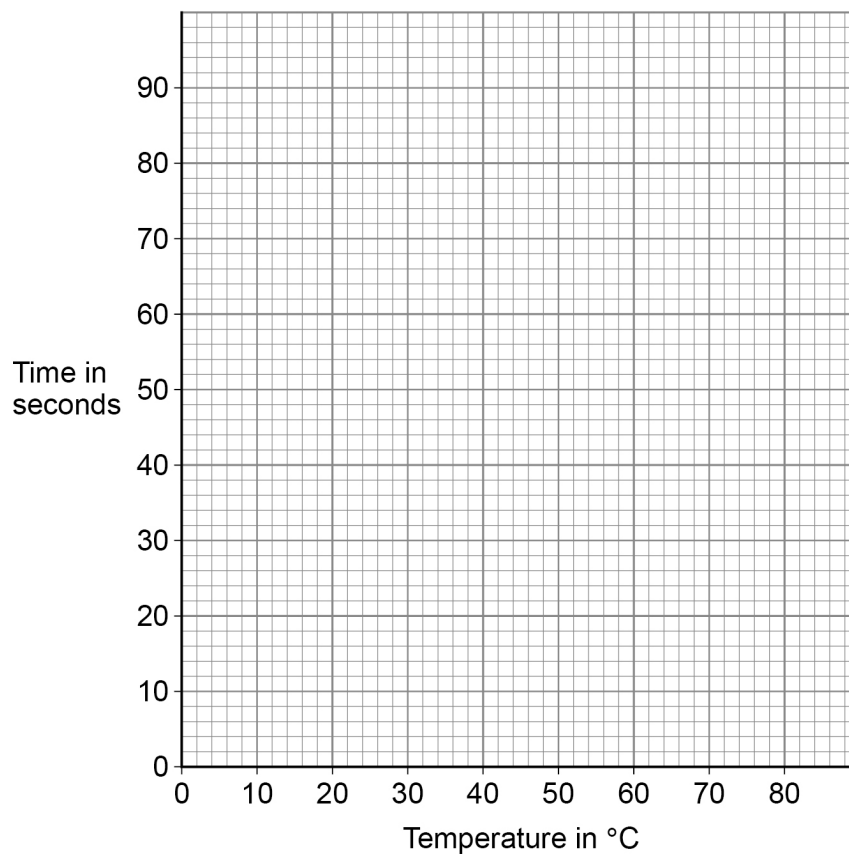
Table 1 shows the results.**Table 1**

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.

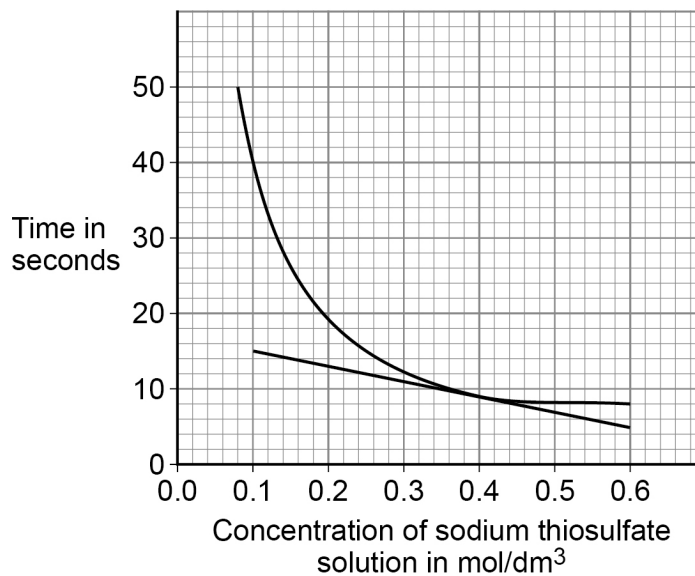
[3 marks]**Figure 4**

20.2

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 = _____

20.3

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]

21.1

What type of substance is a catalyst in biological systems?

[1 mark]

Tick (✓) **one** box.

Algae

☐

Alkene

☐

Enzyme

☐

Formulation

☐

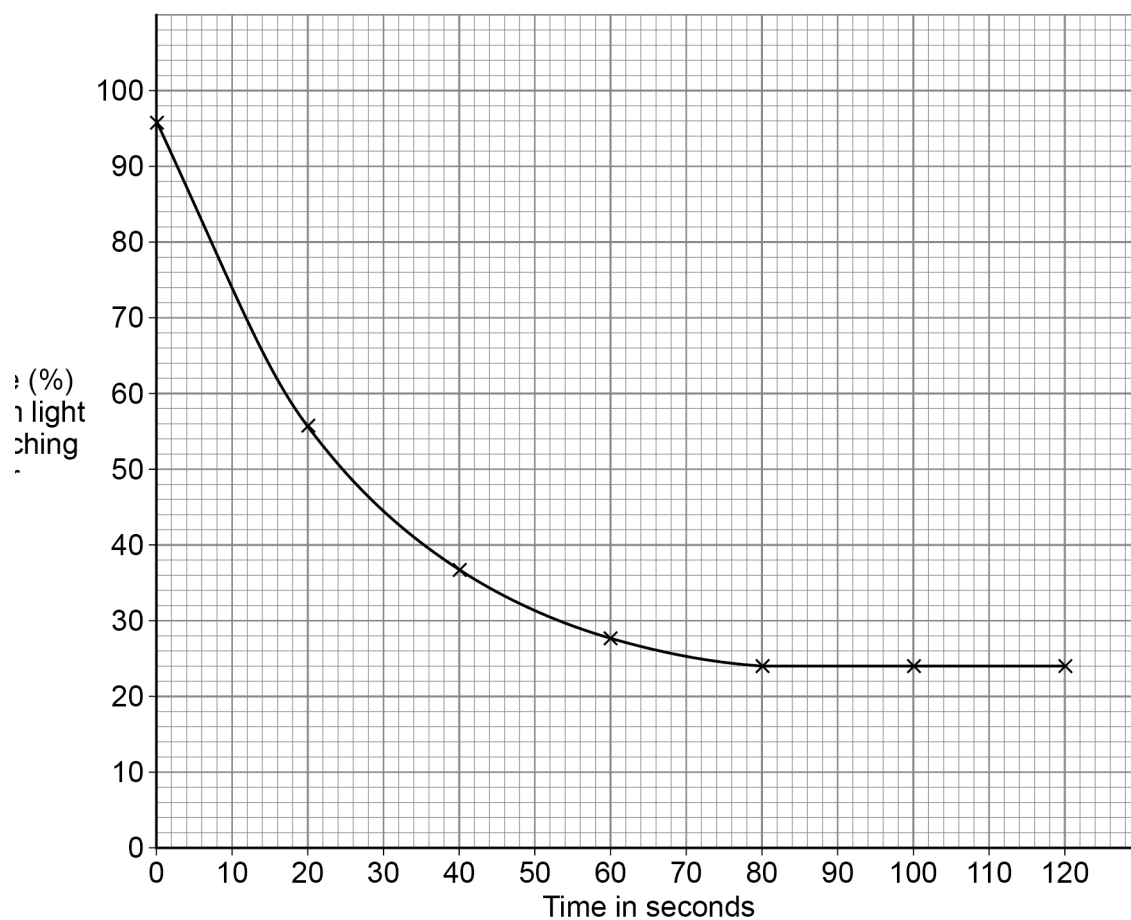
21.2

Explain how a catalyst increases the rate of a reaction.

[2 marks]

Figure 7 shows the results for 0.10 mol/dm³ sodium thiosulfate solution.

Figure 7



22.1

The percentage of light reaching the light sensor decreases by 1% when 7.1×10^{-5} moles of sulfur is produced.

Determine the rate of reaction in mol/s for the production of sulfur at 30 seconds.

You should draw a tangent on **Figure 7**.

[5 marks]

Rate = _____ mol/s

22.2

Explain why the rate of reaction changes between 0 and 60 seconds.

Answer in terms of concentration.

Use **Figure 7**.

[2 marks]

Figure 8 is a repeat of **Figure 7**.

Figure 8

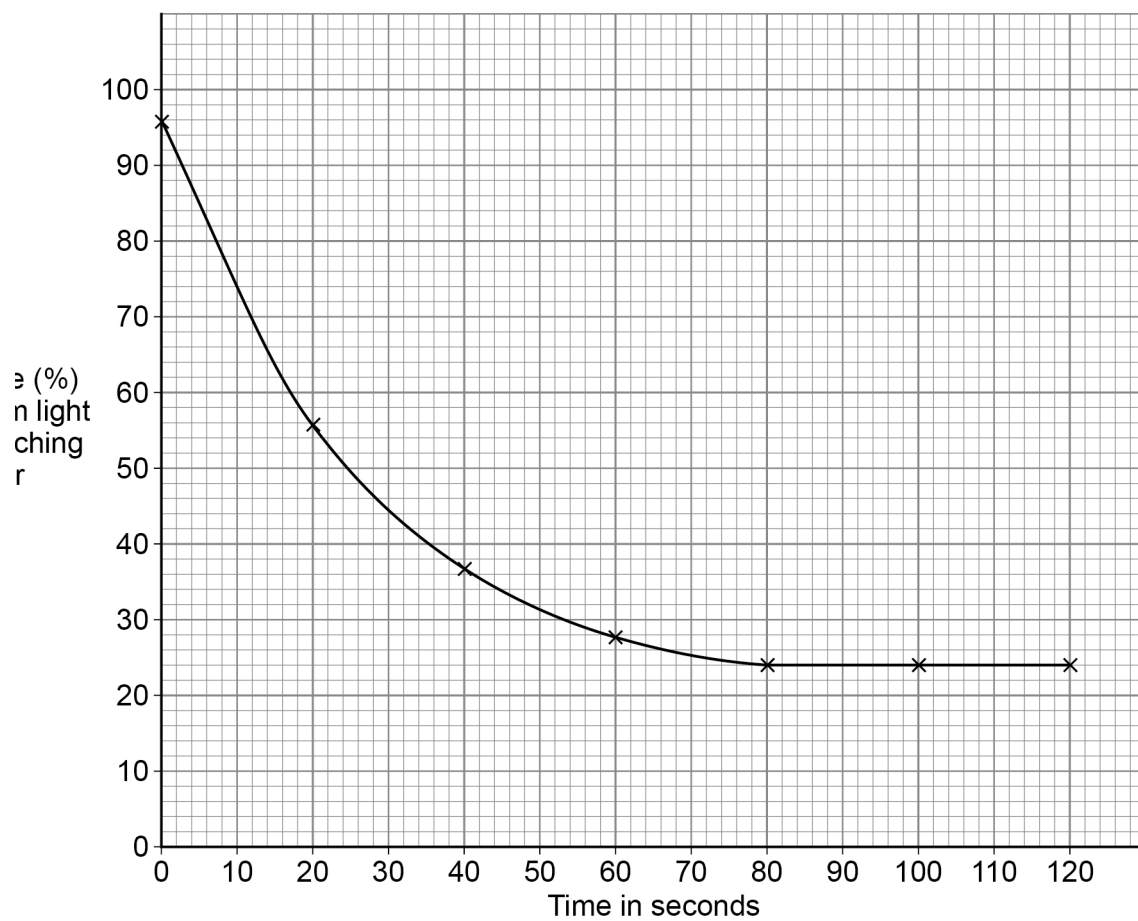


Figure 8 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Sodium thiosulfate solution was in excess in the investigation.

22.3

The line of best fit on **Figure 8** is horizontal between 80 and 120 seconds because the reaction stopped.

Why did the reaction stop?

[1 mark]

22.4

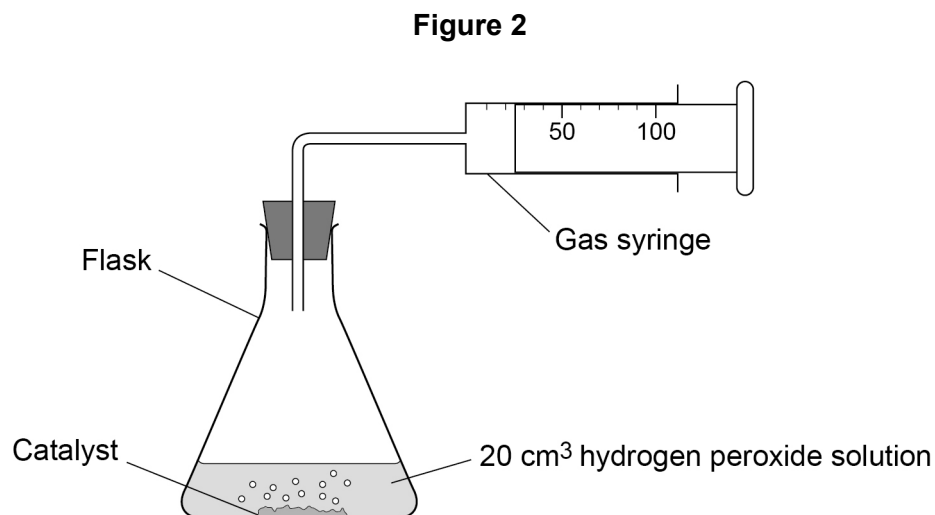
Sketch a line on **Figure 8** to show the results you would predict for 0.20 mol/dm^3 sodium thiosulfate solution.

[2 marks]

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.



This is the method used.

1. Measure 20 cm³ 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.

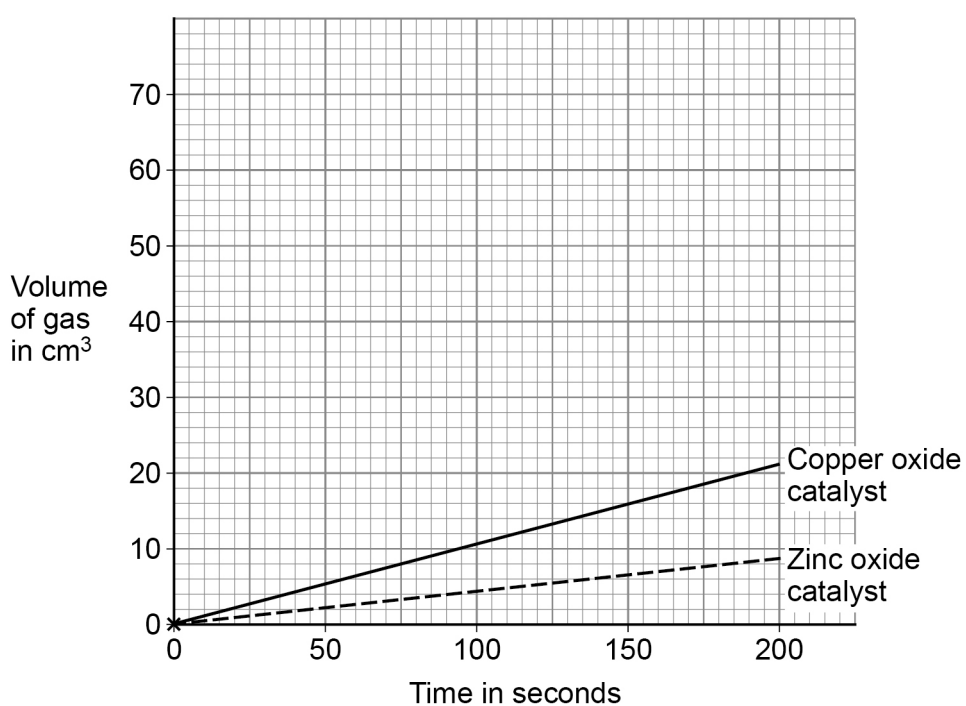
Table 3 shows the results for manganese dioxide catalyst.

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



23.1

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]

23.2

Which catalyst gives the fastest **rate** of reaction?

Give **one** reason for your answer.

Use the completed **Figure 3**.

[2 marks]

Catalyst _____

Reason _____

23.3

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

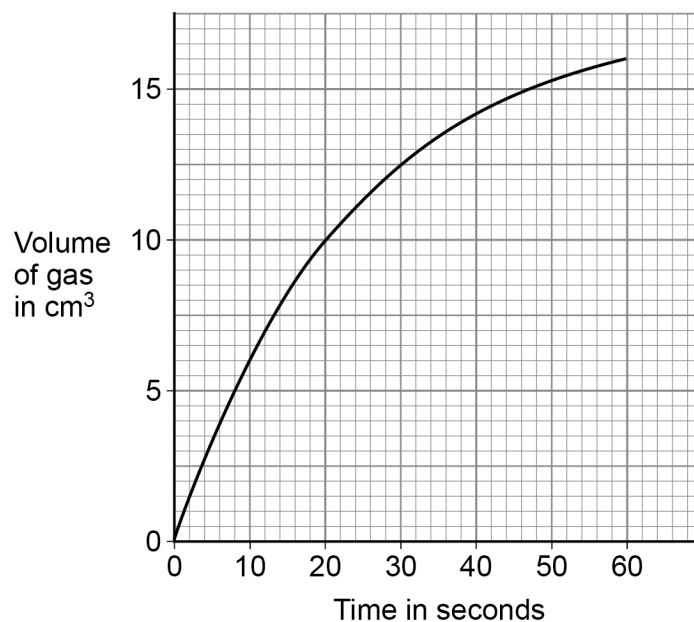
Explain why.

[2 marks]

23.4

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]

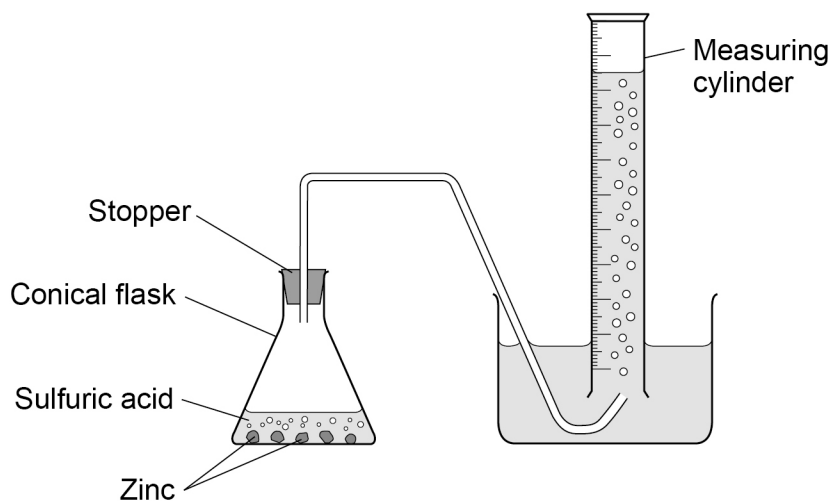
Rate (3 significant figures) = _____ cm³/s

A student investigated the rate of the reaction between zinc and sulfuric acid.

Hydrogen gas is produced during this reaction.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Add 50 cm³ of sulfuric acid to a conical flask.
2. Add 2.0 g of zinc to the conical flask.
3. Quickly put a stopper in the conical flask and start a timer.
4. Measure the time taken to collect 20 cm³ of gas.
5. Repeat steps 1 to 4 three more times.

24.1

The student calculated the rate of the reaction for each trial.

Table 1 shows the results of the calculations.

Table 1

	Trial 1	Trial 2	Trial 3	Trial 4
Rate of reaction in cm³/s	0.78	0.81	0.68	0.81

Determine the mean time taken to collect 20 cm³ of gas.

Do **not** include any anomalous results.

Use the equation:

$$\text{mean rate of reaction} = \frac{\text{volume of gas collected}}{\text{mean time taken}}$$

[5 marks]

Mean time taken = _____ s

24.2

The student changed the investigation so that the mean time taken to collect 20 cm³ of gas was greater.

Which **two** changes would increase the mean time taken to collect 20 cm³ of gas?

[2 marks]

Tick (✓) **two** boxes.

Use a catalyst

☐

Use a larger conical flask

☐

Use a lower temperature

☐

Use smaller pieces of zinc

☐

Use sulfuric acid of a lower concentration

☐

25.1

Explain how a manganese dioxide catalyst increases the rate of decomposition of hydrogen peroxide.

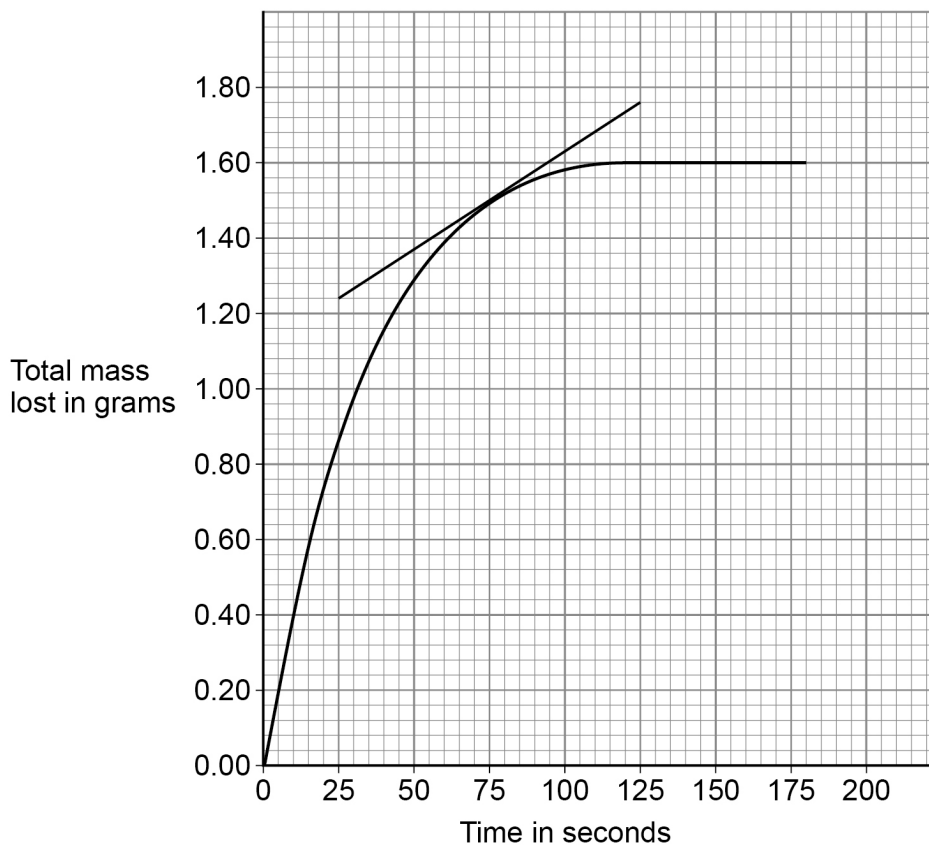
[2 marks]

25.2

Figure 4 shows the results for 50 cm³ of 2.0 mol/dm³ hydrogen peroxide solution and 1.0 g of manganese dioxide.

A tangent to the line has been drawn at 75 seconds.

Figure 4



Determine the rate of reaction when the time was 75 seconds.

Give your answer to 2 significant figures.

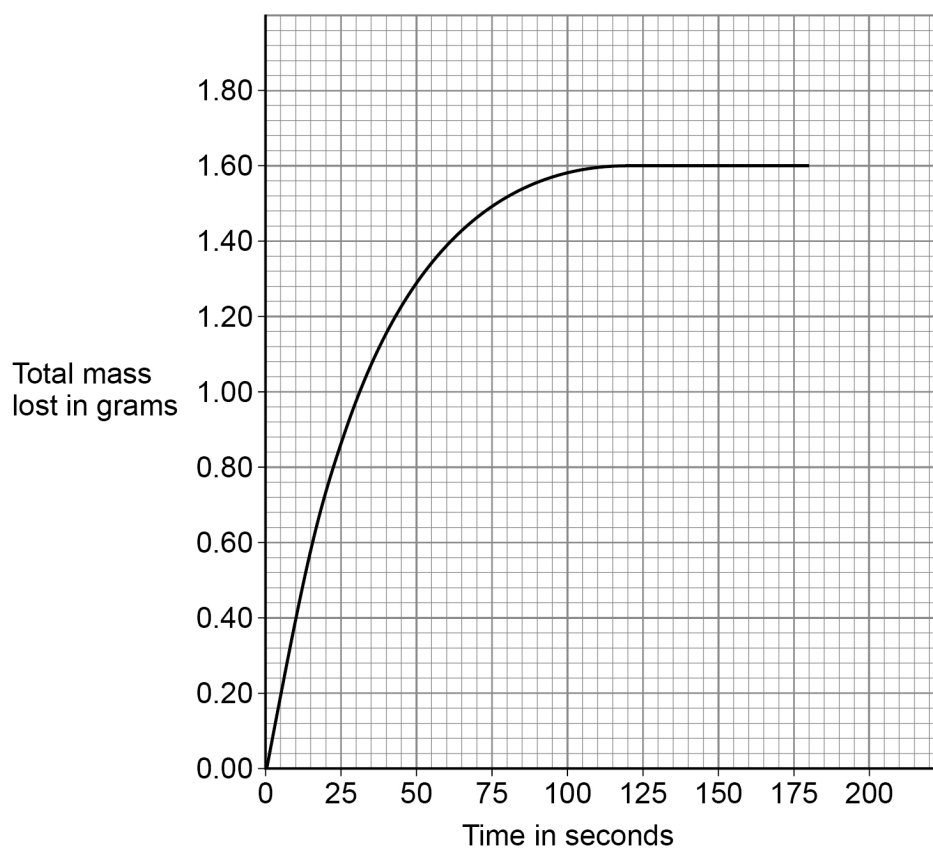
[4 marks]

Rate (2 significant figures) = _____ g/s

25.3

The results for 50 cm³ of 2.0 mol/dm³ hydrogen peroxide solution and 1.0 g of manganese dioxide are shown again on **Figure 5**.

Figure 5



The student repeated the investigation using 50 cm³ of 1.0 mol/dm³ hydrogen peroxide solution and 1.0 g of manganese dioxide.

Sketch the expected results for 1.0 mol/dm³ hydrogen peroxide solution on **Figure 5**.
[2 marks]