Lesson 2

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- How can you recognize the type of chemical reaction by the number or type of reactants and products?
- What are the different types of chemical reactions?

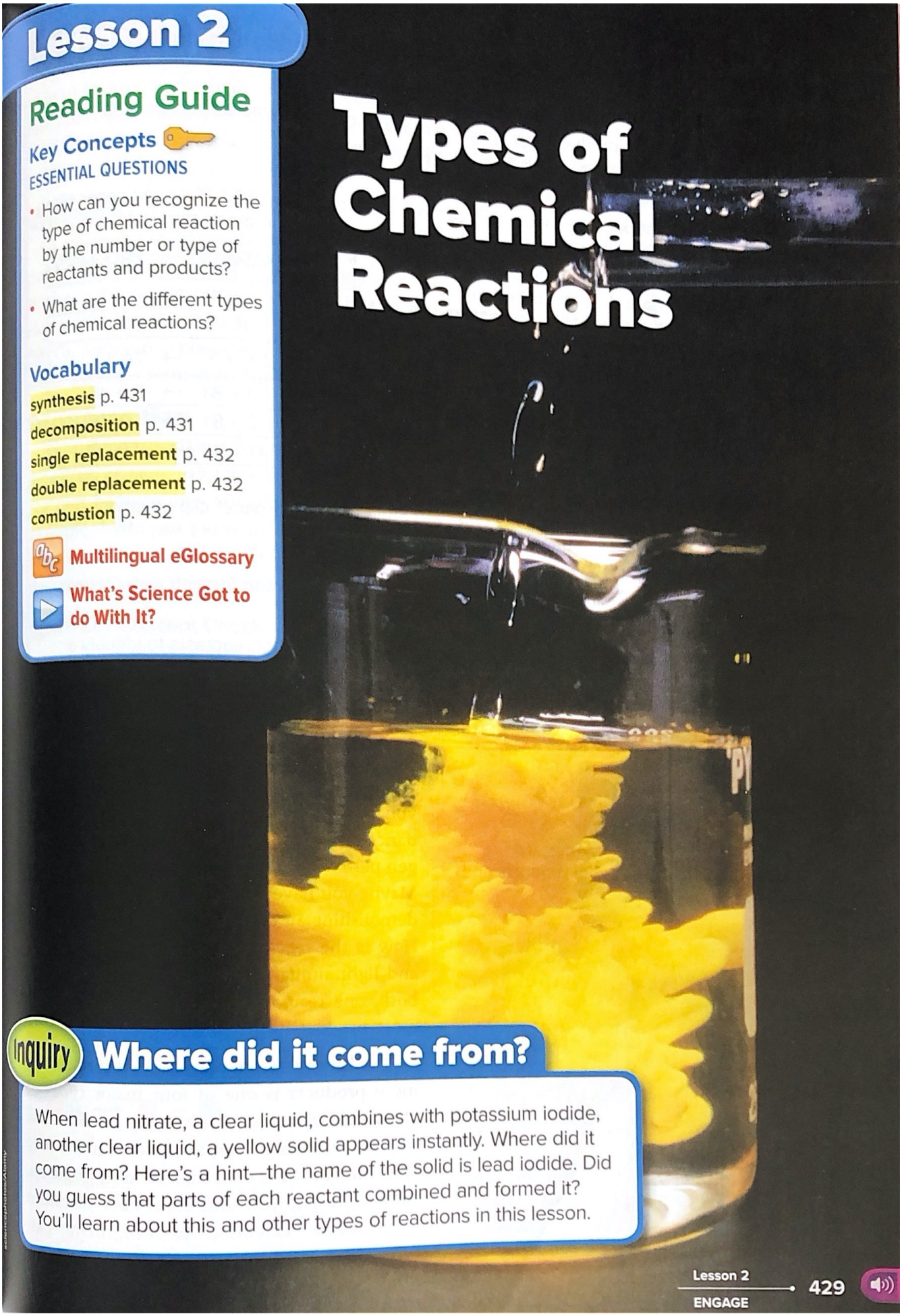
Vocabulary

synthesis p. 431
decomposition p. 431
single replacement p. 432
double replacement p. 432
combustion p. 432

Multilingual eGlossary

What's Science Got to do With It?

Types of Chemical Reactions



Inquiry Where did it come from?

When lead nitrate, a clear liquid, combines with potassium iodide, another clear liquid, a yellow solid appears instantly. Where did it come from? Here's a hint—the name of the solid is lead iodide. Did you guess that parts of each reactant combined and formed it? You'll learn about this and other types of reactions in this lesson.

Launch Lab

15 minutes

What combines with what?

The reactants and the products in a chemical reaction can be elements, compounds, or both. In how many ways can these substances combine?

1. Read and complete a lab safety form.
2. Divide a **sheet of paper** into four equal sections labeled *A*, *B*, *Y*, and *Z*. Place **red paper clips** in section A, **yellow clips** in section B, **blue clips** in section Y, and **green clips** in section Z.
3. Use another sheet of paper to copy the table shown to the right. Turn the paper so that a long edge is at the top. Print *REACTANTS* → *PRODUCTS* across the top then complete the table.
4. Using the paper clips, model the equations listed in the table. Hook the clips together to make diatomic elements or compounds. Place each clip model onto your paper over the matching written equation.
5. As you read this lesson, match the types of equations to your paper clip equations.

	REACTANTS → PRODUCTS
1	$AY \rightarrow A + Y$
2	$B + Z \rightarrow BZ$
3	$2A_2 + Y_2 \rightarrow 2A_2Y$
4	$A + BY \rightarrow B + AY$
5	$Z + BY \rightarrow Y + BZ$
6	$AY + BZ \rightarrow AZ + BY$

Think About This

1. Which equation represents hydrogen combining with oxygen and forming water? How do you know?
2. **Key Concept** How could you use the number and type of reactants to identify a type of chemical reaction?

Patterns in Reactions

If you have ever used hydrogen peroxide, you might have noticed that it is stored in a dark bottle. This is because light causes hydrogen peroxide to change into other substances. Maybe you have seen a video of an explosion demolishing an old building, like in Figure 5. How is the reaction with hydrogen peroxide and light similar to a building demolition? In both, one reactant breaks down into two or more products.

The breakdown of one reactant into two or more products is one of four major types of chemical reactions. Each type of chemical reaction follows a unique pattern in the way atoms in reactants rearrange to form products. In this lesson, you will read how chemical reactions are classified by recognizing patterns in the way the atoms recombine.

Figure 5 When dynamite explodes, it chemically changes into several products and releases energy.

Types of Chemical Reactions

There are many different types of reactions. It would be impossible to memorize them all. However, most chemical reactions fit into four major categories. Understanding these categories of reactions can help you predict how compounds will react and what products will form.

Synthesis

A **synthesis** (SIHN thuh sus) *reaction is a type of chemical reaction in which two or more substances combine and form one compound.* In the synthesis reaction shown in **Figure 6,** magnesium (Mg) reacts with oxygen (O_2) in the air and forms magnesium oxide (MgO). You can recognize a synthesis reaction because two or more reactants form only one product.

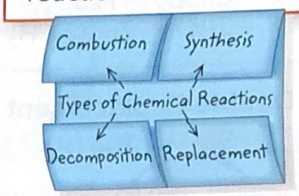
Decomposition

In a **decomposition** *reaction, one compound breaks down and forms two or more substances.* You can recognize a decomposition reaction because one reactant forms two or more products. For example, hydrogen peroxide (H_2O_2), shown in **Figure 6,** decomposes and forms water (H_2O) and oxygen gas (O_2). Notice that decomposition is the reverse of synthesis.

Key Concept Check How can you tell the difference between synthesis and decomposition reactions?

FOLDABLES®

Make a horizontal four-door book. Label it as shown. Use it to organize your notes about the different types of chemical reactions.



WORD ORIGIN

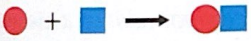
synthesis
from Greek *syn-*, means "together"; and *tithenai*, means "put"

Animation

Figure 6 Synthesis and decomposition reactions are opposites of each other.

Synthesis and Decomposition Reactions

Synthesis Reactions



Examples:

$2Na + Cl_2 \rightarrow 2NaCl$

$2H_2 + O_2 \rightarrow 2H_2O$

$H_2O + SO_3 \rightarrow H_2SO_4$

$2Mg + O_2 \rightarrow 2MgO$

magnesium + oxygen → magnesium oxide

Decomposition Reactions

Examples:

$CaCO_3 \rightarrow CaO + CO_2$

$2H_2O \rightarrow 2H_2 + O_2$

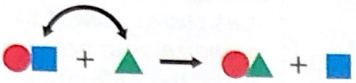
$2KClO_3 \rightarrow 2KCl + 3O_2$

$2H_2O_2 \rightarrow 2H_2O + O_2$

hydrogen peroxide → water + oxygen

Replacement Reactions

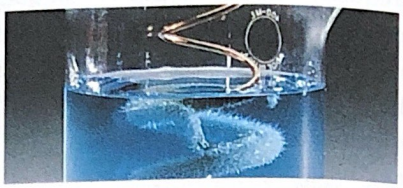
Single Replacement



Examples:

$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

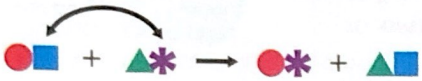
$Zn + 2HCl \rightarrow ZnCl_2 + H_2$



$2AgNO_3$ + Cu → $Cu(NO_3)_2$ + 2Ag

silver nitrate + copper → copper nitrate + silver

Double Replacement



Examples:

$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$

$HCl + FeS \rightarrow FeCl_2 + H_2S$

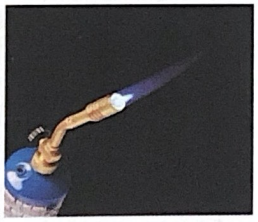
$Pb(NO_3)_2$ + 2KI → $2KNO_3$ + PbI_2

lead nitrate + potassium iodide → potassium nitrate + lead iodide

▲ **Figure 7** In each of these reactions, an atom or group of atoms replaces another atom or group of atoms.

Combustion Reactions

substance + O_2 → substance(s)



C_3H_8 + $5O_2$ → $3CO_2$ + $4H_2O$

propane + oxygen → carbon dioxide + water

Example:

$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

▲ **Figure 8** Combustion reactions always contain oxygen (O_2) as a reactant and often produce carbon dioxide (CO_2) and water (H_2O).

Replacement

In a replacement reaction, an atom or group of atoms replaces part of a compound. There are two types of replacement reactions. *In a* **single-replacement** *reaction, one element replaces another element in a compound.* In this type of reaction, an element and a compound react and form a different element and a different compound. *In a* **double-replacement** *reaction, the negative ions in two compounds switch places, forming two new compounds.* In this type of reaction, two compounds react and form two new compounds. **Figure 7** describes these replacement reactions.

Combustion

Combustion *is a chemical reaction in which a substance combines with oxygen and releases energy.* This energy usually is released as thermal energy and light energy. For example, burning is a common combustion reaction. The burning of fossil fuels, such as propane (C_3H_8) shown in **Figure 8**, produces the energy we use to cook food, power vehicles, and light cities.

Key Concept Check What are the different types of chemical reactions?

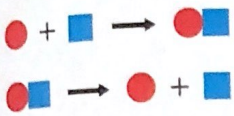
Lesson 2 Review

Online Quiz

Virtual Lab

Visual Summary

Chemical reactions are classified according to patterns seen in their reactants and products.



In a synthesis reaction, there are two or more reactants and one product. A decomposition reaction is the opposite of a synthesis reaction.

In replacement reactions, an element, or elements, in a compound is replaced with another element or elements.

FOLDABLES

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

3. Reactions always start with two or more substances that react with each other.

4. Water can be broken down into simpler substances.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1. **Contrast** synthesis and decomposition reactions using a diagram.

2. A reaction in which parts of two substances switch places and make two new substances is a(n) _____.

Understand Key Concepts

3. **Classify** the reaction shown below.

$$2Na + Cl_2 \rightarrow 2NaCl$$

A. combustion
C. single replacement
B. decomposition
D. synthesis

4. Write a balanced equation that produces H_2 and O_2 from H_2O. Classify this reaction.

5. **Classify** In which two groups of reactions can this reaction be classified?

$$2SO_2 + O_2 \rightarrow 2SO_3$$

Interpret Graphics

6. **Complete** this table to identify four types of chemical reactions and the patterns shown by the reactants and the products.

Type of Reaction	Pattern of Reactants and Products
Synthesis	at least two reactants; one product

Critical Thinking

7. **Design** a poster to illustrate single- and double-replacement reactions.

8. **Infer** The combustion of methane (CH_4) produces energy. Where do you think this energy comes from?

HOW IT WORKS

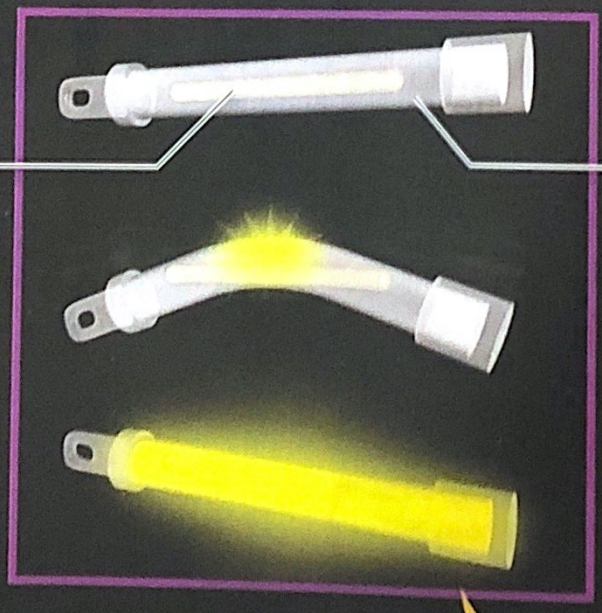
How does a light stick work?

What makes it glow?

Glowing neon necklaces, bracelets, or sticks—chances are you've worn or used them. Light sticks—also known as glow sticks—come in brilliant colors and provide light without electricity or batteries. Because they are lightweight, portable, and waterproof, they provide an ideal light source for campers, scuba divers, and other activities in which electricity is not readily available. Light sticks also are useful in emergency situations in which an electric current from battery-powered lights could ignite a fire.

Light sticks give off light because of a chemical reaction that happens inside the tube. During the reaction, energy is released as light. This is known as chemiluminescence (ke mee lew muh NE sunts).

A light stick consists of a plastic tube with a glass tube inside it. Hydrogen peroxide fills the glass tube.



A solution of phenyl oxalate ester and fluorescent dye surround the glass tube.

When you bend the outer plastic tube, the inner glass tube breaks, causing the hydrogen peroxide, ester, and dye to mix together.

When the solutions mix together, they react. Energy produced by the reaction causes the electrons in the dye to produce light.

It's Your Turn

RESEARCH AND REPORT Research bioluminescent organisms such as fireflies and sea animals. How is the reaction that occurs in these organisms similar to or different from that in a glow stick? Work in small groups, and present your findings to the class.