CHE 3173 EXAM I March 3, 1988

Solution

I. 30 points

$$P(v-b) = RT$$

$$b = y_1 b_1 + y_2 b_2$$

$$RT \ln(\phi_i) = \int_0^P \left(\bar{V}_i - \frac{RT}{P}\right) dP$$

$$\bar{V}_i = \left.\frac{\partial V}{\partial n_i}\right)_{T,P,n_j,j\neq i}$$

$$V - b = \frac{RT}{P}$$

$$V = \frac{nRT}{P} + nb$$

$$\left.\frac{\partial V}{\partial n_2}\right)_{T,P,n_2} = \frac{RT}{P} + n \left.\frac{\partial b}{\partial n_1}\right)_{T,P,n_2} + b$$

$$nb = \cancel{}\; n_1 b_1 + n_2 b_2$$

$$\cancel{\left.\frac{\partial b}{\partial n_1}\right)_{T,P,n_T}}$$

$$\left.\frac{\partial (nb)}{\partial n_1}\right)_{T,P,n_2} = b_1 = n \left.\frac{\partial b}{\partial n_1}\right)_{T,P,n_2} + b$$

$$\left.\frac{\partial b}{\partial n_1}\right)_{T,P,n_2} = \frac{b_1 - b}{n}$$

$$\boxed{\left.\frac{\partial V}{\partial n_1}\right)_{T,P,n_2} = \frac{RT}{P} + b_1 - b + b = \frac{RT}{P} + b_1}$$

$$RT\ln\phi_1 = \int_0^P \left(\cancel{\frac{RT}{P}} + b_1 - \cancel{\frac{RT}{P}} \right) dP$$

$$RT\ln\phi_1 = \int_0^P b_1\, dP = b_1 P$$

$$\phi_1 = \frac{f_1}{y_1 P} = \exp\left(\frac{b_1 P}{RT}\right)$$

$$\boxed{f_1 = y_1 P \exp\left(\frac{b_1 P}{RT}\right)}$$

for pure component, $y_1 \to 1$

$$f_1^{\circ} = P\exp\left(\frac{b_1 P}{RT}\right)$$

$\boxed{f_1 = y_1 f_1^{\circ}}$ which is the Lewis fugacity Rule

II. 30 points

$$f_1^{Liq} = P_1^s \phi_1^s \exp\left[\int_{P_1^s}^{P} \frac{V}{RT}\, dP\right]$$

$$P_1^s = \exp\left(15.8366 - \frac{2697.55}{373.16+(-48.78)}\right)$$

$$\boxed{P_1^s = 1845.64 \text{ mmHg} = 2.428 \text{ atm}}$$

$$\phi_1^s = \underline{1}$$

$$V = MW/\rho = \frac{86.18 \text{ gr/mole}}{0.6603 \text{ gr/cm}^3} = 130.5 \text{ cm}^3/\text{mole}$$

$$\int_{2.428}^{300} \frac{130.5 \text{ cm}^3/\text{mole}}{(82.05)\frac{\text{cm}^3\text{-atm}}{\text{mole}\,^\circ K}\, 373^\circ K}\, dP = \frac{130.5(300-2.428)}{(82.05)(373.15)} = 1.269$$

$$\boxed{f_1^{Liq} = (2.428)\text{atm}\,(\exp(1.269)) = 8.633 \text{atm}}$$

$x^3 + x^2 + x + 1 = 0$

$(x+1)(x^2 + 1) = 0$

$x^2 = -1$

III. 40 pts

$\cancel{P_1^s = 10^{(-.2185}}$

$a = 15$, $b = 15$, $c = 10$

a is dew pt.

b is liquid comp at dew pt

c is bubble pt. pressure

$T = 300°K$ const

$y_1 = .40$

$y_2 = .60$

$$\log_{10} P_1^s = \frac{(-.2185)(6221.6)}{300} + 7.882542$$

$$\log_{10} P_2^s = \left(\frac{-.2185)(6401.0)}{300}\right. + 7.976585$$

$P_1^s = 2244.6$ torr $= 2.9534$ atm

$P_2^s = 2063.1$ torr $= 2.7146$ atm

$y_1 P = x_1 P_1^s$ $\qquad y_1 = \frac{x_1 P_1^s}{P}$

$y_2 P = x_2 P_2^s$ $\qquad y_2 = \frac{x_2 P_2^s}{P}$

$P = x_1 P_1^s + x_2 P_2^s$

$x_1 = \frac{y_1 P}{P_1 s}$ $\qquad 1 = \frac{y_1 P}{P_1^s} + \frac{y_2 P}{P_2 s}$

$x_2 = \frac{y_2 P}{P_2 s}$ $\qquad P = \frac{1}{\frac{y_1}{P_1^s} + y_2/P_2^s}$

$$\boxed{P = \frac{1}{\frac{.4}{2.9534} + \frac{.6}{2.7146}} = 2.805 \text{ atm}}$$ dew pt.

b) $y_1 P = x_1 P_1^s$

$y_2 P = x_2 P_2^s$

$(.4)(2.805) = x_1 (2.9534)$

$(.6)(2.805) = x_2 (2.7146)$

$$\boxed{\begin{aligned} x_1 &= .3800 \\ x_2 &= .6200 \end{aligned}}$$

c) $P = x_1 P_1^s + x_2 P_2^s$

$P = (.4)(2.9534) + (.6)(2.7146)$

$\boxed{P = 2.810 \text{ atm}}$