Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ ( ) Date: _____

Class: 4E___

TOPIC: SPEED / RATE OF REACTION (WORKSHEET 2) – GRAPH & PLANNING

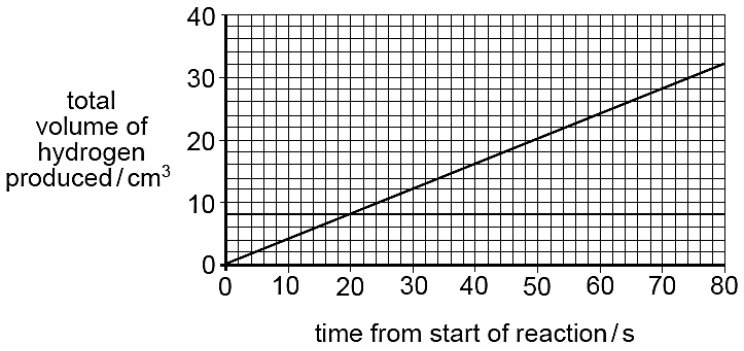
Learning Objectives:

(a) Suggest a suitable method for investigating the effect of a given variable on the speed of a reaction.

(b) Interpret data obtained from experiments concerned with speed of reaction.

Multiple-Choice Questions

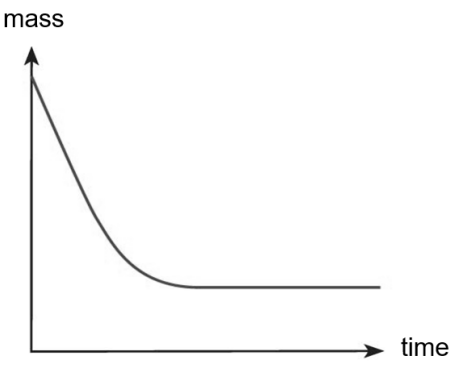
1 Dilute hydrochloric acid was reacted with magnesium ribbon and the volume of hydrogen gas evolved was measured for the first 80 seconds.



What was the average rate of production of hydrogen?

A 0.4 cm^3/s **B** 2.5 cm^3/s
C 4 cm^3/s **D** 40 cm^3/s (**A**)

2 Two reactants were mixed together in a beaker and the mass of the beaker and its contents was recorded at regular time intervals. A graph of mass plotted against time is shown below.

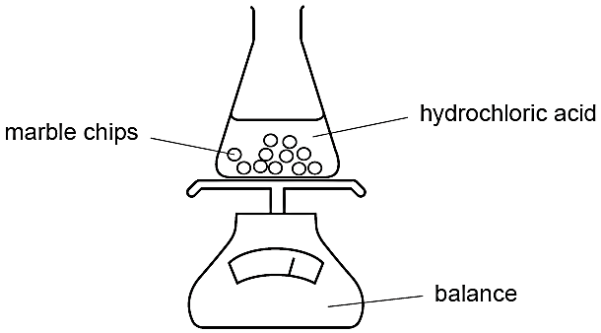


Which of the following are possible reactants?

A sodium hydroxide and hydrochloric acid
B copper sulfate and zinc
C copper(II) carbonate and hydrochloric acid
D sodium hydroxide and copper(II) sulfate

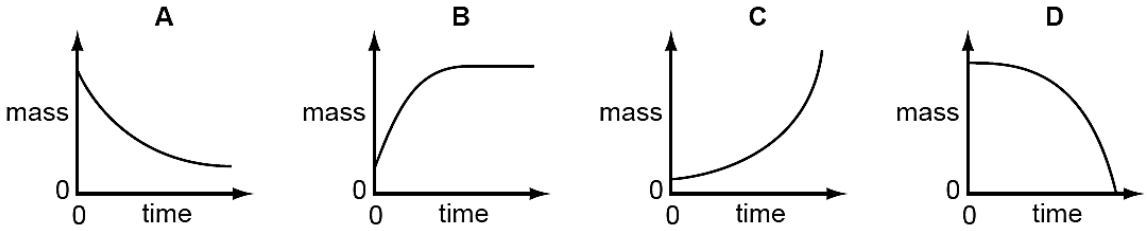
(**C**)

3 A student adds marble chips to hydrochloric acid.



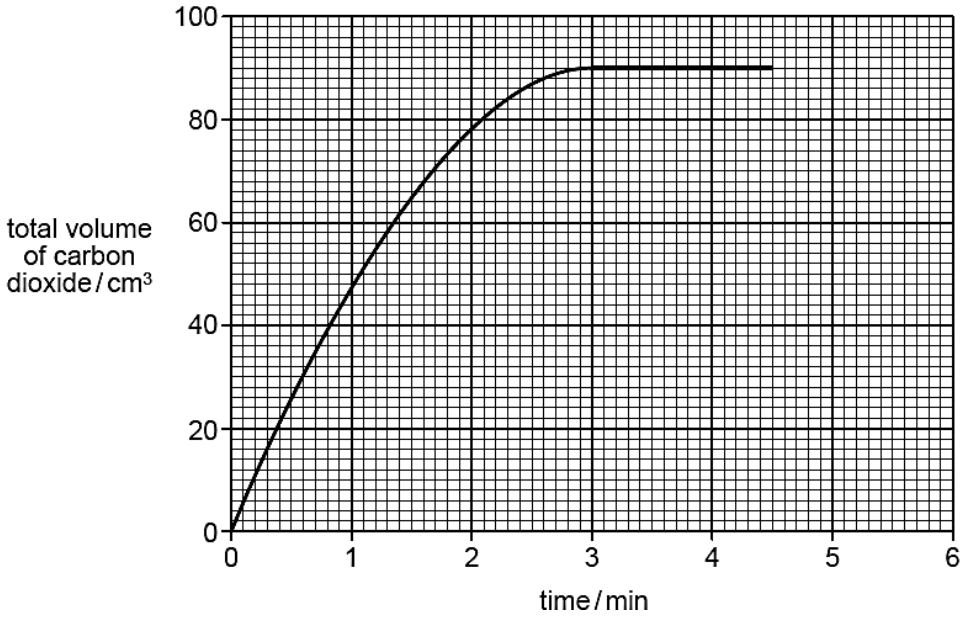
The mass of flask and contents is measured at regular time intervals.

Which graph shows the result?



(**A**)

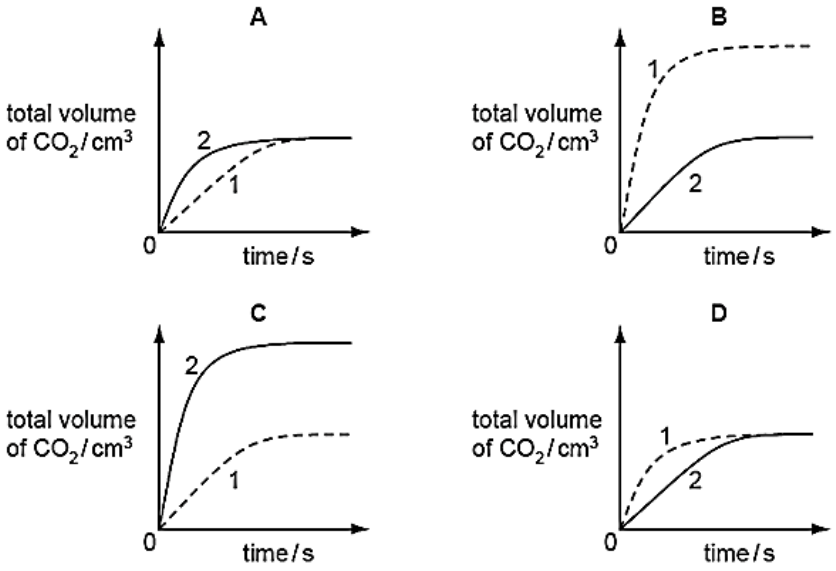
4 The rate of the reaction between a given mass of calcium carbonate and an excess of hydrochloric acid is studied by collecting the carbon dioxide in a graduated syringe. The results are shown in the graph.



How much time is required for half the calcium carbonate to react?

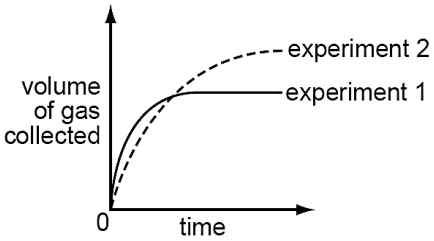
A 0.95 min **B** 1.5 min
C 2.0 min **D** 3.0 min (**A**)

5 In two separate experiments, the reaction of powdered calcium carbonate with an excess of dilute hydrochloric acid is investigated. The powder used in experiment 1 is finer than that used in experiment 2. All other conditions are identical in both experiments. Which graph shows the results?

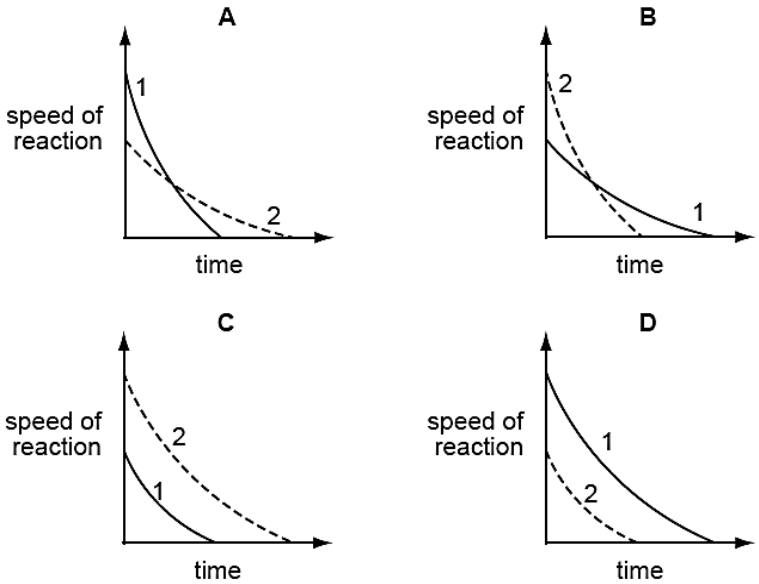


(**D**)

6 In two separate experiments, a substance is decomposed and the gas evolved is collected. The graph shows the total volume of gas collected against time for each experiment.

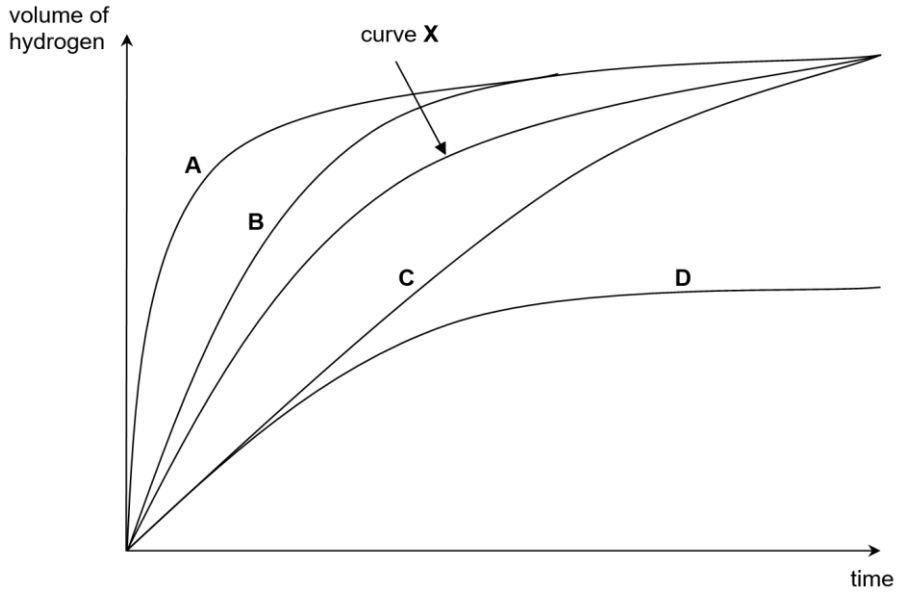


Which graph shows how the speed of reaction varies with time in each experiment?



(**A**)

Use the following information to answer Questions **7** to **10**.



In an experiment, a strip of magnesium ribbon is reacted with excess dilute hydrochloric acid. Curve **X** is obtained when the volume of hydrogen gas given off during the reaction is plotted against time.

Which of the following changes to the experiment would produce the graphs, **A**, **B**, **C** or **D**?

7 Only half the amount of magnesium is reacted with excess acid. (**D**)

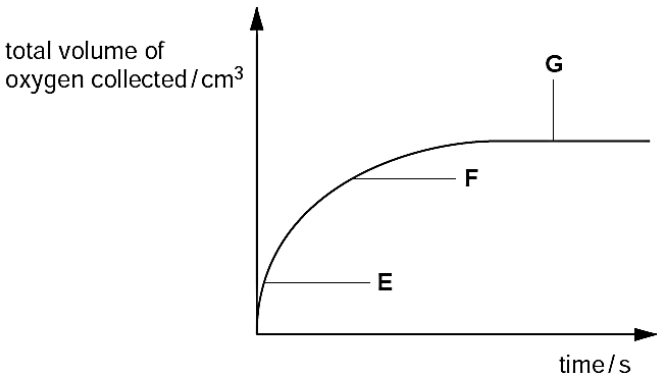
8 The acid is diluted to half of its original concentration but is still in excess. (**C**)

9 The strip of magnesium ribbon is grounded into powder form and then reacted with the acid. (**B**)

10 The strip of magnesium ribbon is grounded into powder form and then reacted with the acid, which has been warmed. (**A**)

Structured Questions

11 Hydrogen peroxide solution decomposes in the presence of a catalyst, producing oxygen gas. The rate of this reaction can be found by plotting total volume of oxygen evolved against time.



(a) Describe the rate of decomposition at points **E**, **F** and **G**.

(i) **E**, **Rate of decomposition is the highest, with the steepest / increasing gradient**

(ii) **F**, **Rate of decomposition is slower, with the decreasing gradient**

(iii) **G**, **Rate of decomposition is the slowest / has completed, with zero gradient**

(b) How does the rate of decomposition depend upon the number of molecules of hydrogen peroxide present in the solution?

Rate of decomposition increases when the number of molecules of hydrogen peroxide increases.

(c) Explain, in terms of reacting particles, why the rate increases when the catalyst is more finely powdered.

A more finely powdered catalyst has a larger surface area. As such, there is a greater area of contact, which particles collide more frequently and the frequency of effective collisions increases, increasing the rate of reaction.

12 Pieces of calcium react with a dilute acid to produce a gas. This reaction completes in five minutes.

(a) List the measurements you would make to determine the speed of this reaction.

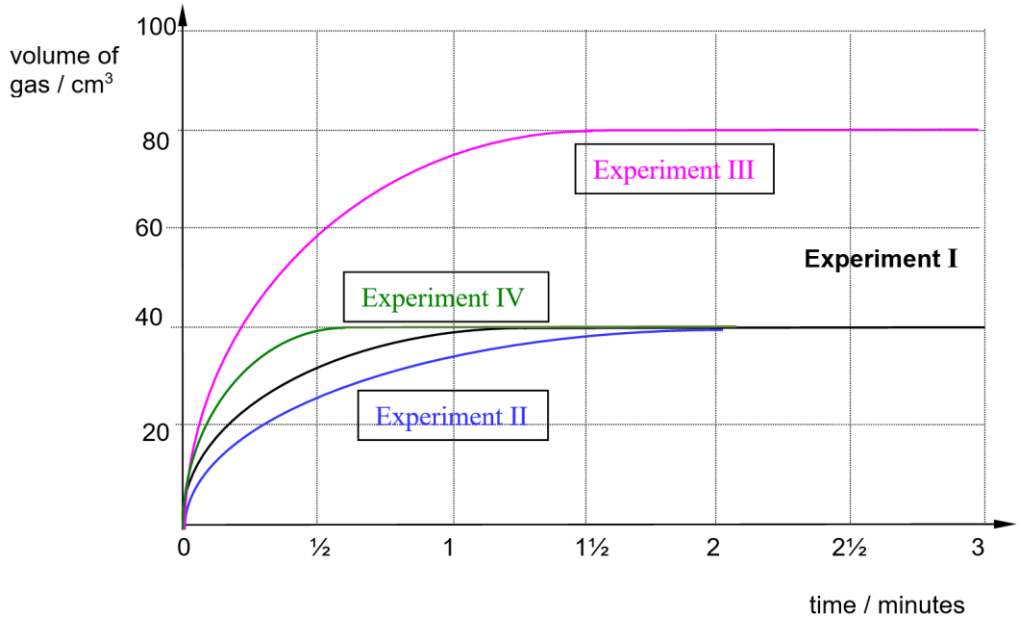
Measure and record the volume of hydrogen gas produced using a gas syringe over regular fixed time intervals of 1 minute using a stopwatch.

(b) On the axes below, draw a graph for the measurements made in **(a)** that would show how the speed of the reaction changes.

(c) Describe how you would use your graph in **(b)** to determine the speed of reaction at two minutes.

At the two minutes point, find the gradient to determine the speed of reaction. The gradient can be calculated through drawing a line of tangent at the two minutes point.

13 In an experiment (Experiment I), a volume of 0.5 mol/dm^3 hydrochloric acid was added to marble chips (calcium carbonate) in a flask. The marble chips were in excess. A graph of volume of gas produced against time is shown in the diagram.



(a) Write the equation, with state symbols, for the reaction.

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

(b) Explain the shape of the graph between 2 to 2½ minutes from the start of reaction.

The gradient of the graph between 2 and 2½ minutes is zero as no more gas is produced. This is because the limiting reagent, hydrochloric acid is being used up.

(c) State and explain the difference in the rate of reaction at ½ minute and at 1 minute from the start of the reaction.

(i) difference in rate,

The rate of reaction at ½ minute is faster than at 1 minute.

(ii) explanation.

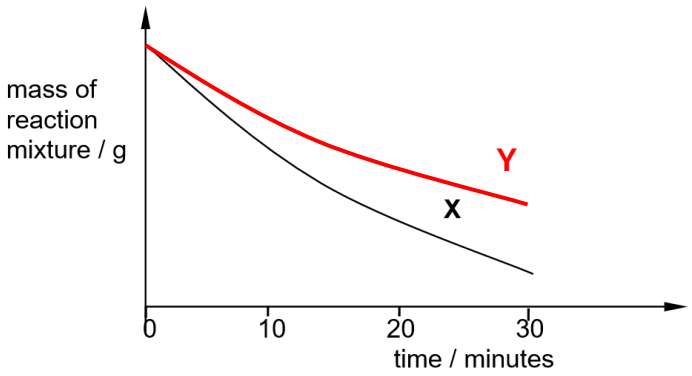
At ½ minute, the concentration of hydrochloric acid is higher than at 1 minute. This is because as the reaction proceeds, the concentration of hydrochloric acid decreases due to the reaction with marble chips.

(d) The experiment was repeated three times, with **one change** in each condition.

experiment	change in conditions
II	lower temperature
III	1.0 mol/dm^3 acid used, but the same volume
IV	smaller pieces of marble chips but the same mass

Label and sketch on the axes the graphs you would expect for Experiments II to IV

14 A student investigates the rate of reaction between solid magnesium carbonate and dilute nitric acid was by measuring the decrease in mass of the reaction mixture over a period of time. Graph **X** below shows the results obtained when a 5.0 g lump of magnesium carbonate was added to an excess of 2.0 mol/dm^3 nitric acid.



(a) Carbon dioxide is one product of the reaction between magnesium carbonate and nitric acid. Name the other **two** products.

magnesium nitrate and water

(b) Do you think the reaction between magnesium carbonate and nitric acid had finished in 30 minutes? Explain your answer.

The reaction has not finished in 30 minutes. The mass of the reaction mixture continues to drop and has not reached a constant mass.

(c) The experiment was repeated using another 5.0 g lump of magnesium carbonate and 1.0 mol/dm^3 nitric acid.

(i) Draw on the diagram above, the graph you would expect. Label this graph **Y**.

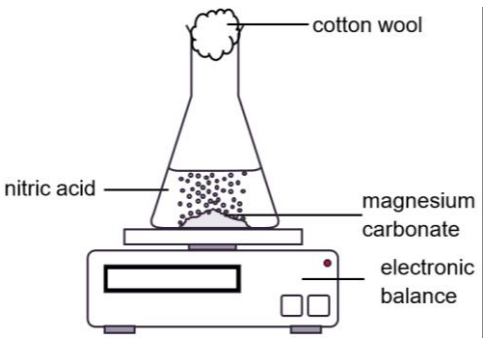
(ii) State **two** conditions which would have to be kept constant in the **two** experiments (**X** and **Y**) to determine the effect of concentration on the rate.

mass of calcium carbonate used / volume of nitric acid used / particle size (surface area) of calcium carbonate / temperature of the surrounding mixture.

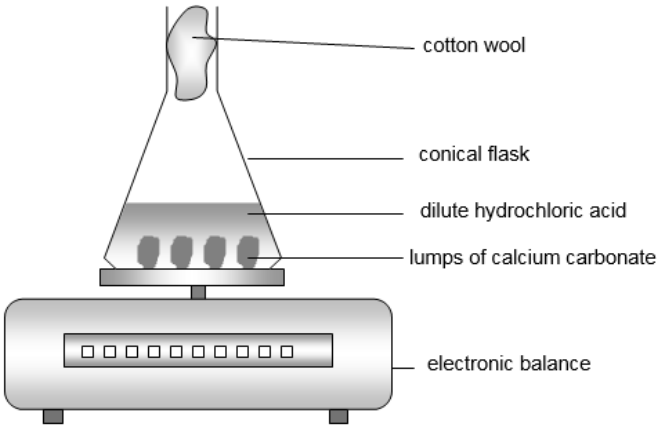
(d) Another student suggested investigating the rate of the same reaction, but using **powdered** magnesium carbonate. Suggest why this method may **not** be suitable.

The time taken for the reaction could be too fast for the student to measure the rate of reaction.

(e) Draw a labelled diagram to show the above method of investigating the rate of reaction between magnesium carbonate and dilute nitric acid.



15 Small lumps of calcium carbonate were added to dilute hydrochloric acid in the apparatus shown in the diagram. The balance reading was noted as soon as the lumps were added and again after five minutes. The experiment was repeated using the same size and number of lumps of calcium carbonate and the same temperature, but changing the concentration of the hydrochloric acid.



The results of both experiments are given in the table.

experiment	initial balance reading / g	balance reading after 5 minutes / g
I	122.8	117.4
II	107.0	98.7

(a) Explain why the electronic balance readings decrease over the five minutes.

The balance readings decreases due to the carbon dioxide gas escaping to the surroundings.

(b) State the purpose of the cotton wool plug.

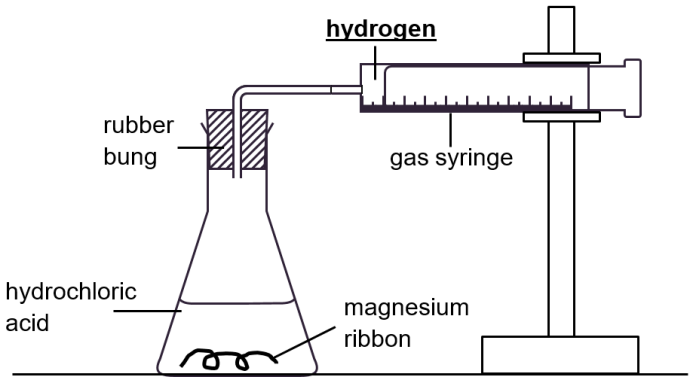
A cotton wool is placed at the conical flask to prevent the acid spray from leaving the flask and dust from entering the conical flask.

(c) With reference to the table, explain which experiment had a higher concentration of acid.

Experiment II. For the same period of time, there is a greater mass lost in Experiment II (8.3 g) than in Experiment I (5.4 g).

16 Consider the reaction between magnesium and dilute hydrochloric acid (HC*l*). The speed of reaction can be determined through the collection of the gas produced.

(a) Draw a labelled diagram of a suitable experimental set-up.



(b) Describe how the **changes** to the speed of reaction can be observed.

Measure the volume of hydrogen gas produced over regular fixed intervals like 10 s. Plot a graph of volume of hydrogen against time and find the gradient. The steeper gradient would indicate a faster rate of reaction while a gentler gradient would indicate a slower rate of reaction.

(c) (i) Explain, in terms of effective collisions, how an increase in concentration of hydrochloric acid increases the speed of reaction.

As the concentration of the acid increases, the number of reacting particles per unit volume of solution increases. As such, particles collide more frequently and the frequency of effective collisions increases, increasing the rate of reaction.

(ii) Explain how you could extend this experiment to show that temperature also affects the speed of this reaction.

- **Repeat the experiment keeping the following conditions constant: length / mass of magnesium, particle size of magnesium, concentration and volume of hydrochloric acid**
- **Place one setup into a water bath of 50 °C, while placing another setup at room temperature. Record the volume of hydrogen gas collected over regular intervals.**
- **Plot on the same graph paper for the new plot of volume against time for the increased temperature. The graph plotted at the higher temperature will have a steeper gradient, indicating that the speed of reaction increases with a higher temperature.**

17 In an experiment, 0.10 g of magnesium ribbon was reacted with 50 cm^3 of 1.0 mol/dm^3 sulfuric acid and the total volume of hydrogen produced was measured every twenty seconds. The results are given in the table after 100 seconds.

time from start of experiment / s	total volume of hydrogen produced / cm^3
0	0
20	52
40	78
60	96
80	100
100	100

(a) The equation for the reaction of magnesium and dilute sulfuric acid is given below.

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

(i) Calculate the number of moles of **magnesium** and of **sulfuric acid** that were used in this experiment.

no of mol of Mg = $\frac{0.1}{24}$ = 0.0041667 mol

no of mol of sulfuric acid = $\frac{50}{1000} \times 1$ = 0.0500 mol

(ii) Hence explain why the reaction stopped.

This is because the limiting reagent, magnesium is completely used up. Hence, there are no more hydrogen gas produced.

(b) The experiment was repeated using the same mass of magnesium but 50 cm^3 of 2.0 mol/dm^3 sulfuric acid. State with a reason how

(i) the initial rate of formation of hydrogen changes,

The initial rate will be faster as a higher concentration of sulfuric acid was used.

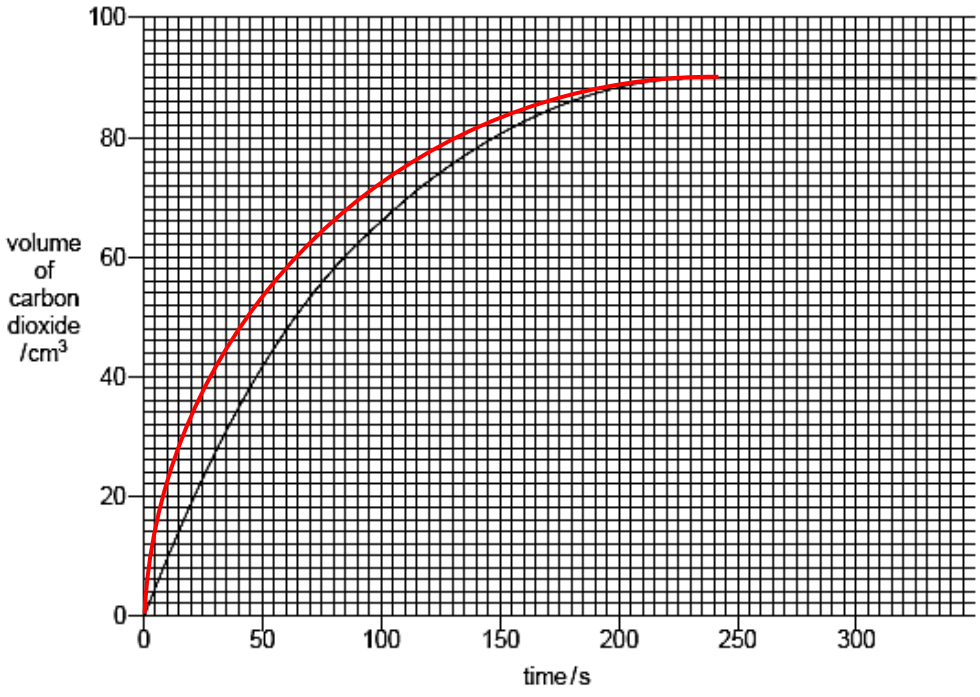
(ii) the total volume of hydrogen collected when the reaction had stopped, would be when compared with the original experiment.

Since magnesium is the limiting reactant, the number of moles of hydrogen obtained will be the same, leading to the same volume of hydrogen collected.

18 A student investigated the reaction of barium carbonate with hydrochloric acid.

$$BaCO_3\,(s) + 2HCl\,(aq) \rightarrow BaCl_2\,(aq) + CO_2\,(g) + H_2O\,(l)$$

The student used large pieces of barium carbonate and carried out the reaction at 20°C. The concentration of hydrochloric acid was 1.0 mol/dm^3. The results of the experiment were plotted as a graph which is shown below.



(a) After how many seconds did the reaction stop?

220 / 225 / 230 s

(b) Calculate the number of moles of carbon dioxide released during the reaction.

$$\text{No of mol} = \frac{0.09}{24}$$

$$= \underline{0.00375 \text{ mol}}$$

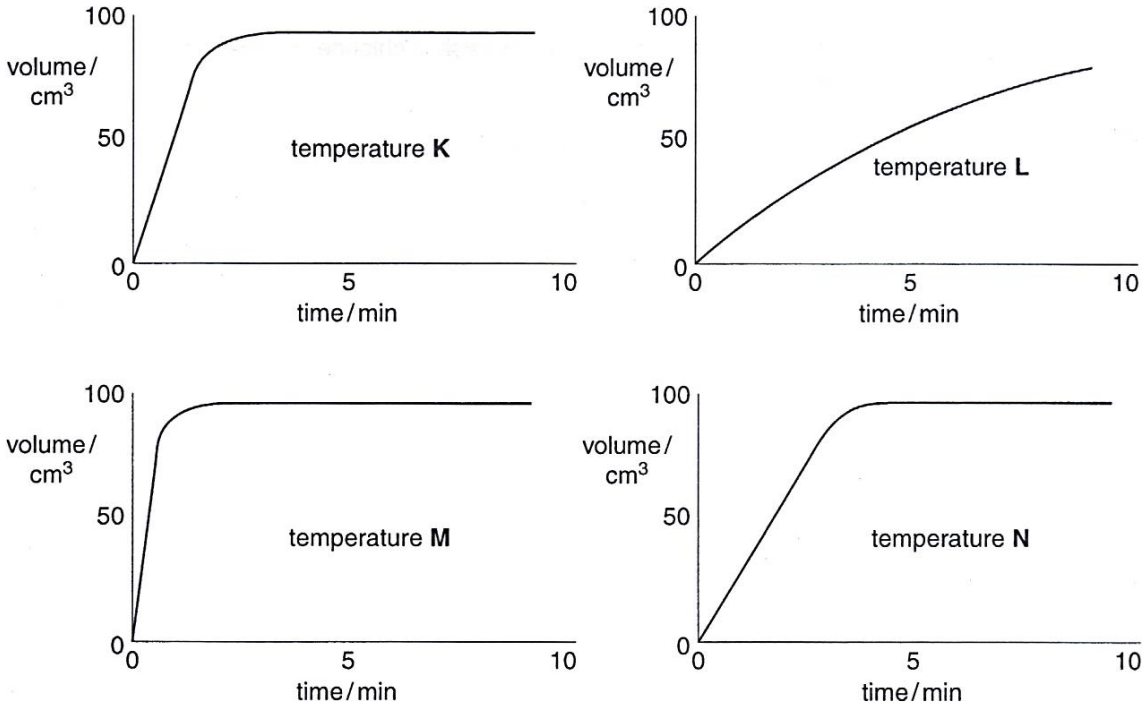
(c) The student repeated the experiment using the same mass of barium carbonate and the same concentration of acid at 20 °C. This time the student used small pieces of barium carbonate. On the **same** grid, sketch the graph for the reaction of small pieces of barium carbonate with hydrochloric acid.

(d) When the student repeated the experiment using hydrochloric acid of higher temperature of 30 °C, the speed of reaction increased. Use the kinetic particle theory to explain why the speed of this reaction increased.

As the temperature increases, the reacting particles gain more kinetic energy and the particles moves faster, colliding more frequently. As such, there is an increase in the number of reacting particles colliding with energy greater or equal to than activation energy and the frequency of effective collisions increases, increasing the rate of reaction.

19 Identical metal carbonate tablets are reacted with solutions of the same volume and concentration of acid. The carbonate and acid are reacted at four different temperatures, **K**, **L**, **M** and **N**. The metal carbonate is in excess.

At each temperature the volume of gas produced is measured at regular time intervals. The results are shown in the figure below.



(a) Which of the temperatures, **K**, **L**, **M** or **N**,

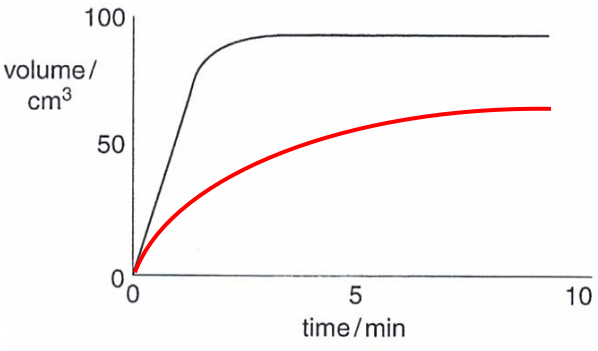
(i) was the lowest, **L**

(ii) produced the fastest reaction, **M**

(iii) resulted in a reaction that was still proceeding after nine minutes. **L**

(b) The experiment at temperature **K**,

(i) is repeated using the same volume of a much less concentrated acid. Add to the figure the graph you would expect. The original graph is already drawn.



(ii) is repeated using the same mass of powdered metal carbonate instead of a tablet. Add to the figure the graph you would expect. The original graph is already drawn.