CH353 – Physical Chemistry I
Spring 2012, Unique 52135

Homework, Week 9

1. Problems 3 and 5 from last week.

2. A liquid mixture is composed of two liquids A and B. At 60 ˚C, the pure vapor pressure of A is 400 Torr and the pure vapor pressure of B is 800 Torr. The total mixture contains 1 mole of A and 4 moles of B. At 60 ˚C and a total pressure of 650 Torr, is the mixture all liquid, all vapor, or in a liquid-vapor equilibrium? Justify your answer.

3. Explain the driving force for equilibrium and why spontaneous reactions rarely go to completion. Use words, diagrams, and equations, and be precise.

4. Because the melting temperature of water decreases with increasing pressure, a commonly repeated hypothesis is that an ice skater is able to move across the surface of solid ice by exerting enough force on the ice to temporarily melt the ice to water, thus dramatically reducing the coefficient of friction.

a) Assume that the above hypothesis is true if the skater is able to exert enough force to lower the melting temperature of ice by 0.1 K. Is this a reasonable hypothesis for a person weighing 70 kg who is wearing ice skating blades that are 30 cm long and 3 mm wide? Justify your answer.

Assume that the ice is maintained at 0˚C, that the density of ice is approximately 0.92 g cm^{-3}, and that the density of liquid water is 1.0 g mL^{-1}. $\Delta H_{fus}(H_2O)$ = 6.01 kJ mol^{-1} at 273 K. You may approximate the force of gravity as 10 N kg^{-1}.

b) To achieve the conditions of the above hypothesis, how much would this skater have to weigh (if wearing the same blades described above)?

c) Provide an alternative hypothesis for how skating across solid ice may be possible.

Draw a temperature-composition diagram of a binary system in terms of the mole concentration of species 1 in which species 1 is the more volatile component. Label the regions of the diagram in which liquid and vapor phases exist.

5. In class, we examined an ideal solution formed between 1-propanol and 2-propanol:

P^*(1-propanol) = 20.9 Torr
P^*(2-propanol) = 45.2 Torr (at 25˚C)

Construct a pressure-composition diagram for this solution in terms of the mole fraction of 2-propanol in both the liquid and vapor phases. Label the regions of the diagram in which liquid,

vapor, and liquid-vapor phases exist. If the mole fraction of 2-propanol in the liquid phase is 0.6, what is the composition of the vapor phase?

6. Concentrated sulfuric acid is sold as a solution that is 98.0% sulfuric acid and 2.0% water by mass. Given that the density of the solution is 1.84 g/mL, calculate the molarity of concentrated sulfuric acid.