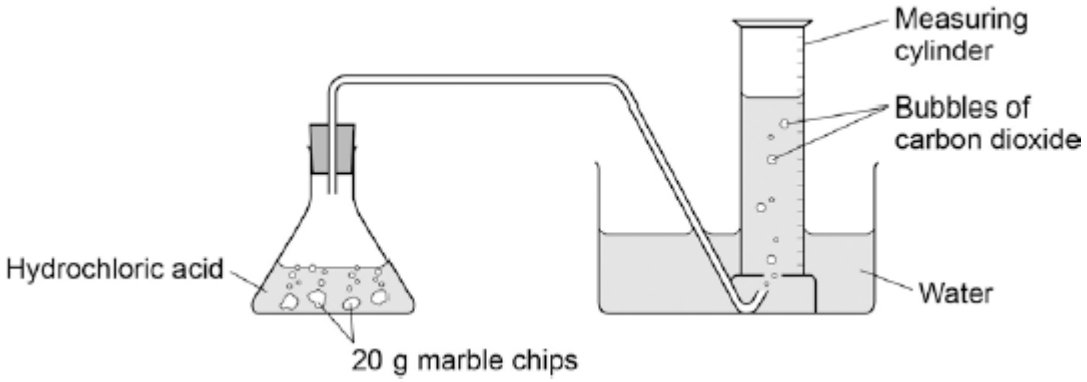
Q1. Marble chips are mainly calcium carbonate ($CaCO_3$).

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)

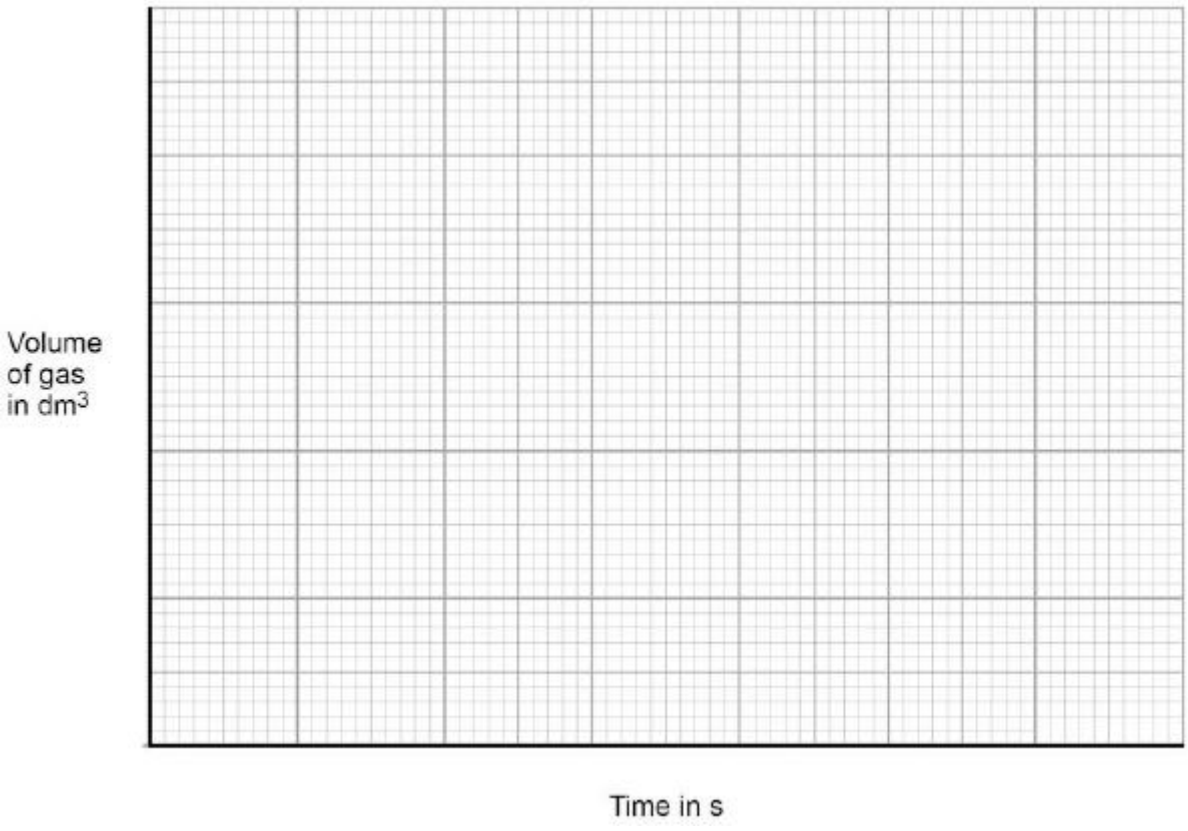
(b) The table below shows the student's results.

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.

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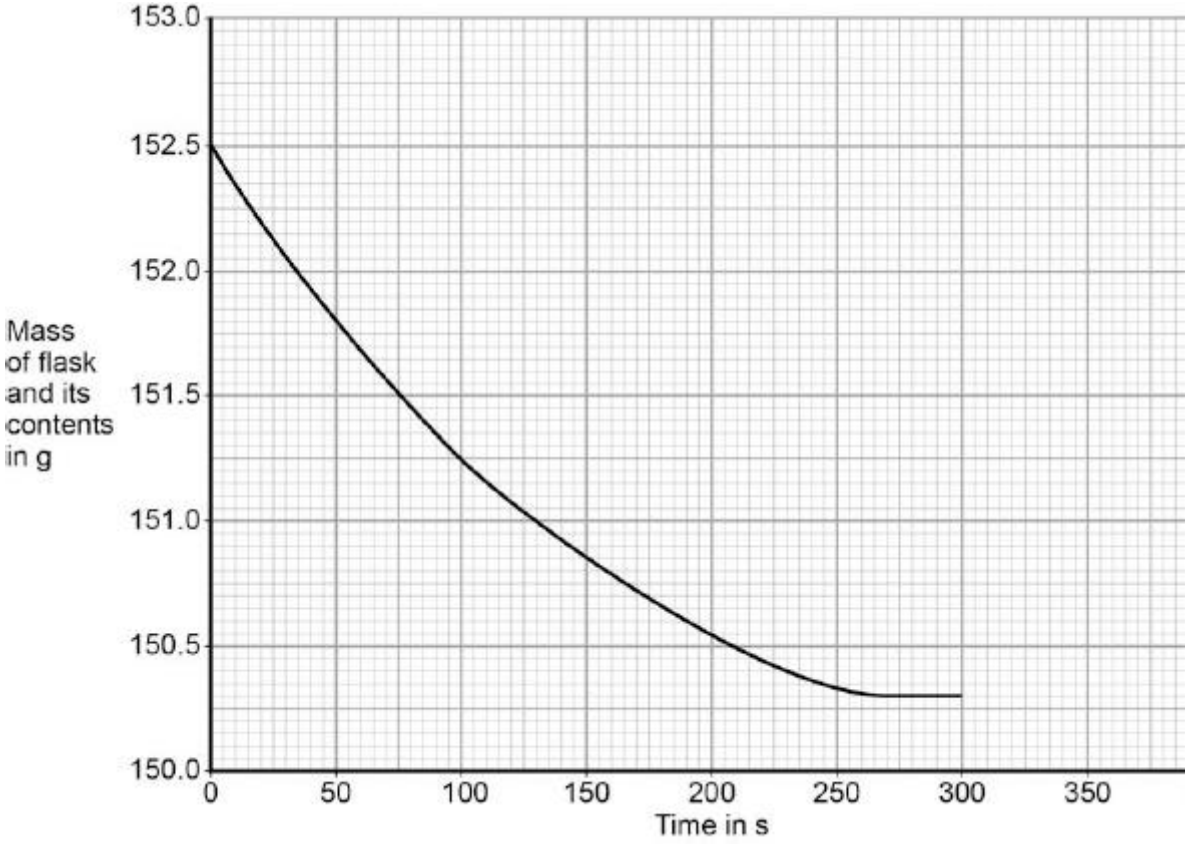
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(4)

(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.

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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.

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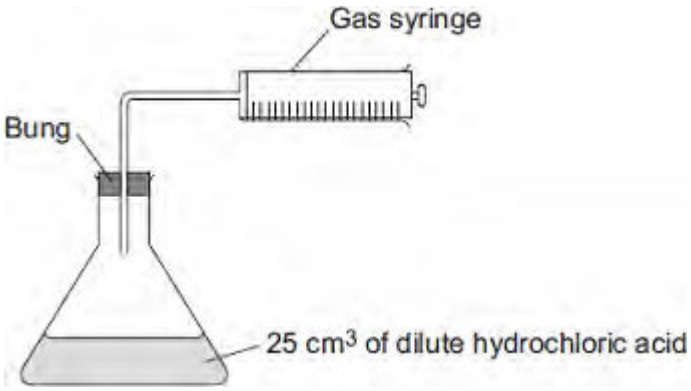
Rate of reaction at 150 s = ... g / s

(4)

(Total 20 marks)

Q2. A student investigated the reaction between magnesium metal and dilute hydrochloric acid.

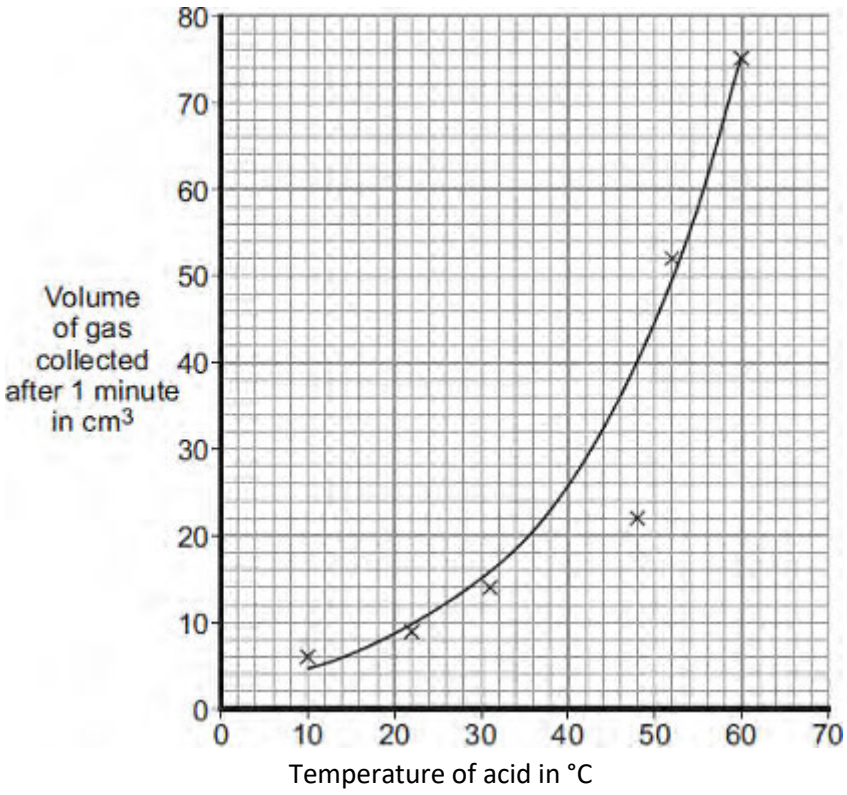
The student placed 25 cm^3 of dilute hydrochloric acid in a conical flask and set up the apparatus as shown in the diagram.



The student:

- took the bung out of the flask and added a single piece of magnesium ribbon 8 cm long
- put the bung back in the flask and started a stopwatch
- recorded the volume of gas collected after 1 minute
- repeated the experiment using different temperatures of acid.

The student plotted his results on a graph.



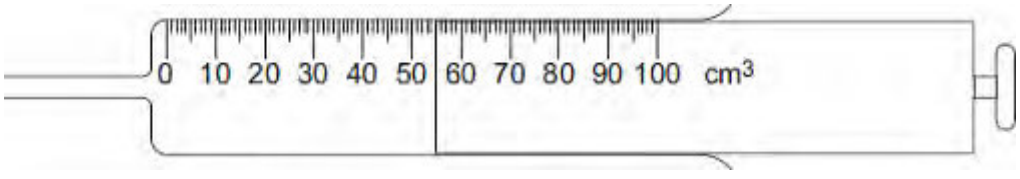
(a) Write the correct state symbols in the equation.

Choose from (s) for solid, (l) for liquid, (g) for gas and (aq) for aqueous.

$Mg(....) + 2\,HCl(....) \longrightarrow MgCl_2(....) + H_2(....)$

(2)

(b) The diagram shows a gas syringe after 1 minute.



(i) What volume of gas has been collected in the gas syringe after 1 minute?

Volume = ... cm^3

(1)

(ii) Use the graph to determine the temperature of the acid used in this experiment.

Temperature = ... °C

(1)

(iii) Calculate the average rate of reaction, in cm^3 of hydrogen made per second (cm^3/s), for this experiment.

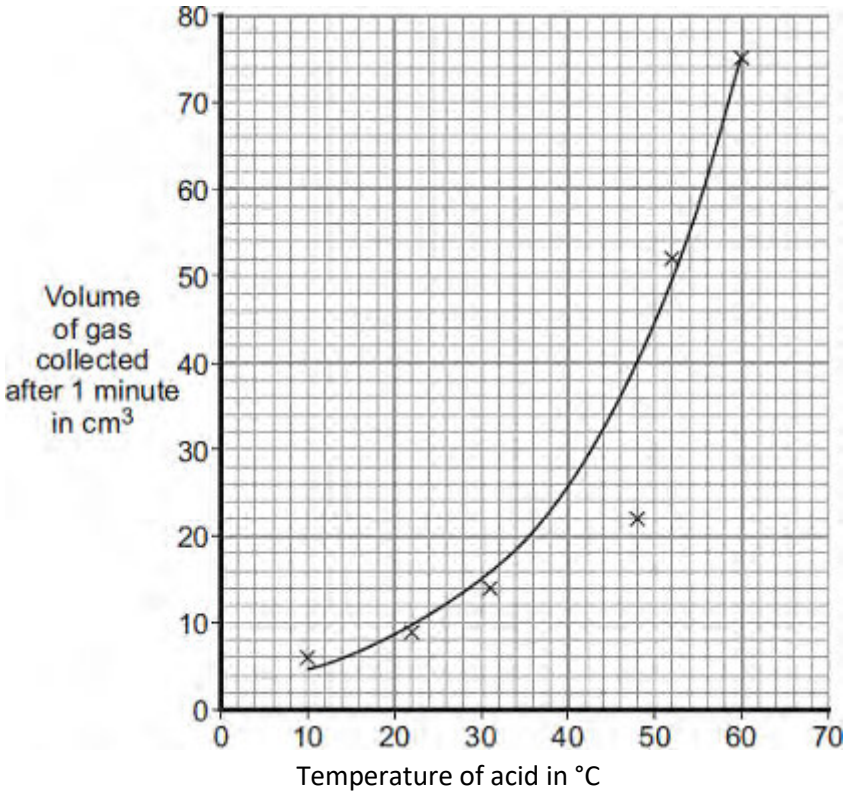
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Rate of reaction = ... cm^3/s

(2)

(c) The student's graph has been reprinted to help you answer this question.



One of the results on the graph is anomalous.

(i) Draw a circle on the graph around the anomalous point.

(1)

(ii) Suggest what may have happened to cause this anomalous result.

Explain your answer.

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(2)

(d) Explain how the student could improve the accuracy of the volume of gas recorded at each temperature.

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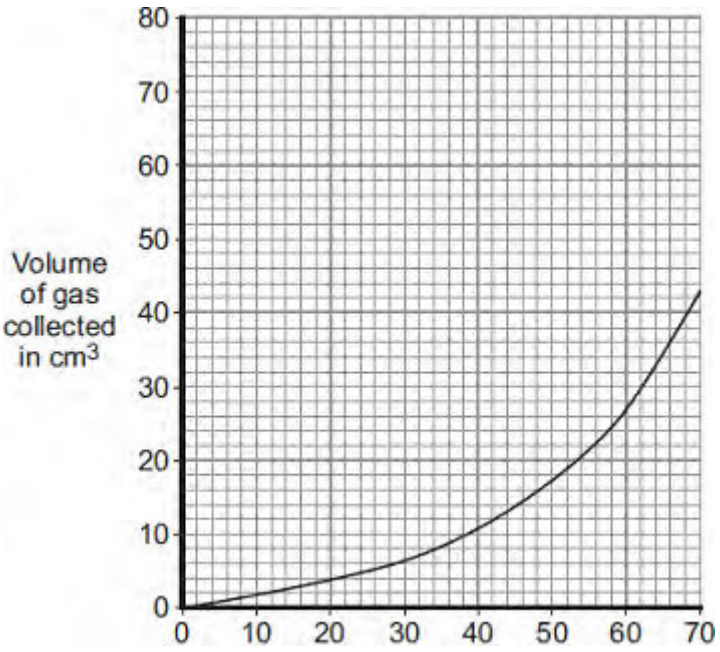
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(3)

(e) The student then used the same apparatus to measure the volume of gas produced every 10 seconds at 40 °C.

The student's results are shown on the graph.



The rate at which the gas was produced got faster over the first 60 seconds.

The student's teacher gave two possible explanations of why the reaction got faster.

Explanation 1
There was a layer of magnesium oxide on the surface of the magnesium.
The layer of magnesium oxide prevented the magnesium reacting with the acid.
As the magnesium oxide reacted slowly with the acid, the magnesium was exposed to the acid and hydrogen gas was produced.

Explanation 2
The reaction is exothermic, and so the temperature of the acid increased during the reaction.

(i) Describe further experimental work the student could do to see if **Explanation 1** is correct.

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(2)

(ii) Describe further experimental work the student could do to see if **Explanation 2** is correct.

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(2)

(Total 16 marks)

Q3. This question is about gold (Au).

(a) An atom of gold is represented as:

$$^{197}_{79}\mathrm{Au}$$

How many neutrons are in this atom of gold? .....

(1)

(b) Gold ions are used as a catalyst.

How does a gold atom (Au) become a gold ion (Au^{3+})?

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(2)

(c) A gold catalyst can be used when carbon monoxide reacts with oxygen to make carbon dioxide.

(i) Complete and balance the equation for this reaction.

.... CO + ... → ..... CO_2

(2)

(ii) Carbon dioxide has a very low boiling point.

Explain why.

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(3)

(d) Gold is used as a catalyst in industrial processes. Gold is rare and increasingly expensive.

Suggest **three** reasons why gold is still used in industrial processes.

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(3)
(Total 11 marks)

Q4. The equation for a reaction to produce hydrogen is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

(a) Explain why changing the pressure does **not** affect the yield of hydrogen at equilibrium.

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(1)

(b) Suggest why the best yield of hydrogen at equilibrium is obtained at **low** temperatures.

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(1)

(c) The temperature used in industry needs to be high enough for the reaction to take place quickly. Explain, in terms of particles, why the rate of reaction increases when the temperature is increased.

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(3)

(d) Scientists have developed catalysts which allow the reaction to take place quickly at lower temperatures. How could this be good for the manufacturer and for the environment?

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(2)
(Total 7 marks)