Experiment: Determining the Relative Masses of Copper and Iron Atoms

An important term in quantitative chemistry is the term “relative”. For example, the periodic table reports the relative masses of the elements; yet, it does not record the actual mass of any single atom. In this experiment you will determine the “relative” masses of copper an iron atoms. In other words we will assign a mass of “1.0” to an atom of iron, and then see what the corresponding mass of a copper atom would be. You will carry out the following reaction:

$$Fe_{(s)} + CuSO_{4(aq)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$$

In this reaction the Cu^{2+} ion of aqueous copper sulfate solution steals two electrons from iron. This type of reaction in which electrons are lost and gained is an example of an oxidation-reduction reaction (redox reaction).

Procedure

Weigh out ***about*** 0.30 g of steel wool (Fe) on a piece of weighing paper. On a second piece of weighing paper weigh out ***about*** 3.00 grams of blue, crystalline copper sulfate pentahydrate ($CuSO_4 \bullet 5H_2O$). Transfer the copper sulfate to a 250 ml Erlenmeyer flask that is two-thirds filled with deionized water. Heat the flask over a Bunsen burner and stir the contents of the flask with a glass-stirring rod. **Do not boil**. As soon as all of the solid has dissolved, add the steel to the flask and turn off the burner. Use your stirring rod to poke the steel wool under the blue solution. Record your observations. Continue to stir the contents of the flask until all of steel wool has reacted.

While you are waiting for the reaction to be complete, determine the mass of a single sheet of filter paper. Place the filter paper into in the Buchner funnel. Wet the filter paper with some distilled water so as to seal it to the funnel. Place the funnel firmly in the opening of the vacuum filtration flask. Turn the cold faucet water all the way on to create the low pressure in the vacuum flask.

Filter the contents of the flask onto the preweighed filter paper. Catch the filtrate (the blue or colorless solution that runs through the paper) in the vacuum flask. Use a wash bottle of distilled water to wash the remaining solid copper onto the filter paper. When the filtration is complete, rinse the solid copper with deionized water. After rinsing, remove the funnel from the vacuum flask. Carefully remove the filter paper from the funnel using a metal spatula and place on a piece of scrap paper. Write your name on the scrap paper and place it off to the side on a side counter or in an empty lab draw to dry. Weigh the dry filter paper and its contents the next day in lab.

Observations

Data

Day 1:

mass of steel wool (Fe) _____ g

mass of copper sulfate ($CuSO_4 \cdot 5H_2O$) _____ g

mass of filter paper _____ g

Day 2:

mass of filter paper + copper _____ g

mass of copper (Cu) _____ g

Calculations & Questions – show all of your work, and include units where appropriate

1. Using your experimental data determine the experimental mass ratio of Cu to Fe.

$$\frac{\text{mass of Cu}}{\text{mass of Fe}} =$$

2. Using the atomic masses from the periodic table determine the "true" mass ratio of Cu to Fe.

$$\frac{\text{mass of Cu}}{\text{mass of Fe}} =$$

3. Determine your percent error. Use the following formula:

$$\%\text{Error} = \frac{|\text{True Value - Experiment Value}|}{\text{True Value}} \times 100\%$$

4. If the copper was wet when you weigh it, how would this affect the Cu/Fe mass ratio? Be specific!

5. If some of the copper was left behind in the funnel, how would this affect the Cu/Fe mass ratio? Be specific!