Solubility (Dissolution and Precipitation)

You are expected to be able to:

- use the *solubility rules* to predict solubility behaviour of binary compounds.
- calculate the *solubility product*, K_{sp}, given the solubilities and vice versa.
- explain the effect of pH and a common ion on solubility.

Solubility rules for ionic compounds

1. Almost all salts of the Group 1A (alkali metals) and of NH_4^+ are soluble in water
2. All nitrates are soluble in water
3. Most chlorides, bromides and iodides are soluble, the exceptions are those of Ag^+ and Hg_2^{2+}
4. Most sulfates are soluble, the major exceptions being those of barium, lead, mercury, bismith and tin. Calcium sulfate is sparingly soluble.
5. Most carbonates, oxides, hydroxides, phosphates and sulfides are insoluble. Exceptions are the alkali metals (rule 1). Calcium and barium hydroxides are fairly soluble.

For the general case where MX(s) represents an ionic compound;

$$MX(s) \quad ========== \quad M^+(aq) \quad + \quad X^-(aq)$$

$$K_{sp} = [M^+][X^-]$$

And solubility (s) is equal to the number of moles of solid dissolved per liter of solution.

In general, ionic compounds are less soluble in a solution that contains either ion from another source. Thus calcium sulfate is less soluble in a solution that contains calcium from another source, such as calcium carbonate.

In general, ionic compounds that contain a basic anion become more soluble in acidic solution as the protons present will associate with the basic anion thus effectively lowering their concentration. Thus, hydroxides, sulfides, carbonates, fluorides and phosphates all become more soluble at low pH.

Sample Excercises:

1. In which of the following cases would you expect precipitation to occur when equal volumes 0.1 **M** solutions are mixed?
a) calcium chloride and silver nitrate
b) potassium sulfide and cadmium chloride
c) barium hydroxide and copper (II) sulfate

2. Given that the K_{sp} of CaF_2 is 5.3×10^{-9} $\mathbf{M}^3$
a) Calculate the solubility of CaF_2
b) Is calcium floride more or less soluble in basic solution?
c) Is calcium fluoride more or less soluble in 'hard' water?