3 Stoichiometry: Reaction of Iron with Copper (II) sulfate

Purpose

The objective of this experiment is to use stoichiometric principles to find the reaction equation for metallic iron and a $CuSO_4$ solution which is a single replacement reaction.

Theory

Stoichiometry is defined as the quantitative study of reactants and products in a chemical reaction. It is based on the fundamental principle that is the law of conservation of mass, which states that the total mass of all substances present after a chemical reaction is the same as the total mass before the reaction. Displacement reactions are reactions where the ion in solution is displaced or replaced through oxidation of an element. The reaction between a metallic iron and a $CuSO_4$ solution is an example for this type. $CuSO_4$ is often added to water to stop algae or fungal growth.

In the aqueous solution chemistry, copper forms two oxidation states: +1 (cuprous) and +2 (cupric). Therefore, the stoichiometric principles expect two possible equations for the reaction between a metallic iron and a $CuSO_4$ solution. These equations are given below;

PRELAB QUESTIONS

Prelab question # 1: Finish below equation, assuming iron forms a +2 ion in iron sulphate.

$$\_\_ Fe_{(s)} + \_\_CuSO_{4(aq)} \rightarrow$$

Prelab question # 2: Finish below equation, assuming iron forms a +3 ion in iron sulphate.

$$\_\_ Fe_{(s)} + \_\_CuSO_{4(aq)} \rightarrow$$

Prelab question # 3: If reaction equation 1 is correct, the moles of elemental iron reacting and the moles of elemental copper produced are in a __:__ ratio.

Prelab question # 4: If reaction equation 2 is correct, the moles of elemental iron reacting and the moles of elemental copper produced are in a __:__ ratio.

Experimental Procedure

Chemicals List	***Equipments***
Fe powder $CuSO_4$	250 mL beaker (x2) Bunsen burner Graduated cylinder

1. Weigh a clean and dry 250 mL beaker and write it on the report data sheet as W_0.
2. Add approximately 1 gram (must be <1.01 grams) of **iron powder** to the beaker. Note the mass of iron on the report data sheet as W_{Fe}.
3. Add 30 mL of 0.5 M $CuSO_4$ solution into a graduated cylinder and then pour it into an another beaker. Heat the beaker slowly to almost boiling.
4. Take the beaker over heat and then pour the hot $CuSO_4$ solution slowly to the other beaker including the iron powder.
5. The reaction should be completed therefore swirl the flask until the reaction has stopped. The product of the reaction will be copper and wait until the copper pieces precipitate. After the precipitation decant the liquid to leave the copper precipitates in the beaker.
6. Add approximately 10 mL of distilled water to the beaker for cleaning the copper pieces. Swirl the beaker and decant the water.
7. Heat the beaker until the copper pieces dry enough. Cool down the beaker and weigh them. Write it on the report data sheet as mass of copper formed, W_{Cu}.
8. After completing the procedure, find the moles of iron used (n_{Fe}) and moles of copper formed n_{Cu}.
9. Find whether iron is formed as Fe^{2+} or Fe^{3+}.

Experiment 3 – Report

Name of the student:	Student ID:
Name and signature of the assistant:	Section & Date:

Data and Calculations

(5 pts) Mass of the empty beaker	W_0	
(5 pts) Mass of iron used	W_{Fe}	

1. (10 pts) Calculate the number of moles of iron that reacted.

2. (5 pts) Calculate the mass of copper that the reaction produced.

3. (10 pts) Calculate the number of moles of copper that the reaction produced.

4. (5 pts) What is the ratio of copper to iron?

Experiment 3 – Report (page 2)

Name of the student:	Student ID:

5. (10 pts) Which one of the equations in the pre-lab part is consistent with your results? Explain your answer.

6. (15 pts) Calculate the amount of copper that should have been produced in the reaction, the theoretical yield. Use the single replacement reaction and the initial masses of the reactants.

7. (15 pts) Determine the percent yield of the copper in this experiment.

Experiment 3 – Report (page 3)

Name of the student:	Student ID:

QUESTIONS

1. (10 pts) How many grams of iron(III) oxide (ferric oxide), Fe2O3, are formed from the reaction of 5.00 g of iron metal with excess oxygen gas?

2. (10 pts) What is the limiting reagent in mixing?