**Copper Cycle**

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**ABSTRACT**

A copper cycle is a cyclical series of different types of reactions. The reactions involved are decomposition, redox and precipitation reactions. There were observations of different states of matter and changes in quantities of substances. Out of five reactions, solid copper was used for the first reaction. After the fifth reaction, copper was reformed and theoretically should have had the same mass as the copper used in the first reaction. However, copper was lost in the course of the five reactions and the final mass of copper was less than the mass of the copper initially used.

1. **INTRODUCTION**

The purpose of this experiment is to observe a copper cycle and the different reactions involved. Since it is a cycle, each following reaction is performed after its previous one. Moreover, what is used in the beginning should be found or reformed at the end as well. These results are theoretical and thus, observations must be made for each reaction in order to learn how copper is lost. If the copper cycle proceeds perfectly, the mass of the copper used initially should be the same as the mass of the copper reformed at the end. But that will not be the case so the mass of the resulting copper should be less than that of the beginning copper.

1. **EXPERIMENTAL**

For reaction 1, the materials used were copper wire, electric balance, nitric acid, test tube and a hot water bath. The copper wire was weighed first and measured 0.148 grams. The copper wire was then placed into the test tube and nitric acid was added into the test tube. The mixture was heated in a hot water bath in the laboratory hood for about ten minutes before the copper wire dissolved and no more nitrogen dioxide gas was being produced. The mixture had a dark blue color after the reaction completed while it was still clear blue at the beginning.

For reaction 2, the materials used were sodium hydroxide, stirring rod, pH paper and the solution from reaction 1. Sodium hydroxide was added to the solution from reaction 1 until a white precipitate formed. A stirring rod was used to mix the solution. The mixture became a cloudy blue color with bubbles and black particles.

For reaction 3, the materials used were distilled water, a pipette and a hot water bath. The solution from reaction 2 was placed in a hot water bath and the solution became black immediately. After 60 seconds, the entire solution was black and no blue precipitates remained. Once the solution was taken out of the hot water bath, the solution was allowed to cool to room temperature. An equal volume of distilled water was added and decanted when the solid settled to the bottom. This was repeated again.

For reaction 4, the materials used were sulfuric acid and a stirring rod. A few drops of sulfuric acid were added to the solution using a dropper and the copper solidified at the bottom. The black solid did not dissolve completely so more sulfuric acid was added until a semi clear blue solution was present.

For reaction 5, the materials used were magnesium ribbons, stirring rod, sulfuric acid, ethanol, ammonia and an electronic balance. The magnesium ribbon was added to the solution and bubbles began forming and the solution became cloudy with white precipitates. More sulfuric acid was added to dissolve the magnesium hydroxide forming. The magnesium ribbon eventually dissolved and the solution became a clear blue liquid with some solids at the bottom. A small sample was taken and water and ammonium hydroxide was added to the sample turning it to a deep blue color. The original solution was decanted with water and ethanol and the final copper solid with water was weighed to equal 0.425 g. The copper alone weighed 0.122 g.

1. **RESULTS AND DISCUSSION**

Reaction 1: Cu (s) + 4 HNO­­3 (aq) 🡪 Cu(NO3)2 (aq) + 2 NO2 (g) + 2 H2O (l)

Reaction 2: Cu(NO3)2 (aq) + 2 NaOH (aq) 🡪 Cu(OH)2 (s) + 2 NaNO3 (aq)

Reaction 3: Cu(OH)2 (s) 🡪 CuO (s) + H2O (l)

Reaction 4: CuO (s) + H2SO4 (aq) 🡪 CuSO4 (aq) + H2O (l)

Reaction 5: CuSO4 (aq) + Mg (s) 🡪 Cu (s) + MgSO4 (aq)

Reactions 1, 3 and 4 are decomposition reactions. Reaction 2 is a precipitation reaction. Reaction 5 is a redox reaction. The percent yield of copper was 82% ((0.122 g / 0.149 g) \* 100). The loss in grams was 0.027 g (0.149 g – 0.122 g) and the loss percentage was 18%.

The systematic errors that could have occurred are: the measurement of copper after the fifth reaction may be inaccurate since a different method was used to measure the mass of copper; not using the dome on the electronic balance to measure the mass of copper; and using different amounts of aqueous solutions like sodium hydroxide and sulfuric acid to create the reaction. Based on the observations made, a systematic error made would be the final weighing of the copper solid because water had to be decanted several times and it was not removed perfectly from the copper so the mass may include some of the water’s weight.

The random errors that could have occurred are: copper remaining on the stirring rod; some copper was lost when liquid was decanted from the solution; and some copper was lost when used on the litmus paper. Based on the observations made, a random error made was the loss of copper when the solution was rinsed with different solutions and then those solutions were decanted.

In the fifth reaction, sulfuric acid reacted with magnesium and not copper because copper’s reactivity is below the hydrogen ion in the activity series while magnesium is above it and is reactive enough to be oxidized by hydrogen ions. Sulfuric acid does not dissolve copper because of the same above reason. Nitric acid does dissolve copper and nitrogen dioxide is formed because nitric acid is a strong oxidizing agent that is strong enough to dissolve copper.

1. **CONCLUSION**

This experiment explains how a copper cycle works with all the different reactions involved and why they occur. In a more general sense, it also explains how in nature, when and why certain reactions occur. A possible answer could point to an activity series which allows specific acids to react only with specific metals. The results emphasize something important as well: there is always some sort of error in an experiment and the errors should be recognized and an attempt should be made to minimize it, not completely avoid it.

Table I. Observations for each reaction is made regarding the chemicals used and any changes that happen in each reaction.

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| Reaction | Observations |
| 1 | Copper wire mass = 0.148 g; brown copper color; nitric acid is clear liquid. The liquid turned blue and the copper wire became white after being placed in the nitric acid. After placing the test tube in the hot water bath for 1 minute, there is a red brown gas forming. After the copper wire completely dissolved, the solution became a dark blue color. |
| 2 | The color of the solution is a dark blue color with a green tint. There are no precipitates. 7 drops of NaOH is added to the solution with a dropper and a white precipitate formed. When enough NaOH was added, the solution became a cloudy blue mixture with bubbles and black particles. The solution was mixed with a stirring rod. A potential error would be the copper sticking to the stirring rod. |
| 3 | The mixture was placed in the hot water bath again and the solution turned black immediately. After 1 minute, the entire solution as black. Water was added and decanted from the solution twice. Some copper may have been lost and is a potential random error. |
| 4 | A few drops of H2SO4 was added and the copper solidified at the bottom of the test tube. The majority of the solution is a clear blue color and the copper is in chunks. More H2SO4 was added to fully dissolve the CuO. |
| 5 | A magnesium ribbon was added and bubbles began forming, the solution became cloudy and whiter in color. There were white precipitates and more H2SO4 was added until the Mg(OH)2 stopped forming and started dissolving. The test tube was also heated to stop the reaction. A sample was taken from the solution and water and ammonium hydroxide was added to the sample and turned it a deep blue color. The main solution was decanted and the copper remained was weighed after the water dried. The final mass is 0.122 g and % yield is 82%. |