OBJECTIVES
Students will:
- investigate the relationship between reactants and products.
- demonstrate that the consumption of reactants results in the production of products.
- manipulate the amount of reactants and observe the effect on the amounts of products produced.
- demonstrate the Law of Conservation of Matter.

Lesson One: Chemical Reaction of Hydrochloric Acid and Mossy Zinc Metal

Materials Per Lab Group
- 1 triple beam balance
- 1 500 mL Erlenmeyer flask
- 1 scoopula
- 1 large 9” balloon
- 1 weigh dish
- 1 100 mL graduated cylinder
- 20 g of mossy Zinc metal in a beaker
- 250 mL of 3M hydrochloric acid (HCl)
- 1 400 mL beaker
- 1 metric ruler
- 1 50 cm piece of string
- 1 calculator
- 1 stop watch
- 1 pair of goggles per student
- 1 apron per student

Background
Chemical reactions usually have two or more chemicals called reactants that are different from one another. The reactants interact during the chemical reaction to form one or more products. These are substances that are different from the reactants and from each other. The reactants and products in a chemical reaction can be written as chemical formulas using letters to represent elements.
Background (continued)
A chemical equation represents the changes that take place in a chemical reaction. The chemical formulas of the reactants are written on the left; an arrow indicates a change to a new substance; and the chemical formulas of the products are written on the right.

In a chemical reaction, the chemical bonds that hold the atoms of the reactants together are broken and reformed in a different arrangement to form the products. Breaking and reforming these bonds occurs when the reactants react with each other. The different arrangement of atoms can be seen by the different formulas that represent the reactants and products. An indication that a chemical reaction has taken place can be one or more of the following: color change, solid formation, an energy change (the reaction gives off heat or absorbs heat) and/or gas formation.

When all of the reactants are consumed in a chemical reaction, they no longer exist in their original form. All the atoms originally found in the reactants can now be found in the products. The observation that all the matter of the reactants is converted into the matter of the products is referred to as the Law of Conservation of Matter.

Sometimes two reactants are not present in equivalent or equal amounts. More of one reactant is present compared to the other. The reactant present in the lesser amount is completely consumed or used up in such a chemical reaction. Since none of this reactant remains, the chemical reaction must stop. When the reaction stops, only a portion of the other reactant has been consumed, meaning that some is still unreacted.

In this Investigation, the following chemical reaction will take place.

\[
\text{Zn} + 2 \text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2
\]

**EXPERIMENT**

1. Six trials will be performed in this investigation. The first 5 trials will use the same amount of mossy zinc metal (Zn) but a different volume of hydrochloric acid (HCl). The last trial will use a different amount of Zn. In all trials, the amount of one of the products, hydrogen gas, will be determined. Use Table A as a guide for the volume of hydrochloric acid and the mass of mossy zinc needed for each trial.

2. Each lab group will perform 2 of the trials as assigned by the teacher.

3. Trials assigned: Trial ________ & Trial ________
Table A: Amount of Hydrochloric Acid and Mossy Zinc Needed for Trials

<table>
<thead>
<tr>
<th>Trial</th>
<th>Volume of HCl (mL)</th>
<th>Mass of Zn (g)</th>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>5</td>
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<tr>
<td>2</td>
<td>15</td>
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<td>3</td>
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<td>6</td>
<td>100</td>
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1. In this investigation, you will observe the reaction of hydrochloric acid (HCl) with mossy zinc.

2. Using the graduated cylinder, measure the amount of HCl needed for the trial and add it to the Erlenmeyer flask.

3. Use the triple beam balance, lab scoop and weigh dish to obtain the amount of mossy zinc needed. Refer to the procedure for *Using a Weigh Dish to Obtain a Sample.*

   Mass of weigh dish
   Mass of weigh dish and mossy zinc

4. Blow up the balloon to stretch it and then deflate it. Use the lab scoop to add the mossy zinc to the balloon. The same person should handle the balloon throughout the investigation.

5. During this step, do not allow any mossy zinc metal to fall into the flask. Stretch the open end of the balloon over the mouth of the Erlenmeyer flask until it securely covers the mouth of the flask.

6. Use the triple beam balance to determine the total mass of the flask, hydrochloric acid (HCl), balloon and the mossy zinc. Record the mass in Table B in the row labeled “Before Reaction.”

7. Making sure that the balloon does not come off the mouth of the flask, hold the balloon and shake the mossy zinc out of the balloon until all of it has fallen to the bottom of the flask into the hydrochloric acid (HCl).

8. Gently swirl the flask, so the mossy zinc stays in contact with the hydrochloric acid. After approximately 5 minutes, or when bubbling stops. The production of the product, hydrogen gas (H₂), will have stopped. *Do not remove the balloon.*
9. Using the triple beam balance, determine the total mass of the flask, hydrochloric acid (HCl), Balloon,” and any remaining mossy zinc metal. Record the mass in Table B in the row labeled “After Reaction.” After all the groups are done, the data will be shared and should be recorded in your data table.

10. Question: Did any mossy zinc remain after the reaction ended? Record your answer in Table B.

| Trial | Before Reaction | After Reaction | Any Remaining Zinc?
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</tbody>
</table>

a. Question: Does the data in Table B support the Law of Conservation of Matter? Why?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

b. Question: What was the product of the reaction that caused the balloon to expand? (Hint: look at the chemical equation in the Background)
________________________________________________________________________

C. Question: Look in the bottom of the flask. Describe any additional product that was produced.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

D. Question: How do you know that a chemical reaction occurred?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

11. To find out how much hydrogen gas (H\textsubscript{2}) was produced, use the string to measure the circumference of the balloon. Use a metric ruler to measure the length of the string in centimeters. The circumference is the distance around the balloon. Record the circumference in Table C for the appropriate trial.
12. Since the balloon is a sphere, the circumference can be used to determine the diameter of the balloon. Calculate the diameter using the following formula,

\[
d = \frac{C}{\pi}
\]

13. **Record:** Enter the diameter of the balloon in Table C in the row for the appropriate trial.

14. Carefully remove the balloon from the flask. Save the balloon for the next trial. Discard the contents of the flask in the 400 mL waste beaker and rinse the flask with water.

15. Repeat steps 2-12 for the next trial.

| Table C: The Effect of Reactant Amounts on Hydrogen Gas Produced |
|---|---|---|---|---|
| Trial | Volume of HCl (mL) | Mass of Zn (g) | Circumference of Balloon (cm) | Diameter of Balloon (cm) | Volume of Balloon (mL) |
| 1 | 2 | 5 | | | |
| 2 | 15 | 5 | | | |
| 3 | 50 | 5 | | | |
| 4 | 75 | 5 | | | |
| 5 | 100 | 5 | | | |
| 6 | 100 | 7 | | | |

**Analysis**

1. Before the data can be analyzed, the amount of hydrogen gas that was produced as a product must be determined for each reaction. This can be done by calculating the volume of the inflated balloon for each reaction.

a. Since the balloon is a sphere, the formula for the volume of a sphere can be used. In the following equations:

\[
\pi = 3.14
\]

\[r = \text{the radius of a sphere in centimeters}\]

\[\text{The volume of a sphere} = \frac{4 \cdot \pi \cdot r^3}{3}\]

b. Enter the calculated volumes in the last column of Table C.
2. **Graph:** Use the axes below to draw a graph that compares the volume of hydrogen gas (H$_2$) that is produced to the volume of hydrochloric acid (HCl) used. Use the data from Table C to draw the graph.

   a. Decide what the independent variable is in the experiment.
   b. Decide what the dependent variable is in the experiment.

**STOP AND DISCUSS**
3. Analyze the graph in the range of hydrochloric acid volumes between 2 and 50 mL. In this range of hydrochloric acid volume, do you think that the hydrochloric acid or the mossy zinc is greater in amount? Why? (Hint: Remember that you looked into the flask after Trials 1-3 were complete to observe if any mossy zinc remained.)

______________________________________________________________________________

______________________________________________________________________________

4. Analyze the graph in the range of hydrochloric acid (HCl) volumes between 50 and 100 mL. In this range of hydrochloric acid volume, do you think that the hydrochloric acid or the mossy zinc is greater in amount? Why? (Hint: Remember that you looked into the flask after Trials 3-5 were complete to observe if any mossy zinc remained.)

______________________________________________________________________________

______________________________________________________________________________

STOP AND DISCUSS

LEARNING REVIEW

List three things you learned about reactants, products, chemical reactions and the Law of Conservation of Matter from this investigation.

a. _________________________________________________________________________
   _________________________________________________________________________
   _________________________________________________________________________

b. _________________________________________________________________________
   _________________________________________________________________________
   _________________________________________________________________________

  c. _________________________________________________________________________
   _________________________________________________________________________

STOP AND DISCUSS
1. If one of the reactants is completely consumed but some of the second reactant remains unreacted, which reactant limits the amount of products that can be produced? Why?

______________________________________________________________________________
______________________________________________________________________________

2. Analyze the graph for the two data points for the reactions of 5g of mossy zinc and 7g of mossy zinc metal with 100mL of hydrochloric acid. Compare the volume of hydrogen produced by the reactions of 5g and 7g of mossy zinc with 100mL of hydrochloric acid. Which reaction produced a greater volume of hydrogen \( \text{H}_2 \)?

______________________________________________________________________________

3. Why did one reaction produce more hydrogen \( \text{H}_2 \) gas than the other?

______________________________________________________________________________

4. Written below is the chemical reaction that you have been studying. Circle the two products you have observed.

\[
\begin{array}{cccccc}
\text{Zn} & + & 2 \text{ HCl} & \rightarrow & \text{ZnCl}_2 & + \text{ H}_2 \\
\text{Zinc} & \text{Metal} & \text{Hydrochloric} & \text{Acid} & \text{Zinc} & \text{Hydrogen} \\
& & & & \text{Chloride} & \text{gas}
\end{array}
\]

5. How does the Law of Conservation of Matter relate to chemical reactions?

______________________________________________________________________________