Unit 7 - Solubility Equilibrium
Chapter 16

Review the following:

- Polyatomic ions and solubility rules
- Equilibrium constant expressions
- ICE charts
- Reaction quotient, Q
- Le Chatelier's Principle (shifts)
- pH = - log $[H^+]$
- pOH = - log $[OH^-]$
- pH + pOH = 14
- $[H^+] = 10^{-pH}$
- $[OH^-] = 10^{-pOH}$

Things to consider:

- Insoluble salts are actually slightly soluble
- Slightly soluble salts establish a dynamic equilibrium with the hydrated cations and anions in solution
    - When solid is first added to water, no ions are initially present in water
    - As dissolution proceeds, the concentration of ions increases until equilibrium is established **(equilibrium = saturated solution)**
- The presence of a **common ion** in solution **will reduce the molar solubility** of a salt
    - Occurs when a salt is dissolved in a solution that already contains the cations and/or anions of the salt being dissolved
- Q is used to determine whether a precipitate forms
    - Q < Ksp, the system is not at equilibrium (unsaturated)
    - Q = Ksp, the system is at equilibrium (saturated)
    - Q > Ksp, the system is not at equilibrium (supersaturated)

    Precipitate forms when Q > Ksp. Concentrations of dissolved ions too high, causes reverse shift, thus precipitate forms.

1. AgCl(s) dissolves in water according to the equation below and has a Ksp value of 1.8×10^{-10}.

$$AgCl(s) \leftrightarrow Ag^+(aq) + Cl^-(aq)$$

    a. Write the Ksp expression for the dissolution of AgCl(s).
    b. What is the molar solubility of AgCl(s) in water?

2. The Ksp of CaF_2 is 4.0×10^{-11}. Calculate the molar solubility of $CaF_2(s)$ in each of the following.
    a. Pure water
    b. 0.025 M NaF(aq)
    c. Calculate the solubility, in grams per liter, of $CaF_2(s)$ in the solution in part (b).

3. The Ksp of $Fe(OH)_2(s)$ is 8.0×10^{-16}. Calculate the molar solubility of $Fe(OH)_2(s)$ in each of the following.
    a. Pure water
    b. 0.010 M $Fe(NO_3)_2(aq)$
    c. 0.020 M NaOH(aq)

4. Copper(I) bromide has a molar solubility of 2.0×10^{-4} M at 25°C. Calculate the Ksp of copper(I) bromide.

5. $Bi_2S_3(s)$ has a molar solubility of 1.0×10^{-15} M at 25°C. Calculate the Ksp of $Bi_2S_3(s)$.

6. A saturated solution of $Mg(OH)_2$ has a pH of 10.36. Calculate the Ksp of $Mg(OH)_2(s)$.

7. A saturated solution of $Cd(OH)_2$ has a pH of 9.333. Calculate the Ksp of $Cd(OH)_2(s)$.

8. 20.0 mL of 0.100 M $Fe(NO_3)_2(aq)$ is mixed with 40.0 mL of 0.0500 M NaOH(aq). Will a precipitate of $Fe(OH)_2$ form? The Ksp of $Fe(OH)_2(s)$ is 8.0×10^{-16}.

9. 0.100 L of 1.5×10^{-3} M $MgCl_2(aq)$ and 0.200 L of 0.025 M NaF(aq) are mixed. Will a precipitate of MgF_2 form? The Ksp of $MgF_2(s)$ is 3.7×10^{-8}.

10. Will a precipitate of Ag_2CrO_4 form when 1.00 mg of $Na_2CrO_4(s)$ is added to 225 mL of 1.5×10^{-4} M $AgNO_3(aq)$? The Ksp of $Ag_2CrO_4(s)$ is 1.1×10^{-12}.

Ksp Equilibrium HW #2

1. Copper (II) sulfide has a Ksp of $1.0 * 10^{-36}$. What is the molar solubility in moles per liter of copper (II) sulfide in
   a. 0.020M copper (II) sulfate solution?
   b. 0.010 M sodium sulfide solution?

2. $Mg_3(PO_4)_2$ has a Ksp of $1.0 * 10^{-24}$. What is the molar solubility in grams per liter of magnesium phosphate in
   a. 0.010M sodium phosphate solution?
   b. 0.030M magnesium nitrate solution?

3. Calculate the $[OH^-]$ in equilibrium with $1.00 * 10^{-4}$ M Zn^{+2} if the Ksp of $Zn(OH)_2$ is $4.0 * 10^{-17}$?

4. What is the pH of the solution in question #3

5. Silver nitrate is added to a solution of $2.00 * 10^{-2}$ M sodium phosphate. What is the equilibrium concentration of Ag^+? (Ksp of silver phosphate is $1.0 * 10^{-16}$)

6. Lead (II) chromate, $PbCrO_4$, is the yellow paint pigment known as "chrome yellow". A solution is prepared by mixing a solution that is $1.0 * 10^{-4}$ M in lead (II) ion with a solution that is $5.0 * 10^{-3}$ M in chromate ion. Ignoring dilution effects, would a precipitate form? The Ksp of lead (II) chromate is $2.0 * 10^{-14}$?

7. A solution is prepared by mixing 25.0 mL of 0.100 M iron(II) nitrate with 50.0 mL of a sodium hydroxide solution of pH 9.00. Will a precipitate form? The Ksp of iron(II) hydroxide is $5.0 * 10^{-17}$?

Answers: 1a) 5.0×10^{-35} M 1b) 1.0×10^{-34} M 2a) 1.89×10^{-5} g/L 2b) 2.53×10^{-8} g/L 3) 6.32×10^{-7} M 4) 7.801 5) 1.71×10^{-5} M 6) Q=5.0 10^{-7}, thus a ppt will form 7) Q=1.47×10^{-12}, thus a ppt will form