



1.

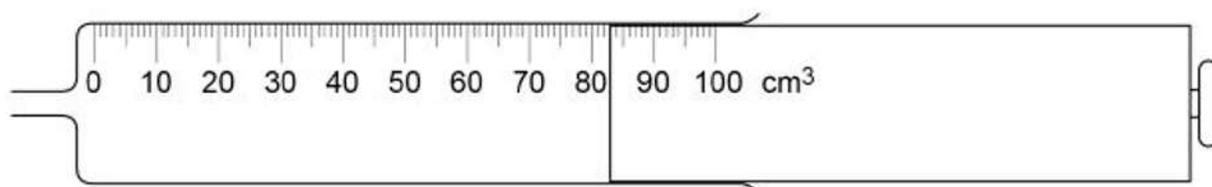
A student investigated how concentration affects the rate of reaction between magnesium and hydrochloric acid.

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 = _____ cm³

(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

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 = _____ cm³

(2)

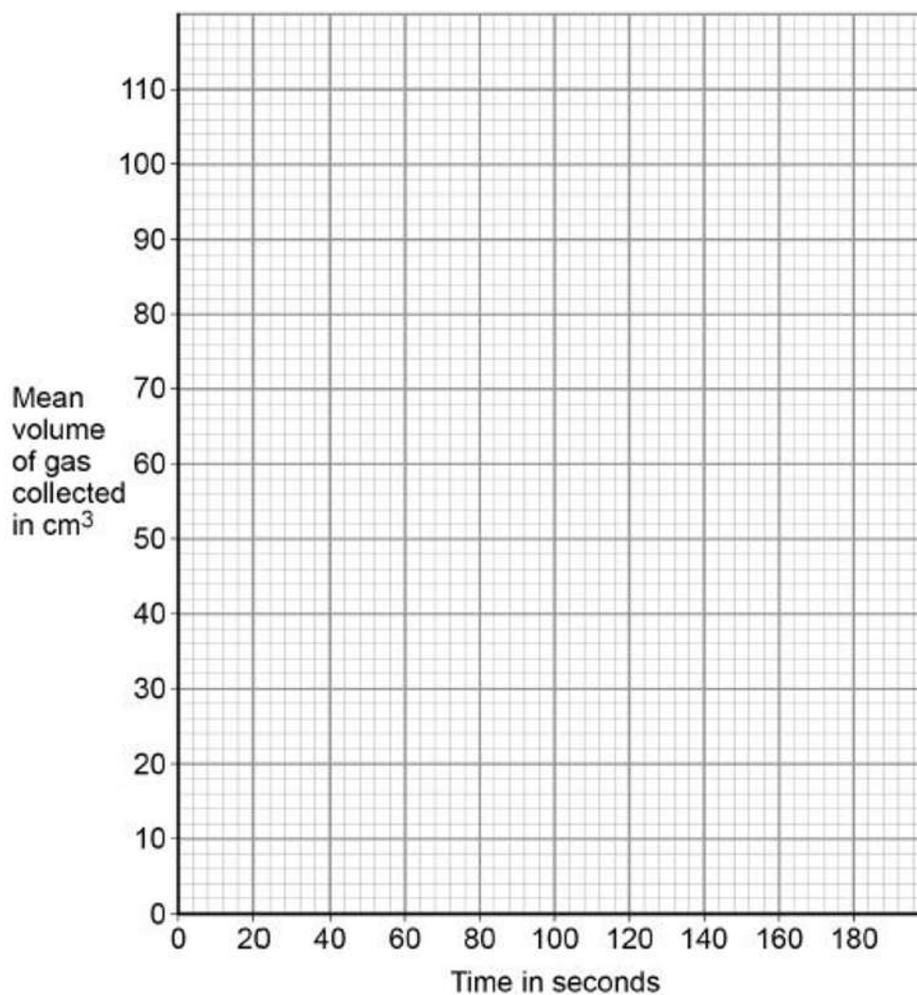
(d) Plot the data from the table above on **Figure 2**.

You should include your answer to Question (c).

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



Figure 2

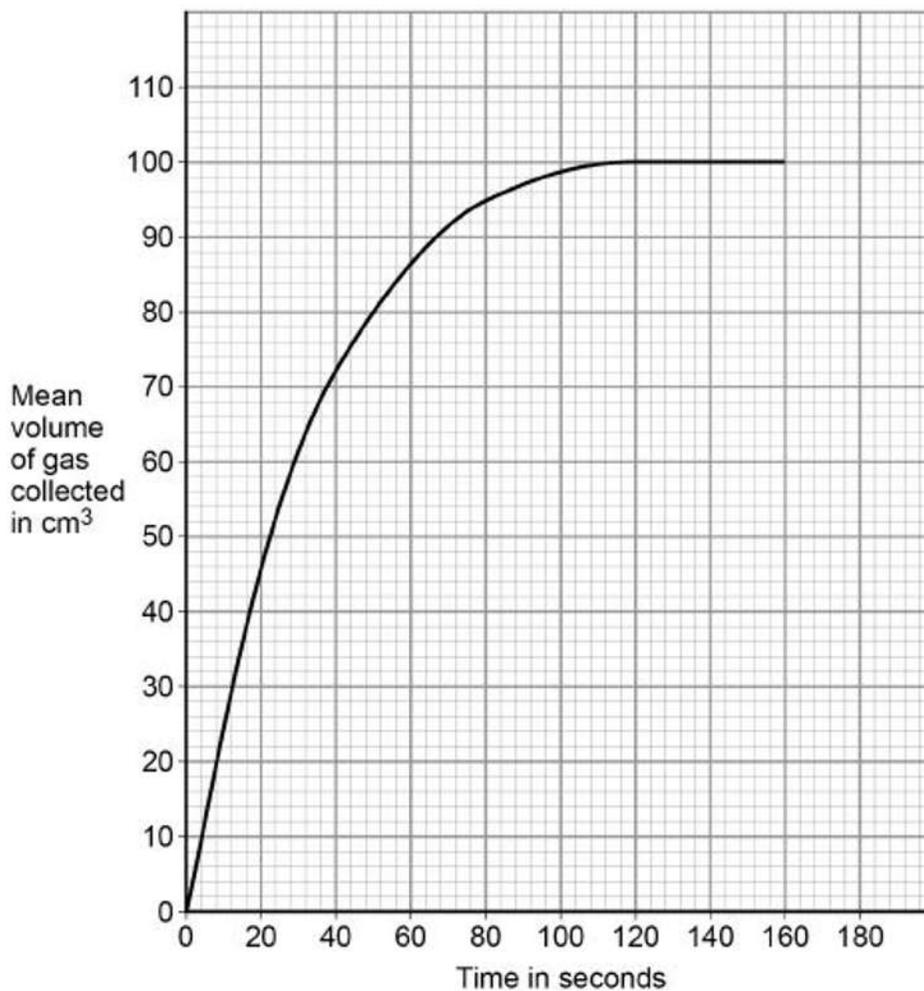


(2)

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 = _____ cm³/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)

2.

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.

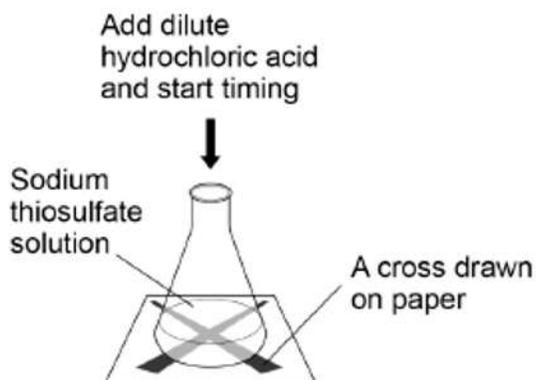
How should sulfur be written in the chemical equation for this reaction?

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 cm³ 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 cm³ 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 | <input type="checkbox"/> |
| Boiling tube | <input type="checkbox"/> |
| Measuring cylinder | <input type="checkbox"/> |
| Test tube | <input type="checkbox"/> |

(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

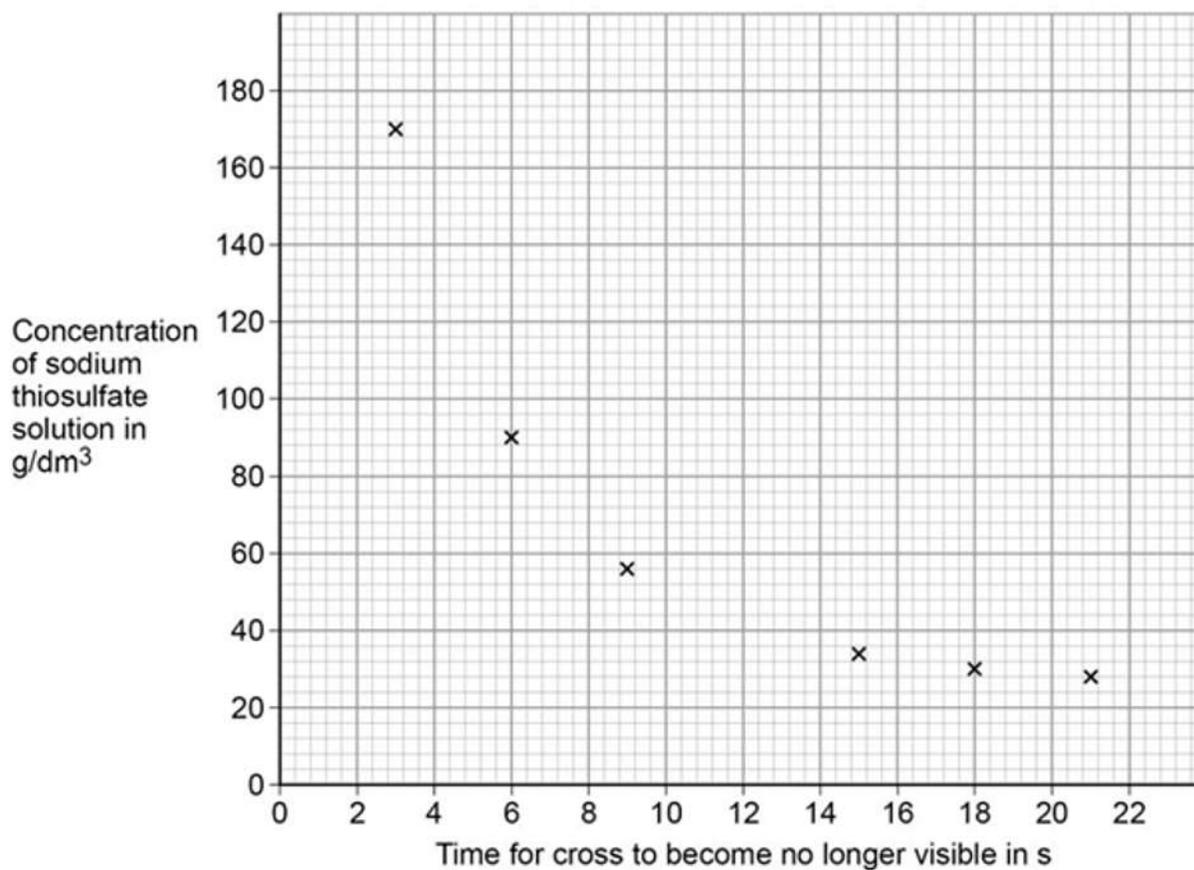
Calculate value X in the table.

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)

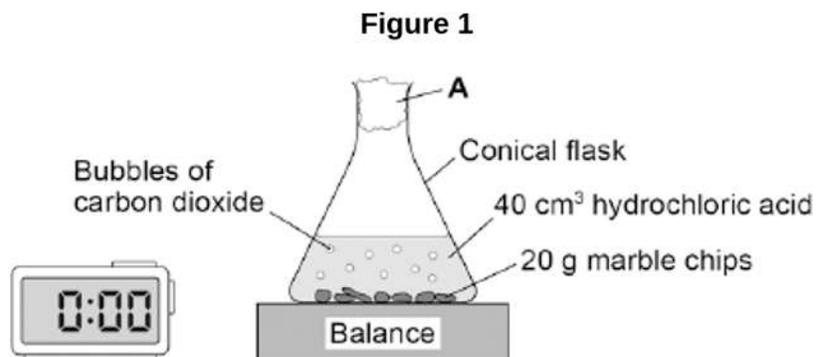


3.

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



Figure 1 shows the apparatus the student used.



(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.



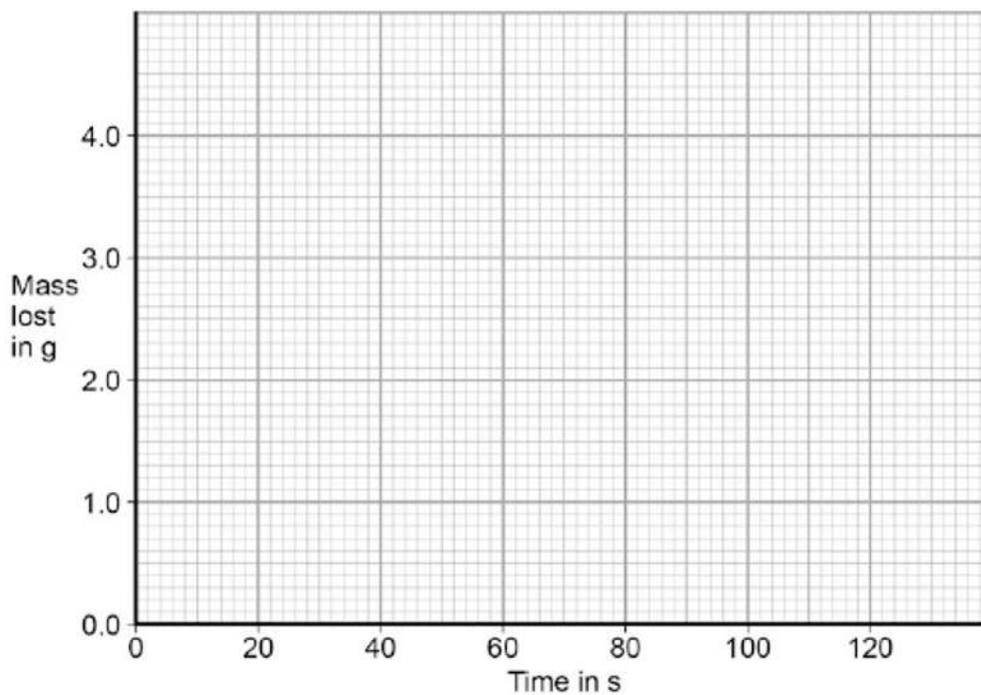
Table 1

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)

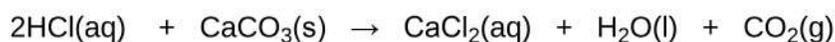
- (c) Use **Figure 2** to complete **Table 2**.

Table 2

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

(2)

- (d) The equation for the reaction is:



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)

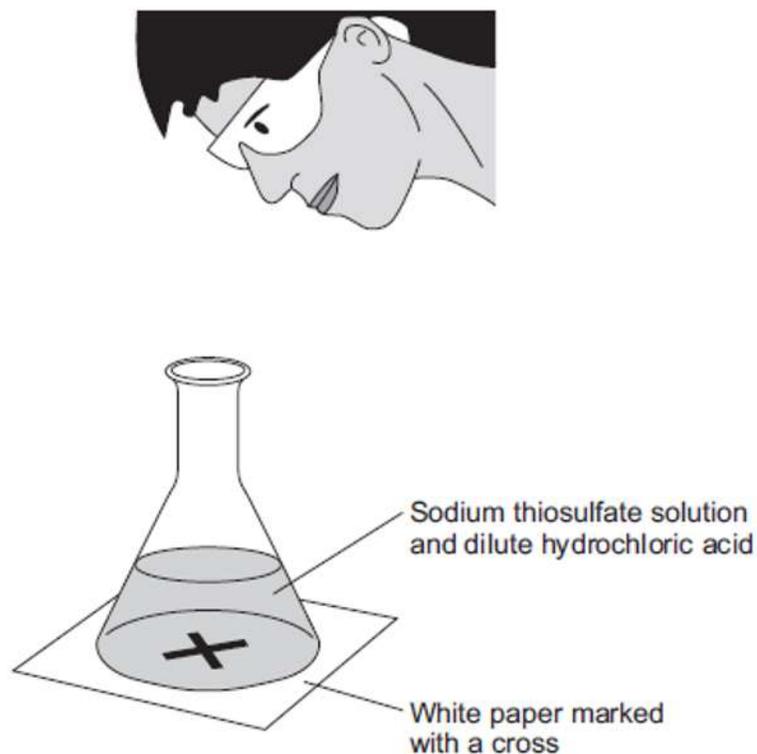
(Total 14 marks)

4.

A student investigated the rate of reaction between sodium thiosulfate solution and dilute hydrochloric acid, as shown in **Figure 1**.



Figure 1

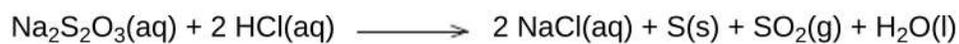


The reaction produced a precipitate, which made the mixture turn cloudy.

The student timed how long it took until she could no longer see the cross.

She calculated the rate of the reaction.

(a) The equation for the reaction is:



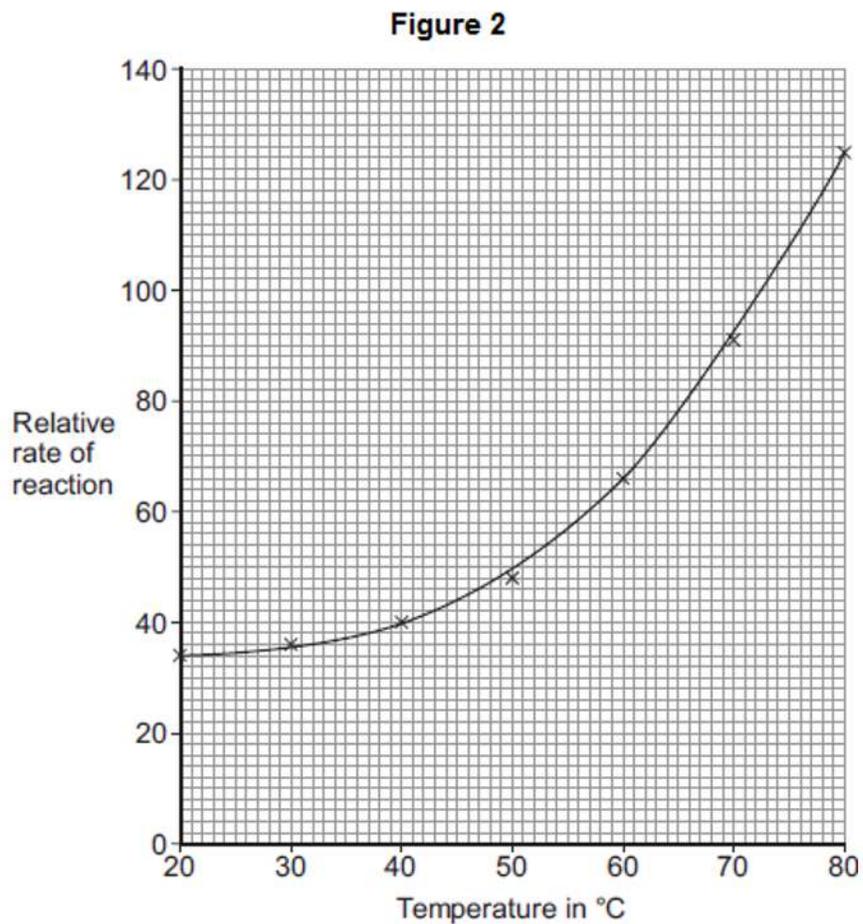
Name the product that made the mixture go cloudy.

(1)

(b) The student investigated the effect of changing the temperature of the sodium thiosulfate solution on the rate of reaction.



She plotted her results on a graph, as shown in **Figure 2**.



Describe the trends shown in the student's results.

(2)

(c) The student then investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction.



- (i) Suggest **two** variables the student would need to control to make sure that her results were valid.

(2)

- (ii) From this investigation the student correctly concluded:

'As the concentration of sodium thiosulfate solution doubles, the rate of reaction doubles.'

Explain the student's conclusion in terms of particles.

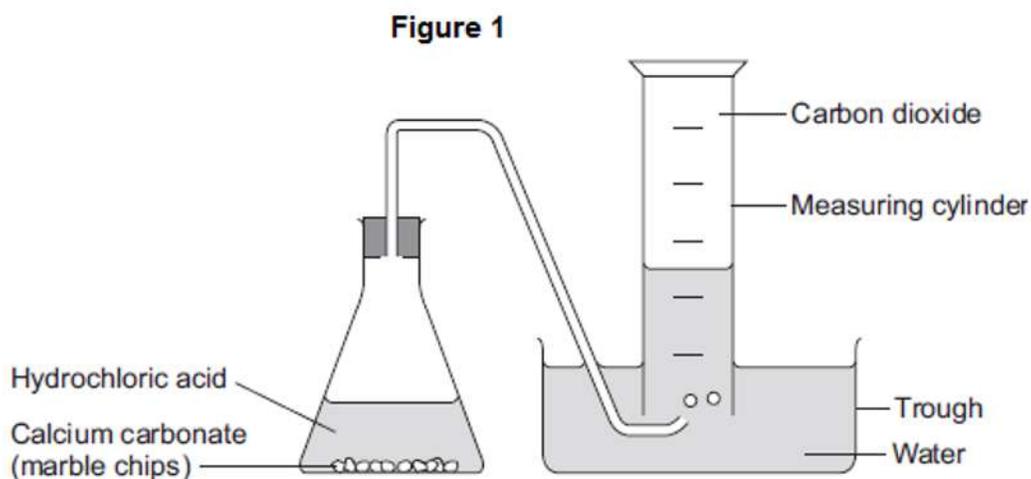
(3)

(Total 8 marks)

5.

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

The student used the apparatus shown in **Figure 1**.



The student:

- recorded the volume of gas collected every 5 seconds
- repeated the experiment using hydrochloric acid at different temperatures.

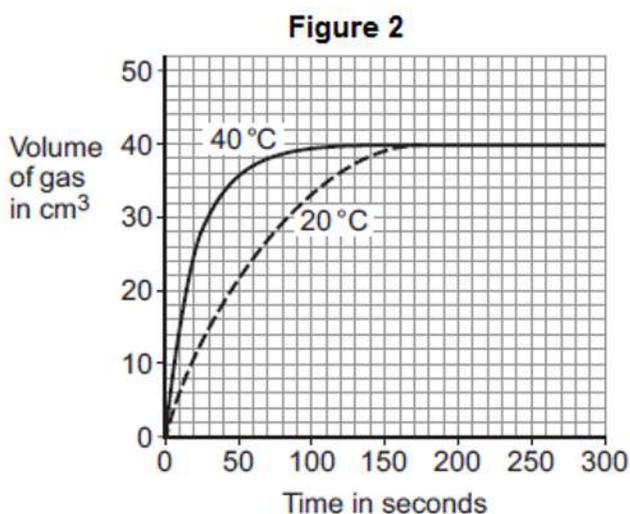
The equation for the reaction is:



- (a) The student plotted results for the hydrochloric acid at 20 °C and 40 °C on a graph.



Figure 2 shows the student's graph.



Use information from **Figure 2** to answer these questions.

- (i) State **one** conclusion the student could make about the effect of temperature on the rate of the reaction.

(1)

- (ii) Give **one** reason why the student could make this conclusion.

(1)

- (iii) For the hydrochloric acid at 60 °C the student had collected 30 cm³ after 15 seconds.
Calculate the average rate of reaction from 0 to 15 seconds.

Rate of reaction = _____ cm³ per second

(1)

(b) The student then investigated how the surface area of marble chips affected the rate of reaction.



(i) Which **two** variables should the student keep constant?

Tick (✓) **two** boxes.

Amount of water in the trough

Concentration of acid

Mass of marble chips

Size of marble chips

Volume of measuring cylinder

(2)

(ii) Explain, in terms of particles and collisions, the effect that increasing the surface area of the marble chips has on the rate of reaction.

(2)

(c) Calcium carbonate is a catalyst for the industrial production of biodiesel.

Give **one** reason why using a catalyst reduces costs.

(1)

(Total 8 marks)