

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 K_{sp} to determine if an aqueous solution of ions is supersaturated and will form a ppt.

$Q > K_{sp} \rightarrow$ solution is _____ lowering the concentration of the dissolved ions to their equilibrium values.

$Q < K_{sp} \rightarrow$ solution is _____, more solid can be added to solution and be dissolved.

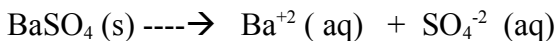
$Q = K_{sp} \rightarrow$ solution is _____.

Types of Problems:

1. Molar Solubility:

The solubility of $BaSO_4$ 0.00246 g/L at 25 deg C. Determine the K_{sp} for $BaSO_4$.

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



$$1.06 \times 10^{-5} \text{ M} \rightarrow 1.06 \times 10^{-5} \text{ M} \quad 1.06 \times 10^{-5} \text{ M}$$

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

$$K_{sp} = 1.12 \times 10^{-10}$$

2. Knowing the K_{sp} 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 K_{sp} is 2.4×10^{-12} . (same way as the K_{sp} 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

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

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

B. Find the M of each ion.

$$[Ba^{+2}] = 0.0010 \text{ mole}/0.200 \text{ L} = 5.0 \times 10^{-3} \text{ M}$$

$$[SO_4^{-2}] = 0.00010 \text{ mole}/0.200 \text{ L} = 5.0 \times 10^{-4} \text{ M}$$

$$Q = [Ba^{+2}] [SO_4^{-2}] = [5.0 \times 10^{-3}] [5.0 \times 10^{-4}] = 2.5 \times 10^{-6}$$

K_{sp} 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 $1.0 \times 10^{-9} \text{ M}$?



$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = 1.6 \times 10^{-10}$$

$$(1.0 \times 10^{-9}) [\text{Cl}^-] = 1.6 \times 10^{-10}$$

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

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 K_{sp} is so low, if a ppt forms, it will do so quantitatively.

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

Verifying that a ppt does occur...

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

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



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

So, $Q > K_{sp}$, so ppt occurs
