PREDICTING THE FORMATION OF PRECIPITATES

Saturated Solution – a solution that contains as much dissolved solute as it can under a given set of conditions. If a solution has more ions dissolved than it can hold, a ppt will form.

Q (ion product) is used to determine if a ppt will form. Q can be compared with the Ksp to determine if an aqueous solution of ions is supersaturated and will form a ppt.

Q> Ksp --→ solution is _____ lowering the concentration of the dissolved ions to their equilibrium values.

Q<Ksp --→ solution is _____, more solid can be added to solution and be dissolved.

Q = Ksp -→ solution is _____.

Types of Problems:

1. Molar Solublility:
The solubility of $BaSO_4$ 0.00246 g/L at 25 deg C. Determine the Ksp for $BaSO_4$.

$$\frac{0.00246 \text{ g } BaSO_4}{\text{L}} \times \frac{1 \text{ mol } BaSO_4}{233 \text{ g } BaSO_4} = 1.06 \times 10^{-5} \text{ M}$$

$BaSO_4$ (s) ----→ Ba^{+2} (aq) + SO_4^{-2} (aq)

1.06×10^{-5} M -→ 1.06×10^{-5} M 1.06×10^{-5} M

$Ksp = [Ba^{+2}] [SO_4^{-2}] = (1.06 \times 10^{-5} \text{ M})(1.06 \times 10^{-5} \text{ M})$

$Ksp = 1.12 \times 10^{-10}$

2. Knowing the Ksp of a slightly soluble salt, the solubility can be found.
Calculate the molar solubility of Ag_2CrO_4 in water at 25 deg C given that its Ksp is 2.4×10^{-12}.
(same way as the Ksp WS)

3. Will a ppt of $BaSO_4$ form when 100 mL of 0.0010 M sodium sulfate and 100 mL of 0.010 M $BaCl_2$ solutions are mixed?

Strategy:
A. Get the # of moles of ions in that make up the ppt

$$\frac{0.010 \text{ mol } Ba^{+2}}{\text{L}} \times 0.100 \text{ L} = 0.0010 \text{ mol } Ba^{+2}$$

$$\frac{0.0010 \text{ mol } SO_4^{-2}}{\text{L}} \times 0.100 \text{ L} = 0.00010 \text{ mol } SO_4^{-2}$$

B. Find the M of each ion.

$[Ba^{+2}] = 0.0010 \text{ mole}/0.200 \text{ L} = 5.0 \times 10^{-3} \text{M}$
$[SO_4^{-2}] = 0.00010 \text{ mole}/0.200 \text{ L} = 5.0 \times 10^{-4} \text{M}$
$Q = [Ba^{+2}] [SO_4^{-2}] = [5.0 \times 10^{-3}] [5.0 \times 10^{-4}] = 2.5 \times 10^{-6}$

Ksp is 1.12×10^{-10}

So, Q> K and a ppt will form

4. What about if we would like to recover silver from an $AgNO_3$ (aq) by precipitating silver ions as the insoluble compound AgCl. What concentration of Cl- ions (from NaCl) is necessary to reduce the concentration of silver ions to 1.0 x 10-9 M?

AgCl (s) <---> Ag+ (aq) + Cl-(aq)
Ksp = [Ag+][Cl-] = 1.6×10^{-10}
(1.0×10^{-9}) [Cl-] = 1.6×10^{-10}

$$[Cl^-] = \frac{1.6 \times 10^{-10}}{1.0 \times 10^{-9}} = 0.16 \text{ M}$$

5. Solubility from Mixing Solutions:

What are the concentrations of the ions in solution once you know if precipitation will occur?
We assume that because Ksp is so low, if a ppt forms, it will do so quantitatively.

ex. Calculate the Ksp of each ion in a solution obtained by mixing 50.0 mL of 6.0×10^{-3}M $CaCl_2$ with 30.0 mL of 0.040 M NaF. (Ksp of calcium fluoride is 4.0×10^{-11})

Verifying that a ppt does occur...

$$[Ca^{+2}] = 6.0 \times 10^{-3}\text{M} \times \frac{50.0 \text{ mL}}{(50.0+30.0)\text{mL}} = 3.8 \times 10^{-3}\text{M}$$

$$[F^-] = 0.040 \text{ M} \times \frac{30.0\text{mL}}{80. \text{ mL}} = 0.015 \text{ M}$$

$Ca^{+2} + 2F^- <---> CaF_2$

$(3.8 \times 10^{-3})(0.015)^2 = 8.4 \times 10^{-7}$

So, Q> Ksp, so ppt occurs