Chapter13. Dilute Solution and Colligative Properties

Q1.

Sol: 2 g of urea $CO(NH_2)_2$

$$n_{urea} = \frac{2}{12+16+2(16)} = \frac{2}{60} = \frac{1}{30} = 0.0333$$

Wt. of water = 31.4 g

$$\therefore n'_{water} = \frac{31.4}{18} = 1.744$$

$$\therefore X_{urea} = \frac{n_{urea}}{m_{urea} + n_{water}} = \frac{0.0333}{1.7777} = 0.018 \approx 0.02 \quad \textbf{Ans}$$

$$X_{water} 1 - X_{urea} = 1 - 0.02 = 0.98 \quad \textbf{Ans}$$

Q2.

Sol: When solution is very dilute

molality ≈ molarity

& when solution is not dilute then molality ≠ molarity

Q3.

Sol: Wt of sugar $(C_{12}H_{22}O_{11}) = 34.2g$

Total wt of sugar syrup = 214.2g

Wt of water (solved) = 214.2-34.2=180 g

$$\therefore \text{molality} = \frac{34.2/342}{180} \times 1000 = \frac{10}{8} = 0.556\text{m}$$

$$X_{sugar} = \frac{\frac{34.2}{342}}{\frac{34.2}{342} + \frac{180}{18}} = \frac{0.1}{0.1+10} = \frac{0.1}{10.1} = 0.0099 \quad \textbf{Ans}$$

Q4.

Sol: $$\text{molality} = 4\text{ m} = \frac{ns}{\text{wt of solvent}} \times 1000$$

$$X_s = \frac{n_s}{n_s + n_{Solvent}} = \frac{\frac{n_s}{\text{wt of solvent}}}{\frac{n_s}{\text{wt of solvent}} + \frac{n_{solvent}}{\text{wt of solvent}}}$$

$$= \frac{\frac{4}{1000}}{\frac{4}{1000} + \frac{1}{18}} \quad \because \text{Since solvent is water } \left(\frac{n_{water}}{W_{water}} = \frac{1}{M.w_{Water}} = \frac{1}{18}\right)$$

$$= \frac{0.004}{0.0595} = 0.0672 \quad \textbf{Ans}$$

Q5.

Sol: % by wt = 70%

Sp. Gravity = 1.42

$d_{sol^n} = 1.42 g/ml$

$$\therefore \text{Molarity} = \frac{\%\text{ by wt} \times \text{density} \times 10}{\text{Mol.wt}} = \frac{70 \times 1.42 \times 10}{63} = \frac{142 \times 7}{639} = 15.8\,M \quad \textbf{Ans}$$

Now since V.f. of $HNO_3 = 1$

$\therefore$ Mol. Wt. = Eq.Wt.

& Molarity = Normality

Q6:

Sol:- $\%\text{ by wt of NaCl} = \frac{1}{10} \times 100 = 10\%$

$d_{Sol^n} = 1.07\, g/cc$

$$\therefore \text{Molarity} = \frac{\%\text{ by wt} \times d_{Sol^n} \times 10}{\text{M.w}} = \frac{10 \times 1.07 \times 10}{58.5} = 1.829\,M \quad \textbf{Ans}$$

$$\text{Molality} = \frac{1/58.5}{9} \times 1000 = 1.899\,m \quad \textbf{Ans}$$

Q7.

Sol: % by wt = 50% of C_2H_5OH

$\therefore$ Wt of C_2H_5OH = 50g in 50 g of solvent

$$m\,C_2H_5OH = \frac{50/46}{50} \times 1000 = \frac{1000}{46} = 21.7\,M \quad \textbf{Ans}$$

$$\therefore \text{Molarity} = \frac{\%\text{ by wt} \times d_{Sol^n} \times 10}{\text{M.w}} = \frac{50 \times 0.9144 \times 10}{46} = 9.93\,M \quad \textbf{Ans}$$

$$\text{mole fraction} = \frac{50/46}{50/40 + 50/18} = \frac{1.087}{1.087 + 2.778} = 0.281 \quad \textbf{Ans}$$

Q8.

Sol: $$\text{Molarity} = \frac{n_{solute}}{V_{solution}} \times 1000 = \frac{n_{Solute}}{\text{wt solution}} \times d_{Solution} \times 1000$$

$$M = \frac{n_{solute}}{Wt_{Solute} + Wt_{Solvent}} \times d_{solution} \times 1000 = \frac{\frac{n_{Solute}}{Wt_{Solvent}} \times 1000 \times d_{solution}}{\left(\frac{Wt_{solute}}{Wt_{solvent}} + \frac{Wt_{solvent}}{Wt_{solvent}}\right)}$$

$$M = \frac{m \times d_{Sol}}{\left(\frac{n_{Solute} \times M_{Solute}}{Wt_{solvent}} + 1\right)} \Rightarrow M = \frac{m \times d_{Sol^n}}{\left(\frac{m}{1000} \times M' + 1\right)}$$

$$d_{solution} = M\left(\frac{M'}{1000}+\frac{1}{m}\right)$$ **Ans**

Q9.

Sol: 400 g with 20% solution

$\therefore$ Wt of solute = $400 \times \frac{20}{100} = 80g$

$\therefore$ 50 g has precipitated,

So 30 g has remained, Wt of sol = 350 g

$\therefore$ % bt wt of solute = $\frac{30}{350} \times 100 = \frac{300}{35} = 8.6\%$ **Ans**

Q10.

Sol: 25 g of $CuSO_4.5H_2O$

$\because$ 249.5 of $CuSO_4.5H_2O$ contains 159.59 of $CuSO_4$

$\therefore 1$ ——————— $\frac{159.5}{249.5}$

$\therefore 25$ ——————— $\frac{159.5}{249.5} \times 25 = 15.98\,g$

For 8% sol, Let x is the wt of solution

$$x \times \frac{8}{100} = 15.98$$

$$x = \frac{1598}{8} = 199.75\,g$$

$\therefore$ Wt of water = 199.75 – 25 = 174.75 g **Ans**

Q11.

Sol: $V_{Water} = 1$ lit, d = 1000 g / lit

$W_{Water} = V.d = 1000\,g$

wt of sol^n = $500 \times 1.20 = 600\,g$

Total wt of sol = 1600 g

Also wt of $HNO_3 = 600 \times \frac{32}{100} 192\,g$

$\therefore$ % by wt of $HNO_3 = \frac{192}{1600} \times 100 = 12.0\%$ **Ans**

Q12.

Sol: Total wt of solution = 300 + 400 = 700 g

Total wt of solute = $300 \times \frac{25}{100} + 400 \times \frac{40}{100}$

= 75 + 160 = 235 g

$\therefore$ % by wt (Now) = $\frac{235\,g}{700\,g} \times 100 = 33.57\%$ **Ans**

Q13.

Sol: $$\text{Nomality} = \frac{\%\text{ by wt} \times d_{\text{Sol}^n} \times 10}{\text{Eg.wt}}$$

$$9.28 = \frac{\%\text{ by wt} \times 1.31 \times 10}{40}$$

$$\%\text{ by wt} = \frac{9.28 \times 4}{1.31} = 28.336\% \qquad \textbf{Ans}$$

Q14.

Sol: $$X_{\text{Solute}} = \frac{P^0_{\text{Solvent}} - P_{\text{Solution}}}{P^0_{\text{Solvent}}} = \frac{2}{100}$$

$$\frac{n_{\text{Solute}}}{n_{\text{Solute}} + n_{\text{Solvent}}} = \frac{2}{100}$$

$$\frac{\dfrac{n_{\text{Solute}}}{wt_{\text{solvent}}}}{\dfrac{n_{\text{solute}}}{wt_{\text{solvent}}} + \dfrac{n_{\text{Solute}}}{wt_{\text{Solvent}}}} = \frac{2}{100}$$

$$\frac{\dfrac{m}{1000}}{\dfrac{m}{1000} + \dfrac{1}{18}} = \frac{2}{100} \Rightarrow \frac{18\,m}{18\,m + 1000} = \frac{2}{100}$$

$$\Rightarrow 1800\,m = 36m + 2000 \Rightarrow m = \frac{2000}{1764} = 1.134 \qquad \textbf{Ans}$$

Q15.

Sol: $$X_{\text{Sucorse}} = \frac{\dfrac{1.68}{342}}{\dfrac{1.68}{342} + \dfrac{15.6}{18}} = \frac{\dfrac{1}{200}}{\dfrac{1}{200} + 0.867} = \frac{5 \times 10^{-3}}{0.872} = 5.734 \times 10^{-3}$$

At $100^\circ C, P^0_{\text{Solvent}} = 760$ torr

$$\therefore \frac{P^0_{\text{Solvent}} - P_{\text{Solution}}}{P^0_{\text{Solvent}}} = 5.734 \times 10^{-3}$$

$$P_{\text{solution}} = 760 - 760 \times 5.734 \times 10^{-3}$$

$$= 760 - 4.358 = 755.6 \text{ torr}$$

$\therefore P_{\text{Solution}} = 755.6$ torr $= 755.56$ cm of Hg **Ans**

($\because$ 1 torr = 1mm of Hg)

Q16.

Sol: $$X_{\text{Solute}} = \frac{760 - 756}{760} = \frac{4}{760}$$

⇨ $$\frac{n_{solute}}{n_{sovent}}=\frac{4}{756}\left(\because \frac{n_s}{n_{solvent}}=\frac{P^0{}_{solvent}-P_{solutin}}{P_{solution}}\right)$$

⇨ $$\frac{\dfrac{\text{wt solute}}{342}}{\dfrac{1000}{18}}=\frac{4}{756}$$

$$\text{Wt of solute}=\frac{4\times 342\times 1000}{756\times 18}=100.53\,g \qquad \textbf{Ans}$$

Q17.

Sol: $$\Rightarrow \frac{n_{Solute}}{n_{solvent}}=\frac{P^0{}_{Solvent}-P_{solution}}{P_{Solution}}=\frac{442-410}{410}$$

⇨ $$\frac{\dfrac{6.1g}{M_{solute}}}{50/74}=\frac{32}{410} \quad \Rightarrow \frac{6.1}{M_{Solute}}\times\frac{74}{50}=\frac{32}{410}$$

$$M_{Solute}=\frac{6.1\times 74\times 410}{50\times 32}=115.67\,g \qquad \textbf{Ans}$$

Q18.

Sol: $P^0{}_{CCl_4}=143\,\text{mm of Hg}$

$\text{Wt of } CCl_4 = V_{CCl_4}\times d_{ccl_4}=100\times 1.58=158\,g$

$$\therefore n_{CCl_4}=\frac{158}{12+4\times 35.5}=\frac{158}{154}=1.026$$

$W_{non\ volatile}=0.5\,g$

$$n_{Solute}=\frac{0.5}{65}=7.7\times 10^{-3}$$

$$\therefore X_{Solute}=\frac{n_{Solute}}{n_{total}}=\frac{7.7\times 10^{-3}}{1.0337}=\frac{143-P_{solution}}{143}$$

$$P_{Solution}=143-143\times 7.45\times 10^{-3}=141.93\,\text{mm of Hg} \qquad \textbf{Ans}$$

Q19.

Sol: $$X_{Solute}=\frac{P_{water}-P_{sol^{-n}}}{P_{Water}} \quad \Rightarrow P_{Sol^{-n}}=P_{water}(1-X_{Solute})$$

$$\text{For molality}=1m; \quad X_{Solute}=\frac{n_{Solute}}{n_{Solute}+n_{Solvent}}=\frac{\dfrac{n_{Solute}}{wt_{Solvent}}}{\dfrac{n_{Solute}}{wt_{Solvent}}+\dfrac{n_{Solvent}}{wt_{Solvent}}}$$

$$X_{Solute} = \frac{\frac{m}{1000}}{\frac{m}{1000}+\frac{1}{18}} = \frac{\frac{1}{1000}}{\frac{1}{1000}+\frac{1}{18}} = \frac{0.001}{0.001+0.055} = 0.0177$$

$\therefore P_{solution} = P_{water}(1 - x_{solute})$

For (b), X_{Solute} is less, so $P_{solution}$ will be higher.

Q20.

Sol: $X_{Solute} = \frac{20/140}{\frac{20}{140}+\frac{80}{18}} = \frac{0.1428}{4.587} = 0.03$

$P_{solution} = X_{Solute}.P_{Solute} + X_{solvent} + P_{solvent}$

$160 = 0.031 \times P^{0}solute + (1 - 0.0311) \times 150$

$160 - 144.42 = 0.03.P^{0}{}_{Solute}$

$\frac{14.58}{0.031} = P^{0}{}_{Solute}$

$P^{0}{}_{Solute} = 470.5\,mm\,of\,Hg$ **Ans**

Q21.

Sol: $d_{benzene} = 0.879 g/cc$ & $d_{toulene} = 0.867 g/cc$

If V is the volume % of benzene

% of toluene = (100-V) ml

$\therefore$ Total mass (100 ml) $= V_{benzene} \times d_{benzene} + V_{total} \cdots_{toulene}$

$= V \times 0.879 + (100 - V) \times 0.867$

$\therefore d_{sol-^{n}} = \frac{total\,mass}{total\,vol.} = \frac{0.879V + 0.867(100 - V)}{100}$ **Ans**

Q22.

Sol: $P^{0}{}_{ethanol} = 44.5\,mm\,of\,Hg$ & $P^{0}{}_{Methanol} = 88.7\,mm\,of\,Hg$

$n_{ethanol} = \frac{W_{ethanol}}{M_{ethanol}} = \frac{60g}{46g} = 1.30$ & $n_{Methanol} = \frac{W_{methanol}}{M_{methanol}} = \frac{40g}{32} = 1.25$

$\therefore X_{ethanol} = \frac{1.3}{1.3+1.25} = 0.51$

$X_{methanol} = \frac{1.25}{1.3+1.25} = 0.49.$ **Ans**

$P_{total} = X_{eth}.P^{0}{}_{eth} + X_{met}P^{0}{}_{meth}$

$= 0.51 \times 44.5 + 0.49 \times 88.7 = 66.16\,mm\,of\,Hg$

$\therefore P'_{ethanol} = X_{eth}.P^{0}{}_{eth} = 0.51 \times 44.5 = 22.7\,mm\,of\,Hg$ **Ans**

$P'_{Methanol} = X_{meth}.P^{0}{}_{meth} = 0.49 \times 88.7 = 43.46\,mm\,of\,Hg$ **Ans**

$$\therefore X_{ethanol} = \frac{P'_{ethanol}}{P_{total}} = \frac{22.7}{66.16} = 0.34$$ **Ans**

Q23.

Sol: $P^0_b = 22$ mm of Hg. $P^0_T = 75$ mm of Hg & $P^0_{Solution} = 50$ mm of Hg

Let mole fraction of benzene is = X_b

mole fraction of toluene is = $1\text{-}X_b$

$$\therefore P_{solution} = V_b.P^0_b + X_T.P^0_T$$

$$50 = X_b.22 + (1 - X_b).75$$

$$50 = 75 + X_b(22 - 75) = 75 - 53X_b$$

$$\Rightarrow 53X_b = 75 - 50 = 25$$

$$\therefore X_b = \frac{25}{53} = 0.47$$

∴ mole fraction of benzene = 0.47

Mole fraction of toluene = $X_T = 1\text{-}\ X_b\} = 0.53$ **Ans**

$$\text{In vapor phase } X'_b = \frac{X_b.P^0_b}{P_{total}} = \frac{0.47\times22}{50} = 0.20$$

$$\therefore X'_T = \frac{X_T.P^0_T}{P_{total}} = \frac{0.53\times75}{50} = 0.80$$ **Ans**

Q24.

Sol: $P_{solution} = 290$ mm of Hg

$P^0_{P.A} = 210$ mm of Hg

$X_{E.A} = 0.65$

$$\therefore X_{P.A} = 1 - X_{E.A} = 1 - 0.65 = 0.35$$

$$\therefore P_{solution} = X_{E.A.}P^0_{E.A} + X_{P.A}P^0_{P.A}$$

$$290 = 0.65P^0_{E.A} + 0.35\times210$$

$$P^0_{E.A} = \frac{290 - 73.5}{0.65} = 333.12 \text{ mm of Hg}$$ **Ans**

Q25.

Sol: For equal no. of molecules of benzene & toluene, they have equal moles & so mole fraction of each one will be $\frac{1}{2}$

$$X_b = X_T = \frac{1}{2}$$

$P^0_b = 95.1$ mm of Hg & $P^0_T = 28.4$ mm of Hg

$$P_{solution} = X_b.P^0_b + X_T.P^0_T$$

$$= \frac{1}{2}\times95.1 + \frac{1}{2}\times28.4 = 61.75 \text{ mm of Hg}$$

$$\frac{P^0_{Water} - P_{Sol^n}}{P^0_{Water}} = X_{Solute} \Rightarrow \frac{2338-2295.8}{2338} = \frac{42.4}{2338} = 0.018$$

$$\therefore X_{Solute} = 0.018$$

$$\frac{n_{Solute}}{n_{Solute}+n_{Solvent}} = 0.018 \Rightarrow \frac{n_{Solute}/wt_{solvent}}{\frac{W_{Solute}}{W_{Solvent}} + \frac{n_{Solvent}}{n_{Solvent}}} = 0.018 \Rightarrow \frac{m/1000}{m/1000 + \frac{1}{18}} = 0.018$$

$$\frac{18m}{18m+1000} = 0.018$$

$$18\text{ m} = 0.325\text{ m} + 18$$

$$(17.675)\text{ m} = 18 \Rightarrow \text{m} = 1.0184$$

Now; $d = M\left(\frac{1}{m} + \frac{M'}{1000}\right)$

$$1.01 = M\left(\frac{1}{1.0184} + \frac{60}{1000}\right)$$

$$M = \frac{1.01}{\left(\frac{1}{1.084} + \frac{6}{100}\right)} = 0.98$$

$$\therefore \pi = MRT$$

$$= 0.98 \times 0.0821 \times 313 = 25.18\,\text{atm} = 2.55 \times 10^6\ \text{Pa}$$ **Ans**

$(\because 1\ \text{atm} \approx 1.01325 \times 10^5\ \text{Pa})$

Q30.

Sol: $\pi = CRT = \left(\frac{4.48/286}{100} \times 1000\right) 0.0821 \times 298$

C is the molarity of the solution

$\pi = 3.83$ atm **Ans**

Q31.

Sol: Wt of the solute = 10.1 g

In vapour phase, volume of this amount of solute = 4 lit

at $T = 100^0C = 313$ K

$P = 70$ cm of Hg

$PV = nRT$

$PV = \frac{W}{M}RT \quad M = \frac{WRT}{PV} = \frac{10.1 \times 0.0821 \times 373}{4 \times 70/76} = 84$ g

Molarity of 2% (2g per 100 ml of sol-^{n}) $= \frac{2/84}{100} \times 1000 = \frac{20}{84} = 0.238$

$\therefore \pi = CRT = 0.238 \times 0.821 \times 273 = 5.336$ atm **Ans**

$$\frac{P^0_{\text{Water}} - P_{\text{Sol}^n}}{P^0_{\text{Water}}} = X_{\text{Solute}} \Rightarrow \frac{2338-2295.8}{2338} = \frac{42.4}{2338} = 0.018$$

$$\therefore X_{\text{Solute}} = 0.018$$

$$\frac{n_{\text{Solute}}}{n_{\text{Solute}} + n_{\text{Solvent}}} = 0.018 \Rightarrow \frac{n_{\text{Solute}}/\text{wt}_{\text{solvent}}}{\frac{W_{\text{Solute}}}{W_{\text{Solvent}}} + \frac{n_{\text{Solvent}}}{n_{\text{Solvent}}}} = 0.018 \Rightarrow \frac{m/1000}{m/1000 + \frac{1}{18}} = 0.018$$

$$\frac{18\,m}{18\,m + 1000} = 0.018$$

$$18\text{ m} = 0.325\text{ m} + 18$$

$$(17.675)\text{ m} = 18 \Rightarrow \text{m} = 1.0184$$

$$\text{Now; } d = M\left(\frac{1}{m} + \frac{M'}{1000}\right)$$

$$1.01 = M\left(\frac{1}{1.0184} + \frac{60}{1000}\right)$$

$$M = \frac{1.01}{\left(\frac{1}{1.084} + \frac{6}{100}\right)} = 0.98$$

$$\therefore \pi = MRT$$

$$= 0.98 \times 0.0821 \times 313 = 25.18\,\text{atm} = 2.55 \times 10^6\text{ Pa} \quad \textbf{Ans}$$

$$(\because 1\text{ atm} \approx 1.01325 \times 10^5\text{ Pa})$$

Q30.

Sol: $\pi = CRT = \left(\frac{4.48/286}{100} \times 1000\right) 0.0821 \times 298$

C is the molarity of the solution

$\pi = 3.83$ atm **Ans**

Q31.

Sol: Wt of the solute = 10.1 g

In vapour phase, volume of this amount of solute = 4 lit

at T = 100°C = 313 K

P = 70 cm of Hg

$PV = nRT$

$$PV = \frac{W}{M}RT \quad M = \frac{WRT}{PV} = \frac{10.1 \times 0.0821 \times 373}{4 \times 70/76} = 84\text{ g}$$

$$\text{Molarity of 2\% (2g per 100 ml of sol}^n) = \frac{2/84}{100} \times 1000 = \frac{20}{84} = 0.238$$

$$\therefore \pi = CRT = 0.238 \times 0.821 \times 273 = 5.336\text{ atm} \quad \textbf{Ans}$$

Q32.

Sol: $\pi = 7.7\,\text{atm at } 40^0\text{C}$

$$\text{(a) } \pi = CRT \quad \Rightarrow C = \frac{\pi}{RT} = \frac{7.7}{0.0821 \times 313} = 0.29\,\text{mole}/\text{lit}$$

(b) $m \approx 0.29$

$$\therefore \Delta T_f = K_f \times m = 1.86 \times 0.29 = 0.5394^0\text{C}$$

$$\therefore T^0_f - T_{f\,sol^n} = 0.5394^0\text{C}$$

$$0 - T_{f\,sol^n} = 0.5394^0\text{C}$$

$$\Rightarrow T_{f\,sol^n} = -0.5394^0\text{C} \qquad \textbf{Ans}$$

Q33.

Sol: For isotonic solution, osmotic pressure are same as at same temperature

$$\pi_{glucose} = \pi_{glycerene}$$

$$C_{glu}.RT = C_{gly}.RT$$

$$\Rightarrow \frac{n_{glu}}{\text{volume sol}^n} = \frac{n_{gly}}{\text{volume of sol}^n}$$

$$\Rightarrow \frac{10.2/M.W}{1\,\text{lit}} = \frac{2/180}{100} \times 1000$$

$$M.W. = \frac{10.2 \times 18}{2} = 91.8\,g \qquad \textbf{Ans}$$

Q34.

Sol: Wt of Sucrose = 45 g /lit

Mol. wt = 343

$\pi = 2.97\,\text{atm at } 273\ K.$

$\pi = CRT$

$$2.97 = \frac{45/343}{1} \times R \times 273$$

$$R = \frac{2.97 \times 343}{45 \times 273} = 0.0827\,\text{lit -atm / mol-K} \qquad \textbf{Ans}$$

Q35.

Sol: $\Delta T_f = K_f \times m$

$$= K_f \times \frac{wt_{solute}}{Mol.wt_{solute} \times wt_{solvent}} \times 1000$$

$$= 1.86 \times \frac{6.84}{342 \times 500} \times 1000 \quad (\text{Sucrose } C_{12}H_{22}O_{11})$$

$$= 0.0741^0\text{C}$$

$$\therefore 0 - T'_{sol} = 0.0744\,(\text{Freezing pt. of water} = 0^0\text{C})$$

$T_{f\,sol-n} = -0.0744^{0}C$ **Ans**

Q36.

Sol: $\Delta T_f = 10^{0} = K_f \times m$

$$= 1.86 \times \frac{Wt_{Solute}}{M.w_{Glycerol} \times Wt_{Solvent}} \times 1000$$

$$10 = 1.86 \times \frac{Wt_{Solute}}{92\,g \times 1000} \times 1000 \quad M.W.\ Glycerol = 92\ g$$

$$\therefore wt_{solvent} = \frac{92 \times 10}{1.86} = 494.6g \quad \textbf{Ans}$$

Q37.

Sol: Percentage by wt of urea = 10% & % by wt of glucose = 5%

$$m_{urea} = \frac{10/60}{85} \times 1000 = \frac{1000}{85 \times 6} = 1.96$$

$$m_{glucose} = \frac{5/180}{85} \times 1000 = \frac{5 \times 1000}{180 \times 85} = 0.3268$$

$$\therefore m = m_{ureal} + m_{glu} = 1.96 + 0.3268 = 2.2876$$

$$\therefore \Delta T_f = K_f \times m = 1.8 \times 2.2876 = 4.255^{0}C$$

$$0 - T_{f\,sol-n} = 4.255^{0}C \quad \therefore T_{f\,sol-n} = -4.255^{0}C \quad \textbf{Ans}$$

Q38.

Sol: Let a particular wt is bought, then

$$\Delta T_f = K_f \times \frac{W_{Solute}}{Mol.wt_{Solute} \times Wt_{Solvent}} \times 1000$$

So that solute will lower the freezing point more this has lower molecular wt.

Since M.W.(CH_3OH) < M.W.(C_3H_5OH)

$\therefore$ So CH_3OH will lower the freezing point more at the same price, so it will be better anti freeze.

Q39.

Sol:- Let w is the wt of ice that separates out it 25g of glycol ($C_2H_4(OH)_2$) is added to 100g of water

$\therefore$ Wt of solvent now = (100 – w)

For this wt of solvent, $\Delta T_f = 10^{0}C$, since the solution is freezed up to $-10^{0}C$

$$\Delta T_f = 10^{0}C = K_f \times m$$

$$10 = 1.86 \times \frac{25}{62 \times (100 - w)} \times 1000 \quad \Rightarrow 100 - w = \frac{25 \times 100 \times 1.86}{62} = 75$$

W = 100 – 75 = 25 g **Ans**

Q40.

Sol: Let $\frac{V_{Water}}{V_{C_2H_6O_2}} = x$ for which solution freeze at $-10\,^0C$

$$\frac{V_{C_2H_6O_2}}{V_{Water}} = \frac{1}{x} \Rightarrow \frac{\frac{wt_{C_2H_6O_2}}{1.12}}{\frac{wt\,H_2O}{1}} = \frac{1}{x}$$

$$\frac{wt_{C_2H_6O_2}}{1.12\times wt_{H_2O}} = \frac{1}{x} \Rightarrow \frac{wt_{C_2H_6O_2}}{wt_{H_2O}} = \frac{1.12}{x}$$

now, $m = \frac{wt_{C_2H_6O_2}}{62\times wt_{H_2O}}\times 1000 = \frac{1.12}{62x}\times 1000 \quad \therefore m = \frac{1120}{62x}$

Now , $\Delta T_f = K_f \times m \Rightarrow 1.86\times\frac{1120}{62x} = 10 \Rightarrow x = 3.36$ **Ans**

Q41.

Sol: Osmotic pressure = dgh = $0.88\times 980\times 0.24$ cm

$$= \frac{206.976\,g}{cm-sec^2} = \frac{206.976\times 10^{-3}\,kg}{10^{-2}\,m-sec^2} = 20.6976\ N\text{-}m^2$$

Now π = CRT

$$20.6976 = \left(\frac{0.2/M.w}{100}\times 1000\right)\times 10\times 8.314\times 298$$

$M.w = \frac{2\times 8.314\times 298\times 10^3}{20.6976} = 2.39\times 10^5$ **Ans**

Q42.

Sol: $\Delta T_f = 5.3$

$K_f = 39.7$

$$\Delta T_f = K_f\times\frac{wt_{Solute}}{M.w_{Solute}\times wt_{camphor}}\times 1000$$

$$5.3 = 39.7\times\frac{0.1}{M.w_{Solute}\times 5}\times 1000$$

$M.W_{Solute} = \frac{39.7\times 100}{5.3\times 5} = 150\,g$ **Ans**

Q43.

Sol: $\Delta T_S = K_b\times m$

$$(100.39-100)^0C = 0.52\times\frac{Wt_{Solute}}{M.w_{Solute}\times Wt_{Solvent}}\times 1000$$

$$0.39^0C = 0.52\times\frac{1.23g}{M.w_{Solute}\times 1\cancel{0}}\times 100\cancel{0}$$

$$M.W_{Solute} = \frac{0.52\times123}{0.39} = 164\,g \quad \textbf{Ans}$$

Q44.

Sol: For 1 g of AB_2, $\Delta T_f = 2.3$

$$\Delta T_f = K_f \times \frac{1}{M.w\times20}\times1000$$

⇨ $$M.w = \frac{5.1\times100}{2.3\times2} = 110.87\,g$$

Similarly For 1 g of AB_4, $\Delta T_f = 1.3$

$$\Delta T_f = Kf \times \frac{1}{M.w_{AB_4}\times20}\times1000$$

⇨ $$M.w_{AB_4} = \frac{5.1\times100}{2\times1.3} = 196.154\,g$$

$\therefore$ At. wt. $_A$ + 2 At. Wt. $_B$ = 110.87 g

At.wt A + 4.At.wt. B = 196.154 g

2At.wt.$_B$ = 85.284

$$At.wt._B = \frac{85.284}{2} = 42.64\,g \quad \textbf{Ans}$$

$\therefore$ At. Wt.$_A$ = 110.87 − 85.284 = 25.58 g **Ans**

Q45.

Sol: $\Delta T_f = 0-(0.93) = 0.93^\circ C$

$Wt_{glycose} = 45g$ & $Wt_{Water} = 500g$

M.W. of glucose = ?

$$0.93 = Kf \times \frac{45}{M.W\times500}\times2000$$

$$M.W = \frac{1.86\times90}{0.93} = 180\,g$$

Simplest formula: CH_2O

$\therefore$ Wt of simplest formula = 30 g

Mol.wt = 180 g

$$\therefore n = \frac{Mol.wt}{wt\ of\ simplest\ formula} = \frac{180}{30} = 6$$

$\therefore$ Molecular formula = $(CH_2O)_6 = C_6H_{12}O_6$ **Ans**

Q46.

Sol: $$Kb = \frac{RT_b^2}{1000\,lv} = \frac{1.98\times(373)^2}{1000\times539.9} = 0.514^\circ C\,m^{-1} \quad \textbf{Ans}$$

R = 1.98 cal / mole K

$T_b = 373$ K for water

Q47.

Sol: $K_b = 3.88\,^0\text{C.m}^{-1}$

$W_{\text{Camphor}} = 0.3\text{g}$ & $Wt_{\text{Chloroform}} = 25.2$

$\Delta T_b = 0.299^0\text{C}$

$$\Delta T_b = K_b \times \frac{W_{\text{Caphor}}}{M.W_{\text{Caphor}} \times Wt_{\text{Chloroform}}} \times 1000$$

$$0.299 = 3.88 \times \frac{0.3}{M.W_{\text{Camphor}} \times 25.2} \times 1000$$

$$M.W_{\text{Camphor}} = \frac{3.88 \times 300}{0.299 \times 25.2} = 1.54\text{g} \qquad \textbf{Ans}$$

Q48.

Sol: $K_f = \frac{RT_f^{\,2}}{1000\,\ell_f} = \frac{1.98 \times (273)^2}{1000 \times 80} = 0.184^0\text{C}$ **Ans**

Q49.

Sol: $Kb_{CCl_4} = 5.02$

$T^0_{b\,CCl_4} = 76.8^0\text{C}$

Molarity = 1 m

$\therefore \Delta T_b = K_b \times m = 5.02 \times 1$

$T_{\text{Sol-n}} - T^0_b = 5.02$

$T_{\text{Sol-n}} = 5.02 + 76.8 = 81.82^0\text{C}$ **Ans**

Q50.

Sol: $T^0_{b\,CHCl_3} = 61.3^0\text{C}$

$T_{\text{sol}^n} = 69.5^0\text{C}$

$\Delta T_b = 69.5 - 61.3 = 8.2^0\text{C}$

$$\Delta T_b = K_b \times \frac{5.02}{128 \times 18} \times 1000$$

$$K_b = \frac{8.2 \times 128 \times 18}{5020} = 3.76\,\text{Cm}^{-1} \qquad \textbf{Ans}$$

Q51.

Sol: If is the van't hoff factor, then

$\Delta T_b = iK_b \times m$

$$(100.975 - 100) = i \times 0.52 \times \frac{1.23}{164 \times 10} \times 1000$$

$$i = \frac{0.975 \times 164}{123 \times 0.52} = 2.5$$

Now, if x is the degree of dissociation, then

	$Ca(NO_3)_2 \rightleftharpoons$	Ca^{2+}	+ $2NO_3^-$
Initialy	1	0	0
At eq-	**1-x**	**x**	**2x**

$$\therefore i = \frac{1-x+x+2x}{1} = \frac{1+2x}{1} = 2.5 \quad \Rightarrow \quad 0.75 \quad \textbf{Ans}$$

$\therefore$ percentage dissociation = 75%

Q52.

Sol: $\Delta T_f = iK_f \times m$

$$(273 - 272.76) = i \times 1.86 \times \frac{0.5/74.5}{99.5} \times 1000$$

$$i = \frac{0.24 \times 99.5 \times 74.5}{500 \times 1.86} = 1.92$$

$\therefore$ Vant-Hoff factor = i = 1.92

	$KCl \rightleftharpoons$	K^+	+ Cl^-
Initially	1	0	0
At eq:	1 − x	x	x

$$i = \frac{1+x}{1} = 1 + x = 0.92 \qquad x = 0.92 \qquad \textbf{Ans}$$

Q53.

Sol: $K_{f\,CCl_4} = 29.9$

$W_{VCl_4} = 60.26g$

$M.W_{VCl_4} = 51 + 4 \times 35.5 = 193\,g$

W_{CCl_4} taken = 1000 g

$$M_{VCCl_4} = \frac{60.26/193}{1000} \times 1000 = 0.31$$

$\Delta T_f = i K_f \times m_{VCCl_4}$

$$5.415 = i \times 29.9 \times 0.31 \quad => \quad i = \frac{5.415}{9.335} = 0.58$$

	$2VCl_4 \rightleftharpoons$	V_2Cl_8
Initially	1	0
At eq	**1-x**	$x/2$

So total moles $= 1 - x + x/2 = 1 - \frac{x}{2}$

$$i = \frac{1 - x/2}{1} = 0.58 \Rightarrow \frac{x}{2} = 1.058 \Rightarrow x = 0.84$$

moles of VCl_4 at eq^b = (1-x). $\frac{60.26}{193}$ = 0.044 moles **Ans**

Now, if x is the degree of dissociation, then

$Ca(NO_3)_2 \rightleftharpoons Ca^{2+} + 2NO_3^-$

Initialy 1 0 0

At eq- **1-x** **x** **2x**

$\therefore i = \frac{1-x+x+2x}{1} = \frac{1+2x}{1} = 2.5 \Rightarrow 0.75$ **Ans**

$\therefore$ percentage dissociation = 75%

Q52.

Sol: $\Delta T_f = iK_f \times m$

$$(273-272.76) = i \times 1.86 \times \frac{0.5/74.5}{99.5} \times 1000$$

$$i = \frac{0.24 \times 99.5 \times 74.5}{500 \times 1.86} = 1.92$$

$\therefore$ Vant-Hoff factor = i = 1.92

$KCl \rightleftharpoons K^+ + Cl^-$

Initially 1 0 0

At eq: $1-x$ x x

$i = \frac{1+x}{1} = 1 + x = 0.92 \quad x = 0.92$ **Ans**

Q53.

Sol: $K_{f\,CCl_4} = 29.9$

$W_{VCl_4} = 60.26 g$

$M.W_{VCl_4} = 51 + 4 \times 35.5 = 193 g$

W_{CCl_4} taken = 1000 g

$$M_{VCCl_4} = \frac{60.26/193}{1000} \times 1000 = 0.31$$

$\Delta T_f = i K_f \times m_{VCCl_4}$

$5.415 = i \times 29.9 \times 0.31 \quad => \quad i = \frac{5.415}{9.335} = 0.58$

$2VCl_4 \rightleftharpoons V_2Cl_8$

Initially 1 0

At eq **1-x** $x/2$ So total moles $= 1 - x + x/2 = 1 - \frac{x}{2}$

$$i = \frac{1 - x/2}{1} = 0.58 \Rightarrow \frac{x}{2} = 1.058 \Rightarrow x = 0.84$$

moles of VCl_4 at eq^b = (1-x). $\frac{60.26}{193}$ = 0.044 moles **Ans**

$$\therefore \text{moles of } V_2Cl_2 \text{ at eq}^b = {}^{x}\!/_{2}\cdot\frac{60.26}{193} = 0.133 \text{ moles} \quad \textbf{Ans}$$

Q54.

Sol: molality = 0.1 m

Degree of dissociation of $CH_3COOH = 1.35\%$

$$\begin{array}{lcc} CH3COOH \longleftrightarrow & CH3COO^- & + \; H^+ \\ 100 & 0 & 0 \\ 100-1.35 & 1.35 & 1.35 \end{array}$$

$$\therefore i = \frac{100-1.35+2\times1.35}{100} \; \frac{101.35}{100} = 1.0135$$

$$\because \Delta T_f = iK_f \times m$$

$$\Delta T_f = 1.0135\times1.86\times0.1 = 0.1885$$

$$\therefore T_{f_{solution}} = -0.1885^\circ C$$

$$\pi = iCRT$$

$$= 1.0135\times0.1\times0.0821\times298$$

(for very dilute sol^n ; $M \approx m$ & molality is less so sol^n is dilute)

$\pi = 2.47$ atm **Ans**

If no dissociation is assumed $i = 1$

$\therefore$ Both ΔT_f & π are little bit higher if $i = 1.0135$ is considered

Q55.

Sol: Relative lowering of vapour pressure $= iX_{Solute}$

$$\frac{17.54-17.536}{17.54} = iX_{Solute}$$

$$i = \frac{2.28\times10^{-4}}{\dfrac{0.01}{0.01+{}^{1000}\!/_{18}}} = 2.28\times10^{-2}\times55.56 = 1.267$$

$$\begin{array}{lcc} BOH \longleftrightarrow & B^+ & + \; OH^- \\ 1 & 0 & 0 \\ 1-x & x & x \end{array}$$

$$\therefore i = \frac{1-x+1+x}{1} = 1+x = 1.267$$

$$X = 1.267 - 1 = 0.267$$

$$\therefore K_b = \frac{0.01(x^2)}{(1-x)} = \frac{(0.267)^2\times10^{-2}}{(1-0.267)} = 9.725\times10^{-4} \quad \textbf{Ans} \quad \left[\therefore K_b = \frac{x^2}{(1-x)}\right]$$

For dilute solution molality = molarity

Q56.

Sol: Wt of water = 150 g

Mol. Wt of solute = 278 g

From Ostwald – Walker experiment,

Loss of weight of solution α Ps

Loss in weight of solvent α $P^0 - Ps$

Gain in weight of H_2SO_4 α P^0

$$\text{So,}\ \frac{\text{Loss in weight of solvent}}{\text{Gain in weight of } H_2SO_4} = \frac{P^0 - P_s}{P^0} = \frac{0.0827}{3.317}$$

$$\text{Also, Relative lowering of vapour pressure} = \frac{P^0 - P_s}{P^0} = X_{solute} = \frac{0.0827}{3.317}$$

$$\Rightarrow \quad \frac{wt/278}{150} \times 1000 = \frac{0.0827}{3.317}$$

$\Rightarrow$ $Wt = 1.309\ g$ **Ans**

Q57.

Sol:

Elements	% by wt	% by wt / At.wt = xi	$\frac{X_r}{X_{min}}$
C	80.78	$80.78/12 = 6.73$	$6.75/0.3476 = 19$
H	13.56	$13.56/1 = 13.56$	$13.56/0.3476 = 38$
O	5.56	$5.56/16 = 0.3476$	$\frac{0.3476}{0.3476} = 1$

$\therefore$ Empirical formula of the compound = $C_{19}H_{38}O$

Empirical wt = $19 \times 12 + 38 + 16 = 282$

Also, $\Delta T_f = K_f \times m$

$$(5.5 - 3.37) = 5.12 \times \frac{1g}{M.W \times 8.5 \times 1.0028} \times 1000$$

$(d_{benzene} = 1.0028\,g/cc)$

$$\therefore M.w = \frac{5.12 \times 1000}{8.5 \times 1.0028 \times 2.13} = 282$$

$$\therefore \text{So M.F} = (C_{19}H_{38}O)_1 = \left(\because n = \frac{M.w}{E.w} = \frac{282}{282} = 1\right)$$

$M.F = C_{19}H_{38}O$ **Ans**

Q58.

Sol: $\frac{P^0{}_{Water} - P_{Solution}}{P^0{}_{Water}} = X_{Solute}$

$$\frac{23.62-P_{solution}}{23.62}=\frac{\frac{1.5}{60}}{1.5/60+50/18}\quad (\text{urea}=Co(NH_2)_2\ M.w=60)$$

$$=\frac{0.025}{2.80278}=8.92\times10^{-3}$$

$P_{solution}=23.62-0.211=23.41$ mm of Hg. **Ans**

Objective Question

Q1. Ans -(a) molality $=\frac{W_{Solute}}{\text{wt of solvent}}\times1000$

$$1=\frac{1}{\text{wt of solvent}}\times1000$$

$\therefore$ Wt of solvent $=1000$ g **Ans**

Q2. Ans - (a) $X_{Solute}=\frac{1.75-17.45}{17.4}=\frac{0.05}{17.5}$

$$\therefore X_{Solvent}=1-x_{Solute}=\frac{1-0.05}{17.5}=0.997$$

Q3. Ans -(a) Relative lowering of vapour pressure, Depression in F.P., Elevation in B.P,.& osmotic Pressure are colligative properties.

Q4. Ans -(c) For Solution A + B

X'_A = mole fraction of A in vapour phase

$$X'_A=\frac{X_A.P^0_A}{X_A.P^0_A}$$

= can be equal to X_A or not which depend on P^0_A & P^0_B.

Q5. Ans - (d) $\pi=CRT \quad\Rightarrow\frac{\pi}{C}=RT$

Q6. Ans - (c) $\pi xT \quad\Rightarrow\frac{\pi_2}{\pi_1}=\frac{T_2}{T_1}=\frac{546}{273}$ => $\pi_2=2\times4=8\text{atm}$

Q7. Ans - (c) $\therefore K_4[Fe(CN)_6]$ & $Al_2(SO_4)_3$ both gives equal no. of ions when ionized.

Q8. Ans - (b) Since urea & glucose both doesn't ionize, so they have equal conc-^{n} & hence osmotic solution.

Q9. Ans - (d) $\therefore$Both $Ca(NO_3)_2$ & Na_2SO_4 gives same no. of ions & hence equal concentration of them equal no. of ions, so same osmotic pressure

Q10. Ans - (c) $P=CRT=\frac{n}{V}RT$

$\therefore$P is not proportional to V.

Q11. Ans - (b) Equal volume are mixed, so the total molarity of glucose & urea will be same as Previously

Total molarity $=\frac{0.1}{2}+\frac{0.1}{2}=0.1$

Q12. Ans - (d) $\Delta T_f = K_f \times m \quad \Rightarrow m = \frac{\Delta T_f}{K_f}$

Q13. Ans - (a) Freezing point lowers as solute (less volatile) is added to solvent. So if water is Solvent (with f.P. = 0^0C) freezing point of solution will be lower than 0^0C.

Q14. Ans-(d) $\because$ $FeCl_3$ can give more no. of ions, so conc-^{n} of ions is maximum in case of 0.1 M $FeCl_3$ sol-^{n}.

Q15. Ans - (a) Freezing point will be lower if molality of sol-^{n} is higher, which will happens if solubility dissociate to give more no. of ions.

Q16. Ans - (c) $\Delta T_f = 1.86\left(\frac{5/62}{85} + \frac{10/180}{85}\right)\times 1000$

$$= 1.86\left(\frac{0.136}{85}\right)\times 1000 = 186\times\frac{136}{85}$$

$$O - T_{f\,sol-^n} = 1.86\times\frac{136}{85} = 1.86\times 136 = -3$$

$$T_{f\,sol^n} = -3^0C$$

Btw, calculation is not required because freezing to will be lower than 0^0C & there is only such option here.

Q17. Ans - (a) $\Delta T_b = 100.5 - 100 = 0.5 = K_b \times \frac{1}{1} \quad \Rightarrow K_b = 0.5$

Q18. Ans - (c) Boiling point of solution will be greater than that of solute.

Q19. Ans - (b) B.P. will be highest if molality is higher, which will happen if Mol.wt of solute will be less & ionisation is higher. Both case is with (b)

Q20. Ans - (c) Because $BaCl_2$ has highest ionisation & gives more no. of ions in the solution.

Q21. Ans - (b)

Q22. Ans - (c) because KCl gives 2 ions on dissociation whereas sugar remain same molecule

Q23. Ans - (a)

$$1 \approx 2 = \frac{\text{Normal.M.w}}{\text{obs.Mol.wt}} \Rightarrow \text{ObS.Mol.wt} \approx \frac{58.5}{2}$$

Q24. Ans - (b)

Wt. of water = 1177 - 2 × 58.5 = 1000 g

wt of sol-^{n} = 1000 ml × 1.117 g/ml

wt of NaCl = 2 × 58.5 g

Q25. Ans - (a)

$$\frac{\Delta T_f}{K_f} = m = \frac{1}{1000} = \frac{W/180}{1000}\times 1000 \quad => \quad w = \frac{180}{1000}\,g = 0.18\,g$$

Q26. Ans -(b)

$\pi = CRT$; **C** = Molarity

Q27. Ans - (a) you should remember it.

Q28. Ans - (b) 2 moles of KCl provides 4 moles of ions.