National Aeronautics and Space Administration

Conservation of Mass

Educator Notes Learning Objectives

- Develop models to demonstrate the chemical composition of molecules.
- Analyze the properties of substances before and after a chemical reaction.
- Explain how atoms within molecules are rearranged to form different substances following a chemical reaction.
- Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
- Determine the differences between an open and closed system.

Safety

- Wear splash-resistant safety goggles to protect eyes when handling chemicals.
- Use caution handling the balloon as the reaction is proceeding. Excess production of gas due to student error in measuring reactants could cause the balloon to rupture.
- Review safety procedures concerning glassware and watch the Lab Safety-STEMonstration.

Background Information

For this STEMonstration, students explore open and closed systems. In physics or chemistry, a system is defined as collection of objects (or smaller systems). The surrounding is everything else that is not in the system. For example, if the system being studied is a motorcycle, the surrounding would be everything else that is not the motorcycle, such as the street and the grass. Systems can be described in three different ways: isolated, closed, or open. An open system is a system where matter and energy are being exchanged with the surroundings. An open pan of boiling water is an example of an open system. A closed system is where only energy is being exchanged with the surroundings. A lid-covered pan of boiling water is an example. During this investigation, students will conduct an experiment to explore the ideas of closed vs open systems, learn about the exchange of energy, and discover how these concepts relate to the International Space Station, the Earth, and the entire universe. Students will also explore the concept of conservation of mass within a system, open or closed. They will practice balancing chemical equations and perform an experiment that will illustrate the concept of mass conservation, as well!

Investigation Details

Inquiry Discussion

- Divide students into groups of 3-5, depending on material availability.
- Distribute a Conservation of Mass Student Worksheet to each student.
- Engage students in a discussion using the questions in the Inquiry Discussion section of their worksheets.

Grades 6 to 8 Suggested Pacing

70 minutes

- Inquiry Discussion - 15 minutes
- Facilitating the Conservation of Mass Investigation - 30 minutes
- Post-lab Discussion - 15 minutes
- STEMonstrations Video - 10 minutes

Materials

This list of materials supports one group of students.

- ☐ Splash-resistant safety goggles (one per student)
- ☐ Spoon
- ☐ Metric scale (a kitchen scale works well)
- ☐ Balloon
- ☐ Funnel
- ☐ 250 mL Erlenmeyer flask or another narrow-mouthed container
- ☐ Graduated cylinder
- ☐ Vinegar
- ☐ Baking soda
- ☐ A color copy of the Conservation of Mass Student Worksheet (one per student)

National STEM Standards

- MS-PS1-1
- MS-PS1-2
- MS-PS1-5

Preparing to Facilitate the Conservation of Mass Investigation

- Set up each group station with a metric scale, Erlenmeyer flask, funnel, spoon, and balloon.
- Place the baking soda and vinegar in a central location where students have access, and where you can monitor their handling of these chemicals. Provide a separate spoon for scooping baking soda, and a graduated cylinder for measuring vinegar.
- Review the Counting Atoms section of the Conservation of Mass Student Worksheet. Students follow along, complete the examples, and receive assistance as needed.
- Instruct students to answer the Pre-Lab Questions on their Conservation of Mass Student Worksheet prior to beginning the investigation.
- Explain to students that the balloon, Erlenmeyer flask, and their contents comprise the system we are examining in the lab investigation.
- Direct students to follow the instructions as indicated under the Investigation Protocol section on their Conservation of Mass Student Worksheet to complete the lab investigation. Students record their data and answer the questions as they follow along with the lab investigation.
    - Students measure the mass of the system before the chemical reaction by placing the Erlenmeyer flask (containing vinegar) and attached balloon (containing baking soda) on the scale. Students record the mass of this system once again following the chemical reaction. Instruct students to record these measurements on their worksheet where indicated.
    - Students draw models describing the substances before proceeding with the reaction.

Post-Lab Discussion

- Ask a few student groups to share their results with the class.
- Engage in a discussion about the chemical reaction and the chemical structures of the compounds involved in the reaction.
- Instruct students to count atoms and balance the chemical equation.
- Following the class discussion, students read and respond to Post-Lab Questions on their worksheet.
- This experiment is not a perfectly closed system. Guide students toward identifying how human error plays a role in unexpected results. Refer to chemical formulas and the chemical equation to provide evidence for the Law of Conservation of Mass.

Watch STEMonstration Video

- Watch the Conservation of Mass STEMonstration video: (https://www.nasa.gov/stemonstrations)
- Discuss with your students the difference between an open and closed system.
- Pose the following questions to your class, and have students explain their answers. Discuss these questions as a class:
    - Is the International Space Station an open or closed system? Closed, because only energy is being exchanged.
    - Is the Solar System an open or closed system? Open, because both matter and energy are being exchanged.
    - Is Earth an open or closed system? Closed, because only energy is being exchanged.

Extensions

- Students visit the following website to learn more about ocean acidification: (https://climatekids.nasa.gov/acid-ocean/#:~:text=The%20Short%20Answer%3A,the%20coast%20of%20New%20Zealand.)
- Discuss other chemical reactions, such as a cake baking or a car rusting, encountered in everyday life, and consider how the number of reactants affects the chemical changes.

Conservation of Mass Student Worksheet

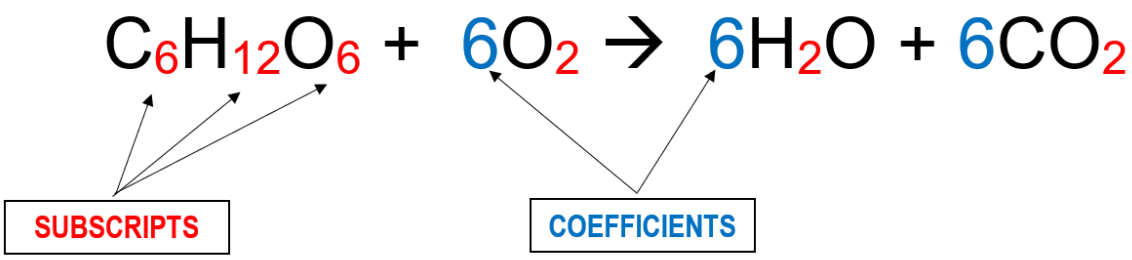
Counting Atoms

Counting Atoms: **Subscripts** (like the numbers in red below) are used to describe how many atoms of each element are present in the molecule. Look at the following examples for clarification. Note that if no subscript is present, it is assumed to be '1.'

Examples:

CO_2	H_2SO_4	NaOH
C: 1	H: 2	Na: 1
O: 2	S: 1	O: 1
	O: 4	H: 1

Counting Atoms in the Balanced Chemical Equation for Respiration



Sometimes more than one molecule is involved in a chemical reaction. While **subscripts** describe the number of atoms present in a molecule, **coefficients** describe how many molecules are present in a chemical reaction. **Subscripts** are numbers that come after the molecule (in **red**) and **coefficients** are the numbers that come before the molecule (in **blue**). Look at the following examples to better understand how coefficients affect the way atoms are counted in a chemical reaction:

Examples:

$5CO_2$	$3H_2SO_4$	$4NaOH$
C: 1x5= 5	H: 2x3= 6	Na: 1x4= 4
O: 2x5= 10	S: 1x3= 3	O: 1x4= 4
	O: 4x3= 12	H: 1x4= 4

Try these! List the elements present in each molecule. Indicate the number of atoms for each element. Circle the coefficients.

H_2O	$C_6H_{12}O_6$	NO_2
$2LiOH$	$5MgCl_2$	$3Fe_2O_3$

Inquiry Discussion

1. What do you already know about the differences between an open and a closed system?

2. Draw a model including symbols and labels to explain your thinking for the question above.

Conservation of Mass Investigation

Pre-Lab Questions:

Use your prior knowledge to respond to the prompts below.

1. List examples of what you might see when observing a chemical reaction.

2. What is the difference between a reactant and a product in a chemical reaction?

3. What is the difference between a closed system and an open system?

Investigation Protocol:

Materials

- 1 pair of splash-resistant goggles per student
- 15g baking soda
- 250mL Erlenmeyer Flask
- 55mL vinegar
- 1 funnel
- 1 digital scale
- 1 balloon

Procedure

1. Obtain 15g of baking soda ($NaHCO_3$) using a digital scale. (Make sure you zero it out first!)
2. Using a funnel, pour the baking soda inside a deflated balloon.
3. Measure 55mL of vinegar (CH_3COOH) and pour it into the Erlenmeyer flask.
4. Carefully secure the mouth of the balloon over the top of the Erlenmeyer flask without dropping the baking soda into the flask. You do not want the reaction to take place just yet.
5. Carefully place the entire system on the digital scale. This needs to be done without dropping the baking soda into the Erlenmeyer flask. You do not want the reaction to take place just yet.
6. Record, in the space provided on your worksheet, the mass of the entire system.
7. Start the chemical reaction by carefully lifting the balloon up to allow all the baking soda to fall into the vinegar.
8. Record, in the space provided on your worksheet, your observations.
9. Once the reaction is complete, measure and record the final mass of the entire system.

Data Collection:

In the data table below, draw a picture for each phase of the chemical reaction experiment and include written observations describing what happened during each phase.

Before the reaction	During the reaction	After the reaction
Model:	Model:	Model:
Written Observations:	Written Observations:	Written Observations

Mass of the system before the chemical reaction: _____

Mass of the system after the chemical reaction: _____

Post-Lab Questions:

Respond to these items based on your observations and data collected.

1. What types of matter were used to generate this chemical reaction?

2. Describe the types of matter formed in this chemical reaction.

3. How do you know a chemical reaction occurred? What evidence indicated a chemical change?

4. How did the mass of the system change throughout the reaction? Explain the reasoning behind your answer.

5. What are the products involved in this chemical reaction?

6. What are the reactants involved in this chemical reaction?

7. Write the balanced equation for this chemical reaction. Circle the reactants and draw a rectangle around the products.

8. How does this lab demonstrate the Law of Conservation of Mass?

Conservation of Mass ANSWER KEY

Counting Atoms

Counting Atoms: **Subscripts** (like the numbers in red below) are used to describe how many atoms of each element are present in the molecule. Look at the following examples for clarification. Note that if no subscript is present, it is assumed to be '1.'

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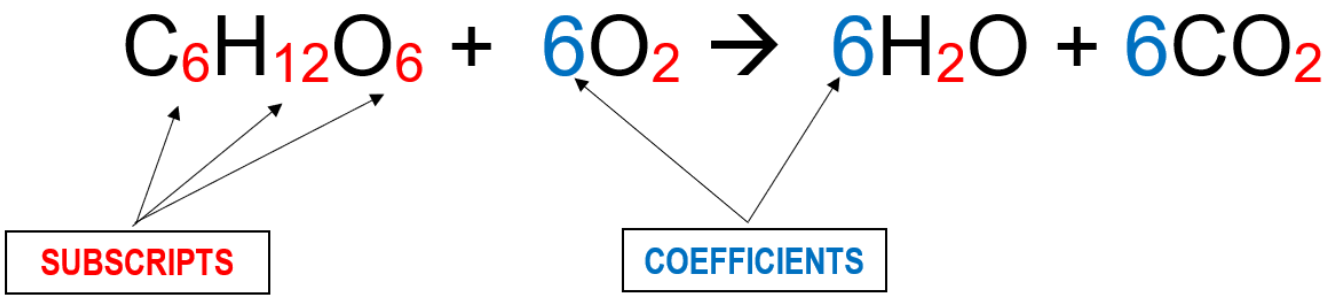

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$5CO_2$	$3H_2SO_4$	$4NaOH$
C: 1x5= 5	H: 2x3= 6	Na: 1x4= 4
O: 2x5= 10	S: 1x3= 3	O: 1x4= 4
	O: 4x3= 12	H: 1x4= 4

Try These! List the elements present in each molecule. Indicate the number of atoms for each element. Circle the coefficients.

H_2O:

H: 1x2= 2

O: 1x1= 1

$C_6H_{12}O_6$:

C: 6x1= 6

H: 12x1= 12

O: 6x1= 6

NO_2:

N: 1x1= 1

O: 2x1= 2

2LiOH:

Li: 1x2= 2

O: 1x2= 2

H: 1x2= 2

$5MgCl_2$:

Mg: 1x5= 5

Cl: 2x5= 10

$3Fe_2O_3$:

Fe: 2x3= 6

O: 3x3= 9

Inquiry Discussion

1. What do you already know about the differences between an open and a closed system?

   Answers will vary.

2. Draw a model including symbols and labels to explain your thinking for the question above.

   Answers will vary

Conservation of Mass Investigation

Pre-Lab Questions:

1. List examples of what you might see when observing a chemical reaction.

Answers will vary but could include examples such as: color change, temperature change, or formation of a gas.

2. What is the difference between a reactant and a product in a chemical reaction?

The substances that go into a chemical reaction are called the reactants, and the products are the substances that are produced after the reaction.

3. What is the difference between a closed system and an open system?

A closed system only exchanges energy and an open systems exchange both energy and matter.

Post-Lab Questions:

1. What types of matter were used to generate this chemical reaction?
Vinegar and baking soda

2. Describe the types of matter formed in this chemical reaction.

Bubbles of carbon dioxide gas

3. How do you know a chemical reaction occurred? What evidence indicated a chemical change?
There was a formation of gas.

4. How did the mass of the system change throughout the reaction? Explain your reasoning behind this change.

There was no change in mass.

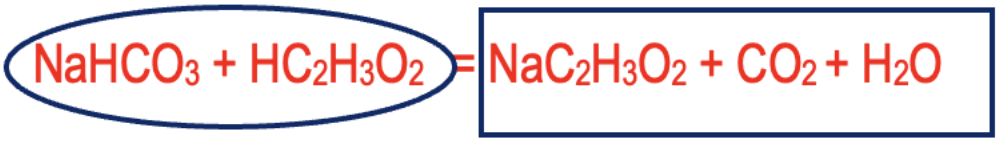
5. What are the products involved in this chemical reaction?

Carbon dioxide gas

6. What are the reactants involved in this chemical reaction?

Vinegar and baking soda

7. Write the balanced equation for this chemical reaction. Circle the reactants and draw a rectangle around the products.



8. How does this lab demonstrate the Law of Conservation of Mass?

There is no loss of matter. The equation balances on both sides of the equation.