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) \( \Delta G_{\text{mix}} \), \( \Delta S_{\text{mix}} \), and \( \Delta H_{\text{mix}} \) 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) \( \Delta G_{f,298}^\circ \) 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:
   \[ \mu_A = \mu_A^* + RT \ln x_A + w x_B^2; \quad \mu_B = \mu_B^* + RT \ln x_B + w x_A^2. \]
   (a) Obtain expressions for the activity coefficients \( \gamma_{IA} \) and \( \gamma_{IB} \) for such a solution.
   (b) Assuming that \( w \) is independent of \( T \), obtain expressions for \( \Delta G_{\text{mix}} \), \( \Delta S_{\text{mix}} \), \( \Delta H_{\text{mix}} \), and \( \Delta V_{\text{mix}} \) 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:
   
   \[ \begin{array}{cccccc}
   \text{mol % K} & 41.1 & 46.8 & 50.0 & 56.1 & 63.0 & 72.0 \\
   P_{\text{Hg}}(\text{torr}) & 31.87 & 17.3 & 13.0 & 9.11 & 6.53 & 3.70 \\
   P_{\text{K}}(\text{torr}) & 0.348 & 0.68 & 1.07 & 1.69 & 2.26 & 2.95 \\
   \end{array} \]
   (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\(^{-1} \) and activity coefficient \( \gamma_m = 2.87 \).
   (a) For this saturated solution, calculate \( a_m \), \( \gamma_{II} \), and \( a_{II} \). (Hint: See Problem 10.10 in Levine.)
   (b) Determine \( \Delta G_{f,298}^\circ \) for sucrose \( (aq) \) on the molality scale [Hint: How are \( \mu(\text{sucrose},aq) \) and \( \mu(\text{sucrose},s) \) related in the saturated solution?]?
   (c) Calculate \( \Delta G_{f,298}^\circ \) for sucrose \( (aq) \) on the Convention II mole fraction scale.
   (d) Use results from problem 10.12 in Levine to determine \( \gamma_c \) 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
   \[ \Delta H_{\text{mix}} = 3.861 m + 1.992 m^{3/2} - 3.038 m^2 + 1.019 m^{5/2}. \]
   Calculate (a) \( \Delta H_{\text{int},NaCl} \) for forming a 2.00 m\(^{-1} \) solution, (b) \( \Delta H_{\text{int},NaCl}^\infty \), (c) \( \Delta H \) for diluting a solution containing 1.000 mol NaCl from a concentration of 2.00 m\(^{-1} \) to 0.100 m\(^{-1} \), (d) \( \Delta H_{\text{diff},NaCl} \) at 2.00 m\(^{-1} \), and (e) \( \Delta H_{\text{diff},H_2O} \) at 2.00 m\(^{-1} \).