# Pre-Lab Information

Purpose Explore the yield of a chemical reaction by identifying the limiting reactant, comparing the theoretical and actual yields, and explaining the sources of error.

Time Approximately 45 minutes

Question While observing a chemical reaction, how can you tell which reactant is limiting?

**Reaction** The reaction of copper(II) chloride and aluminum is shown in this balanced equation:

3CuCl2 + 2Al → 2AlCl3 + 3Cu

Hypothesis If a substance is the limiting reactant, then it will be fully consumed by the time the reaction completes because it is the reactant that reacts completely and the reaction cannot proceed further.

Summary You will react copper(II) chloride with different quantities of aluminum in two trials. You will also calculate percent yield for Trial 2.

# Safety

* Always wear a lab coat and safety goggles while performing an experiment.
* Do not smell or taste any of the chemicals.
* Do not use any equipment unless you have been trained and its use is approved by your teacher.
* Use the right gear; for example, use chemical-resistant gloves when handling chemicals and tongs when moving hot objects.
* Check glassware, such as beakers, for cracks and chips prior to use.
* Report all accidents—no matter how big or small—to your teacher.
* Keep your work area clear of all materials except those needed for the experiment.

# Procedure

1. **Gather Materials**

|  |  |  |
| --- | --- | --- |
| * 250 mL beaker * 250 mL Erlenmeyer flask * Wash bottle * Distilled water | * Filter paper * Funnel * Stirring rod * Watch glass * Spatula | * Electronic balance * Weighing paper * Copper(II) chloride (CuCl2): 2.50 g (Trial 1) and 2.50 g (Trial 2) * Aluminum foil (Al): 0.50 g (Trial 1) and 0.25 g (Trial 2) |

**Note:** Each time you measure mass, be sure to use a weighing pan or paper; do not put material directly on the balance. Also, be sure to tare the balance when the weighing paper is on it.

1. **Prepare Aqueous Copper(II) Chloride (Trial 1)**
   1. Using a spatula and a balance, measure 2.50 g copper(II) chloride (CuCl2). You may need   
      to add and subtract to get exactly 2.50 g.
   2. Put it into a 250 mL beaker.
   3. Measure 50 mL distilled water in the beaker.
   4. Stir the solution gently with the stirring rod to dissolve the copper(II) chloride.
2. **React Copper(II) Chloride with Aluminum (Trial 1)**
   1. Measure exactly 0.50 g aluminum foil (Al). (**Tip:** Do not crumple up the foil; otherwise, it   
      will take longer to react. Instead, break the foil into little pieces.)
   2. Place the aluminum foil in the beaker of aqueous copper chloride.
   3. Stir with the stirring rod to aid the reaction. (This may take a little time.)
   4. As the reaction proceeds, record color changes and other observations, including evidence that the reaction ended.
3. **Determine the Limiting Reactant (Trial 1)**
   1. Convert the masses of the reactants to moles and record them in the data table.
   2. Determine the limiting reactant. Give reasons based on both observation and computation.
4. **Prepare Aqueous Copper(II) Chloride (Trial 2)** (Repeat Step 2 exactly.)
5. **React Copper(II) Chloride with Aluminum (Trial 1)** (Repeat Step 3 using 0.25 g aluminum (Al) instead of 0.50 g.)
6. **Determine the Limiting Reactant (Trial 2)**
   1. Convert the masses of the reactants to moles and record them in the data table.
   2. Determine the limiting reactant. Give reasons based on both observation and computation.
7. **Set Up the Filter System**
   1. Use a pencil to mark a piece of filter paper with your name*.*
   2. Find the mass of the filter paper to the nearest hundredth of a gram. Record it in the   
      data table.
   3. Put the filter paper in a funnel, then place the funnel in the mouth of a 250 mL   
      Erlenmeyer flask so that liquid can drain into the flask.
8. **Recover the Solid Product, Copper**
   1. Pour the contents of the beaker into the filtering setup.
   2. Use distilled water from a wash bottle to further rinse the sample, allowing the liquid to drain to the flask while retaining the copper in the filter.
   3. Dry the copper on a watch glass overnight.
   4. Find the mass of the filter paper and its contents.
9. **Complete Calculations to Fill in the Remainder of the Data Table**
   1. Subtract the mass of the filter paper from the mass of the paper and copper. Record the difference in the data table as the amount of copper.
   2. Convert mass to moles for all three masses you measured. Remember, you can do so   
      by using a proportion, using stoichiometry, or dividing the mass by the molar mass.
   3. Determine the theoretical yield of copper based on the number of moles of the limiting reactant, aluminum.
   4. Determine the percent yield of copper by dividing the actual yield (in moles) by the theoretical yield (in moles).
10. **Dispose of All Materials in Bulk Containers Provided by Your Teacher**

# Data (Trial 1)

**Observations during Reaction:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **3CuCl2(aq) + 2Al(s) → 3Cu(s) +2AlCl3(aq)** | | | |
| **Measured Mass (g)** |  |  | N/A | N/A |
| **Molar Mass** | 134.45 | 26.98 | N/A | N/A |
| **Actual Moles (mol)** |  |  | N/A | N/A |

**Analysis:** The limiting reactant is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because . . .

# Data (Trial 2)

**Observations during Reaction:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **3CuCl2(aq) + 2Al(s) → 3Cu(s) +2AlCl3(aq)** | | | |
| **Measured Mass (g)** |  |  | Filter paper alone  Filter paper + Cu  Cu alone | N/A |
| **Molar Mass** | 134.45 | 26.98 | 63.55 | N/A |
| **Actual Moles (mol)** |  |  |  | N/A |

**Analysis:** The limiting reactant is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because . . .

Theoretical yield of copper based on the limiting reactant; (insert the answer from above)

\_\_\_\_\_\_\_\_: \_\_\_\_\_\_\_\_ moles = \_\_\_\_\_\_\_\_\_\_ g

Percent yield: \_\_\_\_\_\_\_\_%