Chemistry 151
Lab 7: Reactions with Copper

Introduction

In this lab you will perform a series of reactions involving copper, many of which are discussed in Ch. 4 of lecture. First, you will react copper with nitric acid, converting the metal to aqueous copper (II) nitrate.

\[
\text{Cu(s, brown)} + 4\text{HNO}_3(\text{aq}) \rightarrow \text{Cu(NO}_3)_2(\text{aq, blue}) + 2\text{NO}_2(\text{g, brown}) + 2\text{H}_2\text{O(l)} \quad (\text{eq 1})
\]

You will then add sodium hydroxide to this solution, which will first neutralize any excess nitric acid in the solution. After that, it will react with copper nitrate.

\[
\text{Cu(NO}_3)_2(\text{aq, blue}) + 2\text{NaOH(}aq) \rightarrow \text{Cu(OH)}_2(\text{s, blue}) + 2\text{NaNO}_3(\text{aq}) \quad (\text{eq 2})
\]

By applying heat to this solution, you can covert copper (II) hydroxide to copper (II) oxide

\[
\text{Cu(OH)}_2(\text{s, blue}) \xrightarrow{\text{heat}} \text{CuO(s, black)} + \text{H}_2\text{O(l)} \quad (\text{eq 3})
\]

You will isolate the solid using gravity filtration, then react it with sulfuric acid.

\[
\text{CuO(s, black)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{CuSO}_4(\text{aq, blue}) + \text{H}_2\text{O(l)} \quad (\text{eq 4})
\]

We can reform metallic copper by reacting the solution with zinc (the same reaction from Lab 5).

\[
\text{CuSO}_4(\text{aq, blue}) + \text{Zn(s)} \rightarrow \text{Cu(s)} + \text{ZnSO}_4(\text{aq}) \quad (\text{eq 5})
\]

Unlike the previous lab, you will notice significant bubbling occurring in solution, which is a side reaction between zinc and sulfuric acid.

\[
\text{Zn(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{H}_2(\text{g}) \quad (\text{eq 6})
\]

To dry your copper, you will assemble a steam bath, which will reduce the risk of overheating the copper to form copper (II) oxide (similar to eq 3 above).

The only calculation you’ll perform in this lab will be determining the percentage of copper reacted in equation 1 that was recovered in equation 5.

Procedure

Part I – The Reaction of Copper and Nitric Acid
1. Measure the mass of a medium sized beaker (250-400mL).
2. Add approximately 0.40g of copper to the beaker. Record the total mass of the beaker and the copper.
3. In a fume hood, using a disposable pipette, add 4.0 mL of concentrated nitric acid to the beaker a dropperful at a time, stirring in between additions. If any undissolved copper remains after five minutes, add additional acid to the solution (in approximately 1mL increments), with stirring, until it does.

(The remainder of this lab can be done at your work area)
Part II – Conversion of Copper (II) Nitrate to Copper (II) Hydroxide
1. Dilute the solution from Part I with 10 mL deionized water.
2. Measure approximately 25 mL of 6 M sodium hydroxide and take it back to your work area. Using a disposable pipette, slowly (dropperful at a time) add the base to the copper solution, stirring as you do.
3. Once you start to form Cu(OH)$_2$, periodically test the solution with red litmus paper. Remember not to dip the paper into the solution. Instead, dip your stir rod into the solution then touch the end to the paper. Once the solution is basic, the reaction is complete.

Part III – Conversion of Copper (II) Hydroxide to Copper (II) Oxide
1. Add 100 mL deionized water to the solution from Part II. Recheck the basicity and add more 6 M NaOH as needed.
2. Assemble your heating apparatus as follows:
   a. Place a Bunsen burner on a ring stand.
   b. Attach a metal ring to the ring stand then place a wire gauze on the ring.
   c. Set the beaker containing your solution on the wire gauze then place a second ring clamp around the beaker to reduce the chance of an accidental spill.
3. Light the Bunsen burner and gently boil the solution with a cool flame.
4. When the reaction is complete, turn off the burner, set the beaker on the lab bench, and allow the solution to cool (to about room temperature).
5. Begin heating 50-100 mL deionized water. Once it starts to boil, turn off the burner.
6. Prepare your filter funnel as follows
   a. Fold a piece of filter paper in half to make a semi-circle.
   b. Fold it in half once more to make a “pie” shape.
   c. Open a section of the paper to form an open cone.
   d. Place the cone in a short-stemmed funnel. Make sure the funnel is large enough so that all the paper fits inside and none sticks out from the top.
   e. Set the funnel in a medium-sized Erlenmeyer flask (250-400 mL) to collect the filtered solution (the filtrate).
7. If most of the solid has settled to the bottom of the beaker, stir a little to distribute it more evenly in the solution, and then slowly pour the solution into the filter funnel. Do not allow the funnel to fill with solution as it may prolong the filtration process.
8. Add 10 mL of the hot water from step 5 to the beaker to transfer any remaining solid through the filter. If water’s back to room temperature you’ll need to reheat it.
9. Wash the precipitate in the funnel with 10 mL hot water.

Part IV – Conversion of Copper (II) Oxide to Copper (II) Sulfate
1. Replace the Erlenmeyer flask with a second medium-sized beaker. If the funnel won’t set on the mouth the beaker, you’ll need to clamp the funnel to the ring stand and set the beaker beneath it.
2. Add 15 mL of 3 M sulfuric acid to the funnel. If solid remains in the funnel after the solution has passed through, put a clean beaker beneath the funnel and run the solution through again. Continue doing so until all of the copper oxide has reacted with the acid.

Part V – Conversion of Copper (II) ion to Copper Metal
1. Obtain 2 – 4 g of zinc (clean/shine with sandpaper as needed) and carefully place it in the copper solution from Part IV. Stir it often to prevent copper metal from sticking to the zinc. [Do the reaction in the hood if the bubbles irritate your nose.]
2. While the reaction is taking place, obtain an evaporating dish and a beaker it will fit comfortably on top of (~250-400 mL). Add 150 mL of water to the beaker and begin heating it with the apparatus from Part III, adding more water if it begins to boil away. Place the dish on top of the beaker.
3. Once all of the copper ion has been converted to copper metal, isolate it by decantation and dry it using the steam bath from step 2.

Waste Disposal
All solid and solution waste should be disposed of in the waste hood. Filter paper and disposable pipettes may go in the trash.
Name: _____________________________   Section: ______

Data

Part I – The Reaction of Copper and Nitric Acid

1) Mass of beaker, g
   _______

2) Mass of beaker and copper
   _______

3) Mass of copper, g
   _______

Part V – Conversion of Copper (II) ion to Copper Metal

1) Mass of evaporating dish, g
   _______

2) Mass of evaporating dish + Cu, g
   Initial heating
   _______

   2nd heating
   _______

   3rd heating (if needed)
   _______

   4th heating (if needed)
   _______

3) Mass of copper recovered, g
   _______

4) Overall percent yield, %
   _______
Post-Lab Questions

1. It’s common to obtain yields that higher than 100%. Give two reasons (besides “incorrect measurements”) to explain how this can happen?
   1) 
   2) 

2. In Part I you used nitric acid and in Parts IV and V the solution contained sulfuric acid.
   a) Could you use sulfuric acid in Part I instead of nitric? Why or why not?
   b) Could you use nitric acid in Parts IV and V instead of sulfuric? Why or why not?

3. How could each of the following affect the calculated percentage of copper recovered (increase, decrease or no effect)? In each case, explain your answers.
   a) The solution wasn’t basic at the end of Part II
   b) The solution was still blue at then end of Part III
   c) A stoichiometric amount of zinc was used (i.e., the exact amount required to react with the amount of copper measured in Part I) instead of an excess amount.

4. Based on the reactions you performed today, write balanced equations for each of the following (assuming a reaction occurs).
   a) The reaction between aluminum sulfate and barium metal
   b) The reaction between silver and nitric acid.
   c) Heating a sample of chromium (III) hydroxide.
Pre-Lab Questions

1. Complete the following diagram to illustrate the series of transformations that copper will undergo in this lab.

[Diagram of copper (Cu) transformation]

2. Write net ionic equations, balanced with phases, for the six reactions shown in the introduction.

Eq 1  ______________________________________________________

Eq 2  ______________________________________________________

Eq 3  ______________________________________________________

Eq 4  ______________________________________________________

Eq 5  ______________________________________________________

Eq 6  ______________________________________________________
3. Briefly describe (without using equations) how you’ll know when copper has finished reacting in each part of this lab.

Part I

Part IV

Part II

Part V

Part III

4. A student began Part I of this lab with 0.52 g of copper, but only recovered 0.39 g after completing Part V. What was his overall percent yield?