Name: Key
Blk: _____ Date: _____

Chemistry 12
Solubililty Lesson #6
THE SOLUBLITY PRODUCT

The specialized "equilibrium expression" for a saturated solution is called the "Ksp" or the Solubility Product constant:

CaF_2 (s) <-----> Ca^{2+} (aq) + 2 F^- (aq) $\qquad K_{sp} = [Ca^{2+}][F^-]^2$

WE WILL USE THE "K_{sp} TABLE" pg 5 of your Data Booklet IF WE ARE ASKED TO CALCULATE OR COMPARE RELATIVE SOLUBILITIES OF SUBSTANCES.

Example 1: Write out the K_{sp} expressions for the following saturated solutions:
a. $BaSO_4$ b. $Cu(IO_3)_2$

$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$ $\qquad Cu(IO_3)_2(s) \rightleftharpoons Cu^{2+}(aq) + 2\,IO_3^-(aq)$

$K_{sp} = [Ba^{2+}][SO_4^{2-}] = 1.1 \times 10^{-10}$ $\qquad K_{sp} = [Cu^{2+}][IO_3^-]^2 = 6.9 \times 10^{-8}$

BECAUSE THE K_{sp} DEPENDS ON THE CONCENTRATIONS OF THE IONS IN SOLUTION, THE LARGER THE K_{sp} VALUE THE MORE SOLUBLE THE SALT. THE SMALLER THE K_{sp} VALUE THE LESS SOLUBLE THE SALT.

∴ $BaSO_4$ is less soluble than $Cu(IO_3)_2$

Eample 2. Which of the following salts is the most soluble? Which is the least?
$BaSO_4$, $K_{sp} = 1.0 \times 10^{-10}$ $\quad BaCrO_4$, $K_{sp} = 1.2 \times 10^{-10}$ $\quad BaCO_3$, $K_{sp} = 2.6 \times 10^{-9}$

Most (largest #) = $BaCO_3$, $K_{sp} = 2.6 \times 10^{-9}$

Least (smallest #) = $BaSO_4$, $K_{sp} = 1.0 \times 10^{-10}$

SOLVING K_{sp} PROBLEMS:
THERE ARE TWO TYPES OF K_{sp} PROBLEMS THAT YOU WILL ENCOUNTER

Type 1: The saturated solution ion concentrations are given, or they have to be calculated from a given mass → Then calculate the Ksp

Type 2: The Ksp value is given (or see Ksp table) and you are asked to find the individual [ ]'s

Regardless of the type of problem you will start each problem by:

1st: Write out the equilibrium ~~expression~~ equation for the saturated solution. (solid on reactant side always)

2nd: write out the Ksp expression

Example 3: A Solution with a precipitate of BaF_2 contains 4.59×10^{-2} M Ba^{2+} and 2.00×10^{-3} M F^-. What is the K_{sp} for BaF_2 ?

1st: $BaF_2 \rightleftharpoons Ba^{2+}(aq) + 2F^-(aq)$

2nd: $K_{sp} = [Ba^{2+}][F^-]^2$

3rd: $K_{sp} = [4.59 \times 10^{-2}][2.00 \times 10^{-3}]^2$

$= \boxed{1.84 \times 10^{-7}}$

Example 4: A saturated solution contains 7.16×10^{-3} mol of BaF_2 in 2.00 L of solution. What is the K_{sp} for BaF_2 ?

1st: $BaF_2 \rightleftharpoons Ba^{2+}(aq) + 2F^-(aq)$

2nd: $K_{sp} = [Ba^{2+}][F^-]^2$

3rd: Using $[7.16 \times 10^{-3}\ mol / 2.00\ L = 3.58 \times 10^{-3}\ M\ BaF_2$

determine $[Ba^{2+}] = 3.58 \times 10^{-3}\ M$

$[F^-] = 3.58 \times 10^{-3}\ M \times 2 = 7.16 \times 10^{-3}\ M$

4th: plug values into ksp.

$K_{sp} = [3.58 \times 10^{-3}][7.16 \times 10^{-3}]^2$

$= \boxed{1.84 \times 10^{-7}}$

Example 5: What is the $[Mg^{2+}]$ in a saturated solution of $Mg(OH)_2$?

1st: $Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$

$1x \qquad 1x \qquad 2x$

2nd: $K_{sp} = [Mg^{2+}][OH^-]^2 = 5.6 \times 10^{-12}$ (value from table)

3rd: look up ksp value from table. $K_{sp} = 5.6 \times 10^{-12}$

let "x" represent $[Mg(OH)_2]$ $\therefore 1x = [Mg^{2+}]$ and $2x = [F^-]$

4th: plug into ksp + solve for "x"

$5.6 \times 10^{-12} = [1x][2x]^2$

$= 1x \cdot 4x^2 = \boxed{4x^3}$

$\frac{5.6 \times 10^{-12}}{4} = \frac{4x^3}{4}$

$\sqrt[3]{1.4 \times 10^{-12}} = \sqrt[3]{x^3}$

$x = 1.1 \times 10^{-4}$

$\therefore \boxed{[Mg^{2+}] = 1.1 \times 10^{-4}\ M}$

Example 6. What mass of $Mg(OH)_2$ will dissolve in 250 mL of water?

Carry out Steps 1-4 as in example #5

THEN: Convert the $[Mg^{2+}]$ to mass of $Mg(OH)_2$ using STOICHIOMETRY!!!

$Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$

$1x \qquad 1x \qquad 2x$

$\therefore 1x = [Mg(OH)_2]$

Mg = 24.3
2O = 32.0
H = 2.0
58.3g

$$\frac{1.1 \times 10^{-4}\ \text{mol } Mg(OH)_2}{1\ L} \times \frac{58.3\ g\ Mg(OH)_2}{1\ \text{mol } Mg(OH)_2} \times 0.250\ L =$$

$$\boxed{1.6 \times 10^{-3}\ g\ Mg(OH)_2}$$

SEATWORK/HOMEWORK: Exercises 40-55 pgs 91-95
PLO's: I1- I4