

COLLIGATIVE PROPERTIES

Definition: The properties that depend on the number of solute particles irrespective of their nature relative to the total number of particles present in the solution are called colligative properties.

There are four colligative properties:

1. Relative Lowering of vapour Pressure
2. Elevation in Boiling Point
3. Depression in freezing point
4. Osmotic pressure

RELATIVE LOWERING OF VAPOUR PRESSURE

When a non-volatile solute is added to a solvent, the vapour pressure decreases. The lowering of vapour pressure with respect to pure solvent is called relative lowering of vapour pressure.

According to Raoult's Law:

$$P_1 = X_1 P_1^\circ$$

$$\Delta P_1 = P_1^\circ - P_1$$

$$\Delta P_1 = P_1^\circ(1 - X_1)$$

$$X_2 = 1 - X_1$$

$$\Delta P_1 = P_1^\circ X_2$$

$$(P_1^\circ - P_1)/P_1^\circ = X_2$$

$$X_2 = n_2/(n_1+n_2)$$

For dilute solution: $X_2 \approx n_2/n_1$

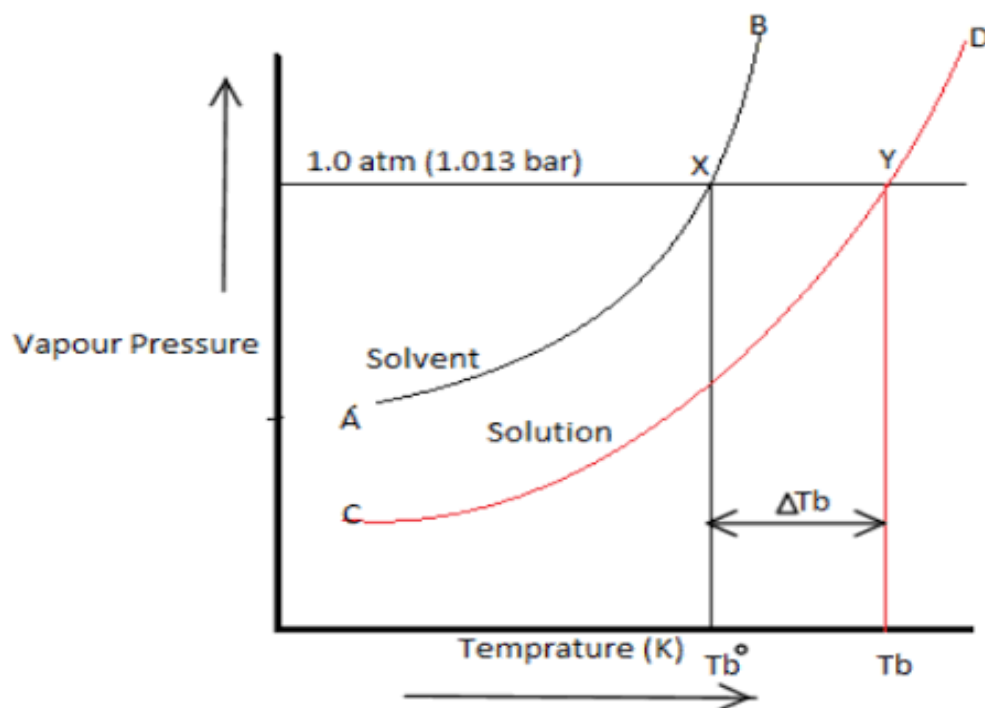
$$(P_1^\circ - P_1)/P_1^\circ = n_2/n_1$$

$$(P_1^\circ - P_1)/P_1^\circ = (w_2 M_1)/(w_1 M_2)$$



ELEVATION IN BOILING POINT

Boiling point of a liquid is the temperature at which vapour pressure equals atmospheric pressure. On adding solute vapour pressure decreases so boiling point increases.



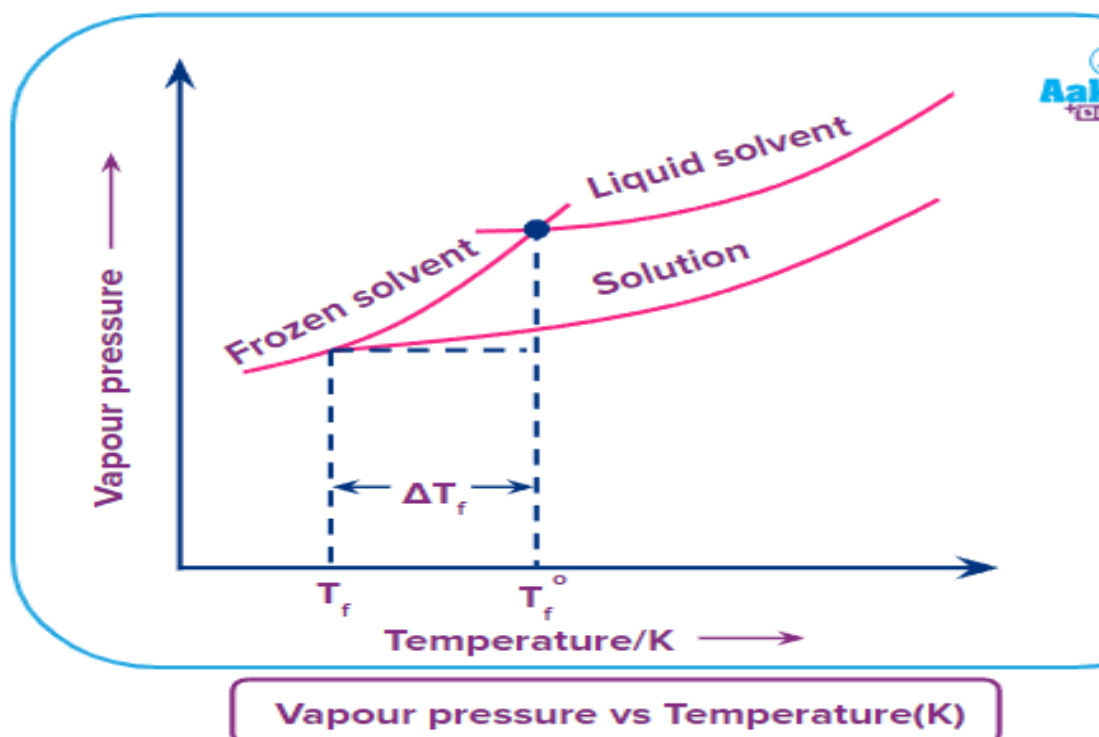
$$\Delta T_b = T_b - T_b^\circ$$

$$\Delta T_b = K_b m$$

$$m = (w_2 \times 1000) / (M_2 \times w_1)$$

$$M_2 = (1000 K_b w_2) / (\Delta T_b w_1)$$

DEPRESSION IN FREEZING POINT



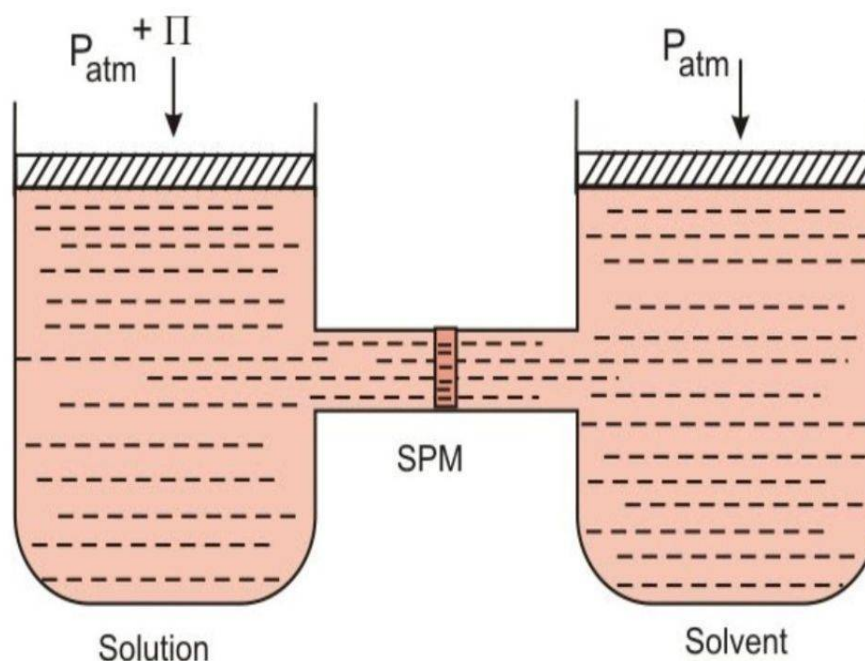
Freezing point is the temperature at which vapour pressure of liquid equals solid phase. On adding solute freezing point decreases.

$$\Delta T_f = T_f^\circ - T_f$$

$$\Delta T_f = K_f m$$

$$M_2 = (1000 K_f w_2)/(\Delta T_f w_1)$$

OSMOTIC PRESSURE



Osmosis is the flow of solvent from pure solvent to solution through semipermeable membrane.

Osmotic pressure is the pressure required to stop osmosis.

$$\pi = C R T$$

$$\pi V = nRT$$

$$M_2 = (w_2 R T)/(\pi V)$$

Isotonic: Solutions having same osmotic pressure at given temperature.

Hypotonic: Lower osmotic pressure solution.

Hypertonic: Higher osmotic pressure solution.

Reverse osmosis: If pressure greater than osmotic pressure is applied, solvent flows from solution to pure solvent through membrane.

Application: Desalination of sea water.

VAN'T HOFF FACTOR

Abnormal molar mass arises due to association or dissociation

i = observed / calculated

For association: $i < 1$

For dissociation: $i > 1$

$$\Delta T_b = i K_b m$$

$$\Delta T_f = i K_f m$$

$$\pi = i C R T$$

