Name ____ Period _________

Lab 7 – Stoichiometry of a Single Replacement Reaction 50 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*).

$CuSO_4 \cdot 5H_2O$ "Hydrated"

→ $Cu + O_2 \rightarrow CuO$ (green)

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

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 sodium based compound (*NaCl*), the catalyst via the reaction below.

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

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.

$CuSO_4 \cdot 5H_2O$ is "hydra- " $CuSO_4$ is "anhydrous" [without water]

Data and Calculations

Chemical Equation	$2Al(s) + 3CuSO_4 \cdot 5H_2O(aq) \rightarrow Al_2(SO_4)_3(aq) + 3Cu(s)$							
Molar Ratio	2	mol	3	1	1	mo	3	mol

Molar Masses for Reactants and Products in Reaction					
MM $CuSO_4$	~~249.72g/mol~~ 159.62	MM Al	26.98gmol	MM Cu	63.55g/mol

Starting Reaction Measurements

Starting Masses for all Reactants in Main Reaction				
Mass $CuSO_4$	15.00g	Mass Al	1.00g	

Theoretical Mass Cu

Convert ____g $CuSO_4$ to mol $CuSO_4$	
15.00g $CuSO_4$	1 mol $CuSO_4$
conv. 1	159.62 g $CuSO_4$
mol $CuSO_4$	0.094 mol $CuSO_4$

Convert _____ mol $CuSO_4$ to mol Cu	
0.094 $CuSO_4$	3 mol Cu
conv.	3 mol $CuSO_4$
mol Cu	0.094 mol Cu

Convert _____ mol Cu to mass Cu	
0.094 mol Cu	63.55g Cu
	1 mol Cu
Theoretical mass Cu	5.97 g Cu

Experimental Mass Cu

Experimental Mass Cu	Mass Cu [Dry] + Filter	6.73g	Mass Dry Filter	1.00g	Mass Cu (*experimental*) (Mass Cu [Dry] w/Filter – Filter)	5.73g
		(Exp Mass)		(Average mass)		

Post Lab Questions

Was the mass of the Cu produced higher or lower than expected in the reaction?	How was stoichiometry used to predict the amount of Cu produced in the reaction?	What are the two main reasons that the final product mass is commonly lower than expected?
Most commonly lower than given mass	Stoich. was used to find mol $CuSO_4 \cdot 5H_2O$ and mol Cu for reaction	Cu metal lost in beaker (hard to remove) Reaction has a hard time going to completion ($CuSO_4$ remains) CuO (green) layer on Cu