6 A Cycle of Copper Reactions

Version: March 31, 2004

- Observe the variety of properties exhibited by the compounds of a single element.
- Classify the reactions involved according to type.
- Write net ionic equations.
- Practice quantitative laboratory technique in recovering the copper.

- *Caution.* WEAR YOUR SAFETY GLASSES. 8 *M* HNO_3 is a very corrosive acid, and the tiniest splash of it in your eye can cause blindness. If any gets on your skin, rinse it off immediately with lots of water.

DISCUSSION

You will cause a weighed piece of copper to undergo a series of chemical reactions, with the last reaction designed to give you back the original copper. The series of reactions is summarized as:

$$Cu \rightarrow Cu(NO_3)_2 \rightarrow Cu(OH)_2 \rightarrow CuO \rightarrow CuSO_4 \rightarrow Cu$$

All but one of these reactions can be classified as one of the following types of reactions: (1) combination, (2) decomposition, (3) displacement, or (4) metathesis.

The law of conservation of mass says that the total amount of copper recovered should equal the original amount of copper. You will test your laboratory technique against this standard, you will observe the variety of copper compounds formed along the way, and you will write net ionic equations for each reaction.

PROCEDURE

A. Copper(II) Nitrate from Copper Metal

1. Weigh a test tube to the nearest 0.001 *g*.
2. Obtain a piece of copper foil, place it in the tube, and reweigh.
3. Put the tube in the test tube rack. In the hood, add 1 *mL* of 8 *M* HNO_3*(aq)* to the copper in your tube. If copper remains after gas production slows, add a few more drops of acid. Repeat the addition of nitric acid if necessary. Record your observations.
4. Copper(II) nitrate gives the color to the aqueous solution. The fumes are nitrogen dioxide (NO_2). The other byproduct is water. Write a chemical equation for this reaction, and balance it. (This reaction does not fit in any of the four categories above.)

B. Copper(II) Hydroxide from Copper (II) Nitrate

5. Once the copper has completely reacted, add distilled water from your wash bottle until the tube is about ¼ full. Return to your work area.

Prepare an ice bath by mixing ice and water in a 250 *mL* beaker. Cool the tube for several minutes in the bath, then add 2 *mL* of 6 *M* NaOH*(aq)*. Stir the mixture with your stirring rod. Check to see if the solution is alkaline. To do so, remove a drop of solution from the tube with the stirring rod, and place it on one end of a piece of red litmus paper. The paper should turn blue. If it does not, add more sodium hydroxide, stir, and test again. Repeat until the solution tests alkaline. Remove your stirring rod from the tube. As you do so, rinse any precipitate into the tube with a few drops of distilled water from your wash bottle. Record your observations.

6. The precipitate is copper(II) hydroxide. What is the byproduct? Write a balanced molecular equation for this reaction, and classify it in one of the four categories.
7. Write the full ionic equation.

8. Write the net ionic equation.

C. Copper(II) Oxide from Copper(II) Hydroxide

9. Prepare a boiling water bath by placing a 150 *mL* beaker, half-filled with tap water, on a ring stand and heating it with a bunsen burner. When the water has come to a boil place the test tube into the boiling water, and heat for several minutes. Record your observations.

10. The precipitate in the tube is copper(II) oxide that was formed when the heat drove water from the copper(II) hydroxide. Write the molecular equation for this reaction, and classify it in one of the four categories.

11. Why are the full ionic and net ionic equations for this reaction no different from the molecular equation?

12. After the reaction is complete, remove the tube, and place it in the ice bath to cool. When the tube is cool enough to handle, wipe the water from the outside of the tube, and centrifuge. Place a balancing tube, containing an equal volume of liquid, across from your sample in the centrifuge head. Centrifuge a few seconds at high speed.

Remove your sample from the centrifuge, and draw off the clear liquid using a long-stemmed dropper. Do not allow any precipitate to be drawn up into the dropper. Squeeze the bulb on the dropper *before* inserting the tip into the liquid. Then slowly release the bulb to draw up the solution.

After removing as much liquid as possible, wash the solid at least once: Add distilled water until the tube is about 1/2 full. Stir, then place the tube in the boiling water bath for a few minutes. Cool in the ice bath, and centrifuge as before. Remember to rinse the stirring rod each time it is removed from the tube. Withdraw and discard the wash water. What is removed by this washing process?

D. Copper(II) Sulfate from Copper(II) Oxide

13. After as much water as possible is removed from the precipitate, add about 3 *mL* of 3 *M* H_2SO_4*(aq)*. Stir carefully with a stirring rod; this speeds up the reaction. Record your observations.

14. Write the molecular equation for this reaction, and classify it in one of the four categories.

15. Write the full ionic equation.

16. Write the net ionic equation.

E. Copper Metal from Copper(II) Sulfate

17. Add about 150 *mg* of granular zinc (about the size of a small pea) to the copper solution, and watch for several minutes. Record your observations. When the reaction is finished, the solution should be colorless and all the excess zinc should have reacted. It may be necessary to add more zinc if the color remains blue, or more sulfuric acid if unreacted zinc (silver colored) is still present.

18. The zinc participates in two separate reactions here. In one, the zinc metal reacts with the copper (II) sulfate to give the copper metal and a zinc (II) byproduct. Identify the byproduct. Write the molecular equation for the reaction, and classify it in one of the four categories.

19. Write the full ionic equation.

20. Write the net ionic equation.

21. In the other reaction, zinc reacts with the excess H_2SO_4 in the solution to produce the gas and a zinc (II) byproduct. Identify the gas and the byproduct. Write the molecular equation for the reaction, and classify it in one of the four categories.

22. Write the full ionic equation.

23. Write the net ionic equation.

24. When the reactions are complete, use the long-stemmed dropper to remove as much liquid as possible from the tube. Rinse the copper with a few milliliters of pure water from your wash bottle. Remove the rinsings with the dropper. Stand the tube in a beaker. Now, dry the remaining contents. According to your instructor's directions, either place the tube in a drying oven for 15 minutes, or allow it to air-dry in your drawer for a week. If you use the drying oven, be sure to mark the beaker and tube with your name.

25. When it is dry, determine the mass of the tube and its contents to the nearest milligram (0.001 *g*).

26. Calculate the mass of the recovered copper.

27. Calculate the mass of the original copper (from Steps 1 and 2).

28. Calculate the percent of the copper recovered by dividing the mass of the recovered copper by the mass of the original copper and multiplying by 100%.

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Name _____
Partner _____
Section _____Locker ____
Instructor _____

Enter the data or answer the questions *according to the corresponding step in the procedure*

A. . Copper (II) Nitrate from Copper Metal

1. Mass of empty test tube	
2. Mass of test tube and copper foil	
3. Observations upon adding nitric acid to the copper:	
4. Chemical equation:	

B. Copper (II) Hydroxide from Copper(II) Nitrate

5. Observations upon adding sodium hydroxide:
6. Molecular equation (and category):
7. Full ionic equation:
8. Net ionic equation:

C. Copper (II) Oxide from Copper(II) Hydroxide

9. Observations upon heating:	
10. Molecular equation (and category):	
11. Why are the full ionic and net ionic equations no different from the molecular equation?	
12. What is removed in the washing process?	

D. Copper (II) Sulfate from Copper (II) Oxide

13. Observations upon adding sulfuric acid:
14. Molecular equation (and category):
15. Full ionic equation:
16. Net ionic equation:

E. Copper Metal from Copper (II) Sulfate

17. Observations upon adding zinc:
18. Molecular equation (and category):
19. Full ionic equation:
20. Net ionic equation:
21. Molecular equation (and category):
22. Full ionic equation:
23. Net ionic equation:

24. Description of final product	
25. Mass of filter paper and copper	
26. Mass of recovered copper	
27. Mass of original copper	
28. Percent of copper recovered	

APPLICATION OF PRINCIPLES

1. What factors could cause the percent recovery to be *below* 100%?

2. What factors could cause the percent recovery to be *above* 100%?