4.2 Copper compound solubility

Subjects: Chemical reactions, solubility Ksp, net ionic equations

Description: This reaction demonstrates the difference of solubility of copper chloride in water, and then with addition of sodium hydroxide.

Materials:
Copper Chloride(s), CuCl₂
1 100 mL beaker
1 400 mL beaker
watch glass
spatula
stir plate*
stir bar
1M NaOH†
wash bottle with water

*Shared item. This item is located in the top drawer opposite the chemical storage cabinets. There are other stir plates on the benchtop.

† Copper chloride is located in the general chemical storage cabinets. Sodium hydroxide is located in the cabinet under the hood.

Procedure:
1. Add some water to the 300 mL beaker and place on a stir plate with a stir bar.
2. Place some copper chloride on a watch glass.
3. Add enough water to dissolve the solid.
4. Transfer the solution to the beaker of water on a stir plate. Stir using a stir bar.
5. Add NaOH to get a precipitate of copper hydroxide.

Discussion:
Copper chloride is soluble in water. It dissociates as follows:

\[ \text{CuCl}_2(s) \rightarrow \text{Cu}^{2+}(aq) + 2\text{Cl}^-(aq) \]

Adding sodium hydroxide produces a precipitate of copper hydroxide.

\[ \text{CuCl}_2(aq) + 2\text{NaOH} (aq) \rightarrow \text{Cu(OH)}_2(s) + 2\text{NaCl}(aq) \]

Net ionic equation:

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

Based on the solubility rules copper hydroxide is not soluble in water while copper chloride is.
The solubility product constant ($K_{sp}$) is an equilibrium constant relating the ionization products of a dissolved substance and allows us to understand why copper hydroxide is seemingly insoluble in water. $K_{sp}$ is determined experimentally by measuring the concentrations of ions in solution. Copper hydroxide does dissolve a tiny amount in pure water and an equilibrium is established. The equation for the equilibrium of copper hydroxide in water is given below:

$$\text{Cu(OH)}_2(\text{s}) \rightleftharpoons \text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq})$$

The solubility product constant, which is the product of the ion concentrations, and has been determined experimentally, is given below:

$$K_{sp} = [\text{Cu}^{2+}][\text{OH}^{-}]^2 = 2.2 \times 10^{-20}$$

$K_{sp}$ is very small meaning that copper hydroxide dissociates very little in water, while the vast majority remains a solid.

**Safety:** Copper chloride is corrosive. Sodium hydroxide is extremely corrosive and can cause severe burns. Wear proper protective equipment including gloves and goggles.

**Disposal:** Copper hydroxide in solution can be saved for demo 4.10 Hydroxide clean-up. To dispose, add some hydrochloric acid to dissolve the hydroxide and dispose in the appropriate aqueous waste container.

**References:**
1. Prof. Botch