

K_{sp} for Copper (II) Tartrate

We have learned about many equilibrium systems during the past four (or more) weeks. The equilibrium constant, the measure of the extent of a reaction, we have discussed include,

K_p, K_c
K_a, K_b, K_w, K_{neutralization}

For every equilibrium constant we needed a chemical equation. The chemical equation was always provided for K_c and K_p, but for the acid-base equilibrium systems, an acid-base theory (Arrhenius or Bronsted-Lowry) was used to arrive at the chemical equation.

This new equilibrium system is described by the dissolution of an ionic compound. The equilibrium constant is K_{sp} (solubility product). An example is K_{sp} (AgCl) that has a value of

$$K_{sp} = 1.7 \times 10^{-10}$$

and the chemical equation is



The equilibrium expression,

$$K_{sp} = [Ag^+][Cl^-]$$

Remember the solid is not included in the equilibrium expression since its concentration does not change.

The magnitude of the K_{sp} is very small. Looking at the dissolution chemical equation a small K_{sp} means that AgCl is not very soluble, since the concentrations of the ions is so small.

There are two common types of problems that are solved when discussing equilibrium systems:

- 1) given ^{initial} amounts of reactants & products and an equilibrium amount, calculate
- 2) given ^K the initial amounts of R & P and K, we calc all the equilibrium amounts.

For dissolution chemical equations

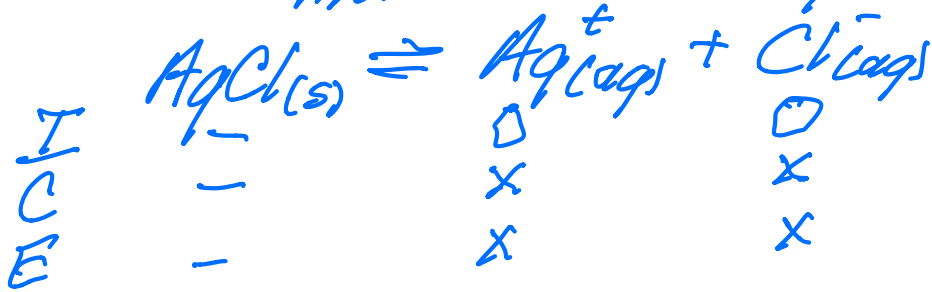
type 1 problems: need to be given the molar solubility and calculate K_{sp}

in type 2 problems give K_{sp} , calculate molar solubility of the ionic compd.

Example Type 1 problem: Calculate the K_{sp} for AgCl given the solubility of AgCl is 1.863×10^{-4} grams AgCl in 100 mL of water.

$$\frac{1.863 \times 10^{-4} \text{ g AgCl}}{100 \text{ mL}} \left(\frac{1 \text{ mol}}{143 \text{ g}} \right) \left(\frac{1000 \text{ mL}}{1 \text{ L}} \right) = 1.3 \times 10^{-5} \frac{\text{mol}}{\text{L}}$$

molar solubility



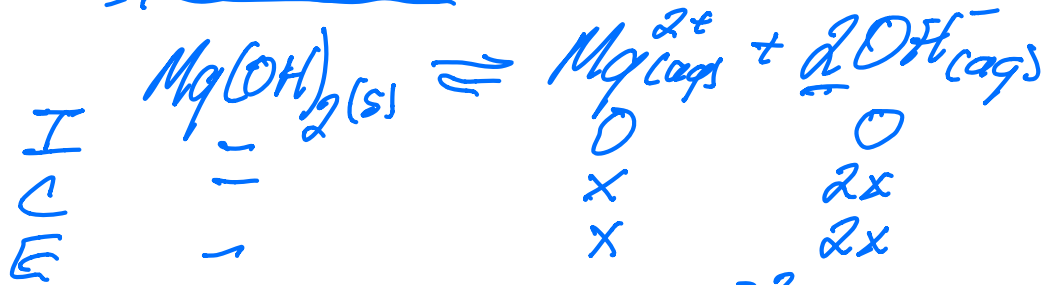
$x = \text{molar solubility AgCl}$
 $\frac{\text{mol AgCl}}{1 \text{ L}}$

$$K_{sp} = [\text{Ag}^+][\text{Cl}^-]$$

$$K_{sp} = (x)(x) = x^2$$

$$= (1.3 \times 10^{-5})^2 = 1.7 \times 10^{-10}$$

Example Type 2 problem: The K_{sp} for $Mg(OH)_2$ is 8.9×10^{-12}
 calculate the solubility of $Mg(OH)_2$ in moles per liter.



$x = \text{molar solubility } Mg(OH)_2$

$$K_{sp} = [Mg^{2+}][OH^{-}]^2$$

$$8.9 \times 10^{-12} = (x)(2x)^2$$

$$8.9 \times 10^{-12} = 4x^3$$

$$2.25 \times 10^{-12} = x^3$$

$$\underline{\underline{1.3 \times 10^{-4} M}} = x = \text{solubility of } Mg(OH)_2$$