Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_\_ Period \_\_\_\_\_\_\_

Cu Again !

Introduction:

Chemical reactions always involve a change in the way the atoms are arranged when going from reactants to products. Based on patterns observed in thousands of reactions, chemists can classify chemical reactions into several general categories. By making this classification, it becomes easier to predict the products of a reaction given the reactants involved. Five of the most common types of reactions are: Composition, Decomposition, Single Displacement, Double Displacement, and Combustion. While these 5 reaction types do not include all reactions, they include thousands of basic reactions.

In this experiment students will start with an aqueous solution of copper (II) sulfate and will observe several different types of reactions that will involve the initial copper. The last reaction will yield solid copper which will be dried and weighed to determine how much of the initial copper has been recovered. As the copper is reacted, each reaction will be written as a balanced equation and the type of reaction will be classified according to the list above. At the completion of the experiment, a percent yield of copper metal, based on the amount of copper nitrate solution at the start, will be calculated.  
Pre-Lab:

Given the reactants, predict the products and write a balanced equation for each of the following and identify the type.

1. zinc metal is reacted with nitric acid (HNO3) TYPE

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. aluminum metal is heated with gaseous oxygen

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. aqueous iron (III) chloride is mixed with aqueous sodium hydroxide

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. phosphorous pentachloride is heated

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. hexane (C6H14) is burned in oxygen

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Purpose: The purpose of this investigation is to:

* recognize that changes of color, formation of a precipitate, or the evolution of heat and a gas are associated with a chemical change and to study the reactions of copper.
* write balanced chemical equations for the observed reactions.
* calculate the percent yield of copper recovered from a chemical process

Safety: Wear goggles at all times. Avoid skin contact with solids and solutions. Dispose of all solutions in the containers provided by your teacher. Wash your hands before leaving the lab.

Materials: test tube 250 mL beaker stirring rod Al wire filter paper funnel 150 mL beaker  
solutions: 3.0 M NaOH, 3.0 M HCl, 1.00M Cu(NO3)2, deionized water disposable pipets

Procedure: Record what you see throughout the laboratory activity in the data tables provided.

***Before you begin reaction #1, set up a water bath on the hot plate by filling a 250mL (or larger) beaker ½ full of water and adjust the heat to medium. This is for reaction #3. The water should be hot but NOT boiling.***

Reaction #1:

1. **Your teacher will demonstrate** for the class the reaction of pure copper, Cu, with concentrated nitric acid, HNO3. This must be done in a fume hood because of the poisonous gases produced. One student will be asked to feel the sides of the demonstration flask and report to the group. **The products formed are copper (II) nitrate solution, Cu(NO3)2 (aq), nitrogen dioxide gas, NO2 (g), and water, H2O (l).** Record observations and write a balanced equation for this reaction in your data table.

Reaction #2:

1. Dispense 1.00 mL of 1.00 M **Cu(NO3)2** using a graduated pipet into a labeled test tube. Record the volume in data table (2).
2. Measure out 2.0 mL of **NaOH** with a graduated pipet. (Caution: Avoid contact with sodium hydroxide; it burns the skin.) Add this **slowly** to the test tube. This reaction may give off heat detected by touching the sides of the test tube. Record any observations in your data table.
3. Mix the solutions, carefully, in the test tube with a stirring rod.
4. Use a pipet to add a couple of drops of deionized water to the test tube. Stir to mix. A precipitate (solid) should form. Record observations in your data table
5. Write a balanced equation for the reaction between Cu(NO3)2 and NaOH forming Cu(OH)2 and NaNO3 and identify the type of reaction.

Reaction #3:

1. Label your test tube.
2. Place your test tube in the hot water bath. Leave it in the bath until the solid turns completely black. Stir with a stirring rod if necessary. Run cool water over the outside of the test tube to cool it. Record observations in your data table. Rinse any solid off of the stirring rod into the test tube.
3. Allow the solid material to settle to the bottom of the test tube. Decant or use the “waste” pipet to remove the clear liquid from above the black copper (II) oxide. ***Do not remove any of the solid.***
4. Discard the waste material in the sink with running water. Wash the precipitate by adding about ½ pipet of deionized water. Stir to mix.
5. Allow the solid to settle. Carefully remove and discard the liquid above the solid into the sink as before.
6. Record any observations in your data table and write a balanced chemical equation for Reaction #3. The solid product (precipitate) from reaction #2, Cu(OH)2 will be the only reactant and the products are copper (II) oxide and water. Identify the type of reaction.

Reaction #4:

1. Fill the appropriately labeled pipet with 3.0 mL of **HCl**. Add this (approximately 3 mL) to the black solid. Stir well until all of the black CuO is dissolved and the solution is blue and clear.
2. Record any observations in your data table. Write a balanced chemical equation for this reaction. The reactants are CuO and HCl forming aqueous CuCl2 and water. Identify the type of reaction.

Reaction #5:

1. Add the pre-cut piece of aluminum wire to the test tube. (The wire can be dropped into the test tube and retrieved with forceps.) Place the test tube in a cool water bath (use tap water for the bath). After a while, shake the Al wire to release the copper solid, which has formed. If necessary, gently scrape the Cu off with a stirring rod. Record any observation in your data table. Write a balanced equation for the reaction of the aluminum wire with the copper (II) chloride solution forming copper and aluminum chloride.Allow this reaction to continue until the blue color of the solution is completely gone.
2. Make sure all of the copper remains in the test tube and remove the aluminum wire. Place the Al wire in the appropriate waste container.
3. Allow the copper to settle to the bottom of the test tube. Then remove the liquid with the “waste” pipet. Discard this liquid in the sink.
4. Wash the solid copper with half a pipet of deionized water. Remove and discard this liquid. Repeat this step twice to ensure that the copper is completely washed.
5. **Use a pencil to label a piece of filter paper**. *Measure the mass* of the filter paper and record this value in your data table. Set up a funnel with the filter paper above an empty beaker and filter the copper. Wash the copper with deionized water. Allow it to drain dry. Remove the filter paper and allow it to dry as directed by your teacher.
6. Clean all lab equipment and wash your hands.
7. When the copper and filter paper are dry, mass the copper and filter paper. Record this value in your data table. Once you record the mass of copper, you may dispose of the copper in the garbage.

**Qualitative Data Table 1: Equations and Observations for Reactions Involving Copper**

|  |  |  |  |
| --- | --- | --- | --- |
| **Rxn** | **Type of Reaction** | **Balanced Equation** | **Observations** |
| #1 |  |  |  |
| #2 |  |  |  |
| #3 |  |  |  |
| #4 |  |  |  |
| #5 |  |  |  |

**Quantitative Data Table 2: Volume of Cu(NO3)2 and Masses of Copper**

|  |  |  |
| --- | --- | --- |
| Volume of 1.0M Cu(NO3)2 (mL) | Mass of dry filter paper(g) | Mass of filter paper and dried Copper (g) |
|  |  |  |

**Calculations:**

1. Determine the number of **moles of copper** present in the initial 1.0 M Cu(NO3)2 solution.

**HINT: M = mol / liter which means mol = MxL. Convert mL to L. Multiply by M x L.**

1. Based on calculation #1, calculate the **mass (g) of copper** in the initial solution.

1. Calculate the **mass of copper** recovered at the end.

1. Calculate the % copper recovered. **% copper = mass of copper recovered x 100**

**mass of theoretical copper**

**Conclusion / Analysis:**

1. State the results as they relate to the purpose: Compare the mass of copper that was recovered at the end of the lab to the initial mass of copper.
2. How would the moles of copper recovered in the end change if the original copper (II) nitrate (Cu(NO3)2) solution was diluted to 0.25 M? (Assume the volume remains the same). Explain your reasoning.
3. Error analysis:
   1. State one logical error that could have occurred in reaction #3, 4 or 5. A logical error is one that agrees with your results.
   2. Explain how this error affected the final mass of copper produced in your experiment.
   3. Suggest one improvement to the procedure that would yield better results.
4. Write the **balanced equation** for each step on appropriate arrow. Write the **copper product** for each reaction in the box at the end of the corresponding arrow.

5

4

3

2

1