CONCEPT: SOLUBILITY PRODUCT CONSTANT

_____ represents the maximum amount of solute that could successfully dissolved in a solvent.

- Associated with any solid is a ***Ksp*** value, which stands for the solubility product constant.
- The larger the solubility product constant then the _____ soluble an ionic solid is in a solvent.
- The smaller the solubility product constant then the _____ soluble an ionic solid is in a solvent.

EXAMPLE 1: A hypothetical compound MX_3 has a molar solubility of 0.00562 M. What is the value of K_{sp} for MX_3?

a) 3.16×10^{-5}

b) 2.99×10^{-9}

c) 9.48×10^{-5}

d) 2.69×10^{-8}

EXAMPLE 2: Which of the following compounds will have the highest molar solubility in pure water?

a) $Co(OH)_2$ $K_{sp} = 1.3 \times 10^{-15}$

b) $Sr_3(PO_4)_2$ $K_{sp} = 4.0 \times 10^{-28}$

c) $PbCl_2$ $K_{sp} = 1.60 \times 10^{-5}$

d) AgCN $K_{sp} = 5.97 \times 10^{-17}$

e) $PbSO_4$ $K_{sp} = 1.82 \times 10^{-8}$

PRACTICE: SOLUBILITY PRODUCT CONSTANT CALCULATIONS 1

EXAMPLE 1: $La(OH)_3$ has a K_{sp} of 2.0×10^{-21}. How many grams of $La(OH)_3$ (MW: 189.93 g/mol) are dissolved as hydroxide ions in 2.5 liter of a saturated solution of $La(OH)_3$?

EXAMPLE 2: Find the pH of a saturated solution of Aluminum hydroxide, $Al(OH)_3$. The K_{sp} of $Al(OH)_3$ is 1.9×10^{-10}.

PRACTICE: SOLUBILITY PRODUCT CONSTANT CALCULATIONS 2

EXAMPLE: Calculate the molar solubility of $FeCO_3$ in a solution of 0.00167 M Na_2CO_3. K_{sp} for $FeCO_3$ is 2.1 x 10^{-11}.

PRACTICE 1: What is the molar solubility of $Fe(OH)_3$ (s) in a solution that is buffered at pH 3.50 at 25 °C? The K_{sp} of $Fe(OH)_3$ is 6.3 x 10^{-38} at 25 °C.

PRACTICE 2: Arsenic trisulfide (As_2S_3) occurs naturally as the orange-yellow colored mineral orpiment. As_2S_3 is a highly insoluble substance with a K_{sp} value of 2.90×10^{-72}. Calculate the solubility of As_2S_3 in g/100mL. (Molar mass of As_2S_3 = 246.04 g/mol)

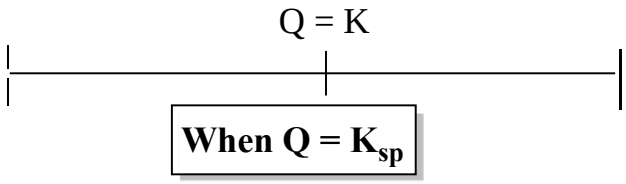
CONCEPT: THE REACTION QUOTIENT, Q

The reaction quotient, Q, is used to determine if our chemical reaction is at equilibrium and if a precipitate will form.

- If the reaction quotient Q is _____ the equilibrium constant K then our reaction is at equilibrium.

$$AgCl\,(s) \rightleftharpoons Ag^{+}\,(aq) + Cl^{-}\,(aq)$$

1.3 x 10^{-5} M **1.3 x 10^{-5} M**



$$K_{sp} = 1.77 \times 10^{-10}$$

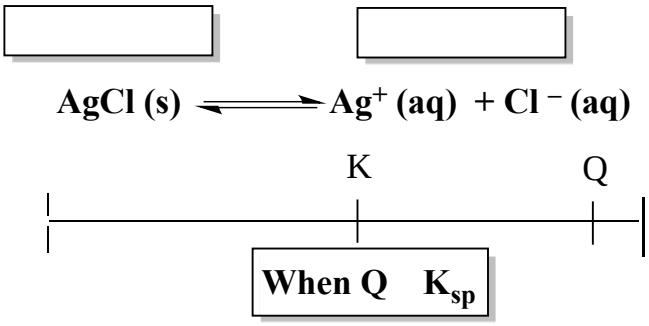
$$Q = \frac{\text{products}}{\text{reactants}} = [Ag^{+}][Cl^{-}] = [1.3 \times 10^{-5}][1.3 \times 10^{-5}] = 1.77 \times 10^{-10}$$

Comparing the reaction quotient Q to the equilibrium constant K will determine the direction the reaction will shift.

- If Q is _____ than K then our reaction will shift to the _____ .

$$AgCl\,(s) \rightleftharpoons Ag^{+}\,(aq) + Cl^{-}\,(aq)$$

0.250 M **0.250 M**



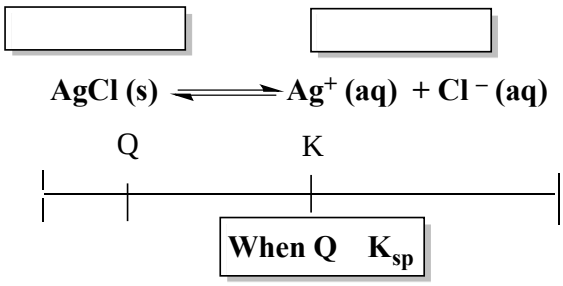
$$K_{sp} = 1.77 \times 10^{-10}$$

$$Q = \frac{\text{products}}{\text{reactants}} = [Ag^{+}][Cl^{-}] = [0.250][0.250] = 6.25 \times 10^{-2}$$

- If Q is _____ than K then our reaction will shift to the _____ .

$$AgCl\,(s) \rightleftharpoons Ag^{+}\,(aq) + Cl^{-}\,(aq)$$

4.6 x 10^{-9} M **1.1 x 10^{-15} M**



$$K_{sp} = 1.77 \times 10^{-10}$$

$$Q = \frac{\text{products}}{\text{reactants}} = [Ag^{+}][Cl^{-}] = [4.6 \times 10^{-9}][1.1 \times 10^{-15}] = 5.06 \times 10^{-24}$$

PRACTICE: THE REACTION QUOTIENT CALCULATIONS 1

EXAMPLE 1: Will a precipitate form when 0.150 L of 0.100 M $Pb(C_2H_3O_2)_2$ and 0.100 L of 0.20 M NaCl are mixed? The K_{sp} value of $PbCl_2$ is 1.2×10^{-5}.

EXAMPLE 2: What is the minimum pH at which $Fe(OH)_2$ will precipitate if the solution has $[Fe^{2+}] = 0.0583$ M? Ksp of $Fe(OH)_2$ is 4.87×10^{-17}?