Question Number III *(16 Marks ~ 28.8 minutes)*

A liquid mixture is formed by mixing 20 kg of n-hexane [C_6H_{14}] and 80 kg n-octane [C_8H_{18}]. The molar masses for n-hexane and n-octane are 86 kg/kmol and 114 kg/kmol, respectively. The data available for the two liquids is shown in the table below:

	Temperature (°C)	Vapor Pressure (mmHg)	
		n-hexane	n-octane
323.15 ←	50	405.6	50.3
373.15 ←	100	1844.4	351.1

a) Calculate the mole fraction of n-hexane and n-octane in the mixture. (/2)

$n_1 = \frac{20}{86} = 0.2326$ kmol

$n_2 = \frac{80}{114} = 0.7018$ kmol

> 0.9344 kmol

$x_1 = 0.25$ hex

$x_2 = 0.75$ oct

b) Estimate the latent heat of vaporization of pure n-octane in units of kJ/kg. (/4)

$$\ln(P_2/P_1) = \frac{\Delta H_v}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\ln\left(\frac{351.1}{50.3}\right) = \frac{\Delta H_v}{R}\left(\frac{1}{323.15} - \frac{1}{373.15}\right)$$

$$4686 = \frac{\Delta H_v}{R} \rightarrow \Delta H_v = 38959 \frac{kJ}{kmol}$$

$$\frac{38959 \frac{kJ}{kmol}}{114 \frac{kg}{kmol}} = 341.74 \text{ kJ/kg}$$

c) Estimate the boiling point of pure n-octane at 200 mmHg in units of °C. (/2)

$P_3 = 200$ $T_3 = ?$

$$\ln\left(\frac{200}{50.3}\right) = 4686\left(\frac{1}{323.15} - \frac{1}{T_3}\right)$$

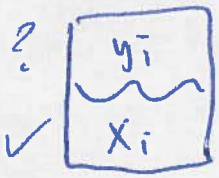
$$2.9456 \times 10^{-4} = \frac{1}{323.15} - \frac{1}{T_3}$$

$T_3 = 357.15$ K

$T_3 = 84$ °C

d) The liquid mixture (20 kg of n-hexane and 80 kg n-octane) is maintained at 80°C. Calculate the following:

i. Equilibrium (total) pressure in units of mmHg. (/4)



$T = 80\,^{\circ}C$ $\quad \Sigma y_i = 1.0$ $\quad P_{v_i} x_i = P y_i$

$P = ?$ $\quad y_1 + y_2 = 1$ $\quad \frac{P_{v_i} x_i}{P} = y_i$

$$\frac{P_{v_1} x_1}{P} + \frac{P_{v_2} x_2}{P} = 1$$

$$P = P_{v_1} x_1 + P_{v_2} x_2 = 837.7$$

ii. Estimate the composition of the vapor in equilibrium with liquid. (/2)

$$y_1 = \frac{P_{v_1} x_1}{P} = \frac{172.41 \times 0.25}{837.7}$$

$y_1 = 0.051$

$y_2 = 1 - y_1 = 0.949$

n-octane $80°C = 353.15\ K$

$$\ln(P_2/50.3) = 4686\left(1/323.15 - 1/353.15\right)$$

$$P_2 = 172.41\ mm\ Hg = P_{v_1}$$

n-hexane

$$\ln\left(\frac{1844.4}{405.6}\right) = \frac{\Delta H_v}{R}\left(\frac{1}{323.15} - \frac{1}{373.15}\right)$$

$$\frac{\Delta H_v}{R} = 3652.6$$

$$\ln(P_2/405.6) = 3652.6\left(\frac{1}{323.15} - \frac{1}{353.15}\right)$$

$$P_2 = 1059.5\ mm\ Hg = P_{v_2}$$

$$P = 172.41(0.25) + 1059.5(0.75)$$

$$P = 837.7\ mm\ Hg$$