Practice Problems on Equilibrium

All of the problems given here assume the use of proper thermodynamic equilibrium constants (phrased in terms of activities).

1. Write equilibrium constant expressions for the following reactions both in terms of activities and in terms of the observables (pressure, concentration, mole fraction) which underlie them.

    (a) $C_{(s)} + CO_{2(g)} \rightleftharpoons 2CO_{(g)}$
    (b) $CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$
    (c) $(NH_4)_2CO_{3(s)} \rightleftharpoons 2NH_{3(g)} + CO_{2(g)} + H_2O_{(g)}$
    (d) $Ba(OH)_{2(s)} \rightleftharpoons Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)}$

2. For the reaction $I_{2(g)} \rightleftharpoons 2I_{(g)}$, $K = 2.3 \times 10^{-10}$ at 500 K. Analysis of a mixture kept at 500 K shows that the partial pressure of I_2 is 0.87 atm while the partial pressure of iodine atoms is 8.2×10^{-7} atm. Is the mixture in equilibrium? If not, in what direction is the reaction spontaneous?

3. When the reaction $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ reaches equilibrium at 250°C, the partial pressures of the reactant and products are as follows: $P_{PCl_5} = 1.8 \times 10^{-3}$ atm, $P_{PCl_3} = 0.56$ atm, $P_{Cl_2} = 0.17$ atm. What is the equilibrium constant for the reaction at this temperature?

4. At 1000 K, the equilibrium mixture for the gas-phase reaction of sulfur dioxide with oxygen forming sulfur trioxide contains 3.77×10^{-3} mol/L of sulfur dioxide, 4.13×10^{-3} mol/L of sulfur trioxide and 4.30×10^{-3} mol/L of oxygen. Calculate the equilibrium constant.

5. The equilibrium constant for the dissociation of iodine molecules into iodine atoms ($I_{2(g)} \rightleftharpoons 2I_{(g)}$) is 0.31 at 1000 K. If 25 g of iodine is placed in a 12 L flask at 1000 K, what are the equilibrium pressures of iodine molecules and atoms?

6. The equilibrium constant for the reaction $COBr_{2(g)} \rightleftharpoons CO_{(g)} + Br_{2(g)}$ at 73°C is 5.4. If 0.015 mol of $COBr_2$ is warmed to 73°C in a 2.5 L flask, what is the final pressure reached?

    Hint: The pressure at any time is the sum of the partial pressures of all gases present.