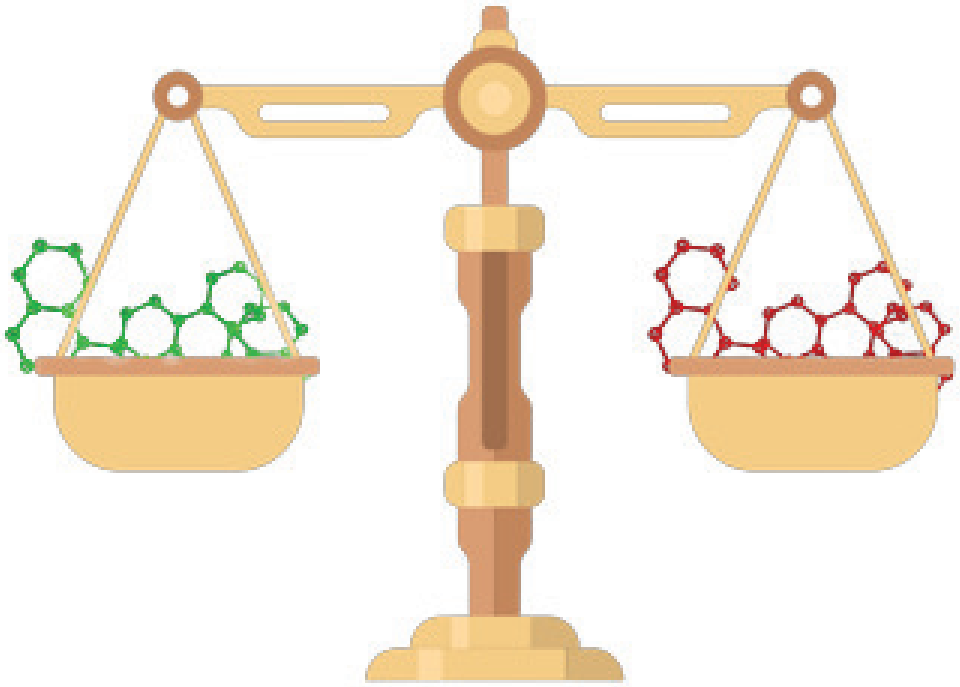
EQUILIBRIUM



EQUILIBRIUM

Introduction

Equilibrium is the most important characteristic property of reversible reactions. These reactions for which the forward reaction occurs to a much greater extent are considered to be unidirectional in nature and whenever the rate of forward reaction is equal to rate of backward reaction, equilibrium is attained, not to forget that equilibrium exists only in closed system.

It is the state of system at which temperature, pressure, volume and composition have fixed value and does not vary with time. Chemical Reactions can be divided into two categories:

Irreversible Reactions: The reactions which proceed to completion and the products fail to recombine to give back reactants. For example:

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

Reversible Reactions: The reactions which never go to completion and products recombine to give back reactants. For example:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Physical Equilibrium

We know that solid, liquid and gas are the three states of substance. Therefore, three types of physical equilibrium are possible. These are

Solid(s) ⇌ liquid (l)

Liquid(l) ⇌ gas(g)

Solid(s) ⇌ gas(g)

Here the sign double half arrows (⇌) pointing in the opposite directions is both for the reversible change as well as for the equilibrium state.

1. **Solid(s) – liquid(l) equilibrium:** At equilibrium two processes takes place at the same rate i.e.,

   Ice(s) ⇌ water(l)

   $H_2O(s) \rightleftharpoons H_2O(l)$

At equilibrium,

Rate of melting of ice = Rate of freezing of water

The temperature at which the solid and liquid states of a pure substance are in equilibrium at the atmospheric.

pressure is called the normal freezing point or melting point of that substance.

2. Liquid(l) – gas(g) equilibrium:

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

   In such type of equilibrium,

   Rate of vaporisation of water = Rate of condensation of water vapour

3. **Solid(s) – gas(g) equilibrium:** Such type of equilibrium is attained in case of volatile solids.

   Example: If solid iodine is placed in a closed vessel, violet vapours starts appearing in the vessel.

   The intensity of violet vapour increases with time and ultimately it becomes constant.

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

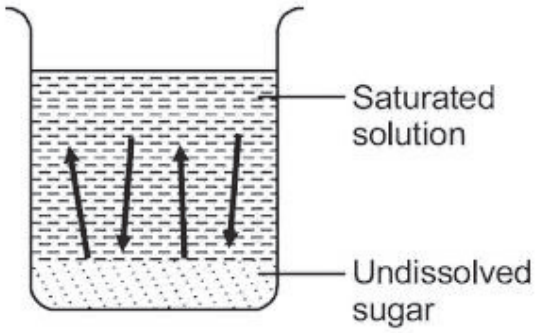
   In this equilibrium,

   Rate of sublimation = Rate of condensation

4. **Solids in liquids:** Suppose sugar is added continuously into a fixed volume of water at room temperature and stirred thoroughly with a glass rod. First the sugar will keep on dissolving but then a stage will come when no more sugar dissolves. Instead it settles down at the bottom. The solution is now said to be saturated and in a state of equilibrium. In this state

   Rate of dissolution = Rate of precipitation

   Sugar(s) ⇌ Sugar (in solution)



The amount of the solid in grams that dissolves in 100 g of the solvent to form a saturated solution at a particular temperature is called the solubility of that solid in the given solvent at that temperature.

Gases in liquids

Such type of equilibrium is present in soda water bottle in which CO_2 gas is dissolved in water under high pressure. There is a state of dynamic equilibrium between the CO_2 present in the solution and the vapours of the gas above the liquid surface at a given temperature.

$CO_2(g) \rightleftharpoons CO_2(aq)$

Henry's law

Periodic table may be defined as the tabular arrangement of elements in such a way that the elements having same properties are kept together.

$m \propto p$

$m = kp$

where k is Henry's constant and its value depends upon the nature of the gas, nature of liquid and temperature.

General Characteristics of Physical Equilibrium:

1. Equilibrium is possible only in a closed system at a given temperature.
2. Both the opposing processes occur at the same rate and there is a dynamic but stable condition.
3. All measurable properties of the system remain constant.
4. When equilibrium is attained for a physical process, it is characterised by constant value of one of its parameters at a given temperature.
5. The magnitude of such quantities at any stage indicates the extent to which the physical process has proceeded before reaching equilibrium.

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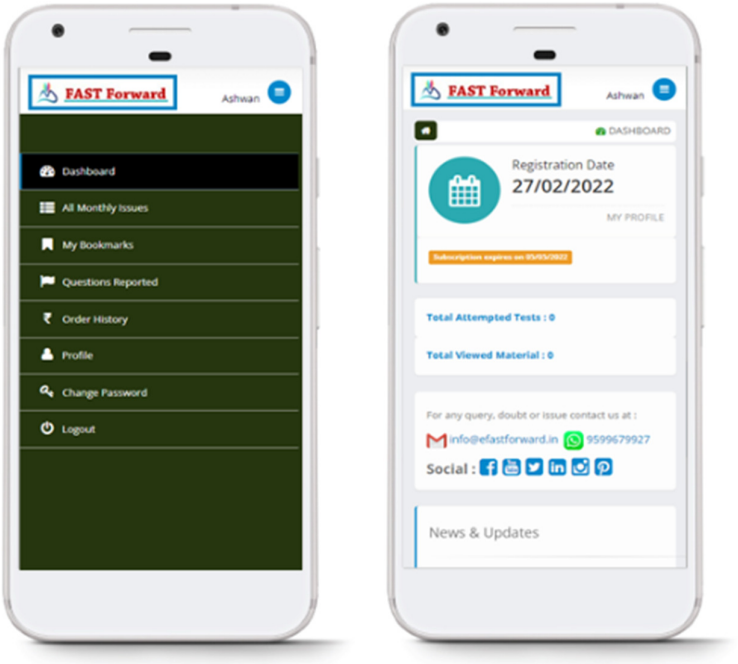

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