

Assignment -5 solutions

1. $k_f = 6.94$ for Naphthalene, compound added say B to Naphthalene

$$m_B = \frac{\text{mass of B}}{n_B}$$

also, $n_B = \text{mass of naphthalene} \cdot b_B$ $b_B = \text{molality}$

$$b_B = \frac{\Delta T}{k_f} \quad \text{so } m_B = \frac{(\text{mass of B})}{\text{mass of naphthalene} \cdot b_B}$$

$$m_B = \frac{\text{mass of B} \times k_f}{\text{mass of naphthalene} \cdot b_B \times \Delta T}$$

$$m_B = \frac{5 \times 6.94 \text{ K kg mol}^{-1}}{(0.250 \text{ kg}) (0.780 \text{ K})} = 178 \text{ g mol}^{-1}$$

2. $\Delta G_{\text{mix}} = nRT \sum_j x_j \ln x_j$

$$\Delta S_{\text{mix}} = -nR \sum_j x_j \ln x_j = \frac{-\Delta G_{\text{mix}}}{T}$$

$$n = 1 + 1 = 2 \text{ mol}$$

$$x(\text{Hex}) = x(\text{Hept}) = 0.5$$

Therefore,

$$\begin{aligned} \Delta G_{\text{mix}} &= 2 \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 298 \times (0.5 \ln 0.5 + 0.5 \ln 0.5) \\ &= -3.43 \text{ kJoules} \end{aligned}$$

$$\Delta S_{\text{mix}} = \frac{+3.43}{298} = 11.5 \text{ Joules K}^{-1}$$

$$\Delta H_{\text{mix}} = \Delta G_{\text{mix}} + T \Delta S_{\text{mix}} = (-3.43 \times 10^3 \text{ J}) + (298 \text{ K}) (11.5 \text{ J K}^{-1}) = \text{Zero}$$

4. From Van't Hoff equation

$$\Pi = c \cdot R \cdot T \quad \text{so, } c = \frac{\Pi}{RT}$$

The expression for freezing point depression includes molality

b. Therefore,

$$b = \frac{n_B}{m_A} = \frac{n_B}{V_{\text{sol}} \rho_{\text{sol}}} = \frac{[B]}{\rho_{\text{sol}} n} \quad \text{or } \frac{c}{\rho_{\text{sol}} n} = \frac{\Pi}{RT \rho_{\text{sol}}}$$

Freezing point depression is

$$\Delta T = K_f \cdot b = \frac{K_f \cdot \Pi}{RT \rho_{\text{sol}}} \quad \text{where } K_f = 1.86 \text{ K mol}^{-1} \text{ kg}$$

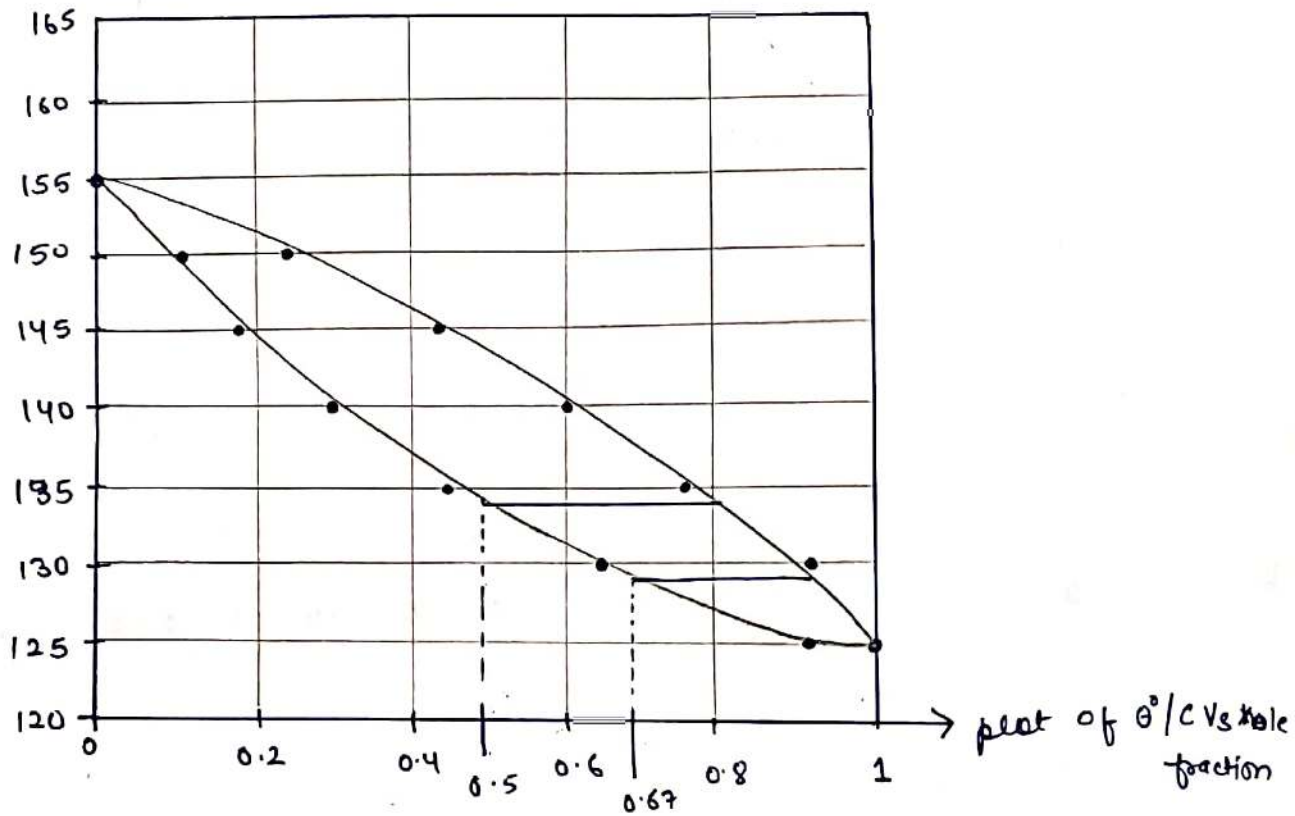
Density of a dilute aqueous solution is approximately that of water $\rho = 1 \text{ g cm}^{-3} = 10^3 \text{ kg m}^{-3}$

$$\text{So, } \Delta T = \frac{(1.86 \text{ K kg mol}^{-1})(120 \times 10^3 \text{ Pa})}{(8.3145 \text{ J K}^{-1} \text{ mol}^{-1})(300 \text{ K})(10^3 \text{ kg m}^{-3})} = 0.089 \text{ K}$$

\therefore solⁿ will freeze at ~~273.15 K~~ - 0.09 K

3. The phase Rule for 3 components ($c=3$) implies that the degree of freedom $f = 5 - P$. If we use two of those degree of freedom to fix temperature and pressure, then the remaining degrees of freedom equals $3 - P$. The maximum number of phases in equilibrium at any $T \neq P$, therefore is 3. If then there would be no remaining degrees of freedom (fixed T, P & 3 component's proportions)

57. Add the boiling point of A to the table at $x_A = y_A = 1$ and the boiling point of B at $x_B = y_B = 0$. plot the boiling temperatures against liquid mole fractions and the same boiling temperature against vapour mole fractions on same plot.



- (1) Find $x_A = 0.50$ on the lower curve and draw a horizontal tie line to upper curve. The mole fraction at that point $y_A = 0.82$
- (2) Find $x_A = 0.67$ (i.e. $x_B = 0.33$) on the lower curve and draw a horizontal line to the upper curve. The mole fraction at that point is $y_A = 0.91$ (i.e. $y_B = 0.09$)
6. We assume that the solvent, benzene is ideal and obeys Raoult's law. As usual, let A denote the solvent (benzene) but let's avoid using B and call the solute O.

$$P_A = x_A \cdot P_A^* \quad \text{and} \quad x_A = \frac{n_A}{n_A + n_O}$$

Hence $p_A = \frac{n_A P_A^*}{n_A + n_0}$, which solves to

$$n_0 = n_A \frac{(P_A^* - p_A)}{p_A}$$

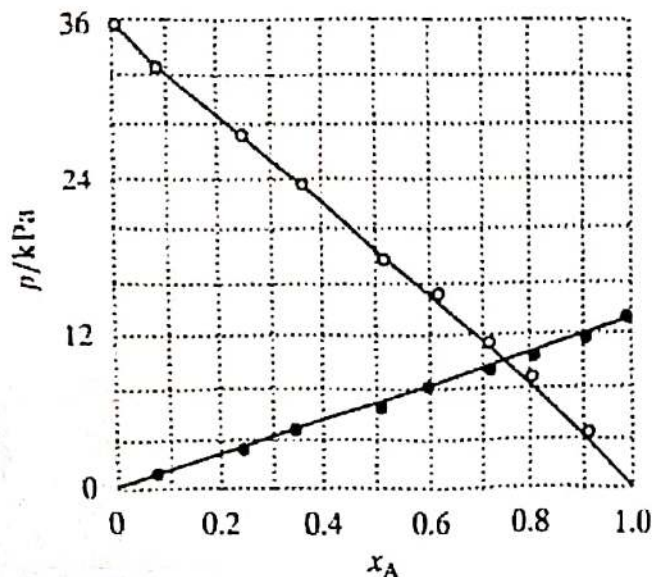
Then, since $n_0 = \frac{m_0}{M_0}$, where m_0 is the mass of 0 present

$$m_0 = \frac{m_0 p_A}{n_A (P_A^* - p_A)} = \frac{m_0 M_A p_A}{M_A (P_A^* - p_A)}$$

From the data

$$m_0 = \frac{19 \times 78.11 \text{ g mol}^{-1} \times 51.5 \text{ kPa}}{500 \text{ g} (53.3 - 51.5) \text{ kPa}} = 85 \text{ g mol}^{-1}$$

5.	x_A	0	0.0898	0.2476	0.3577	0.5194	0.6036	0.7188	0.8019	0.9105	1
	y_A	0	0.0410	0.1154	0.1762	0.2772	0.3393	0.4450	0.5435	0.7284	1
	x_B	0	0.0895	0.1981	0.2812	0.3964	0.4806	0.6423	0.7524	0.9102	1
	y_B	0	0.2716	0.4565	0.5550	0.6607	0.7228	0.8238	0.9846	0.9590	1
	p_A	0	1.399	3.566	5.044	6.996	7.940	9.211	10.105	11.287	12.295
	p_B	0	4.209	8.487	11.487	15.462	18.243	23.582	27.334	32.722	36.066



The data plotted is shown on previous page. We can assume, lowest concentrations of both A and B, that Henry's law will hold. The Henry's law constants are given by 5

$$K_A = \frac{P_A}{x_A} = 15.58 \text{ kPa} \quad \text{from that point } x_A = 0.0898$$

$$K_B = \frac{P_B}{x_B} = 47.03 \text{ kPa} \quad \text{from that point } x_B = 0.0895$$