Observing a Limiting Reactant

When two substances react, they react in exact amounts. You can determine what amounts of the two reactants are needed to react completely with each other by means of mole ratios based on the balanced chemical equation for the reaction. In the laboratory, precise amounts of the reactants are rarely used in a reaction. Usually, there is an excess of one of the reactants. As soon as the other reactant is used up, the reaction stops. The reactant that is used up is called the *limiting reactant.* Based on the quantities of each reactant and the balanced chemical equation, you can predict which substance in a reaction is the limiting reactant.

Problem

How can the mole concept be used to predict the limiting reactant in a chemical reaction?

Objectives

- **Calculate** the number of moles of each reactant.
- **Write** a balanced chemical equation for the reaction of hydrochloric acid and magnesium.
- **Predict,** using the balanced chemical equation, which substance will be the limiting reactant.
- **Compare** the actual results with your predicted results.

Materials

dropper bottle containing 6*M* HCl

magnesium ribbon (2 pieces, 3–5 cm each)

test-tube rack

20 × 150-mm test tube

test-tube holder

Safety Precautions

- **Always wear safety goggles, a lab apron, and gloves.**
- **Point open end of test tube away from your face and away from others.**
- **Do not inhale released vapors.**
- **Handle acids carefully.**
- **Do not use open flames in the lab. Hydrogen gas is flammable.**

Pre-Lab

1. Magnesium and hydrochloric acid react to form magnesium chloride and hydrogen gas. Write the balanced chemical reaction for the reaction.
2. Calculate
   a. the number of moles of magnesium in 5.0 g of magnesium.
   b. the number of moles of hydrochloric acid in 10 mL of 6.0M HCl; 6.0M HCl contains 6 moles of HCl per liter of solution.
3. Based on the chemical equation and your calculations, what would be left over if these amounts of magnesium and hydrochloric acid were combined? What would be used up?
4. Describe the term *limiting reactant* in your own words.
5. Read the entire laboratory activity. Form a hypothesis about which reactant will be the limiting reactant at steps 5, 6, and 7 in the experiment. Record your hypothesis on page 90.

Procedure

1. Obtain two pieces of magnesium ribbon that are 3–5 cm long.
2. Determine and record the mass of the first piece of magnesium. Set the second piece aside to use in step 8.
3. In the data table, record your observations of the color, length, and texture of your piece of magnesium.
4. Bend the piece of magnesium several times and put it into the test tube.
5. Place the test tube containing the magnesium in a test-tube rack and add ten drops of 6M HCl. Record in **Data Table 1** any observations during and immediately following the reaction. **CAUTION: Do not inhale vapors or look down into test tube. Observe the reaction from the side of the test tube.**
6. After the reaction has stopped, add another ten drops of 6M HCl to the test tube. Record any observations during and immediately following the reaction.
7. Now begin adding 6M HCl one drop of at a time, watching the reaction and recording observations after each drop has stopped reacting. Stop adding drops of hydrochloric acid when all of the magnesium ribbon in the test tube has reacted.
8. Place the second piece of magnesium ribbon into the test tube and record your observations.

Hypothesis

Cleanup and Disposal

1. Dispose of the waste material in a waste container in the fume hood as instructed by your teacher. **CAUTION: Use a test-tube holder to move the test tube.**
2. Clean up your lab area and wash your hands before leaving the lab.

Data and Observations

Mass of Mg (g)_____

Data Table 1	
Substance(s)	**Observations**
Mg	
Mg + 10 drops HCl	
Mg + 20 drops HCl	
Mg + 30 drops HCl (if needed)	
Mg + 40 drops HCl (if needed)	
Mg + 45 drops HCl (if needed)	
Mg + 50 drops HCl (if needed)	
Mg + 55 drops HCl (if needed)	
HCl + second piece of magnesium	

Analyze and Conclude

1. **Observing and Inferring** What was the total number of drops of HCl needed to react with all of the magnesium?

2. **Observing and Inferring** Explain what happened when the second piece of magnesium was added to the test tube. Did it react? Why or why not?

3. **Collecting and Interpreting Data** Based on your observations, describe which substance was the limiting reactant at the end of step 5, step 6, and step 7. How were you able to determine this?

4. **Measuring and Using Numbers** What volume of *6M* HCl would be necessary to completely react with the first strip of magnesium?

5. **Thinking Critically** What steps would need to be added to this lab to accurately determine the stoichiometric ratio of Mg to HCl at each step in this lab?

6. **Error Analysis** Compare your data with that of your classmates. Did others use more drops or fewer drops of HCl while using a similar size piece of magnesium? What could be the sources of error?

Real-World Chemistry

1. Why is it important for a chemical manufacturer to be able to determine which reactant is the limiting reactant?
2. How would the idea of limiting reactants be used when discussing automobiles?