

HW 8 key

1. See key from HW 7.

2.  $G = G(T, P, n_1, n_2)$

$$dG = \left( \frac{\partial G}{\partial T} \right)_{P, n_1, n_2} dT + \left( \frac{\partial G}{\partial P} \right)_{T, n_1, n_2} dP + \left( \frac{\partial G}{\partial n_1} \right)_{T, P, n_2} dn_1 + \left( \frac{\partial G}{\partial n_2} \right)_{T, P, n_1} dn_2$$

$$\left( \frac{\partial G}{\partial n_i} \right)_{T, P} = \mu_i; \quad \left( \frac{\partial G}{\partial P} \right)_T = V; \quad \left( \frac{\partial G}{\partial T} \right)_P = -S$$

$$dG = -SdT + VdP + \mu_1 dn_1 + \mu_2 dn_2$$

3.  $T = 298 \text{ K}$

50% by mass EtOH/H<sub>2</sub>O

$$\rho = 0.914 \text{ g/cm}^3$$

$$V_m(\text{H}_2\text{O}) = 17.4 \text{ cm}^3/\text{mol}$$

$$V_m(\text{EtOH}) = ?$$

Assume 100 mL soln.

$$V = n_A V_A + n_B V_B$$

$$V = n_{\text{H}_2\text{O}} V_{\text{H}_2\text{O}} + n_{\text{EtOH}} V_{\text{EtOH}}$$

$$\rho = \frac{m}{V}$$

$$m = \rho V = (0.914 \text{ g/cm}^3)(100 \text{ cm}^3)$$

$$m = 91.4 \text{ g}$$

$$50\% \text{ by mass} \Rightarrow \begin{array}{l} 45.7 \text{ g H}_2\text{O} \\ 45.7 \text{ g EtOH} \end{array}$$

continued:  $FW(H_2O) = 18 \text{ g/mol}$   
 $FW(ETOH) = 46 \text{ g/mol}$

$$n_{H_2O} = 2.54 \text{ mol}$$

$$n_{ETOH} = 0.993 \text{ mol}$$

$$V_{ETOH} = \frac{V - n_{H_2O} V_{H_2O}}{n_{ETOH}}$$

$$= \frac{(100 \text{ cm}^3) - (2.54 \text{ mol})(17.4 \frac{\text{cm}^3}{\text{mol}})}{0.993 \text{ mol}}$$

$$V_{ETOH} = 56.2 \text{ cm}^3/\text{mol}$$

4. maximum  $\Delta S_{mix}$   
assume ideal soln.

$$\Delta S_{mix} = -nR(x_1 \ln x_1 + x_2 \ln x_2)$$

$$x_2 = 1 - x_1$$

$$\Delta S_{mix} = -nR(x_1 \ln x_1 + (1 - x_1) \ln(1 - x_1))$$

$$\text{Optimized } \frac{d\Delta S_{mix}}{dx_1} = -nR(\ln x_1 + 1 - \ln(1 - x_1) - 1)$$

$$\frac{d\Delta S_{mix}}{dx_1} = -nR \ln\left(\frac{x_1}{1 - x_1}\right) = 0 \text{ at } x_1 = 0.5$$

So maximum entropy by mole fraction:  $x_1 = x_2 = 0.5$

completely independent of chemical identity

5. acetone/methanol solution: A=acetone B=methanol

(3)

$$T = 57.2^\circ\text{C} = 330.35\text{K}$$

$$P_{\text{ext}} = 1\text{atm}$$

$$x_A = 0.400 \text{ when } y_A = 0.516$$

$$P_A^* = 105\text{ kPa}$$

$$P_B^* = 73.5\text{ kPa}$$

$$y_A = \frac{P_A}{P_A + P_B} \quad P_A + P_B = P_{\text{ext}}$$

$$P_A = y_A (P_A + P_B) = (101\text{ kPa})(0.516)$$

$$\underline{P_A = 52.1\text{ kPa}}$$

$$P_B = (P_A + P_B) - P_A = P_{\text{ext}} - P_A$$

$$\underline{P_B = 48.9\text{ kPa}}$$

The vapor is enriched in the more volatile component.