Homework 7

1. Benzene and toluene form nearly ideal solutions. The boiling point of pure benzene is 80.1°C. Calculate the chemical potential of benzene relative to that of pure benzene when $x_{\text{benzene}} = 0.30$ at its boiling point. If the activity coefficient of benzene in this solution were actually 0.93 rather than 1.00, what would be its vapor pressure?

2. What proportions of hexane and heptane should be mixed (a) by mole fraction, (b) by mass in order to achieve the greatest entropy of mixing.

3. The excess Gibbs energies of solutions of methylcyclohexane (MCH) and tetrahydrofurane (THF) at 303.15 K were found to fit the expression:

$$G^{\text{E}} = RTx(1-x)\{0.4857 - 0.1077(2x-1) + 0.0191(2x-1)^2\}$$

where x is the mole fraction of the methylcyclohexane. (G^{E} is a molar quantity). Calculate the Gibbs energy of mixing when a mixture of 1.00 mol of MCH and 3.00 mol of THF is prepared.

4. By measuring the equilibrium between liquid and vapor phases of a solution at 30°C at 1.00 atm, it was found that $x_{\text{A}} = 0.220$ when $y_{\text{A}} = 0.314$. Calculate the activities and activity coefficients of both components in this solution on the Raoult's law basis. The vapor pressures of the pure components at this temperature are: $p_{\text{A}}^* = 73.0$ kPa and $p_{\text{B}}^* = 92.1$ kPa. (x_{A} is the mole fraction in the liquid and y_{A} the mole fraction in the vapor.)

5. Calculate the ionic strength of a solution that is 0.040 mol kg^{-1} in $K_3[Fe(CN)_6](aq)$, 0.030 mol kg^{-1} in KCl(aq), and 0.050 mol kg^{-1} in NaBr(aq).

6. The mean activity coefficients of HBr in three dilute solutions at 25°C are 0.930 (at 5.0 mmol kg^{-1}), 0.907 (at 10.0 mmol kg^{-1}), and 0.879 (at 20.0 mmol kg^{-1}). Estimate the value of B in the extended Debye-Hückel law.

7. At 90°C, the vapor pressure of pure methylbenzene is 400 Torr and that of pure 1,2-dimethylbenzene is 150 Torr. What the composition of a liquid mixture that boils at 90°C when the pressure is 0.50 atm? What is the composition of the vapor produced?

8. It is found that the boiling point of a binary solution of A and B with x_A = 0.6589 at 88°C. At this temperature the vapor pressures of pure A and B are 957.0 Torr and 379.5 Torr, respectively. (a) Is this solution ideal? (b) What is the initial composition of the vapor above the solution?

9. Show that the osmotic pressure of a real solution is given by $\Pi V = -RT\ln a_A$. Go to show that, provided that the concentration of the solution is low, this expression takes the form $\Pi V = \phi RT[B]$ and hence that the osmotic coefficient , ϕ, (which is defined as $\phi = -(x_A/x_B)\ln a_A$) may be determined by osmometry.