Experiment 8
What's In A Cent?

OUTCOMES

After completing this experiment, the student should be able to:

- describe and perform several different types of separation.
- conclusively report information about the composition of pennies.
- write balanced chemical equations, given word descriptions, and relate them to procedures carried out in the experiment.

DISCUSSION

The purpose of this lab is for you to perform and observe a number of reactions and then write balanced chemical equations given a written description of those reactions. You should carefully write down your observations for each reaction since you will be using your observations to determine the phase labels for your balanced equations. (For example, if a cloudy, black solution is observed, that means a solid black precipitate is present).

In part 1 of this experiment, a pre-1982 penny will react with nitric acid in which the solid copper changes to a copper(II) cation-containing product. This product will undergo a series of reactions in which Cu^{2+} cation will be paired with anions that give either a soluble or insoluble compound. For example, copper(II) sulfide is **insoluble,** while copper(II) chloride is **soluble**. At the conclusion of the reaction series, the solid copper will be regenerated.

You will use decanting, a physical separation technique that is used for separating a liquid from a solid compound. This procedure involves allowing the solid to settle, then gently pouring the liquid off without disturbing most of the solid (also called a precipitate). A cloudy solution usually means that the solid compound is suspended in the solution and hasn't yet settled out.

Chemical separation techniques utilize the different reactivities of compounds to isolate the desired substance. For example, copper reacts with nitric acid but not hydrochloric acid, while zinc reacts with both acids. We use this difference of reactivity near the end of the experiment when hydrochloric acid is used to get rid of the excess zinc leaving the copper metal.

PROCEDURE

⚠ ***Wear large chemical splash goggles at all times for this experiment.***

⚠ ***Wear gloves while working with the chemicals in this experiment.*** *This experiment involves the use of concentrated acids and bases, all of which may cause serious burns and place holes in your clothing. Concentrated nitric acid causes painful discoloration of the skin. Imagine what it would do to your eyes!!! If you should get any of these substances on your skin, immediately* ***rinse with cold water*** *for 15 minutes and report it to your instructor. Notify the instructor immediately of any spills in the laboratory!*

Part 1

1. Start chilling 100 mL of deionized water in an ice bath. Obtain one pre-1982 penny for four groups. Place the penny in a 400 mL beaker and put the beaker in the fume hood.

⚠ ***The beaker must be in the fume hood before proceeding.***

⚠ ***Use extra care when working with concentrated nitric acid (HNO_3)! It causes severe chemical burns! Goggles and gloves are critical!***

Using a graduated cylinder, carefully measure and add 20 mL of concentrated nitric acid. Record your observations. Allow the beaker to remain in the fume hood until the entire penny is consumed. If the penny has not completely reacted after most of the bubbling has ceased, carefully add an additional 5 mL of the nitric acid.

2. While stirring, cautiously add 100 mL of chilled deionized water to the beaker. Mix the solution thoroughly with a stirring rod. Use a graduated cylinder to divide the solution into four *equal* portions, pouring the solution into separate 150 mL beakers. Take care so as to avoid spilling any of the solution. From this point forward, you will work in pairs with the solution in your own 150 mL beaker.

⚠ ***Use care when working with sodium hydroxide (NaOH)*** *– it causes serious chemical burns.*

3. While stirring, add 10 mL of 6 *M* NaOH to the solution in the beaker. Test the solution with litmus paper to see if the solution is basic. (Your instructor should demonstrate the proper use of litmus paper. Be sure not to confuse the color of the precipitated solid in your reaction solution with the color of the litmus paper!) If the solution is NOT basic, add a few drops of NaOH at a time, while stirring, until the solution becomes basic. It is very important that the correct amount of NaOH has been added, otherwise later portions of the experiment will not proceed correctly.

4. Place the beaker onto a hotplate under the hood and heat the mixture to a gentle boil.

⚠ ***Stir the mixture constantly while heating.***

The solid should turn black. Carefully remove the beaker from the heat and add 50 mL of deionized water to the beaker. Stir the mixture, allow it to settle, then decant and dispose of the clear liquid, keeping the black precipitate for the following steps.

⚠ ***Use care when working with sulfuric acid (H_2SO_4)*** *– it causes serious chemical burns.*

5. Pour 8 mL of 6 *M* H_2SO_4 into the beaker and stir gently until the precipitate dissolves.

6. While under the hood, add about 2.5 g of granulated zinc to the solution and stir briefly. Allow the mixture to react undisturbed for several minutes. The solution should become light blue or colorless as the reaction proceeds. Continue to step 7 if instructed OR after a few minutes, show the copper to your instructor and discard it into the specified container

⚠ ***Use care when working with hydrochloric acid (HCl)*** *– it causes serious chemical burns.*

7. *(Optional Step. Consult with your instructor if you are to complete this step.)* Once the blue color has disappeared and the evolution of hydrogen is slow, decant the liquid and add 3 mL of 6 *M* HCl. Once the bubbling ceases, the zinc has been removed. Decant and dispose of the liquid. Wash the copper in the beaker 3 times with 15 mL portions of deionized water, thoroughly stirring the copper, and decanting the liquid each time. Show the copper to your professor and discard it into the specified container.

⚠ ***Dispose of all chemicals in the proper waste container.***

⚠ ***Clean all countertops (including in the fume hood) and glassware thoroughly*** *so the next class is not exposed to any hazardous chemicals.*

Part 2

The instructor will demonstrate this part. Two different pennies – one pre-1982 and one post 1982 – were filed on their edges using a triangular file. They were then placed into a 150 mL beaker containing about 20 mL of 6 *M* HCl. The beakers have been set aside, so you can observe occasionally throughout the laboratory period. If possible, try to observe the pennies the following day, after they have been removed from the acid and rinsed with water. What happened to the pennies? What is significant about the date on the pennies?

Name____ Lab Section_______________

PRELAB QUESTIONS

1. In the data part of this lab, you will be balancing the equations for the reactions that you observe. Practice balancing the following chemical equations. In the cases where no additional coefficient is needed, write a "1". A coefficient of 1 is not normally written but is shown here for clarity.

   a. _____ C_3H_8 + _____ O_2 → _____ CO_2 + _____ H_2O

   b. _____ H_3PO_3 → _____ H_3PO_4 + _____ PH_3

   c. _____ Ca + _____ H_2O → _____ $Ca(OH)_2$ + _____ H_2

2. What does it mean to decant a liquid? In which step(s) in the experiment will you decant the liquid?

3. Does copper metal react with nitric acid (HNO_3)? Yes or No?

4. Does copper metal react with hydrochloric acid (HCl)? Yes or No?

5. Write the formula for the following compounds (you may want to review the section on nomenclature in your text):

   A. copper(I) oxide ____

   B. copper(II) oxide ____

   C. zinc oxide ____

   D. iron(II) oxide ____

   E. iron(III) oxide ____

(more on back)

6. In this lab, you will be asked to write out chemical equations from a description of the chemical reagents used. Write balanced chemical equations from the following descriptions. You will also need to indicate the phase label for each reactant or product, *i.e.,* solid (*s*), liquid (*l*), gas (*g*) and dissolved in water (*aq*).

    a. Gaseous ammonia reacts with gaseous hydrogen chloride to form solid ammonium chloride.

    b. Iron metal reacts with oxygen gas in the air to form solid iron(II) oxide.

    c. Magnesium metal reacts with liquid water to form solid magnesium hydroxide and hydrogen gas.

7. Which safety precautions must be observed during this experiment? List specific hazards.

Name____ Lab Section______________

Partner's Name___________________________

DATA AND QUESTIONS

Part 1

1. Throughout the experiment you encountered several different reactions used to isolate the copper. For each word description of a reaction given below, (1) tell which step in the procedure the particular reaction was carried out, (2) write a balanced chemical equation for the reaction, (3) write your observations of the reaction and (4) include phase labels for reactants and products in all equations.

    a) Copper(II) hydroxide, when heated, decomposes, forming copper(II) oxide and water.

Step	Balanced Chemical Equation	Observations

    b) Copper metal reacts with nitric acid (HNO_3), producing copper(II) nitrate, nitrogen dioxide gas, and water.

Step	Balanced Chemical Equation	Observations

    c) Copper(II) oxide reacts with sulfuric acid, producing copper(II) sulfate and water.

Step	Balanced Chemical Equation	Observations

d) Copper(II) nitrate reacts with sodium hydroxide to produce copper(II) hydroxide and sodium nitrate.

Step	Balanced Chemical Equation	Observations

e) Copper(II) sulfate reacts with zinc metal to yield zinc sulfate and copper metal.

Step	Balanced Chemical Equation	Observations

(This is an optional step.)

f) Hydrochloric acid reacts with zinc metal to yield zinc chloride and hydrogen gas.

Step	Balanced Chemical Equation	Observations

Part 2

Observations of pennies:	
Pre-1982 Penny	**Post-1983 Penny**

2. If there was any leftover zinc in your product at the end of your experiment, it could have been dissolved with hydrochloric acid, leaving the copper unharmed. How might this relate to your observations in Part 2 of this experiment?