

Experiment 7

Isolating Copper from a Penny

In this experiment, you will perform several chemical reactions to isolate the copper from other elements in a penny. You will then quantitatively determine what percentage of the penny was composed of copper.

7.1 Introduction

Pennies used to be mostly copper. However, over time, the value of copper metal became nearly equal to the face value of the coin. So, in 1982 they changed the penny, and it is now only 2.5% Cu. Pennies dated after 1982 simply have a zinc core with a copper surface. Copper is one of the elements from the coinage group in the periodic table (with Ag and Au). These elements are unreactive and therefore hold up well in use. Quarters and dimes used to be made of silver but now have a nickel surface over an interior that is made from an inexpensive alloy.

Although copper is quite unreactive, it can be isolated from a penny by carrying out several oxidation-reduction reactions. First, the copper will be dissolved by an oxidizing agent, nitric acid. The products are copper (II) nitrate ($\text{Cu}(\text{NO}_3)_2$) and nitrogen dioxide (NO_2), a toxic red/brown gas. The other element in the penny, zinc, must be separated from the copper by a precipitation reaction where sodium hydroxide (NaOH) is used to form zinc hydroxide ($\text{Zn}(\text{OH})_2$). Addition of more NaOH will then convert the $\text{Zn}(\text{OH})_2$ to the soluble complex ion, $\text{Zn}(\text{OH})_4^{2-}$. However, the copper (II) hydroxide ($\text{Cu}(\text{OH})_2$) that is formed with the addition of NaOH is insoluble in excess NaOH . When the solid $\text{Cu}(\text{OH})_2$ is heated, the copper (II) oxide (CuO) forms. CuO dissolves in HCl and is converted to CuCl_2 . Aluminum is a strong reducing agent and will react with Cu^{2+} ion in CuCl_2 to produce elemental Cu. From the mass of copper recovered, the percent Cu in a pre-1982 penny will be calculated.

7.2 Precautionary Measures

- Nitric and hydrochloric acids are strong acids and sodium hydroxide is a strong base. These chemicals will burn your skin if you come in contact with them. In case some is spilled on you, rinse your skin thoroughly with cool water for at least five minutes and notify your instructor immediately.

You should wear gloves and goggles at all times throughout this experiment.

- The NO_2 gas given off in the first step of the procedure is toxic. This part of experiment should be carried out in the hood.

7.3 Procedure

Record lab notebook entries as you have for previous labs. This experiment has a lot of *qualitative* observations (e.g. color changes, precipitate formation, dissolving, etc.). Make sure to record *what you did in each step* and the consequences (observations) of those actions. Watch for points in the procedure below that prompt you for observations. You will be asked about your observations as well as calculations in the Chem21 Assignment for this experiment.

When observing colors, use a white piece of paper under your beaker to help the color show up more clearly. Also, this lab is **quantitative**, meaning that it's important to not lose any of your

sample. Careful workmanship is important. Be sure to collect every speck of your products as you go along.

1. Weigh 1/4 of a penny (pre-1982) and place it in a 150 mL beaker. Place the beaker under the hood and add approximately (no need to record the exact volume) 5 mL of concentrated nitric acid (HNO₃). You should observe the evolution of the toxic gas, NO₂. *Record what you did and any observations from the reaction! What ions are in the solution at this step of the reaction? What color is the solution? Are there any solids present?*
2. Wet a short strip of pH paper with DI water and use tongs to *briefly* hold the strip in the gases coming from the penny reaction. *Observe any color changes. What is the pH?*
3. After the penny has completely reacted, place a clean magnetic stir bar in the solution, place the beaker on the magnetic stirrer, and start the stirrer motor so the stirring rate is slow with no splashing. Slowly add 20 mL of 6 M NaOH. Make sure the reaction is mixed well. Use the DI water squirt bottle to wash down the sides of the beaker. *What species should be in solution at this point of the experiment? What solids should form at this point in the experiment? What are the colors of the solids/solution at this step?*
4. Heat the solution on the hot plate while *observing* any color changes. *What species should be in solution at this point of the experiment? What solids should form at this point in the experiment? What are the colors of the solids/solution at this step?*
5. After the reaction is complete (no more color change), remove it from the hot plate and allow it to cool for 10 minutes. Set up a vacuum filtration apparatus as demonstrated by your instructor. Pour the mixture from the previous step into the Büchner funnel. (It's okay if the stir bar is transferred into the funnel.) Use a rubber policeman and/or small portions of DI water to make sure you transfer *all* of the precipitate to the filter paper. Rinse the **precipitate** (the solid on the filter paper) three times with small portions of DI water. Be sure to wait until the funnel stops dripping between each rinsing. Then, set the **supernatant liquid** or **filtrate** (the liquid in the filter flask below the funnel) aside. *What species should be in your funnel? What does the precipitate look like? What species is in the filtrate? What does the filtrate look like?*
6. Place the funnel containing your precipitate over a clean 150 mL beaker. (You should not use the vacuum for this step.) Slowly, add 20 mL of 4 M HCl to the funnel. Use water from your wash bottle to break up any solid clumps. Add 20 mL more of the 4 M HCl, again breaking up clumps with water from the wash bottle. Repeat once more with an additional 20 mL of 4 M HCl. All the solid black material should be gone. If not, use additional 4 M HCl and water from your wash bottle. *What reaction is taking place at this step of the procedure? Describe color changes.*
7. Add a stir bar to the green solution and place the beaker on the stirrer. Start stirring at a *slow* speed (no splashing!). Add an aluminum wire loop (as illustrated by your instructor). Continue stirring until the solution becomes colorless. *What reaction is taking place at this step of the procedure? Describe color changes.*
8. Obtain a new piece of filter paper, write your initials on it in PENCIL. Place the filter paper on a watch glass and weigh the watch glass and filter paper together. **RECORD THIS MASS IN**

YOUR NOTEBOOK. Then, place the filter paper in the Büchner funnel. Transfer the reddish-tan precipitate (pure copper!) from the beaker into the funnel. Use the rubber policeman to assure complete transfer. Rinse the whole filter paper twice with DI water. If you were to weigh your product right now, it would be heavier than it should be because of the excess water. To help speed the drying process, rinse the filter paper with several small batches of acetone, a liquid that evaporates very quickly. Try to let the filter paper go “dry” between each rinse.

- Carefully remove the filter paper and place it on a folded paper towel to soak up some of the excess acetone. Then, place the filter paper on a watch glass (**THE SAME WATCH GLASS YOU USED IN STEP 8**) and let it dry in the oven. Remember, acetone evaporates quickly so the paper should be dry in 15 minutes. Weigh the filter paper and precipitate to determine the mass of copper obtained.

7.4 Results

Calculate the mass of pure copper recovered from your original piece of penny. The percent copper is the amount of pure copper recovered divided by the original mass of your penny piece times 100. Show these calculations in your notebook. Pay attention to significant figures.

7.5 Conclusion

Compare the % copper found in this experiment to a literature value for the % copper in a pre-1982 penny. You may use a reliable internet source to obtain the literature value for % copper in a pre-1982 penny. Calculate your percent error:

$$\text{Percent Error} = \frac{|\text{literature value} - \text{experimental value}|}{\text{literature value}} \times 100$$

7.6 Wrap Up

7.6.1 Waste Handling

The chemicals used in the copper experiment generate toxic waste. Save all the liquids in a large beaker and transfer them to the labeled waste container in the hood or at the front of the lab once your experiment is complete. Be careful to save your stir bars! Don't let them go down the drain or into the waste container! The solid materials that are left over may be safely thrown into the trash baskets.

7.6.2 Clean-up

Clean and dry your glassware and return it to your station. Then, wipe down your bench-top with a wet paper towel and dry it. Have your instructor check your station before you leave.

BEFORE YOU LEAVE LAB: Tear out the carbon-copy pages of your notebook. Make sure your name, your partner's name and your section number are on each page. Staple these pages together and turn them in to your instructor.

7.6.3 Laboratory Assignment

Enter all of your data, calculations and answers to questions in the Experiment 7 Assignment in Chem21. You will need to refer to your notebook for this. The Assignment is 48 hours after your lab ends.