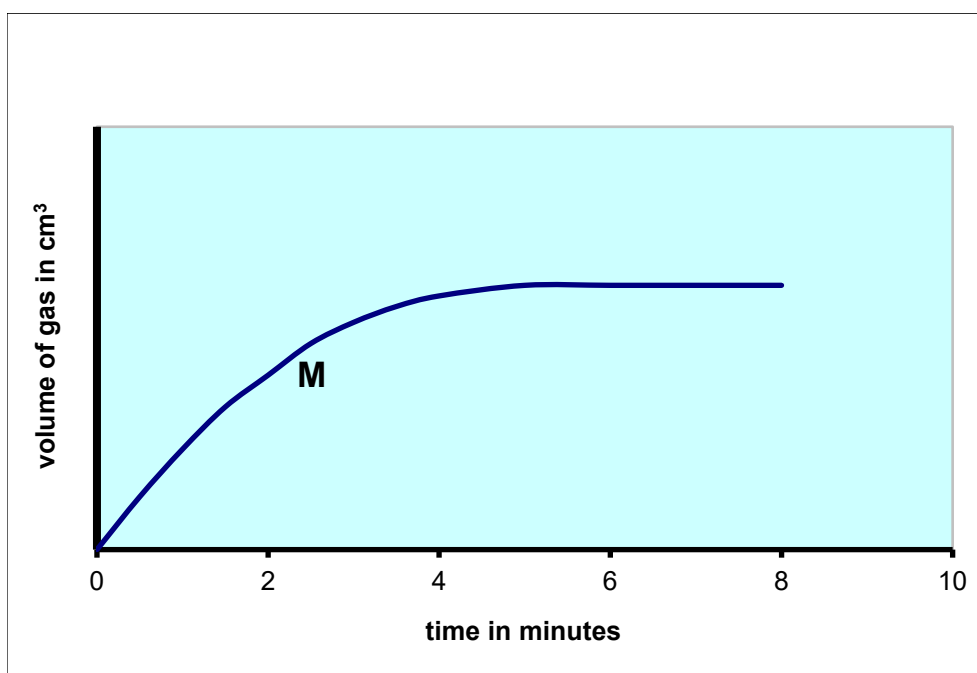# Rates of Reaction

1 Sue studied the reaction between calcium carbonate and hydrochloric acid. Sue carried out three experiments to study the effect of surface area of the calcium carbonate. She used calcium carbonate in the form of small lumps or medium lumps or large lumps. In each experiment she used the same mass of calcium carbonate, volume of hydrochloric acid and concentration of hydrochloric acid. She measured the volume of gas collected in a gas syringe at intervals.

   (a)   In each experiment all the calcium carbonate had reacted within five minutes. Sue's graph for medium lumps is shown on the grid. Sketch graph lines for small lumps and large lumps. Label your lines **S** for small lumps and **L** for large lumps.   [3]

   (1) L curve has lower initial gradient
   (1) S curve higher initial gradient
   (1) Both curves end with same volume of gas as M.

   (b)   Explain, using your knowledge of particles, why the rate of reaction is different when small marble chips are used.   [3]

   (1) Small chips have higher surface area
   (1) So more particles available to react
   (1) So more frequent collisions (must be this exact phrase to score this mark, number of collisions/successful collisions are not acceptable)

   (c)   Sue does the experiment with the medium-sized chips again. This time she adds an equal volume of water to the hydrochloric acid before adding the marble chips. How would the rate of reaction be different from the original experiment? Use your knowledge of particles to explain your answer. [3]

   (1) slower rate
   (1) as concentration has decreased
   (1) so frequency of collisions decreases.

2 This question is about catalysts.

(a) Explain what is meant by the term **catalyst**. [2]

(1) (provides an alternative route with a) lower activation energy
(1) is not used up in the reaction

(b) Sam does an experiment at 20 ºC. She uses 25 cm^3 of hydrogen peroxide solution and 1 g of catalyst **X**. She measures the volume of gas given off each minute for five minutes. The table shows her results.

time in minutes	0	1	2	3	4	5
volume of gas in cm^3	0	25	40	53	50	50

i) Smooth line of best fit which does NOT go through the point at 3 min, this point is an anomaly [1]

(ii) How much catalyst was left at the end of the reaction? …………1g………… [1]

(iii) Sam does the experiment again but this time at 30 ºC. Draw on the same grid, the graph she would expect to get. Label this curve A. [2]

(1) greater initial gradient
(1) levels of at same volume of gas (50cm^3)

(iv) Why, in terms of particles, does increasing the temperature affect the rate of reaction? 3]

(1) Particles have more energy
(1) More particles have enough energy to react
(1) A higher % of collisions are successful
    Ignore references to increasing frequency/number of collisions

(v)Sam does a third experiment using 12.5 cm^3 of the same hydrogen peroxide solution. Draw on the same grid, the graph she would expect to get. Label this curve B. [2]

(1) Same initial gradient
(1) Levels off at exactly 25cm^3 of gas