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:

$$\text{hydrogen} + \text{iodine} \rightleftharpoons \text{hydrogen iodide}$$

This reversible reaction reaches equilibrium in a sealed container.

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

_____

(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.

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 _____.

This is because at higher pressures the distance

between the particles _____.

This means that the frequency of collisions _____.

(3)

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

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

_____

_____

(1)

(Total 8 marks)

Q2.

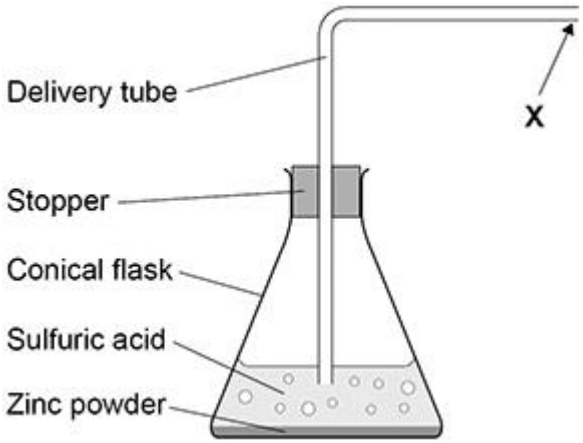
A student investigated the rate of the reaction between zinc and sulfuric acid.

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 _____

_____

Problem caused _____

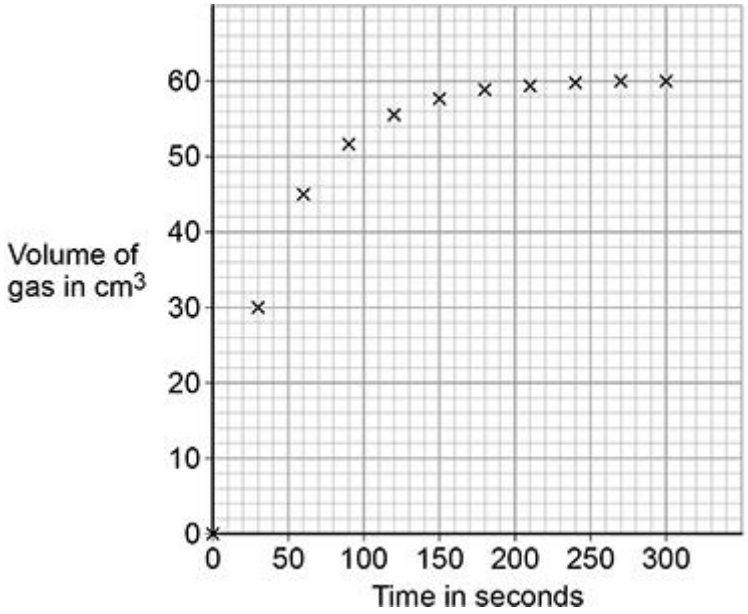
_____

(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:

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

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 = _____ Unit _____

(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:

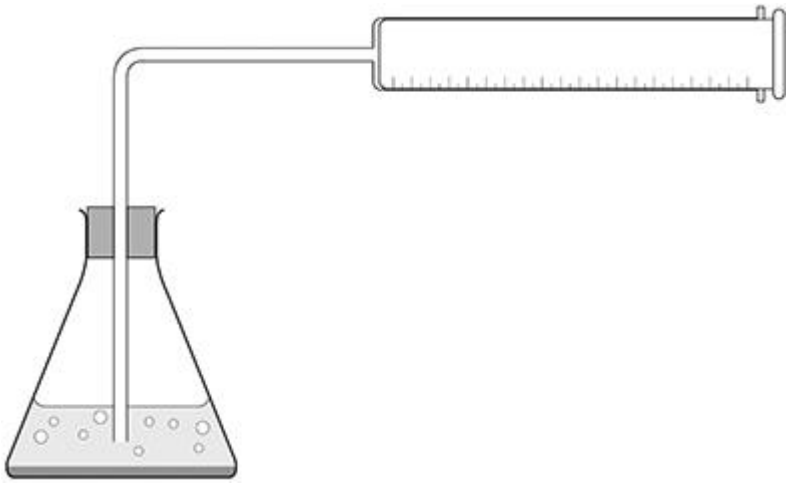
$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

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?

_____

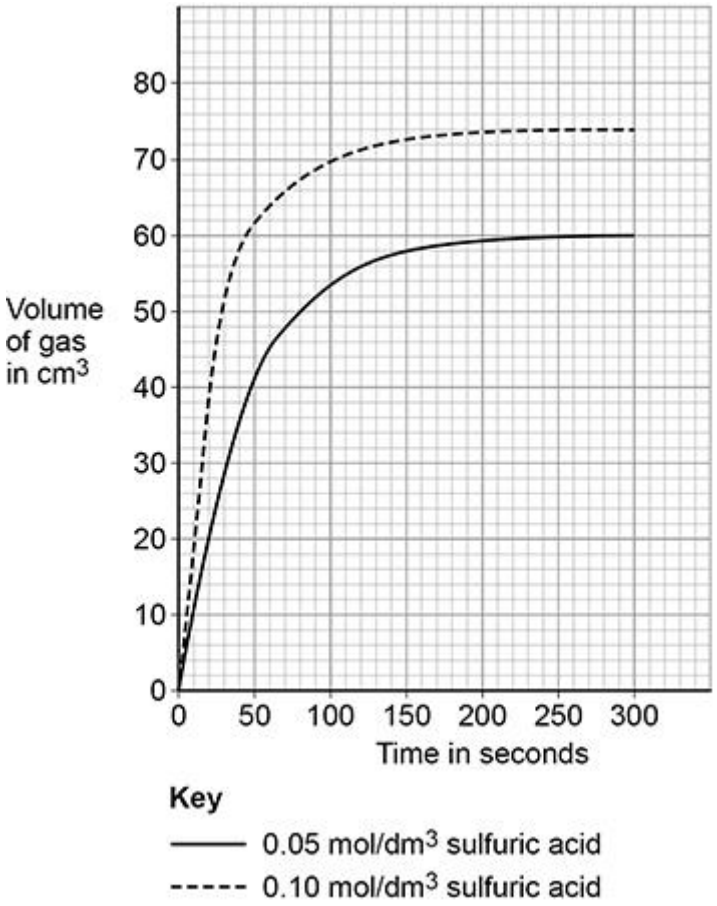
_____

(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.

_____

_____

_____

_____

(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?

_____

_____

(1)

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

Show your working on **Figure 2**.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

_____

Rate of reaction (2 significant figures) = _____ 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^{+} ☐

(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.

_____

(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 ☐

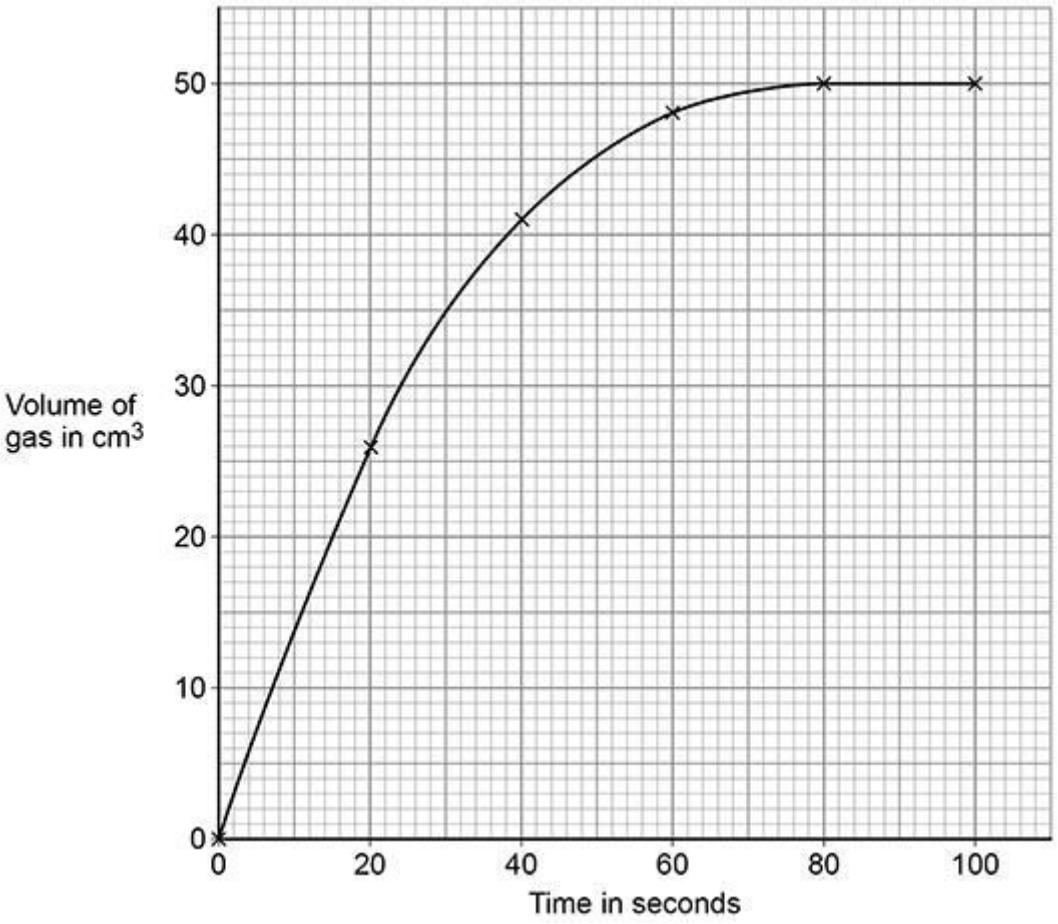
(1)

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 = _____ 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

_____

_____

Between 80 and 100 seconds

_____

_____

(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.

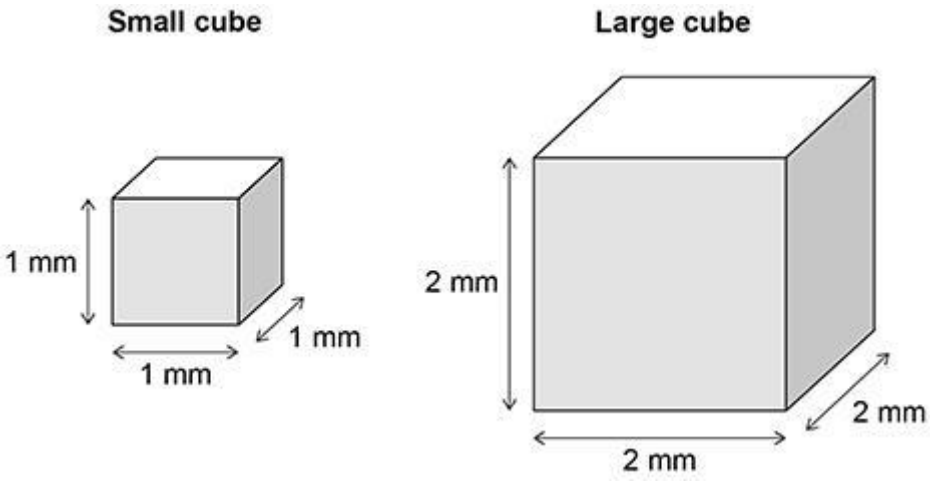
What type of error was caused by the balance?

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.

Total surface area = _____ 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 _____.

(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		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.

(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.

(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.

_____

_____

_____

_____

_____

_____

_____

_____

(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)**

_____

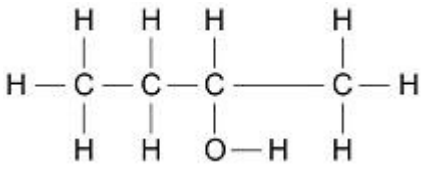
(1)

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

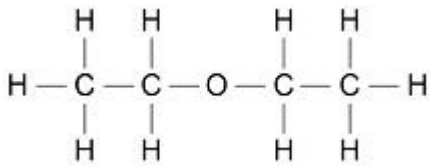
Ethanoic acid and ethanol join together in the same way to produce an ester.

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

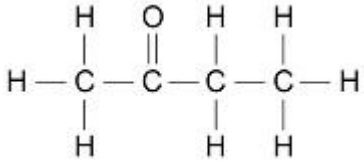
Tick (✓) **one** box. **(separate only)**



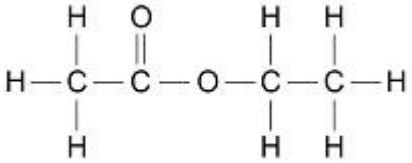
☐



☐



☐



☐

(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

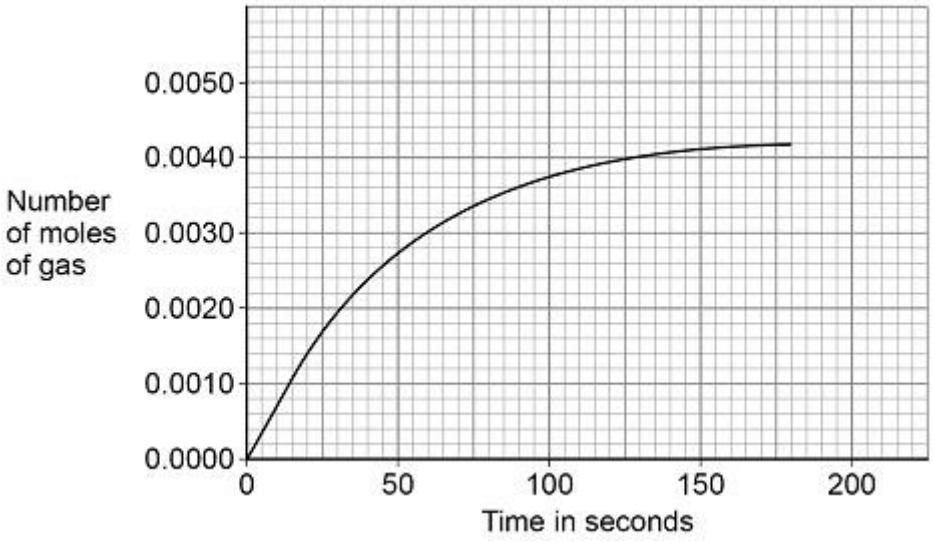
180	0.0040

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 of reaction = _____ Unit _____

(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?

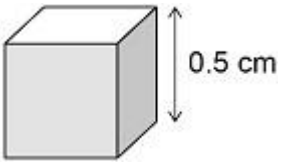
_____

_____

(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 : volume = _____ **:** _____

(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.

_____

_____

(1)

(Total 12 marks)

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

_____.

(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. ☐

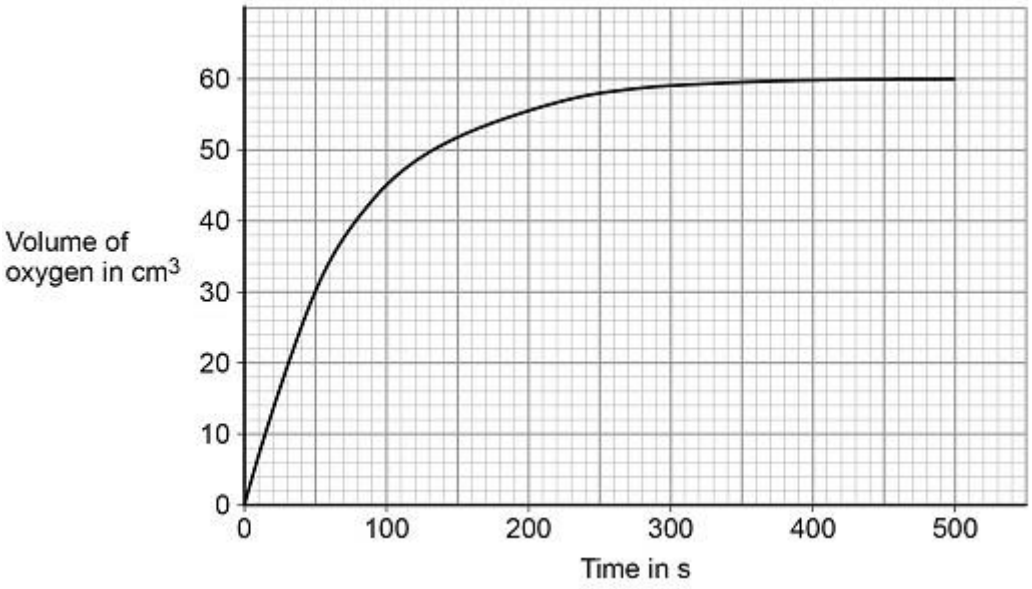
Calculate a mean but do not include the first set of results. ☐

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 _____

Time taken _____

_____

_____

_____

_____

Mean rate of reaction = _____ cm^3/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?

_____

(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 _____

2 _____

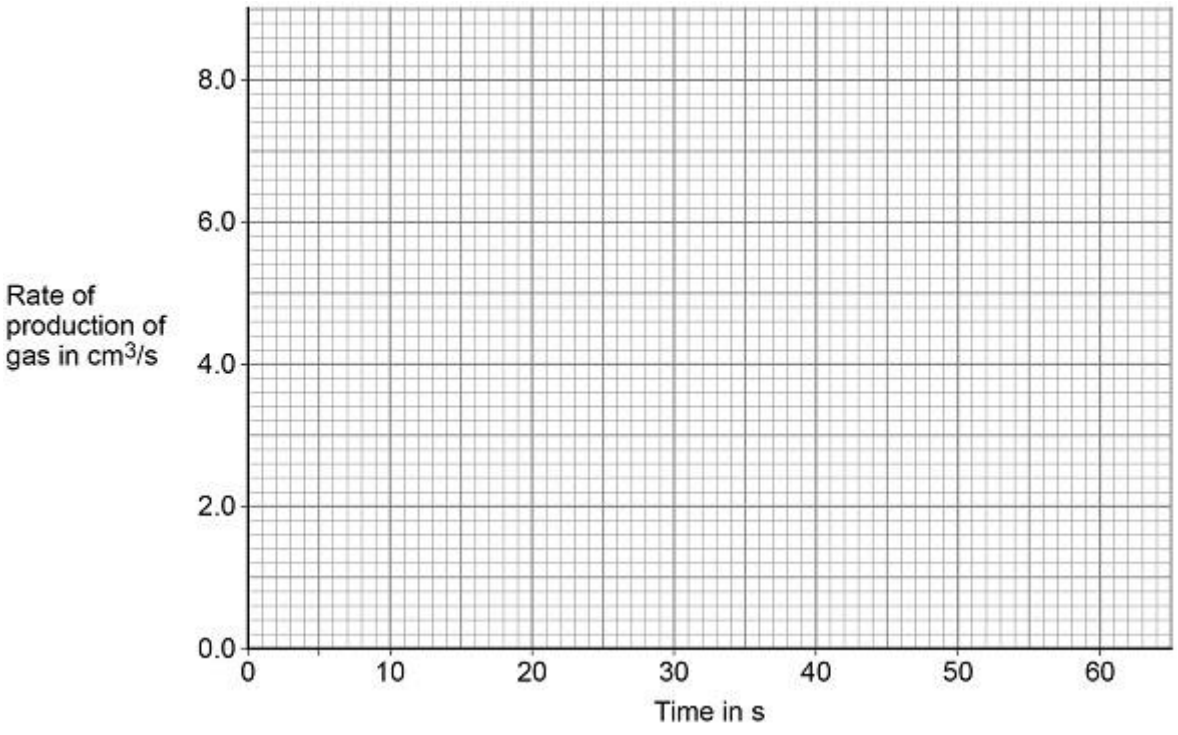
(2)

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 _____

_____

2 _____

_____

3 _____

_____

(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 _____

_____

Result _____

_____

(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?

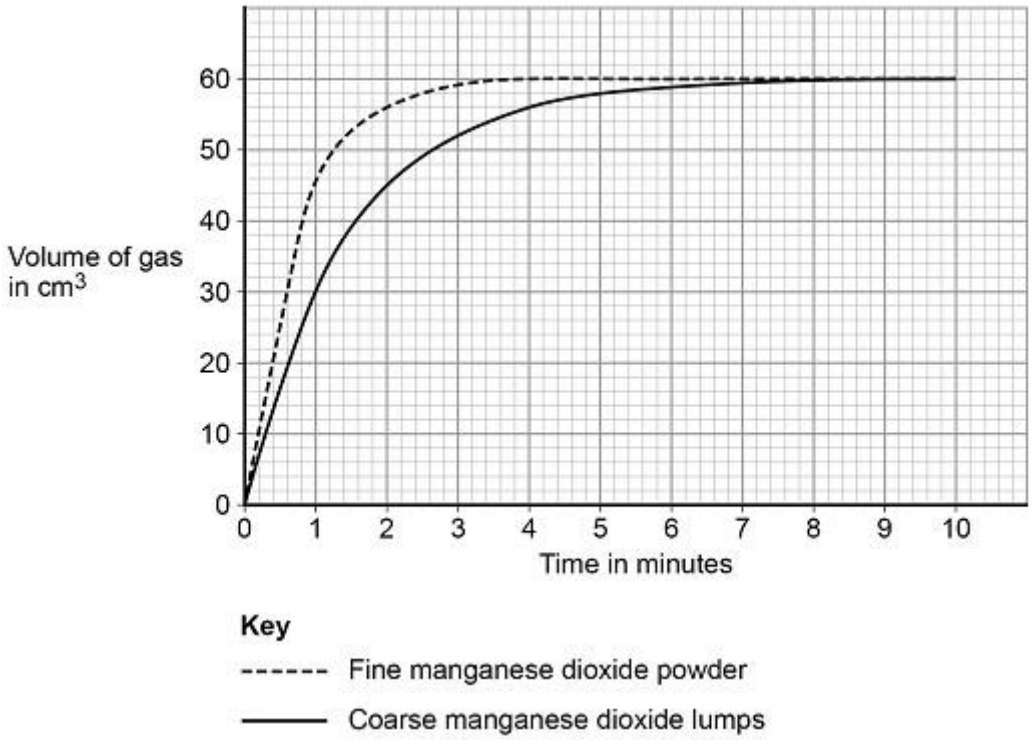
Tick (✓) **two** boxes.

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 of reaction = _____ 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.

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.

_____

_____

_____

_____

(2)

(Total 11 marks)

Q10.

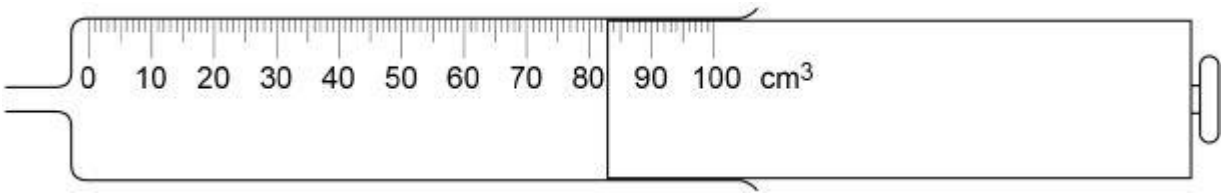
A student investigated how concentration affects the rate of reaction between magnesium and hydrochloric acid.

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 = _____ 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 = _____ cm^3

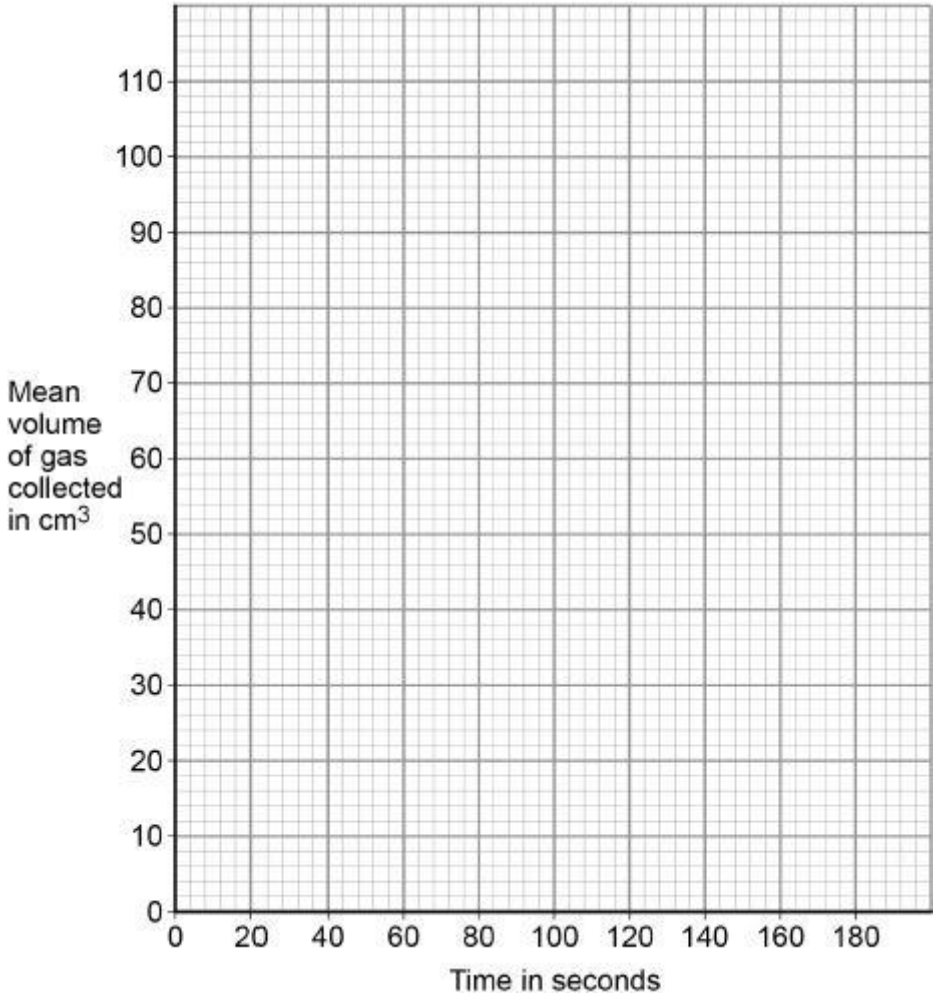
(2)

(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.

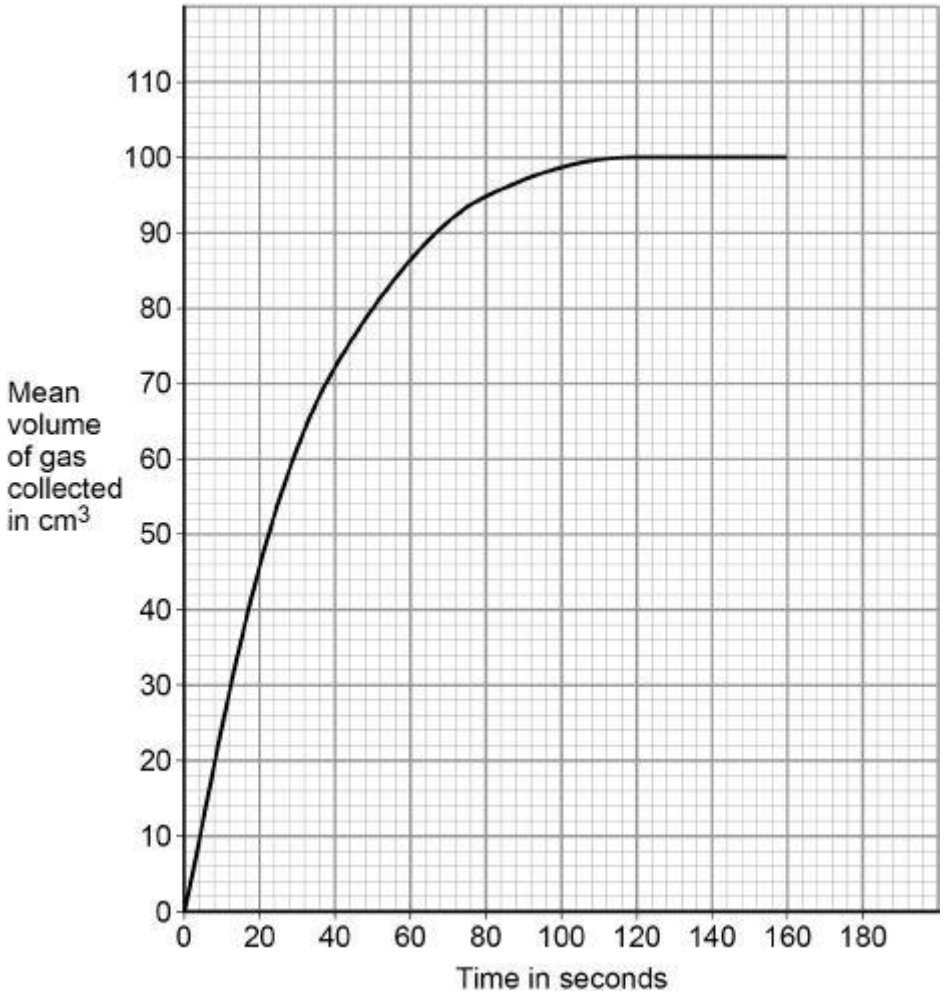
Figure 2



(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 of reaction = _____ cm^3/s

(2)

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

Use **Figure 3**.

_____

_____

_____

_____

_____

_____

(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.

_____

_____

(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

_____

Result _____

_____

(2)

(Total 17 marks)

Q11.

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

(a) Explain why the contents of the conical flask lose mass.

_____

_____

_____

_____

(2)

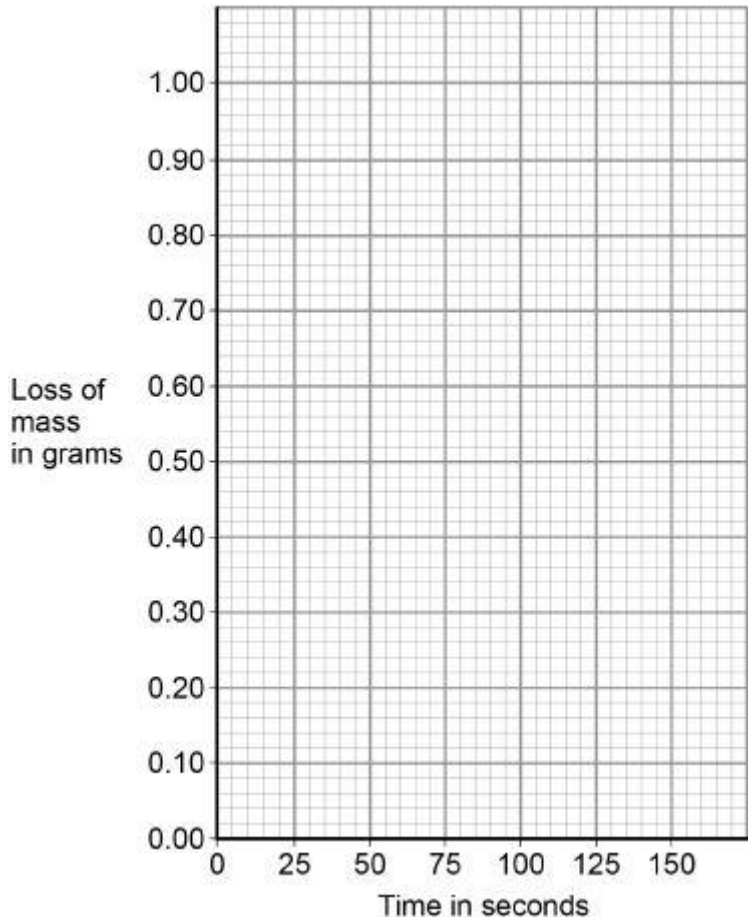
(b) The table below shows the student's results for hydrochloric acid at 30 °C

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 the table above on **Figure 1**.

Draw a line of best fit.

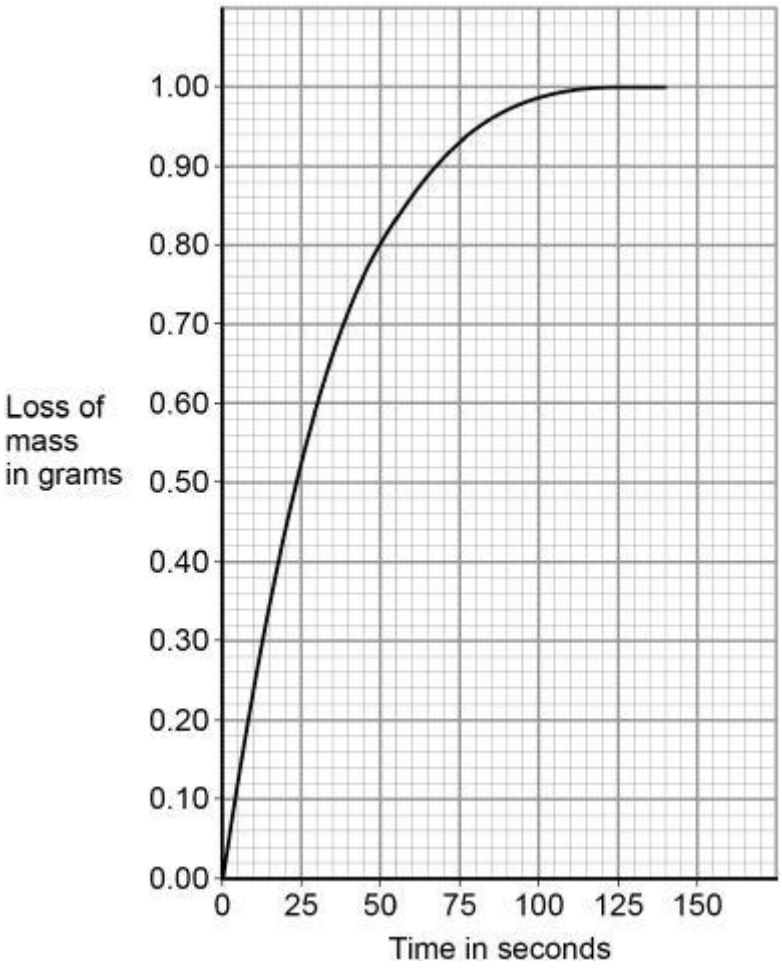
Figure 1



(3)

Figure 2 shows the student's results for hydrochloric acid at 50 °C

Figure 2



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

Show your working on **Figure 2**.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

Rate of reaction = _____ g/s

(4)

(Total 9 marks)

Q12.

A student investigates the effect of concentration on the rate of reaction.

The student reacts sodium thiosulfate solution with dilute hydrochloric acid.

This produces a cloudy mixture.

(a) The cloudiness is produced by the formation of solid sulfur.

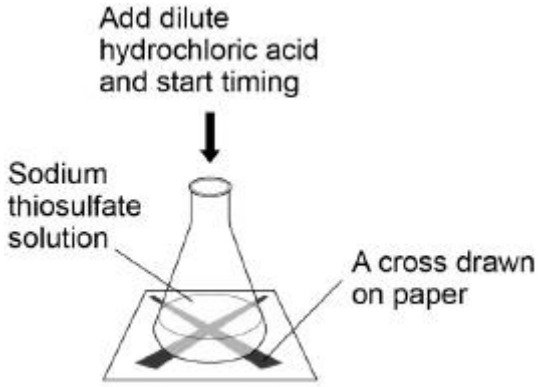
How should sulfur be written in the chemical equation for this reaction?

Tick (✓) **one** box.

S(aq) ☐ S(g) ☐ S(l) ☐ S(s) ☐

(1)

The diagram shows some of the apparatus the student uses.



This is the method used.

1. Measure 40 cm^3 sodium thiosulfate solution into a conical flask.
2. Stand the flask on a piece of paper with a cross drawn on it.
3. Add 10 cm^3 of dilute hydrochloric acid to the flask.
4. Time how long it takes the cross to become no longer visible.
5. Repeat steps 1–4 twice more.
6. Repeat steps 1–5 with sodium thiosulfate solutions of different concentrations.

(1)

(b) Which apparatus could be used to measure 10 cm^3 of dilute hydrochloric acid?

Tick (✓) **one** box.

Beaker ☐

Boiling tube ☐

Measuring cylinder ☐

Test tube ☐

(1)

(c) Draw **one** line from each type of variable to the description of the variable.

Type of variable	Description of the variable
	Concentration of sodium thiosulfate solution
Dependent variable	Size of conical flask
	Size of cross drawn on paper
Independent variable	Time for cross to become no longer visible
	Volume of hydrochloric acid

(2)

(d) The student draws a new cross for each experiment.

Suggest why this might give inaccurate results.

_____

_____

(1)

(e) The table shows the student's results for sodium thiosulfate solution with a concentration of 12 g / dm^3

Time for cross to become no longer visible in s			
Trial 1	**Trial 2**	**Trial 3**	**Mean**
43	78	41	**X**

Calculate value **X** in the tabble.

Do **not** use any anomalous results in your calculation.

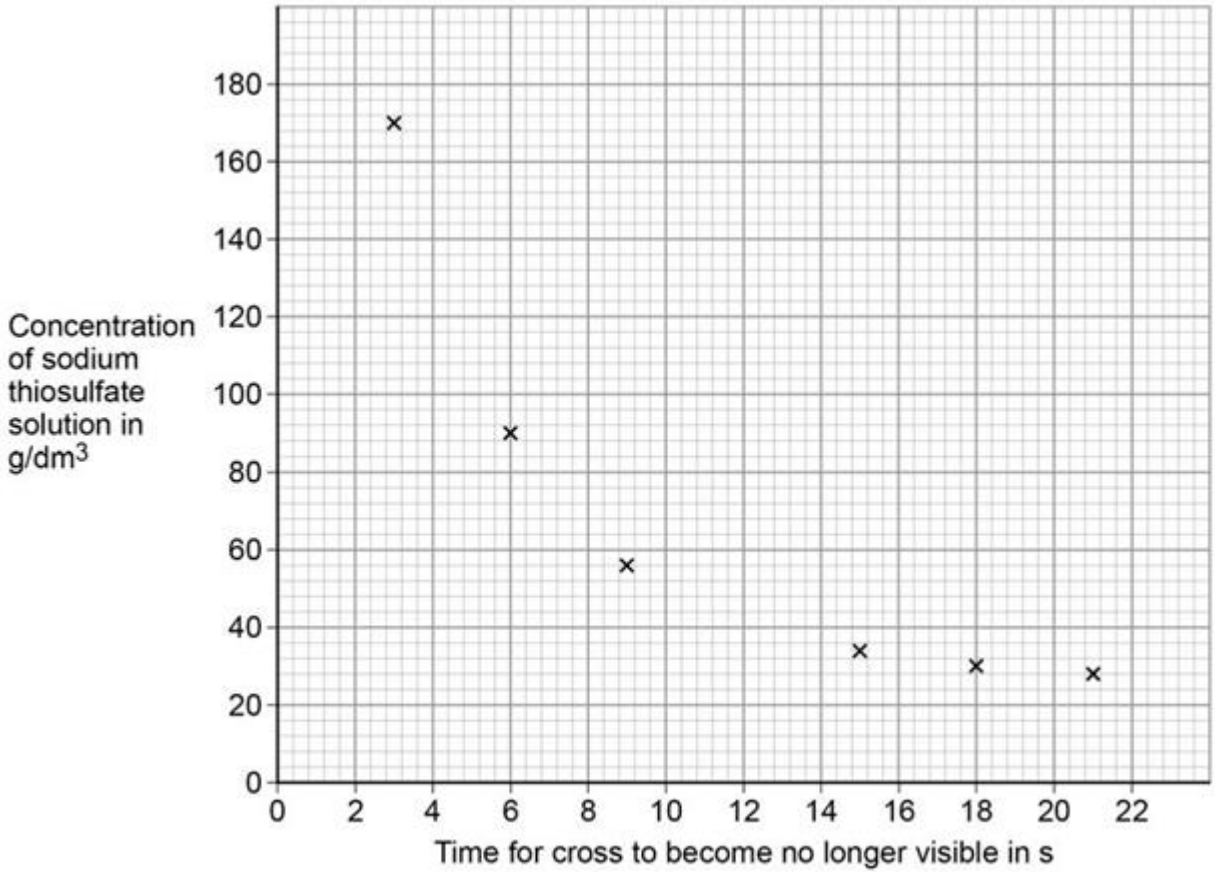
_____

_____

X = _____ s

(2)

(f) The graph shows some of the student's results.



Draw a smooth curve of best fit on the graph above.

(1)

(g) Another student does the same investigation.

Both students have a similar pattern in their results.

Which word describes investigations performed by different students, which give a similar pattern of results?

Tick (✓) **one** box.

Accurate ☐

Precise ☐

Reproducible ☐

Valid ☐

(1)

(h) The more concentrated the sodium thiosulfate solution, the less time is taken for the cross to become no longer visible.

Give **two** reasons why.

Tick (✓) **two** boxes.

Particles are more spread out ☐

Particles collide more frequently ☐

Particles have more energy ☐

Particles move more quickly ☐

There are more particles in a fixed volume ☐

(2)

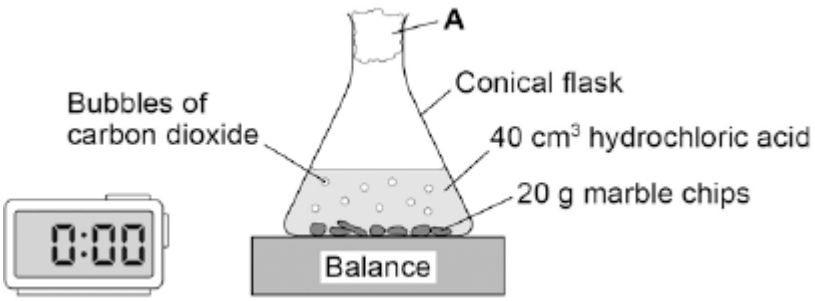
(Total 11 marks)

Q13.

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

Figure 1 shows the apparatus the student used.

Figure 1



(a) What is **A**?

Tick **one** box.

cotton wool ☐

limestone ☐

poly(ethene) ☐

rubber bung ☐

(1)

(b) **Table 1** shows the student's results for one investigation.

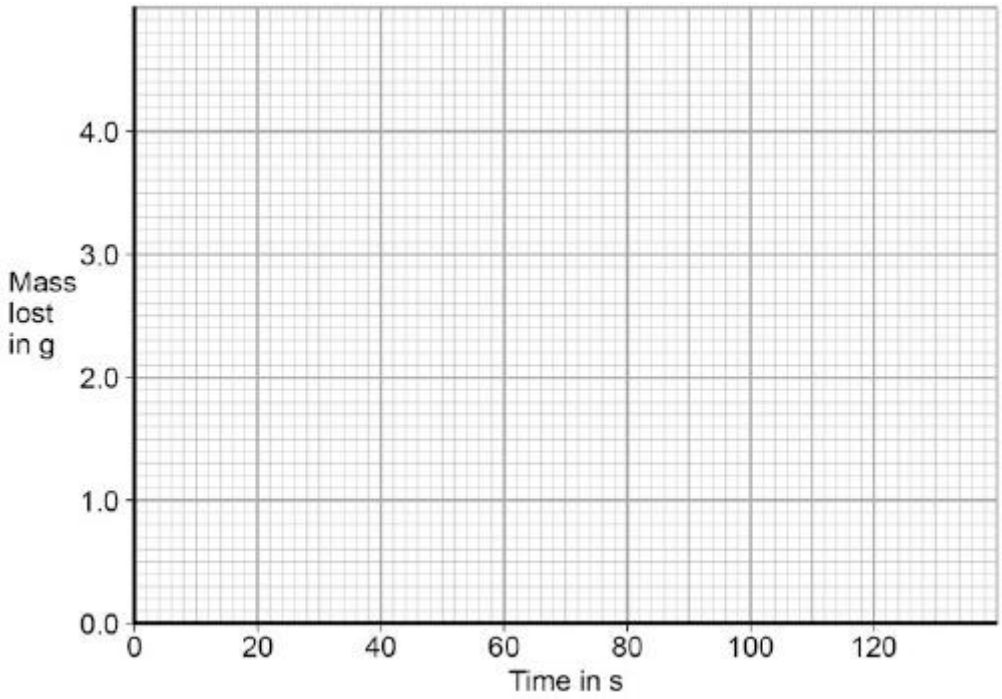
Table 1

Time in s	Mass lost in g
0	0.0
20	1.6
40	2.6
60	2.9
80	3.7
100	4.0
120	4.0

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(3)

(c) Use **Figure 2** to complete **Table 2**.

Table 2

Mass lost after 0.5 minutes	_____ g
Time taken to complete the reaction	_____ s

(2)

(d) The equation for the reaction is:

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

Explain why there is a loss in mass in this investigation.

_____

_____

_____

_____

(2)

(e) Another student investigated the rate of a different reaction.

Table 3 shows the results from the different reaction.

Table 3

Mass lost when the reaction was complete	9.85 g
Time taken to complete the reaction	2 minutes 30 seconds

Calculate the mean rate of the reaction using **Table 3** and the equation:

$$\text{mean rate of reaction} = \frac{\text{mass lost in g}}{\text{time taken in s}}$$

Give your answer to two decimal places.

_____

_____

Mean rate of reaction = _____ g / s

(2)

(f) The student measured the change in mass of the reactants.

Describe another method, other than measuring the change in mass of the reactions, that the student could have used to find the rate of the reaction between marble chips and hydrochloric acid.

_____

_____

_____

_____

(2)

(g) Another student planned to investigate the effect of temperature on the rate of reaction.
The student predicted that the rate of reaction would increase as the temperature was increased.

Give **two** reasons why the student's prediction is correct.

Tick **two** boxes.

The particles are more concentrated. ☐

The particles have a greater mass. ☐

The particles have a larger surface area. ☐

The particles have more energy. ☐

The particles move faster. ☐

(2)

(Total 14 marks)

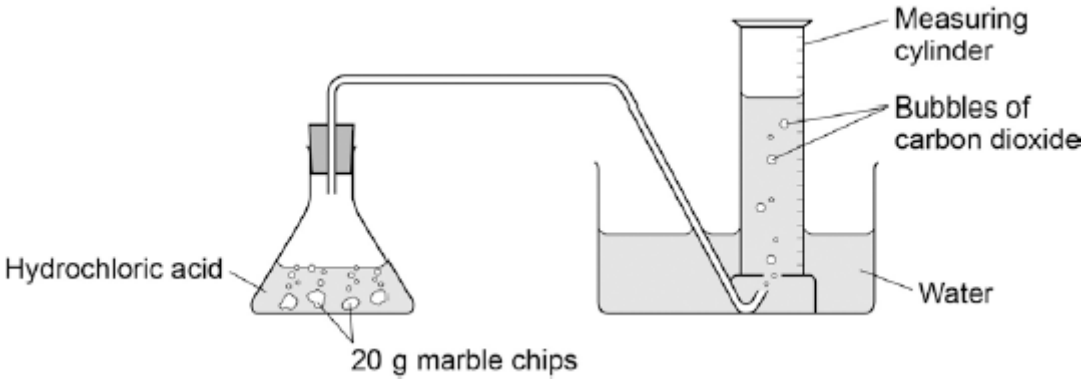
Q14.

Marble chips are mainly calcium carbonate ($CaCO_3$).

A student investigated the rate of reaction between marble chips and hydrochloric acid (HCl).

Figure 1 shows the apparatus the student used.

Figure 1



(a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.

_____ + _____ → $CaCl_2$ + _____ + _____

(2)

(b) The table below shows the student's results.

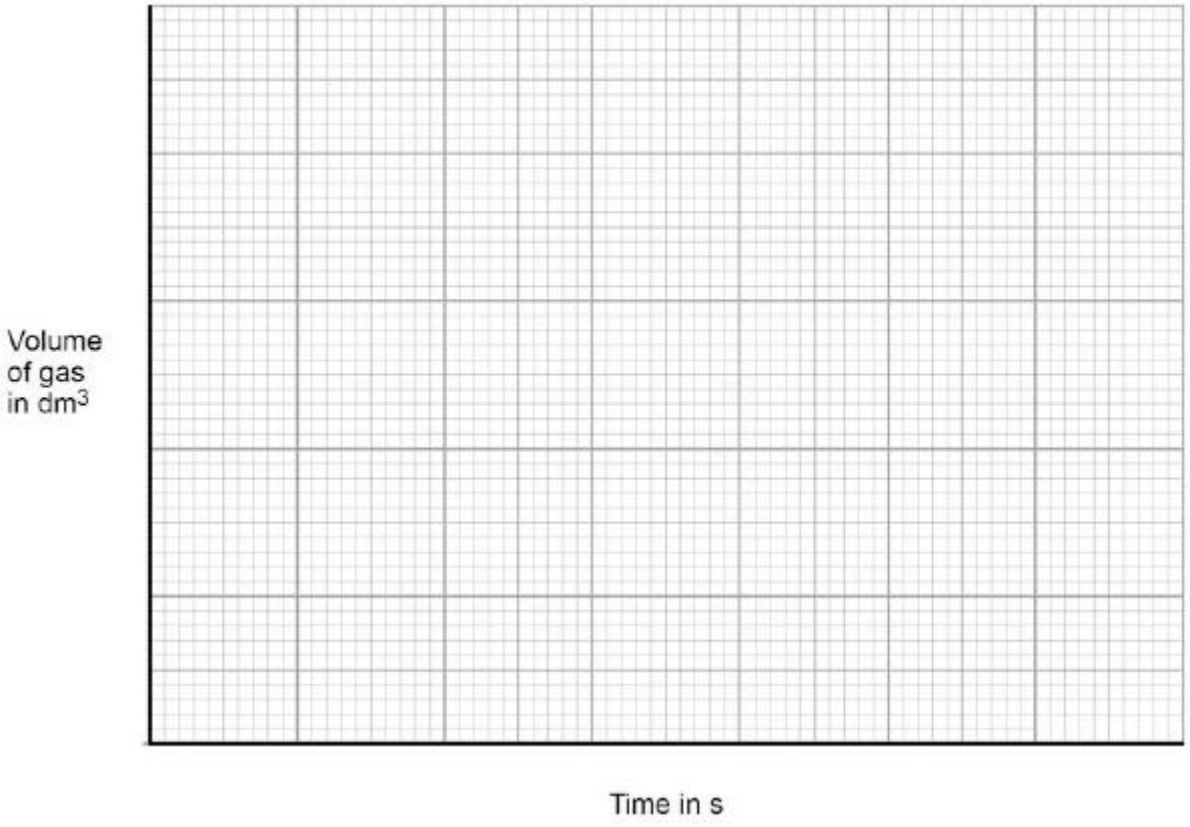
Time in s	Volume of gas in dm^3
0	0.000
30	0.030
60	0.046
90	0.052
120	0.065
150	0.070
180	0.076
210	0.079

240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

(c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

_____

_____

_____

_____

_____

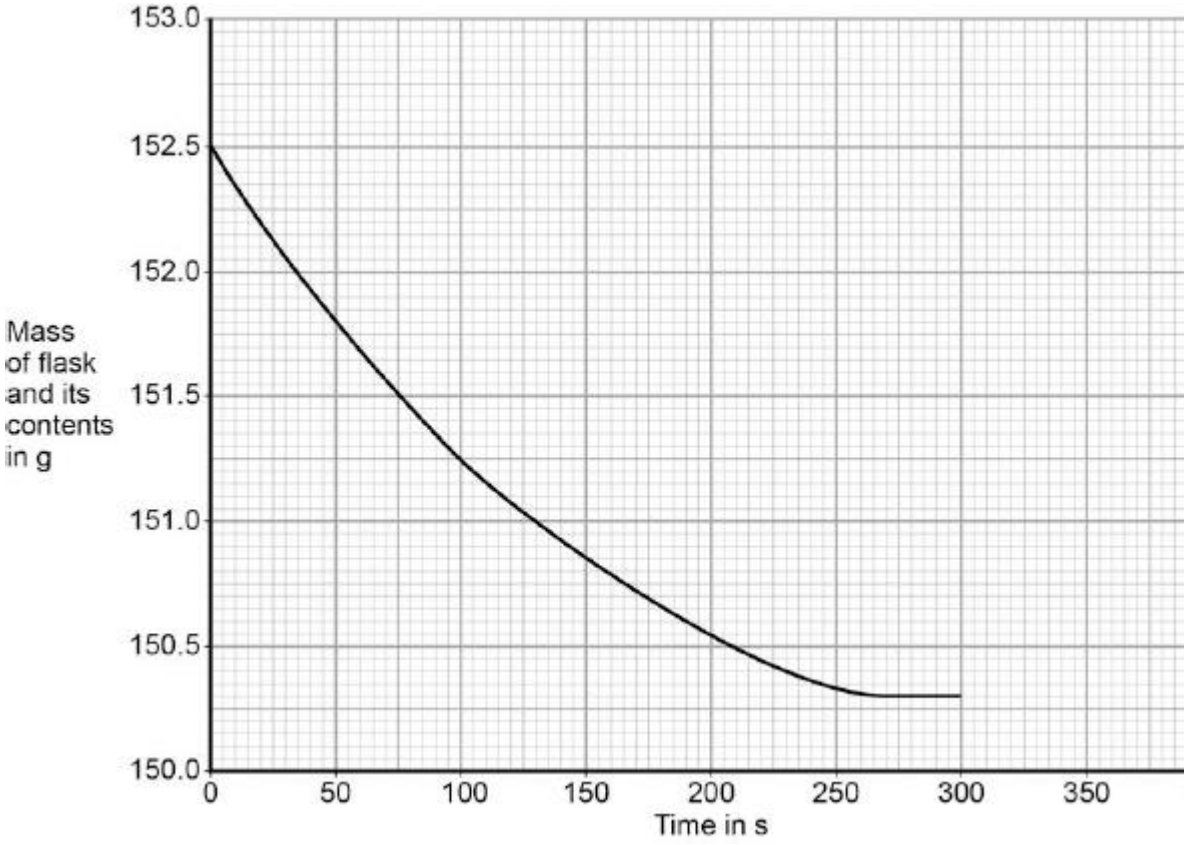
_____

(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

_____

_____

_____

_____

_____

_____

_____

_____

Mean rate of reaction = _____ g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

_____

_____

_____

_____

_____

Rate of reaction at 150 s = _____ g / s

(4)

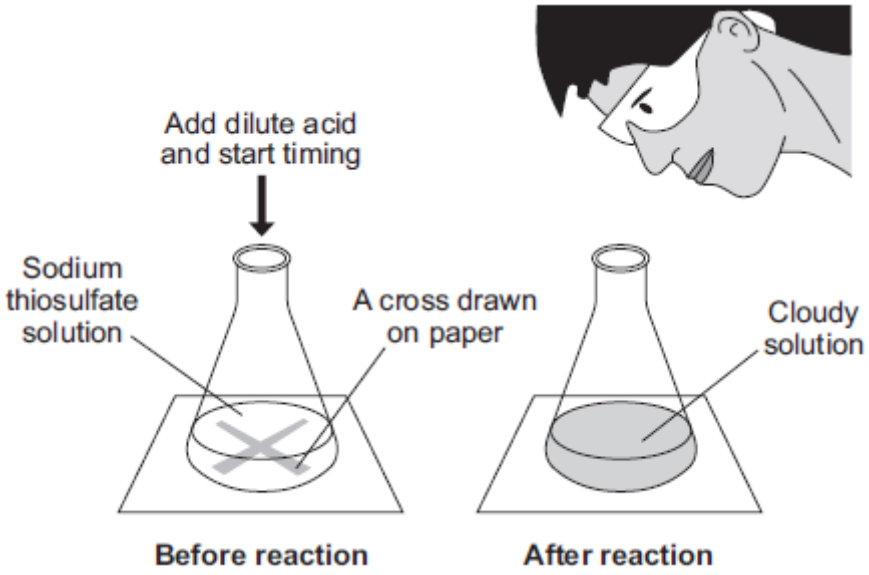
(Total 20 marks)

Q15.

A student investigated the effect of temperature on the rate of a reaction.

Figure 1 shows an experiment.

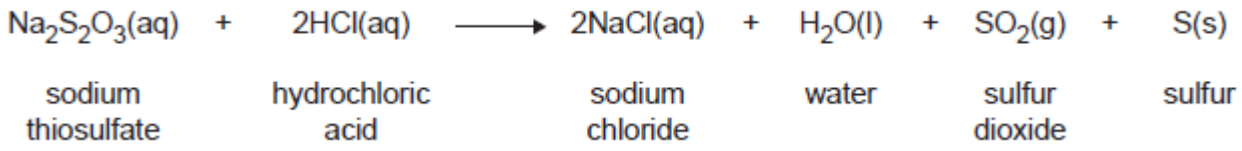
Figure 1



The student:

- put 50 cm^3 sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added 5 cm^3 dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

The equation for the reaction is:



(a) Which product is a gas?

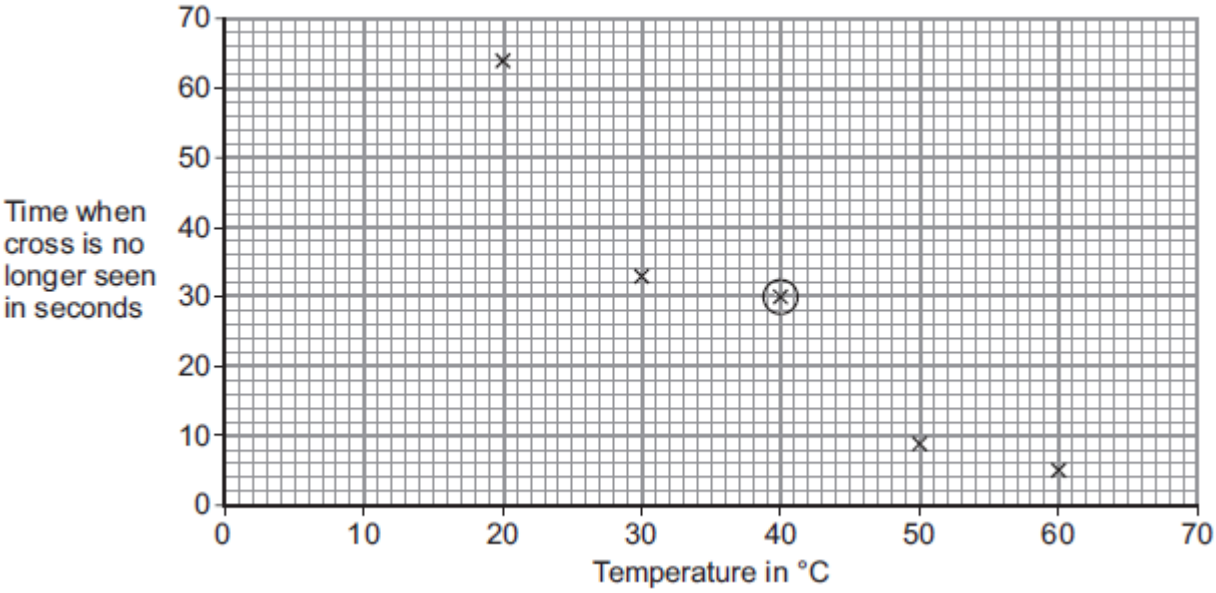
_____

(1)

(b) **Figure 2** shows the results of this experiment at five different temperatures.

The circled result point is anomalous.

Figure 2



(i) Draw a line of best fit on **Figure 2** to show how the reaction time varied with reaction temperature.

(1)

(ii) Give a possible reason for the anomalous result at 40 °C.

_____

_____

(1)

(iii) The reaction at 20 °C produced 0.32 g of sulfur in 64 seconds.

Calculate the rate of the reaction at 20 °C using the equation:

$$\text{Rate of reaction} = \frac{\text{mass of sulfur}}{\text{time}}$$

_____

_____

_____

_____

Rate of reaction = _____ grams per second

(2)

(iv) Give **two** reasons why the rate of the reaction increases as the temperature increases.

Tick (✓) **two** boxes.

The particles move faster.	☐
The particles collide less often.	☐
All the particles have the same energy.	☐
The particles collide with more energy.	☐
The number of particles increases.	☐

(2)

(v) Use the correct answer from the box to complete the sentence.

activation	**collision**	**exothermic**

The minimum amount of energy particles must have to react is called the _____ energy.

(1)

(Total 8 marks)

Q16.

When sodium thiosulfate solution reacts with dilute hydrochloric acid, the solution

becomes cloudy.

The equation for the reaction is:

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

(a) Why does the solution become cloudy?

_____

_____

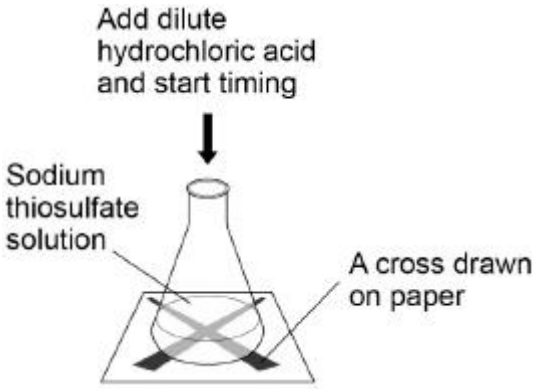
_____

_____

(2)

Some students used this reaction to investigate the effect of concentration on rate of reaction.

The diagram shows the apparatus used.



This is the method used.

1. Measure 25 cm^3 sodium thiosulfate solution into a conical flask.
2. Stand the conical flask on a cross drawn on paper.
3. Add 10 cm^3 of dilute hydrochloric acid.
4. Time how long it takes the cross to become no longer visible.
5. Repeat steps 1–4 with sodium thiosulfate solutions of different concentrations.

(b) The students used a measuring cylinder to measure 25 cm^3 of sodium thiosulfate solution.

Suggest a more accurate way of measuring 25 cm^3 of sodium thiosulfate solution.

_____

_____

(1)

(c) Name one control variable the students should use in this investigation.

_____

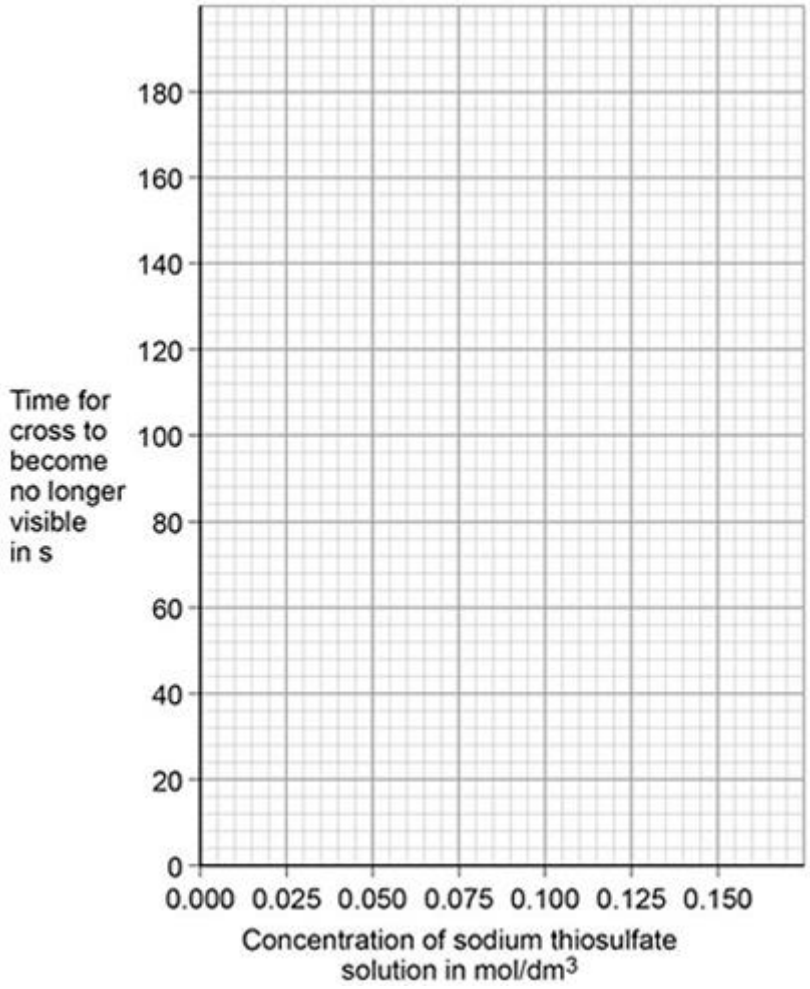
(1)

The table shows the students' results.

Concentration of sodium thiosulfate solution in mol / dm^3	**Time for cross to become no longer visible in s**
0.020	170
0.040	90
0.060	82
0.080	42
0.100	34
0.120	30
0.140	28

(d) Plot the data from the table above on the graph below.

Draw a line of best fit.



(3)

The students repeated the investigation two more times.

They obtained similar results each time.

(e) What word describes an investigation by the same students which gives similar results each time?

_____

(1)

(f) Describe how the students can use their results to improve the accuracy of the investigation.

_____

_____

_____

_____

(2)

(g) The students analysed their results to give a conclusion and an

explanation for their investigation.

Conclusion: 'The higher the concentration, the lower the rate of reaction.'

Explanation: 'At higher concentrations, the particles have more energy, so they are moving faster. Therefore the collisions are more energetic.'

The students are not correct.

Give a **correct** conclusion **and** explanation for the results of the investigation.

Conclusion

_____

_____

_____

Explanation

_____

_____

_____

_____

_____

(3)

(h) A solution containing 0.18 g of sodium thiosulfate reacts with dilute hydrochloric acid in 2 minutes.

Calculate the mean rate of reaction in g / s.

Give your answer in standard form.

_____

_____

_____

_____

Mean rate of reaction = _____ g / s

(3)

(Total 16 marks)