

# The Nature of Chemical Reactions

## KEY IDEAS

As you read this section, keep these questions in mind:

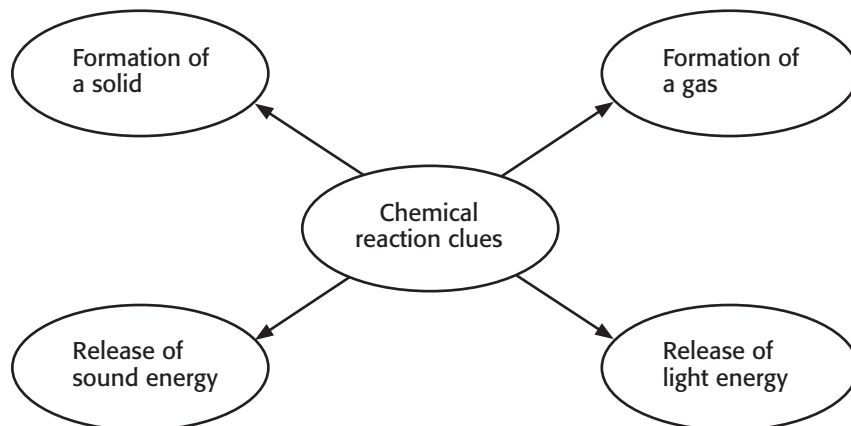
- What happens in a chemical reaction?
- What is the role of energy in a chemical reaction?
- What is the difference between an exothermic and an endothermic reaction?

## What Is a Chemical Reaction?

Scientists often carry out chemical reactions in laboratories. However, chemical reactions also happen outside science laboratories. In fact, chemical reactions happen around you and inside you all the time. A tree growing, an apple ripening, a leaf decaying, and a log burning are all chemical reactions. Digestion and respiration are also chemical reactions. In a *chemical reaction*, substances go through chemical changes to form new substances. ✓

Consider what happens when you combine sugar, water, flour, and yeast to make bread. The yeast breaks down the sugar to form new substances. One of these substances is carbon dioxide gas, which causes the bread to rise.

The formation of a gas is a clue that a chemical reaction has happened. Sometimes a gas from a chemical reaction forms bubbles that you can see. For example, if you mix baking soda and vinegar, gas bubbles will form. The gas bubbles indicate that a reaction has happened. Other clues that a chemical reaction has happened are shown below.



## READING TOOLBOX

**Organize** After you read this section, make a Concept Map using the section vocabulary terms. Review your Concept Map with a partner. You and your partner may have organized the terms differently.



## READING CHECK

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

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**SECTION 1** The Nature of Chemical Reactions *continued***BREAKING BONDS AND REARRANGING ATOMS**

Recall that matter is made of atoms. Compounds consist of atoms of two or more different elements bonded to one another. During a chemical reaction, the bonds between some atoms break. The atoms rearrange and new bonds form. In other words, the atoms recombine to form new substances. Atoms are never destroyed in a chemical reaction. ✓

**READING CHECK**

**2. Explain** How do new substances form in a chemical reaction?

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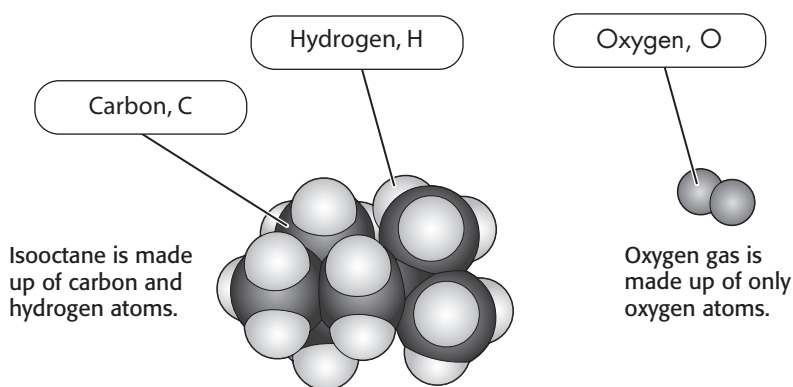


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Consider what happens when gasoline burns in an engine. Gasoline contains isooctane ( $C_8H_{18}$ ). When gasoline burns, isooctane reacts with oxygen gas ( $O_2$ ). These molecules are shown below.



Isooctane and oxygen react to form carbon dioxide ( $CO_2$ ) and water ( $H_2O$ ).

**LOOKING CLOSER**

**3. Compare** Examine the molecules in this figure and those in the figure above. Where did the oxygen and hydrogen atoms in  $H_2O$  come from?

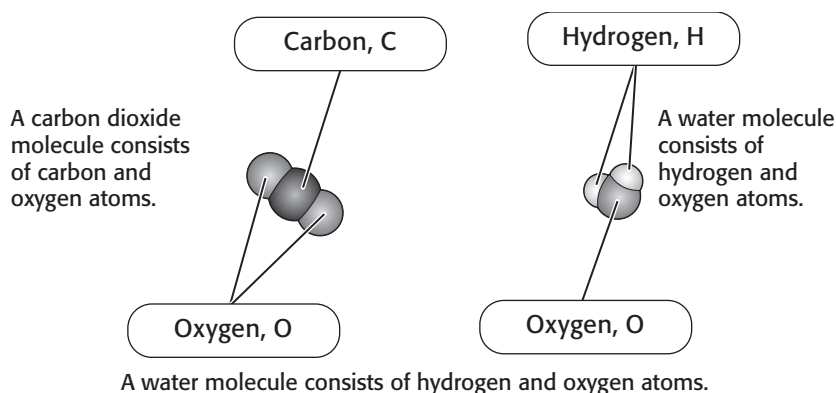
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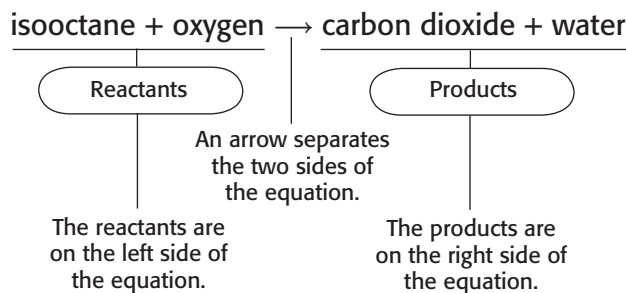


If you compare the figures above, you will see that bonds between the carbon and hydrogen atoms in isooctane broke. Bonds also broke between the oxygen atoms in the oxygen molecule. The atoms recombined to form new substances. New bonds formed between carbon atoms and oxygen atoms to make carbon dioxide. New bonds also formed between hydrogen atoms and oxygen atoms to make water.

**SECTION 1** The Nature of Chemical Reactions *continued***REACTANTS AND PRODUCTS**

When gasoline burns in an engine, isooctane and oxygen are the reactants. A **reactant** is a substance that participates in a chemical reaction. Isooctane and oxygen react to produce carbon dioxide and water, which are the products. A **product** is a substance that forms during a chemical reaction. ✓

You can use a word equation to show what happens in a chemical reaction. For example, the following word equation shows what happens when gasoline burns.

**What Is the Role of Energy in Chemical Reactions?**

Chemical reactions always involve changes in energy. Most chemical reactions need added energy to start. Some chemical reactions produce, or release, energy. Other chemical reactions absorb energy.

Chemical compounds store energy in the bonds between their atoms. Energy that is stored in the form of chemical bonds is called **chemical energy**.

During a chemical reaction, chemical energy may change form. For example, it could become light or heat energy. However, the total amount of energy in the reactants must equal the total amount of energy in the products. In other words, energy in a chemical reaction can change form, but no energy is created or destroyed. ✓

**FORMING BONDS**

Recall that new bonds form in chemical reactions. When new bonds form, energy is released. For example, when gasoline burns, energy is released as heat and light.

**READING CHECK**

**4. Identify** What do scientists call a substance that forms during a chemical reaction?

**LOOKING CLOSER**

**5. Identify** On what side of the equation are reactants found?

**READING CHECK**

**6. Identify** Where is energy stored in chemical compounds?

**SECTION 1** The Nature of Chemical Reactions *continued*

**BREAKING BONDS**

Recall that some bonds between atoms break in a chemical reaction. Breaking bonds requires energy. For example, energy is needed to break bonds between the atoms in isooctane and oxygen. A spark from a spark plug provides the energy needed to break these bonds. An open flame can also start this reaction. For this reason, sparks and flames are not allowed near a gas pump.

**LIGHT ENERGY AND PHOTOSYNTHESIS**

During photosynthesis, plants use light energy to change carbon dioxide and water into sugars and oxygen. As a result of photosynthesis, light energy is changed into chemical energy. This chemical energy is stored in the bonds of carbohydrate molecules. You gain some of this chemical energy when you eat fruits and vegetables.

**Critical Thinking**

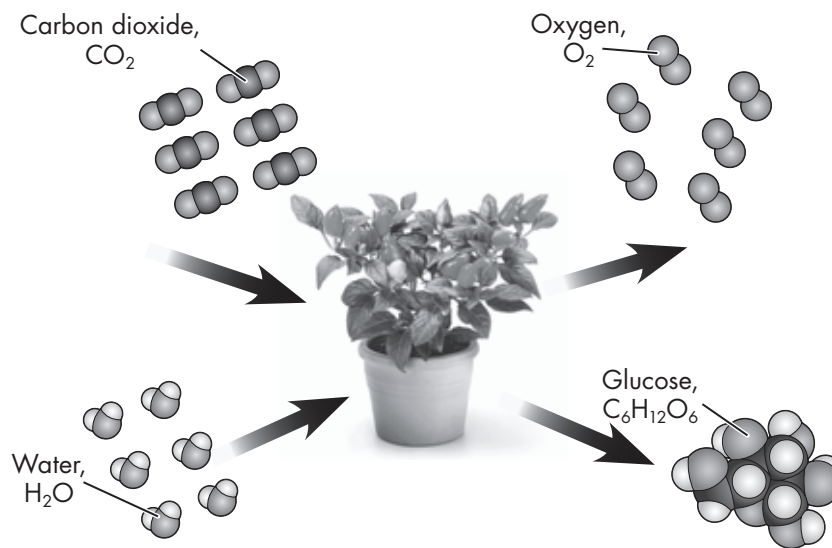
**7. Infer** The cells in your body get energy from the foods you eat. However, your cells must use energy to get this energy. Why?

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**What Are Endothermic and Exothermic Reactions?**

Recall that during a chemical reaction, energy is needed to break bonds in the reactants. Energy is released as new bonds form in the products. In an **endothermic reaction**, more energy is needed to break the bonds in the reactants than is released when new bonds form in the products. In other words, endothermic reactions absorb more energy than they release. In an endothermic reaction, the products have more chemical energy than the reactants do.

**READING CHECK**

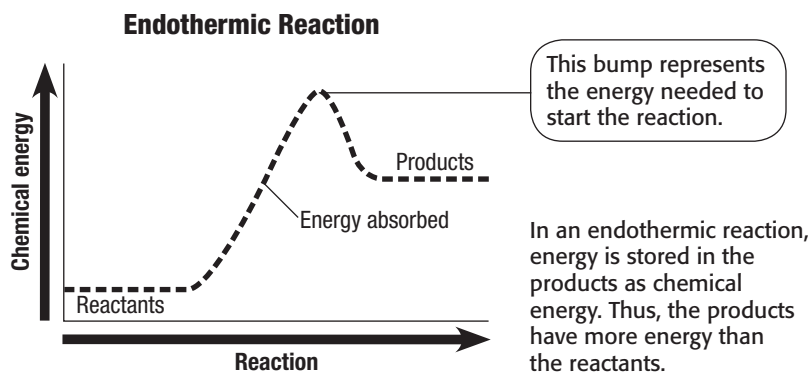
**8. Describe** How does the energy of the reactants and products differ in an endothermic reaction?

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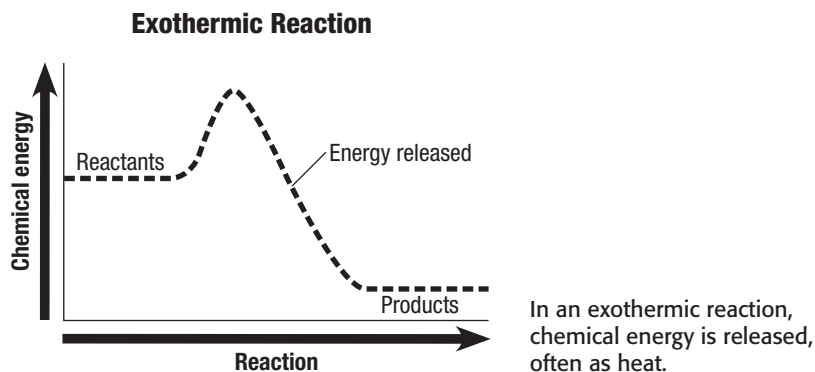
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**SECTION 1** The Nature of Chemical Reactions *continued*



In an **exothermic reaction**, more energy is released when new bonds form than is needed to break bonds. In other words, exothermic reactions release more energy than they absorb. In an exothermic reaction, the products have less chemical energy than the reactants do. All combustion reactions are exothermic.



**Graphing Skills**

**9. Interpret** How does the energy of the products differ from the energy of the reactants in an exothermic reaction?

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**CONSERVATION OF ENERGY**

All chemical reactions obey the law of conservation of energy. The *law of conservation of energy* states that energy cannot be created or destroyed. In both endothermic and exothermic reactions, energy changes from one form into another form. However, no energy is created or destroyed.

If no energy is created or destroyed, how can the products of an exothermic reaction have less energy than the reactants? How can the products of an endothermic reaction have more energy than the reactants?

**Endothermic reaction:**

Energy of reactants + energy absorbed = energy of products

**Exothermic reaction:**

Energy of reactants = energy of products + energy released

**LOOKING CLOSER**

**10. Explain** How can products and reactants have different amounts of energy without violating the law of conservation of energy?

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# Section 1 Review

## SECTION VOCABULARY

**chemical energy** the energy released when a chemical compound reacts to produce new compounds

**endothermic reaction** a chemical reaction that requires energy input

**exothermic reaction** a chemical reaction in which energy is released to the surroundings as heat

**product** a substance that forms in a chemical reaction

**reactant** a substance or molecule that participates in a chemical reaction

**1. List** What are three clues that may tell you a chemical reaction is happening?

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**2. Predict** Caramel forms when table sugar,  $C_{12}H_{22}O_{11}$ , reacts with oxygen. What elements make up caramel?

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**3. Apply Concepts** Identify whether or not each of the following is a chemical reaction. Explain your answers.

a. melting ice

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b. burning a candle

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c. rusting iron

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**4. Describe** What is the role of energy in forming bonds? What is the role of energy in breaking bonds?

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**5. Apply Concepts** Is a firecracker exploding an example of an endothermic reaction or an exothermic reaction? Explain your answer.

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