Chemical Equilibrium
(Unit – 1)

Synopsis

- Rate of reaction – definition, expression and unit .
- Factors affecting rate of reaction.
- Reversible reactions – definition, examples and conditions.
- Irreversible reactions – definition and examples.

General observation

Rusting of iron – very slow reaction

Burning of a wood – very fast reaction

Rate of Reaction

Consider the following reactions :

1.The solution of sodium chloride and silver nitrate when mixed, there is an instantaneous formation of precipitate of silver chloride.

$$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl \downarrow$$

This reaction is very fast.

2. Nitrogen pentoxide decomposes on heating to give nitrogen dioxide and oxygen.

$$4NO_2 + O_2 \longrightarrow 2N_2O_5$$

The rate of this reaction can be measured.

3.A piece of iron when exposed to moist air a brown layer of iron oxide is formed over a period of time.

$$Fe \xrightarrow{\text{moist air}} Fe_2O_3 \cdot xH_2O$$

(rust)

This reaction is very slow

Can we generalize anything ?

- The various chemical reactions take place at different rates or speeds or velocities.

- The rate of a chemical reaction means speed with which a chemical reaction takes place.

What does happen during a chemical reaction ?

As a chemical reaction progresses the reactants are consumed and the products are formed.

How is that happen?

As **time changes** during a chemical reaction……..

Molar concentration of a reactant decreases

AND

Molar concentration of a product increases

How do we generally explain ?

Consider a general reaction,

$$\mathbf{A \rightarrow B}$$

The concentration product ‘B’ is zero initially.

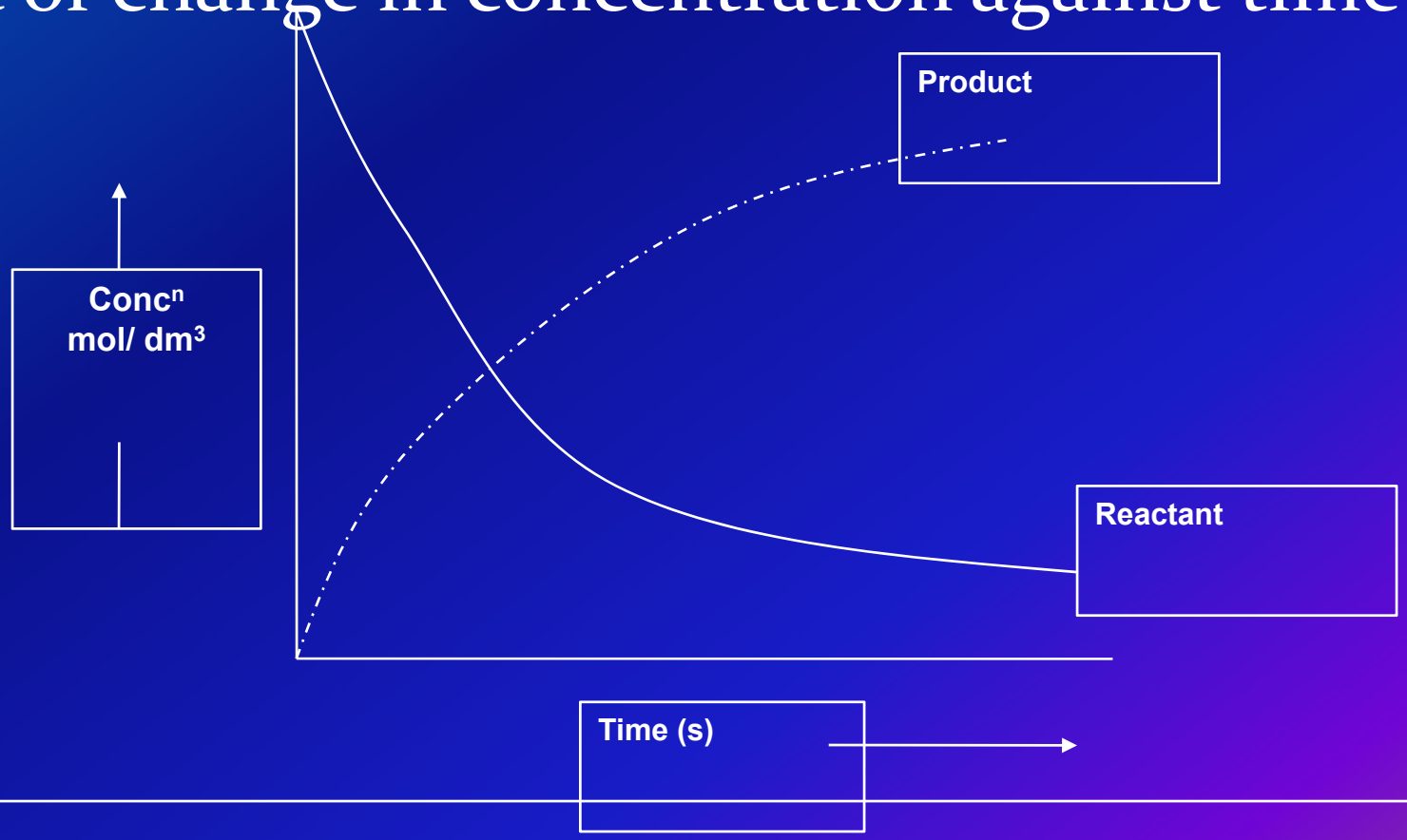
But with the time the concentration of ‘B’ increases and that of ‘A’ decreases.

Illustration

Time	Reactant	Product
	A $\longrightarrow$	B
0 min	1mol	0 mol
5 min	0.8 mol	0.2 mol
10 min	0.6 mol	0.4 mol
15 min	0.5 mol	0.5 mol
-------	--------	-------

Can we plot this ?

Plot of change in concentration against time



Define rate of reaction.

The decrease in the concentration of a reactant or increase in the concentration of a product per unit time.

OR

The ratio of the change in the concentration of any one of the reactant or product with time

How can we express it?

Rate of reaction = rate of disappearance of a reactant.

= rate of appearance of a product.

Expression with respect to reactant

Rate of reaction $= \frac{\text{decrease in molar conc}^n \text{ of reactant}}{\text{Time}}$

$= -\frac{dc}{dt}$ (-ve sign indicates a decrease in the concentration)

OR

Rate $= \frac{-d[A]}{dt}$

Where '[ ]' represents the concentration in mole / dm3

Expression with respect to product

$$\text{Rate of reaction} = \frac{\text{increase in molar conc}^n \text{ of product}}{\text{Time}}$$

$$= + \frac{dc}{dt}$$ (+ve sign indicates a increase in the concentration)

OR

$$\text{Rate} = +\frac{d[B]}{dt}$$

Rate Expression and Unit

$$\text{Rate} = \pm \frac{dc}{dt}$$

Unit = mol $dm^{-3}s^{-1}$

Remember…..

Rate of reaction is also called **velocity of reaction**

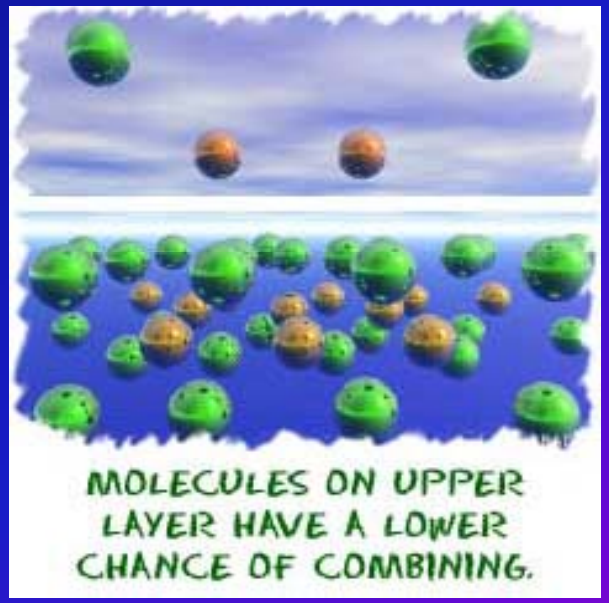
What are the factors affecting rate of reaction?

1. Concentration of reactants
2. Temperature
3. Catalyst
4. Nature of reactants

How does concentration affect the rate of reaction?

The rate of a reaction increases with increase in concentration of reactants.

The collisions between the reacting molecules increase with increase in concentration.



How does temperature affect the rate of reaction?

The rate of a reaction increases with increase in temperature. With the increase of temperature, large number of reacting molecules will collide each other due to increase in their kinetic energy.

How does a catalyst affect the rate of reaction?

- A catalyst by its mere presence in the reaction increases its rate.
- **A positive catalyst increases the rate of a reaction.**
- Ex. MnO_2 acts as positive catalyst in the thermal decomposition of $KClO_3$.

A negative catalyst decreases the rate.

- **Ex.** Glycerine acts as negative catalyst in the decomposition of H_2O_2

How does nature of reactants affect the rate of reaction?

The reactions involving ionic (inorganic) compounds are fast, while those involving covalent (organic) compounds are slow.

Reversible reactions

The reactions in which the products formed during the reaction combine to give back the reactants are called reversible reactions.

How is a reversible reaction indicated?

It is indicated by writing two half headed arrow marks between the reactants and products.

$$A + B \rightleftharpoons C + D$$

What do arrow marks indicate?

The arrow head pointing to the right represents the forward reaction.

AND

The arrow head pointing to the left represents the backward reaction.

Conditions for a reversible reaction

1. The reaction should be carried out in a closed vessel
2. The products should not be removed from the vessel
3. Temperature and pressure should be kept constant

Examples for reversible reactions

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$$

$$N_{2(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3(g)}$$

Irreversible reactions

The reactions in which products formed do not combine to give back the reactants are called irreversible reactions

How do they proceed?

- The irreversible reactions proceed only in one direction.

- They are indicated by writing an arrow between reactants and products.

$$A + B \longrightarrow C + D$$

Can irreversible reactions be made reversible ?

An irreversible reaction can not be made reversible even if it is carried out in a closed vessel.

Examples for irreversible reactions

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

$$Mg + 2\ HCl \longrightarrow MgCl_2 + H_2\uparrow$$

$$AgNO_3 + KCl \longrightarrow AgCl\downarrow + KNO_3$$

Best of Luck.....