This page is a brief introduction to solubility product calculations. The solubilities of the ionic compounds in the examples below are given in mol dm\(^{-3}\). If it is given in g dm\(^{-3}\), or another concentration unit, it must first be converted into mol dm\(^{-3}\).

**Example 1**

The solubility of barium sulfate at 298 K is \(1.05 \times 10^{-5}\) mol dm\(^{-3}\). Calculate the solubility product. The equilibrium is given below:

\[
\text{BaSO}_4(s) \rightleftharpoons \text{Ba}^{2+}(aq) + \text{SO}_4^{2-}(aq)
\]

Notice that each mole of barium sulfate dissolves to give 1 mole of barium ions and 1 mole of sulfate ions in solution. That means that:

\[
[\text{Ba}^{2+}] = 1.05 \times 10^{-5}\ \text{mol dm}^{-3}
\]
\[
[\text{SO}_4^{2-}] = 1.05 \times 10^{-5}\ \text{mol dm}^{-3}
\]

Substitute these values into the solubility product expression, and simplify:

\[
K_{sp} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = (1.05 \times 10^{-5}) \times (1.05 \times 10^{-5})
\]

\[= 1.10 \times 10^{-10}\ \text{mol}^2\ \text{dm}^{-6}\]

Verify that the units are correct.

These calculations are very simple if for compounds in which ratio of the numbers of positive and negative ions is 1:1. This next example illustrates the procedure for a different ratio.

**Example 2**

The solubility of magnesium hydroxide at 298 K is \(1.71 \times 10^{-4}\) mol dm\(^{-3}\). Calculate the solubility product. The equilibrium is:

\[
\text{Mg(OH)}_2(s) \rightleftharpoons \text{Mg}^{2+}(aq) + 2\text{OH}^-(aq)
\]

For every mole of magnesium hydroxide that dissolves, one mole of magnesium ions is generated, but twice that number of hydroxide ions form. So the concentration of the dissolved magnesium ions is the same as the dissolved magnesium hydroxide:

\[
[\text{Mg}^{2+}] = 1.71 \times 10^{-4}\ \text{mol dm}^{-3}
\]

The concentration of dissolved hydroxide ions is twice that:

\[
[\text{OH}^-] = 2 \times 1.71 \times 10^{-4}\ \text{mol dm}^{-3}
\]

Substitute these values into the solubility product expression as before:
Calculating Solubilities from solubility products

Consider the magnesium hydroxide example as above, but this time start from the solubility product and work back to the solubility.

If the solubility product of magnesium hydroxide is $2.00 \times 10^{-11}$ mol$^3$ dm$^{-9}$ at 298 K, calculate its solubility in mol dm$^{-3}$ at that temperature.

\[
\text{Mg(OH)}_2(\text{s}) \rightleftharpoons \text{Mg}^{2+}(\text{aq}) + 2\text{OH}^- (\text{aq})
\]

The trick this time is to give the unknown solubility a symbol like $x$ or $s$. Let $s$ stand for the concentration of magnesium hydroxide in mol dm$^{-3}$; then:

\[
\begin{align*}
[Mg^{2+}] &= s \text{ mol dm}^{-3} \\
[OH^-] &= 2s \text{ mol dm}^{-3}
\end{align*}
\]

Using these values, simplify the equilibrium expression:

\[
\begin{align*}
K_{sp} &= [Mg^{2+}][OH^-]^2 \\
&= s \times (2s)^2 \\
&= 4s^3
\end{align*}
\]

\[
K_{sp} = 4s^3 \\
s^3 = \frac{2.00 \times 10^{-11}}{4} \\
s = \sqrt[3]{5.00 \times 10^{-12}} \\
s = 1.71 \times 10^{-4} \text{ mol dm}^{-3}
\]

Contributors

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