Separate Science (Chemistry) Unit 6 Rate and extent of chemical change

Foundation

Question number	Description	Marks	Page number
4.6.1 Rate of reaction			
1	Naming equipment multiple choice, observations to show reaction taking place between magnesium and hydrochloric acid, placing results into results table, calculating rate of reaction from a graph using equation and giving unit, determine time when reaction finished from graph, rate of reaction multiple choice	14	4
3	Balancing symbol equation, apparatus to measure volume of hydrochloric acid, completing results table with headings and results, suggest reason for results lower than expected, giving control variables, rate of reaction gap fill	12	10
5	Matching variables and examples, naming compound symbol formulae, suggesting how to improve method, calculating rate of reaction using equation in question, identifying unit for rate of reaction, plotting results on graph and line of best fit, surface area multiple choice	11	13
7	(4.8.2 gas test for oxygen), repeatable and accuracy multiple choice based on method, reading values on graph and calculating gradient using equation, sketching rate of reaction line on graph, rate of reaction surface area multiple choice	10	17
7	Reading measurement on gas syringe, control variables multiple choice, calculate mean from results table, plotting results onto graph, reading values from graph to calculate rate of reaction, describing rate of reaction graph, rate of reaction multiple choice (4.8.2 gas tests)	17	21
4.6.2 Reversible reactions and dynamic equilibrium			
1	Copper sulphate reversible reaction multiple choice, conservation of mass (g) calculations, compound symbol formulae matching with names multiple choice	8	27
6	Reversible reaction symbol, reading balance and calculating mass of water and copper sulphate in results table, reading	7	30

	measurement on a thermometer (4.5.1 exothermic multiple choice)		

Common content

Question number	Description	Marks	Page number
4.6.1 Rate of reaction			
3	States of matter symbols, pieces of apparatus for measuring rate of production of hydrogen gas, plotting results onto graph and line of best fit, giving conclusions on rate of reaction from results table and graph, multiple choice on rate of reaction when changing temperature	11	34

Higher

Question number	Description	Marks	Page number
4.6.1 Rate of reaction			
5	Ionic equation for magnesium and hydrochloric acid reaction, plotting results onto graph and line of best fit, describing changes in rate of reaction, explaining why rate of reaction changes	11	37
5	Completing symbol equation between calcium carbonate and hydrochloric acid, describing trend in graph, describing how to calculate the rate of reaction for curved part of line, give units for rate of reaction, conclusion from results table, reason for maximum volume of gas produced, calculate surface area of cube, explaining why surface area affects rate of reaction, explaining difference in rate of reaction graph for different concentrations of acids	17	41
5	Explain why sodium thiosulphate reaction becomes cloudy, plan investigation between sodium thiosulphate and hydrochloric acid (6 marks)	8	46
6	Equipment for measuring volume of hydrogen produced, drawing and completing results table for experiment, calculating rate of reaction for point on curved line and answer to two significant figures, explaining why rate of reaction is increased at higher temperatures	11	48

8	Explain why conical flask loses mass when gas produced in a reaction, plotting results onto a graph, calculating rate of reaction for point on curved line and answer to two significant figures	9	51
9	(4.8.2 test for oxygen), improvements to method multiple choice, calculating mean rate of reaction from graph to two significant figures, sketching line on rate of reaction graph, explain how surface area affects rate of reaction	11	54
4.6.2 Reversible reactions and dynamic equilibrium			
4	(4.7.1 products of cracking, explain why shorter chain alkene has lower boiling point), explain how changing pressure affects percentage yield for reversible reaction graph, evidence from graph that forward reaction is exothermic, (4.5.1 reaction profile), suggest why catalyst does not affect yield at equilibrium	13	58
6	(4.8.2 test for oxygen), explaining the effect of removing product on position of equilibrium, **calculate the mass of product from balanced symbol equation and mass of one reactant**	8	61
6	(4.8.2 test for chlorine), explain why equilibrium is reached in closed system, explain what happens to equilibrium when closed system is opened, predict and explain effect on product of increasing temperature of reversible reaction, explain the effect on equilibrium of increasing pressure of reversible reaction	12	63
9	Moles in symbol equation multiple choice, explain the effect on yield when temperature in reversible reaction is increased, explain why higher pressure gives greater yield and rate of reaction in reversible reaction, explain how catalyst increases rate of reaction, effect of catalyst on equilibrium	12	66

Answer **all** questions in the spaces provided.

Do not write outside the box

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

The reaction produced a gas.

0 1 . 1 Which gas is produced in the reaction?

[1 mark]

Tick (✓) **one** box.

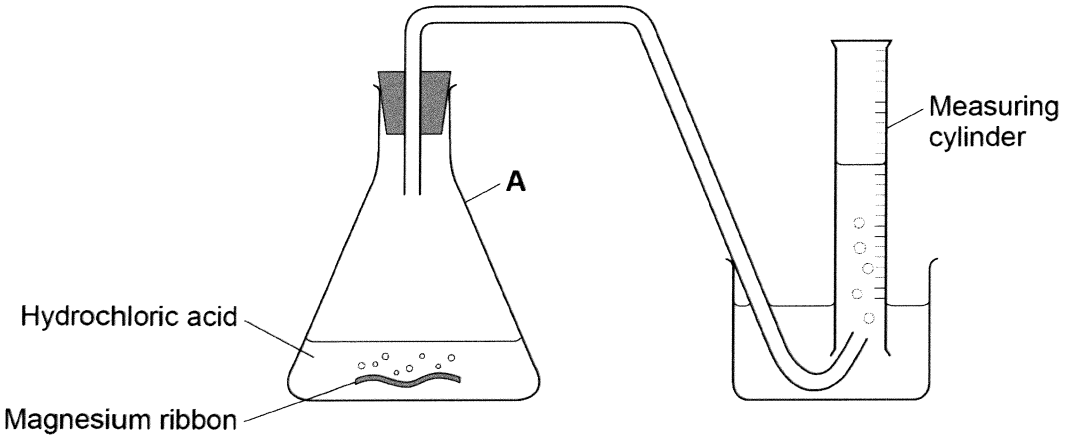
- Carbon dioxide ☐
- Chlorine ☐
- Hydrogen ☐
- Oxygen ☐

Question 1 continues on the next page

Do not write outside the box

0 1 . 2 **Figure 1** shows the apparatus used.

Figure 1



What is the piece of equipment labelled **A**?

[1 mark]

Tick (✓) **one** box.

- Conical flask ☐
- Delivery tube ☐
- Glass beaker ☐
- Test tube ☐

Do not write outside the box

0 1 . 3 The student saw that a chemical reaction was taking place.

Give **two** observations that would show a chemical reaction was taking place.

[2 marks]

1 _____

_____

2 _____

_____

0 1 . 4 At the start of the investigation the volume of gas in the measuring cylinder was zero.

The student measured the volume of gas collected every 20 seconds for 2 minutes.

The readings for the volume of gas were 24 cm^3, 44 cm^3, 59 cm^3, 70 cm^3, 76 cm^3 and 79 cm^3

Complete **Table 1**.

[3 marks]

Table 1

Time in seconds	
0	0
	24
	44
	59
	70
	76
	79

Question 1 continues on the next page

Do not write outside the box

0 1 . 5 How could the student make the reaction faster?

[1 mark]

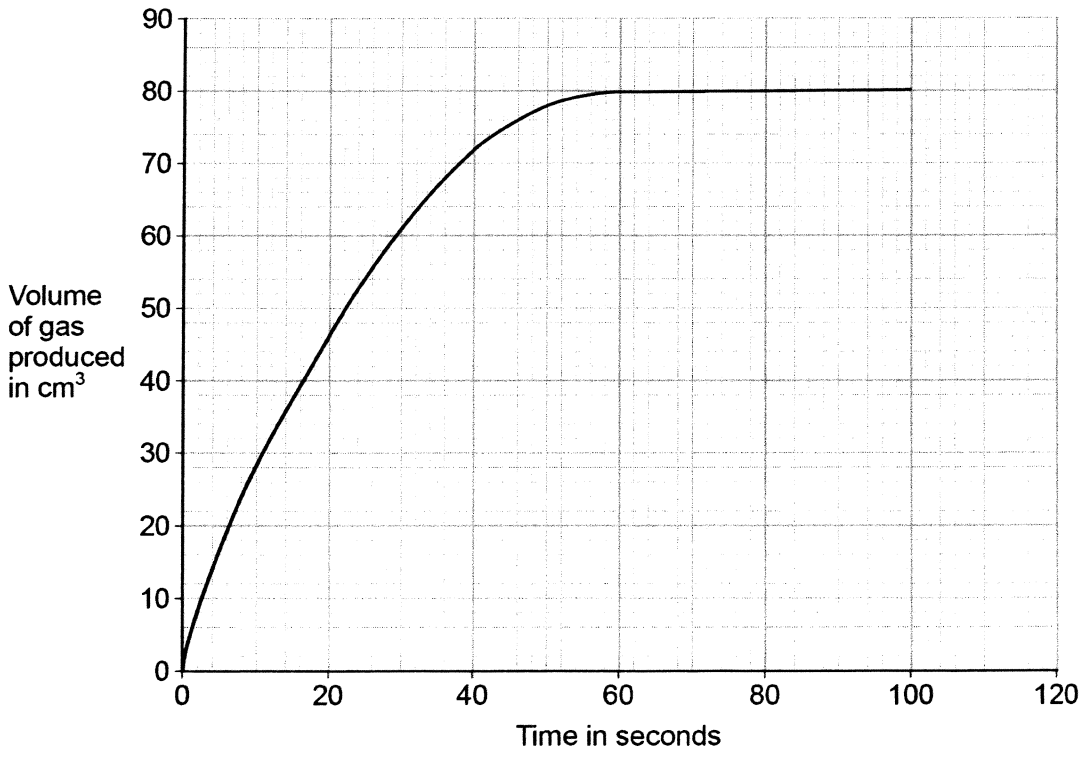
Tick (✓) **one** box.

- Dilute the hydrochloric acid ☐
- Replace magnesium ribbon with magnesium powder ☐
- Use a larger measuring cylinder ☐
- Use a smaller volume of hydrochloric acid ☐

The student repeated the investigation at a higher temperature.

Figure 2 shows the results.

Figure 2



Do not write outside the box

0 1 . 6 Determine the mean rate of reaction for the first 10 seconds.

Use the equation:

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

Give the unit.

Choose the unit from the box.

[3 marks]

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

Mean rate of reaction = _____ Unit _____

0 1 . 7 Determine the time at which the reaction finished and no more gas was produced.

Use **Figure 2**.

[1 mark]

Time = _____ s

Question 1 continues on the next page

Do not write outside the box

0 1 . 8 Why does the rate of reaction increase when the temperature is higher?

[2 marks]

Tick (✓) **two** boxes.

Concentration of particles increases ☐

Particles collide more often ☐

Particles have more energy ☐

Particles increase in size ☐

Particles move more slowly ☐

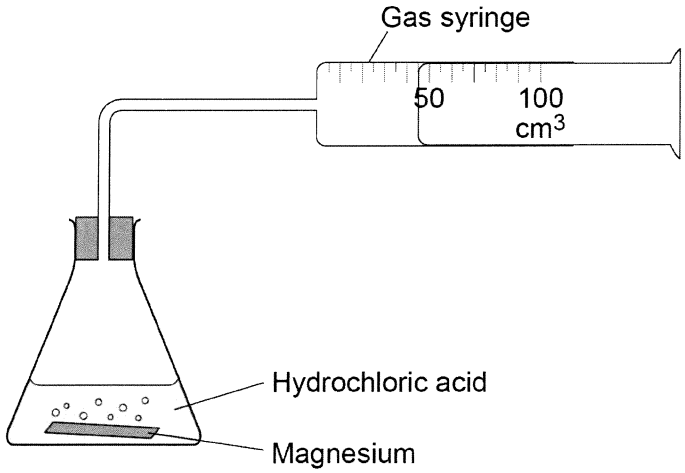
14

Do not write outside the box

0 3 A student investigated the rate of the reaction between magnesium and hydrochloric acid.

Figure 4 shows the apparatus the student used.

Figure 4



0 3 . 1 Balance the equation for the reaction.

[1 mark]

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

0 3 . 2 The student used 50 cm^3 of hydrochloric acid.

Which apparatus would measure 50 cm^3 of hydrochloric acid with the greatest accuracy?

[1 mark]

Tick (✓) **one** box.

50 cm^3 beaker ☐

50 cm^3 conical flask ☐

50 cm^3 measuring cylinder ☐

Do not write outside the box

0 3 . 3 The student measured the volume of gas produced every 20 seconds for 2 minutes.

The volume of gas was zero at the start of the experiment.

The measured volumes of gas were:

26 cm^3 38 cm^3 47 cm^3 55 cm^3 59 cm^3 60 cm^3

Complete **Table 2** to show these results.

[4 marks]

Table 2

0	0

0 3 . 4 The volumes of gas were lower than expected.

Suggest **one** reason.

[1 mark]

_____

_____

0 3 . 5 The student repeated the experiment using different concentrations of hydrochloric acid.

Give **two** variables the student should keep the same.

[2 marks]

1 _____

2 _____

Turn over ▶

Do not write outside the box

0 3 . 6 Complete the sentences.

[3 marks]

As the concentration of the hydrochloric acid increased, the rate of the reaction _____ .

This is because there were more acid _____ in each cubic centimetre (cm^3).

So the collisions happened more _____ .

12

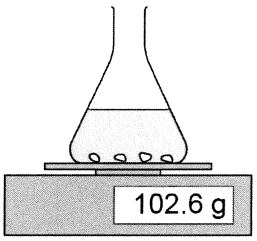
0 5 A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10.0 g of marble chips into the flask.
2. Add 50 cm^3 of hydrochloric acid and start a timer.
3. Record the mass lost from the flask every 10 seconds.
4. Repeat steps 1 to 3 with different sizes of marble chips.

Figure 10 shows the apparatus.

Figure 10



0 5 . 1 Draw **one** line from each type of variable to the correct example of the variable.

[2 marks]

Type of variable	Example of variable
	Mass lost from flask
Independent	Size of flask
	Size of marble chips
Control	
	Time taken
	Volume of acid

Do not write outside the box

0 5 . 2 The equation for the reaction is:

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

Name the **three** products.

[2 marks]

1 _____

2 _____

3 _____

0 5 . 3 Another student suggests putting some cotton wool in the top of the flask.

Suggest why this improves the investigation.

[1 mark]

_____

_____

0 5 . 4 The reaction produces 1.6 g of gas in 30 seconds.

Calculate the mean rate of the reaction in the first 30 seconds.

Use the equation:

$$\text{mean rate of reaction} = \frac{\text{mass of product produced in grams}}{\text{time in seconds}}$$

[1 mark]

_____

_____

Mean rate of reaction = _____

0 5 . 5 What is the unit for the mean rate of reaction calculated in question **05.4**?

[1 mark]

Tick **one** box.

g ☐ g/s ☐ s ☐ s/g ☐

0 5 . 6 **Table 5** shows the student's results.

Table 5

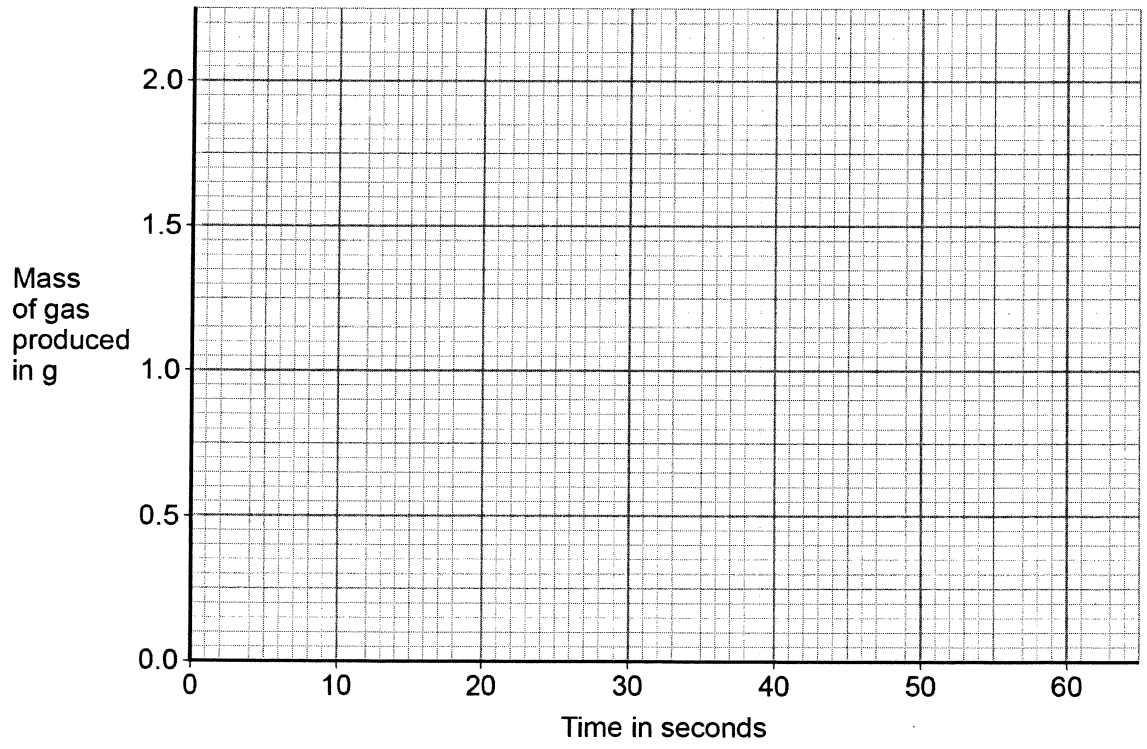
Time in seconds	Mass of gas produced in g
0	0.0
10	0.8
20	0.6
30	1.6
40	1.8
50	2.0
60	2.0

Plot the data from **Table 5** on **Figure 11**

Draw a line of best fit.

[3 marks]

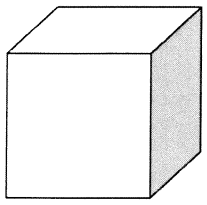
Figure 11



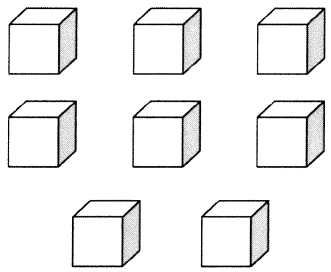
Do not write outside the box

0 5 . 7 **Figure 12** shows a large marble chip and eight small marble chips.

Figure 12



Large marble chip



Eight small marble chips

The large marble chip has the same total volume as the eight small marble chips, but a different surface area.

Why do the eight small marble chips react faster than the large marble chip?

[1 mark]

Tick **one** box.

The eight small marble chips have a larger surface area, so less frequent collisions. ☐

The eight small marble chips have a larger surface area, so more frequent collisions. ☐

The eight small marble chips have a smaller surface area, so less frequent collisions. ☐

The eight small marble chips have a smaller surface area, so more frequent collisions. ☐

11

Turn over for the next question

Do not write outside the box

0 7 Some students investigated the rate of decomposition of hydrogen peroxide.

The equation for the reaction is:

hydrogen peroxide → water + oxygen

0 7 . 1 Complete the sentence.

Choose an answer from the box.

[1 mark]

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 _____ .

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.

Do not write outside the box

0 7 . 2 The method student **A** used did **not** give repeatable results.

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

[1 mark]

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 cm^3 hydrogen peroxide. ☐

Student **A** should use a beaker instead of a conical flask. ☐

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

0 7 . 3 How could student **B** improve the accuracy of these results?

[1 mark]

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. ☐

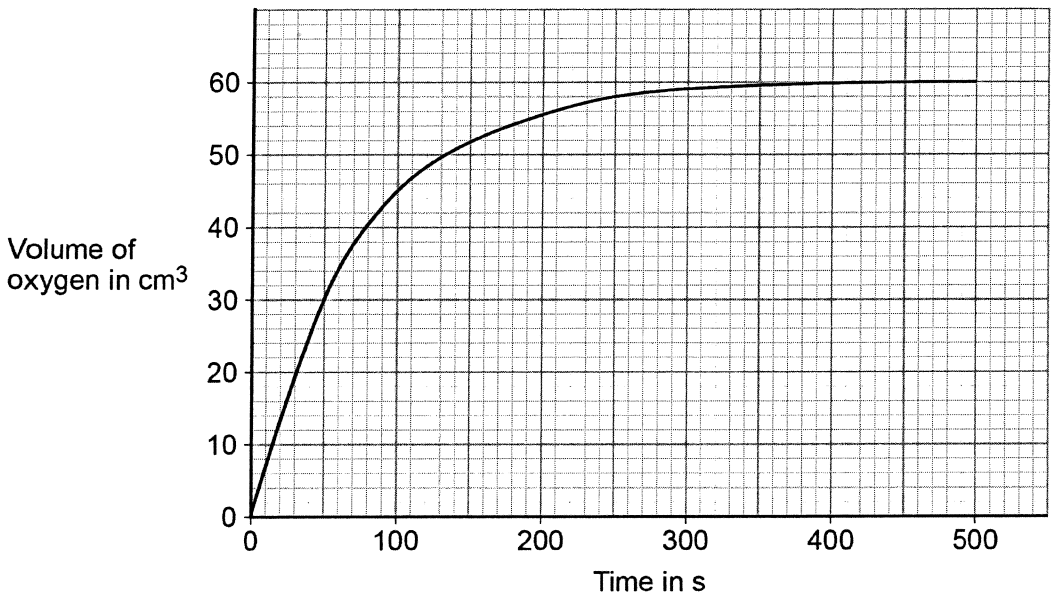
Record the results in a table and plot the results on a bar chart. ☐

Record the results in a table and plot the results on a line graph. ☐

Do not write outside the box

Figure 5 shows student **B**'s results for coarse manganese dioxide lumps.

Figure 5



0 7 . 4 Calculate the mean rate of reaction between 30 and 250 seconds for coarse manganese dioxide lumps.

Use **Figure 5** and the equation:

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

Give your answer to 3 significant figures.

[4 marks]

Volume of oxygen formed _____

Time taken _____

_____

_____

_____

_____

Mean rate of reaction = _____ cm^3/s

Do not write outside the box

0 7 . 5 Fine manganese dioxide powder produces a higher rate of reaction than coarse manganese dioxide lumps.

Sketch on **Figure 5** the results you would expect for student **B**'s experiment with fine manganese dioxide powder.

[2 marks]

0 7 . 6 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?

[1 mark]

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. ☐

Turn over for the next question

10

Do not write outside the box

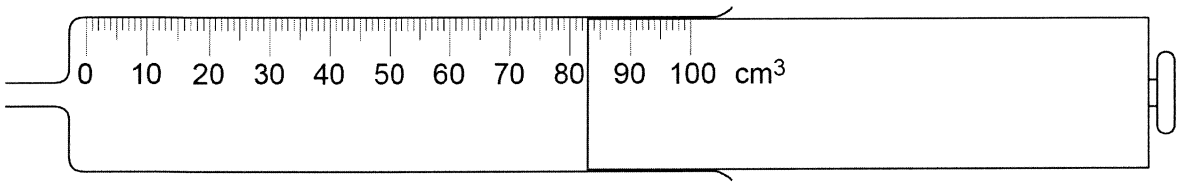
0 7 A student investigated how concentration affects the rate of reaction between magnesium and hydrochloric acid.

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.

0 7 . 1 **Figure 5** shows a gas syringe.

Figure 5



What is the volume of gas in the syringe?

[1 mark]

Volume = _____ cm^3

0 7 . 2 Which **two** variables should the student keep the same to make the investigation a fair test?

[2 marks]

Tick **two** boxes.

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

Turn over ▶

Do not write outside the box

Table 5 shows the student's results for the experiment with hydrochloric acid of a lower concentration.

Table 5

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

0 7 . 3 Calculate mean value **X** in **Table 5**.

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

Give your answer to 2 significant figures.

[2 marks]

X = _____ cm^3

Do not write outside the box

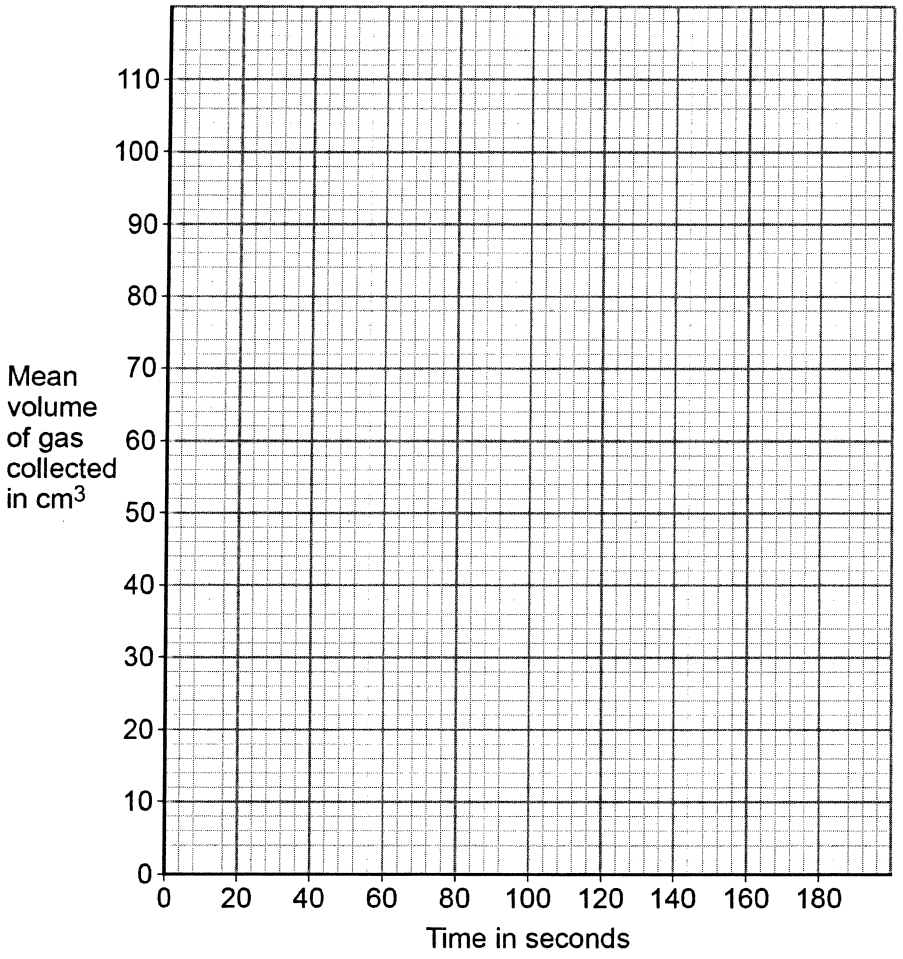
0 7 . 4 Plot the data from **Table 5** on **Figure 6**.

You should include your answer to Question **07.3**.

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

[2 marks]

Figure 6

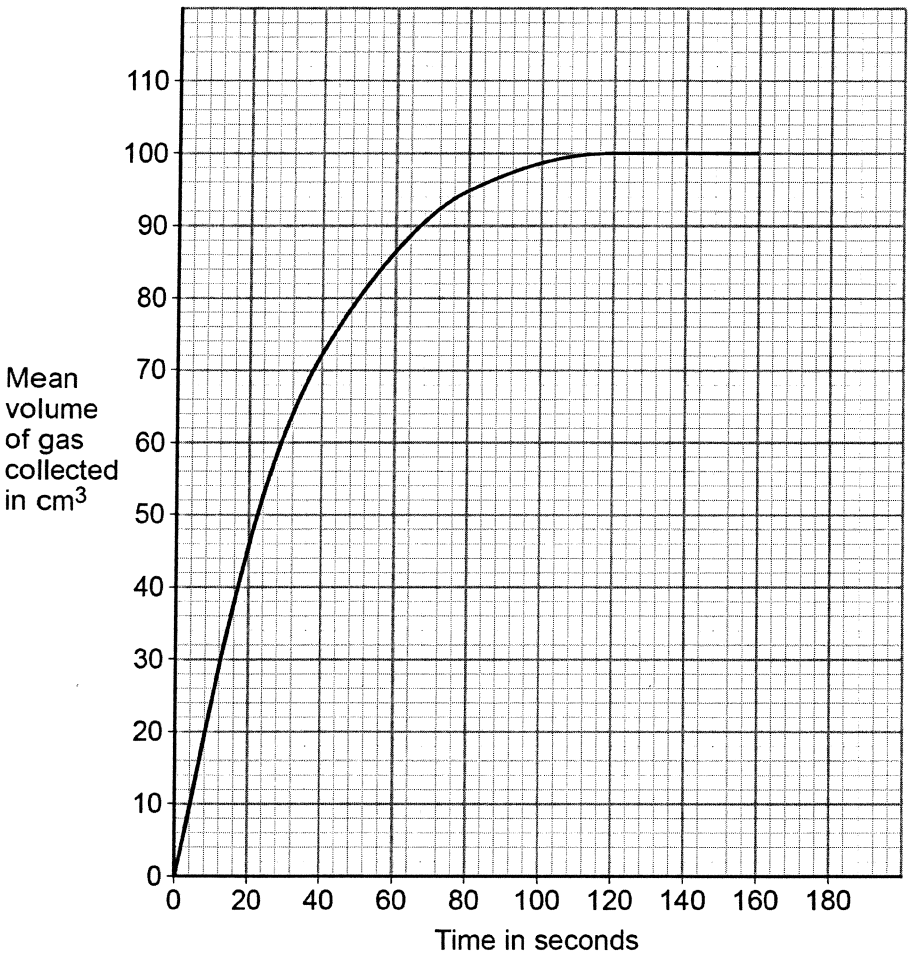


Question 7 continues on the next page

Do not write outside the box

Figure 7 shows results of the experiment with the hydrochloric acid of a higher concentration.

Figure 7



0 7 . 5 Calculate the mean rate of reaction between 0 and 50 seconds.

Use **Figure 7** and the equation:

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

[2 marks]

Mean rate of reaction = _____ cm^3/s

Do not write outside the box

0 7 . 6 Describe how the **rate of reaction** changes between 0 and 160 seconds.

Use **Figure 7**.

[3 marks]

0 7 . 7 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?

[2 marks]

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 ☐

Question 7 continues on the next page

Do not write outside the box

0 7 . 8 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.

[1 mark]

_____

_____

0 7 . 9 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.

[2 marks]

Name of gas _____

Result _____

_____

17

Do not write outside the box

0 1 This question is about copper sulfate.

Blue copper sulfate turns white when it is heated.

The word equation for the reaction is:

hydrated copper sulfate ⇌ anhydrous copper sulfate + water

blue white

0 1 . 1 What name is given to hydrated copper sulfate in this reaction?

[1 mark]

Tick **one** box.

- Catalyst ☐
- Element ☐
- Product ☐
- Reactant ☐

0 1 . 2 What does the symbol ⇌ mean?

[1 mark]

Tick **one** box.

- Endothermic ☐
- Exothermic ☐
- Reversible ☐
- Polymerisation ☐

Do not write outside the box

0 1 . 3 Complete the sentence.

[1 mark]

The colour change when water is added to anhydrous copper sulfate

is white to _____ .

A student heats 2.5 g of hydrated copper sulfate in a test tube.

0.9 g of water is given off.

The remaining solid is anhydrous copper sulfate.

0 1 . 4 Calculate the mass of anhydrous copper sulfate produced.

[1 mark]

_____

_____

Mass of anhydrous copper sulfate = _____ g

0 1 . 5 Calculate the percentage of water contained in 2.5 g of hydrated copper sulfate.

[2 marks]

_____

_____

_____

Percentage of water = _____ %

Question 1 continues on the next page

Do not write outside the box

0 1 . 6 Draw **one** line from each compound to the formula for the compound.

[2 marks]

Compound	Formula for the compound
Copper sulfate	CuO
	CuS
	$CuSO_4$
Water	H_2O
	H_2SO_4

8

Do not write outside the box

0 6 This question is about reversible reactions.

When blue hydrated copper sulfate is heated, white anhydrous copper sulfate and water are produced.

The equation for the reaction is:

$$\underset{\text{hydrated}}{CuSO_4.5H_2O(s)} \rightleftharpoons \underset{\text{anhydrous}}{CuSO_4(s)} + 5H_2O(g)$$

0 6 . 1 How does the equation show that this is a reversible reaction?

[1 mark]

A student investigated the forward reaction.

This is the method used.

1. Place an empty test tube on a balance.
2. Zero the balance with the test tube on it.
3. Add 1.26 g of hydrated copper sulfate to the test tube.
4. Heat the test tube and contents for 5 minutes.
5. Measure the mass of the solid left in the test tube.
6. Repeat steps 4–5 until the mass of the solid is constant.

0 6 . 2 **Figure 5** shows the test tube on the balance at the end of the investigation.

Figure 5

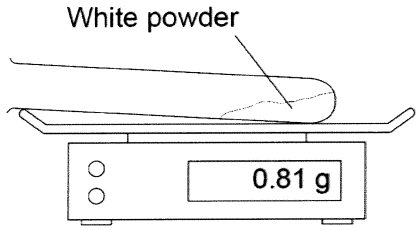


Table 5 shows some of the student's results.

Table 5

Substance	Mass of substance in g
Hydrated copper sulfate	1.26
Anhydrous copper sulfate	**X**
Water	**Y**

Determine the values **X** and **Y**.

Use **Figure 5** and **Table 5**.

[2 marks]

_____

_____

X = _____ g

Y = _____ g

Question 6 continues on the next page

Do not write outside the box

0 6 . 3 Why did the student keep heating the test tube and its contents until the mass was constant?

[1 mark]

Tick (✓) **one** box.

To make more hydrated copper sulfate ☐

To make sure all the water was removed ☐

To melt the anhydrous copper sulfate ☐

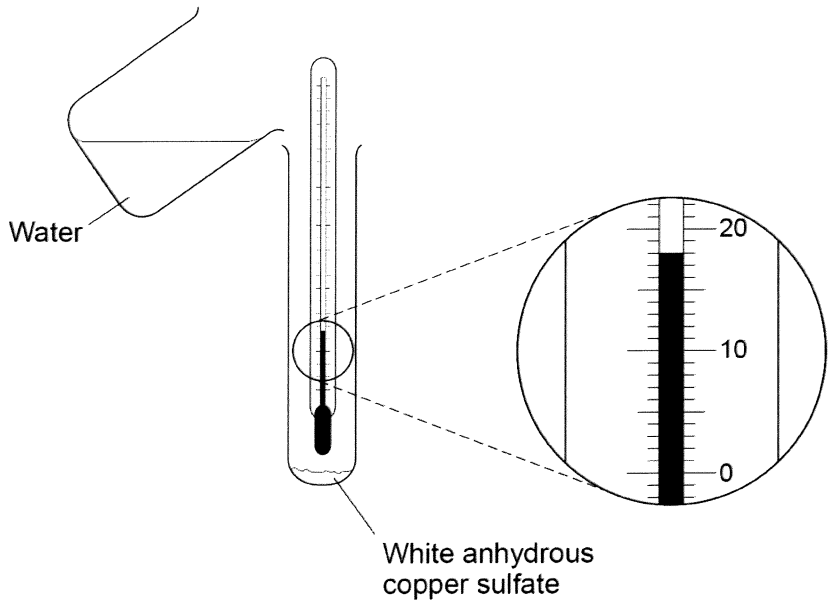
The student then investigated the reverse reaction.

The student added water to anhydrous copper sulfate.

This reaction is exothermic.

Figure 6 shows the apparatus used.

Figure 6



Do not write outside the box

0 6 . 4 What is an exothermic reaction?

[1 mark]

Tick (✓) **one** box.

A reaction where there is no energy change ☐

A reaction that gives out energy to the surroundings ☐

A reaction that takes in energy from the surroundings ☐

0 6 . 5 What is the temperature shown on the thermometer in **Figure 6**?

[1 mark]

Temperature = _____ °C

0 6 . 6 The student measured the temperature during the reaction.

Complete the sentence.

Choose the answer from the box.

[1 mark]

decreases	**increases**	**stays the same**

When water is added to anhydrous copper sulfate, the

temperature _____ .

7

Do not write outside the box

0 3 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:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

0 3 . 1 Which state symbol in the equation for the reaction does **not** represent one of the three states of matter?

[1 mark]

_____

The student determined the rate of production of hydrogen gas.

0 3 . 2 What **two** pieces of measuring apparatus could the student use to find the rate of production of hydrogen gas?

[2 marks]

1 _____

2 _____

Question 3 continues on the next page

Do not write outside the box

Table 2 shows the results of the investigation.

Table 2

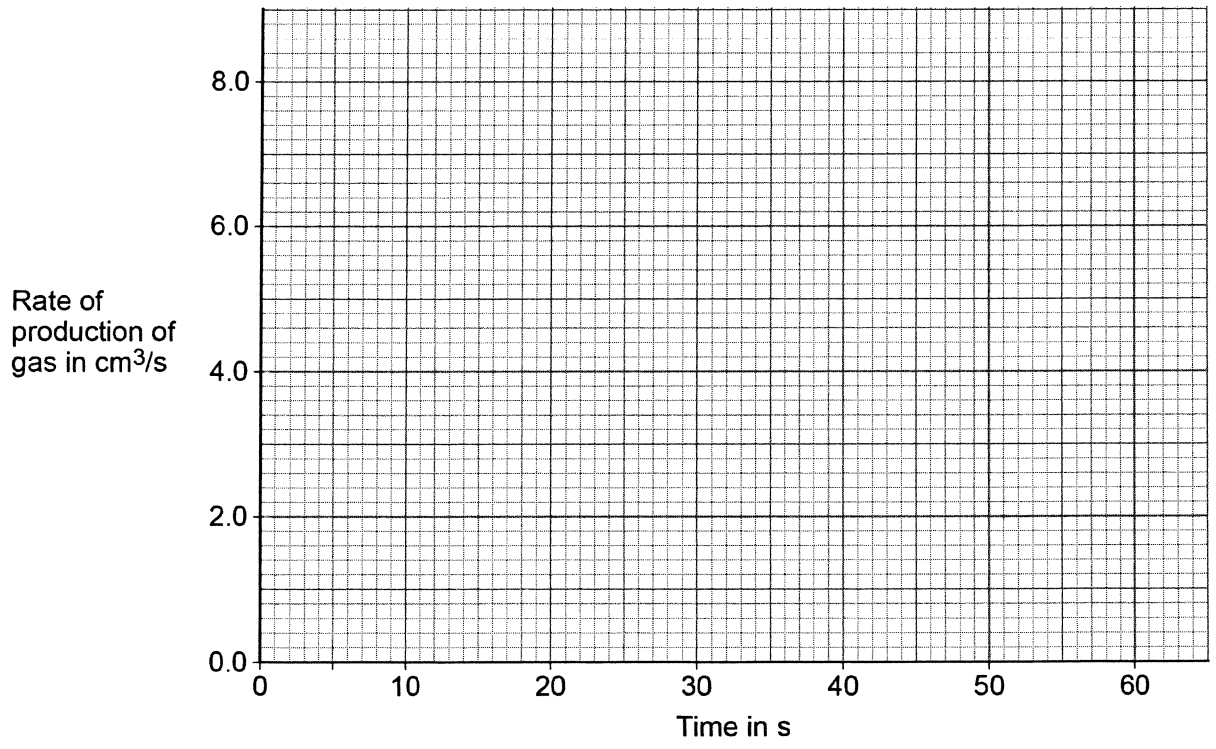
Time in s	Rate of production of gas in cm^3/s
10	6.9
20	3.9
30	2.0
40	0.9
50	0.3
60	0.0

0 3 . 3 Plot the data from **Table 2** on **Figure 3**.

You should draw a line of best fit.

[3 marks]

Figure 3



Do not write outside the box

0 3 . 4 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 _____

_____

0 3 . 5 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. ☐

11

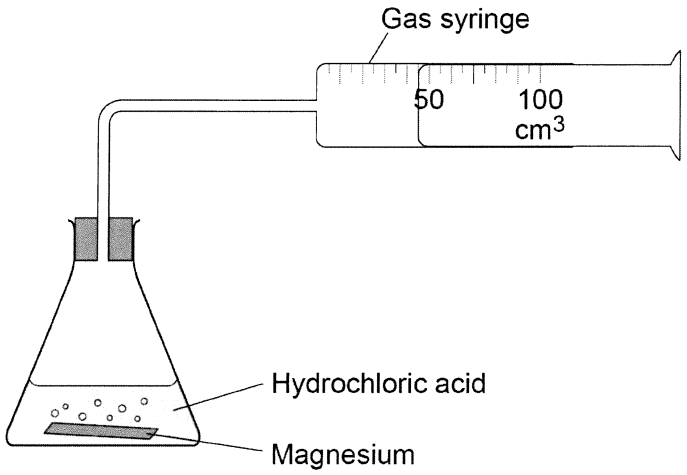
Do not write outside the box

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.

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

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

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

$Mg^+ + Cl^- \rightarrow MgCl$ ☐

Do not write outside the box

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

Do not write outside the box

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

Table 2

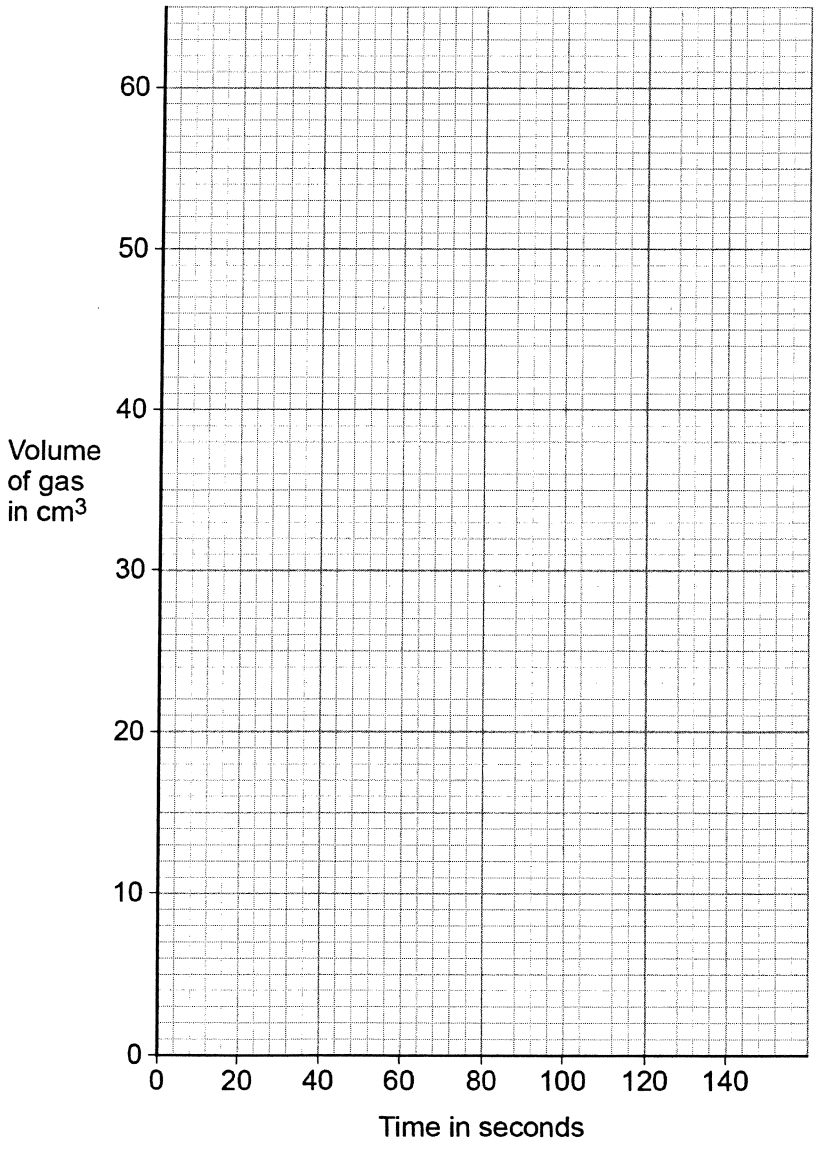
Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm^3	0.0	12.5	36.0	43.5	59.0	60.0	60.0

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

Draw a line of best fit.

[3 marks]

Figure 3



Do not write outside the box

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

Turn over for the next question

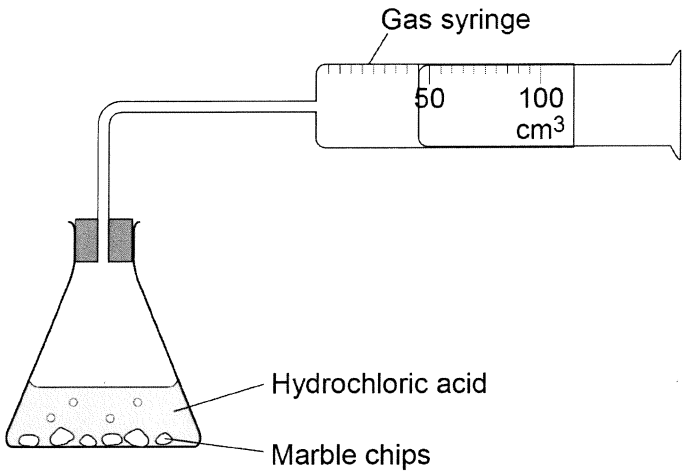
0 5 A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

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]

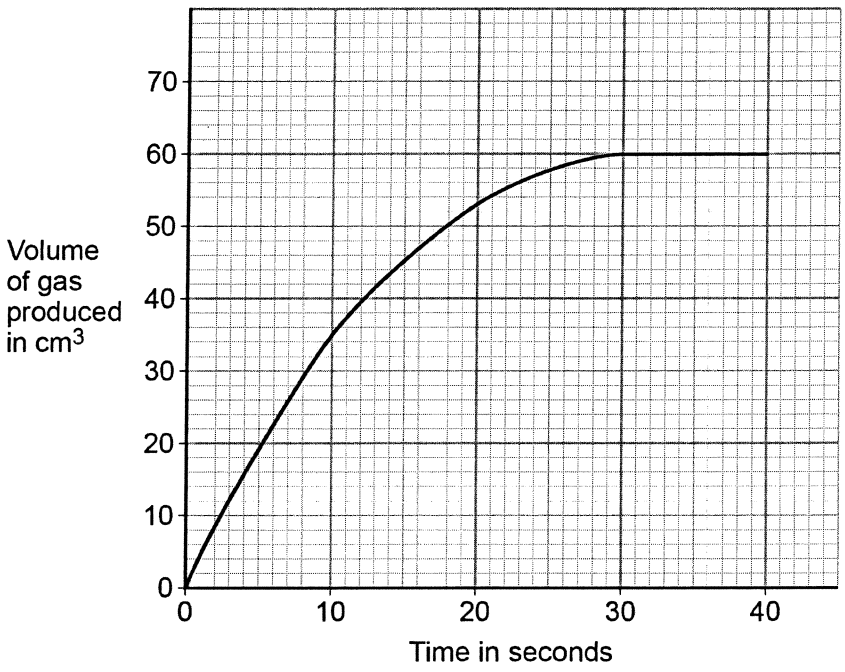
$CaCO_3$ + ___ HCl → _____

Question 5 continues on the next page

Do not write outside the box

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]

Do not write outside the box

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]

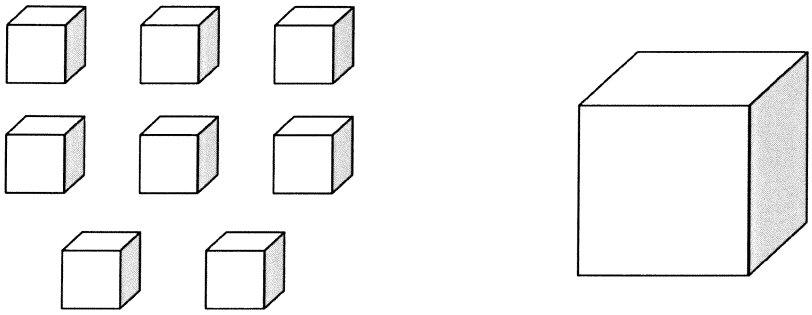
0 5 . 6 Suggest why all three sizes of marble chips produce a maximum volume of 60 cm^3 of gas.

[1 mark]

Do not write outside the box

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'.

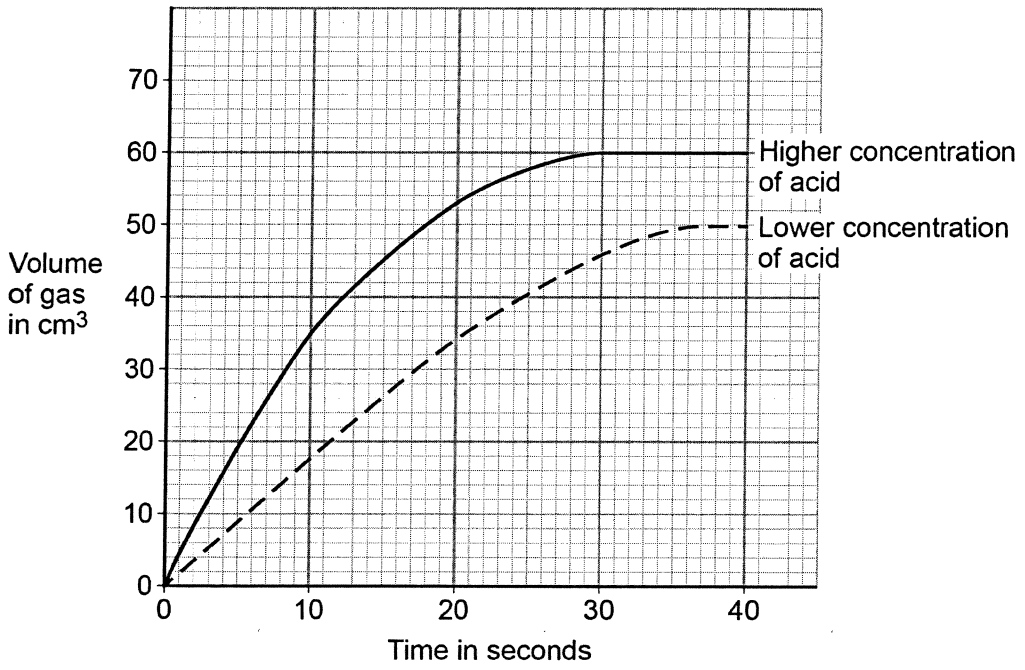
[2 marks]

Do not write outside the box

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

Turn over for the next question

Do not write outside the box

0 5 Sodium thiosulfate solution reacts with dilute hydrochloric acid.

The solution becomes cloudy as the reaction takes place.

0 5 . 1 The equation for the reaction is:

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

Explain why the solution becomes cloudy.

[2 marks]

0 5 . 2 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]

Do not write outside the box

8

Turn over for the next question

Do not write outside the box

0 6 A student investigated the rate of the reaction between magnesium and hydrochloric acid.

The student measured the volume of hydrogen gas produced.

0 6 . 1 How could the student collect and measure the volume of gas produced?

[1 mark]

0 6 . 2 At the start of the investigation the volume of gas was 0 cm^3

The student took readings at 20-second intervals.

Readings for the volume of gas were 24 cm^3, 44 cm^3, 59 cm^3, 70 cm^3, 76 cm^3 and 79 cm^3

Draw a results table for the investigation.

Include the student's results in the table.

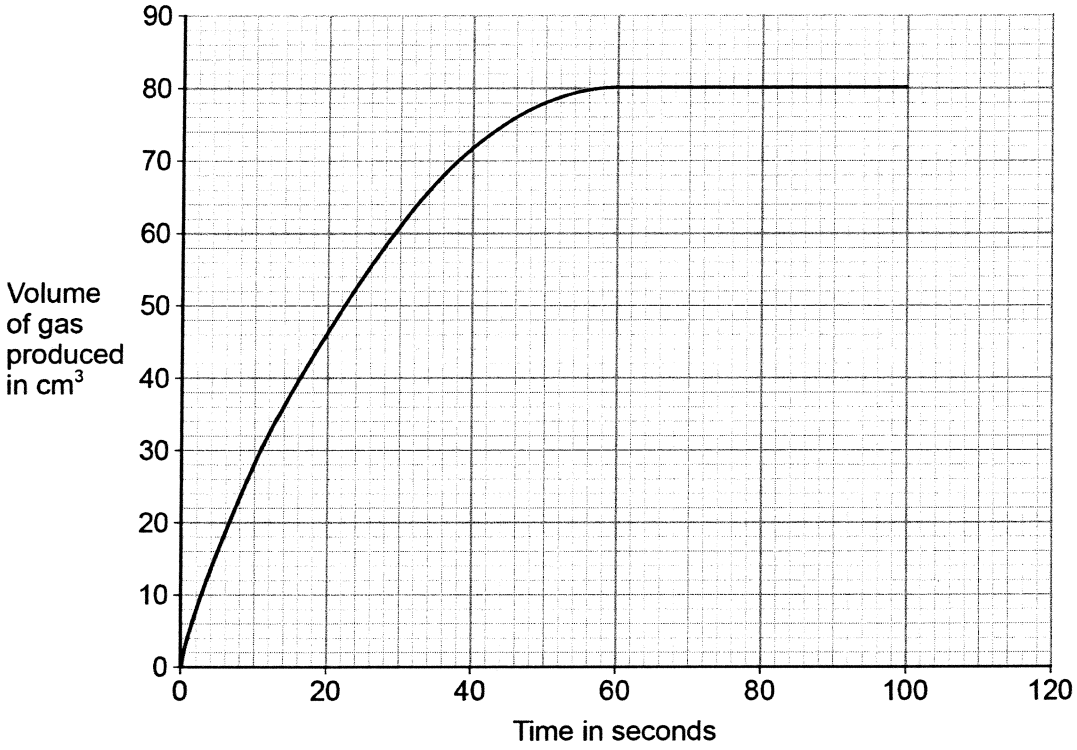
[3 marks]

Do not write outside the box

The student repeated the investigation at a higher temperature.

Figure 7 shows the results.

Figure 7



0 6 . 3 Determine the rate of reaction at 30 seconds.

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

Rate = _____ cm^3/s

Question 6 continues on the next page

Turn over ▶

Do not write outside the box

0 6 . 4 The rate of reaction increases at higher temperatures.

Explain why.

Answer in terms of particles.

[3 marks]

11

Do not write outside the box

0 8 A student investigated how temperature affects the rate of reaction between magnesium carbonate and dilute hydrochloric acid.

This is the method used.

1. Heat hydrochloric acid to 30 °C in a conical flask.
2. Add magnesium carbonate powder to the conical flask.
3. Measure the loss in mass of the flask and contents every 20 seconds for 140 seconds.
4. Repeat steps 1-3 with hydrochloric acid heated to 50 °C

0 8 . 1 Explain why the contents of the conical flask lose mass.

[2 marks]

0 8 . 2 **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

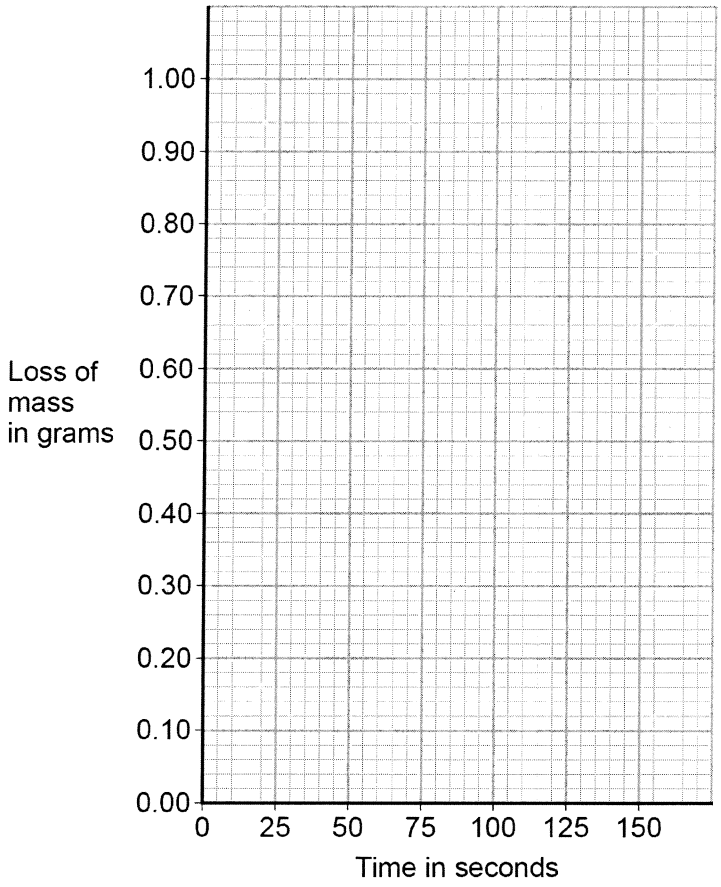
Do not write outside the box

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

Draw a line of best fit.

[3 marks]

Figure 6

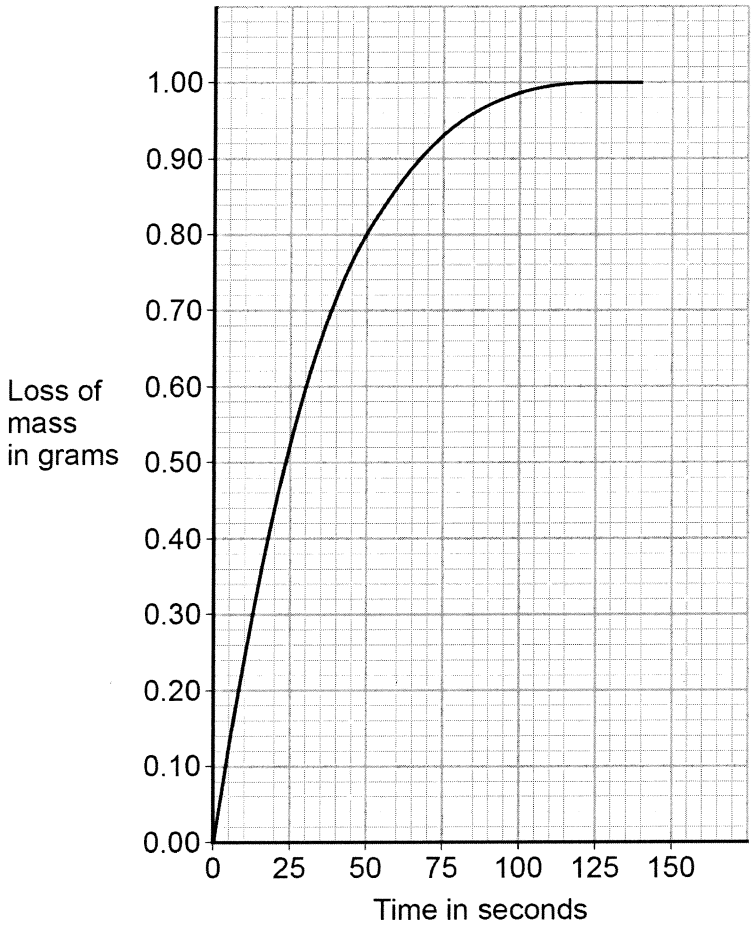


Question 8 continues on the next page

Do not write outside the box

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

Figure 7



0 8 . 3 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

9

Do not write outside the box

0 9 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.

0 9 . 1 Describe a test to identify the gas produced in the reaction.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

Do not write outside the box

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.

0 9 . 2 The method student **A** used did **not** give valid results.

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

[2 marks]

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. ☐

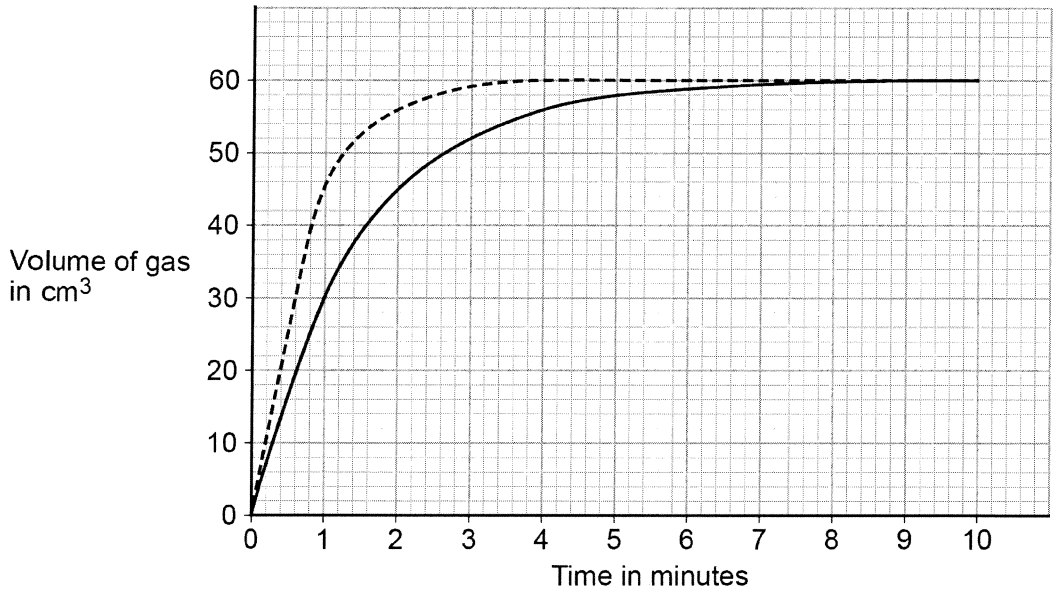
Use a mass of 1 g manganese dioxide each time. ☐

Question 9 continues on the next page

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

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

Figure 9



0 9 . 3 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

Do not write outside the box

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

0 9 . 4 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]

0 9 . 5 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]

11

Turn over for the next question

Do not write outside the box

0 4 This question is about hydrocarbons.

0 4 . 1 When a hydrocarbon $C_{10}H_{22}$ is cracked, two substances are produced.

Complete the equation for the reaction.

[1 mark]

$$C_{10}H_{22} \rightarrow C_7H_{16} + \_\_\_\_\_$$

0 4 . 2 Explain why the hydrocarbon C_7H_{16} has a lower boiling point than $C_{10}H_{22}$

[2 marks]

Question 4 continues on the next page

Do not write outside the box

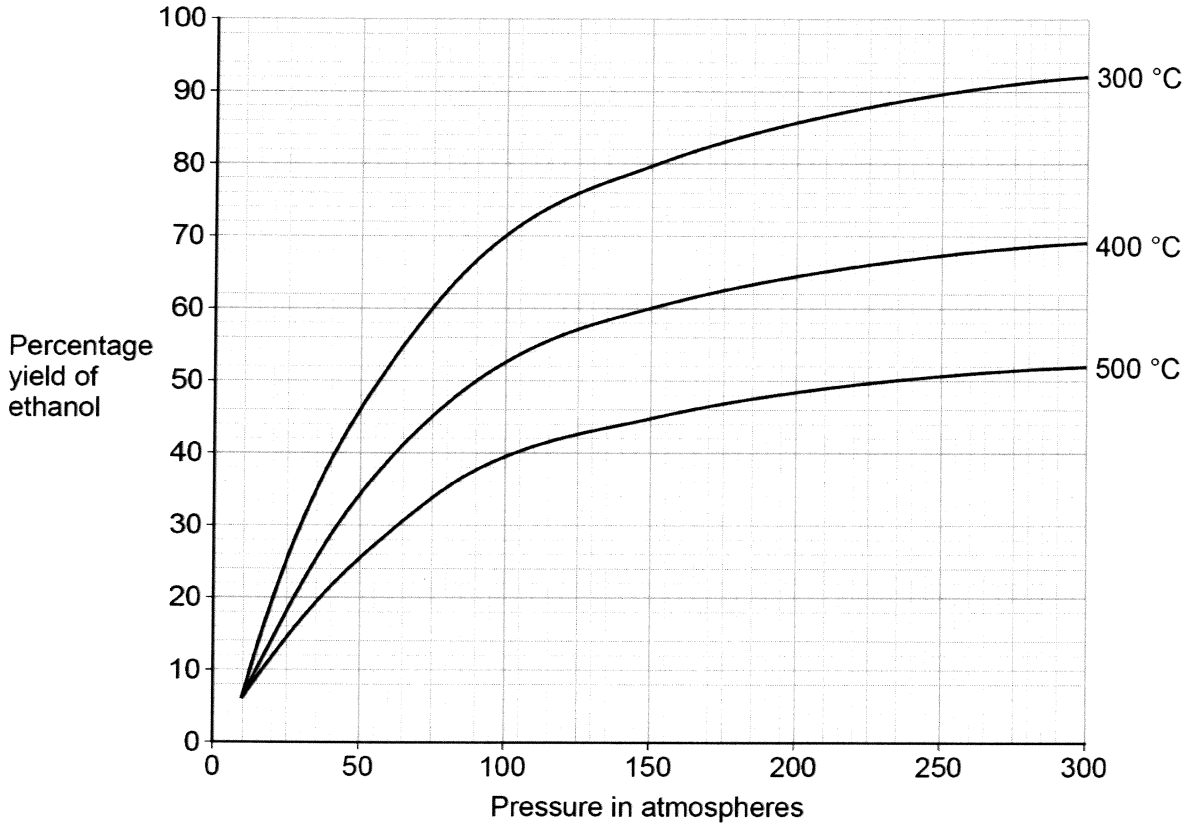
Ethanol is produced by reacting ethene with steam.

The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

Figure 4 shows the percentage yield of ethanol using different reaction conditions.

Figure 4



0 4 . 3 Explain why changing the pressure affects the percentage yield of ethanol.

[3 marks]

Do not write outside the box

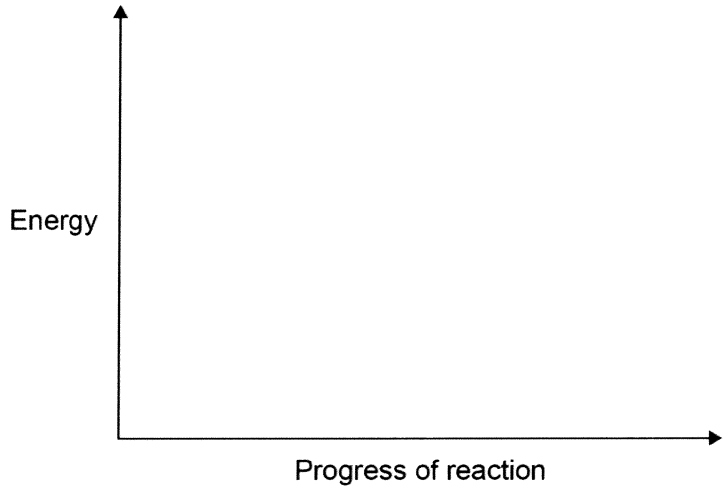
The forward reaction is exothermic.

0 4 . 4 How does **Figure 4** provide evidence for this?

[1 mark]

0 4 . 5 **Figure 5** shows part of a reaction profile diagram.

Figure 5



A catalyst is used in the reaction to produce ethanol.

Complete **Figure 5** to show how the catalyst increases the rate of this reaction.

You should label the reaction profile diagram.

[4 marks]

0 4 . 6 Suggest why the catalyst does **not** affect the yield of ethanol at equilibrium.

[2 marks]

13

Turn over ▶

Do not write outside the box

0 6 This question is about oxygen (O_2) and sulfur dioxide (SO_2).

0 6 . 1 Give the test and result for oxygen gas.

[2 marks]

Test _____

Result _____

0 6 . 2 The reaction between oxygen and sulfur dioxide is at equilibrium.

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

Some of the sulfur trioxide (SO_3) is removed.

Explain what happens to the position of the equilibrium.

[2 marks]

_____

_____

_____

_____

Do not write outside the box

0 6 . 3 Sulfur dioxide is an atmospheric pollutant.

Sulfur dioxide pollution is reduced by reacting calcium oxide with sulfur dioxide to produce calcium sulfite.

$$CaO + SO_2 \rightarrow CaSO_3$$

7.00 g of calcium oxide reacts with an excess of sulfur dioxide.

Relative atomic masses (A_r): O = 16 S = 32 Ca = 40

Calculate the mass of calcium sulfite produced.

[4 marks]

Mass of calcium sulfite produced = _____ g

8

Turn over for the next question

Do not write outside the box

0 6 Bleach is a solution of sodium hypochlorite (NaClO).

Chlorine gas is produced when bleach reacts with hydrochloric acid.

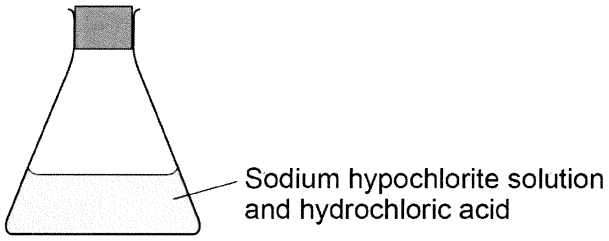
$$NaClO(aq) + 2HCl(aq) \rightleftharpoons NaCl(aq) + H_2O(l) + Cl_2(g)$$

0 6 . 1 Give the test and result for chlorine gas.

[2 marks]

Figure 8 shows a sealed flask of sodium hypochlorite and hydrochloric acid at equilibrium.

Figure 8



0 6 . 2 Explain why equilibrium is reached in this reaction.

[2 marks]

Do not write outside the box

0 6 . 3 The stopper in **Figure 8** is removed and hydrochloric acid is added.

The stopper is replaced.

Explain what happens to the equilibrium.

[4 marks]

Question 6 continues on the next page

Do not write outside the box

Chlorine gas is also produced when hydrogen chloride decomposes.

$$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$$

The forward reaction is endothermic.

0 6 . 4 Predict the effect of increasing the temperature on the amount of chlorine gas produced at equilibrium.

Explain your answer using Le Chatelier's Principle.

[2 marks]

0 6 . 5 Explain the effect of increasing the pressure on this equilibrium.

[2 marks]

12

END OF QUESTIONS

Do not write outside the box

0 9 This question is about methanol.

0 9 . 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 ☐

In industry, methanol is produced by reacting carbon monoxide with hydrogen.

The equation for the reaction is:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

0 9 . 2 How many moles of carbon monoxide react completely with 4.0×10^3 moles of hydrogen?

[1 mark]

Tick **one** box.

1.0×10^3 moles ☐

2.0×10^3 moles ☐

4.0×10^3 moles ☐

8.0×10^3 moles ☐

Do not write outside the box

0 9 . 3 The reaction is carried out at a temperature of 250 °C and a pressure of 100 atmospheres.

The forward reaction is exothermic.

Explain what happens to the yield of methanol if a temperature higher than 250 °C is used.

[2 marks]

0 9 . 4 A pressure of 100 atmospheres is used instead of atmospheric pressure.

The higher pressure gives a greater yield of methanol **and** an increased rate of reaction.

Explain why.

[4 marks]

Question 9 continues on the next page

Do not write outside the box

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

0 9 . 5 Explain how a catalyst increases the rate of a reaction.

[2 marks]

0 9 . 6 Suggest why a catalyst is used in this industrial process.

Do **not** give answers in terms of increasing the rate of reaction.

[1 mark]

0 9 . 7 Suggest the effect of using the catalyst on the equilibrium yield of methanol.

[1 mark]

12