6.1 Rate of Reaction

Question Paper

Course	AQA GCSE Chemistry
Section	6. Chemical Change: Rate & Extent
Topic	6.1 Rate of Reaction
Difficulty	Hard

Time Allowed 80

Score /61

Percentage /100

Question 1a

A student used the reaction between calcium carbonate and dilute hydrochloric acid to investigate how temperature affects the rate of reaction.

The student used the method as shown below.

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

Explain why there is a loss in mass of the contents of the conical flask.

[2 marks]

Question 1b

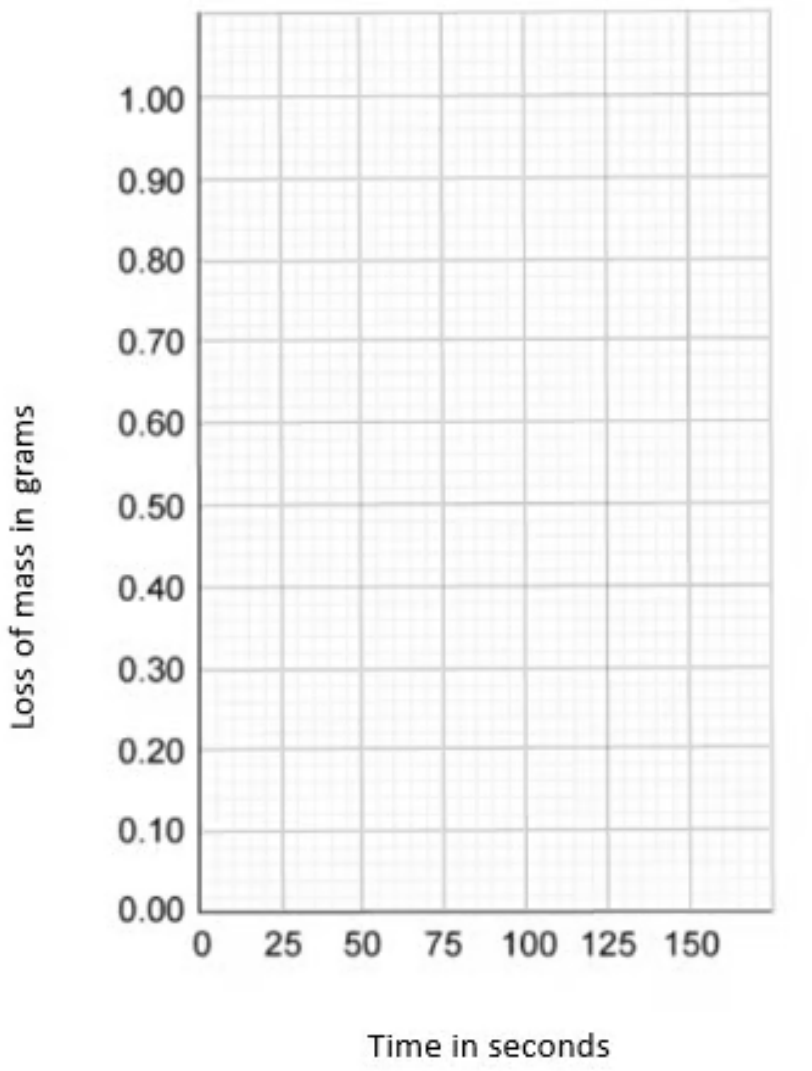
Table 1 shows results the student obtained for hydrochloric acid at 30 °C

Table 1

Time in seconds	Loss of mass in grams
0	0.00
20	0.27
40	0.49
60	0.68
80	0.83
100	0.92
120	0.97
140	0.99

Plot the data from the table above on **Figure 1** and draw a line of best fit.

Figure 1

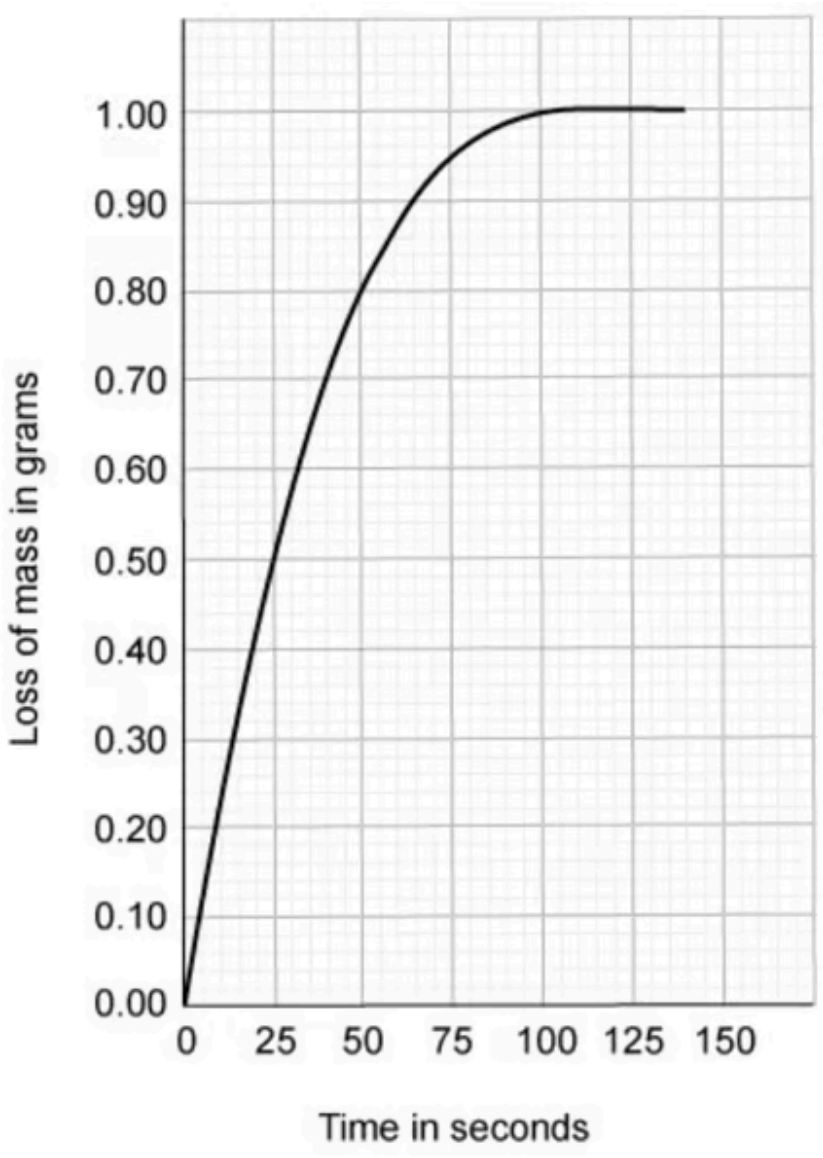


[3 marks]

Question 1c

Figure 2 shows the results that the student obtained for hydrochloric acid at a temperature of 50 °C

Figure 2



Use the graph to determine the rate of reaction at 50 °C when the loss of mass is 0.90 g.

You should show your working clearly in **Figure 2**.

Give your answer correct to 2 significant figures.

[4 marks]

Question 2a

This question is about rates of reaction.

Hydrogen peroxide, H_2O_2 decomposes in the following reaction:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The catalyst for this reaction is manganese dioxide.

A student investigated the effect of manganese dioxide particle size on the rate of reaction using the following method:

1. Measure 30 cm^3 of 0.3 mol/dm^3 hydrogen peroxide solution into a conical flask
2. Add a spatula of coarse manganese dioxide powder to the conical flask
3. Measure the volume of gas made every minute for ten minutes.
4. Repeat steps 1–3 with some fine manganese dioxide lumps.

This method did not give the student valid results.

Which two improvements would need to be made that would produce valid results?

Tick (✓) **two** boxes.

Use 0.02 mol/dm^3 hydrogen peroxide solution	
Use a mass of 1.5 g manganese dioxide each time	
Measure the volume of gas produced every 30 seconds	
Measure the mass of the conical flask and its contents	
Place the conical flask in a water bath at a constant temperature	

[2 marks]

Question 2b

Describe and give the result of a test that could be done to identify the gas made during the decomposition of hydrogen peroxide.

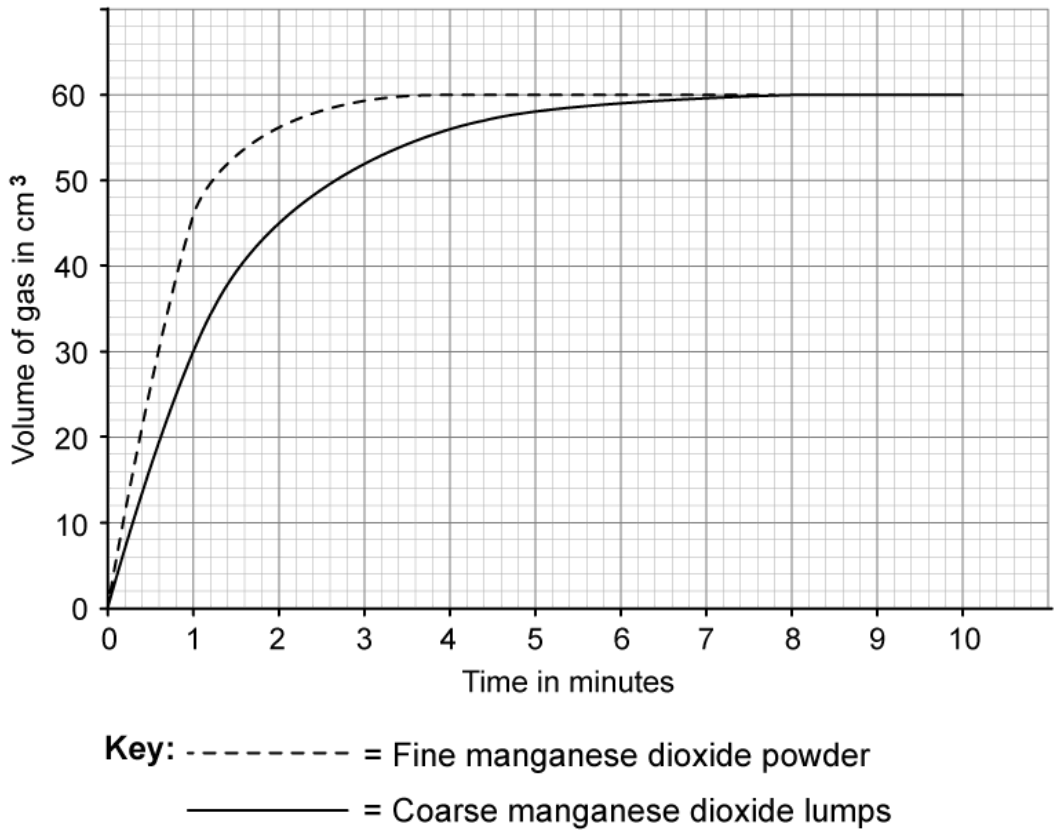
[2 marks]

Question 2c

Another student followed a method that produced valid results.

The results are shown in **Figure 1.**

Figure 1



Calculate the mean rate of reaction, in cm^3/s, between 1 and 3 minutes for coarse manganese lumps.

Give your answer to 2 significant figures.

Use data from the graph.

[3 marks]

Question 2d

The student repeated the experiment with coarse lumps of manganese dioxide.

They used the same volume of hydrogen peroxide but used a concentration of 0.1 mol/dm^3

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

Assume that the reaction is complete after 9 minutes.

[2 marks]

Question 2e

Explain why the rate of reaction is different when manganese dioxide is used as coarse lumps rather than fine powder.

You should answer in terms of collision theory.

[2 marks]

Question 3a

A solution of sodium thiosulfate reacts with dilute hydrochloric acid producing a cloudy solution as the reaction progresses.

The reaction equation is:

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

Explain why the solution turns cloudy.

[2 marks]

Question 3b

The rate of reaction is affected by the concentration of the sodium thiosulfate solution.

Plan an investigation to show this relationship.

Your plan should allow the collection of valid results.

[6 marks]

Question 3c

Another student investigated the effect of increasing temperature of the sodium thiosulfate solution on the rate of reaction.

State what the effect would be and explain this effect in terms of particles and collisions.

[4 marks]

Question 4a

A student investigated the rate of reaction between hydrochloric acid and marble chips using the apparatus shown in **Figure 3.**

Figure 3

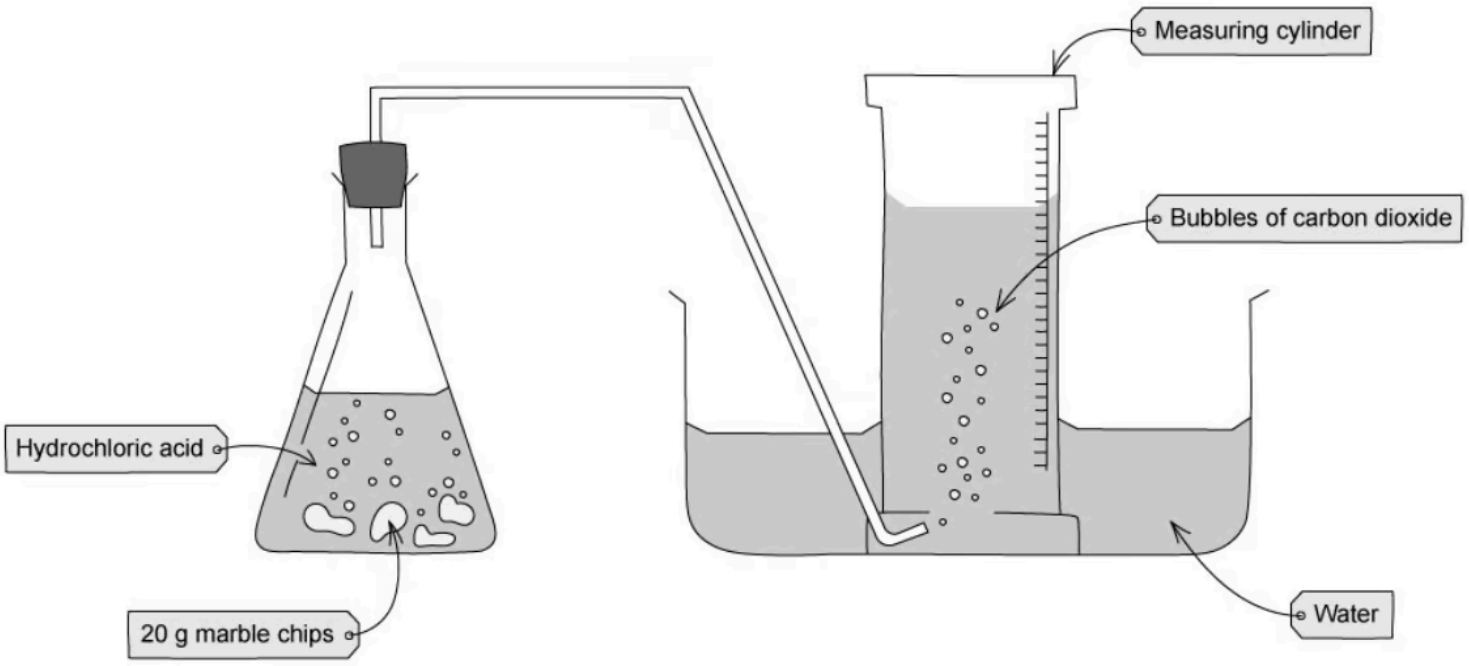


Table 2 below shows the student's results.

Table 2

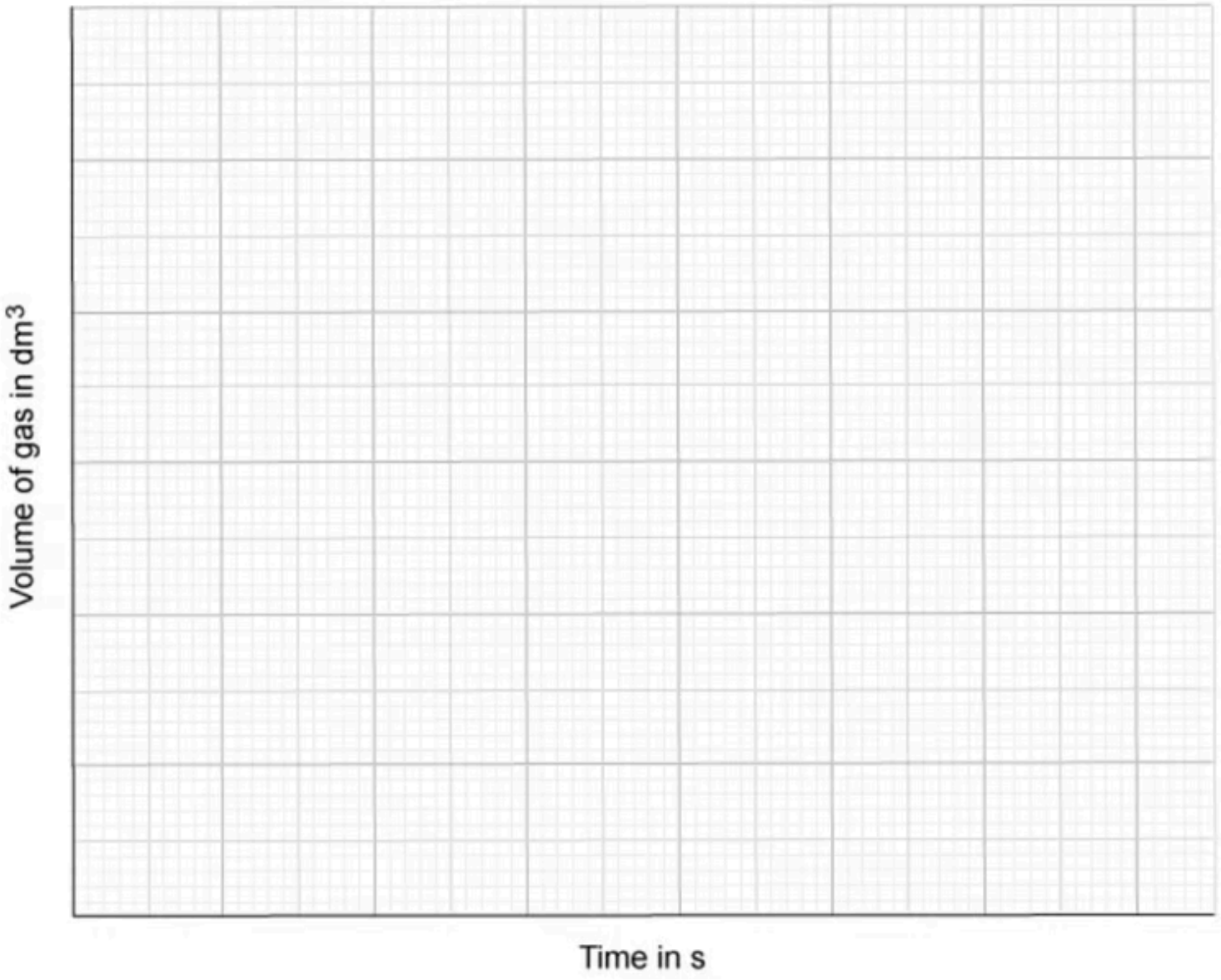
Time in s	Volume of gas in dm^3
0	0.000
30	0.032
60	0.048
90	0.054
120	0.067
150	0.072

180	0.078
210	0.081
240	0.083
270	0.083

On **Figure 4**:

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

Figure 4



[4 marks]

Question 4b

Sketch a line on the grid in **Figure 4** to show the results you would expect if the experiment was repeated but instead using 20 g of marble chips of smaller size.

[2 marks]

Question 4c

Explain, in terms of particles, how and why the rate of reaction changes during the reaction.

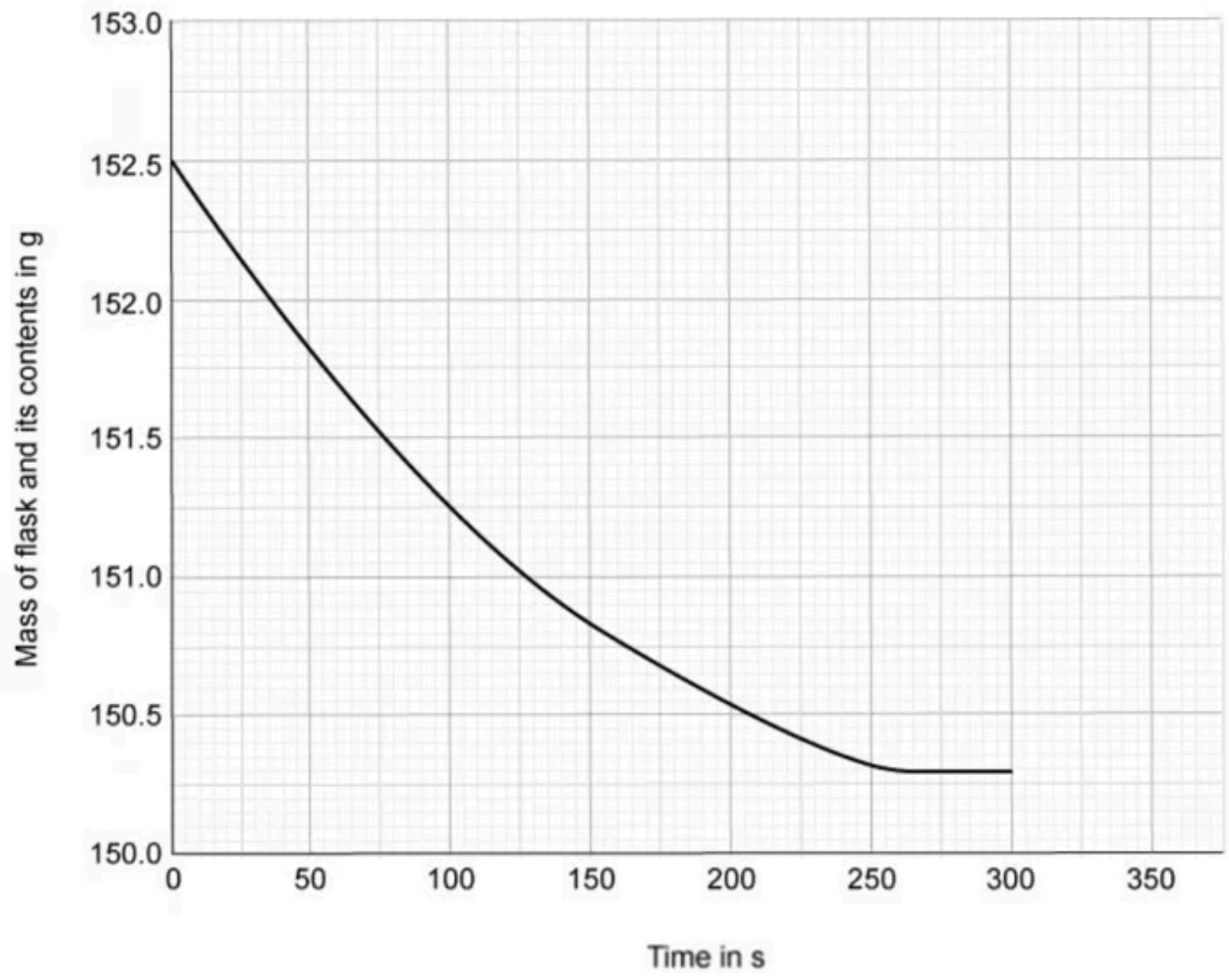
[4 marks]

Question 4d

A different student investigated the rate of reaction for the same reaction by measuring the change in mass.

Figure 5 shows the graph plotted from the results obtained in this investigation.

Figure 5



Use **Figure 5** to calculate the mean rate of the reaction up to the time when the reaction has gone to completion.

Give your answer correct to three significant figures.

Mean rate of reaction = _____ g / s

[4 marks]

Question 4e

Use **Figure 5** to determine the rate of reaction at 150 seconds.

Show your working clearly on **Figure 5**, giving your answer in standard form.

[4 marks]

Question 5a

A student investigated the effect of the size of calcium carbonate lumps, $CaCO_3$, on the rate of reaction with hydrochloric acid, HCl, using the following method:

1. Put 50 cm^3 of hydrochloric acid into a conical flask
2. Add 12 g of large calcium carbonate lumps into the flask
3. Attach the gas syringe
4. Measure the volume of gas produced every 30 seconds for 180 seconds
5. Repeat steps 1 - 4 using 12 g of small calcium carbonate lumps.
6. The number of moles of gas for each volume was calculated.

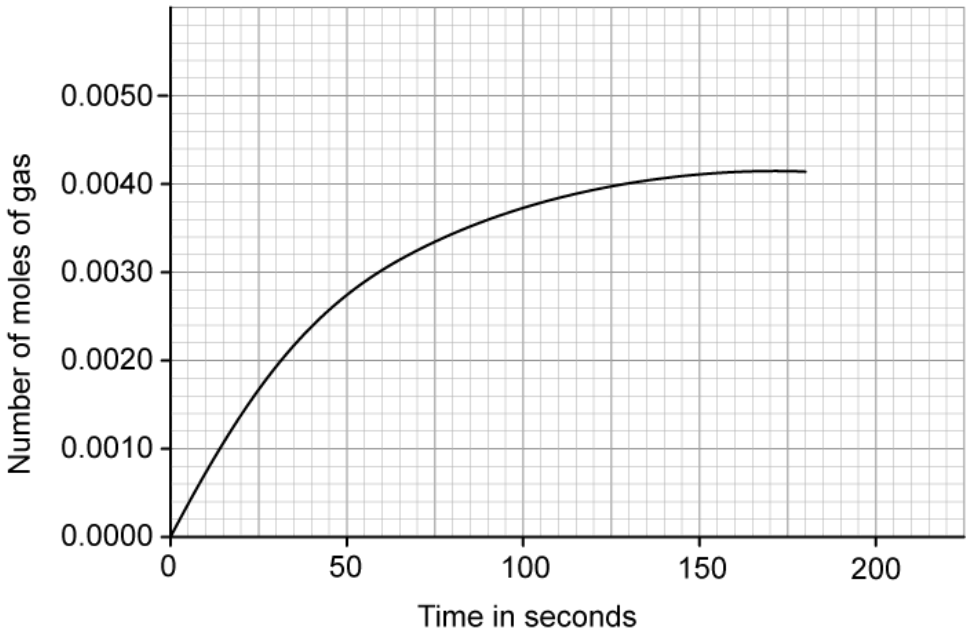
The results for large calcium carbonate lumps are shown below.

Table 1.

Time in seconds	Number of moles of gas
0	0.000
30	0.0012
60	0.0022
90	0.0030
120	0.0034
150	0.0037
180	0.0038

The student had already plotted the data for small calcium carbonate lumps.

Plot the data for the large calcium carbonate lumps and draw a line of best fit.



[3 marks]

Question 5b

Determine the mean rate of reaction for **small** calcium carbonate lumps between 35 seconds and 90 seconds.

Give the unit.

Use the graph in part (a)

[4 marks]

Question 5c

What conclusion can be made about the rate of reaction of small calcium carbonate lumps compared to large calcium carbonate lumps?

Give **one** reason for your answer.

[2 marks]

Question 5d

Complete and balance the equation for the reaction between calcium carbonate and hydrochloric acid.

_____ + _____ → $CaCl_2$ + _____ + _____

[2 marks]