IX) Type B Problems: Calculating Solubility

In Type B problems, you must calculate the solubility of a salt using the $K_{sp}$ constant from p.5 of the data booklet. Remember that solubility is the molarity at saturation.

Example:

1. Calculate the solubility of CaCO$_3$ in water at 25°C.

   \[
   \text{CaCO}_3(s) \rightleftharpoons \text{Ca}^{2+}(aq) + \text{CO}_3^{2-}(aq)
   \]

   \[
   K_{sp} = [\text{Ca}^{2+}][\text{CO}_3^{2-}]
   \]

   \[
   K_{sp} = 5.0 \times 10^{-9}
   \]

   \[
   \text{Let} \ x = [\text{Ca}^{2+}]
   \]

   \[
   \therefore x = [\text{CO}_3^{2-}]
   \]

   \[
   \sqrt{5.0 \times 10^{-9}} = (x)(x) \Rightarrow x^2 = \frac{1}{5.0 \times 10^{-9}}
   \]

   \[
   x = 7.07 \times 10^{-5} \text{ M} = [\text{Ca}^{2+}] = [\text{CO}_3^{2-}]
   \]

   \[
   \text{The solubility of CaCO}_3 \text{ is } 7.1 \times 10^{-5} \text{ M}
   \]

2. Calculate the solubility of PbI$_2$ in g/L.

   \[
   \text{PbI}_2(s) \rightleftharpoons \text{Pb}^{2+}(aq) + 2\text{I}^{-}(aq)
   \]

   \[
   K_{sp} = [\text{Pb}^{2+}][\text{I}^-]^2
   \]

   \[
   K_{sp} = 8.5 \times 10^{-9} \text{ (from table)}
   \]

   \[
   \text{Let} \ x = [\text{Pb}^{2+}]
   \]

   \[
   \therefore 2x = [\text{I}^-]
   \]

   \[
   K_{sp} = (x)(2x)^2 = 4x^3
   \]

   \[
   \sqrt[3]{8.5 \times 10^{-9}} = \frac{4x^3}{3}
   \]

   \[
   x = 1.28564 \times 10^{-3} \text{ M}
   \]

   \[
   \frac{1.28564 \times 10^{-3} \text{ mol}}{1 \text{ mol}} \times 161.06 = 0.206 \text{ g/L}
   \]

   \[
   \text{Note: 0.206 g PbI}_2 \text{ can be added to 1L of water to reach a point of saturation.}
   \]

   \[
   \text{Before a ppt will form}
   \]

3. How many grams of PbBr$_2$ can be dissolved in 250.0 mL of water at 25°C?

   \[
   \text{PbBr}_2(s) \rightleftharpoons \text{Pb}^{2+}(aq) + 2\text{Br}^{-}(aq)
   \]

   \[
   K_{sp} = [\text{Pb}^{2+}][\text{Br}^-]^2
   \]

   \[
   K_{sp} = 1.6 \times 10^{-6} \text{ (from table)}
   \]

   \[
   \frac{1.18167 \times 10^{-2} \text{ M} = \text{mol}}{250 \text{ mL}} \times 366.35 = 0.057 \text{ g}
   \]
Assignment 7: Type B Exercises

1. The $K_{sp}$ at a certain temperature for Ni(OH)$_2$ is $1.6 \times 10^{-16}$. Calculate the solubility of Ni(OH)$_2$.

2. Find the solubility of CaSO$_4$ in g/L.

3. Which saturated solutions at 25°C will have a greater $[Ag^+]$, AgCl or Ag$_2$CO$_3$?

4. Calculate the mass of MgCO$_3$ which could be dissolved in 3.0L of water at 25°C.

\[
K_{sp} = [Pb^{2+}]^2[Br^-]^2
\]
\[
K_{sp} = 6.6 \times 10^{-6} \text{ (from table)}
\]

Let $x = [Pb^{2+}]$

\[
2x = [Br^-]
\]
\[
6.6 \times 10^{-6} = (x)(2x)^2
\]
\[
\sqrt{\frac{6.6 \times 10^{-6}}{4}} = \sqrt{\frac{4x^3}{4}}
\]
\[
x = 1.18167 \times 10^{-2} M = [Pb^{2+}]
\]

\[
\text{In 250.0 mL, you can add 1.1 g of PbBr}_2 \text{ before a precipitate forms. (at saturation)}
\]

\[
\text{in 250 mL, you can add 1.1 g of PbBr}_2 \text{ before a precipitate forms. (at saturation)}
\]