Factors influencing rate of a reaction

Rate of a reaction depends upon

i) Concentration of reactants or pressure (in case of gas) of reactants

ii) temperature

iii) Catalyst

Dependence of rate on concentration

The expression in which reaction rate is given in terms of molar concentration of reactants with each term raised to some power, which may or may not be same as the stoichiometric coefficient of the reacting species in a balanced chemical equation is known as rate law.

For example

i) $2NO + O_2 \rightarrow 2NO_2$, $r = k[NO]^2[O_2]$

$\frac{dx}{dt} = k[NO]^2[O_2]$

ii) $CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$, $r = \frac{dx}{dt} = k[CHCl_3][Cl_2]^{1/2}$

iii) $CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$, $r = \frac{dx}{dt} = k[CH_3COOC_2H_5]$

This expression is differential rate equation

k (proportionality constant) is called rate constant. It is rate of reaction when concentration of each specie present in rate law expression is unity.

- Rate law for any reaction must be determined experimentally, balanced chemical equation do not give any idea about rate law expression.

- Rate law expression generally involves reactants but it may involve products or catalysts in some cases.

Order of reaction

The sum of powers of concentration of the reactants in rate law expression is called the order of that chemical reaction.

Consider a reaction

$$a\,A + b\,B \rightarrow c\,C + d\,D$$

with $r = k\,[A]^x\,[B]^y$

order $= x + y$.

Units of rate constant (k)

For a general reaction

$$a\,A + b\,B \rightarrow c\,C + d\,D$$

$$\text{rate} = k\,[A]^x\,[B]^y$$

$$\text{order} = x + y = n$$

$$k = \frac{\text{rate}}{[A]^x\,[B]^y} = \frac{\text{concentration}}{\text{time}\ (\text{concentration})^n}$$

$$= (\text{concentration})^{1-n}\ \text{time}^{-1}$$

$$= (\text{mol L}^{-1})^{1-n}\ \text{s}^{-1}$$

Reaction	Units of k
Zero order ($n = 0$)	$\text{mol L}^{-1}\ \text{s}^{-1}$
first order ($n = 1$)	s^{-1}
Second order ($n = 2$)	$\text{mol}^{-1}\ \text{L s}^{-1}$