Reactions of Copper

Goals

- To learn synthetic techniques.
- To identify reactants and products in a series of chemical reactions.
- To write balanced chemical equations

Background

In this experiment, you will be studying two types of chemical reactions: electron transfer and metathesis. In an electron transfer reaction, one material looses one or more electrons (is oxidized) while a second reactant simultaneously gains electrons (is reduced.) All electron transfer reactions involve a simultaneous oxidation of one reagent and reduction of a second; consequently such processes are known as redox reactions. In a metathesis reaction, the cations and anions of the reagents change partners. Metathesis reactions often yield insoluble products that can be isolated by filtration. Both types of chemical transformations of forms of copper, Cu, will be explored in this experiment. A transition metal, copper forms many colored compounds. The blue pigment azurite is a mixed salt of Cu(II): $2CuCO_3Cu(OH)_2$. Azurite, a naturally occurring semiprecious gem, can react with acids to form green malachite, $CuCO_3Cu(OH)_2$, long used in jewelry and other ornamental objects. Solutions of blue $CuSO_4.5H_2O$ serve as a disinfectant.

Safety

The practice of wearing eye protection in the lab must be rigorously followed with the concentrated acids used in this experiment. You may wish to wear gloves when handling these materials. Wash any spills with soap and water. The reactions of nitric acid with copper must be done in the fume hood because of the toxicity of the gases formed.

Experimental

1. Reaction of Cu with HNO_3. Weigh by a ball of Cu turnings (approx. 1 g) into a 50ml beaker. Complete the remainder of this work in the HOOD: Prepare a dilute solution of HNO_3 by adding 5 mL of concentrated acid to 8 mL of H_2O, then add the diluted acid to the Cu turnings. Allow the Cu to completely dissolve. Carefully record your observations in your notebook

$$Cu(s) \longrightarrow Cu^{2+}_{(aq)} + 2\,e^- \qquad (1)$$

From nitric acid:

$$NO_3^- + 4\,H^+ + 3\,e^- \longrightarrow NO_{(g)} + 2H_2O \qquad (2)$$

Write a balanced equation for the reaction of Cu with nitric acid and identify the oxidizing and reducing agents.

Note that the gas nitrogen oxide, NO, is colorless but reacts further to give reddish NO_2:

$$2\ NO_{(g)} \quad + \quad O_{2(g)} \longrightarrow \quad 2\ NO_{2(g)} \qquad (3)$$

What is the source of oxygen?

2. Formation of $CuCO_3$. Slowly add the Cu^{2+} solution, formed above, to 75 mL of saturated $NaHCO_3$ with vigorous stirring. Rinse the beaker originally containing the copper with 1-2 mL of water and add the rinsings to the bicarbonate solution. Filter the precipitate that is formed through a Buchner funnel and wash it with 2-5 mL portions of water.

Record your observations and write a chemical equation consistent with your observations.

3. Reaction with zinc. Transfer the dry precipitate from above to a 150 ml beaker with a minimum amount of water. Slowly add 5 mL 12 M H_2SO_4. Add water to a total volume of 75 mL and cool the beaker in an ice bath. Add approximately 1.2 g of granular Zn stirring continuously. If all the zinc disappears and the solution remains blue, add more Zn (in SMALL increments). Finally, when the solution is colorless and if any solid zinc is left, add more sulfuric acid. (If no zinc is visible, do not add more acid.) Isolate the solid by vacuum filtration and wash it with water and acetone.

Record your observations and write a chemical equation consistent with your observations.

4. Reaction Yield. Dry the product using aspiration. Weigh the final product and calculate the percent yield. Store the product for week and reweigh at the beginning of the next lab period. Calculate the percent yield again.

Questions

1. Write balanced chemical equations (net ionic) to describe the reactions occurring with the addition of each reagent.
2. What type of reaction is occurring in each step?
3. Report the overall percentage yield of the procedure.
4. Suppose you wished to improve the yield in this procedure. Identify the steps in which you lost material and describe how you might improve your procedure.

Disposal

Place all waste solutions in the appropriately marked waste bottles.
After re-weighing the product next week, place it in the appropriate waste