Name: **Honors Chemistry**

Section: Solubility Product Constants

The **solubility product** is just the equilibrium constant for the dissolving of a slightly soluble solid. Here are some examples:

$AgCl(s) \leftrightarrow Ag^+(aq) + Cl^-(aq)$ $\quad K_{sp} = [Ag^+][Cl^-]$

$MgF_2(s) \leftrightarrow Mg^{2+}(aq) + 2\ F^-(aq)$ $\quad K_{sp} = [Mg^{2+}][F^-]^2$

Since the reactant is always a solid, there is no denominator on solubility equilibrium expressions. Assume that the denominator is always "1".

There are two basic types of $K_{sp}$ problems:
1. Give the solubility (also known as the concentration of a saturated solution), find the $K_{sp}$.
2. Given the $K_{sp}$, find the molarity or the concentration of a saturated solution (also known as the solubility) of the solid in question.

*Watch out—these problems all use different ways of saying the same thing*!

General Problem-Solving Strategy
**List what you know.**
Write out the balanced ionization expression.
List known values. Identify the unknown(s).
**Set up the problem.**
Write the $K_{sp}$ expression.
**Estimate and calculate.**
Substitute and evaluate. Use sig figs.

1. The solubility of AgCl is $1.34 \times 10^{-5}$ M. Find the $K_{sp}$ of AgI. Model Calculation:

2. The concentration of a saturated solution of barium carbonate, $BaCO_3$, is $7.00 \times 10^{-5}$ M. Calculate the $K_{sp}$ of barium carbonate. ($4.90 \times 10^{-9}$)

3. What is the $K_{sp}$ of $Pb(IO_3)_2$ if a saturated solution has a concentration of 2.30 mg/100 $cm^3$? ($2.82 \times 10^{-13}$)

4. Find the $K_{sp}$ of copper (II) sulfide if a saturated solution is $2.51 \times 10^{-18}$M. ($6.31 \times 10^{-36}$)

5. The $K_{sp}$ of strontium oxalate, $SrC_2O_4$, is $1.58 \times 10^{-7}$. Find the concentration of a saturated solution of strontium oxalate.
   Model Calculation:

6. If the $K_{sp}$ of barium chromate is $2.00 \times 10^{-10}$, what is the solubility of $BaCrO_4$?
   ($1.41 \times 10^{-5}$ M)

7. What will be the concentration of copper ions in a saturated solution of copper (II) carbonate, $CuCO_3$? (The $K_{sp}$ of copper carbonate is $8.7 \times 10^{-9}$). ($9.3 \times 10^{-5}$ M)

8. What is the molarity of a saturated solution of lead (II) iodide, $PbI_2$? The $K_{sp}$ of lead (II) iodide is $7.08 \times 10^{-9}$. (Note: Be careful! Write the balanced equation first, then express the unknown concentrations of the ions in terms of each other.) ($1.21 \times 10^{-3}$ M)

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Section: Ksp Problems Level 2

A useful application of $K_{sp}$ data is to determine if precipitation will occur when a salt and a solution or when two solutions are mixed. Precipitation takes place only when the ion product exceeds the Ksp.

| | |
|---|---|
| Ion product < $K_{sp}$ | no precipitate will form |
| Ion product = $K_{sp}$ | no precipitate will form |
| Ion product > $K_{sp}$ | precipitate will form |

Remember that if the final solution is formed by mixing two solutions, it is necessary to consider dilution. Each solute is diluted when the other solution is added.

**Example:**
Will precipitation occur when 50.0 mL of a $3.00 \times 10^{-2}$ M $Pn(NO_3)_2$ solution is added to 50.0 mL of $2.00 \times 10^{-3}$ M KCl? The Ksp of $PbCl_2$ is $1.62 \times 10^{-5}$.

- Assume volumes are additive (total volume = 100.0 mL)
- Calculate new concentrations of ions in mixture
- Substitute into Ksp expression

1. 25.0 mL of $6.00 \times 10^{-6}$ M $Sr(NO_3)_2$ is mixed with 25.0 mL of $4.00 \times 10^{-7}$ $H_3PO_4$. Will precipitation occur? The Ksp of $Sr_3(PO_4)_2$ is $4.07 \times 10^{-28}$. (No precipitation)

2. Determine if a precipitate of silver chromate, $Ag_2CrO_4$, will form when 100.0 mL of .100 M $AgNO_3$ are added to 100.0 mL of .350 M K2CrO4. The $K_{sp}$ of $Ag_2CrO_4$ is $9.00 \times 10^{-12}$. (ppt will form)

3. Predict whether calcium carbonate will precipitate when 0.5 L of 0.001 M $Ca(NO_3)_2$ is mixed with 0.5 L of 0.0008 M $Na_2CO_3$ to form 1.0 L of solution. The Ksp of $CaCO_3$ is $4.5 \times 10^{-9}$ M. (ppt will form)

4. The solubility product constant for lead (II) chloride is $1.7 \times 10^{-5}$. How many moles of lead nitrate can dissolve in 1.00 L of a 0.1 M solution of sodium chloride? (Hint: One of the ions found in $PbCl_2$, the chloride ion, is already present in the solution. That can be taken to be its equilibrium concentration.) (0.0017 mol can be dissolved)