Mole Relationship between Copper and Iron in a Single Replacement Reaction

Purpose: to determine the balanced equation for the single replacement of Cu by Fe

Apparatus:

250 mL beaker	Bunsen burner
glass rod	drying oven
wire gauze	retort stand
retort ring	electronic balance

Materials: copper(II) sulphate pentahydrate
iron metal (powder)

Procedure:

1. Carefully determine the mass of a clean dry 250 mL beaker. Record the value in the data table. This beaker must be free of tape or other labels. The mass of the beaker must be less than 115 g or you will run into trouble later. USE THE GOOD BALANCE FOR THIS MASS.

2. Mass out approximately 15 g of copper(II) sulphate pentahydrate using a weighing boat. USE THE CHEAP BALANCE FOR THIS – DO NOT RECORD THIS NUMBER.

3. Place the copper(II) sulphate pentahydrate in this beaker and add 50 mL of **DISTILLED WATER.**

4. Carefully mass out 2 g of iron metal powder into a second weighing boat. Record the value in the data table. Be sure to record all three decimal places. (Does not need to be exactly 2.000g, but must be weighed accurately. BE SURE TO TARE THE BALANCE WITH THE EMPTY WEIGHING BOAT ON IT. USE THE GOOD BALANCE FOR THIS MASS.

5. Heat the solution of copper(II) sulphate pentahydrate to the boiling point using the retort stand, ring, wire gauze and Bunsen burner setup as demonstrated by the teacher. Once the solution begins to boil, **REMOVE THE HEAT SOURCE AND PROMPTLY GO TO THE NEXT STEP.**

6. WAIT FOR BOILING TO CEASE. Add the iron metal powder **SLOWLY** while stirring with the glass rod. If the iron powder is add too fast the solution may boil over! Be sure that you have added all of the iron. You may rinse the weighing dish with water to help ensure all of the iron has been added. Allow 5 minutes for the reaction to complete. Re-boil the solution for two minutes once most of the activity dies down. Do not let the mixture boil over. Record visible observations.

7. Carefully decant the solution as demonstrated by your teacher. This first decant should be done in the chemical waste bucket.

8. Rinse with 25 mL of **DISTILLED WATER** and decant, repeat four more times

9. Place the beaker in an oven to dry overnight. Do not label the beaker! Place the beaker on a piece of paper with your name on it.

10. Carefully find the mass of the beaker plus the copper metal product.

Mass of Empty Beaker	
Mass of Iron Metal	
Mass of Beaker Plus Copper	

Visual Observations:_____

_____

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Calculations:

1. In this chemical reaction one product is pure copper, the other is a combination of iron and sulphate. Write the chemical formula and the I.U.P.A.C. names for two possible iron sulphate compounds bases on the more common oxidation states of iron (Fe^{2+} & Fe^{3+}). If you have done this correctly you should have TWO formula and TWO names!

2. Based on your answer to #1, write TWO different balanced chemical equations that could represent this single replacement reaction. Use the formula $CuSO_4$ for the copper(II) sulphate pentahydrate (ignore the five attached water molecules). Also note that water is simply the medium for the reaction and does not enter into the chemical equations.

3. Based on your answer to #2, do TWO separate stoichiometric calculations that predict the expected mass of copper product based on the mass of iron you used in your experiment. Both of these calculations will require three conversion factors. These answers are called theoretical values since they are based on "stoichiometric theory".

4. Find your experimental mass of copper product. This will require a standard three line calculation. Compare your two possible theoretical masses of copper metal with your experimentally observed mass of copper. Identify the balanced chemical equation from #2 that best matches your experimental results.

5. Based on your answer to #4 perform a %error calculation using your experimental and theoretical mass of copper metal.

$$\% \text{ error} = \frac{|\text{experimental mass} - \text{theoretical mass}|}{\text{theoretical mass}} \times 100\ \%$$

Concluding Questions:

1. Find and write definitions for oxidation and for reduction.

2. Synthesis, Decomposition and Single Replacement reactions are also Redox Reactions. This means that one element has undergone a reduction and a second element has undergone an oxidation (Redox is short for RED uction-OX idation). Write the chemical reaction (the one you have determined to be the best from above) and write the oxidation states of all elements above each elements symbol. Next, using these oxidation states, determine which element was oxidized and which element was reduced. Make sure that this is clearly stated. You may wish to answer your question using the arrow method shown in class!

3. Is the reaction between Fe and $CuSO_4$ reaction endothermic or exothermic? Back up your answer with one clear visual observation.

4. How can you test that the copper product was in fact dry?

5. Identify three good sources of error inherent in this experimental procedure.