

CHAPTER 14 Chemical Reactions

SECTION 1 **Forming New Substances**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is a chemical reaction?
- What can you tell that a chemical reaction is happening?
- What happens during a chemical reaction?

**National Science Education Standards**  
PS 1b, 3a, 3e

**What Is a Chemical Reaction?**

Chemical reactions happen around you all the time. Wood burns and turns to ash. Rust forms on iron. Bread dough rises. These are all chemical reactions.

A **chemical reaction** happens when substances break apart or combine to form one or more new substances. New substances form when bonds break and new bonds form. The chemical properties of the new substances are different from those of the original substances. ✓

**STUDY TIP**

**Construct** Make a Concept Map for chemical reactions. Your map should show the signs of a chemical reaction happening and what happens to chemical bonds during a reaction.

**What Are the Signs of a Chemical Reaction?**

There are several ways to tell that a chemical reaction has happened. Sometimes, you can see the new substance that forms during the reaction. For example, during some chemical reactions, a precipitate forms. A **precipitate** is a solid substance that forms in a solution. The figure below shows some of the signs that a chemical reaction is happening.

**READING CHECK**

**1. Describe** What happens in a chemical reaction?

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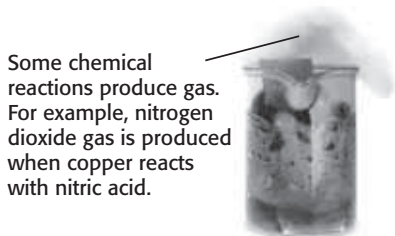
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Some chemical reactions produce gas. For example, nitrogen dioxide gas is produced when copper reacts with nitric acid.



Some chemical reactions produce a precipitate. For example, solid silver chromate forms when potassium chromate solution is added to silver nitrate solution.



Some chemical reactions give off energy. For example, burning wood gives off light and heat energy. Other chemical reactions take in energy.



During some chemical reactions, a color change happens. For example, the chemical reaction between the blue dye in jeans and bleach will cause the jeans to change color.

**TAKE A LOOK**

**2. Describe** How can you tell that a precipitate has formed?

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**SECTION 1** Forming New Substances *continued***CHANGING CHEMICAL PROPERTIES**

Seeing signs of a chemical reaction does not always mean that a reaction is happening. For example, a gas (water vapor) is given off when water boils. Recall that boiling is a physical change, not a chemical reaction. You can tell that it is a physical change because water vapor can condense to form liquid water. In a chemical change, a new substance must be produced. ✓

**READING CHECK**

**3. Explain** Does seeing a gas produced always mean a chemical reaction is occurring? Explain.

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How can you be sure that a chemical reaction is happening? The best way is to look at the chemical properties of the substance that forms. The new substances that form during chemical reactions always have different chemical properties than the original substances. The figure below shows an example of how chemical properties change during a chemical reaction.

This sulfuric acid is a clear liquid.



This sugar is a white solid.



When sulfuric acid reacts with sugar, new substances with different properties form. Carbon is a black solid. Water vapor is a colorless gas.

The starting materials in this reaction are sugar and sulfuric acid. There are signs that a chemical reaction occurs. Bubbles form, a gas is given off, and the beaker gets very hot.

The most important sign that a chemical reaction occurs is the formation of new substances. The new substances are carbon, a brittle black solid, and water vapor, a colorless gas. The properties of these new substances are not at all like the properties of sugar and sulfuric acid.

**STANDARDS CHECK**

**PS 1b** Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group.

**Word Help: chemical** of or having to do with the properties or actions of substances

**4. Explain** What happens to the chemical properties of substances during a chemical reaction?

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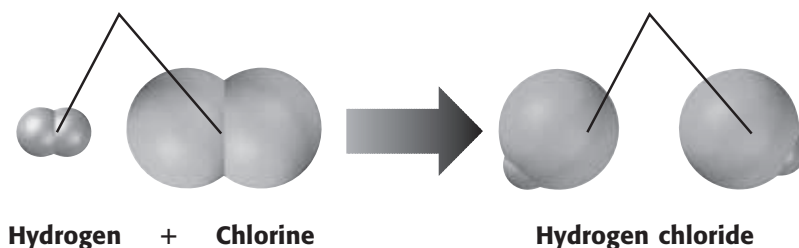
**SECTION 1** Forming New Substances *continued***How Do New Substances Form?**

Chemical reactions happen when chemical bonds are broken and formed. A *chemical bond* is a force that holds two atoms together in a molecule. During a chemical reaction, some of the bonds in the original molecule break. New bonds form to produce a new substance. ✓

Remember that molecules are always moving. If the molecules in a substance bump into each other with enough energy, some of the bonds in the molecules can break. The atoms can form new bonds with different atoms. A new substance forms. The figure below shows an example of how new substances can form.

Hydrogen and chlorine are diatomic molecules. Diatomic molecules are made of two atoms bonded together. In order for hydrogen to react with chlorine, the bonds between the atoms must break.

New bonds can form between hydrogen atoms and chlorine atoms. A new substance, hydrogen chloride, forms. Hydrogen chloride is also a diatomic molecule.



In this example, both elements exist as diatomic molecules. Chlorine is a greenish-yellow gas and hydrogen is a colorless gas that is flammable. When they react, the bond between the hydrogen atoms breaks and the bond between the chlorine atoms breaks.

New bonds form between hydrogen and chlorine atoms. The product of the reaction is hydrogen chloride. Hydrogen chloride is a nonflammable, colorless gas. Its properties are very different from those of hydrogen or chlorine.

Let's look at another example. Sodium is a metal that reacts violently with water. When sodium and chlorine react, they make a new substance, sodium chloride. You use sodium chloride as table salt. Sodium and chlorine are both toxic substances, but sodium chloride is not.

**READING CHECK**

**5. Describe** What happens to chemical bonds during a chemical reaction?

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**TAKE A LOOK**

**6. Identify** Hydrogen and chlorine react to produce hydrogen chloride. What bonds are broken and what bonds are formed during this reaction?

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# Section 1 Review

NSES PS 1b, 3a, 3e

## SECTION VOCABULARY

**chemical reaction** the process by which one or more substances change to produce one or more different substances

**precipitate** a solid that is produced as a result of a chemical reaction in solution

**1. Identify** Why is the formation of a precipitate a possible indication of a chemical reaction?

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**2. Identify** Complete the table to identify the four possible signs of a chemical change.

Observed during a chemical reaction	Sign of a chemical reaction
a precipitate forms in a solution	
heat given off	
green gas observed	
colorless solution turned blue	

**3. Identify** What is the force that holds two atoms together in a molecule?

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**4. Apply Concepts** Explain why water boiling is not a chemical reaction, even though it releases a gas.

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**5. Infer** A scientist mixes substance A and substance B in a beaker. Neither substance A nor substance B can conduct electricity. The material in the beaker changes color, and the beaker becomes very hot. The material left in the beaker conducts electricity. Has a chemical reaction occurred? Explain your answer.

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- a lot of energy
- because positive ions are attracted to negative ions

**Review**

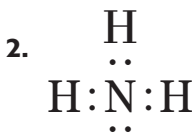
- Magnesium loses its two electrons to a nonmetal atom. It becomes a positive ion with a charge of 2+.
- Two arrows should be drawn from the outermost electrons in magnesium to the outermost electron levels in sulfur.
- Potassium will become a positive ion because it will lose an electron. Fluorine will become a negative ion because it will gain an electron.
- crystal lattice

**SECTION 3 COVALENT AND METALLIC BONDS**

- Electrons are shared in covalent bonds; they are not gained or lost.
- covalent
- H
- H:H
- diatomic molecule
- Chlorine: eight  
Oxygen: eight  
Nitrogen: eight
- Chlorine: one pair  
Oxygen: two pairs  
Nitrogen: three pairs
- three covalent bonds
- four
- It is formed by the attraction between positively charged metal ions and the electrons around the ions.
- The electrons can move throughout the metal.
- Valence electrons are free to move throughout the wire.
- Ductility means being able to be shaped into long, thin wires. Malleability means being able to be hammered into sheets.

**Review**

<b>1. Forms covalent bonds</b>	<b>Forms metallic bonds</b>
<u>oxygen</u>	<u>gold</u>
<u>carbon</u>	<u>aluminum</u>
<u>fluorine</u>	<u>copper</u>



- First question: You would use substances with covalent bonds as insulation.  
Second question: You would use a metal to conduct heat.
- The properties of oxygen change; water does not have the same properties as oxygen.
- Metals can conduct electricity, can be stretched into wires, and can be hammered into thin sheets.

**Chapter 14 Chemical Reactions**

**SECTION 1 FORMING NEW SUBSTANCES**

- One or more substances break apart or combine to form one or more new substances.
- A solid forms in a solution.
- No, some physical changes, like boiling, may produce a gas.
- The chemical properties of the new substances are different from those of the original substances.
- Some bonds are broken and new bonds form.
- The bonds in the hydrogen and chlorine molecules are broken. The bonds in the hydrogen chloride molecule form.

**Review**

- New substances are formed during a chemical reaction. Formation of a precipitate is one sign that a new substance has been formed.

<b>2. Observed during a chemical reaction</b>	<b>Sign of a chemical reaction</b>
precipitate in a solution	<u>solid formation</u>
heat given off	<u>energy change</u>
green gas	<u>gas formation</u>
colorless solution turned blue	<u>color change</u>

- chemical bond
- When water boils, a new substance is not formed. The water vapor that forms during boiling can condense into liquid water.
- The chemical properties of the material in the beaker are different from those of the original substances. This shows that a chemical reaction must have occurred.

## SECTION 2 CHEMICAL FORMULAS AND EQUATIONS

- the elements found in a substance and how many atoms of each element are in a molecule
- three
- $\text{PCl}_3$
- $3+$
- a short way to show what happens in a chemical reaction using symbols and formulas
- Reactants: C,  $\text{O}_2$   
Products:  $\text{CO}_2$
- If you use the wrong chemical formula, a chemical equation will not describe the reaction you are trying to describe.
- A chemical equation shows that no atoms are lost or gained during a chemical reaction.
- a number that is placed in front of a chemical formula
- subscripts
- $2\text{Na} + \text{Cl}_2 \longrightarrow 2\text{NaCl}$

### Review

- A chemical formula represents a substance. A chemical equation represents a chemical reaction.

Chemical equation	Number of atoms in the reactants	Number of atoms in the products	Is the equation balanced?
$\text{Na} + \text{Cl}_2 \longrightarrow \text{NaCl}$	Na = <u>1</u> Cl = <u>2</u>	Na = <u>1</u> Cl = <u>1</u>	no
$\text{HCl} + \text{NaOH} \longrightarrow \text{NaCl} + \text{H}_2\text{O}$	H = <u>2</u> Cl = <u>1</u> Na = <u>1</u> O = <u>1</u>	H = <u>2</u> Cl = <u>1</u> Na = <u>1</u> O = <u>1</u>	yes
$2\text{Sb} + 3\text{I}_2 \longrightarrow 2\text{SbI}_3$	Sb = <u>2</u> I = <u>6</u>	Sb = <u>2</u> I = <u>6</u>	yes

- $\text{SiO}_2$ : silicon dioxide  
 $\text{SbF}_3$ : antimony trifluoride

- Changing the subscripts changes the substance in the chemical reaction. Therefore, if you change subscripts, you change the chemical reaction that you are describing.
- $3\text{Mg} + \text{N}_2 \longrightarrow \text{Mg}_3\text{N}_2$

## SECTION 3 TYPES OF CHEMICAL REACTIONS

- a reaction in which two or more substances combine to form a new compound
- $\text{C} \longrightarrow \text{A} + \text{B}$
- a new compound and the replaced element
- more reactive
- synthesis, decomposition, single-displacement, and double-displacement reactions

### Review

- synthesis and decomposition.
- Synthesis is the combination of two or more substances to make a new substance. The new substance cannot be an element, because it is a combination of at least two elements.
- double-displacement, decomposition, synthesis
- Aluminum must be less reactive than calcium. In a single displacement reaction, a more reactive element replaces a less reactive element.
- It appears to be a double-displacement reaction. A precipitate is often an indication that a new substance formed by the exchange of ions between two compounds in the solutions.

## SECTION 4 ENERGY AND RATES OF CHEMICAL REACTIONS

- It is released into the surroundings.
- It is absorbed from the surroundings.
- heat, light, and electricity
- Energy cannot be created or destroyed.
- They must collide.
- the reactants to the highest point on the curve
- products
- Reactions occur faster at higher temperatures.
- It increases the rate of reaction.
- The reaction rate is faster.
- Catalysts speed up reactions, and inhibitors slow or stop them.