

Chemistry of Our Environment - Lab

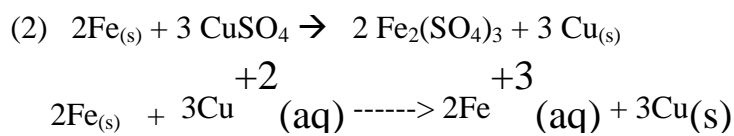
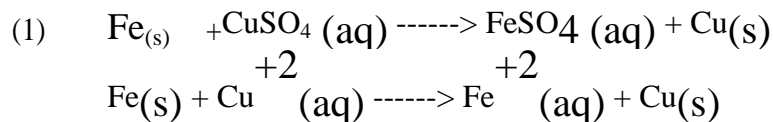
STOICHIOMETRY:

The Reaction of Iron with Copper (II) Sulfate

Introduction

In this experiment we will use stoichiometric principles to deduce the appropriate equation for the reaction between metallic iron and a solution of copper (II) sulfate. This reaction produces metallic copper, which is seen precipitating as a finely divided red powder. This type of reaction, in which one metal "displaces" another from a solution of one of its salts, is known as a single substitution reaction. A metal capable of displacing another from a solution of one of its salts is said to be "more active" than the displaced metal. In this experiment, iron is more active than copper.

Iron forms 2 types of ions, namely Fe^{+2} and Fe^{+3} . We shall use stoichiometric principles to determine which of these ions is formed in the reaction between iron and copper (II) sulfate solution. If Fe^{+2} is formed, then equation (1) is correct, while equation (2) is correct if Fe^{+3} is formed. Your task is to find out which equation is consistent with the results of your experiment.



An excess of copper (II) sulfate solution (to make sure that all the iron is reacted) will be added to a known amount of iron. The metallic copper produced will be weighed. These weighings will be used to calculate the moles of iron used and the moles of copper formed. If equation (1) is correct, the moles of copper should equal the moles of iron. If equation (2) is correct, we should obtain 1.5 moles of copper per mole of iron.

PROCEDURE

1. Weigh a clean, dry 100 or 250 mL beaker.
2. Accurately weigh approximately 1.00 gram of iron powder into the beaker. Do not exceed 1.00 grams.
3. Measure 30 mL of 1.0 M CuSO_4 solution into a graduated cylinder. Pour it into an Erlenmeyer flask, and heat gently to *almost* boiling. Turn off hot plate.
4. **Slowly** add the hot CuSO_4 solution to the beaker containing the iron powder. ***Be sure the addition is slow to avoid excess frothing and possible loss of material.*** It will help to avoid frothing if a wooden applicator stick is placed in the beaker before adding the hot CuSO_4 solution.
5. Swirl the flask to insure completeness of reaction. When the reaction has ceased, allow the copper product to settle. Then carefully decant the liquid from the copper, (pour off the liquid and leave the solid behind). You may observe a thin copper colored sheen on the surface of the liquid which does not settle out. You may ignore this. **Make sure you do not pour off any copper (leaving a few drops of liquid behind is fine).**
6. Add about 10 mL of distilled water to the solid copper and swirl to wash any remaining ions from the copper.

Decant the wash water from the copper and add 10 more mL of distilled water, swirl and decant again. **Make sure you do not pour off any copper (leaving a few drops of liquid behind is fine).**

7. Now add several mL of isopropyl alcohol (***CAUTION: isopropyl alcohol is very flammable***) to the copper. Swirl and allow to stand a few minutes and decant off the acetone. Repeat with a second portion of isopropyl alcohol. Discard the isopropyl alcohol in Organic Wastes. Again, **make sure you do not pour off any copper (leaving a few drops of liquid behind is fine).** The isopropyl alcohol readily dissolves the water and removes it. The isopropyl alcohol is easily removed by gently heating or by using a stream of air since isopropyl alcohol has a low boiling point and readily evaporates. We will use gentle heat.
8. Heat the beaker with the copper product on *medium* heat on a hot plate to evaporate the isopropyl alcohol. Carefully break up any clumps of copper with a spatula, if drying proves difficult. ***Be sure not to remove any copper from the beaker.***
9. When the copper is dry, carefully dry the outside of the beaker and reweigh to find the mass of copper formed. **Show your copper sample to your instructor.** You

will lose points, if you fail to show your copper sample to your instructor.

10. Calculate the moles of iron used and the moles of copper formed. Deduce whether iron goes into solution as Fe^{+2} or Fe^{+3} .

Data and Calculations

Name _____

Mass of Empty Beaker (A) _____

Mass of Beaker Plus Iron (B) _____

Mass of Iron Used ($C = B - A$) _____

Moles of Iron Used ($D = C / 55.85$) _____

Mass of Beaker Plus Copper (E) _____

Mass of Copper Formed ($F = E - A$) _____

Moles of Copper Formed ($G = F / 63.55$) _____

Ratio: Moles of Cu : Moles of Fe
(G / D) _____

Calculation Work

Results

1. From your data, which equation (1) or (2) gives the correct stoichiometry for this reaction? Explain your answer.