Chapter 16 – Solubility and Complex Ion Equilibria

16.1 Solubility Equilibria and the Solubility Product

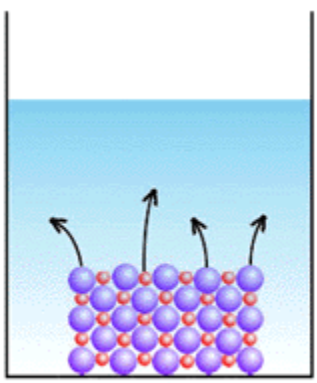
A. Dynamic Equilibrium

$CaF_2(s) \rightarrow Ca^{2+}(aq) + 2F^-(aq)$

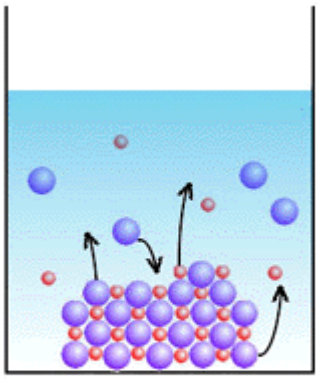
$\underline{Ca^{2+}(aq) + 2F^-(aq) \rightarrow CaF_2}$

$CaF_2(s) \leftrightarrows Ca^{2+}(aq) + 2F^-(aq)$

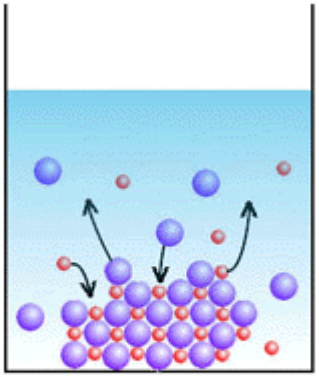
1. Equilibrium occurs when the solution is saturated



Salt is initially put into the water and begins dissolving.



Salt continues to dissolve; however, dissolved ions will also precipitate. Because the salt dissolves faster than its ions precipitate, the net movement is towards dissolution.



Eventually, the rate of dissolution will equal the rate of precipitation. The solution will be in equilibrium, but the ions wil continue to dissolve and precipitate.

B. K_{sp} (Solubility Product Constant, Solubility Product)

$K_{sp} = [Ca^{2+}][F^-]_2$

1. Experimentally determined solubility of an ionic solid can by used to calculate its K_{sp} value
2. The solubility of an ionic solid can be calculated if its K_{sp} value is known

C. Relative Solubilities

1. IF the salts being compared produce the same number of ions in solution, K_{sp} can be used to directly compare solubility
   a. NaCl(s), KF(s)
      K_{sp} = [cation][anion] = x^2
2. IF the salts being compared produce different numbers of ions, K_{sp} cannot be directly compared
   a. $Ag_2S(s)$
      $K_{sp} = [2x]^2[x]$
   b. $Bi_2S_3(s) = [2x]^2[3x]^3$

D. Common Ion Effect

1. The solubility of a solid is lowered if the solution already contains ions common to the solid
   a. Dissolving silver chloride in a solution containing silver ions
   b. Dissolving silver chloride in a solution containing chloride ions

E. pH and Solubility

1. If anion X^- is an effective base (HX is a weak acid), the salt MX will show increased solubility in acidic solution
    a. Effective bases include:
        OH^- , S^{2-} , CO_3^{2-} , $C_2O_4^{2-}$, CrO_4^{2-}

16.2 Precipitation and Qualitative Analysis

Instructor's Note: We will skim over much of sections 7 and 8, hitting only the high points and performing a lab on selective precipitation

A. Selective Precipitation

1. Mixtures of metal ions in aqueous solution are often separated by using a reagent whose anion forms a precipitate with only one or a few of the metal ions in the mixture