**Quantitative Study of a Reaction: Iron & Copper(II) Sulfate**

* **Question:** How does the law of conservation of mass relate to writing and balancing chemical equations?
* **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.

(1) Fe(s) + CuSO4(aq) ⭢ FeSO4(aq) + Cu(s)

(2) 2 Fe(s) + 3CuSO4(aq) ⭢ Fe2(SO4)3(aq) + 3Cu(s)

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.

**Data Table**

*(Copy into your lab notebook before lab day.)*

|  |  |
| --- | --- |
|  | Mass (g) |
| empty beaker |  |
| iron wire (before reaction) |  |
| iron wire (after reaction) |  |
| beaker with copper crystals |  |

* **Safety:** Goggles, gloves and aprons are required. Be careful with the copper(II) sulfate, it is an eye and skin irritant and is toxic by ingestion. After cleaning up your lab station including sponging your entire lab bench, wash your hands before leaving the lab.
* **Procedure:** *( 🗹 each of the steps as you complete them.)*

Day One

* 1. Label your beaker with your name, your partner’s name and class period.
* 2. Using your lab balance, measure the mass of your beaker. Record the mass on your data table.
* 3. Add a scoopula of copper(II) sulfate into the beaker.
* 4. Fill the beaker about ¾ full with distilled water and then using a glass stirring rod, stir to dissolve the copper(II) sulfate.
* 5. Using your lab balance, measure the mass of your iron wire coil. Record the mass of your data table.
* 6. Hang your iron wire coil from the lip of the beaker so that it hangs into the copper(II) sulfate solution (like a Christmas ornament).
* 7. Store the beaker overnight in the area indicated by your teacher.

Day Two

* 1. Lift the iron wire coil and shake into the beaker any residue which has formed. Rinse any remaining residue from the iron nail into your beaker with distilled water from a wash bottle.
* 2. Dip the rinsed iron wire coil into a beaker of acetone supplied by your teacher. Place the iron nail on a paper towel to dry. When dry, measure and record the mass of the nail.
* 3. Obtain another beaker. *(This new beaker is your waste beaker.)* Decant the liquid from your beaker into the waste beaker. Your goal is to have your beaker emptied of as much liquid as possible without sacrificing any of the copper crystals.
* 4. Rinse your crystals by adding 10mL of distilled water to your beaker, stirring gently, allowing to settle and then decanting the liquid into your waste beaker.
* 5. Place your beaker in the drying oven.

Day Three

* 1. Measure and record the mass of your beaker with the copper crystals.
* 2. Once your teacher has signed your data sheet, dump the copper crystals into the trash and then clean your beaker.
* **Calculations**

1. **Mass of iron reacted**

Subtract the mass of the iron wire *after* the reaction from the mass of the iron wire *before* the reaction.

*Mass of iron wire before reaction – Mass of iron wire after* reaction *= Mass of iron reacted*

1. **Moles of iron reacted**

Divide the mass of the reacted iron by the atomic mass of iron.

*Mass of iron reacted ÷ Atomic mass of iron (from periodic table) = Moles of iron reacted*

1. **Mass of copper produced**

Subtract the mass of the empty beaker from the mass of the beaker with copper crystals.

*Mass of the beaker with copper crystals – Mass of empty beaker = Mass of copper produced*

1. **Moles of copper produced**

Divide the mass of the copper produced by the atomic mass of copper.

*Mass of copper produced ÷ Atomic mass of copper (from periodic table) = Moles of copper produced.*

1. **Coefficients**
2. Write the ratio of moles of Fe reacted : moles of Cu produced
3. Reduce the ratio of moles to the lowest whole number by dividing both by the smaller of the two.

* **Conclusion: Balanced equation**

Use your calculated coefficients to choose which balanced equation in the introduction is the correct one. Write this equation down as your conclusion.

EXTRA CREDIT: Using the balanced equation for the reaction, the number of moles of Fe reacted and their respective molar masses, calculate the number of moles of copper(II) sulfate reacted and the number of moles of iron sulfate produced.