Stoichiometry

Name:

Date:

Period:

of a

Single Replacement Reaction

**Purpose:**

1) To determine the number of grams of copper that will be produced from a single replacement reaction when a known mass of Aluminum (Al) reacts with a known amount of copper (II) sulfate pentahydrate (CuSO4 • 5H2O).

2) To compare the theoretical yield (calculated with stoichiometry) to the actual yield of copper and determine accuracy by calculating percent yield and percent error.

**Background Knowledge:** Answer the following in complete sentences (when applicable)

1.Write a balanced chemical equation for the single replacement reaction between CuSO4 and Al.

2. Knowing that this reaction WILL take place, which metal would you expect to be higher on the activity series, Cu or Al?

 3. When a substance is described as aqueous, what does this mean?

 4. Is copper (II) sulfate pentahydrate considered a “salt”? Explain your answer.

5. DRAW and LABEL a picture of your experimental setup for this laboratory. (Hint: See Nielsen’s demo setup)

**Materials and Setup:**

aluminum foil CuSO4 • 5H2O 400 ml beaker

stirring rod Bunsen burner Wire gauze with ceramic center

filter paper electronic balance Erlenmeyer flask

ring stand funnel 1.0 M HCl

tongs DI H2O scoopula

oven mitt striker

You will obtain a measured sample of aluminum foil and a measured amount of copper (II) sulfate pentahydrate. You will then react the two in an aqueous medium within a medium-sized beaker; stirring frequently. You will filter, dry, and weigh the resulting product.

**Procedure:**

1. Obtain a 400 ml beaker.

2. Add 150 ml of tap water to the beaker; place on the wire gauze on your ring stand above your Bunsen burner and begin heating.

3. Measure out about 5 g of copper (II) sulfate pentahydrate (CuSO4 • 5 H2O) and **record the exact mass** in the data table. Then slowly add the salt crystals to the heating water.

4. With a glass stirring-rod, stir the solution until the copper (II) sulfate pentahydrate is dissolved.

5. While the copper (II) sulfate crystals are dissolving, one member of the group can go and get the aluminum foil. Carefully weigh out a piece of aluminum foil that has a mass of approximately 0.3 grams. **Record the exact mass** into the data table.

6. Do not crumple the foil! Keeping the foil as flat as possible, place the foil in the beaker labeled 1.0 M HCl solution on your lab table and submerge and stir it (use stirring rod) for approximately 3 minutes. Quickly remove the foil with your tongs and submerge and stir it in the beaker labeled distilled H2O. Quickly remove the foil and carefully add it to the hot solution (CuSO4 • 5H2O) with continuous stirring.

7. Continue stirring to allow the reaction to occur completely. The reaction is complete when you can’t see any more silvery foil pieces. Once you can’t see anymore silvery foil pieces (no matter how small), heat an additional 2 to 3 minutes, then remove from the heat.

8. Write your names around the outside edge of the filter paper (so you can claim it later), weigh and **record the mass of the filter paper** in the data table.

9. Use the filter paper and your funnel to filter the copper residue. Fold the filter paper in half twice until you have a quarter circle that fits into the funnel. While holding the filter paper in place, use your rinse bottle to wet the paper. This will seal it to the funnel. Place the funnel with filter paper over the Erlenmeyer flask. Carefully pour the solution into the funnel. Be careful to not let the solution go over the top of your filter paper. (Be patient!)

10. Use your scoopula to place all of the copper into the filter paper. Rinse out your beaker with a small (amount just covering the bottom of the beaker) of water and pour it through the filter to be sure you obtained all of the copper product/residue.

11. Remove the filter paper from the funnel and spread it out on a paper towel to dry overnight.

12. Clean and dry the glassware. Straighten up your area.

13. Upon returning the next day, weigh the filter paper and dry copper residue and record that mass in the data table. Throw the filter paper and residue away in the trash can.

**Data Table:**

**Mass of Various Substances Measured in Lab**

|  |  |
| --- | --- |
| **Substance** | **Mass (grams)** |
| **Copper (II) sulfate pentahydrate** |  |
| **Aluminum foil** |  |
| **Filter paper** |  |
| **Copper residue +****filter paper** |  |

**Observations:**

In complete sentences, list any qualitative observations you made during the lab. Include any physical properties of the chemicals or evidences of a chemical reaction taking place.

**Data Processing:**

1. Using stoichiometry, Calculate the **theoretical yield of Copper (Cu).** Start with the mass of the aluminum foil and calculate the mass of the copper you theoretically would form. (Hint: complete a mass to mass problem.) **Show ALL work!**

**Theoretical yield of Cu = \_\_\_\_\_\_\_\_\_ g**

2. Calculate the **experimental yield of Copper (Cu).** Simply subtract the mass of the filter paper from the mass of copper residue + filter paper . This is your actual yield of copper. **Show ALL work!**

**Experimental yield of Cu = \_\_\_\_\_\_\_\_\_ g**

3. Calculate the **percent yield of Copper (Cu).** The formula for this is:

**Percent yield of Cu = \_\_\_\_\_\_\_\_\_ %**

4. Calculate the **percent error.** The formula for this is

**Percent error = \_\_\_\_\_\_\_\_\_ %**

**Discussion Questions:** Answer each of the following in complete sentences

1. What color is the copper sulfate when you dissolve the crystals in water?

2. What happened to the aluminum during the experiment?

3. What would happen if you put lead foil in the solution? Would the copper form? Explain! (Hint: use the activity series!)

4. Assume that you measured exactly 15.0 grams of copper (II) sulfate. How many moles of CuSO4 is this? Show ALL work!

5. If you were trying to produce 80.5 grams of Cu, how many grams of Al would you need? Show ALL work! (Hint: mass to mass problem using balanced equation)

6. If you were trying to produce 80.5 grams of Cu, how many grams of CuSO4 would you need? Show ALL work! (Hint: mass to mass problem using balanced equation)

**Conclusion and Evaluation:**

This is the most important part of your lab report. It must be at least two paragraphs.

Paragraph 1:

* Begin with a topic sentence that refers to the purpose of your lab. (TS)
* Then state the significant data -- summarize the results. (CD)
* Next refer to your background information and explain why that happened and/or tell what you infer from the data -- What does the data tell you? (CM)
* End this paragraph with a concluding sentence that tells what you learned. (CS)

Paragraph 2:

Was your data consistent with your expectations and/or known data? Discuss possible errors by providing a couple of reasons why you think the amount of copper that should have formed (theoretical yield) and the amount of copper that actually formed (experimental yield) were different. Be very specific to your lab experience. Provide specific recommendations that would improve your result.

Hint Box

IF… THEN….

actual (experimental) yield **<** theoretical yield NORMAL (% yield < 100%)

actual (experimental) yield **=** theoretical yield PERFECT lab ☺ (% yield = 100%)

actual (experimental) yield **>** theoretical yield CONTAMINATED (% yield > 100%)

 \*This is NOT possible if the product is PURE\*