7 KINETICS

Rates of reaction and collision theory

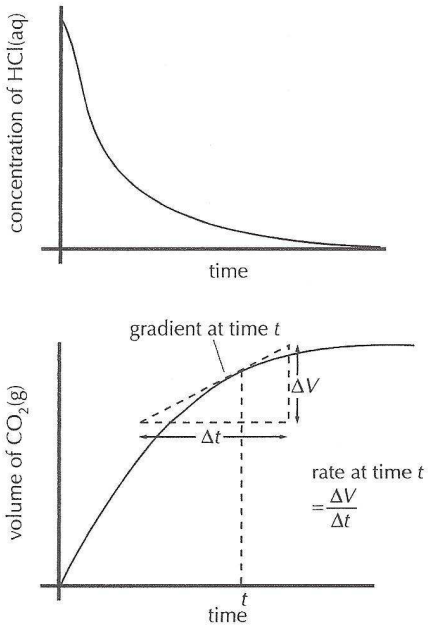
RATE OF REACTION

Chemical kinetics is the study of the factors affecting the rate of a chemical reaction. The rate of a chemical reaction can be defined either as the increase in the concentration of one of the products per unit time or as the decrease in the concentration of one of the reactants per unit time. It is measured in mol dm^{-3} s^{-1}.

The change in concentration can be measured by using any property that differs between the reactants and the products. Common methods include mass or volume changes when a gas is evolved, absorption using a spectrometer when there is a colour change, pH changes when there is a change in acidity, and electrical conductivity when there is a change in the ionic concentrations. A graph of concentration against time is then usually plotted. The rate at any stated point in time is then the gradient of the graph at that time. Rates of reaction usually decrease with time as the reactants are used up.

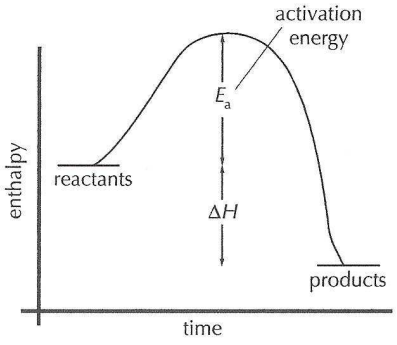
The reaction of hydrochloric acid with calcium carbonate can be used to illustrate the two typical curves obtained depending on whether the concentration of reactant or product is followed.

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



COLLISION THEORY

For a reaction between two particles to occur two conditions must be met. The particles must not only collide so that the reactive parts of the particles come into contact with each other, but they must collide with sufficient energy to bring about the reaction. This minimum amount of energy required is known as the **activation energy**. Any factor that either increases the frequency of the collisions or increases the energy with which they collide will make the reaction go faster.



REACTION MECHANISMS

Many reactions do not go in one step. This is particularly true when there are more than two reactant molecules as the chances of a successful collision between three or more particles is extremely small. When there is more than one step then each step will proceed at its own rate. No matter how fast the other steps are the overall rate of the reaction will depend only upon the rate of the slowest step. This slowest step is known as the **rate determining step**.

e.g. consider the reaction between A and B to form A_2B: $2A + B \rightarrow A_2B$. A possible mechanism might be:

Step 1 $A + A \xrightarrow{\text{slow}} A\text{–}A$ rate determining step

Step 2 $A\text{–}A + B \xrightarrow{\text{fast}} A_2B$

However fast A–A reacts with B the rate of production of A_2B will only depend on how fast A–A is formed.