Lab: Mole Relationships in a Single Displacement Reaction

FOR THE TEACHER

Summary
In this lab, students will carry out a reaction between metallic copper and an aqueous solution of silver nitrate to determine the mole ratio between the reactants and the products and write a balanced equation based on the data.

Grade Level
High school

Objectives
By the end of this lesson, students should be able to
- Observe a single replacement reaction
- Verify their predicted balanced chemical equation
- Determine the limiting reactant and the excess

Chemistry Topics
This lesson supports students’ understanding of
- Limiting reactant
- Single replacement
- Percent error

Time
Teacher Preparation: 30 minutes
Lesson: three 30 minute blocks (day one: mix solution and begin reaction, day two: collect silver, day three: take mass of silver and complete calculations)

Materials
- Copper wire (approximately 8 inches in length per group)
- Ruler
- Balance
- 150-ml Beaker
- Stirring rod
- Filter paper (two pieces)
- Silver nitrate, solid (give each group a different amount, ranging between 1.2g – 3.0g)
- Rinse bottle with distilled water
- Distilled water
- Funnel
- Drying oven

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
The dilute copper (II) nitrate product solution can be disposed of down the sink and flushed with water.
Silver nitrate is corrosive, causes burns, and stains skin and clothing. Avoid contact with eye and skin. It is highly toxic, with LD50, 1173 mg/kg.

Teacher Notes
- This reaction occurs slowly and should sit until the next lab period to ensure completion.
- In order to complete all of lab procedures, teachers should allow for three 30 minute blocks of time. Two overnight periods are necessary; the first at procedure step 11, and the second at procedure step 19. The final day should be used to collect the final silver product and complete the calculations.
- Demonstrating the filtering/decanting technique required in procedure steps 16-18 would be advised at the start of the second lab day. Flinn Scientific has a good short video to assist in this.
- I collect data from all lab groups to share with the class. I have the students consider all of the data when completing analysis question #1.
- I give each student or group of students a different amount of silver nitrate in procedure step 4, between 1.2–3.0 grams so a range of class data is obtained.
- The dried silver metal that is produced as a product in the reaction is collected, stored and sold after several years of accumulation.
- This experiment is appropriate for a first-year high school chemistry course.
- This lab was modified from an old Chem Study laboratory experiment.

FOR THE STUDENT

Lesson

Objective
In this experiment you will carry out a reaction between metallic copper and an aqueous solution of silver nitrate. The objective is to determine the mole ratio between the reactants and the products and write a balanced equation based on the data.

Materials
- Copper wire (~8 inches)
- Ruler
- Balance
- 150-ml Beaker
- Stirring rod
- Filter paper (two pieces)
- Silver nitrate
- Rinse bottle with distilled water
- Funnel
- Drying oven
Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- The dilute copper (II) nitrate product solution can be disposed of down the sink and flushed with water.
- Follow teacher instructions for clean-up and disposal of lab materials.
- Silver nitrate is corrosive, causes burns, and stains skin and clothing. Avoid contact with eye and skin. It is highly toxic, with LD50, 1173 mg/kg.

Procedure
1. Obtain a heavy copper wire about eight inches long. Form the lower part into an elongated coil and bend the opposite end to form a hook. Mass the wire and record it in the data table.
2. Find the mass of a piece of filter paper and record its mass in the data table.
3. Obtain a clean 150-ml beaker. Place it on the balance and record its mass in the data table.
4. While the beaker is on the balance, your teacher will add a sample of solid silver nitrate. Record the total mass of the beaker and silver nitrate in your data table.
5. Now add distilled water until the beaker is about two-thirds of the way full.
6. Stir the solution with a clean stirring rod until all of the solute is dissolved.
7. Using a wash bottle, wash the stirring rod into the beaker.
8. Suspend the coil of copper in the silver nitrate solution by hanging the hook over the edge of the beaker.
9. Label the beaker with your name.
10. Observe the beaker and wire for several minutes.
11. Allow the beaker to stand overnight.
12. Observe the beaker the next day.
13. Carefully shake the crystals from the copper coil into the beaker. Using the wash bottle, rinse the coil into the beaker.
14. Allow the coil to dry.
15. Using the balance, find the mass the dry copper coil. Record the mass in the data table as "mass of copper coil after reaction."
16. Decant the solution onto the weighed filter paper in a funnel with the appropriate set-up (your teacher will demonstrate this for you).
17. Add water until the beaker is empty and all contents are on the filter paper.
18. Wash the residue with distilled water at least three times.
19. Remove the filter paper from the funnel and place it back in the original beaker. Place the beaker in the drying oven overnight.
20. Find the mass of the beaker and its contents and record the value in the data table.

Data

<table>
<thead>
<tr>
<th>Mass of copper coil before reaction</th>
<th></th>
</tr>
</thead>
</table>
Mass of copper coil after reaction
Mass of copper reacted
Moles of copper reacted
Mass of filter paper
Mass of beaker and silver nitrate
Mass of empty beaker
Mass of silver nitrate
Moles of silver nitrate
Mass of beaker, silver, and filter paper
Mass of silver
Moles of silver
Moles silver/Moles copper reacted
Moles silver/Moles silver nitrate

Calculations
Complete the following calculations, and record the final values in the appropriate row of the data table:
- Mass of copper reacted
- Moles of copper reacted
- Mass of silver nitrate
- Moles of silver nitrate
- Mass of silver
- Moles of silver
- Moles silver/Moles copper reacted
- Moles of silver/Moles silver nitrate

Analysis
1. Use class data to write a balanced equation for the reaction. Explain how this data supports the equation.
2. List one source of error in the experiment and explain how this would affect the answer.
3. Account for the blue color produced in the solution.
4. Classify the type of reaction that occurred.
5. Why was distilled water used in this lab?