CHEMISTRY

CLASS - 11

Equilibrium

Equilibrium in physical process

Chemical equilibrium is the condition which occurs when the concentration of reactants and products participating in a chemical reaction exhibit no net change over time.

- The state of equilibrium is a state in which the measurable properties of the system will not undergo any observable change under a given set of conditions.
- All these observable properties of a system become constant at the state of equilibrium.
- At equilibrium the rate of forward reaction becomes equal to the rate of backward reaction.
- At equilibrium, there is no net change in the concentration of the molecules of the system.

SOLID - LIQUID EQUILIBRIUM

When a solid – liquid system at melting point is taken in a well – insulated container, then this system constitute a system in which solid is in dynamic equilibrium with liquid.

For Example: If ice and water at 273K (melting point of ice) taken in a perfectly insulated thermos flask. It may be noted that temperature as well as masses of ice and water remain constant. This represents a dynamic equilibrium between ice and water.

$$\text{Ice} \rightleftharpoons \text{Water}$$

Since there is no change in mass of ice and water, the number of molecules going from ice into water is equal to number of molecules going from water into ice. Thus, at equilibrium,

$$\text{Rate of melting} = \text{Rate of freezing}$$

LIQUID – GAS EQUILIBRIUM

Evaporation of water in a closed evacuated vessel at room temperature continues for some time leading to the gradual decrease in level of water. After some time the level of water becomes constant indicating that a state of equilibrium has attained between water and water vapours.

$$H_2O\,(l) \rightleftharpoons H_2O\,(g)$$

$$\text{Rate of evaporation} = \text{Rate of condensation.}$$

SOLID – GAS EQUILIBRIUM

Volatile solids sublime and form vapours. When kept in closed container at constant temperature equilibrium is established.

$$I_2\,(s) \rightleftharpoons I_2(g)$$

Characteristics of Physical Equilibria

- In the case of Liquid ⇌ vapour equilibrium, the vapour pressure is a constant at a given temperature.
- For solid ⇌Liquid equilibrium , there is only one temperature(melting point) at 1 atm at which the two phases can coexist without any exchange of heat with the surroundings, the mass of the two phases remain constant.
- For dissolution of solids in liquids, the solubility is constant at a given temperature.
- For dissolution of gases in liquids the concentration of a gas in liquid is proportional to the pressure(concentration) of the gas over the liquid.

Equilibrium in Chemical process

A large number of chemical reactions do not go to completion and attain a state of equilibrium after some time. The state of equilibrium involving a chemical system is referred to as chemical equilibrium.

Reversible reaction : $N_2 + 3\,H_2 \rightleftharpoons 2\,NH_3$

Irreversible reaction : $NaCl(s) + NaNO_3(aq) \downarrow AgCl \rightarrow AgNO_3(aq) + NaCl(aq)$

A reversible reaction can be made irreversible if one of the product (s) which is gaseous is allowed to escape out. This is why reversible reactions are done in a closed vessel.

Characteristics of Chemical Equilibrium

The important characteristics of chemical equilibrium are :

(i) At equilibrium the concentration of each component of reactants and products becomes constant.

(ii) The rate of forward reaction will be equal to rate of backward reaction. So, a chemical equilibrium is said to be dynamic in nature.

(iii) A chemical equilibrium is established provided none of the products is allowed to escape, i.e., only in a closed system a chemical equilibrium can be attained and not in an open system.

(iv) Chemical equilibrium can be attained either from the direction of reactants or from the direction of products depending upon the conditions like temperature and pressure.

(v) A catalyst does not alter the state of equilibrium. It is due to fact that a catalyst influences both the forward and backward reaction to the same extent. It only helps to attain the equilibrium rapidly.