Name ____ Period _________

Lab – Stoichiometry of a Single Replacement Reaction 60 Points

Introduction

In this lab you will be performing a single replacement reaction between copper(II)sulfate pentahydrate ($CuSO_4{\cdot}5H_2O$) and Aluminum metal (*Al*).

$$2Al(s) + 3CuSO_4{\cdot}5H_2O(aq) \rightarrow Al_2(SO_4)_3(aq) + 3Cu(s) + 15H_2O(l)$$

By using stoichiometry you will calculate the amount of aluminum metal needed based on the starting amount of copper(II)sulfate pentahydrate, and the predicted amount of copper metal (*Cu*) to be produced. In the results you will then compare this predicted mass of copper metal to the mass actually produced.

The lab requires the use of a catalyst, a chemical added to the reaction to allow the reaction to speed up faster that it would normally occur. The aluminum used in the lab has an oxide layer (Al_2O_3) that needs to be removed by an acid (*HCl*), the catalyst via the reaction below.

$$Al_2O_3(s) + HCl(aq) \rightarrow H^{1+}(aq) + 3O^{2-}(aq) + 2Al^{3+}(aq) + Cl^{1-}(aq)$$

The aluminum ions (Al^{3+}) produced from the oxide layer combined with the aluminum metal (*Al*) not part of the oxide layer to product the aluminum reactant for the reaction.

Procedure

Part 1 – Obtaining the starting materials for the reaction

1. Using the scale provided on the lab table weigh a weighing boat on the scale and hit the tare (*zero*) button. The mass of the weighing boat should be around 2.5g (*check unit on scale*) before hitting tare.
2. Add a thin layer of $CuSO_4{\cdot}5H_2O(s)$ to the weighing boat and record the mass from the scale on the data table below. The mass should be around 10 – 15g (*record exact amount on table*)
3. Using the stoichiometry chart in the data section below calculate the mass of aluminum (Al) needed to the reaction.
4. Repeat steps 1 and 2 for the aluminum (Al) including taring a new weighing boat, and adding Al until the mass of the Al is the same as calculated in step 3. Tear up the aluminum (Al) foil into small pieces.

Part 2 – Performing the single replacement reaction

5. Make a solution of water and NaCl by adding a scoop of NaCl to a 150 – 250mL beaker and fill it half-way to the top with the NaCl(*aq*) solution in the large beaker on the table.
6. Add the aluminum (Al) foil to the beaker and use a stirring rod to stir in the aluminum for about 30 – 60s
7. Add the $CuSO_4{\cdot}5H_2O(s)$ to the beaker and stir until the entire beaker changes from a blue to a grey color. You should see no silver aluminum flakes in the solution.

Part 3 – Filtering the and weighing the product

8. Obtain a plastic funnel from the stock table along with a coffee style filter. Weigh the filter (*only, not with the funnel*) and record the mass on the data table
9. Using the stirring rod move the liquid and solid into the filter from the beaker. Stirring the liquid in the beaker as you pour will make removing the solid easier. If solid remains in the beaker use a bit on water from the stock table to rinse out the beaker into the filter.
10. Remove the filter paper from the beaker, open the filter paper onto a regular sheet of paper. Write your group names on the paper and place in the back on the room.
11. Once dry (*next class period*) remove the filter from the paper and weight the filter + solid on the scale. Record the mass of the copper with filter paper on the data table. Observe the color and the texture of the copper (Cu) in the filter after weighing.
12. Discard filter with copper (Cu) sample in the trash. Do not remove the Cu or paper from the lab due to trace acids and other chemicals on the filter paper.

Data and Calculations

Molar Ratios: 2mol Al : 3mol $CuSO_4$: 3mol Cu

Part 1.3 Calculation
Mass of Al metal for Reaction

Measured Mass $CuSO_4$ (*Blue Salt*) ___________ g $CuSO_4$

g $CuSO_4$	1mol $CuSO_4$	2mol Al	26.98g Al
	249.72g $CuSO_4$	3mol $CuSO_4$	1mol Al

_______________ g Al

Part 2 Calculation
Experimental Mass of Cu for Reaction

Measured Mass $CuSO_4$ (*Blue Salt*) ___________ g $CuSO_4$

g $CuSO_4$	1mol $CuSO_4$	3mol Cu	63.55g Cu
	249.72g $CuSO_4$	3mol $CuSO_4$	1mol Cu

_______________ g Cu
Theoretical Mass Cu

Part 3 Calculation
Experimental Mass of Cu from Reaction

Mass Cu w/Filter (*after drying*) = _____________ g Cu + Paper

Mass Filter (*dry*) = _____________ g Filter

Mass Cu (*dry*) = Mass Cu w/Filter – Mass Filter

Mass Cu (*dry*) = _____________ g Cu
Experimental Mass Cu

Results and Error Analysis
Error Analysis

Relative Error
Relative Error = Experimental Mass – Theoretical Mass

Percent Error
$$\text{Percent Error} = \frac{\text{Relative Error}}{\text{Theoretical Mass}} \times 100(\%)$$

Relative Error = _____________ g

Percent Error = _____________%