Chemical Equilibrium

1. Write equilibrium expressions for the following reactions.

a. $NH_4HS(g) \rightleftharpoons NH_3(g) + H_2S(g)$

b. $4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$

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

d. $CuSO_4 \cdot 3H_2O(s) + 2H_2O(g) \rightleftharpoons CuSO_4 \cdot 5H_2O(s)$

2. At 793 K, the equilibrium constant for the reaction $NCl_3(g) + Cl_2(g) \rightleftharpoons NCl_5(g)$ is 39.3.

a. Do products or reactants dominate in this equilibrium?

b. If the equilibrium constant for this reaction were less than 1, would the reactants or products be dominant?

3. At 773 K, the reaction $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ produces the following concentrations: $[NO] = 3.49 \times 10^{-4}M$; $[O_2] = 0.80M$; $[NO_2] = 0.25M$.

a. What is the equilibrium constant expression for the reaction?

b. What is the equilibrium constant for the reaction?

4. If you wished to maximize the products of the following reactions, which concentrations would you lower or raise?

a. $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$

b. $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$

c. $SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$

d. $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$

5. For each reaction, state whether increasing or decreasing the volume of the reaction vessel would yield more product at equilibrium. Give the reason for your choice.

a. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

b. $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

c. $CH_4(g) + 2O_2(g) \rightleftharpoons CO_2(g) + 2H_2O(g)$

d. $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$

6. What effect would an increase in temperature have on these reactions at equilibrium? Why?

a. $\text{Heat} + H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

b. $CH_4(g) + 2O_2(g) \rightleftharpoons CO(g) + 2H_2O + \text{heat}$

c. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$

d. $\text{Heat} + CH_4(g) \rightleftharpoons C(s) + 2H_2(g)$

7. Phosphorous pentachloride decomposes to phosphorous trichloride according to this equation: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. At equilibrium, $[PCl_5] = 1.00M$ and $[Cl_2] = 3.16 \times 10^{-2}M$.

a. Write the expression for determining the concentration of PCl_3.

b. What is the equilibrium concentration of PCl_3? Use: $K_{eq} = 1.00 \times 10^{-3}$.

8. The solubility product constant (K_{sp}) of Ag_2SO_4 is 1.2×10^{-5}.

a. How would you estimate the molar solubility of SO_4^{2-} without actually calculating it?

b. What is the calculated molar solubility of SO_4^{2-}?