16 Rates of Reactions

The questions on the *Rates of Reactions* chapter often appear as full questions on the Leaving Certificate Higher Level Chemistry examination paper. Recall that there are two mandatory experiments in this chapter and therefore a full question can appear in either Section A or in Section B of the examination paper. In some cases, this chapter is examined in the form of short questions given as part of full questions.

2002 Question 3

To investigate the effect of concentration on a reaction rate, a student measured 100 cm^3 of a 0.10 M solution of sodium thiosulfate into a conical flask, added 10 cm^3 of 1.0 M hydrochloric acid, and then placed the flask on top of a cross on a sheet of white paper as shown in the diagram. The student noted the time (in minutes) taken for the cross to become obscured by the pale yellow precipitate formed in the solution. The reciprocal of the time (1/time) was used as a measure of the initial rate of the reaction.

Samples of the 0.10 M solution of sodium thiosulfate were diluted to make 100 cm^3 portions of 0.08, 0.06, 0.04 and 0.02 M sodium thiosulfate. Each of these was, in turn, reacted with 10 cm^3 of 1.0 M hydrochloric acid as described above. The results obtained are shown in the following table.

Concentration of sodium thiosulfate solution (M)	Time taken for the cross to become obscured (minutes)	1/time (min^{-1}) i.e. Rate
0.10	1.25	0.80
0.08	1.56	0.64
0.06	2.08	0.48
0.04	3.13	0.32
0.02	6.25	0.16

(a) Identify the pale yellow precipitate that obscured the cross on the sheet of paper. **(5)**

(b) Describe the procedure for preparing the 0.08 M solution of sodium thiosulfate from the 0.10 M solution. **(12)**

(c) Plot a graph to show the relationship between the initial rate of this reaction (1/time) and the concentration of the sodium thoisulfate solution. What conclusion can be drawn from the graph about the relationship between the rate of reaction and the concentration of the sodium thoisulfate? **(18)**

(d) Use the graph to determine how long it would have taken for the cross on the sheet of paper to become obscured if the student had used a 0.05 M sodium thoisulfate solution. **(9)**

(e) Explain why the reciprocal of the time (1/time) may be used as a measure of the initial rate of the reaction. **(6)**

Answer

(a) Sulfur **(5)**

(b) The procedure for preparing the 0.08 M solution of sodium thiosulfate from the 0.1 M solution may be summarised in the following steps:

- Use a graduated cylinder.
- Place 80 cm^3 of the 0.1 M sodium thiosulfate solution in the conical flask.
- Add 20 cm^3
- Of deionised water **(4 × 3)**

(c)

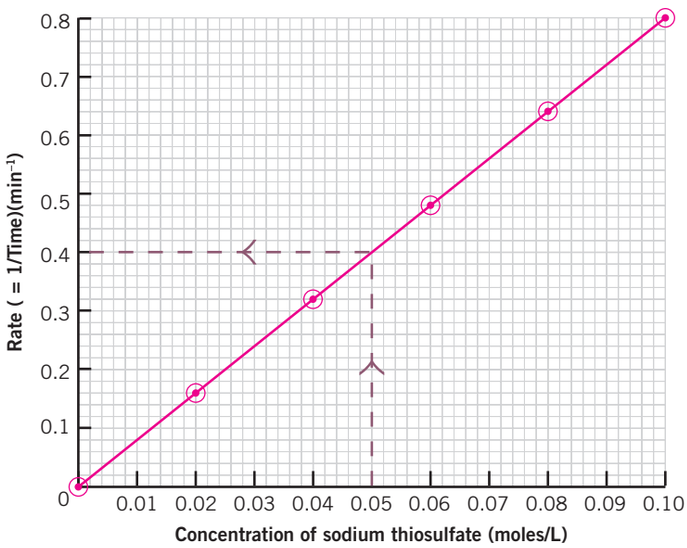

Fig. 16.1

The main points from the above graph are as follows:

Axes correct **(3)**, correctly labelled **(3)**, points correctly plotted **(3)**, straight line through the origin **(3)**.

A straight line through the origin is obtained showing that the rate of reaction is directly proportional to the concentration of the sodium thiosulfate solution. **(6)**

(d) From the graph, the rate corresponding to a 0.05 M sodium thiosulfate solution is 0.4 min^{-1}. **(3)**

$\Rightarrow \frac{1}{t} = 0.4$ **(3)**

$\Rightarrow t = 2.5$ minutes **(3)**

(e) Time and rate are inversely proportional (e.g. when the rate is doubled, the time is halved).

$\text{Rate } \alpha \frac{1}{\text{time}}$

The shorter the length of time taken for the cross to be obscured, the faster the rate of reaction. The longer the time it takes the cross to be obscured, the slower the rate of reaction. **(6)**

2003 Question 7

(a) Define *rate of a chemical reaction*. **(5)**

Calcium carbonate (marble chips) reacts with hydrochloric acid according to the following equation.

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

Using simple experiments involving marble chips, $CaCO_3$, and hydrochloric acid, **HCl**, describe how you could demonstrate the effects of

(i) particle size, *(ii) concentration* on the rate of a chemical reaction. **(18)**

(b) What is a *catalyst*? **(6)**

Catalytic converters are used in cars.

(i) Identify **one** reaction which is catalysed in the catalytic converter in a car.
State **one** of the environmental benefits of this process. **(12)**

(ii) Name **one** element used as a catalyst in a catalytic converter.
What type of catalysis is involved in a catalytic converter? **(9)**

Answer

(a) The rate of reaction is defined as the change in concentration per unit time of any one reactant or product. **(5)**

(i) Effect of particle size on rate:

- Place a conical flask containing about 20 g of **large** marble chips and a graduated cylinder containing about 50 cm^3 of dilute hydrochloric acid on the top of the electronic balance. Add the HCl to the marble chips. **(3)**

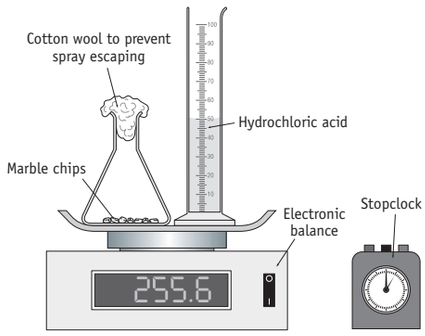

Fig. 16.2

- Note the time it takes for the reaction to finish. **(3)**
- Repeat the experiment, but this time use the same mass of **small** marble chips and add the same volume of HCl of the same concentration. It is observed that the smaller particles react faster. **(3)**

TIP: ***Full marks for the results of this experiment can be obtained from a graph as shown in Fig. 16.3.***

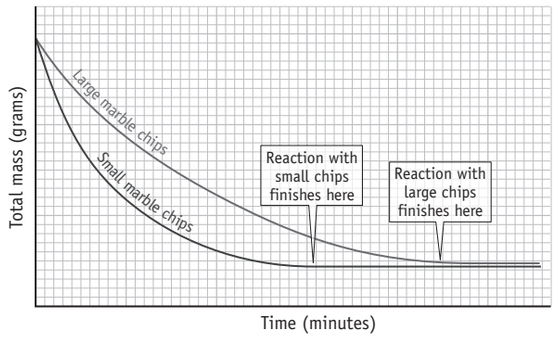

Fig. 16.3

(ii) Effect of particle size on concentration:

- Place a conical flask containing about 20 g of marble chips and a graduated cylinder containing about 50 cm^3 of dilute hydrochloric acid on the top of the electronic balance. Add the HCl to the marble chips. **(3)**
- Note the time it takes for the reaction to finish. **(3)**
- Repeat the experiment, but this time add the same volume of HCl of different concentrations to the same mass of equal-sized marble chips. It is observed that the reaction is faster with the more concentrated hydrochloric acid. **(3)**

(b) A catalyst is a substance that alters the rate of a chemical reaction **(3)**, but is not consumed in the reaction **(3)**.

(i) The main reaction which happens in the catalytic converter is the reaction between the polluting gases themselves (carbon monoxide and nitrogen monoxide) to form carbon dioxide and nitrogen:

$$\underset{(3)}{2CO} + 2NO \rightarrow \underset{(3)}{2CO_2} + N_2$$