

LESSON 25

Mass and Chemical Reactions



In this lesson, you will study what happens to the mass of reactants and products in this chemical reaction.

INTRODUCTION

In this lesson, you will continue to investigate what happens to the mass of matter when it undergoes change. What rules apply to phase change and to dissolving? Can the same rules be applied to chemical reactions? For example, what do you think happens to the mass of a candle when it is burned? What happens to the mass of a nail when it rusts? What do you think happens to the total mass of matter in a chemical reaction when one of the products is a gas (for example, when you reacted magnesium with acid)? Is the mass of the reactants of these chemical reactions the same as the mass of the products? In Inquiry 25.1, you will investigate mass changes in a chemical reaction. You will measure mass before and after adding half an effervescent tablet to a beaker of water. You will then perform the same experiment inside a sealed bottle. You will be asked to interpret any changes in mass that take place in both experiments and to decide whether the law of conservation of mass can be applied to chemical reactions.

OBJECTIVES FOR THIS LESSON

Conduct an inquiry to compare the mass of the reactants and the mass of the products in the chemical reaction that takes place when an effervescent tablet is added to water in both open and closed containers.

Determine whether the law of conservation of mass can be applied to chemical reactions.

Getting Started

- 1.** Your teacher will conduct a review of Lessons 8 and 14, which discussed the conservation of mass during phase change and dissolving. After the review, write in your science notebook your own definition of the law of conservation of mass.
- 2.** Discuss with your partner whether the law of conservation of mass can be applied to chemical reactions. Think about a chemical reaction you have observed. The following are some questions you should consider during your discussion:
 - A. What were the reactants and the products of the reaction?*
 - B. Were they all the same phase of matter? Do you think this affects the mass of the matter?*
 - C. You observed a burning candle in Lesson 1. What do you think happened to the mass of matter in that chemical reaction?*
- 3.** Your teacher will ask you about some of your ideas. While you are doing Inquiry 25.1, think about the points raised during this discussion and how your ideas change in response to the experimental evidence.

MATERIALS FOR LESSON 25

For you

- 1 copy of Student Sheet 25.1: Measuring Mass in a Chemical Reaction
- 1 copy of Student Sheet 25: Review for Compounds, Elements, and Chemical Reactions
- 1 pair of safety goggles

For you and your lab partner

- 1 250-mL beaker
- 1 effervescent tablet
- 1 paper towel
- 1 clear plastic soda bottle with a screw cap
- Access to an electronic balance
- Access to water

Inquiry 25.1

Measuring the Mass of Reactants and Products

SAFETY TIP

Wear your safety goggles throughout the inquiry.

PROCEDURE

1. One member of your group should collect a plastic box of materials. In this lesson, you will work with your lab partner. Each plastic box contains the materials for two pairs of students. Make sure your pair has the apparatus listed in the materials list.
2. Pour about 50 mL of water into the beaker. If you get the outside of the beaker wet, dry it using a paper towel.
3. Break the tablet in half. Shake or blow off any loose grains of tablet.
4. Go to the balance. Make sure the pan of the balance is dry. If not, gently wipe it dry with a paper towel. Check that the balance reads 0.0 g.
5. Place a half of the tablet next to the beaker of water *on* the balance (see Figure 25.1). Record their total mass in column 2 of Table 1 on Student Sheet 25.1.
6. Remove the beaker and tablet from the pan. Return to your place with the beaker and the tablet. Carefully place the tablet in the beaker, *without splashing or getting your fingers wet*. Observe what happens (think back to Inquiry 1.8). Record your observations in column 5 of Table 1.
7. Wait until you can see no further reaction taking place in the beaker (about 2–3 minutes).
8. Return to the balance and measure the mass of the beaker and its contents. Record the mass in column 3 on Table 1. Then calculate any change in mass and record it in the appropriate place in column 4.

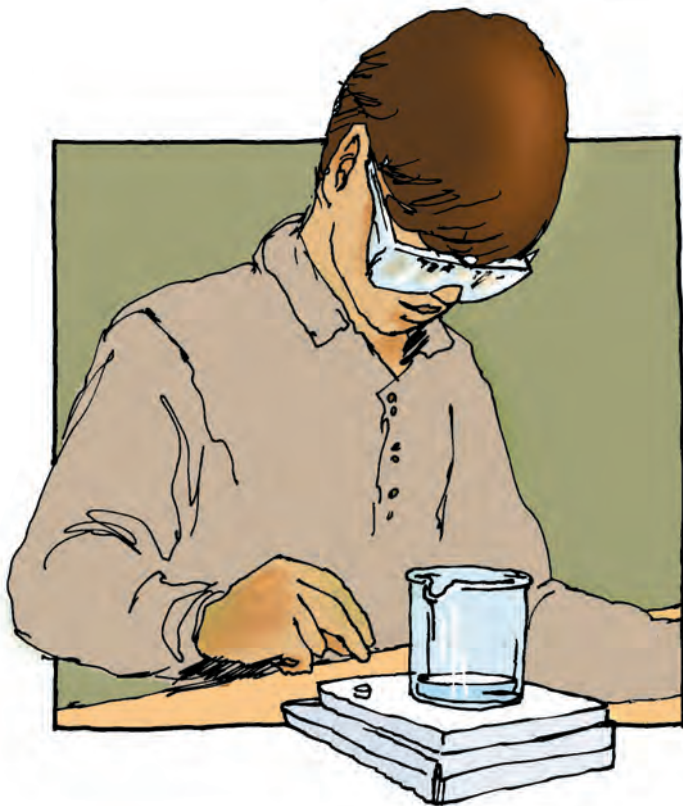


Figure 25.1 Make sure the pan of the balance is dry before finding the mass of the beaker, water, and half of the dry tablet.

9. Repeat the procedure with the other half of the tablet, but this time use *the plastic soda bottle instead of the beaker*.
- A. Measure the mass of the tablet half, the bottle containing 50 mL of water, *and the cap* on the balance. Record the mass on Table 1.
- B. Add the piece of tablet to the bottle, and *immediately* screw the cap on very tightly. Watch what happens in the bottle and record your observations on Table 1.
- C. When the reaction stops, measure the mass of the sealed bottle (see Figure 25.2) and record your result in Table 1.
- D. Calculate any change in mass and record it in the table.



Figure 25.2 After the reaction has stopped, measure the mass of the bottle, its cap, and its contents, keeping the cap tightly sealed.

10. Unscrew the bottle cap. What do you hear? Why did it make that noise?
11. Allow the open bottle to stand for 2–3 minutes. Place the bottle, the solution, and the cap on the balance and measure their mass.
12. Record your results at the bottom of column 3 in Table 1. Calculate the difference in mass between the open bottle and the closed bottle. Record your measurement in the table.
13. Rinse the beaker and the bottle. Return them to the plastic box.
14. Examine the data in Table 1. Answer the following questions on Student Sheet 25.1: What evidence do you have that a chemical reaction took place when you added the tablet to the water? What happened to the mass when the experiment was performed in an open beaker? Try to explain this result. Why didn't you get the same result when you used the closed bottle? What happened to the mass of the bottle, cap, and contents after the cap was removed? Explain this result.

REFLECTING ON WHAT YOU'VE DONE

1. Using your results and your knowledge of the precision of your apparatus, do you think that the law of conservation of mass applies to chemical reactions? Write your answer in your notebook.
2. Can you formulate your own law of conservation of mass that applies to phase change, dissolving, and chemical reactions? Discuss possible wording of such a law with your partner. Write your definition on Student Sheet 25.1. Your teacher will ask you to contribute your ideas to a class discussion.
3. At the end of the class discussion, write the class definition of the law of conservation of mass on the student sheet.

The Mass of Matter

Matter may change from a solid to a liquid. Elements may react together to form compounds. What happens to the mass of matter in a bowl of water when it is left to stand in the hot sun? What happens to the mass of matter in a piece of paper when it is burned? Sometimes in situations like this it seems as if matter is disappearing. But the disappearance of matter is an illusion.

Matter may change from one form into another. For example, when the water in the bowl absorbs energy from the sun and evaporates, it becomes water vapor in the atmosphere. The piece of paper gives off heat and light energy as it burns, and the matter in it is converted into carbon dioxide, water vapor, and other gases that escape into the atmosphere. Some of the mass will remain behind as ash. In both cases, the matter changes its form, but its total mass stays the same. The same mass of each element is present before

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Antoine and Marie-Anne Lavoisier worked together on experiments that led to the law of conservation of mass.

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Antoine Lavoisier (1743–1794) was one of the founders of modern chemistry.

and after the change. Matter is neither created nor destroyed during these changes.

It took early scientists hundreds of years of scientific study before the law of conservation of mass became accepted. For a long time, scientists had suspected that matter could not be created or destroyed, but nobody had performed an experiment that proved it.

During the late 18th century, French chemist Antoine Lavoisier and his wife Marie-Anne conducted several experiments that demonstrated the conservation of mass. Antoine was famous for his accurate observations and insistence on careful measurements. He used accurate balances that could measure very small changes in mass during his experiments.

Many of the Lavoisiers' experiments were conducted in sealed glass containers from which matter could not escape or enter. For

example, in one experiment, Antoine put fruit into a sealed container, measured its mass, and then left it in a warm place for a few days. The fruit rotted and changed into a putrid mess. Gas was released from the decomposing fruit and droplets of water formed on the glass, but nothing escaped from the container. Lots of changes had taken place, but the mass of the sealed container and the rotten fruit was equal to the mass measured at the beginning of the experiment.

In other experiments, Antoine heated elements in enclosed containers with air inside them. He discovered that new substances were formed but that the container and its contents had the same mass as they did before heating. When he measured the mass of the new solid substances he had made, he discovered that they were heavier than the original elements he heated. In this way, he determined that they must have gained their mass from the air. On the basis of these experiments, he also concluded that air contained several gases,

one of which reacted with the elements in the experiment. He called this gas oxygen (which had previously been discovered and described—but not named—by Carl Wilhelm Scheele and by Joseph Priestley).

In 1789, Antoine wrote the best textbook on chemistry the world had seen. In it, he introduced a new scientific law that he called the law of conservation of mass. This law stated that in any closed system (as small as a sealed container or as big as the whole universe!) the total mass remains the same, regardless of what changes take place inside. □

QUESTION

Imagine you are Antoine Lavoisier. How could you design an experiment to investigate what happens to the total mass of matter when a caterpillar eats a leaf? Draw a picture of the apparatus you would use and write a short description of the procedure you would follow. Remember that Antoine Lavoisier did not have electronic balances.

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Antoine Lavoisier was particularly interested in the chemistry of gases. This picture shows him working with other scientists on an investigation of the gases exchanged during breathing.