# E4-A SEQUENCE OF CHEMICAL REACTIONS

 The purpose of this experiment is to test the Law of Conservation of Mass by determining the percent recovery of copper from a sequence of chemical reactions involving copper in several forms.

The sequence is:Cu(s) 🡪 Cu2+(aq) 🡪 Cu(OH)2(s) 🡪 CuO(s) 🡪 Cu2+(aq) 🡪 Cu(s)

PROCEDURE: Wear your **safety glasses** while doing this experiment.

**Step 1**

 Weigh about 0.25 g of copper into a 250 mL beaker. Describe the color and form of the sample. Record the exact mass of the sample.

**WORK IN THE HOOD**! Add 2-3 droppers-full of the concentrated HNO3 **slowly** to the copper. If it does not all dissolve, add several more and swirl well. Wait until the copper has dissolved completely and no more gas forms. Then add 10 mL of deionized H2O, slowly.

 Note the color of the solution. What is the chemical state of the copper after this reaction?

## Step 2

 You may return to your work station to finish the experiment; only work in the hood when noted. Add 6 M NaOH(aq) very slowly, with stirring, until the mixture changes AND the solution turns red litmus paper to blue. (Use a stirring rod to test a drop of solution on a corner of the test paper. Repeat as needed using the same paper for multiple tests.) Do not confuse the color of the precipitate with the color of the litmus paper. Note any color changes; a solid will form (called a precipitate).

 Describe the solid and the “supernatant.” What is the identity of the solid?

### Step 3

 Add deionized water to make a total volume of about 100 mL. Add a magnetic stir bar to the solution. Use a hot plate with gentle stirring to heat the solution JUST to the boiling point. Heat/boil gently for about 4 minutes. Be sure to heat very carefully to avoid bumping of the solution. Use beaker tongs to remove the beaker if it begins to bump or spatter. Note any color changes. Allow the solution to cool, then prepare a filter by folding a piece of filter paper to fit your funnel (see Figure 4) and dampening it with deionized H2O. Filter the boiled mixture and discard the filtrate. Use your wash bottle (filled with deionized water) to transfer the last traces of solid onto the filter. Heat about 20 mL of deionized water; wash the residue at least 3 times with 5 mL portions of this hot water. Allow each portion to drain through the filter. Keep the solid, with the filter paper, until you are ready for step 4.

 Record the color of the residue and the color of the filtrate. What is the identity of the solid?



*Figure 4: Folding a Filter Paper*

### Step 4

Dissolve the solid from Step 3 by adding about 10 mL of 3 M H2SO4 to the residue on the filter paper from step 3. Let the solution drain into a 250 mL beaker. If any solid remains in the filter, pour the solution through the filter again. Repeat this step until the solid is completely dissolved. Note the color change!

Wash the empty filter paper with cold deionized water; add the washings to the acid solution and save the solution for step 5. Confirm the presence of aqueous copper(II) ion as follows: withdraw a few drops of the solution to a small test tube and add a drop of 3 M aqueous ammonia. Observe any color change.

What is the identity of the solute after Step 4?

### Step 5

 Once again, **WORK IN THE HOOD**.

Roughly weigh out about 1 gram of zinc metal. Add several small pieces of zinc metal to the acidic copper solution. Observe what happens to both the zinc and the solution. If any blue color remains after the zinc has dissolved, add additional pieces of zinc, a few at a time, until the solution is no longer blue and a **small amount** of excess zinc remains. Test for complete reaction of the aqueous copper ion by withdrawing a few drops of the solution and adding a drop of 3 M aqueous ammonia. What indicates that the reaction is complete? Once the reaction is complete, dissolve any excess zinc with a small amount (about 5 mL) of 3 M H2SO4. What gas is evolved as the zinc reacts with H2SO4?

### Step 6

 You may return to your work station.

 Once the excess zinc has been removed, allow the precipitated copper to settle. Decant the supernatant liquid from the solid. Wash the solid 3 times with 20 mL portions of deionized water, stirring, allowing the solid to settle after each addition and decanting the water. (Collect the washings until you are finished in case of a slip.) Some liquid remains with the solid by this procedure.

If your evaporating dish is dirty, wash it and dry it for ten minutes in the oven. (Write your name on the bottom with a Sharpie; do not use tape.) Cool and weigh it. Transfer the copper into the cool, dried evaporating dish using a stream of water from the wash bottle. Pour off as much of that waste water as you can without disturbing the solid. Next remove the water from the copper by adding a small portion (just enough to cover the solid) of acetone or ethanol and then decanting off that solvent. The solvent should be collected until you finish (in case of an accidental slip) but then can be discarded in the sink. Do this at least three times and let the dish sit until all of the solvent odor is gone and the solid is dry.

Allow the dish and copper to dry and then weigh them. As long as the dish is cool to the touch on the bottom, the solvent is still evaporating – WAIT LONGER for it to dry. Calculate the weight of the copper by difference.

Describe any differences in the copper's properties after the sequence of reactions.

 Turn in the copper sample, in a labeled vial, to your instructor.

#  E4-A SEQUENCE OF CHEMICAL REACTIONS

Section\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Report Sheet

# Quantitative Analysis

mass of Cu(s) at beginning of experiment: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

mass recovered at the end of the experiment: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

% Cu recovered: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Comments and discussion:

1) Show your calculation for % copper recovered.

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

3) Another student reported less than 100% yield. Is this a violation of the law of conservation of mass? Explain.

4) Compare the theoretical mass of zinc (calculated in the Pre-lab) with the amount we actually use. Explain any differences.

# Qualitative Analysis

Table of observations

| The steps in the experiment | Write the symbol / formula for the form of copper that is present in the following steps of the experiment | The color of the solution in each step |
| --- | --- | --- |
| a. before adding nitric acid |  |  |
| b. after adding nitric acid:  |  |  |
| c. after adding NaOH (litmus paper turns blue): |  |  |
| d. after boiling: |  |  |
| e. after adding sulfuric acid: |  |  |
| f. after adding zinc: |  |  |

**QUESTIONS**

1) What should the student do, if the solution is still blue in step d in the table above?

2) What should the student do, if the solution is still blue in step f in the table above?

 3) What was the purpose of adding concentrated nitric acid to the original copper sample?

Write the reaction equation:

4) What was the purpose of adding 6 M NaOH to the solution from Step 1in the procedure?

Write the reaction equation:

5) What was the purpose of heating the mixture (precipitate and aqueous layer) in Step 3 in the procedure?

Write the reaction equation:

6) What was the purpose of adding 3 M sulfuric acid to the solid that you recovered in Step 3 in the procedure?

Write the reaction equation:

7) What was the purpose of adding zinc to the copper solution in Step 5 in the procedure?

Write the reaction equation:

8) What was the purpose of adding 3M sulfuric acid to the copper/zinc mixture in Step 5 in the procedure?

Write the reaction equation:

9) What was the purpose of rinsing the final solid with DI water?

 Why was acetone/ethanol used in the last step?

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Section\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Pre-Laboratory Assignment

1. Find in the procedure and describe:

1. A test for a basic solution
2. A test to decide whether enough zinc has been added

2. Does observing a color change always indicate that a chemical change has occurred? Explain.

3. The equation for the reconversion of copper into copper metal is as follows:

 Zn(s) + Cu2+(aq) 🡪 Cu(s) + Zn2+(aq)

Calculate the theoretical mass of zinc needed to carry out the reaction for a 0.424 g copper sample. Show all of your work.