Chemistry 230 -- Quiz 10 (Take-home)

Due November 30, 2001, at noon — Tellinghuisen

Pledge and signature:

1. (3) Mixtures of ethanol and *n*-propanol behave ideally. At 36.4˚C their vapor pressures are 108 torr (ethanol) and 40.0 torr.

   (a) A certain mixture boils at 36.4˚C and 72.0 torr. What are the compositions of the liquid and gaseous solutions present at equilibrium under these conditions?

   (b) 1.50 mol of ethanol is mixed with 2.50 mol *n*-propanol at this T. Calculate (*i*) the vapor pressure of the solution, and (*ii*) ΔG_{mix}, ΔS_{mix}, and ΔH_{mix} for the preparation of this solution.

2. (3) The Henry's law constant for O_2 in water at 25˚C is 773 atm mol^{-1} kg. Calculate (a) the solubility (m) of O_2 in water at P = 1.00 atm and 25˚C, and (b) $\Delta G^\circ_{f,298}$ for $O_2(aq)$ (using the molality-based reference state).

3. (3) A *regular* binary solution is characterized by the following expressions for the chemical potentials:

$$\mu_A = \mu_A^* + RT \ln x_A + w\, x_B^2; \qquad \mu_B = \mu_B^* + RT \ln x_B + w\, x_A^2 .$$

   (a) Obtain expressions for the activity coefficients $\gamma_{I,A}$ and $\gamma_{I,B}$ for such a solution.

   (b) Assuming that w is independent of T, obtain expressions for ΔG_{mix}, ΔS_{mix}, ΔH_{mix}, and ΔV_{mix} for such a solution.

4. (6) At 387.5˚C the vapor pressures of K and Hg are 3.25 torr and 1280 torr, respectively. Measurements of the vapor pressures of potassium amalgams at this T yield the following results:

mol % K:	41.1	46.8	50.0	56.1	63.0	72.0
P_{Hg}(torr):	31.87	17.3	13.0	9.11	6.53	3.70
P_K(torr):	0.348	0.68	1.07	1.69	2.26	2.95

   (a) Calculate the Convention I activity coefficients for both components and plot them vs. composition in the range studied.

   (b) Calculate the molar excess Gibbs energy G^E/n for the amalgam over this same range and plot it also. (Hint: See Section 10.2 of Levine and Figure 10.1.)

   (c) Comment on the nature of the deviations from ideality for K/Hg solutions in this composition range.

5. (6) At 25˚C a saturated solution of sucrose in water has a density of 1.330 g/cm^3, while that of water is 0.99707 gm/cm^3. This solution has a molality m = 6.05 m° and activity coefficient γ_m = 2.87.

   (a) For this saturated solution, calculate a_m, γ_{II}, and a_{II}. (Hint: See Problem 10.10 in Levine.)

   (b) Determine $\Delta G^\circ_{f,298}$ for sucrose (*aq*) on the molality scale [Hint: How are μ(sucrose,*aq*) and μ(sucrose,*s*) related in the saturated solution?].

   (c) Calculate $\Delta G^\circ_{f,298}$ for sucrose (*aq*) on the Convention II mole fraction scale.

   (d) Use results from problem 10.12 in Levine to determine γ_c and a_c for this same solution. Compare your results with Fig. 10.7.

6. (5) The enthalpy of mixing for dissolving m moles of NaCl in 1.000 kg of water at 25˚C is given by

$$\Delta H_{mix} = 3.861\, m + 1.992\, m^{3/2} - 3.038\, m^2 + 1.019\, m^{5/2}.$$

   Calculate (a) $\Delta H_{int,NaCl}$ for forming a 2.00 m° solution, (b) $\Delta H_{int,NaCl}^\infty$, (c) ΔH for diluting a solution containing 1.000 mol NaCl from a concentration of 2.00 m° to 0.100 m°, (d) $\Delta H_{diff,NaCl}$ at 2.00 m°, and (e) $\Delta H_{diff,H_2O}$ at 2.00 m°.