1. The solubility is essentially the molarity of a saturated solution of a substance and it has the units of concentration. It is the amount of solute that dissolves in a certain amount of solvent at a certain temperature.

2. An insoluble substance dissolves to a very small extent, insoluble does not mean that no solute dissolves at all.

3. The K_{sp} of a soluble salt is very large, much greater than 1, because more of the species dissolves. The K_{sp} of an insoluble salt is very small, usually less than 1, because very little of the substance dissolves.

4. If you have a saturated solution you know the system is in dynamic equilibrium and the K_{sp} can be used to solve for concentrations of ions.

5. Always write the equilibrium constant expression first. $K_{sp} = [Ag^+]^2[SO_4^{2-}]$. For every 1 mol of Ag_2SO_4 that dissolves 2 mol of Ag^{2+} and 1 mol of SO_4^{2-} are formed. Therefore the solubility of Ag_2SO_4 is equal to the $[SO_4^-]$ and $2[Ag^+]$. Substitute the solubilities into the expression and solve for K. $\{2(1.55 \times 10^{-2})\}^2(1.55 \times 10^{-2}) = 1.5 \times 10^{-5}$.

6. $K_{sp} = [Li^+][F^-] = 1.7 \times 10^{-3}$ and since 1 mol of Li^+ and 1 mol of F^- are formed for every mole of LiF that dissolves the expression can be written as $1.7 \times 10^{-3} = x^2$. x = solubility = 0.04 M.

7. The concentration of Pb^{2+} in a saturated solution is the same as the solubility of the solid, 5.3×10^{-6}.

8. Because the equilibrium constant changes value when the temperature changes.

9. The pOH = 14 - 8 = 6 so the $[OH^-] = 1 \times 10^{-6}$ M. The $[Ni^{2+}]$ is the same as the solubility of the solid, 0.002 M. Therefore the $K_{sp} = (0.002)(1 \times 10^{-6})^2 = 2 \times 10^{-15}$.

10. $K_{sp} = [Al^{3}+][OH-]^3$ and since 3 mol of OH^- are formed for every 1 mol of solid that dissolves, $K_{sp} = (x)(3x)^3 = 27x^4 = 3 \times 10^{-34}$. $x = 1.8 \times 10^{-9}$ and $[OH^-] = 3x = 5.5 \times 10^{-9}$.

CHEMISTRY
The Complete Course

Lesson Thirty
Solubility Equilibria

KA8530

Worksheet

I. VIDEOTAPE FOLLOW-UP QUESTIONS

I. The term "solubility equilibria" refers to the kind of equilibria that exist in saturated solutions of slightly soluble ionic solids.

A. A classic example would be the equilibrium that exists in a saturated solution of silver chloride, AgCl.

1. This equilibrium can be represented by the equation $AgCl(s) \leftrightarrow Ag^+ + Cl^-$.
2. The equilibrium constant for this system is given the symbol K_{sp}, and is referred to as a solubility product.
   a. For this system, $K_{sp} = [Ag^+][Cl^-]$.
   b. There is no denominator in the expression for the solubility product because the denominator is a pure solid, and pure solids and liquids are never included in equilibrium constant expressions.

B. One important difference between dissociation equilibria and solubility equilibria is that in a dissociation equilibrium the value of the equilibrium constant must always be satisfied, whereas in a solubility equilibrium the solubility product is only satisfied if the solution is saturated.

C. In these types of equilibria it is important to not confuse the molar solubility of the substance with the value of its solubility product.

1. The term "solubility" refers to how much of a substance can be dissolved in a liter of solution, i.e., the molarity of a saturated solution.
2. The term "solubility product" refers to the numerical value of the equilibrium constant for the equation that represents the substance dissolving in water.
3. For example, the solubility of AgCl in water is about 1.3×10^{-5} M, whereas the value of the solubility product is 1.8×10^{-10}.
4. Two "classic" types of problems are to determine the molar solubility of an ionic solid given the value of this solubility product, and vice-versa.

II. In this lecture several problems relating to the solubility and the solubility product of various ionic solids are presented and solved.

II. SUPPLEMENTARY EXERCISES

1. Define solubility. What are the units of solubility?

2. What does it mean when a chemist states that a substance is insoluble?

3. What is the difference between the K_{sp} of a soluble salt and an insoluble salt?

4. What is the significance of a saturated solution of a substance?

5. The solubility of Ag_2SO_4 in water at 25°C is 1.55×10^{-2} M. What is the solubility product at this temperature?

6. The K_{sp} of LiF is 1.7×10^{-3} at 25°C. What is the solubility of LiF at this temperature?

7. The K_{sp} of $Pb(OH)_2$ is 6×10^{-16} at 25°C. What is the $[Pb^{2+}]$ in a saturated solution of $Pb(OH)_2$ at this temperature?

8. Why is it important to specify the temperature in solubility product problems?

9. At a pH = 8.0 at 25°C, the solubility of $Ni(OH)_2$ is 0.002 M. What is the K_{sp} of $Ni(OH)^2$?

10. What is the $[OH^-]$ of a saturated solution of $Al(OH_3)$ at 25°C, if the K_{sp} is 3×10^{-34}?