
Experiment #6: Synthesis of Copper(II) Compounds

The law of conservation of mass states that matter is neither created nor destroyed during a chemical reaction. This was first observed by Antoine Lavoisier in the late eighteenth century, in which he observed that the total mass of all substances present after a chemical reaction is the same as the total mass before the reaction. Any changes which occur during a reaction merely involve the rearrangement of atoms. In theory, this means that an element may go through several reactions until it is transformed back into its original state without the loss of any mass. In practice, however, this may not always *appear* to be the case.

In this experiment, Lavoisier's theory is tested by reacting solid copper with certain reagents and synthesizing various compounds in order to arrive at the original mass of copper at the conclusion of the experiment.

Procedure

1. Weigh approximately 0.35 g of copper into a 250 mL beaker. Describe the color and form of the sample. Record the mass of the sample.
2. Part A: WORK IN THE HOOD! Add 3–5 mL of concentrated HNO_3 slowly to dissolve the copper; warm gently on a hot plate if all of the copper does not dissolve. After the copper has dissolved, remove the solution from the hot plate and add 15 mL of deionized H_2O slowly. Note the color of the solution as well as the reaction that is occurring.
3. IN THE FUME HOOD, prepare a boiling water bath for Part C: Fill a 400 mL beaker with about 200 mL of water and add 2–3 boiling stones. Heat this solution at about 50 % power on a hot plate. While waiting for the water to boil, continue to Part B.
4. Part B: Use NO HEAT during this step! Add 6 M $\text{NaOH}(\text{aq})$ very slowly while stirring until the solution turns red litmus paper blue (use a stirring rod to test a drop of solution). Do not confuse the color of the precipitate with the color of the litmus paper. Note any color changes; a precipitate will form. Describe the color and the supernatant. Note the reaction that is occurring.
5. Part C: Dilute the solution to 100 mL total with DI water. Place your 250 mL beaker in the boiling water bath that you prepared in the fume hood. If the water bath is not boiling yet, you may increase the power on the hot plate to bring the water to a boil. Allow your solution to heat up and note any color changes. When all of the solid material appears to have changed color, allow the solution to heat for an additional 3 minutes, then turn off the hot plate, remove the 250 mL beaker from the water bath and allow the solution to cool. While the solution is cooling, prepare a filter by folding a piece of filter paper in half twice to fit your funnel. Filter the cooled mixture and discard the liquid. Rinse the filter with deionized water. You will return the solid to the original beaker, so it is not necessary to completely transfer the solid. Record the color of the residue and the filtrate. Note the reaction that is occurring.

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6. Part D: Transfer the filter paper and solid back to the original beaker. Dissolve the solid copper oxide by adding approximately 10 mL of 3 M $\text{H}_2\text{SO}_4(\text{aq})$ to the filter paper containing the residue from the previous step. Once the solid has dissolved, remove the filter paper and rinse it with 10 – 20 mL of deionized water. Add the washings to the acid solution, and save the solution for the next step. Note any color change. Also note the reaction that is occurring.
7. Part E: **WORK IN THE HOOD!** Add about 0.40 g of zinc metal to the acidic copper solution. If any blue color remains after the zinc has dissolved, a bit more zinc may need to be added (record in your report!). Note the reaction that is occurring. Dissolve any excess zinc with a small amount (approximately 5 mL) of 3 M $\text{H}_2\text{SO}_4(\text{aq})$.
8. Filter the supernatant liquid from the solid and wash the solid 3 times with 20 mL portions of deionized water.
9. Transfer the solid copper onto a large watch glass and place it in the laboratory oven (PS 103 or PS 107) for 15 to 20 minutes at around 100 °C or until dry. Weigh to determine the mass of recovered copper.

Data Analysis and Calculations

Initial color and form of the copper _____

Mass of Cu(s) at the beginning of the experiment _____

Mass Recovered _____

% Recovery _____

Comment and discussion: Do your results support Lavoisier's law of conservation of mass? How does your percent recovery deviate from the expected 100%? Briefly explain.

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Post-lab Questions

1. Write the symbol or formula for the form of copper that is present in the following parts of the experiment:

A. after adding nitric acid _____

B. after adding NaOH, litmus paper turns blue _____

C. after boiling _____

D. after adding sulfuric acid _____

E. after adding zinc _____

2. Now give the color of the copper substances in each of the steps above:

A. _____ D. _____

B. _____ E. _____

C. _____

3. A student reports 115% recovery. How could he/she possibly have more copper at the end of the experiment than he/she started with? Explain.

4. If a student used a penny as the source of copper in this experiment, would it matter if a pre-1982 penny (essentially pure copper) versus a post-1982 penny (copper exterior over a zinc core) was used? Would using a post-1982 penny pose any experimental complications? Briefly explain.

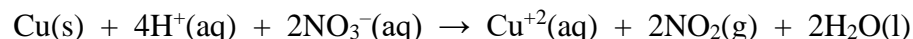
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5. Part A in today's experiment is classified as a redox reaction in which electrons are transferred via oxidation of Cu and reduction of the N in HNO₃. The balanced molecular equation is:



The net ionic equation for this reaction is:



Write balanced molecular, ionic, and net ionic equations for the other four reactions in this inorganic sequence. Classify the types of each reaction in as many possible ways (i.e. redox, synthesis, combustion, decomposition, single replacement, double displacement, precipitation, neutralization).

Part B:

Part C:

Part D:

Part E:

6. Referring to part E, write the reaction for the reduction of copper(II) ion into solid copper using zinc. Calculate the theoretical mass of zinc needed to carry out the reaction based on the initial mass of copper used. Compare this theoretical mass of zinc with the actual amount used in the laboratory. Justify any differences.

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Pre-lab Questions

Upon reading the procedure in preparation for this experiment, you should also answer the following questions:

1. Use the outlined procedure to describe:
 - a) a test for determining whether a solution is basic enough.
 - b) a test to decide whether enough zinc has been added.
2. Write out and classify the molecular, ionic, and net ionic equations that take place when H_2SO_4 is added to the excess zinc in part E.
3. Does observing a color change always indicate that a chemical change has occurred? Explain why or why not.
4. What should the student do if the solution in step E is still blue?