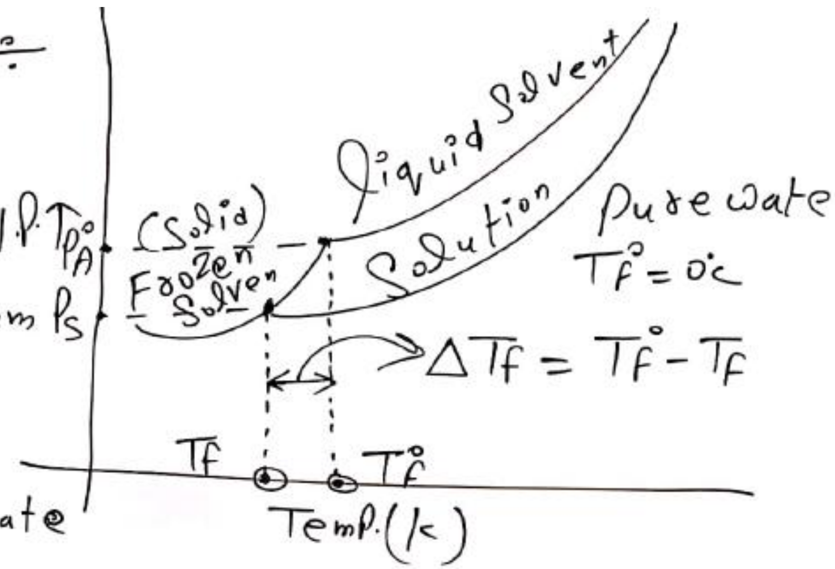
Depression in Freezing Point ÷ (ΔT_f)

The freezing of a liquid is that Temp. at which liquid and its Solid State exist in equilibrium with each other.

It may be defined as the temp. at which liquid & Solid State of a Substance have Same V.P.

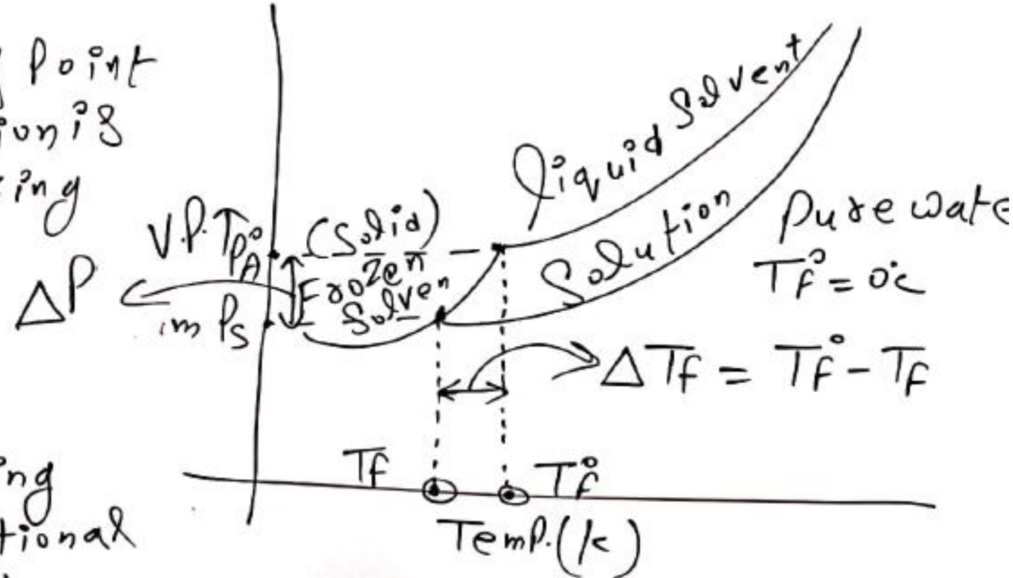


When a non-Volatile Solute is dissolved in Pure Solvent then V.P. of Solvent decreases

If T_f° is freezing of Pure Solvent and T_f is the freezing of Solution then $T_f < T_f^\circ$

The difference in freezing point of pure solvent and solution is k/a depression in freezing point.

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



The depression in freezing point is directly proportional to lowering in V.P. (ΔP)

$$\Delta T_f \propto \Delta P \propto \frac{n_B}{N_A} \propto m$$

$$\Delta T_f \propto m$$

$$\Delta T_f = k_f \cdot m$$

Here : $k_f \Rightarrow$ molal depression Constant or cryoscopic Constant

$k_f \rightarrow$ depends only nature of Solvent which can be explained by Thermodynamic.

$$\# \quad K_f = \frac{R \cdot T_f^{\circ 2}}{1000 L_f} = \frac{R T_f^{\circ 2} M}{1000 \Delta H_f}$$

Here :- T_f° freezing point of pure solvent
L_f latent heat of fusion per gm of solvent
$\Delta H_f \Rightarrow$ enthalpy of fusion per mole of solvent
$M \Rightarrow$ molar mass of solvent

$\# \quad K_f$ of water $\Rightarrow 1.86$
Camphor $\Rightarrow 39.7$

$\frac{{}^\circ C \, kg_m}{mol} \Big/ \frac{K \cdot kg_m}{mol}$

$$\Delta T_b = K_b \cdot (m)$$

$$\Delta T_f = K_f \cdot m$$

$$K_b / K_f = \frac{\Delta T_b / \Delta T_f}{m}$$

$$\Rightarrow \frac{{}^\circ C \cdot kg_m}{mol}$$

Ques.1. B.P. of Soln made by dissolving 12gm of Solute in 100gm of water is 100.34°C. Cal. molar mass of Solute.

$K_b = 0.52 \left(\frac{K - kgm}{mol}\right)$

Sol. given : $T_b = 100.34°C$, $T_b^{\circ} = 100°C$ $\rightarrow \Delta T_b = 0.34$; $W_B = 12\,gm$, $W_A = 100\,gm$; $m_B = ?$, $M_A = 18$

$$\Delta T_b = K_b \cdot m \Rightarrow \Delta T_b = K_b \cdot \frac{W_B}{m_B} \times \frac{1000}{W_A}$$

$$0.34 = 0.52 \cdot \frac{12}{m_B} \times \frac{1000}{100}$$

$$m_B = \frac{5.2 \times 12}{0.34} \Rightarrow m_B = \frac{64.4}{0.34} \Rightarrow \boxed{m_B = 189.41}^{*}$$

Q.2. Cal B.P and F.P of 5 % by mass Aqueous Soln of Urea. $K_b = 0.5$ K-kgm/mol ; $K_f = 1.86$ K-kgm/mol.

$T_b = ?$; $T_f = ?$

$T_b^\circ = 100^\circ C$

$T_f^\circ = 0^\circ C$

Sol. $\left(\frac{w}{W}\right)\% = 5\%$ by mass Aq. Soln of Urea ;

5 gm Solute (Urea) present in 100 gm Soln.

mass of Solvent = 100 − 5 = 95 gm.

$\Delta T_b = K_b \cdot m$.

$\Delta T_b = 0.52 \times \frac{5}{60} \times \frac{1000}{95} \Rightarrow \Delta T_b = \frac{1}{2} \times \frac{5 \times 100}{570} = 0.41$

$\Delta T_b = T_b - T_b^\circ \Rightarrow 0.41 = T_b - 100 \Rightarrow$ $T_b = 100.41^\circ C = 373.41\,K$

$\Rightarrow \Delta T_f = K_f \cdot m \Rightarrow \Delta T_f = 1.86 \times \frac{5}{60} \times \frac{1000}{95} = \frac{186 \times 5}{570} \Rightarrow \Delta T_f = 1.63$

$\Delta T_f = T_f^\circ - T_f \Rightarrow 1.63 = 0 - T_f \Rightarrow$ $T_f = -1.63^\circ C$ $\Rightarrow T_f = -1.63 + 273 = 271.37\,K$ Ans.

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Q.3. An Aq. Sol^n of non-volatile Solute Boils at $\underline{100.19°c}$ at what temp. will Sol^n freeze.

$k_b = 0.52$ -"- ; $k_f = 1.86$ -"- $\quad T_b = 100.19$

Sol. $\Delta T_b = k_b \cdot m$ — (1)

$\Delta T_f = k_f \cdot m$ — (2)

$\frac{\Delta T_b}{\Delta T_f} = \frac{k_b}{k_f} \Rightarrow \frac{0.19}{\Delta T_f} = \frac{0.52}{1.86}$

$\Delta T_b = 100.19 - 100 = 0.19$

$\Delta T_f = 0.63 \Rightarrow \boxed{T_f = -0.63}$

Q.4. Cal. B.P. of Sol^n Prepared by mixing 2% (w/V) Aq. Sol^n of glucose ($d = 1.10$ gm/ml) & 3% (w/W) Aq. Sol^n of urea ($k_b = 0.52$ -"-)

Sol. given :- 2% (w/V) ⇒ 2 gm glucose in 100 ml Sol^n.

$d_{sol} = \frac{w}{V} \Rightarrow \boxed{w_{sol^n} = 1.10 \times 100 = 110 gm}$

$w_{solvent} = 110 - 2 = 108$ gm.

$n_1 = \frac{2}{180}$

3% (w/W) ⇒ 3 gm Urea present in 100 gm Sol^n. ; $n_2 = \frac{3}{60}$

$w_{solvent} = 100 - 3 = 97$ gm.