Lab: Limiting Reactant Lab Activity

Summary
In this lab, students react copper(II) chloride with aluminum to determine the limiting reactant. They then isolate one product to determine its percent yield.

Resource Type  Grade Level
Lab                High school

Objectives
By the end of this lesson, students should be able to
- determine the limiting reactant given the initial masses of two reactants.
- calculate percent yield.

Chemistry Topics
This lesson supports students’ understanding of
- Stoichiometry
- Limiting reactants
- Percent yield

Time
Teacher Preparation: 15 minutes
Lesson: 2 days of 50 minute periods

Materials
For each group:
- Copper(II) chloride dihydrate
- Aluminum foil
- 250-mL Erlemeyer flask
- Balance
- Graduated cylinder
- Distilled water
- Filter paper
- Safety goggles

Safety
- Always wear safety goggles when working with chemicals in a laboratory setting.
- 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.

Teacher Notes
- This lab requires substances to be dried overnight, so must take place over two days.
- Assign each group a group number prior to beginning the activity. This number will determine the masses of their two reactants.
For the Student
Student Activity Sheet: Limiting Reactant Lab

Lesson

Purpose
To determine the limiting reactant in a reaction between copper(II) chloride dihydrate and aluminum.

Safety
Wear goggles during this experiment. Avoid skin contact with copper(II) chloride dihydrate. Wash your hands before leaving the laboratory.

Prelab Questions
On a separate piece of paper, create a data table to contain the data you will collect in this activity. (This will require you to read through the lab sheet!)

Materials
- Copper(II) chloride dihydrate
- Aluminum foil
- 250-mL Erlenmeyer flask
- Balance
- Graduated cylinder
- Distilled water
- Filter paper

Procedure
1. Aluminum metal reacts with aqueous copper(II) chloride dihydrate ($\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$) to form copper metal, aqueous aluminum chloride, and water. Write the balanced equation for this reaction.
2. Each lab group will be using a different mass of aluminum metal and copper(II) chloride dihydrate. Your teacher will assign you a group number. Using the chart below, find your group number to determine the mass of aluminum metal and copper(II) chloride dihydrate you will be using in this activity:

<table>
<thead>
<tr>
<th>Group</th>
<th>Mass of Al (g)</th>
<th>Mass of CuCl$_2 \cdot 2\text{H}_2\text{O}$ (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td>2</td>
<td>0.50</td>
<td>2.00</td>
</tr>
<tr>
<td>3</td>
<td>0.50</td>
<td>4.00</td>
</tr>
<tr>
<td>4</td>
<td>0.50</td>
<td>6.00</td>
</tr>
<tr>
<td>5</td>
<td>0.25</td>
<td>5.00</td>
</tr>
<tr>
<td>6</td>
<td>0.25</td>
<td>4.00</td>
</tr>
</tbody>
</table>
3. Weigh out the copper(II) chloride dihydrate in a 250-mL Erlenmeyer flask and record the actual mass you use.
4. Using a graduated cylinder, measure out about 100 mL of distilled water and add it to the flask containing the copper(II) chloride dihydrate. Stir until the salt dissolves completely. Note the color of the solution here:
5. Weigh out the appropriate mass of aluminum foil and record the actual mass of aluminum in your data table. Loosely crumple it up into a few small pieces and add it to the copper(II) chloride solution. Swirl the solution gently and then allow it to sit undisturbed for 5-10 minutes. Write observations below.
6. While allowing the reaction to proceed, answer the following questions. **Show all work below.** Note: when calculating the molar mass of the CuCl₂·2H₂O, don’t forget to add the mass of two moles of water!
   Group #__________
   a. Which is your limiting reactant?
   b. What is your theoretical yield (in grams) of copper metal?
   c. What is your theoretical yield (in grams) of aluminum chloride?
   d. What mass of the excess reactant will remain when the limiting reactant is consumed?
7. If you solution is still blue at the end of the reaction, which was your limiting reactant?
8. If you can’t see any blue in your flask at the end of the reaction, can you be certain about which reactant was the limiting? Why or why not?
9. Think carefully about your limiting and excess reactants and the products you have formed. Which of the two products will you be able to isolate and calculate a percent yield for? Consult with your teacher if you are not sure which product you should isolate.

Here are the procedures for isolation:

**Isolation of copper:** Find the mass of a piece of filter paper. Filter the mixture through the filter paper (see your teacher if you need to be reminded of the correct set-up). Wash the copper well with distilled water to remove the dissolved aluminum chloride. Discard the filtrate (liquid) and let the copper in the filter paper dry overnight. Weigh the dry copper & filter paper.

**Isolation of aluminum chloride:** Find the mass of a clean, dry beaker. Separate the solids from the dissolved aluminum chloride through filtration, catching the filtrate in your clean, dry beaker. Wash the solids three times with 2.00 ml distilled water to get all the aluminum chloride into the beaker. Discard the solids. Then proceed to separate the water from the aluminum chloride using evaporation (set it in the drying oven overnight). Find the mass of the cool, dry aluminum chloride and beaker.
10. Isolate the correct product for your particular lab activity and calculate your percent yield. Show your calculation.

11. Does your percent yield seem reasonable? If not, is it because you did a bad job with the lab or does it seem as if the chemistry involved might be more complicated than the lab allowed for? Support your answer with evidence.