

1. At 25°C, the vapour pressure of methyl alcohol is 96.0 torr. What is the mole fraction of CH_3OH in a solution in which the (partial) vapor pressure of CH_3OH is 24.0 torr at 25°C?
1. 25°C पर, मेथिल एल्कोहल का वाष्प दाब 96.0 torr है। इस विलयन में CH_3OH के मोल प्रभाज क्या है, जिसमें CH_3OH का आंशिक वाष्प दाब 25°C पर 24.0 torr है ?

Acc. to Raoult's law ;

$$p_s = \bar{p}_A \cdot X_A; \text{ where}$$

p_s = vapour pressure of solution

\bar{p}_A = vapour pressure of pure solvent

X_A = mole fraction of A in the solution

$$\Rightarrow \text{given} : - \bar{p}_A^0 = 96 \text{ torr} ; p_s = 24 \text{ torr} ;$$

$$\Rightarrow 24 = 96 \times X_{\text{CH}_3\text{OH}} \Rightarrow X_{\text{CH}_3\text{OH}} = \frac{24}{96} = \frac{1}{4}$$

2. The vapour pressure of ethanol and methanol are 44.0 mm and 88.0 mm Hg respectively. An ideal solution is prepared at the same temperature by mixing 69 g of ethanol with 40 g of methanol. Calculate total vapour pressure of the solution.
2. ऐथेनॉल तथा मेथेनॉल का वाष्प दाब क्रमशः 44.0 mm Hg तथा 88.0 mm Hg होता है। 69 g ऐथेनॉल तथा 40 g मेथेनॉल को मिश्रित करके समान तापमान पर एक आदर्श विलयन बनाया जाता है। विलयन का कुल वाष्प दाब ज्ञात कीजिए।

Ans. 64.0 mm Hg

Acc. to Raoult's law;

$$P_s = p_A^\circ \chi_A + p_B^\circ \chi_B; \text{ where}$$

χ_A, χ_B = mole fractions of A & B in the liquid phase, respectively

p_A°, p_B° = vapour pressures of pure A & pure B, respectively

P_s = vapour pressure of the binary solution of A & B

$$\Rightarrow \chi_{\text{C}_2\text{H}_5\text{OH}} = \frac{n_{\text{C}_2\text{H}_5\text{OH}}}{n_{\text{C}_2\text{H}_5\text{OH}} + n_{\text{CH}_3\text{OH}}} = \frac{\frac{40 \text{ g}}{32 \text{ g/mol}}}{\frac{40 \text{ g}}{32 \text{ g/mol}} + \frac{69 \text{ g}}{46 \text{ g/mol}}} = \frac{\frac{1.25}{1.25+1.5}}{1.25+1.5} = \frac{1.25}{2.75} = \frac{5}{11}$$

$$\Rightarrow \chi_{\text{CH}_3\text{OH}} = 1 - \frac{5}{11} = \frac{6}{11}$$

$$\Rightarrow P_s = \left(\frac{5}{11}\right)(88 \text{ mm}) + \left(\frac{6}{11}\right)(44 \text{ mm})$$

$$= 64 \text{ mm}$$

3. Liquide 'A' and 'B' form an ideal solution. The vapour pressure of solution containing equal moles of both liquids is 80 cm Hg. At the same temperature, the vapour pressure of solution containing 25 mole percent of liquid 'A' is 70 cm Hg. Calculate P_A^0 and P_B^0 .
3. Ans. $P_A^0 = 100 \text{ cmHg}$, $P_B^0 = 60 \text{ cmHg}$.

Acc. to Raoult's law;

$$P_s = p_A^\circ \chi_A + p_B^\circ \chi_B; \text{ where}$$

χ_A ; χ_B = mole fractions of A & B in the liquid phase, respectively

p_A° ; p_B° = vapour pressures of pure A & pure B, respectively

P_s = vapour pressure of the binary solution of A & B

Given:- $P_s = 80 \text{ cmHg}$; when $\chi_A = \chi_B = \frac{1}{2}$

$P_s = 70 \text{ cmHg}$; when $\chi_A = \frac{1}{4}$; $\chi_B = \frac{3}{4}$

$$\Rightarrow 80 = \frac{1}{2}(P_A^\circ) + \frac{1}{2}(P_B^\circ) \quad \text{---(1)}$$

$$70 = \frac{1}{4}(P_A^\circ) + \frac{3}{4}(P_B^\circ) \quad \text{---(2)}$$

Solve to get P_A° & P_B°

4. Liquids 'A' and 'B' form an ideal solution. Calculate the mole-fraction of 'A' in the vapours above the liquid solution containing the liquids 'A' and 'B' in 2 : 3 mole ratio, at equilibrium.

[Given : $P_A^0 = 0.4 \text{ atm}$, $P_B^0 = 0.8 \text{ atm}$]

4. Ans. 0.25

Acc. to Raoult's law;

$$P_s = P_A^\circ \chi_A + P_B^\circ \chi_B; \text{ where}$$

χ_A ; χ_B = mole fractions of A & B in the liquid phase, respectively

P_A° ; P_B° = vapour pressures of pure A & pure B, respectively

P_s = vapour pressure of the binary solution of A & B

$$\therefore P_s = (0.4 \text{ atm}) \left(\frac{2}{5} \right) + (0.8 \text{ atm}) \left(\frac{3}{5} \right)$$

$$= 0.64 \text{ atm}$$

Acc. to Dalton's & Raoult's law;

$$P_A = P_A^\circ \chi_A = P_s y_A; \text{ where}$$

y_A = mole fraction of A in the vapours above the solution

$$\therefore y_A = \frac{P_A^\circ \chi_A}{P_s} = \frac{(0.4 \text{ atm})(\frac{2}{5})}{0.64 \text{ atm}}$$

5. Liquids 'P' and 'Q' form an ideal solution. At equilibrium, the vapours contain 40% molecules of 'P'. Calculate the vapour pressure of solution.

[Given : $P_P^0 = 0.4 \text{ bar}$, $P_Q^0 = 0.6 \text{ bar}$]

5. Ans. 0.5 bar

Acc. to Raoult's law;

$$\frac{1}{P_s} = \frac{y_A}{P_A^0} + \frac{y_B}{P_B^0}; \text{ where;}$$

y_A ; y_B = mole fraction of A & B in the vapour above solution

P_A^0 ; P_B^0 = vapour pressure of pure A & pure B in the solution.

$$P_s = \dots$$

Given:- $y_P = 0.4$; $y_Q = 0.6$

$$\frac{1}{P_s} = \frac{0.4}{0.4 \text{ bar}} + \frac{0.6}{0.6 \text{ bar}}$$

6. Liquids 'X' and 'Y' form an ideal solution. The vapour pressure of solution may be expressed as : $P[\text{cmHg}] = (80 - 25x)$, where 'x' is the mole-fraction of liquid 'X' in the liquid solution at equilibrium. Calculate the vapour pressures of pure liquids 'X' and 'Y'.

- Ans. $P_X^0 = 55 \text{ cmHg}$, $P_Y^0 = 80 \text{ cmHg}$

Acc. to Raoult's law;

$$P_s = p_A^\circ X_A + p_B^\circ X_B; \text{ where}$$

X_A ; X_B = mole fractions of A & B in the liquid phase, respectively

p_A° ; p_B° = vapour pressures of pure A & pure B, respectively

P_s = vapour pressure of the binary solution of A & B

$$P_s = p_X^\circ X_X + p_Y^\circ X_Y$$

$$= p_X^\circ X_X + p_Y^\circ (1-X_X) = (p_X^\circ - p_Y^\circ) X_X + p_Y^\circ$$

comparing with the equation given in question

$$p_Y^\circ = 80; \quad p_X^\circ - p_Y^\circ = -25$$

7. Liquid 'R' and 'S' form an ideal solution. The mole-fraction of 'R' in liquid and vapour phases at equilibrium are 0.25 and 0.40, respectively. If the vapour pressure of solution is 0.50 bar, calculate P_R^0 and P_S^0

7. Ans. $P_R^0 = 0.8$ bar, $P_S^0 = 0.4$ bar

Acc. to Raoult's law;

$$P_R = P_R^0 \cdot X_R ; \quad P_S = P_S^0 \cdot X_S$$

where; P_R^0 ; P_S^0 = vapour pressures of pure R & S
resp.

X_R ; X_S = mole fraction of R & S in liquid phase, resp.

Acc. to Dalton's law;

$$P_R = P_T \cdot y_R ; \quad P_S = P_T \cdot y_S ; \quad \text{where}$$

P_T = Total vapour pr. of the solution;

y_R ; y_S = mole fraction of R & S in vapour phase.

$$\text{Given;} \quad X_R = 0.25 ; \Rightarrow X_S = 0.75$$

$$y_R = 0.4 ; \Rightarrow y_S = 0.6$$

combining the two laws;

$$P_R^0 = \frac{P_T \cdot y_R}{X_R} = \frac{0.5 \text{ bar} \times 0.4}{0.25}$$

$$P_S^0 = \frac{P_T \cdot y_S}{X_S} = \frac{0.5 \text{ bar} \times 0.6}{0.75}$$

8. The vapour pressure of pure liquid solvent A is 0.80 atm. When a nonvolatile substance B is added to the solvent its vapour pressure drops to 0.60 atm. What is the mole fraction of component B in the solution?
8. शुद्ध द्रव विलायक A का वाष्प दाब 0.80 atm है। जब विलायक में अवाष्पशील पदार्थ B मिलाया जाता है तो इसका वाष्प दाब 0.60 atm रह जाता है। विलयन में घटक B के मोल प्रभाज क्या हैं ?

Ans. 0.25

Acc. to Raoult's law)

$$P_s = f_A \cdot X_A; \text{ where}$$

P_s = vapour pressure of solution

f_A = vapour pressure of pure solvent

X_A = mole fraction of A in the solution

$$(0.6 \text{ atm}) = (0.8 \text{ atm}) \cdot X_A \Rightarrow X_A = \frac{3}{4}$$

$$\Rightarrow X_B = \frac{1}{4}$$

9. Calculate the relative lowering in vapour pressure if 100 g of a nonvolatile solute (mol.wt.100) are dissolved in 432 g water.
9. यदि 432 g ग्राम जल में 100 g अवाष्पशील विलेय (अणुभार 100) घुला हुआ है, तो वाष्प दाब में सापेक्ष अवनमन की गणना कीजिए।

Ans. 0.04

Acc. to relative lowering of vapour pressure;

$$\frac{P^0 - P_s}{P^0} : \frac{\Delta p}{P^0} = \frac{n_{\text{solute}}}{n_{\text{solute}} + n_{\text{solvent}}} ; \text{ where}$$

P^0 = vapour pressure of pure solvent;

P_s = " " " solution;

$\frac{\Delta p}{P^0}$ = relative lowering of vapour pressure

$$\Rightarrow n_{\text{solute}} = \frac{100 \text{ g}}{100 \text{ g/mol}} = 1 \text{ mol} ;$$

$$n_{\text{solvent}} : \frac{432 \text{ g}}{18 \text{ g/mol}} = 24 \text{ mol}$$

$$\Rightarrow \frac{\Delta p}{P^0} = \left(\frac{1}{1+24} \right) = \frac{1}{25} -$$

10. The vapour pressure of pure benzene at 30° C is 640 mm of Hg and the vapour pressure of a solution of a solute in C₆H₆ at the same temperature is 624 mm of Hg. Calculate molality of solution.
 10. 30°C पर शुद्ध बैंजीन का वाष्प दाब 640 mm Hg है तथा समान तापक्रम पर C₆H₆ में छुले हुए विलयन का वाष्प दाब 624 mm Hg है। विलयन की मोललता की गणना कीजिए।

Ans. 0.32 m

Acc. to Raoult's law;

$$P_s = P_A \cdot X_A; \text{ where}$$

P_s = vapour pressure of solution

P_A = vapour pressure of pure solvent

X_A = mole fraction of A in the solution

Given; P_{Benzene}^o = 640 mm Hg
 P_s = 624 mm Hg

$$\Rightarrow X_{\text{Benzene}} = \frac{624 \text{ mm Hg}}{640 \text{ mm Hg}} = 0.975 = \frac{n_{\text{solute}}}{n_{\text{C}_6\text{H}_6} + n_{\text{solute}}}$$

$$\Rightarrow \frac{n_{\text{solute}}}{n_{\text{Benzene}}} = 0.025$$

$$\Rightarrow \frac{n_{\text{solute}}}{w\text{t C}_6\text{H}_6} \times \frac{M_{\text{C}_6\text{H}_6}}{1000} = 0.025$$

$$\Rightarrow \text{molality} = \frac{0.025 \times 1000}{78} = 0.328 \text{ m}$$

11. The vapour pressure of pure benzene at a certain temperature is 640 mm of Hg. A nonvolatile nonelectrolyte solid weighing 2.175 g is added to 39.0 g of benzene. The vapour pressure of the solution is 600 mm of Hg. What is molecular weight of solid substance?

11. एक निश्चित तापमान पर शुद्ध बेन्जीन का वाष्प दाब 640 mm Hg है। 2.175 g अवाप्शील ठोस को 39.0 g बेन्जीन में मिलाया जाता है। विलयन का वाष्प दाब 600 mm Hg है। ठोस पदार्थ का आण्विक भार क्या है?

Ans. 65.25

Acc. to Raoult's law;

$$P_s = P_A \cdot X_A; \text{ where}$$

P_s = vapour pressure of solution

P_A = vapour pressure of pure solvent

X_A = mole fraction of A in the solution

Given; $P_{\text{Benzene}}^0 = 640 \text{ mm Hg}$

$$P_s = 600 \text{ mm Hg}$$

$$\Rightarrow 600 \text{ mm} = 640 \text{ mm} \times \frac{n_{\text{Benzene}}}{n_{\text{Benzene}} + n_{\text{solute}}}$$

$$\Rightarrow 0.9375 = \frac{\frac{39 \text{ g}}{78 \text{ g/mol}}}{\frac{39 \text{ g}}{78 \text{ g/mol}} + \frac{2.175 \text{ g}}{M_{\text{solute}}}} ; \text{ where}$$

$$M_{\text{solute}} = \text{molar mass of solute} = 65.25 \text{ g/mol}$$

12. The vapour pressure of water is 17.54 mm Hg at 293 K. Calculate vapour pressure of 0.5 molal solution of a solute in it.
12. 293 K पर जल का वाष्प दाब 17.54 mm Hg है। इसमें घुले हुए विलेय के 0.5 मोलल विलयन के वाष्प दाब की गणना कीजिए।

Ans. 17.38 mm Hg

Acc. to Raoult's law;

$$P_s = P_A \cdot X_A; \text{ where}$$

P_s = vapour pressure of solution

P_A = vapour pressure of pure solvent

X_A = mole fraction of A in the solution

Given; $P^o = 17.54 \text{ mm}$; molality = 0.5

$$\Rightarrow \frac{n_{\text{solute}}}{w_{H_2O}(\text{kg})} = 0.5$$

\Rightarrow consider 1 kg water; $\Rightarrow n_{\text{solute}} = 0.5 \text{ mol}$

$$n_{\text{solvent}} = \frac{1000 \text{ g}}{18 \text{ g/mol}}$$

$$= 55.55 \text{ mol}$$

$$\Rightarrow P_s = (17.54 \text{ mm}) \left(\frac{55.55 \text{ mol}}{0.5 \text{ mol} + 55.55 \text{ mol}} \right) = 17.38 \text{ mm}$$

13. When 10.5 g of a nonvolatile substance is dissolved in 742 g of ether, its boiling point is raised 0.25°C. What is the molecular weight of the substance? Molal boiling point constant for ether is 2.12°C·kg/mol.

13. जब अवाप्तशील पदार्थ के 10.5 g को 742 g ईथर में घोला जाता है, इसका क्वथनांक 0.284°C से बढ़ जाता है। पदार्थ का अणुभार क्या है? ईथर के लिए मोलल क्वथनांक स्थिरांक 2.12°C·kg/mol है।

Ans. 120 g/mol

Ques & Ans

Ans. to elevation in boiling point;

$$\Delta T_b = T_b' - T_b = k_b \times m \times i ; \text{ where}$$

k_b = ebullioscopic constant or
molal elevation constant

m = molality of soln;

i = van't Hoff factor

T_b' = Boiling point of soln

T_b = " " " pure solvent

$$\Rightarrow 0.25^\circ\text{C} = \left(2.12^\circ\text{C} - \frac{k_b}{m \times i}\right) \times \left(\frac{10.5\text{g}}{m}\right) \times \frac{1}{0.742\text{kg}} ;$$

m = molar mass of solute = 120 g/mol

14. Calculate the molal elevation constant, K_b for water and the boiling point of 0.1 molal urea solution. Latent heat of vaporisation of water is 9.72 kcal mol⁻¹ at 373.15 K. $([373.15]^2 = 258 \times 540]$
14. जल के लिए मोलल उन्नयन स्थिरांक, K_b तथा 0.1 मोलल यूरिया के विलयन के लिए कवरथनांक की गणना कीजिए। 373.15 K ताप पर जल के वाष्पन की गुप्त उष्मा 9.72 kcal mol⁻¹ है।
- Ans. $K_b = 0.516 \text{ kg mol}^{-1} \text{ K}^{-1}$, $T_b = 373.20 \text{ K}$

Ans. - elevation in boiling point;

$$\Delta T_b = T_b' - T_b = k_b \times m \times i; \text{ where}$$

k_b = ebullioscopic constant or
molal elevation constant

m = molality of soln;

i = van't Hoff factor

T_b' = Boiling point of soln
 T_b = " " " pure solvent

$$k_b = \frac{m_{\text{solute}} \times R \times T_b^2}{1000 \times \Delta H_{\text{vap}}} ; \text{ where}$$

ΔH_{vap} = molar enthalpy of vaporisation;

R = gas constant;

m_{solute} = molar mass of solvent

$$\Rightarrow k_b = \frac{\left(2 \text{ cal}/\text{mol} \cdot \text{K}\right) \times 18 \frac{\text{g}}{\text{mol}} \times (373.15 \text{ K})^2}{\left(9.72 \times 1000 \frac{\text{cal}}{\text{mol}}\right) \times 1000} = 0.516 \text{ K} \cdot \frac{\text{kJ}}{\text{mol}}$$

$$\Delta T_b = k_b \times m \times i = \left(0.516 \frac{\text{K} \cdot \text{kJ}}{\text{mol}}\right) \times (0.1 \text{ mol}) \times 1 = 0.0516 \text{ K}$$

$$\Rightarrow T_b' = (373.15 + 0.0516) \text{ K} = 373.2 \text{ K}$$

15. Pure benzene freeze at 5.45°C . A solution containing 6.72 g of $\text{C}_2\text{H}_2\text{Cl}_4$ in 120 g of benzene was observed to freeze at 3.75°C . What is the molal freezing point constant of benzene?
15. शुद्ध बैंजीन 5.45°C पर जमती है। 7.24 g $\text{C}_2\text{H}_2\text{Cl}_4$ को 115.3 g बैंजीन में घोलकर बनाया गये विलयन का, 3.55°C पर जमना प्रेक्षित हुआ। बैंजीन का मोलल हिमांक स्थिरांक क्या है।

Ans. 5.1 K-kg/mol

(due to depression in freezing point)

depression in freezing point = ΔT_f

$$= T_f - T_f'$$

T_f = freezing point of pure solvent

T_f' = " " " solution

k_f = cryoscopic constant or
molal depression constant

m = molality of solute

i = van't Hoff factor

$$\Rightarrow \Delta T_f = (5.45 - 3.75)^\circ\text{C} = k_f \times \frac{\frac{6.72 \text{ g}}{168 \text{ g/mol}}}{0.12 \text{ kg}}$$

$$\therefore k_f = 5.1 \text{ K-kg/mol}$$

16. The freezing point of a solution containing 2.40 g of a compound in 60.0 g of benzene is 0.10°C lower than that of pure benzene. What is the molecular weight of the compound? (K_f is 5.12°C/m for benzene)
16. 60.0 g बैंजीन में 2.40 g यौगिक रखने वाले विलयन का हिमांक शुद्ध बैंजीन से 0.10°C कम है। यौगिक का अणुभार क्या है? (बैंजीन के लिए $K_f = 5.12^\circ\text{C}/\text{m}$)

Ans. 2048 g/mol

Auto depression in freezing point

$$\text{depression in freezing point} = \Delta T_f$$

$$= T_f - T_f'$$

T_f : freezing point of pure solvent

T_f' : " " " " solution

k_f : cryoscopic constant or
molal depression constant

m : molality of soln;

i : van't Hoff factor

$$\Rightarrow 0.1^\circ\text{C} = (5.12^\circ\text{C}/\text{m}) \times \frac{2.4}{m} \times i ; \text{ where}$$

m = molar mass of solute = 2048 gm/mol

① CRAVEN's rule

② OXENBERG's rule

(17) A 6.84% solution (w/v) of cane-sugar (Mol. weight = 342) is isotonic with 0.8% (w/v) solution of non-volatile solute. Find molecular weight of solute.

(17) इक्षु शर्करा (अणुभार = 342) का 6.84% विलयन (w/v) यूरिया के 0.8% (w/v) विलयन के साथ समपरासरी है।

Ans. 40 g/mol विलय

विलय

Solution :-

According to osmotic pressure equation;

$$\pi = CRT \times i; \text{ where}$$

π = osmotic pressure of the solution

c = molarity of the solution

$$R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

T = Temperature of the solution

$$\% \text{ w/v} = \frac{\text{wt. of solute (g)}}{\text{vol. of solution (ml)}} \times 100$$

$$= \frac{n_{\text{solute}} \times M_{\text{solute}}}{\text{vol. of solution (ml)} \times 1000} \times 100$$

$$= \frac{\text{molarity} \times M_{\text{solute}}}{10}$$

M = molar mass of the solute

$$\Rightarrow \pi_{\text{cane-sugar}} = \pi_{\text{non-volatile solute}}$$

$$\Rightarrow M_{\text{cane-sugar}} = M_{\text{non-volatile solute}}$$

$$\Rightarrow \frac{\frac{10 \times \% \text{ w/v}}{M_{\text{cane-sugar}}}}{=} = \frac{\frac{10 \times \% \text{ w/v}}{M_{\text{non-volatile solute}}}}$$

$$\Rightarrow \left(\frac{6.84}{342} \right) = \frac{0.8}{M} \Rightarrow M = \left(\frac{0.8 \times 342}{6.84} \right) = 40$$

Oxembergs

(18)

Calculate the osmotic pressure of 12% (w/v) aq. urea solution at 27°C.

Ans. 49.26 atm

According to osmotic pressure equation;

$$\pi = CRT \times i; \text{ where}$$

π = osmotic pressure of the solution

c = molarity of the solution

$$R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

T = Temperature of the solution

$$\eta_{\text{osm}} = \frac{\text{wt. of solute (g)}}{\text{vol. of solution (ml)}} \times 1000$$

$$= \frac{n_{\text{solute}} \times M_{\text{solute}}}{\text{vol. of solution (ml)}} \times 1000$$

$$= \frac{\text{molarity} \times M_{\text{solute}}}{1000}$$

M = molar mass of the solute

$$\begin{aligned}
 \Rightarrow \pi &= \left(\frac{10 \times 0\% w/v}{m_{\text{solute}}} \right) \times 0.0821 \frac{\text{L-atm}}{\text{mol-K}} \times 300 \text{ K} \\
 &= \left(\frac{(10 \times 12) \text{g/L}}{60 \text{ g/mol}} \right) \times 0.0821 \frac{\text{L-atm}}{\text{mol-K}} \times 300 \text{ K} \\
 &= 49.26 \text{ atm}
 \end{aligned}$$

(19) Calculate the osmotic pressure of a solution containing 18 gm glucose and 17.1 gm canesugar ($C_{12}H_{22}O_{11}$) per litre, at 27°C.

Ans: 3.69 atm

According to osmotic pressure equation,

$$\pi = CRT \times i; \text{ where}$$

π = osmotic pressure of the solution

c = molarity of the solution

$$R = 0.0821 \frac{\text{L-atm}}{\text{mol}\cdot\text{K}}$$

T = Temperature of the solution

$$\Rightarrow \pi = \left(\frac{18 \text{ g}}{180 \text{ g/mol}} + \frac{17.1 \text{ g}}{342 \text{ g/mol}} \right) \times 0.0821 \frac{\text{L-atm}}{\text{mol}\cdot\text{K}} \times 300 \text{ K}$$

$$= 3.69 \text{ atm}$$

(20) A storage battery contains a solution of H_2SO_4 38% by weight. What will be the Van't Hoff factor if the $\Delta T_{f(experiment)}$ is 22.8K. [Given $K_f = 1.86 \text{ mol}^{-1} \text{ Kg}$]

(20) एक संचायक बैटरी, H_2SO_4 का 38% भारतमक विलयन रखती है। यदि $\Delta T_{f(experiment)}$ 22.8K है, तो वाण्ट हॉफ कारक क्या होगा। [दिया है : $K_f = 1.86 \text{ mol}^{-1} \text{ Kg}$]

Ans. 1.96

Ans. to depression in freezing point,

depression in freezing point = ΔT_f

$$= T_f - T_f'$$

T_f = freezing point of pure solvent

T_f' = n u u solution

K_f = cryoscopic constant or
molal depression constant

m = molality of soln;

i = van't Hoff factor

consider 100 gm soln; \Rightarrow wt H_2SO_4 = 38 gm

$$\Rightarrow n_{H_2SO_4} = 0.3877$$

$$\Rightarrow \text{wt}_{H_2O} = 62 \text{ gm} = 0.062 \text{ kg}$$

$$\Rightarrow \text{molality} = \frac{0.3877}{0.062} = 6.254 \frac{\text{mol}}{\text{kg}}$$

$$\Delta T_f = 22.8 \text{ K} = 1.86 \frac{\text{K} \cdot \text{kg}}{\text{mol} \cdot \text{K}} \times 6.254 \frac{\text{mol}}{\text{kg}} \times i$$

$$\Rightarrow i = 1.96$$

(21) A certain mass of a substance, when dissolved in 100 g C₆H₆, lowers the freezing point by 1.28°C. The same mass of solute dissolved in 100g water lowers the freezing point by 1.40°C. If the substance has normal molecular weight in benzene and is completely ionized in water, into how many ions does it dissociate in water? K_f for H₂O and C₆H₆ are 1.86 and 5.12K kg mol⁻¹.

(21) पदार्थ के एक निश्चित द्रव्यमान को जब 100 g C₆H₆ में घोला जाता है तो हिमांक में 1.28°C की कमी आती है। समान द्रव्यमान वाले विलेय को 100g जल में घोला जाता है तो हिमांक में 1.40°C की कमी आती है। यदि पदार्थ बैंजीन में सामान्य अणुभार रखता है तथा जल में पूर्णतया आयनीकृत होता है, यह जल में कितने आयनों में वियोजित होता है ? H₂O तथा K_f for H₂O and C₆H₆ are 1.86 and 5.12K kg mol⁻¹.

Ans. 3 ions

Ans. to depression in freezing point,

$$\text{depression in freezing point} = \Delta T_f \\ = T_f - T_f'$$

T_f = freezing point of pure solvent

T_f' = " " " solution

K_f = cryoscopic constant or
molal depression constant

m = molality of solute

i = van't Hoff factor

normal molecular wt. in benzene means that
the solute is neither dissociating nor
associating ; $\Rightarrow i_{\text{benzene}} = 1$

complete dissociation in water means ; $x=1$

$$\Rightarrow i_{\text{water}} = 1 + (y-1)(1) = y$$

$$\Rightarrow \frac{(i_f)_\text{benzene}}{(i_f)_\text{water}} = \frac{(k_f)_\text{benzene} \times m \times i_\text{benzene}}{(k_f)_\text{H}_2O \times m \times i_\text{water}}$$

molarity \Rightarrow same in both the solvents;

$$\Rightarrow \left(\frac{1.28}{1.4} \right) = \left(\frac{5.12}{1.86} \right) \times \frac{1}{i_{\text{water}}}$$

$$\Rightarrow i_{\text{water}} = 3 = y_{\text{water}}$$

- (21) 2.0 g of benzoic acid dissolved in 25.0g of benzene shows a depression in freezing point equal to 1.96K. Molal depression constant (K_f) of benzene is 4.9 K.kg.mol⁻¹. What is the percentage association of the acid?
- (22) 25.0g बैंजीन में जब 2.0 g बैंजोइक अम्ल को घोला जाता है तो हिमांक में 1.62K की कमी आती है। बैंजीन का मोलल अवनमन स्थिरांक (जी) 4.9 K.kg.mol⁻¹ gΣA अम्ल का प्रतिशत संगुणन क्या है?
- Ans. 78 %

Ans. to depression in freezing point

$$\text{depression in freezing point} = \Delta T_f \\ = T_f - T_f'$$

T_f = freezing point of pure solvent

T_f' = " " " solution

K_f = cryoscopic constant or
molal depression constant

m = molality of solute

i = Van't Hoff factor

$$\text{molality} = \frac{\frac{2g}{122\text{ g/mol}}}{0.025\text{ kg}} = 0.655 \frac{\text{mol}}{\text{kg}}$$

$$\Delta T_f = 1.96 \text{ K} = \left(4.9 \frac{\text{K} \cdot \text{kg}}{\text{mol}} \right) \times 0.655 \frac{\text{mol}}{\text{kg}} \times i$$

$\Rightarrow i = 0.61 \Rightarrow i < 1 \Rightarrow$ association taking place



$$\Rightarrow 0.61 = 1 + \left(\frac{1}{2} - 1 \right) \alpha \Rightarrow \alpha = 0.78$$

(23) A decimolar solution of potassium ferrocyanide is 50% dissociated at 300K. Calculate the osmotic pressure of the solution. ($R=8.314 \text{ JK}^{-1} \text{ mol}^{-1}$)

(23) 300K पर पोटेशियम फेरोसायनाइड के डेसी मोलर विलयन का 50% वियोजन होता है। विलयन के परासरण दाब की गणना कीजिए। ($R=8.314 \text{ JK}^{-1} \text{ mol}^{-1}$)

Ans. $7.482 \times 10^5 \text{ Nm}^{-2}$

According to osmotic pressure equation;

$$\pi = CRT \times i; \text{ where}$$

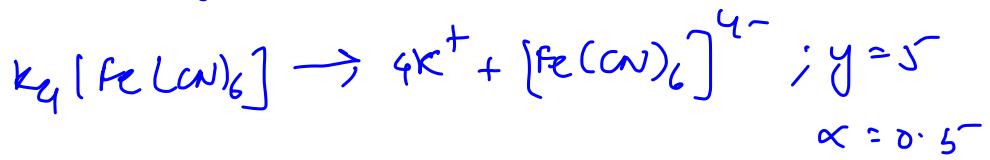
π = osmotic pressure of the solution

c = molarity of the solution

$$R = 0.0821 \frac{\text{L-atm}}{\text{mol}\cdot\text{K}}$$

T = Temperature of the solution

$$i = 1 + (y-1)\alpha$$



$$\therefore i = 1 + (5-1)(0.5) = 3$$

$$\therefore \pi = \left(0.1 \frac{\text{mol}}{\text{L}} \times 10^3 \frac{\text{L}}{\text{m}^3}\right) \left(8.314 \frac{\text{J}}{\text{mol}\cdot\text{K}}\right) \times (300\text{K}) \times 3$$
$$= 7.482 \times 10^5 \text{ N/m}^2$$

(24)

A 1.2% solution (w/v) of NaCl is isotonic with 7.2% solution (w/v) of glucose. Calculate degree of ionization and Van't Hoff factor of NaCl.

(24) A 1.2% solution (w/v) of NaCl is isotonic with 7.2% solution (w/v) of glucose. Calculate degree of ionization and Van't Hoff factor of NaCl.

Ans. 0.95; 1.95

According to osmotic pressure equation;

$$\pi = CRT \times i; \text{ where}$$

π = osmotic pressure of the solution

c = molarity of the solution

$$R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

T = Temperature of the solution

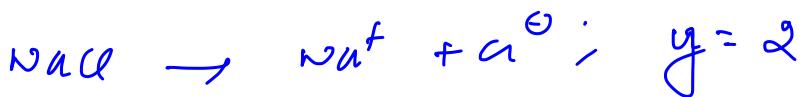
$$\% \text{ w/v} = \frac{\text{wt. of solute (g)}}{\text{vol. of solution (ml)}} \times 100$$

$$= \frac{n_{\text{solute}} \times M_{\text{solute}}}{\text{vol. of solution (ml)} \times 1000} \times 100$$

$$= \frac{\text{molarity} \times M_{\text{solute}}}{1000}$$

$$\pi_{\text{NaCl}} = \pi_{\text{Glucose}}$$

$$\Rightarrow (CRT \times i)_{\text{NaCl}} = (CRT \times i)_{\text{Glucose}}$$



$$\Rightarrow i_{\text{NaCl}} = 1 + (z-1)\alpha = (1+\lambda)$$

$$i_{\text{Glucose}} = 1$$

$$\Rightarrow c_{\text{NaCl}} \times i_{\text{NaCl}} = c_{\text{Glucose}} \times i_{\text{Glucose}}$$

$$\Rightarrow \left(\frac{10 \times 1.2}{58.5} \right) (1+\lambda) = \left(\frac{10 \times 7.2}{180} \right) \times 1$$

$$\Rightarrow \lambda = 0.95$$

$$i_{\text{NaCl}} = 1 + \lambda \approx 1.95$$

25

How many gm O₂ gas will dissolve in 100 gm water at 9 bar and 27°C? (K_H = 40 Kbar)

Ans. 0.04

Acc. to Henry's law;

$$p_i = k_H \cdot x_i ; \text{ where;}$$

p_i = partial pressure of gas above the liquid

x_i = mole fraction of gas in the liquid

K_H = Henry's constant

$$\Rightarrow 9 \text{ bar} = 40 \times 1000 \text{ bar} \times \frac{n_{O_2}}{n_{O_2} + \left(\frac{100}{18} \right)}$$

$$\Rightarrow n_{O_2} \approx \frac{9}{40000} \times \frac{100}{18}$$

$$\Rightarrow w_{O_2} = 0.04 \text{ gm}$$

(26) The Henry law constant for dissolution of a gas in aqueous medium is 3×10^2 atm. At what partial pressure of the gas (in atm), the molality of gas in aqueous solution will be $\frac{5}{9}$ m.

(26) जलीय माध्यम में गैस के विलायकन के लिए हेनरी नियम स्थिरांक 3×10^2 atm है। गैस के किस आंशिक दाब (atm में) पर जलीय विलयन में गैस की मोललता $\frac{5}{9}$ m. होगी।

Ans.(3)

Acc. to Henry's law;

$$p_i = k_h \cdot \chi_i ; \text{ where;}$$

p_i = partial pressure of gas above the liquid

χ_i = mole fraction of gas in the liquid

k_h = Henry's constant

$$\text{molality} = \frac{n_{\text{solute}}}{\text{wt. solvent (kg)}} = \frac{5}{9}$$

\Rightarrow consider 900 gm of water

$$\Rightarrow n_{\text{solute}} = 0.5$$

$$\Rightarrow n_{H_2O} = \frac{900 \text{ g}}{18 \text{ g/mol}} = 50 \text{ mol}$$

$$\Rightarrow p = (3 \times 10^2 \text{ atm}) \times \left(\frac{0.5}{50} \right) = 3 \text{ atm}$$

