Questions are for both separate science and combined science students unless indicated in the question

Q1.

This question is about reactions between gases.

When hydrogen gas is heated with iodine gas, hydrogen iodide gas is produced.

The equation for this reversible reaction is:

hydrogen + iodine ⇌ hydrogen iodide

This reversible reaction reaches equilibrium in a sealed container.

(a) How does the equation show that the reaction is reversible?

Equation contains the symbol ⇌

(1)

(b) Which **two** statements are correct when the reaction reaches equilibrium?

Tick (✓) **two** boxes.

The forward reaction and reverse reaction are both exothermic. ✗	☐
The gases have escaped from the container. ✗	☐
The hydrogen no longer reacts with iodine. ✗	☐
The mass of each substance does not change.	✓
The rates of the forward reaction and reverse reaction are equal.	✓

(2)

(c) The initial mixture of hydrogen and iodine in the sealed container is purple.

Hydrogen iodide is colourless.

How will the colour of the mixture in the sealed container have changed when equilibrium is reached?

Tick (✓) **one** box.

Hydrogen + Iodine ⇌ Hydrogen iodide
purple colourless

The mixture will have become a deeper purple.	☐

The mixture will have become a paler purple.	✓
The mixture will have become colourless.	

(1)

(d) The rate of reaction between gases is affected by changing the pressure.

Complete the sentences.

When the pressure of the reacting gases is increased,

the rate of reaction Increases.

This is because at higher pressures the distance

between the particles Decreases.

This means that the frequency of collisions Increases.

(3)

(e) Give **one** other way of changing the rate of reaction between gases.

You should **not** refer to pressure in your answer.

Change the temperature or:
Use a catalyst

(1)

(Total 8 marks)

Q2.

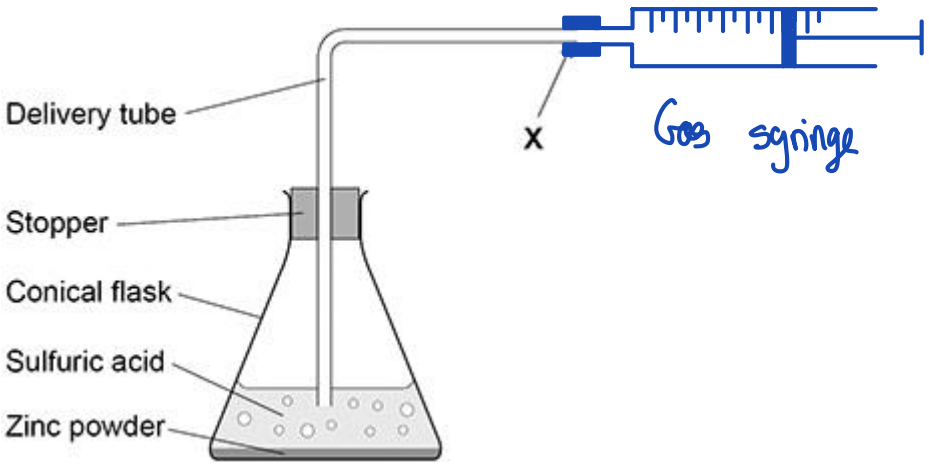
A student investigated the rate of the reaction between zinc and sulfuric acid.

This is the method used.

1. Pour 40 cm^3 of sulfuric acid into a conical flask.
2. Add 2.0 g of zinc powder to the conical flask.
3. Put the stopper in the conical flask.
4. Measure the volume of hydrogen gas collected every 30 seconds for 5 minutes.

Figure 1 shows part of the apparatus used.

Figure 1



(a) **X** shows where a piece of equipment is connected to measure the volume of hydrogen gas collected.

Complete **Figure 1** to show the equipment used.

(1)

(b) The student made an error setting up the delivery tube shown in **Figure 1**.

Describe the error **and** the problem this error would cause.

Error made Delivery tube is in the sulfuric acid solution

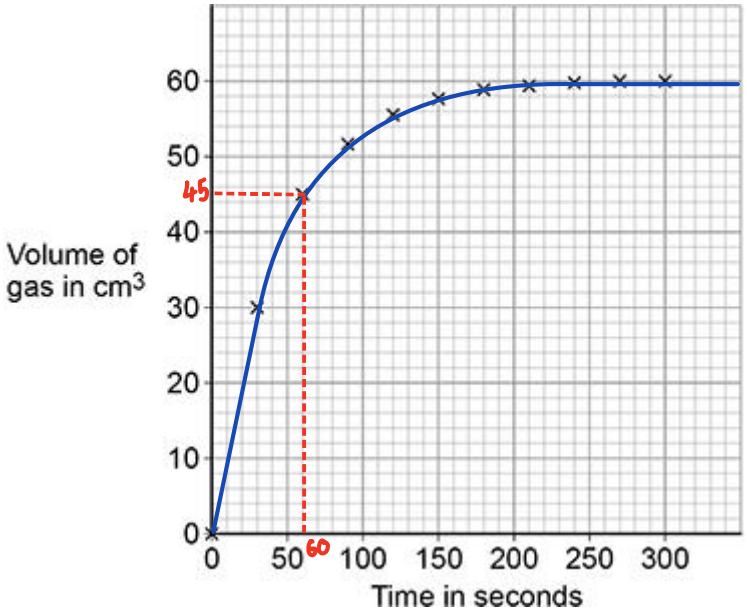
Problem caused Sulfuric acid will travel up the tube

(2)

The student then set up the apparatus correctly.

Figure 2 shows the student's results.

Figure 2



(c) Complete **Figure 2** by drawing a line of best fit.

(1)

(d) Determine the mean rate of reaction between 0 seconds and 60 seconds.

Use the equation:

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

$\frac{cm^3}{s}$

$= cm^3/s$

Use data from **Figure 2**.

Give the unit.

Choose the answer from the box.

cm^3/ s	**g / s**	**s / cm^3**	**s / g**

Mean Rate of Reaction $= \frac{45}{60} = 0.75$

Mean rate of reaction = 0.75 Unit cm^3/s

(4)

(e) The student repeated the investigation using sulfuric acid of a higher concentration.

The student plotted the results and drew a line of best fit.

How would the line of best fit for higher concentration compare with the line of best fit for lower concentration?

Tick (✓) **one** box.

The line of best fit for higher concentration would have a less steep slope.	☐
The line of best fit for higher concentration would have a steeper slope.	✓
The lines of best fit would have slopes with the same steepness.	☐

(1)

(Total 9 marks)

Q3.

A student investigated how a change in concentration affects the rate of the reaction between zinc powder and sulfuric acid.

The equation for the reaction is:

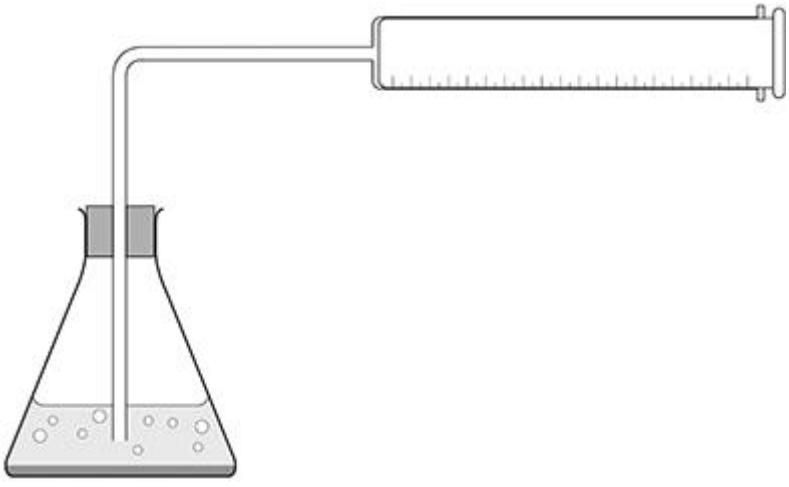
$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

This is the method used.

1. Pour 50 cm^3 of sulfuric acid of concentration 0.05 mol/dm^3 into a conical flask.
2. Add 0.2 g of zinc powder to the conical flask.
3. Put the stopper in the conical flask.
4. Measure the volume of gas collected every 30 seconds for 5 minutes.
5. Repeat steps 1 to 4 with sulfuric acid of concentration 0.10 mol/dm^3

Figure 1 shows the apparatus used.

Figure 1



(a) The student made an error in setting up the apparatus in **Figure 1**.

What error did the student make?

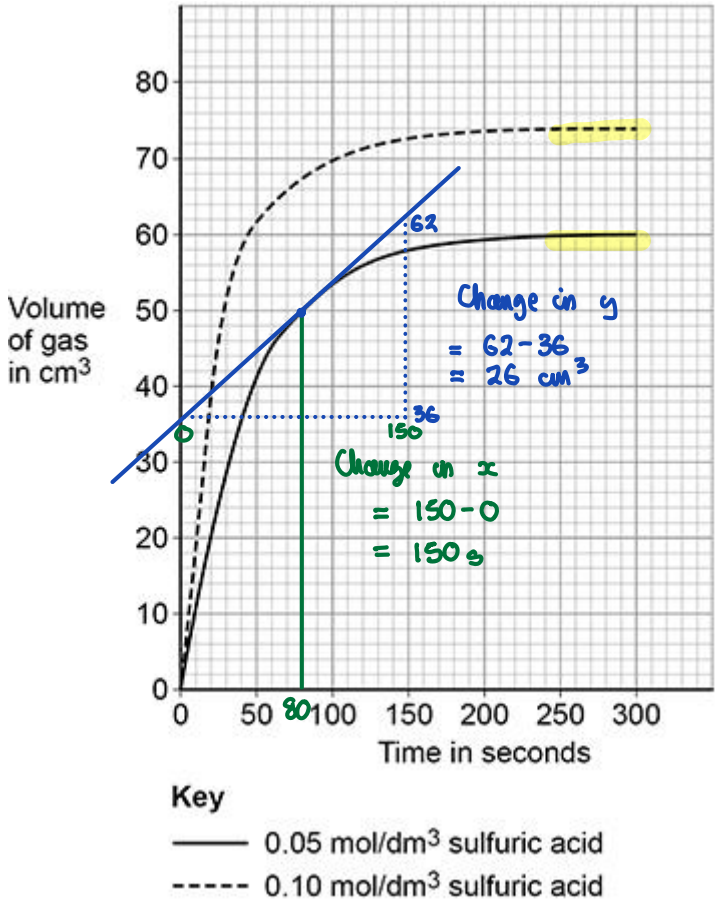
Delivery tube is in the sulfuric acid solution.

(1)

The student corrected the error.

Figure 2 shows the student's results.

Figure 2



(b) Explain why the lines of best fit on **Figure 2** become horizontal.

Lines become horizontal because reaction has stopped.
Because a reactant has been used up.

(2)

(c) How does **Figure 2** show that zinc powder reacts more slowly with 0.05

mol/dm^3 sulfuric acid than with 0.10 mol/dm^3 sulfuric acid?

0.05 line is less steep, producing less gas in fixed time, and takes longer to finish

(1)

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

gradient.

Show your working on **Figure 2**.

Give your answer to 2 significant figures.

Rate of Reaction = $\frac{\text{Change in } y \text{ } cm^3}{\text{Change in } x \text{ } s}$

$= \frac{26}{150} \frac{cm^3}{s}$

$= 0.1733 \text{ } cm^3/s$

Rate of reaction (2 significant figures) = 0.17 cm^3/s

(5)

(e) The activation energy for the reaction between zinc and sulfuric acid is lowered if a solution containing metal ions is added.

What is the most likely formula of the metal ions added?

Tick (✓) **one** box.

Al^{3+} ☐

Ca^{2+} ☐

Cu^{2+} ☑

Na^{+} ☐

Zn
H
Cu
↑ Reactivity

(1)

(Total 10 marks)

Q4.

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 hydrochloric acid into a conical flask up to the 50 cm^3 line.
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 20 seconds for 100 seconds.
5. Repeat steps 1 to 4 using 10.0 g of large calcium carbonate lumps.

(a) The student used the 50 cm^3 line on the conical flask to measure the volume of hydrochloric acid.

Suggest a piece of equipment the student could use to make the measurement of volume more accurate.

measuring cylinder / pipette

(1)

(b) Carbon dioxide gas is produced in the reaction between hydrochloric acid and calcium carbonate.

Which test is used to identify carbon dioxide gas?

Tick (✓) **one** box.

A burning splint pops	☐
A glowing splint relights	☐
Damp litmus paper is bleached	☐
Limewater turns milky	✓

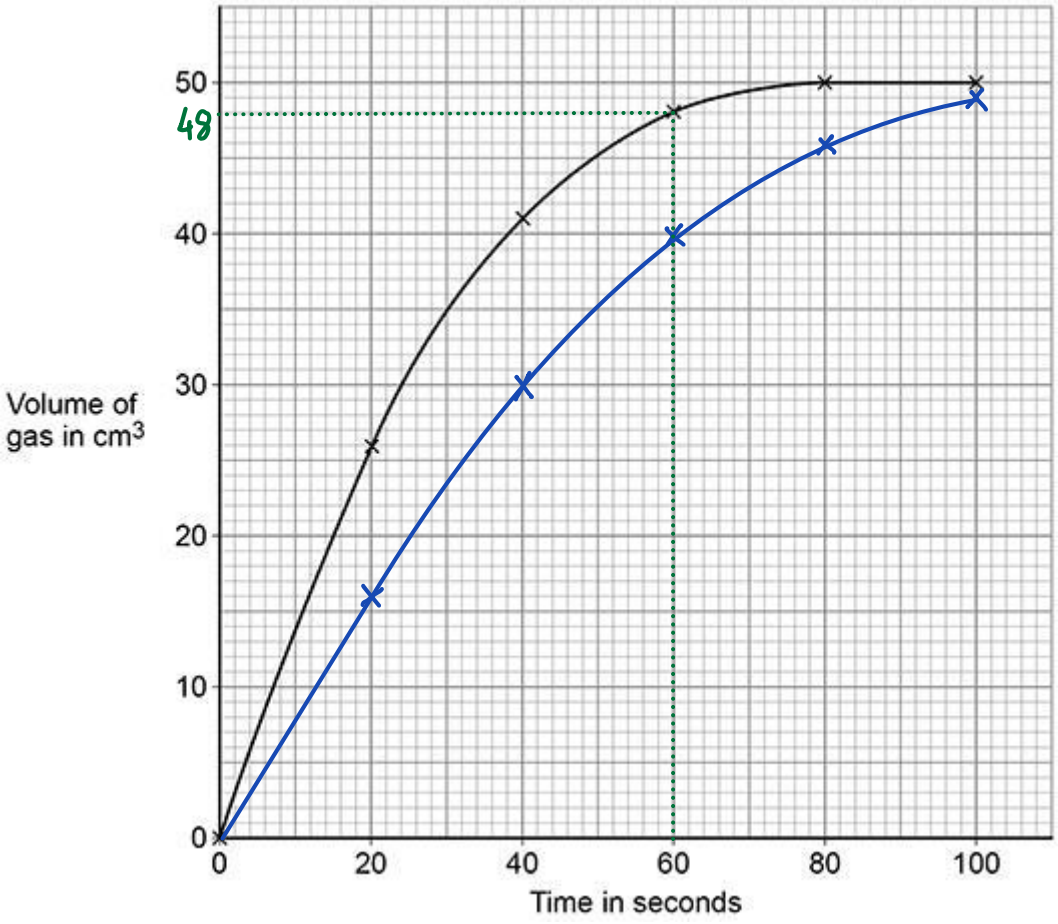
(1)

The table below shows the student's results for large calcium carbonate lumps.

Time in seconds	Volume of gas in cm^3
0	0
20	16
40	30

60	40
80	46
100	48

The graph below shows the student's results for small calcium carbonate lumps.



(c) Complete the graph above.

You should:

- plot the data for large calcium carbonate lumps from the table above on the graph paper
- draw a line of best fit for large calcium carbonate lumps.

(3)

(d) Determine the mean rate of reaction using **small** calcium carbonate lumps between 0 seconds and 60 seconds.

Use the equation:

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

Use the graph above.

Mean Rate of Reaction = $\frac{48 \text{ cm}^3}{60 \text{ s}}$

$= 0.8 \text{ cm}^3/\text{s}$

Mean rate of reaction = 0.8 cm^3/s

(3)

(e) Describe what happens to the volume of gas collected using **small** calcium carbonate lumps:

- between 0 and 20 seconds
- between 80 and 100 seconds.

Use the graph above.

Between 0 and 20 seconds

Volume of gas increases

Between 80 and 100 seconds

No change in volume of gas (reaction stops)

(2)

(f) The balance used to weigh 10.0 g of calcium carbonate lumps caused an error.

The balance always read 0.2 g before being used.

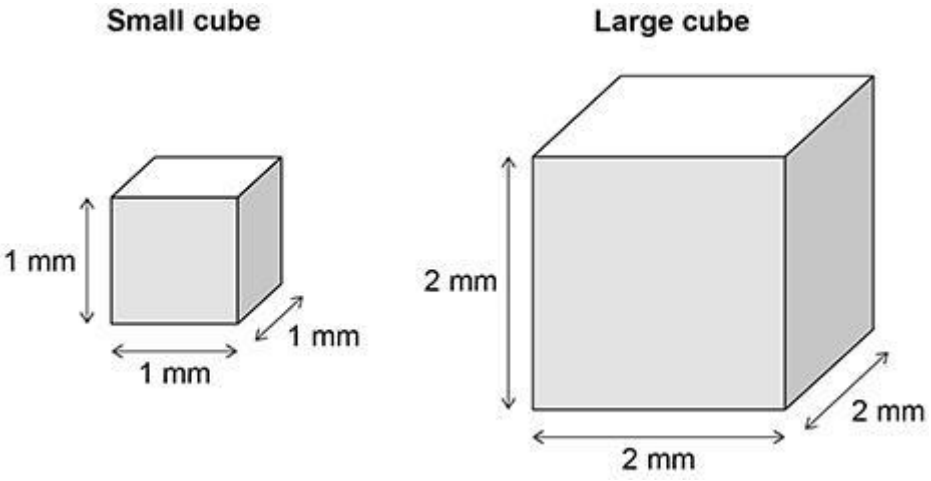
What type of error was caused by the balance?

Tick (✓) **one** box.

Human error	☐
Random error	☐
Systematic error	✓

(1)

The diagram shows the dimensions of two cubes of calcium carbonate.



(g) A cube of calcium carbonate has six faces.

Calculate the total surface area of the **large** cube of calcium carbonate.

Use the diagram above.

Surface area of 1 side = 2mm x 2mm
= 4 mm^2

Cube has 6 sides = 6 x 4 mm^2
∴ Total Surface area = 24 mm^2

Total surface area = 24 mm^2

(3)

(h) The large cube of calcium carbonate was divided into eight smaller cubes.

The eight smaller cubes have a greater total surface area than the one large cube.

Compare the rate of reaction when using the eight smaller cubes with the rate of reaction when using the large cube.

Complete the sentence.

Choose the answer from the box.

faster	slower	the same

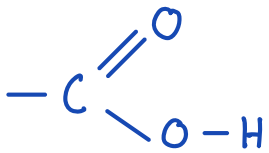
The rate of reaction of the eight smaller cubes is faster.

(1)

(Total 15 marks)

Q5.

This question is about carboxylic acids.



Carboxylic acids belong to a homologous series.

The table below shows information about the first three carboxylic acids in this homologous series.

Name	Formula	pH of a 0.01 mol/dm^3 solution
Methanoic acid	HCOOH	2.91
Ethanoic acid	CH_3COOH	3.39
	CH_3CH_2COOH	3.44

(a) Complete the table above. **(separate only)**

(2)

(b) Ethanoic acid ionises in water.

The equation for the reaction is:

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

Explain how the equation shows that ethanoic acid is a weak acid.

Reversible reaction shows partial ionisation

(2)

(c) A student adds a solution of ethanoic acid to zinc carbonate in an open flask on a balance.

Explain what happens to the mass of the flask and its contents during the reaction.

Mass of flask and contents decreases because carbon dioxide is produced which escapes from the flask

(3)

(d) The student compares the rates of the reaction of zinc carbonate with:

- 0.01 mol/dm^3 methanoic acid
- 0.01 mol/dm^3 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 the table above.

Methanoic acid has a lower pH so has a higher concentration of hydrogen ions H^+

(3)

Ethanoic acid reacts with ethanol to produce an ester.

(e) Give the name of the ester produced when ethanoic acid reacts with ethanol. **(separate only)**

ethyl ethanoate

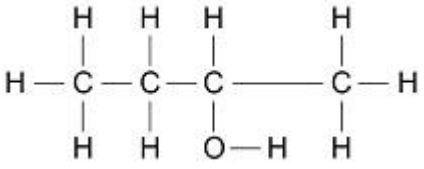
(1)

(f) Hexanedioic acid and ethanediol join together to produce a polyester.

Ethanoic acid and ethanol join together in the same way to produce an ester.

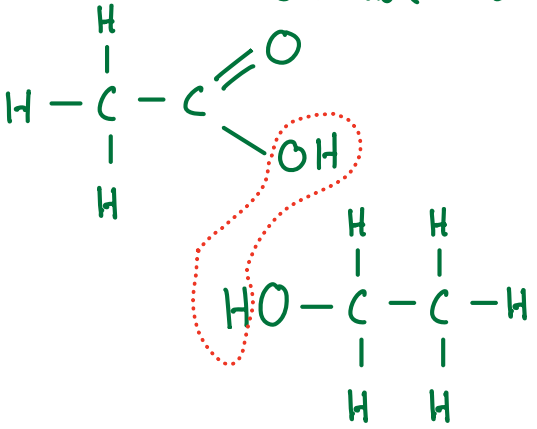
Which is the displayed structural formula of the ester produced when ethanoic acid reacts with ethanol?

Tick (✓) **one** box. **(separate only)**

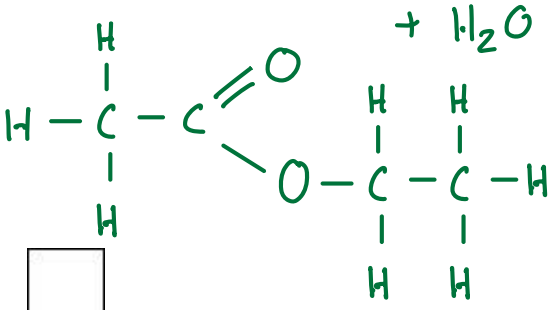


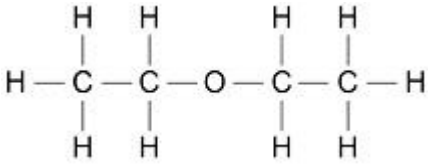
☐

ethanoic acid



ethanol





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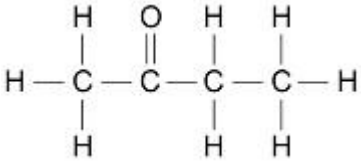

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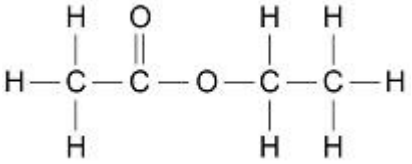


☑

(1)

(Total 12 marks)

Q6.

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 cm^3 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.

The table below shows the student's results for large calcium carbonate lumps.

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

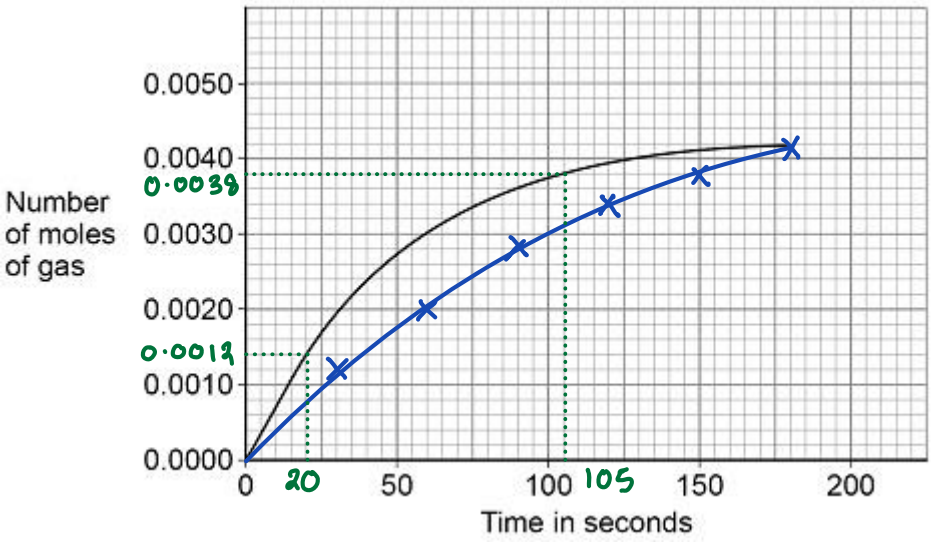
180	0.0040

The student plotted the results for small calcium carbonate lumps on the graph below.

(a) Complete the graph below.

You should:

- plot the data for large calcium carbonate lumps from the table above
- draw a line of best fit.



(3)

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

Give the unit.

Use the graph above.

Mean Rate (20 - 105) = $\frac{\text{Change in N° mols gas}}{\text{Change in time}}$ $\frac{\text{mol}}{\text{s}}$

$= \frac{0.0038 - 0.0017}{105 - 20} = \frac{0.0026}{85}$ $\frac{\text{mol}}{\text{s}}$

=

Mean rate of reaction = 3.06×10^{-5} Unit mol / s

(4)

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

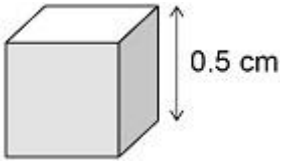
How do the student's results show that this conclusion is correct?

For large lumps a smaller number of moles of gas is collected in the same time.

(1)

The difference in the rates of reaction of large lumps and of small lumps of calcium carbonate depends on the surface area to volume ratios of the lumps.

The diagram below shows a cube of calcium carbonate.



(d) Calculate the surface area to volume ratio of the cube in above diagram.

Give your answer as the simplest whole number ratio.

Surface Area $= 6 \times 0.5\text{ cm} \times 0.5\text{ cm}$

$= 1.5\text{ cm}^2$

Volume $= 0.5\text{ cm} \times 0.5\text{ cm} \times 0.5\text{ cm}$

$= 0.125\text{ cm}^3$

S.A. : V $= 1.5 : 0.125$

$= \frac{1.5}{0.125} : \frac{0.125}{0.125}$

$= 12 : 1$

Surface area : volume = 12 : 1

(3)

(e) A larger cube of calcium carbonate has sides of 5 cm

Describe how the surface area to volume ratio of this larger cube differs from that of the cube shown in the diagram above.

sides change $0.5 \rightarrow 5$ · factor of 10

S.A. : Vol ratio decreases by factor of 10

(1)

(Total 12 marks)

$6 \times 5^2 : 5^3$

$150 : 125$

$\frac{150}{125} : \frac{125}{125} = 1.2 : 1$

Q7.

Some students investigated the rate of decomposition of hydrogen peroxide.

The equation for the reaction is:

hydrogen peroxide → water + oxygen

(a) Complete the sentence.

Choose an answer from the box.

a burning splint	**a glowing splint**
damp litmus paper	**limewater**

The students tested the gas produced to show that it was oxygen.

The students used a glowing splint.

(1)

Student **A** investigated the effect of the particle size of a manganese dioxide catalyst on the rate of the reaction.

This is the method used.

1. Measure 25 cm^3 hydrogen peroxide solution into a conical flask.

2. Add some fine manganese dioxide powder to the conical flask.

3. Measure the volume of oxygen produced every 30 seconds for 10 minutes.

4. Repeat steps 1 to 3 two more times.

5. Repeat steps 1 to 4 with coarse manganese dioxide lumps.

(b) The method student **A** used did **not** give repeatable results.

How could student **A** make the results repeatable?

Tick (✓) **one** box.

- Student **A** should make measurements every 2 minutes. ☐
- Student **A** should measure the mass of manganese dioxide. ☑
- Student **A** should use 50 cm3 hydrogen peroxide. ☐
- Student **A** should use a beaker instead of a conical flask. ☐

(1)

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

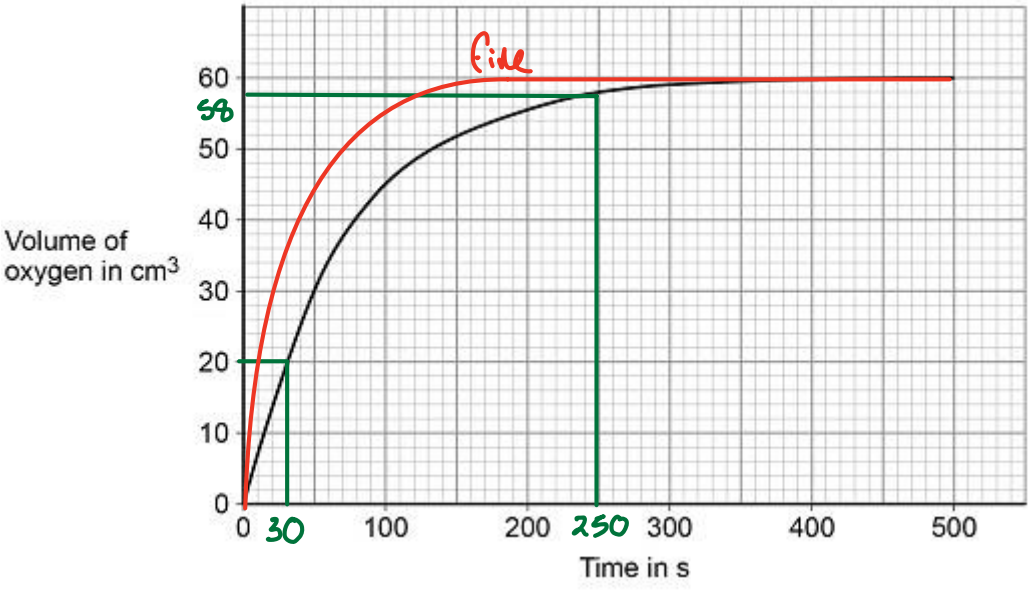
(c) How could student **B** improve the accuracy of these results?

Tick (✓) **one** box.

Calculate a mean but do not include any anomalous results.	✓
Calculate a mean but do not include the first set of results.	
Record the results in a table and plot the results on a bar chart.	
Record the results in a table and plot the results on a line graph.	

(1)

The figure below shows student **B**'s results for coarse manganese dioxide lumps.



(d) Calculate the mean rate of reaction between 30 and 250 seconds for coarse manganese dioxide lumps.

Use the figure and the equation:

$$\text{Mean rate of reaction} = \frac{\text{Volume of oxygen formed}}{\text{Time taken}}$$

Give your answer to 3 significant figures.

Volume of oxygen formed 58 − 20 = 38 cm^3

Time taken 250 − 30 = 220 s

Mean rate = $\frac{38\ cm^3}{220\ s}$

= 0·1727 cm^3/s

Mean rate of reaction = 0·173 (3 s.f.) cm³/s

(4)

(e) Fine manganese dioxide powder produces a higher rate of reaction than coarse manganese dioxide lumps.

Sketch on the figure above the results you would expect for student **B**'s experiment with fine manganese dioxide powder.

(2)

(f) Hydrogen peroxide molecules collide with manganese dioxide particles during the reaction.

Why does fine manganese dioxide powder produce a higher rate of reaction than coarse manganese dioxide lumps?

Tick (✓) **one** box.

Fine manganese dioxide powder has a larger surface area.	✓
Fine manganese dioxide powder has larger particles.	
Fine manganese dioxide powder produces less frequent collisions.	

(1)

(Total 10 marks)

Q8.

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:

$$Mg(s) + 2\,HCl(aq) \rightarrow MgCl^{2}(aq) + H2(g)$$

(a) Which state symbol in the equation for the reaction does not represent one of the three states of matter? solid liquid gas

(aq)

(1)

The student determined the rate of production of hydrogen gas.

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

1 Gas syringe

2 Stopwatch

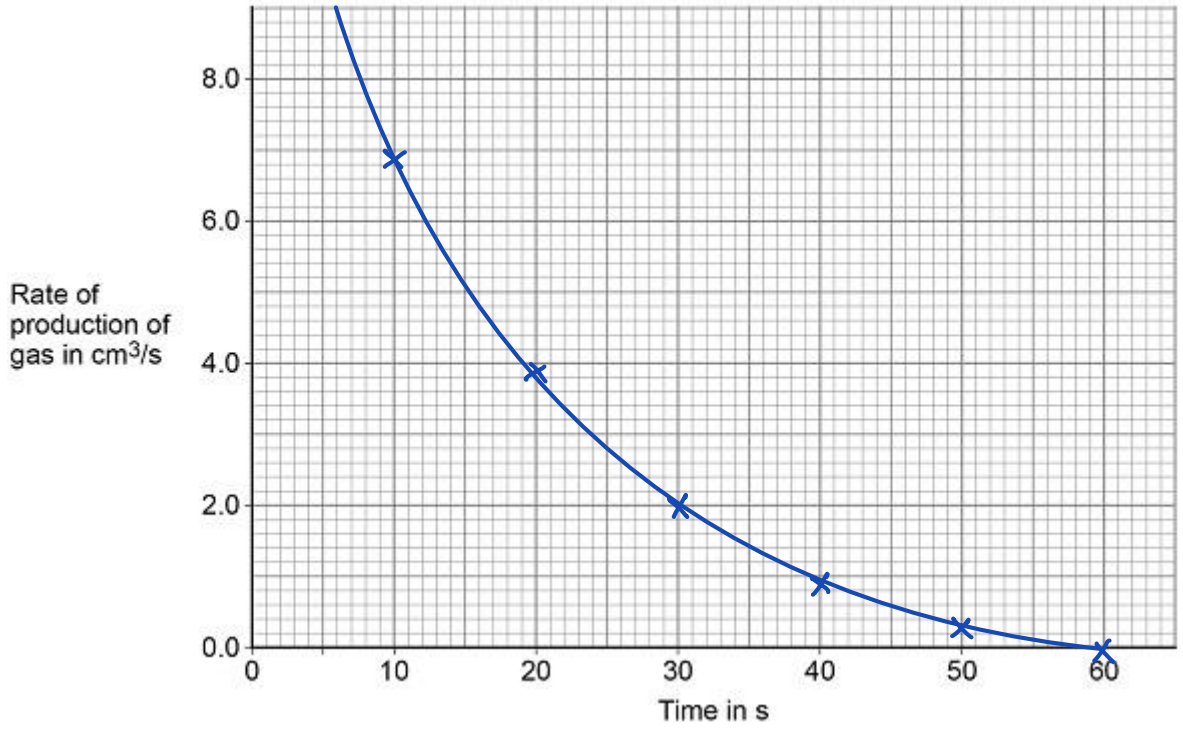
(2)

The following table shows the results of the investigation.

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

(c) Plot the data from the table on the graph below.

You should draw a line of best fit.



(3)

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

Use data from the graph and the table above.

1 Rate decreases with time

2 Rate decreases more slowly with time

3 Rate becomes 0 at 60s.

(3)

(e) 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?

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.	

(2)

(Total 11 marks)

Q9.

Some students investigated the rate of decomposition of hydrogen peroxide, H_2O_2

The equation for the reaction is:

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

The catalyst for the reaction is manganese dioxide.

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

Give the result of the test.

Test Glowing splint

Result Relights

(2)

Student **A** investigated the effect of the particle size of manganese dioxide on the rate of the reaction.

This is the method used.

1. Measure 25 cm^3 of 0.3 mol/dm^3 hydrogen peroxide solution into a conical flask.

2. Add a spatula of fine manganese dioxide powder to the conical flask.

3. Measure the volume of gas produced every minute for 10 minutes.

4. Repeat steps 1 to 3 with some coarse manganese dioxide lumps.

(b) The method student **A** used did not give valid results.

What **two** improvements could student **A** make to the method to give valid results?

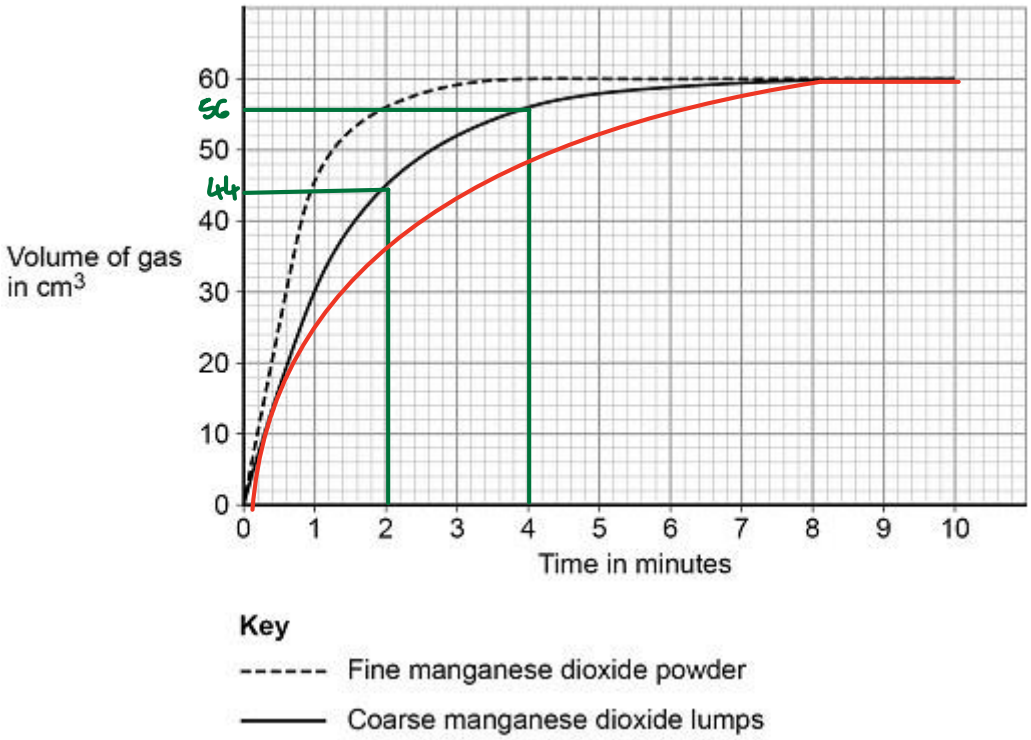
Tick (✓) **two** boxes.

Measure the increase in mass of the conical flask and contents.	☐
Measure the volume of gas produced every 2 minutes.	☐
Place the conical flask in a water bath at constant temperature.	✓
Use 0.05 mol/dm^3 hydrogen peroxide solution.	☐
Use a mass of 1 g manganese dioxide each time.	✓

(2)

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

The graph below shows student **B**'s results.



(c) 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 the graph.

Mean Rate = $\frac{56 - 44 \text{ cm}^3}{4 - 2 \text{ min}} = \frac{12}{2}$

$\frac{56 - 44 \text{ cm}^3}{240 - 120 \text{ s}} = \frac{12}{120}$

Mean rate of reaction = 0.1 cm^3/s

(3)

Hydrogen peroxide molecules must collide with manganese dioxide particles for catalysis to take place.

(d) 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.

Both lower Rate

Sketch on the graph above the curve you would expect to see.

Assume that the reaction is complete after 9 minutes.

(2)

(e) 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.

Surface area of fine powder greater.
Leading to more collisions per unit time.

(2)

(Total 11 marks)

Q10.

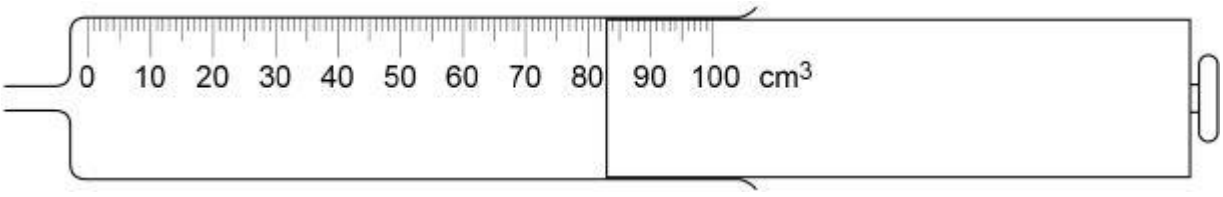
A student investigated how concentration affects the rate of reaction between magnesium and hydrochloric acid.

This is the method used.

1. Place hydrochloric acid in a conical flask.
2. Add magnesium powder.
3. Collect the gas produced in a gas syringe.
4. Measure the volume of gas every 40 seconds for 160 seconds.
5. Repeat steps 1-4 three more times.
6. Repeat steps 1-5 with hydrochloric acid of a higher concentration.

(a) **Figure 1** shows a gas syringe.

Figure 1



What is the volume of gas in the syringe?

Volume = 83 cm^3

(1)

(b) Which **two** variables should the student keep the same to make the investigation a fair test?

Tick **two** boxes.

Concentration of hydrochloric acid	☐
Mass of magnesium powder	✓
Temperature of hydrochloric acid	✓
Time for reaction to end	☐
Volume of gas collected	☐

(2)

The table below shows the student's results for the experiment with hydrochloric acid of a lower concentration.

Time in seconds	Volume of gas collected in cm^3				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Mean**
0	0	0	0	0	0
40	46	30	47	49	**X**
80	78	83	83	82	82
120	98	94	96	95	96
160	100	100	100	100	100

(c) Calculate mean value **X** in the table above.

Do **not** include the anomalous result in your calculation.

Give your answer to 2 significant figures.

$X = \frac{46 + 47 + 49}{3}$

$= 47.33$

X = 47 (2 s.f.) cm^3

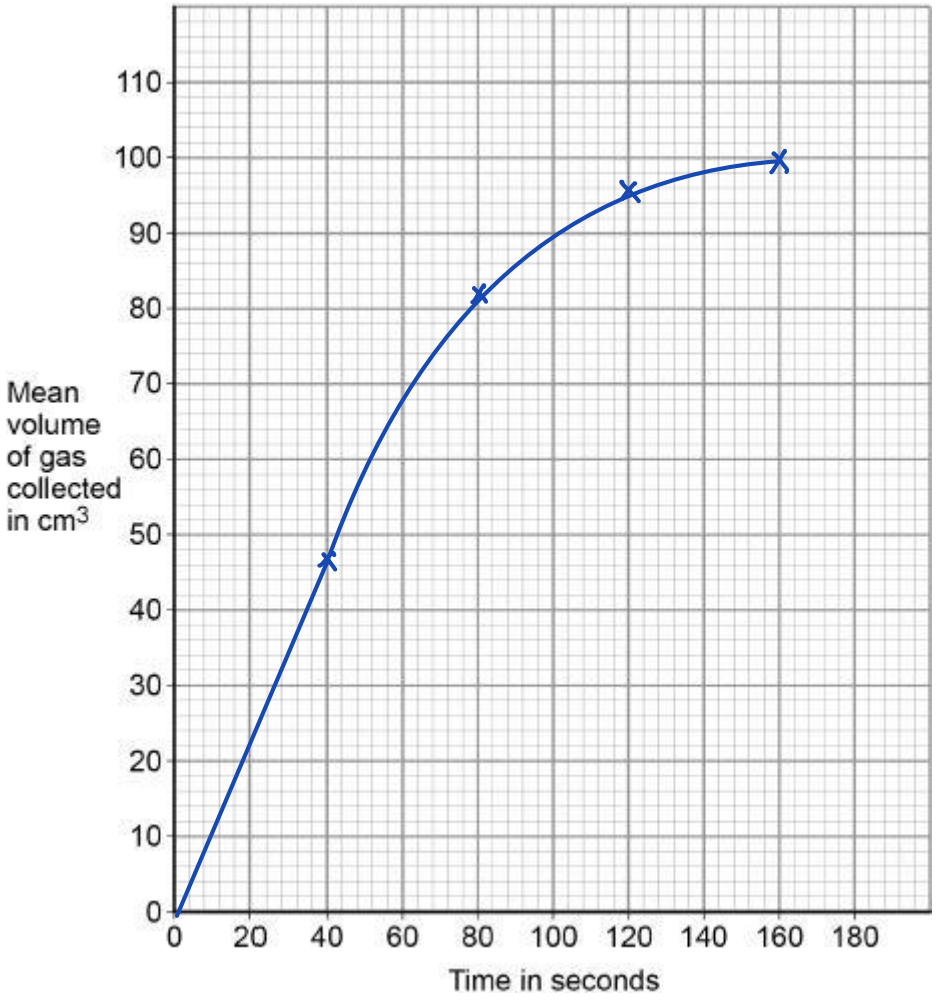
(2)

(d) Plot the data from the table above on **Figure 2**.

You should include your answer to Question **(c)**.

You do **not** need to draw a line of best fit.

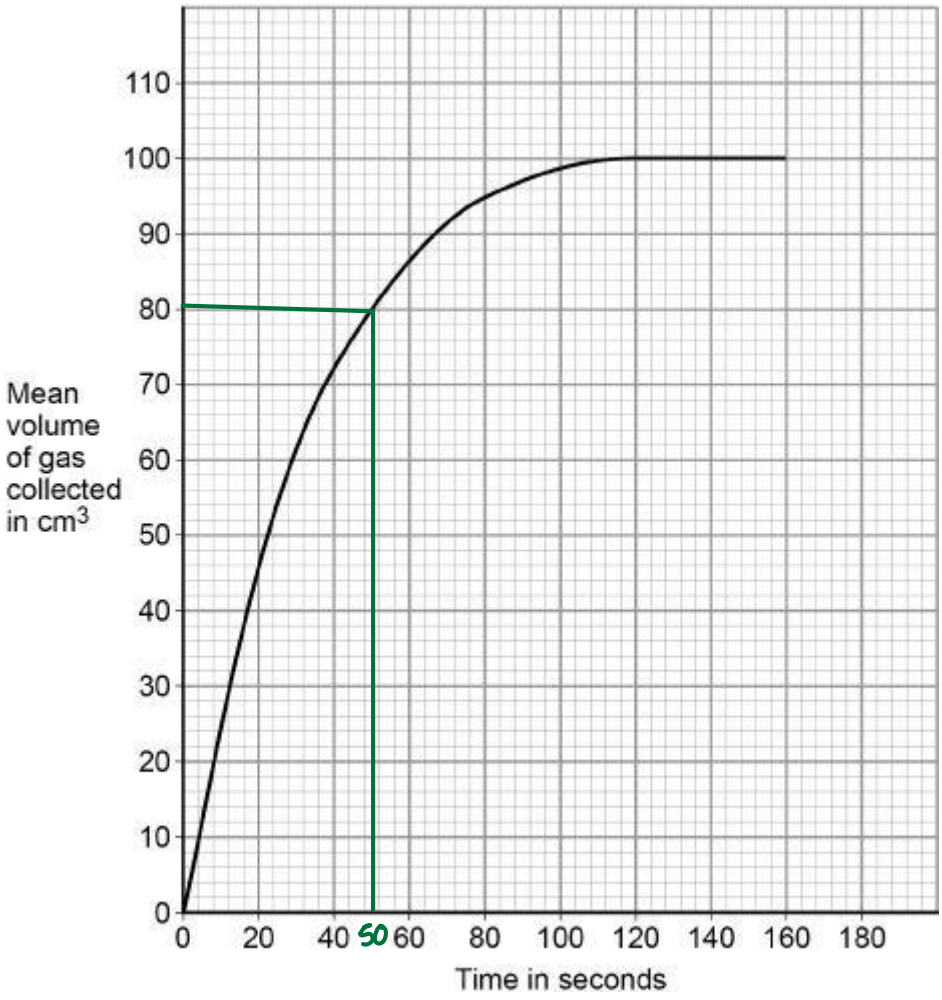
Figure 2



(2)

Figure 3 shows results of the experiment with the hydrochloric acid of a higher concentration.

Figure 3



(e) Calculate the mean rate of reaction between 0 and 50 seconds.

Use **Figure 3** and the equation:

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

Mean rate $= \frac{80 - 0}{50 - 0}$ $\frac{cm^3}{s}$

$= 1.6$ cm^3/s

Mean rate of reaction = 1.6 cm^3/s

(2)

(f) Describe how the **rate of reaction** changes between 0 and 160 seconds.

Use **Figure 3**.

Rate is greatest at start, then decreases

before reaction stops.

(3)

(g) The student concludes that the rate of reaction is greater when the concentration of hydrochloric acid is higher.

Why is the rate of reaction greater when the concentration of hydrochloric acid is higher?

Tick **two** boxes.

The particles are moving faster	☐
The particles have more energy	☐
The surface area of magnesium is smaller	☐
There are more particle collisions each second	☑
There are more particles in the same volume	☑

(2)

(h) The student tests the gas produced by bubbling it through limewater.

No change is seen in the limewater.

Give **one** conclusion the student can make about the gas.

Gas is not carbon dioxide

(1)

(i) The student tests the gas produced using a burning splint.

Name the gas the student is testing for.

Give the result of a positive test for this gas.

Name of gas Hydrogen

Result squeaky pop.