1. Find K_c for the reaction: $2NH_3(g) + 3I_2(g) \rightleftharpoons 6HI(g) + N_2(g)$, given the information below.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad K = 54$$
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad K = 1.04 \times 10^{-4}$$

2. Write an expression for the equilibrium constant of each of the following reactions:
   a. $2C_2H_4(g) + 2H_2O(g) \rightleftharpoons 2C_2H_6(g) + O_2(g)$ (Write K_c and K_p)
   b. $Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$
   c. $NH_3(aq) + H2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
   d. $HCOOH\ (aq) \rightleftharpoons H^+\ (aq) + HCOO^-\ (aq)$
   e. $2HgO(s) \rightleftharpoons 2Hg(l) + O_2(g)$
3. The following equilibrium constants were determined at 1123 K:

$$C(s) + CO_2\ (g) \rightleftharpoons 2CO(g) \qquad K_1 = 1.3 \times 10^{14}$$
$$CO\ (g) + Cl_2\ (g) \rightleftharpoons COCl_2\ (g) \qquad K_2 = 6.0 \times 10^{-3}$$

   Calculate the equilibrium constant for the following reaction at 1123 K and write the K expression for ALL reactions:

$$C(s) + CO_2\ (g) + 2Cl_2\ (g) \rightleftharpoons 2COCl_2\ (g) \qquad K_3 = ???$$

4. The equilibrium constant, K_c, for the reaction $H_2\ (g) + F_2(g) \rightleftharpoons 2HF(g)$ has the value 2.1×10^3 at a particular temperature. When the system is analyzed at equilibrium at this temperature, the concentrations of $H_2(g)$ and $F_2\ (g)$ are both found to be 0.0021 M. What is the concentration of HF(g) in the equilibrium system under these conditions?
5. At 25°C, $K_p = 5.3 \times 10^5$ for the reaction

$$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$$

   When a certain partial pressure of $NH_3\ (g)$ is put into an otherwise empty rigid vessel at 25°C, equilibrium is reached when 50.0% of the original ammonia has decomposed. What was the original partial pressure of ammonia before any decomposition occurred?

1. Find K_c for the reaction: $2NH_3(g) + 3I_2(g) \rightleftharpoons 6HI(g) + N_2(g)$, given the information below.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad K = 54$$
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad K = 1.04 \times 10^{-4}$$

2. Write an expression for the equilibrium constant of each of the following reactions:
   a. $2C_2H_4(g) + 2H_2O(g) \rightleftharpoons 2C_2H_6(g) + O_2(g)$ (Write K_c and K_p)
   b. $Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$
   c. $NH_3(aq) + H2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
   d. $HCOOH\ (aq) \rightleftharpoons H^+\ (aq) + HCOO^-\ (aq)$
   e. $2HgO(s) \rightleftharpoons 2Hg(l) + O_2(g)$
3. The following equilibrium constants were determined at 1123 K:

$$C(s) + CO_2\ (g) \rightleftharpoons 2CO(g) \qquad K_1 = 1.3 \times 10^{14}$$
$$CO\ (g) + Cl_2\ (g) \rightleftharpoons COCl_2\ (g) \qquad K_2 = 6.0 \times 10^{-3}$$

   Calculate the equilibrium constant for the following reaction at 1123 K and write the K expression for ALL reactions:

$$C(s) + CO_2\ (g) + 2Cl_2\ (g) \rightleftharpoons 2COCl_2\ (g) \qquad K_3 = ???$$

4. The equilibrium constant, K_c, for the reaction $H_2\ (g) + F_2(g) \rightleftharpoons 2HF(g)$ has the value 2.1×10^3 at a particular temperature. When the system is analyzed at equilibrium at this temperature, the concentrations of $H_2(g)$ and $F_2\ (g)$ are both found to be 0.0021 M. What is the concentration of HF(g) in the equilibrium system under these conditions?
5. At 25°C, $K_p = 5.3 \times 10^5$ for the reaction

$$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$$

   When a certain partial pressure of $NH_3\ (g)$ is put into an otherwise empty rigid vessel at 25°C, equilibrium is reached when 50.0% of the original ammonia has decomposed. What was the original partial pressure of ammonia before any decomposition occurred?

6. For the following reaction:

$$CO\ (g) + Cl_2\ (g) \rightleftharpoons COCl_2\ (g)$$

the equilibrium constant, K_C, has been determined to be 6.0×10^{-3} at 1123 K. If a mixture of 3.0 M CO, 2.0 M Cl_2 and 0.25 M $COCl_2$ is put in a vessel, which way will the reaction proceed to reach equilibrium?

7. A mixture of 0.500 mol H_2 and 0.500 mol I_2 was placed in a 1.00 L steel container at 430°C. The equilibrium constant, K_C, for the reaction

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

8. The following equilibrium constants have been determined for oxalic acid at 25°C:

$$H_2C_2O_4\ (aq) \rightleftharpoons H^+\ (aq) + HC_2O_4^-\ (aq) \qquad K_1 = 6.5 \times 10^{-2}$$
$$HC_2O_4^-\ (aq) \rightleftharpoons H^+\ (aq) + C_2O_4^{2-}\ (aq) \qquad K_2 = 6.1 \times 10^{-5}$$

Calculate the equilibrium constant for the following reaction at the same temperature:

$$H_2C_2O_4\ (aq) \rightleftharpoons 2H^+\ (aq) + C_2O_4^{2-}\ (aq) \qquad K_3 = ???$$

9. For the following reaction:

$$PCl_5\ (g) \rightleftharpoons PCl_3\ (g) + Cl_2\ (g)$$

The initial concentration of PCl_5 is 0.200 moles per liter and there are no products in the system when the reaction starts. If the equilibrium constant is 0.030, calculate all the concentrations at equilibrium.

10. Given this equation:

$$COCl_2 \rightleftharpoons CO + Cl_2$$

2.00 g of $COCl_2$ and 5.00 g of Cl_2 are placed in a 2.50 L flask. Calculate all three equilibrium partial pressures when $K_p = 0.680$ at 25°C.

6. For the following reaction:

$$CO\ (g) + Cl_2\ (g) \rightleftharpoons COCl_2\ (g)$$

the equilibrium constant, K_C, has been determined to be 6.0×10^{-3} at 1123 K. If a mixture of 3.0 M CO, 2.0 M Cl_2 and 0.25 M $COCl_2$ is put in a vessel, which way will the reaction proceed to reach equilibrium?

7. A mixture of 0.500 mol H_2 and 0.500 mol I_2 was placed in a 1.00 L steel container at 430°C. The equilibrium constant, K_C, for the reaction

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

8. The following equilibrium constants have been determined for oxalic acid at 25°C:

$$H_2C_2O_4\ (aq) \rightleftharpoons H^+\ (aq) + HC_2O_4^-\ (aq) \qquad K_1 = 6.5 \times 10^{-2}$$
$$HC_2O_4^-\ (aq) \rightleftharpoons H^+\ (aq) + C_2O_4^{2-}\ (aq) \qquad K_2 = 6.1 \times 10^{-5}$$

Calculate the equilibrium constant for the following reaction at the same temperature:

$$H_2C_2O_4\ (aq) \rightleftharpoons 2H^+\ (aq) + C_2O_4^{2-}\ (aq) \qquad K_3 = ???$$

9. For the following reaction:

$$PCl_5\ (g) \rightleftharpoons PCl_3\ (g) + Cl_2\ (g)$$

The initial concentration of PCl_5 is 0.200 moles per liter and there are no products in the system when the reaction starts. If the equilibrium constant is 0.030, calculate all the concentrations at equilibrium.

10. Given this equation:

$$COCl_2 \rightleftharpoons CO + Cl_2$$

2.00 g of $COCl_2$ and 5.00 g of Cl_2 are placed in a 2.50 L flask. Calculate all three equilibrium partial pressures when $K_p = 0.680$ at 25°C.