Problem Set 8
(Due, Monday November 05)

1. The surface melting of ice may play a role in enabling speed skaters to achieve peak performance. Carry out the following calculation to test this hypothesis. At 1 atm pressure, ice melts at 273.15 K, $\Delta H_{\text{fusion}} = 6010$ J mol$^{-1}$, the mass density of ice is 920 kg m$^{-3}$, and the mass density of liquid water is 998 kg m$^{-3}$.

   a. What pressure is required to lower the melting temperature by 5.0ºC?
   b. Assume that the width of the skate in contact with the ice is $25 \times 10^{-3}$ cm, and that the length of the contact area is 15 cm. If a skater of mass 85 kg is balanced on one skate, what pressure is exerted at the interface of the skate and the ice? (Remember, pressure=force/unit area).
   c. What is the melting point of ice under this pressure?
   d. If the temperature of the ice is –5.0ºC, do you expect melting of the ice at the ice–to–skate interface to occur?

2. An ideal solution is formed by mixing liquids A and B at 298 K. The vapor pressure of pure A is 180 Torr and that of pure B is 82.1 Torr. If the mole fraction of A in the vapor is 0.450, what is the mole fraction of A in the solution?

3. A and B form an ideal solution. At a total pressure of 0.900 bar, $x_A^g = 0.450$ and $x_A^l = 0.650$. Using this information, calculate the vapor pressure of pure A and of pure B.

4. The partial molar volumes of water and ethanol in a solution with $x_{\text{H}_2\text{O}} = 0.60$ at 25ºC are 17.0 and 57.0 cm$^3$ mol$^{-1}$, respectively. The densities of water and ethanol are 0.997 and 0.7893 g cm$^{-3}$, respectively, at this temperature. Calculate the volume change upon mixing sufficient ethanol with 2.00 mol of water to give this concentration.

5. An ideal solution is composed of 5.00 mol of benzene and 3.25 mol of toluene. Calculate $\Delta G_{\text{mix}}$ and $\Delta S_{\text{mix}}$ at 298 K and 1 bar pressure. Is mixing spontaneous?