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Topics :- Colligative Properties

Those properties of the solutions which depend only upon the total number of molecules of the solute / per unit volume and not on its chemical nature are called colligative properties.

Four main properties of solutions are as follows :-

(1) Lowering of vapour pressure
(2) Elevation of boiling point
(3) Depression in freezing point
(4) Osmotic pressure

The colligative properties are widely used for the determination of molecular mass of substances.

Mathematical expression :

From the above definition of colligative properties, it follows that if two solutions are made from different components, they may show identical values colligative properties which are dependent only on mole fractions in solution.

Thus, Colligative properties measured $\propto$ (Mole fraction of the solute

Suppose a system of two components A and B (A is solvent and B is solute) is considered. In this system, W_A is the molecular mass of the solvent

whose mass is W_A. Similarly, in this solution, M_B is the molecular mass of the solute whose mass is W_B

Now,

Number of moles of solvent, $n_A = \frac{W_A}{M_A}$

and number of moles of solute $n_B = \frac{W_B}{M_B}$

Hence, mole fraction of solvent $x_A = \frac{n_A}{n_A + n_B}$

and mole fraction of solute $x_B = \frac{n_B}{n_A + n_B}$

But according to definition,

$$\text{Colligative property} \propto \frac{n_B}{n_A + n_B}$$

$$\text{or, Colligative Property} = Y \cdot \frac{n_B}{n_A + n_B}$$

$$= Y \cdot \frac{W_B/M_B}{\frac{W_A}{M_A} + \frac{W_B}{M_B}} \quad \text{---(i)}$$

where Y = Proportionality constant which depends upon the nature of colligative property

Equation (i) is very useful because it can be used for calculating the value of any of the involved factors provided the values of all the rest are known.

Q:- Explain the terms: Osmosis, Osmotic pressure and Isotonic solution. How osmotic pressure determined experimentally?

Ans: OSMOSIS: When a solution is separated from its solvent by a semipermeable membrane, the solvent molecules pass through it into solution to have uniform concentration on both sides of membrane. "The spontaneous flow of solvent into a solution, or from a more dilute to a concentrated solution through a semipermeable membrane is known as Osmosis."

OSMOTIC PRESSURE:

When a solution is separated from the pure solvent by a semipermeable membrane, a diffusion of solvent takes place through the membrane from the pure solvent into the solution. In case if two solutions of different concentration are separated by semipermeable membrane, the solvent molecules move from the dilute solution to the more concentrated solution side. This spontaneous movement of solvent molecules through a semipermeable membrane from a region of dilute solution into a region of concentrated solution is termed as Osmotic pressure.

ISOTONIC SOLUTION:

The solutions having same osmotic pressure are known as isotonic solutions. When such solutions are separated by a semipermeable membrane, no osmosis takes place.

For two solutions, $PV = P'V'$

If the solution are isotonic $P = P'$, then V must be same as V'. Hence the volume of these solutions containing 1 mole of the respective substances must be same.

In other words, "The isotonic solutions have same molar concentrations."

Berkley and Hartley's Method for the measurement of osmotic pressure:

It is based on the fact that counter pressure applied on the solution so as to prevent osmosis is a measure of osmotic pressure.

(i) The apparatus consists of two concentric tubes, the inner one being that of porcelain having electrically deposited semipermeable membrane of copper ferrocyanide in its walls. The two ends of the inner tube are connected to a capillary T on one side and dropping funnel D on the other. The outer tube is made of gun metal and it is fitted with an arrangement for applying definite pressure.

(ii) In the annular space between the two tubes is introduced the solution whose osmotic pressure is to be measured while the inner tube is filled with water by means of dropping funnel up to a definite level T in the capillary tube.

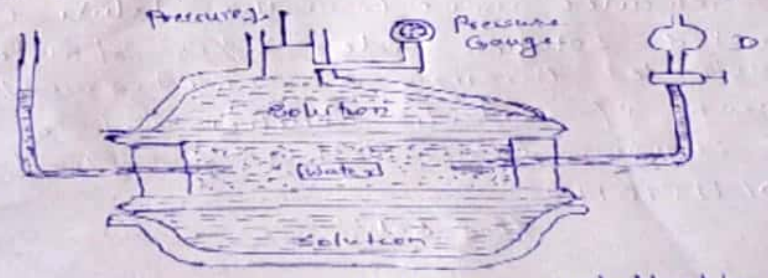

Fig:- Berkley and Hartley's Method

(iii) Due to osmosis the water from the inner tube tends to pass into the solution which is indicated by the downward motion of water meniscus in the capillary tube T. The external pressure is applied on the solution to prevent the flow of water and consequently lowering of meniscus. This pressure so applied is equal to osmotic pressure and is directly measured by means of pressure gauge attached to a piston.

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