CH353 – Physical Chemistry I
Spring 2015, Unique 51170

Homework, Week 10

1. Determine ΔG^0_{rxn} and K_P at 298 K for each of the following reactions:

a) $N_2O_4(g) \leftrightarrow 2\ NO_2(g)$
b) $H_2(g) + I_2(g) \leftrightarrow 2\ HI(g)$
c) $3\ H_2(g) + N_2(g) \leftrightarrow 2\ NH_3(g)$

2. The synthesis of ammonia is given by the formula

$$N_{2(g)} + 3\ H_{2(g)} \leftrightarrow 2\ NH_{3(g)}$$

a) If you begin the reaction with n_0 moles of $N_{2(g)}$ and $3n_0$ moles of $H_{2(g)}$, find an exact expression for z_{eq}. Use this expression to discuss how z_{eq} varies with P and relate your conclusions to Le Chatelier's principle.

3. Sufuryl chloride, SO_2Cl_2, decomposes to sulfur dioxide and chlorine gas:

$$SO_2Cl_2(g) \leftrightarrow SO_2(g) + Cl_2(g)$$

$\Delta G^0_f(SOCl_2) = -371.3$ kJ/mol, $\Delta G^0_f(SO_2) = -300.2$ kJ/mol.
a) Determine the equilibrium concentrations of each species if the system initially contains 1 mole of SO_2Cl_2 and 0 moles of SO_2 and Cl_2 at 1 bar
b) Determine the equilibrium concentrations of each species if the system initially contains 1 mole of SO_2Cl_2, 1 mole of SO_2, and 0 moles of Cl_2 at 1 bar.
c) Describe any differences according to Le Chatelier's principle.

4. The water-gas shift reaction is an important industrial source of pure $H_2(g)$ for ammonia synthesis:

$$CO(g) + H_2O(g) \leftrightarrow H_2(g) + CO_2(g)$$

What would happen to the equilibrium concentration of each species if you increase the total pressure of the system by a factor of 100?

5. Until recently, values of K_P were reported assuming a standard state of 1 atm. Determine a general equation for converting K_P values at 1 atm to 1 bar.

6. Under certain conditions, water vapor dissociates into $H_2(g)$ and $O_2(g)$. At 2000 K and 1 bar, water vapor is 0.53% dissociated. At 2100 K and 1 bar, it is 0.88% dissociated. Determine the enthalpy of the dissociation reaction, assuming it is constant over this temperature range.