O Level Combined Chemistry Structured

Speed of Reaction Test 1.0

Q1

5 g of magnesium ribbon was added to 100 cm^3 of 1.0 mol/dm^3 of excess hydrochloric acid. The hydrogen evolved was collected in a gas syringe and the volume collected is recorded every 30 seconds.

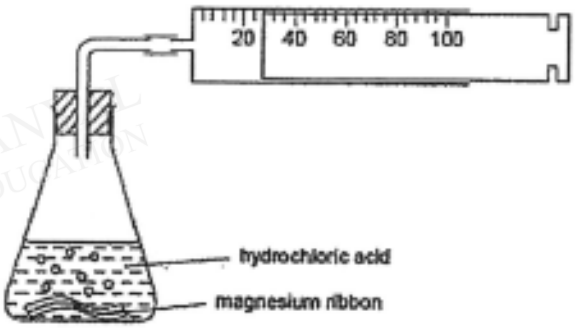


Fig. 6.1 shows the results obtained for the experiment.

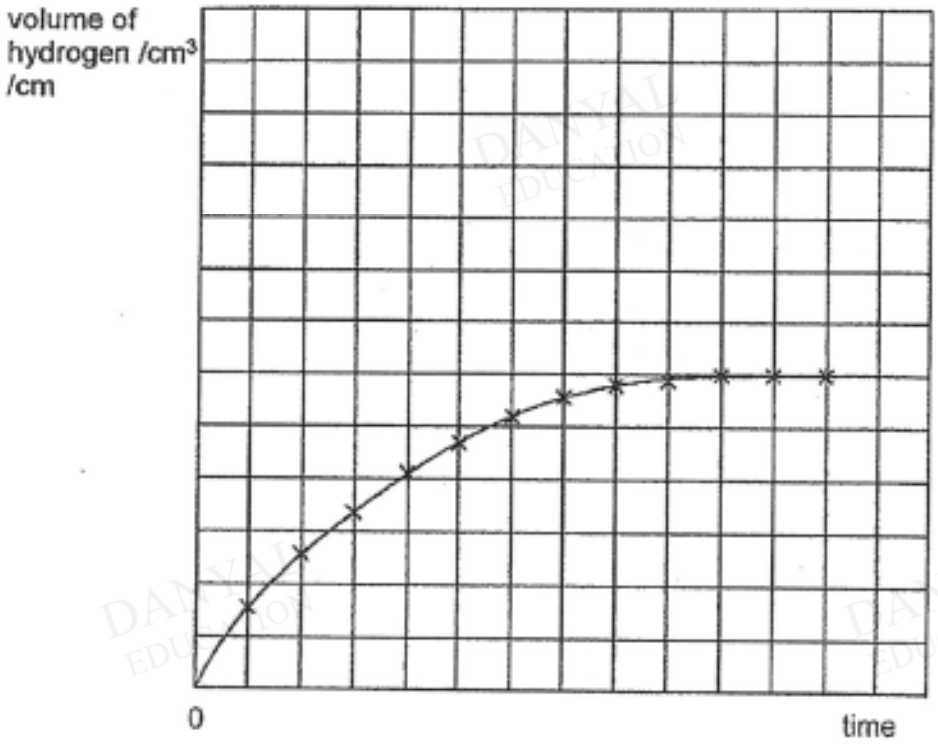


Fig. 6.1

(a) Write a balance chemical equation for the reaction between magnesium and hydrochloric acid. Include state symbols in your chemical equation.

..... [2]

(b) Calculate the volume of hydrogen gas produced.

Volume of hydrogen gas :..... dm^3 [2]

(c) Suggest how you would calculate the average speed of reaction for the reaction between magnesium and hydrochloric acid.

.....

.....

..... [1]

(d) (i) The experiment was repeated with 5 g of magnesium ribbon and 100 cm^3 of 0.5 mol/dm^3 hydrochloric acid. Sketch the graph that you would obtain from the results of this experiment on the same grid in Fig. 6.1. Label it X.

(ii) The experiment was repeated using 2.5 g of magnesium ribbon and 100 cm^3 of 1.0 mol/dm^3 sulfuric acid. Sketch the graph that you would obtain from the results of this experiment on the same grid in Fig. 6.1. Label it Y. [2]

(e) Explain the graph obtained in **d(ii)**.

.....

.....

..... [2]

Q2

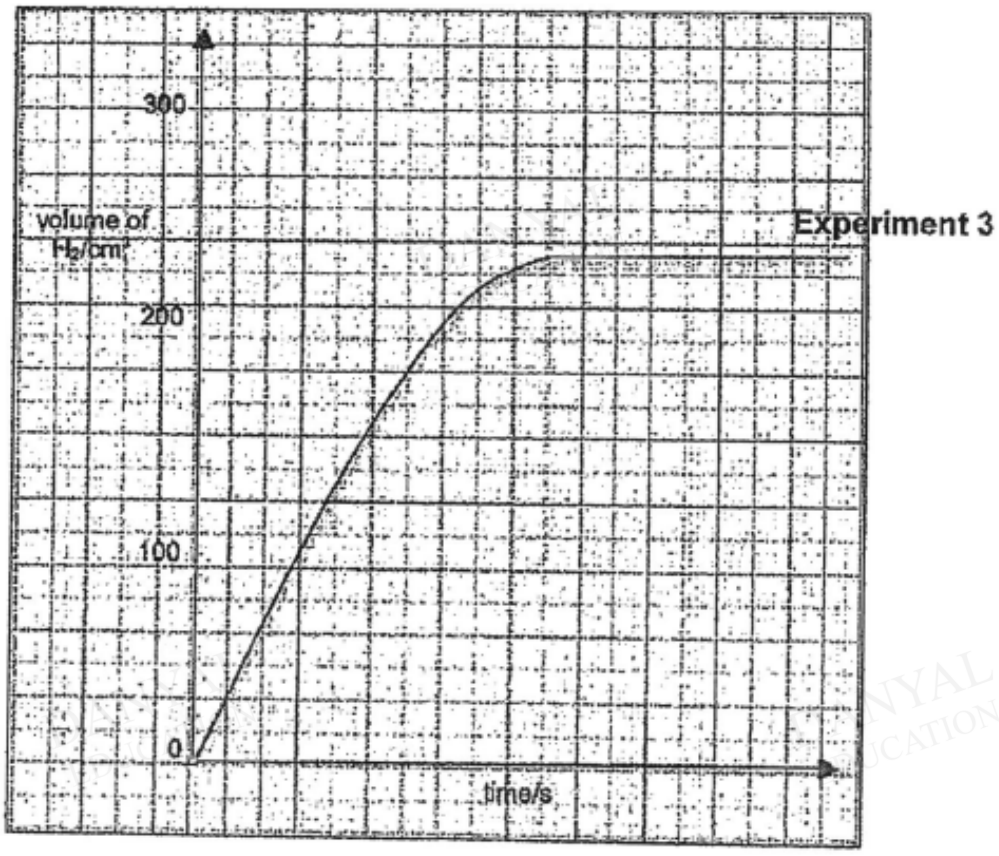
A series of experiment were carried out using a data logger to investigate the effect of concentration on the rate of reaction at room temperature.

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

In each experiment, the volumes of hydrogen produced were measured at regular time intervals.

Experiment	Mass of Mg used / g	Volume of H_2SO_4 used / cm^3	Concentration of H_2SO_4 used / mol/dm^3
1	0.24	20	2.0
2	0.24	20	1.0
3	0.24	20	0.5
4	0.24	20	0.25

The results obtained for **Experiment 3** are shown in the graph below.



(a) (i) Draw on the graph above, the results you would expect in Experiment 2. Label your graph as **Experiment 2**. [1]

(ii) Use ideas of collisions between particles to explain how increasing concentration of dilute sulfuric acid affect the speed of reaction.

.....

.....

.....

.....

[2]

(b) Using the data given for **Experiment 4**,

(i) calculate the number of moles of magnesium used.

[1]

(ii) calculate the number of moles of sulfuric acid used.

[1]

(iii) Based on your calculations, determine the limiting reactant and hence calculate the volume of hydrogen produced.

[2]

Q3

Calcium carbonate, in the form of marble chips, react with hydrochloric acid in the reaction shown below.

$$CaCO_3 + 2\,HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

5.0 g of marble chips was added to 60.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid at room temperature and pressure. The rate of reaction was tracked by measuring the volume of carbon dioxide produced during the reaction at regular time intervals.

Table 11.1 shows the results from the experiment.

time/min	0	2	4	6	8	10	12	14
total volume of CO_2/cm^3	0	240	360	440	460	474	480	480

Table 11.1

(a) Using the information from Table 11.1, describe how the rate of reaction changes with time.

.....

.....

.....[2]

(b) Use your knowledge of reacting particles to explain the changes in the rate of reaction with time.

.....

.....

.....[2]

(c) Calculate the number of moles of marble chips and hydrochloric acid used in the reaction. Hence, determine the limiting reagent.

Number of moles of marble chips ..... mol

Number of moles of hydrochloric acid ..... mol

[2]

(d) Calculate the volume of carbon dioxide produced at room temperature and pressure during the reaction.

volume of carbon dioxide .....
[2]

(e) The graph in Fig. 11.2 shows the results obtained when 5.0 g of marble chips was added to 60.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid.

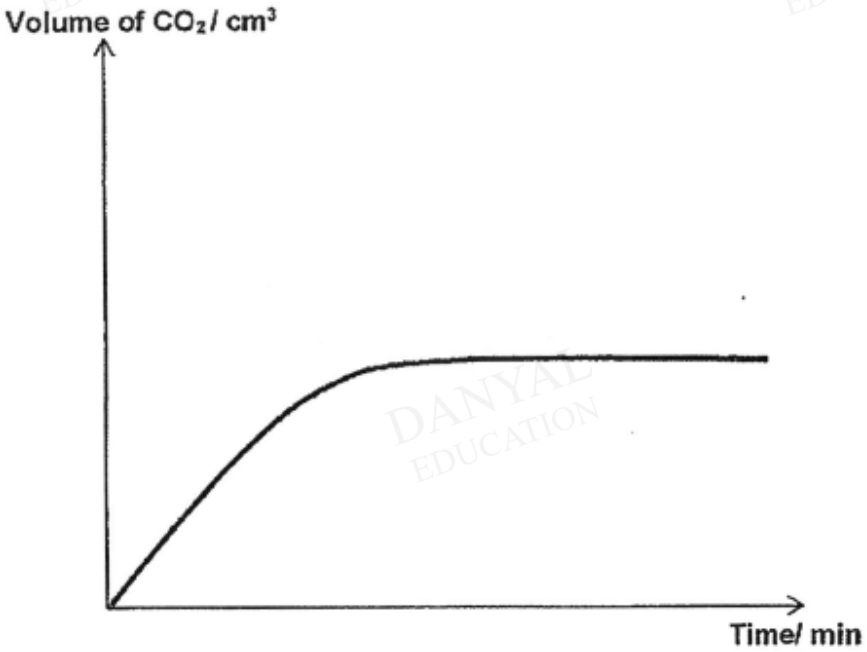


Fig. 11.2

The experiment above,

(i) is repeated using the 60.0 cm^3 of 1.0 mol/dm^3 hydrochloric acid.
Add to Fig. 11.2 the graph you would expect. Label this **graph A.**
[1]

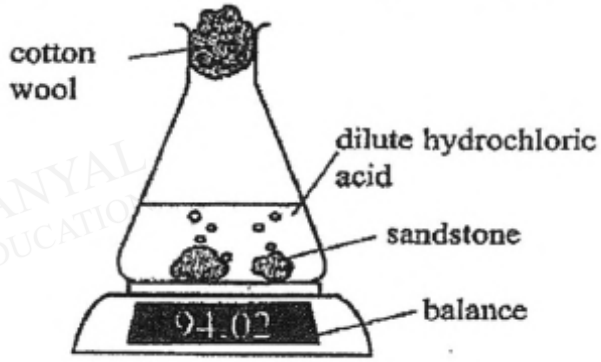
(ii) is repeated using the same mass of powdered calcium carbonate.
Add to Fig. 11.2 the graph you would expect. Label this **graph B**
[1]

Q4

Sandstone contains sand (mainly silicon dioxide)and calcium carbonate.
Excess sandstone was reacted with dilute hydrochloric acid.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

The rate of reaction was followed by meassuring the mass lost during the reaction.



This is a table of the results.

time t/minutes	total mass lost/g
0	0.00
4	0.18
8	0.30
12	0.38
16	0.44
20	0.48
24	0.51

(i) Use information from the table to show that the rate of reaction decreased.

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..... [2]

(ii) Explain using ideas about particles colliding, why the rate of reaction decreased.

.....

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.....

.....

..... [2]

(iii) Draw a labelled diagram to show a **different** method of following the rate of reaction between sandstone and hydrochloric acid.

[2]

Q5

Equal masses of calcium carbonate was reacted with dilute nitric acid of the same concentration in Experiment I and II. Nitric acid was added in excess.

Experiment I: lumps of calcium carbonate powder was added.
Experiment II: powdered calcium carbonate powder was added.

The mass of calcium carbonate was measured and calculated at regular time intervals.
The results of the experiments are shown in Fig. 6.1.

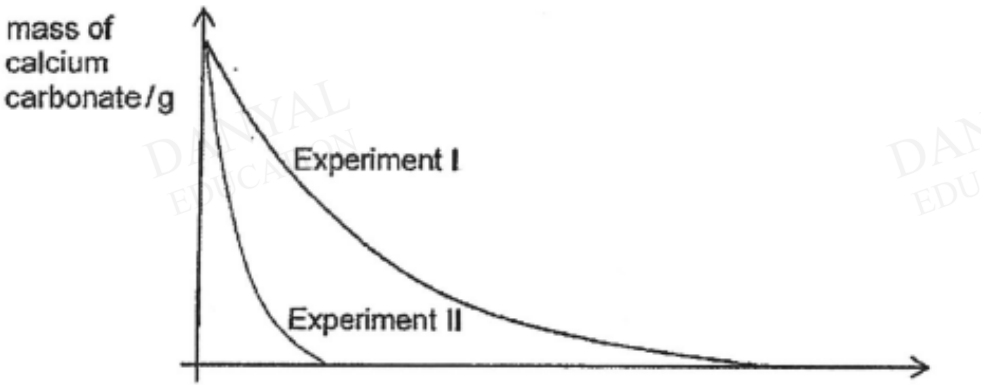


Fig. 6.1

(a) Describe **one** measure to be taken so that a fair experiment is conducted.

.....[1]

(b) State the experiment that is faster.

.....[1]

(c) Using your knowledge of collisions between reacting particles, explain your answer in **(b)**.

.....

.....

.....[2]

(d) Write out a balanced chemical equation for this reaction.

.....[2]

(e) If 28.6 g of calcium carbonate was reacted, calculate the volume of gas evolved at room temperature and pressure.

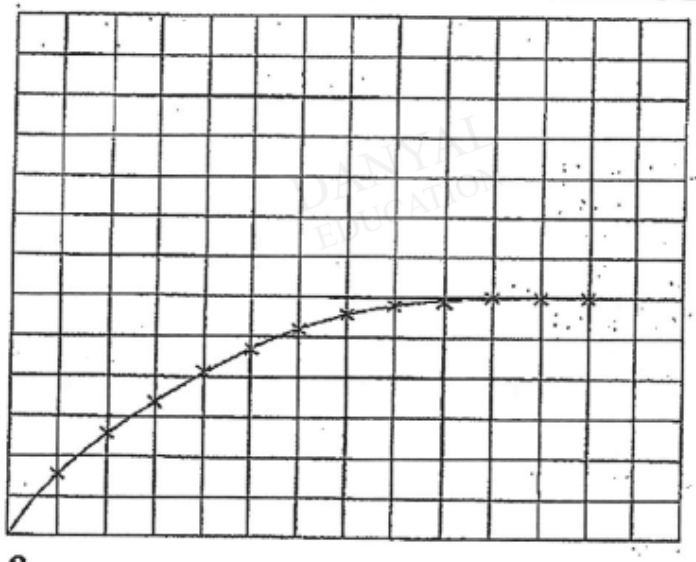
[2]

Answers

Speed of Reaction Test 1.0

Q1

(a)	No. of mole of magnesium = **5/24 mol / 0.208 mol** Or **Mole ratio :** 1 mol of Mg produces 1 mol of H_2 **0.208 mol of Mg produces 0.208 mol of H_2** **Volume of H_2 = 0.208 × 24 = 4.992 dm^3 or 5 dm^3**	[1] [1]
(b)	Average speed of reaction can be calculated by dividing the **total volume** of hydrogen produced **to total time** taken for the reaction to stop / no more effervescence observed/ maximum volume reached.	[1]

(c)	volume of hydrogen  0 Graph X ½ mark : gradient is lower than original graph / time taken is more than original time ½ mark : final volume is same Graph Y ½ mark : gradient is steeper than original graph ½ mark : final volume is half of the original volume	[2]
(d)	The final volume of hydrogen gas produced is half of the volume produced in the original experiment. This is because, the mass of magnesium used is reduced by half. The speed of reaction is faster because, in same number of mole of sulphuric acid and hydrochloric acid, there's more concentration of hydrogen ions.	[1] [1]

Q2

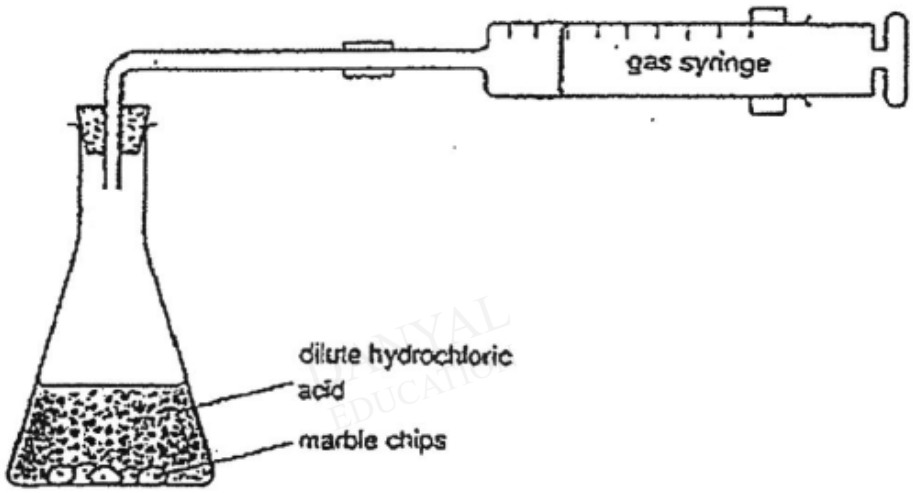
6ai	Graph showing steeper gradient and same volume of H_2
ii	Increasing concentration causes the **number of sulfuric acid particles per unit volume to increase. Frequency of collisions** to increase. **Chance of effective collisions increases** resulting in **speed of reaction** to increase.
bi	Number of moles of magnesium used = 0.24 ▯24= 0.0100 mole
ii	Number of moles of sulfuric acid used = $0.02dm^3$ x $0.25mol/dm^3$ = 0.00500 moles
iii	From eqn, 1 mole Mg reacts with 1 mole of H_2SO_4 0.01 mole H_2SO_4 needed to react with 0.01 mole Mg but only 0.005 moles H_2SO_4 is present. Therefore is H_2SO_4 the limiting reagent. 1 mole H_2SO_4 produces 1 mole H_2 0.005 mole H_2SO_4 produces 0.005 mole H_2 Volume of hydrogen produced = 0.005 x 24 = $0.120dm^3$

Q3

(a) From the results, the volume of carbon dioxide formed in the first 2 minutes is 240 cm^3. However, between the 6^{th} and 8^{th} minutes, only about 20 cm^3 of carbon dioxide is formed. Finally, between 10^{th} and 14^{th} minutes, only 6 cm^3 of carbon dioxide is formed. Hence, we can see that the rate of reaction is decreasing over time.	1m: state that rate of reaction is decreasing 1m: use at least 3 sets of data to show the decreasing trend.
(b) The rate of reaction is the fastest at the beginning.[1] As reaction progress, there is lesser reacting particles, hence the frequency of effective collisions decreases, resulting in a decreasing speed of reaction. [1] 1m: – recognize that speed of reaction is fast at beginning due to ready available reacting particles 1m: recognize that reacting particles decrease over time, resulting in decreasing speed of reaction	2m
(c) Number of moles of marble chips = 5/100 = 0.05 mol Number of moles of HCl = 2 x (60/1000) = 0.120 mol 0.05 mol of $CaCO_3$ will require (0.05 x 2) = 0.100 mol of HCl. However, there is 0.120 mol of acid available, hence marble chips, $CaCO_3$ will be used up first.	Both correct: 1m 1m : statement to show that $CaCO_3$ is the limiting reagent. (Deduct 1m if missing)
(d) Number of moles of CO_2 = 0.06 mol Volume of CO_2(g) = 0.06 x 24 = 1.44 dm^3	1m (can be embedded) 1m
(e) (i) Graph A – gentler gradient, end slightly later, volume of gas will be halved (less) ; acid is now the limiting reagent (ii) Graph B – steeper gradient, same volume of gas obtained, end slightly earlier	1m 1m

Q4

(i)	Rate of reaction from 0 to 4 min is 0.18 /4 = 0.45 g/min	1
	Rate of reaction from 4 to 8 min is 0.12/4 = 0.03/min	
	Rate of reaction from 8 to 12 min is 0.08/4 = 0.016/min	1
	Some form of calculations shown to show decrease in rate	
(ii)	Molecules of limiting agent ,HCl decreases	1
	Less effecting collisions per unit volume	1
(iii)	Following rate of reaction by measuring gas volume	



Q5

(a)	Ensure **temperature remains constant** for both experiments.	[1]
(b)	Experiment II	[1]
(c)	In Experiment II, powdered calcium carbonate is used. The smaller particle size leads to an **increase in total surface area**, thus more surfaces exposed.	[1]
	Collision between particles increases, leading to **increase in frequency/rate of effective collision**, thus, faster speed of reaction.	[1]
(d)	$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$	[2]
	[1 mark for balanced equation, 1 mark for correct chemical formula]	
(e)	No. of moles of $CaCO_3$ = 28.6 /(40+12+3(16)) = 0.286 mol	[1]
	Mole ratio of $CaCO_3$: CO_2 = 1 : 1	
	Thus, no. of mole of HCl = 0.286 mol	
	Volume of HCl = 0.286 x 24 = 6.864 dm^3	[1]