***Honors Chemistry: Reactions of Copper Experiment***

***Objective***

In this experiment, you will start with a known mass of solid copper that will be used in five sequential chemical reactions. The end product of these reactions is solid copper. Your objective is to re-collect the copper at the end of the reactions, compare it to your initial mass of copper used, and determine a percent yield. In theory, you should be able to re-collect all of the copper you started with. You will gain familiarity with basic laboratory procedures and some chemical reactions of a typical transition element, copper. Ultimately, this will be a test of your laboratory skills.

At the end of the experiment, you will calculate the percent yield by comparing the recovered mass of Cu to the initial mass of Cu used, multiplied by 100:

recovered mass Cu

initial mass Cu

% yield = x 100

***Discussion***

Most chemical syntheses involve the separation and purification of a desired product from unwanted side products.  Some methods of separation, such as filtration and decantation, have already been discussed in class. In this experiment, you will complete various chemical reactions, including decomposition, dehydration, single replacement, and double replacement reactions. You will start with copper metal and, during the five reactions, create various copper compounds only to produce solid copper at the end. The specific chemical reactions used are discussed within the procedure.

As discussed previously in class, single replacement reactions occur according to the activity series, in which a lone element replaces its counterpart in a compound (i.e., metal for metal, nonmetal for nonmetal). The lone element must be more reactive than its counterpart, or higher on the activity series, for the reaction to occur.

Double replacement reactions occur only when certain types of products are created: a precipitate, a gas, or water. These three products constitute the driving forces for the reaction to occur. When DR reactions do occur, you can think of it as the two cations switching places, bonding with the other anion present.

***Procedure: Day One***

1. Weigh approximately 0.5 g (+/- 0.05) of copper wire to the nearest 0.001 g and place it in a 250 mL beaker. In your data table, record the exact mass of Cu you used

***Fume Hood 1***

1. **Reaction A:** Add 4 - 5 mL of concentrated nitric acid (HNO3) to your beaker with the Cu. For safety reasons, instead of measuring this volume using a graduated cylinder, you will use two full squirts of nitric acid from a disposable pipet. Carefully swirl the beaker and make observations while the reaction is occurring. Once the reaction is complete, it should no longer produce brown gas. You may now leave the fume hood.

Before you proceed with the next step, **write down your observations from Reaction A on your report sheet.** Include as much detail as possible (e.g., color changes, production of gas, heat changes).

*In reaction A, you reacted copper metal with nitric acid to produce aqueous copper (II) nitrate, nitrogen dioxide gas, and liquid water****. On your report sheet, write and balance this equation, showing the correct phases of each chemical.***

1. Add 100 mL distilled H2O to your beaker. **Write down your observations on your report sheet.**

***Fume Hood 2***

1. **Reaction B:** Add 30 mL of 3.0 *M* sodium hydroxide (NaOH) to the solution in your beaker. You may leave the fume hood as the reaction proceeds. **Write down your observations on your report sheet.**

*In reaction B, you are reacting the copper (II) nitrate produced in reaction A with aqueous sodium hydroxide in a double replacement (DR) reaction.* ***On your report sheet, predict the products of this DR reaction and balance the equation, showing the correct phases of each chemical.***

1. **Reaction C:** Carefully heat the solution on a hot plate and stir the solution constantly with a glass stirring rod. Heat the solution and stir until the blue gel has turned into a fine, black solid. **Write down your observations on your report sheet.**

*In reaction C, you are decomposing the copper (II) hydroxide produced in Reaction B by heating it on the hot plate. Hint: This reaction could also be considered a dehydration reaction.* ***On your report sheet, predict the products of this reaction and balance the equation.***

1. Allow the black solid precipitate, copper (II) oxide, to settle to the bottom of the beaker. Decant off the liquid, leaving the solid behind.  Add about 50 mL distilled water to the beaker to rinse the solid. Once the solid settles to the bottom, again decant off the liquid. Rinse and decant two more times.

***Procedure: Day Two***

***Fume Hood 1***

1. **Reaction D:** In the fume hood, add 15 mL of 6.0 *M* sulfuric acid (H2SO4). You may leave the fume hood as the reaction proceeds. **Write down your observations on your report sheet.**

*In reaction D, you are reacting the copper (II) oxide produced in reaction C with sulfuric acid in a double replacement (DR) reaction.* ***On your report sheet, predict the products of this DR reaction and balance the equation, showing the correct phases of each chemical.***

***Fume Hood 2***

1. **Reaction E:** Add several 2 cm squares of aluminum foil and a *3-5 drops* of concentrated hydrochloric acid (HCl) to your beaker.  Stir the solution and allow it to react. Continue to add pieces of aluminum until the liquid becomes colorless. Once the reaction has ceased, you may leave the fume hood. **Write down your observations on your report sheet.**

*In reaction E, you are reacting the copper (II) sulfate produced in reaction D with aluminum in a single replacement (SR) reaction.* ***On your report sheet, predict the products of this SR reaction and balance the equation.***

1. Decant off the solution, leaving your copper solid behind. Wash the copper with distilled water, and allow the copper to settle back down to the bottom. Decant off the liquid, leaving the copper solid behind.
2. Mass a disposable plastic cup and record its mass on your report sheet. Use a wash bottle to rinse and transfer the copper solid from the beaker into the cup. Decant off the liquid, leaving the copper solid behind.
3. Allow the copper solid to dry overnight. Mass the cup with the copper the following day. Record this mass on your report sheet.