Reactions of Copper

Introduction

In this experiment you will do a series of reactions with the element copper. These reactions will involve the use of some new techniques and some interesting color changes. In addition, they will illustrate the principles and techniques of *oxidation, reduction,* and *precipitation*. It is important that you make careful observations as your carry out these procedures. It is also very important that you do the questions as they appear in the procedures. This will keep you from falling into the trap of the cookbook approach that was discussed earlier and help you more fully understand the principles involved in the experiment.

In the first reaction you will dissolve elemental copper and make a solution of copper nitrate. This solution will then be treated with base which causes a precipitation. The resulting precipitate will then be heated to produce an oxide of copper. The oxide will then be treated with sulfuric acid to produce a blue colored solution of copper(II) sulfate. Finally, the copper ion will be reduced by zinc to produce copper metal which you will collect and dry.

In some steps of this experiment you are given amounts of chemicals to use so that you have an idea of the scale at which you should work. In other steps you are left to make your own decisions. Keep in mind the things you learned about chemical reactions in the last experiment. They will be of use to you here.

> In preparation for next week's experiment, each student must obtain about 4.5 grams of primary-standard grade potassium acid phthalate, KHP, in a vial and dry it in an oven at 110^{o} C for 2 hours. Place the vial of KHP in a small, beaker to keep it from spilling. Label your beaker using a graphite pencil in the white frosted area. Cover the beaker with a watch glass and place it in the oven. After two hours, remove your beaker from the oven. While keeping the watch glass on top of the beaker, let it cool until it is warm but safe to handle. Remove the watch glass and place the beaker containing the uncapped vial in a desiccator.

Safety: Carry out all steps that produce fumes in the hoods as described. Be especially careful with acids and bases. Wear your goggles.

Procedure

Work in pairs on this experiment. The actual data analyses and the written reports must be done entirely independently of your lab partner or other students. Make sure that you avoid unauthorized collaboration and plagiarism. All suspected violations of the Code of Academic Conduct will be referred to Student Judicial Affairs.

1. Making a Solution of Copper(II) Nitrate. Accurately weigh out 0.500 - 0.530 g sample of copper wire and record the measurement in your notebook. Using your pencil or pen, coil the wire into a flat spiral and place it into a clean 250 mL Erlenmeyer flask. Measure 4 mL of concentrated nitric acid found in the FUMEHOOD into a graduated cylinder. Keep the flask and graduated cylinder in the hood and pour the nitric acid into the flask. Make observations regarding any changes that occur during the reaction. **Be careful not to breathe any of the fumes!** Make notes of your observations in your notebook. Swirl the flask to be sure all the copper dissolves. If all the copper fails to dissolve within 10 minutes, then add an additional mL of nitric acid. Once all the copper has dissolved then add about 100 mL of deionized water and take the flask to your laboratory bench. **Be sure that no more fumes are being created before you remove the flask from the fume hood.**

Question A: *(Answer this question before proceeding.)* This reaction is an oxidation-reduction reaction that is somewhat complicated.

$$8\ HNO_{3(aq)} + 3\ Cu_{(s)} + O_{2(g)} \rightarrow 3\ Cu(NO_3)_{2(aq)} + 4\ H_2O_{(l)} + 2\ NO_{2(g)}$$

Identify the elements oxidized and reduced in this reaction and indicate how many electrons are transferred.

2. Acid/Base Reaction The second reaction that you should perform is the synthesis of copper(II) hydroxide from the copper(II) nitrate you made in the last step. This may be accomplished by adding 6 M sodium hydroxide to the copper solution. Add a minimum of sodium hydroxide, but also be sure that you have added enough to complete the reaction. This volume will be around 10 - 20 mL.

Question B: *(Answer this question before proceeding.)* How do you determine that you have added enough sodium hydroxide?

Question C: *(Answer this question before proceeding.)* Write the balanced chemical equation for the reaction in this step. Assume the precipitate is copper(II) hydroxide.

3. Formation of the Oxide To change the hydroxide to the oxide, slowly and carefully heat the solution containing the precipitate over a Bunsen burner. BE SURE TO STIR THE SOLUTION CONTINUOUSLY DURING THE HEATING WITH A GLASS STIR ROD. This will avoid the possibility of "bumping" which can occur when a large steam bubble forms within a solution due to a local region of overheating. Bumping will cause a loss of product in addition to possible injury! Watch the solution carefully and record observations. When the reaction is complete, remove the burner and continue to stir for a couple of minutes to avoid bumping of the cooling solution. Then stop stirring and allow

the product to settle. Once the product has settled, decant the solution and place it in the waste bottle that can be found in the fumehood. Be careful not to lose any solid. Next wash the solid with hot deionized water. After the solid has settled, decant off the wash and place it in the waste bottle. Save the solid for the next step.

Question D: *(Answer this question before proceeding.)* Write the balanced chemical equation for the reaction in this step. Assume the products are copper(II) oxide and water.

4. Formation of Copper(II) Sulfate Copper(II) oxide will react with sulfuric acid to produce copper(II) sulfate. Perform this reaction using 3 M sulfuric acid. As with all reactions, use enough solution to get the job done, but do not generate excess waste. **Now move back to the fume hood.**

Question E: Write the balanced chemical equation for this reaction. Assume the products are copper(II) sulfate and water.

5. Formation of Copper Metal Working in the fume hood, quickly add 1.0 g of zinc metal and stir. The reaction will be complete when the solution is colorless. Record your observations. When the reaction is complete, decant the solution into a clean beaker. Examine the solid, if you note any solid zinc then add 10 mL of 6 M HCl and stir the solution until the zinc is no longer present. When gas is no longer being produced, decant this solution into your beaker containing the previous decantant. This solution can be poured down the drain with copious amounts of water.

Question F: *(Answer this question before proceeding.)* Was the reaction between zinc and hydrochloric acid endothermic or exothermic? What was the gas produced in the reaction?

Question G: *(Answer this question before proceeding.)* Write the balanced chemical equation for the reaction in this step. Assume the reactants are copper(II) sulfate and zinc, and that the products are copper metal and zinc(II) sulfate.

Question H: *(Answer this question before proceeding.)* Indicate the reducing agent and the oxidizing agent in this reaction.

6. Recovery of Copper Metal: You will now transfer the copper from the flask into the casserole dish. First weigh your dry casserole dish. Using your rubber policeman, transfer all the solid to the casserole dish. Use 5 mL of deionized water from your wash bottle to aid this transfer. Stir the solid in the water to wash away water soluble impurities. Decant the water and wash two more times with 5 mL aliquots of deionized water. Carefully and slowly heat the casserole on a hot plate or Bunsen burner. Watch this carefully to keep the solid from bumping. Continue the heating and stir the precipitate vigorously with a policeman, be careful not to melt the rubber policeman. Once the solid is completely dry, allow the casserole to cool, and weigh the casserole. Calculate the percent yield you obtained. This can be found by dividing the actual yield you obtained by the theoretical yield. The theoretical yield is the ideal yield you would have if there was no loss or contamination during the experiment. The actual yield is the yield you actually obtained in the experiment.

Question I: Give reasons as to why you might expect your percent yield to be low. Give reasons as to why you might expect the percent yield to be high. Explain why your percent yield is high (>100%) or low (<100%)?

Clean-Up. Clean all glassware that was used before leaving the laboratory. Clean the casserole by soaking it in the nitric acid solution in the hood.