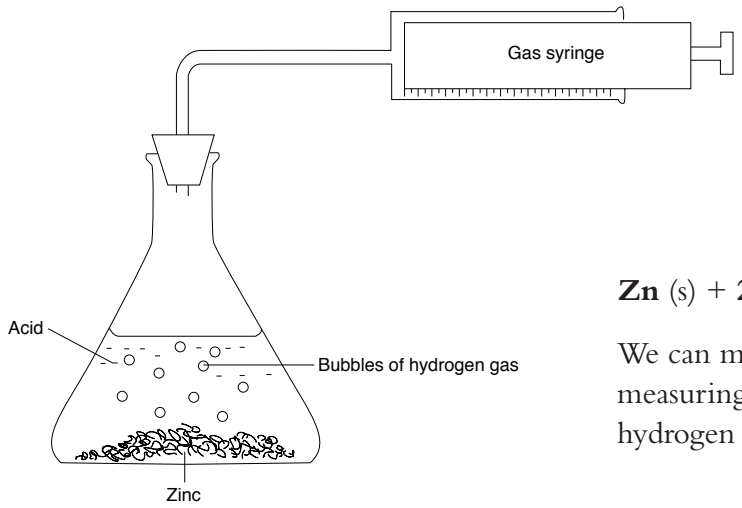
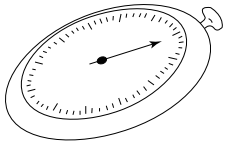
Rates of Reaction

Some reactions occur very quickly, like the burning of petrol in air in an engine. Other reactions can take a very long time, like the rusting of iron. The speed at which a reaction goes is called the **rate of reaction**.

Measuring the rate of a reaction





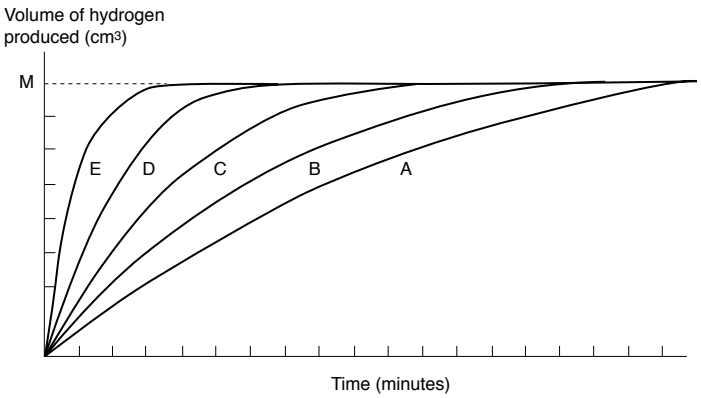
$$\mathbf{Zn}\ (s) + \mathbf{2HCl}\ (aq) \longrightarrow \mathbf{H_2}\ (g) + \mathbf{ZnCl_2}\ (aq)$$

We can measure the rate of this reaction by measuring at regular intervals the volume of hydrogen collected.

Factors affecting the rate of a reaction

Plotting this data in a graph, as shown below, we find that after all the acid is used up, no more gas is evolved and the volume reading of the syringe stays constant (at volume M).

Repeating the experiment starting with the same amount of acid and zinc, but warming the acid solution, curve **B** will be produced. This shows a faster initial and overall rate of reaction because **B** reaches level M sooner than curve **A** did.



Graph showing the rate of evolution of hydrogen when an acid is added to metallic zinc

Starting with the same amount of acid but using powdered zinc instead of lumpy zinc, results in curve **C**.

Curve **D** shows the reaction rate when powdered zinc is reacted with warm acid. We can make the reaction go quicker still (**E**) by using concentrated **and** warm acid with powdered zinc. Note that each curve shows the same **final** volume (M) of hydrogen produced. Each curve differs from the others only in the **time** that it takes to reach the final volume M.

To summarise, the rate of reaction can be affected by: (1) **temperature**, (2) **particle size**, and (3) **concentration of the reactants**. Still another factor which can change a reaction's rate is a **catalyst**. This is a substance which changes the rate of a reaction but remains, itself, unchanged. Most catalysts are used to speed up reactions, although some others are used to slow down reactions; some glues, for example, are stronger when they set slowly, so 'slowing down' catalysts are used in this case.

Tick the box next to the correct answer.

1 The rate of reaction between hydrochloric acid and marble chips can be increased by:

A cooling ☐
B stirring ☐
C using larger chips ☐
D using less hydrochloric acid ☐

2 Using a catalyst will increase the rate of reaction because the:

A reactants have increased KE ☐
B enthalpy change is reduced ☐
C activation energy is lowered ☐
D reactants collide more frequently ☐

3 Increasing the concentration of reactants will increase the rate of a chemical reaction because:

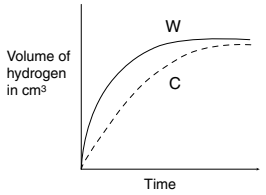
A the reactants are moving faster ☐
B there are more collisions ☐
C the solution is more concentrated ☐
D there is more space for reactants to react ☐

4 Zinc reacts with sulphuric acid according to the equation:

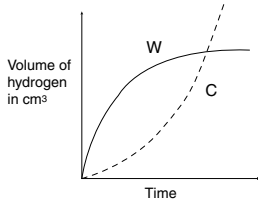
$Zn\ (s) + H_2SO_4\ (aq) \longrightarrow ZnSO_4\ (aq) + H_2\ (g)$

If we add a catalyst, it speeds up the reaction. Which of the following graphs correctly shows the results of the reactions, one without a catalyst **W** and one with a catalyst **C**?

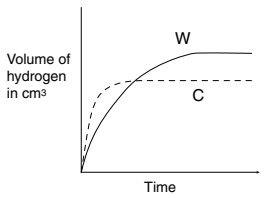
A ☐



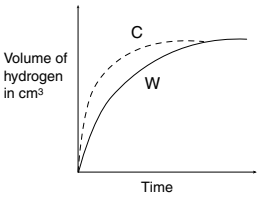
B ☐



C ☐



D ☐



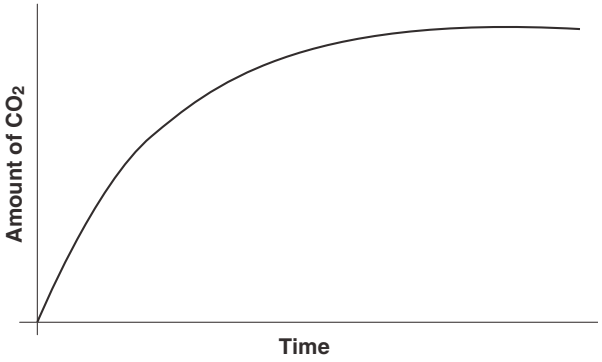
5 Decreasing the temperature of a chemical reaction will decrease its rate of reaction. The main reason for this is:

A the reactants are moving more slowly ☐
B there are fewer collisions with sufficient KE ☐
C there is less space between reactants ☐
D the activation energy has increased ☐

6 The graph shows the rate of reaction when CO_2 is produced at 60°C. Sketch onto this graph two curves:

a One for this same reaction carried out at 30°C, label it **L**.

b Sketch another for the reaction carried out at 60°C, with a catalyst; label it C.



7 Magnesium was reacted with dilute hydrochloric acid:

$Mg\ (s) + 2\ HCl\ (aq) \longrightarrow H_2\ (g) + MgCl_2\ (aq)$

The total volume of hydrogen produced was measured at intervals:

Volume of H_2 produced (cm^3)	0	7	14	19	23	26	31	38	40	40	40
Time (min)	0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0

How much hydrogen was produced during:

a the first minute? _____

b the third minute? _____

c the sixth minute? _____

d When did the reaction finish? _____

e What was the total volume of hydrogen produced? _____

f What was the average rate of the reaction? _____

Tick the box next to the correct answer.

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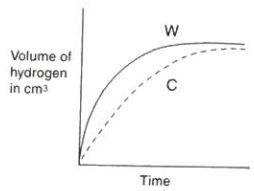
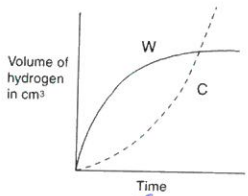
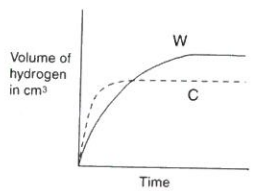


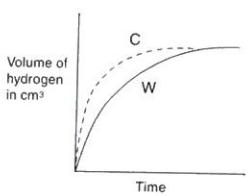
B ☐



C ☐



D ☑



same products but C is faster

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C there is less space between reactants ☐
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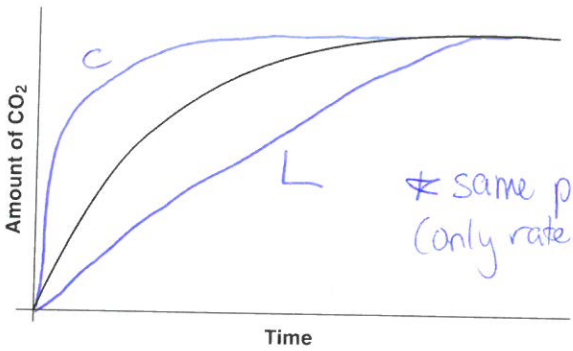

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How much hydrogen was produced during:

a the first minute? (ie 0-1min) 14 cm^3
b the third minute? (ie 2-3mins) 31-23 = 8 cm^3
c the sixth minute? 40-40 = 0 cm^3
d When did the reaction finish? 5mins
e What was the total volume of hydrogen produced? 40 cm^3
f What was the average rate of the reaction? 40/5 = 8 cm^3/min