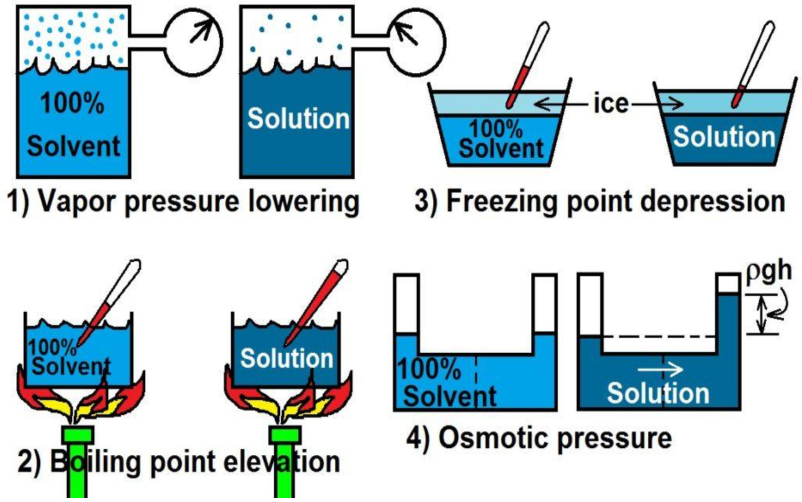
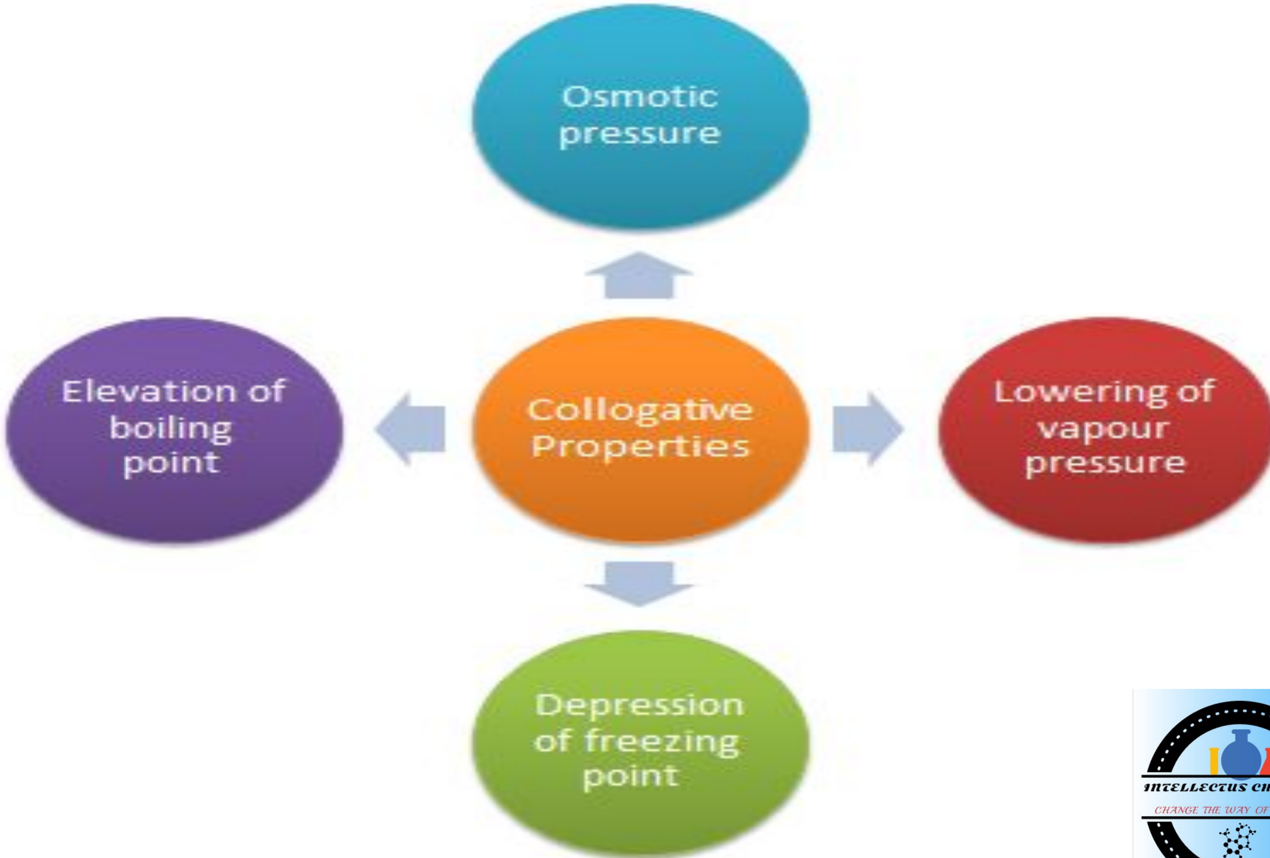
Class - 12 NCERT

SOLUTION



Colligative Properties 2

SOLUTION


Osmotic pressure
Elevation of boiling point
Collogative Properties
Lowering of vapour pressure
Depression of freezing point

SOLUTION

- Osmosis & Osmotic pressure
- Isotonic Solution
- Hypertonic Solution
- Hypotonic Solution
- Reverse Osmosis & Water Purification
- Abnormal Colligative Property
- Van't Hoff Factor

(4) Osmosis & Osmotic Pressure :-

* **Osmosis :-** Osmosis is defined as the ~~spontaneous~~ spontaneous flow of solvent molcule through semipermeable membrane from a dilute solution to a solution or from a dilute solution to a concentrated solution.

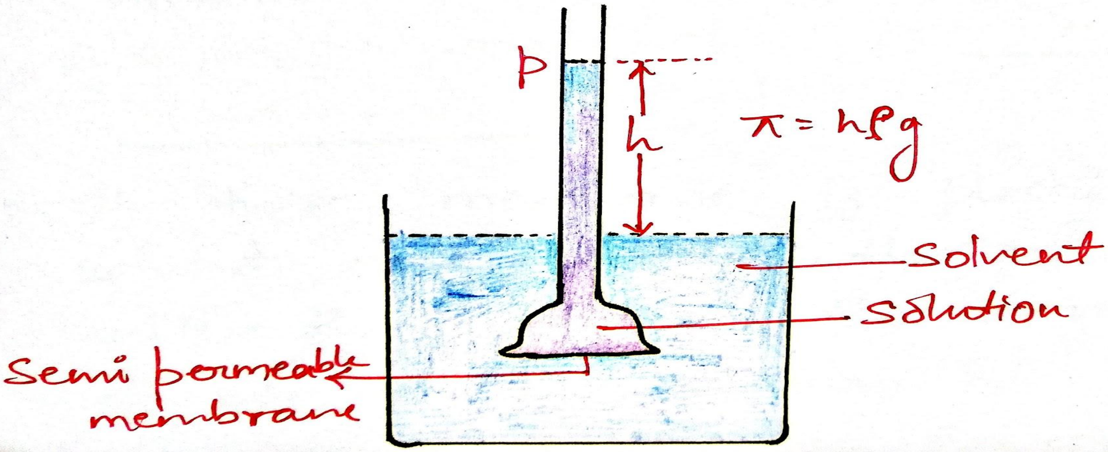


fig:- level of sol^n rises in the thistle funnel due to Osmosis of solvent.

— Eg:- raw mangoes shrivel when pickled in brine (salt water), wilted flower revived when placed in fresh water, blood cell collapse when suspended in saline water etc.

— If we look into these processes we find one thing common in all, that is all these substances are bound by membranes. These membranes can be of animal or vegetable origin & these occure naturally viz pig's bladder or parchment or can be synthetic viz. cellophane.

- They contain a network of submicroscopic holes or pores. Small solvent molecules like water, can pass through these holes but the passage of bigger molecule like solute is hindered. Membranes having this kind of properties are known as Semipermeable membranes (SPM).

- If these membrane is placed between the solvent and solution, the solvent molecule will flow through the membrane from pure solvent to the solution. This process of flow of the solvent is called Osmosis.

- The flow will continue till the equilibrium is attained. The flow of the solvent from its side to solution side across a semipermeable membrane can be stopped if some extra pressure is applied on the solution. This pressure that just stops the flow of solvent is called <u>Osmotic pressure</u> of the solution.

- The solvent molecule always flow from lower concentration to higher concentration of solution.
- The osmotic pressure of a solution is the excess pressure that must be applied to a solution to prevent osmosis.
- Osmotic pressure is a colligative property as it depends on the number of solute molecules and not their identity.

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- It has been found experimentally that Osmotic pressure is proportional to the molarity, C of the solution at a given temperature T.

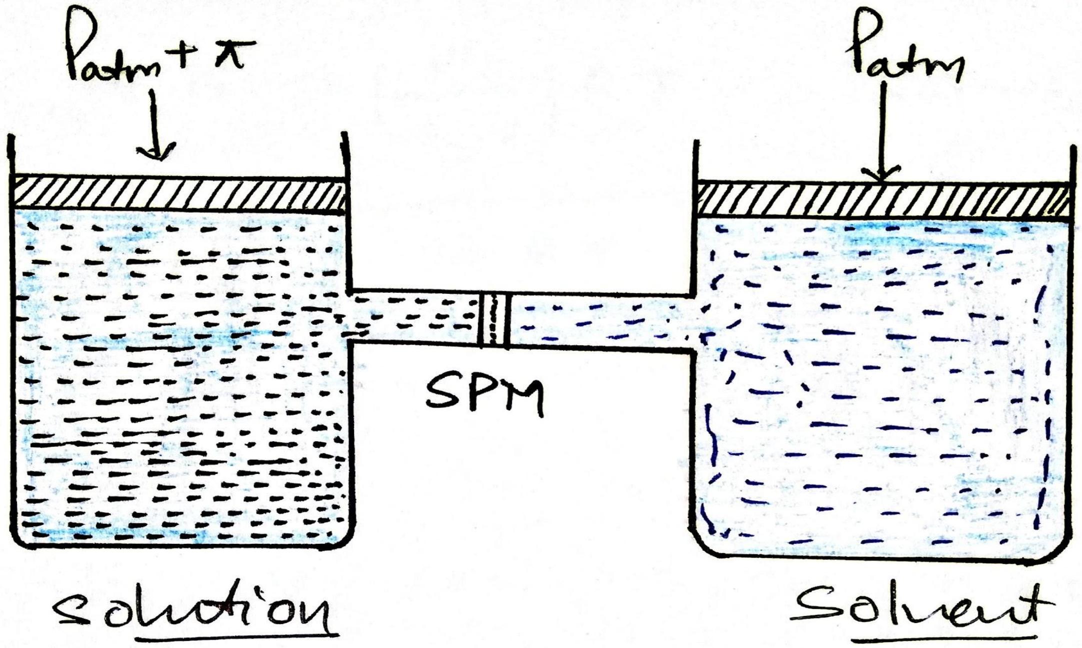

Fig:- Osmotic pressure applied to prevent Osmosis.

— Thus, $\pi = CRT$ —— (1)

* Here, π = Osmotic pressure

R = Gas Constant

$$\Rightarrow \pi = \left(\frac{n_2}{V}\right) RT \quad \text{—— (2)}$$

* Here, V = volume of solution in litre

n_2 = moles of solute.

— If w_2 gram of solute of molar mass M_2 is present in solution, then,

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$$n_2 = \frac{w_2}{M_2},$$

and we can write equ^n (2) as follows:—

$$\Rightarrow \pi = \left(\frac{w_2}{M_2 \cdot V}\right) RT \quad \text{—— (3)}$$

$$\Rightarrow \boxed{M_2 = \frac{w_2 RT}{\pi \cdot V}} \quad \text{—— (4)}$$

— Thus, knowing the quantities w_2, T, π, & V we can calculate the molar mass of solute.

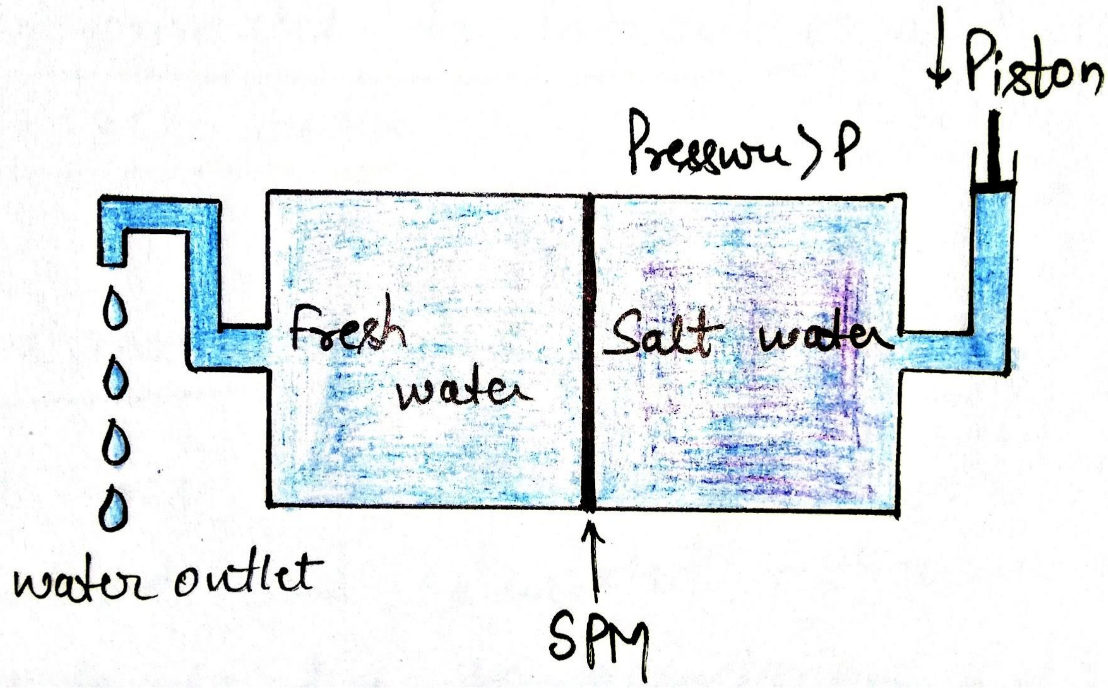
- These methods are widely used to determine molarmass of proteins, polymers and other macromolecules.
- As compared to other colligative properties, its magnitude is larger even for very dilute solutions.
- The technique of osmotic pressure for determination of molar mass of solute is particularly useful for biomolecules as they are generally not stable at higher temperatures & polymers have poor solubility.

* **Isotonic Solution :-** Two solutions having same osmotic pressure at a given temperature are called isotonic solution. When such solutions are seperated by semipermeable membrane no osmosis occurs between them.

- Eg:- the osmotic pressure associated with the fluid inside the blood cell is equivalent to that of 0.9% (m/v) NaCl solution, called normal saline solution and it is safe to inject intravenously.

- On the other hand, if we place the cells in a solution containing more than 0.9% (m/v) NaCl, water will flow out of the cell & they would shrink. Such a solution is called Hypertonic solution.
- If the salt concentration is less than 0.9% (m/v), the solution is said to be Hypotonic solution. In this case water will flow into the cells and they would swell.

Reverse Osmosis and water purification :-



- The direction of osmosis can be reversed if a pressure larger than the osmotic pressure, is applied to the solution side. That is now the pure solvent flows out of the solution through the semipermeable membrane. This phenomena is called Reverse Osmosis. and is of great practical utility. Reverse Osmosis is used in desalination of sea water.

- when pressure more than osmotic pressure is applied. pure water is sqeezed out of the sea water through the membrane. The pressure required for the reverse osmosis is quite high.
- A workable porous membrane is a film of cellulose acetate, is permeable to water but impermeable to impurities and ions present in sea water.

Abnormal Colligative Properties :-

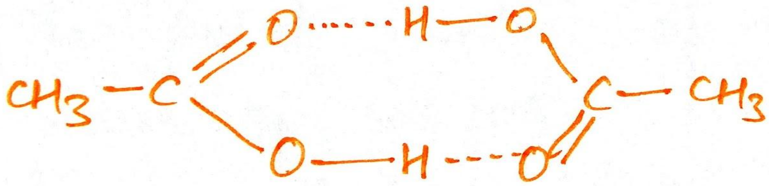
- It has been observed that difference in the observed and calculated molecular masses of solute is due to association & dissociation of solute molecules in solution.

- It results in a change in the number of particles in solution.

* Association of solute particle :-

- The formation of a bigger molecule by the union of two, three or more solute molecules is called association. Eg:-

$$2\,CH_3COOH \rightleftharpoons (CH_3COOH)_2$$



* Molecules of acetic acid dimerise in benzene due to hydrogen bonding.

* As a result, the total number of particles in solution becomes less than the number of molecules initially dissolved in the solution and hence the colligative properties will have lower value.

* As the molar mass of solute is inversally proportional to the colligative properties, so the molar mass of solute will be greater than theoretical value.

* Dissociation of solute molecules :-

— Molecules of electrolyte undergo ionization or dissociation in ionizing solvent to give two or more particles in solutions.

— Eg:- $AB \rightleftharpoons A^+ + B^-$

$NaCl \rightleftharpoons Na^+ + Cl^-$

* The dissociation results in an increase in the total number of particles, and therefore the value of colligative properties of such solutions will be higher.

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* As the colligative properties are inversally related to molecular weight, so the molecular weight of ionizable solute will be less than the theoretical value.

Van't Hoff Factor (i) :-

- In order to express the extent of association or dissociation with certain solutes are expected to undergo in solution.
- Van't Hoff in 1886, introduced a factor, called Van't Hoff factor (i). The factor (i) is defined as-

$$i = \frac{\text{Observed Colligative property}}{\text{Normal colligative property}}$$

$$i = \frac{\text{Normal or actual molecular weight}}{\text{observed molecular weight}}$$

$$i = \frac{\text{Total number of moles of particles after association / Dissociation}}{\text{Number of moles of particles before association / Dissociation.}}$$

- In case of association of solute particles in solution, the observed molecular weight of solute being more than the normal the value of factor, i, is less than unity.
- For dissociation the value of i is greater than unity because the observed molecular weight has lesser value than normal molecular weight.

Relative lowering of vapour pressure of solvent

$$\frac{p_1^0 - p_1}{p_1^0} = i\frac{n_2}{n_1}$$

Elevation of boiling point, $\Delta T_b = i K_b \cdot m$

Depression of freezing point, $\Delta T_f = i K_f \cdot m$

Osmotic pressure of solution. $\pi = iCRT$.

To be continue...

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