Assignment -5 solutions

1. $k_f = 6.94$ for Napthalene, compounded added say B to Napthalene

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

also, n_B = mass of napthalene . b_B $\quad$ b_B = molality

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

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

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

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

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

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

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

Therefore,

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

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

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

4. From Van't Hoff equation

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

The expression for freezing point depression includes molality b. Therefore,

$$b = \frac{n_B}{m_A} = \frac{n_B}{V_{sol}\,\rho_{sol}} = \frac{[B]}{\rho_{soln}} \text{ or } \frac{c}{\rho_{soln}} = \frac{\pi}{RT\rho_{sol}}$$

Freezing point depression is

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

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

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

∴ Soln will freeze at ~~0.089 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 & P, Therefore is 3. 1 for then there would be no remaining degrees of freedom (fixed T, P & 3 component's proportions)

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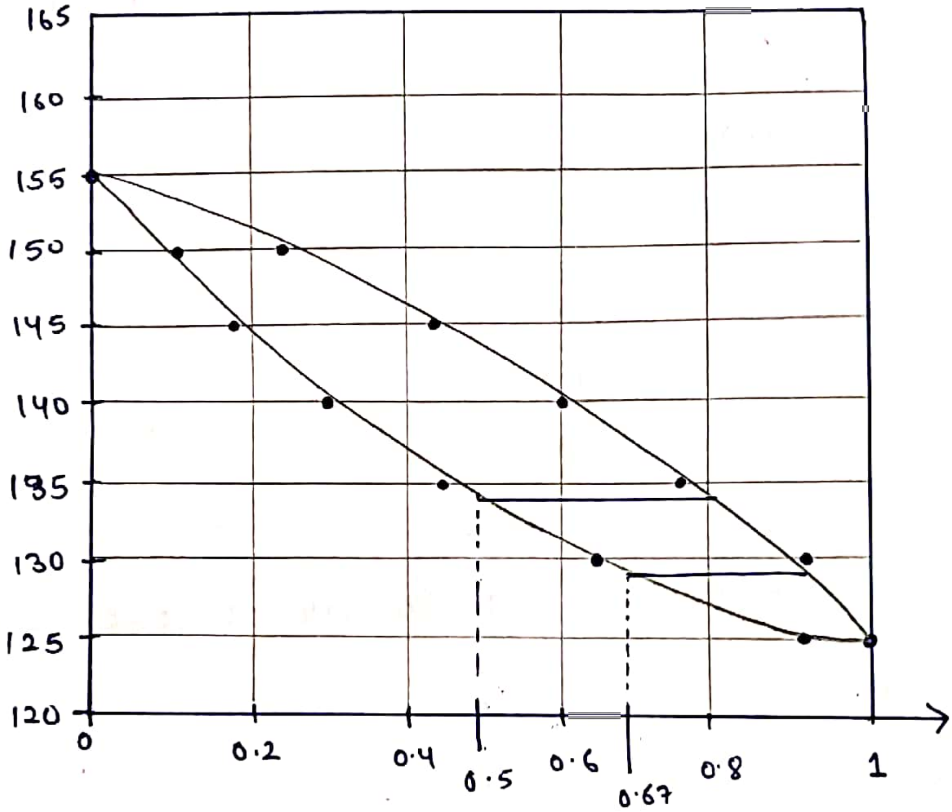
5 7. Add the Boiling point of A to the table at $x_A = y_A = 1$ and the boiling point of B at $x_B = y_B = 0$. plot the boiling temperatures against liquid mole fractions and the same boiling temperature against vapour mole fractions on same plot.



plot of $\theta°/C$ Vs Mole fraction

(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 $x_A = 0.67$ (ie $x_B = 0.33$) on the lower curve and draw a horizontal line to the upper curve. The mole fraction at that point is $y_A = 0.91$ (ie $y_B = 0.09$)

6. We assume that the solvent, benzene is ideal and obeys Rault'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 $p_A = \dfrac{n_A p_A^*}{n_A + n_0}$, which solves to

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

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

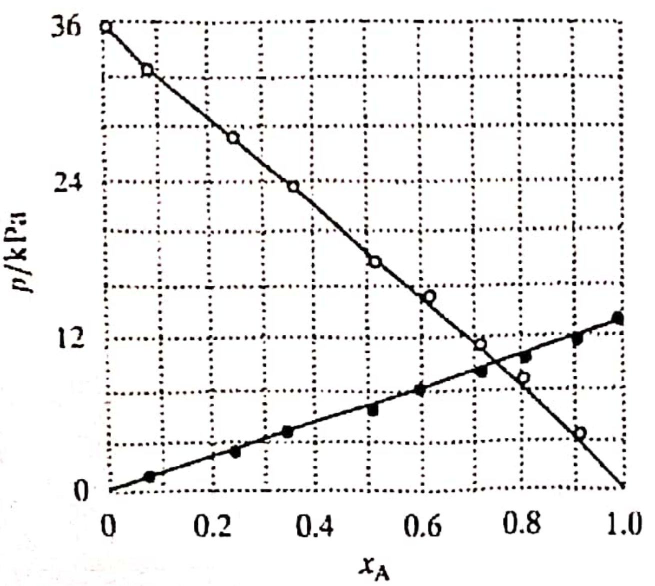
$$M_0 = \frac{m_0 p_A}{n_A (p_A^* - p_A)} = \frac{m_0 M_A p_A}{m_A (p_A^* - p_A)}$$

From the data

$$M_0 = \frac{19 \times 78.11\ \mathrm{g\,mol^{-1}} \times 51.5\ \mathrm{kPa}}{500\mathrm{g}\ (53.3 - 51.5)\ \mathrm{kPa}} = 85\ \mathrm{g\,mol^{-1}}$$

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	0.8846	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

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

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