

Osmosis and Osmotic pressure of the solution.

The flow of solvent from pure solvent or from solution of lower concentration into solution of higher concentration through a semi-permeable membrane is called **Osmosis**. Osmosis may be divided in following types,

(1) **Exo-Osmosis**: The outward osmotic flow of water from a cell containing an aqueous solution through a semi-permeable membrane is called as Exo-osmosis. For example, egg (after removing hard shell) placed in conc. NaCl solutions, will shrink due to Exo-osmosis.

(2) **Endo-osmosis**: The inward flow of water into the cell containing an aqueous solution through a semi-permeable membrane is called as endo-osmosis. e.g., an egg placed in water swells up due to endo-osmosis.

(3) **Reverse osmosis**: If a pressure higher than osmotic pressure is applied on the solution, the solvent will flow from the solution into the pure solvent through the semi-permeable membrane. Since here the flow of solvent is in the reverse direction to that observed in the usual osmosis, the process is called reverse osmosis.

Differences between osmosis and diffusion

Osmosis	Diffusion
In osmosis movement of molecules takes place through a semi-permeable membrane.	In diffusion there is no role of semi-permeable membrane.
It involves movement of only solvent molecules from one side to the other.	It involves passage of solvent as well as solute molecules from one region to the other.
Osmosis is limited to solutions only.	Diffusion can take place in liquids, gases and solutions.
Osmosis can be stopped or reversed by applying additional pressure on the solution side.	Diffusion can neither be stopped nor reversed

Osmotic pressure (π):Osmotic pressure may be defined in following ways,

The osmotic pressure of a solution at a particular temperature may be defined as the excess hydrostatic pressure that builds up when the solution is separated from the solvent by a semi-permeable membrane. It is denoted by π .

Or

Osmotic pressure may be defined as the excess pressure which must be applied to a solution in order to prevent flow of solvent into the solution through the semi-permeable membrane.

Or

Osmotic pressure is the excess pressure which must be applied to a given solution in order to increase its vapor pressure until it becomes equal to that of the solution.

Or

Osmotic pressure is the negative pressure which must be applied to (i.e. the pressure which must be withdrawn from) the pure solvent in order to decrease its vapor pressure until it becomes equal to that of the solution.

Measurements of osmotic pressure:Following methods are used for the measurement of osmotic pressure: (i) Pfeffer's method, (ii) Morse and Frazer's method, (iii) Berkeley and Hartley's method, (iv) Townsend's negative pressure method, (v) De Vries plasmolytic method.

Determination of molecular mass of non-volatile solute from osmotic pressure (π):

According to Van't Hoff equation,

$$\pi = \frac{n_B}{V} RT ; \boxed{M_B = \frac{W_B RT}{\pi V}}$$
 Where, W_B = known mass of solute in gm

This method is especially suitable for the determination of molecular masses of macromolecules such as proteins and polymers. This is due to the reason that for these substances the values of other colligative properties such as elevation in boiling point or depression in freezing point are too small to be measured. On the other hand, osmotic pressure of such substances are measurable. Conditions for getting accurate value of molecular mass are,

- (i) The solute must be non-volatile.
- (ii) The solution must be dilute.

(iii) The solute should not undergo dissociation or association in the solution.

Van't Hoff's solution equation:

The osmotic pressure is a colligative property. For a given solvent the osmotic pressure depends only upon the molar concentration of solute but does not depend upon its nature. Osmotic pressure is related to the number of moles of the solute by the following relation:

$$\pi V = nRT \text{ or } \pi = \frac{n}{V} RT \Rightarrow \boxed{\pi = CRT}; \text{ here, } C = \text{concentration of solution in moles per litre}$$

R = gas constant; T = temperature; n = number of moles of solute; V = volume of solution

Above eq. is called Van't Hoff's solution equation

Relation of osmotic pressure with different colligative properties: Osmotic pressure is related to relative lowering of vapor pressure, elevation of boiling point and depression of freezing point according to the following relations.

$$(1) \pi = \left(\frac{P_A^\circ - P_A}{P_A^\circ} \right) \times \frac{dRT}{M_B} \quad (2) \pi = \Delta T_b \times \frac{dRT}{1000 \times K_b} \quad (3) \pi = \Delta T_f \times \frac{dRT}{1000 \times K_f}$$

In the above relations, π = Osmotic pressure; d = Density of solution at temperature T; R = Universal gas constant; M_B = Mol. Mass of solute; K_b = Molal elevation constant of solvent; K_f = Molal depression constant of solvent

Isotonic, Hypertonic and Hypotonic solutions

Isotonic or iso-osmotic solutions: Two solutions of different substances having same osmotic pressure at same temperature are known as isotonic solutions.

For isotonic solutions, $\pi_1 = \pi_2$ Primary Condition(i)

Also,

$$C_1 = C_2$$

or

$$\frac{n_1}{V_1} = \frac{n_2}{V_2}$$

or

$$\frac{w_1}{m_1 V_1} = \frac{w_2}{m_2 V_2}$$

} Secondary Conditions

}(ii)

Eq. (ii) holds good only for those solutes which neither possess the tendency to get associate nor dissociate in solution, e.g.,

(a) Urea and glucose are isotonic then, $\pi_1 = \pi_2$ and $C_1 = C_2$

(b) Urea and NaCl are isotonic then, $\pi_1 = \pi_2$ but $C_1 \neq C_2$
(dissociate)

(c) Urea and Benzoic acid are isotonic then, $\pi_1 = \pi_2$ but $C_1 \neq C_2$
(associate)

Hypertonic and Hypotonic Solution: The solution which has more osmotic pressure than the other solution is called as hypertonic solution and the solution which has lesser osmotic pressure than the other is called as hypotonic solution.

The flow of solvent is always from lower osmotic pressure to higher osmotic pressure i.e. from hypotonic to hypertonic solution.