

Limiting Reactant and Percent Yield Lab

Objectives:

- Learn to determine the limiting reagent of a reaction.
- Learn how to calculate theoretical, actual, and percent yield of a reaction.

Background:

During a chemical reaction when two substances react, often times one reactant will be consumed before the other. The substance that is consumed first is called the limiting reactant. This is the substance that controls or limits the amount of products formed.

Think about it in terms of making grilled cheese. If to make one grilled cheese it takes two pieces of bread and one piece of cheese and you have four pieces of bread and one piece of cheese how many sandwiches can you make? The answer is one and therefore the cheese would be considered the limiting reactant. The two other slices of bread would be left unused and considered the excess reactant.

The limiting reactant for a specific reaction can be determined by calculating the amount of product that each reactant can produce. The reactant that forms the **least** amount of product will be the limiting reactant. The amount of product formed by the limiting reactant is the theoretical yield of the reaction.

The theoretical yield of a chemical reaction is the maximum amount of product that can be formed if the reaction proceeds perfectly. However, not all reactions proceed perfectly. Sometimes not all of the limiting reactant is used up or some of the product can be lost during collection. The amount recovered from the reaction is known as the actual yield. The ratio of the actual yield to the theoretical yield is known as the percent yield and can be calculated using the formula below.

$$\text{Percent yield} = (\text{actual yield}/\text{theoretical yield}) \times 100$$

Pre-lab Questions:

1. Write the balanced reaction of Al with CuCl_2 .
2. What is the limiting reactant if 0.5 g Al is reacted with 3.5 g CuCl_2 ? Take into account CuCl_2 is a dihydrate when calculating the molecular weight.

3. What is the theoretical yield of copper produced by this reaction?

Materials:

- Copper (II) chloride
- Aluminum foil
- Stirring rod
- Two 100 mL beakers
- Graduated cylinder
- Safety glasses
- Spatula or scoopula
- Balance
- Filter paper
- Funnel
- Watch glass
- Ring stand
- Iron ring

Safety:

- ❖ Safety glasses must be worn at all times!
- ❖ Copper (II) chloride is an irritant and moderately toxic. Avoid inhaling the powder and ingestion.
- ❖ Wash hands thoroughly after completing the lab.
- ❖ The reaction is exothermic and produces a lot of heat. Follow procedure carefully.
- ❖ **DO NOT** look into the beaker directly. Observe the reaction from the side.

Procedure:

1. Weigh approximately 3.5 g of CuCl_2 and place them in the 100 mL beaker. Record the exact mass in the data table below. Note the appearance of the CuCl_2 crystals in the observation section.
2. Add 50 mL of distilled water to the beaker containing the CuCl_2 crystals. Stir the solution until all of the CuCl_2 crystals have dissolved. Record any observations in the observation section.
3. Weigh out approximately 0.2 g of aluminum foil. Record the exact mass in the data table.
4. Loosely crumple the piece of aluminum foil into a ball. Carefully place it into the CuCl_2 solution. Stir the reaction occasionally. Record your observations of the resulting reaction.
5. Set up a ring stand with an iron ring securely attached to it. Place a funnel in the iron ring.
6. Obtain a piece of filter paper and determine its mass. Record the mass in the data table.

7. Fold a piece of filter paper in half and then in half again. Pull one side out and place it in the funnel.
8. Pour the reaction mixture into the funnel to separate the solid from the liquid. Make sure all of the solid is collected in the filter paper. Use a distilled water bottle to rinse the solid from the reaction beaker if necessary.
9. Pour the liquid collected into the waste beaker.
10. Allow the filter paper to dry until the next laboratory period.
11. Obtain the mass of the filter paper and solid. Record the mass in the data table below.
12. Place the solid in the solid waste beaker and throw out the filter paper.

Data Table:

Mass of CuCl_2 (g)	
Mass of aluminum foil (g)	
Mass of filter paper (g)	
Mass of filter paper and solid product (g)	

Observations:

CuCl_2 crystals	
CuCl_2 solution	
Chemical reaction between aluminum foil and CuCl_2	

Solution after reaction is complete	
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Results/Discussion Questions:

1. Calculate the amount of copper obtained by the reaction. Was it the amount you expected? Explain.
2. What was the color of the solution after the reaction was complete? What does this tell you about the reactants?
3. Determine the percent yield of copper.