9.10: Solubility of Ionic Compounds

The solubility of ionic compounds in water can also be described using the concepts of equilibrium. If you consider the dissociation of a generic salt MX

$$MX(s) \rightleftharpoons M^+(aq) + X^-(aq)$$

The equilibrium expression is

$$K_{sp} = [M^+][X^-]$$

K_{sp} is the **solubility product** and is the equilibrium constant that describes the solubility of an electrolyte. And again, the pure solid MX is not included in the expression since it has unit activity throughout the establishment of equilibrium.

Example 9.10.1:

What is the maximum solubility of CuS at 25 °C? ($K_{sp} = 1 \times 10^{-36}\ M^2$)

Solution

Yup – time for an ICE table.

	CuS	Cu^{2+}	S^{2-}
Initial		0	0
Change		+x	+x
Equilibrium		x	x

So the equilibrium expression is

$$1 \times 10^{-36} M^2 = x^2$$

$$x = \sqrt{1 \times 10^{-36}\ M^2} = 1 \times 10^{-18}\ M$$

Example 9.10.2: Common Ion

What is the maximum solubility of CuS at 25 °C in 0.100 M NaS with ($K_{sp} = 1 \times 10^{-36}\ M^2$)?

Solution

In this problem we need to consider the existence of S^{2-}(aq) from the complete dissociation of the strong electrolyte NaS. An ICE table will help, as usual.

	CuS	Cu^{2+}	S^{2-}
Initial		0	0.100 M
Change		+x	+x
Equilibrium		x	0.100 M + x

Given the miniscule magnitude of the solubility product, x will be negligibly small compared to 0.100 MS the equilibrium expression is

$$1 \times 10^{-36} M^2 = x(0.100\ M)$$

$$1 \times 10^{-35}\ M$$

The huge reduction in solubility is due to the common ion effect. The existence of sulfide in the solution due to sodium sulfide greatly reduces the solutions capacity to support additional sulfide due to the dissociation of CuS.