

**Figure 2.47** Some chemical reactions in the body

change. How do you decide whether a chemical reaction has occurred? Find out in the next activity.

You can smell brownies baking in the oven and smoke from a campfire. You can see gas bubbles produced when you combine vinegar and baking soda. These are signs of chemical changes. Some chemical changes are easy to detect. Other chemical changes are less obvious.

In a **chemical reaction**, two or more substances undergo a reorganization of atoms to form other substances. The substances that go into a chemical reaction are the **reactants**. The substances produced by a chemical reaction are the **products**. The properties of the products are different from those of the reactants. Changes in properties that might occur in a chemical reaction are shown in Figure 2.48 (on this page and the next page).

Not all changes in colour, temperature, and odour indicate chemical reactions. Boiling water creates a gas, but no chemical change has happened — water has only changed state from liquid to gas. A change in state is a physical



**Figure 2.48A** When iodine solution is placed on a raw potato, the iodine reacts with the starch to produce a blue-black colour. *Colour change* can indicate a chemical reaction.



**Figure 2.48B** A precipitate is a suspension of small solid particles in a liquid. Sometimes a *precipitate* and/or *gas* is produced or dissolved in a chemical reaction.



**Figure 2.48C** *Heat* and *light* can be absorbed or produced during a chemical reaction. When charcoal briquettes are burned, heat and light are produced.



**Figure 2.48D** When food spoils, its odour may change. *Odour changes* can indicate a chemical reaction has taken place.

## Is It a Chemical Reaction?

Several reactions have been set up in the science room. Which substances are undergoing chemical reactions? Search for the evidence.

### Safety Precautions



### Procedure Performing and Recording

1. Make an observation chart to collect your data.
2. Visit one of the stations. Carefully follow the instructions and safety precautions you find there. Record your observations on your chart.
3. Decide if a chemical reaction is taking place. If so, list the reactants.
4. Repeat steps 2 and 3 at each of the stations.

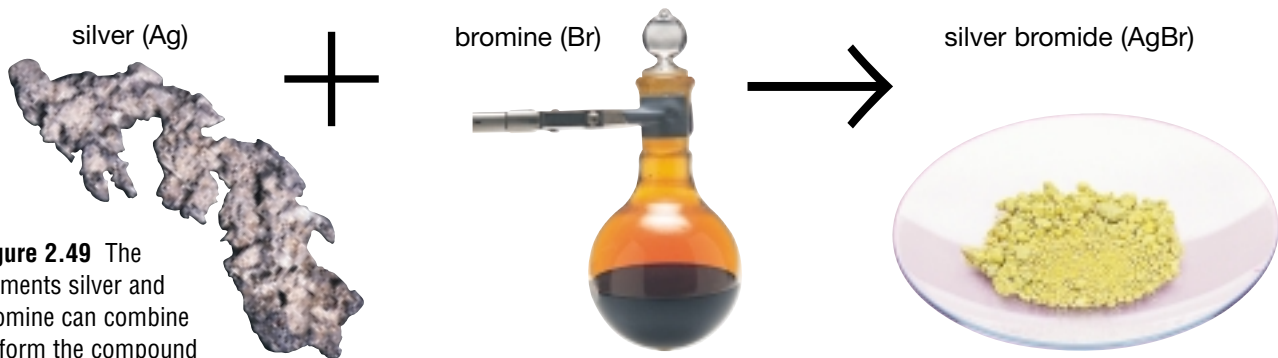
## Find Out ACTIVITY

### What Did You Find Out? Analyzing and Interpreting

1. Which stations had chemical reactions? What evidence made you think that a chemical change had occurred?
2. Which stations had physical reactions? What evidence made you think that a physical change had occurred?
3. When two or more substances are chemically combined, new substances are formed. Infer which new substances might have been formed at each of the stations with chemical reactions.
4. List three examples of chemical reactions in your everyday life. What evidence tells you that each is a chemical reaction?

## Chemical Equations

How do chemists describe chemical reactions? For example, how might the reaction of silver and bromine Figure 2.49 be described?

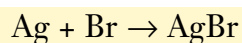


**Figure 2.49** The elements silver and bromine can combine to form the compound silver bromide.

One way to describe a chemical reaction is with a word equation that describes the reactants and products. The arrow means “produces.”

silver + bromine → silver bromide

You can convert a word equation into a chemical equation by substituting the chemical formulas for the chemical names:

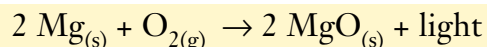


(silver) (bromine) (silver bromide)

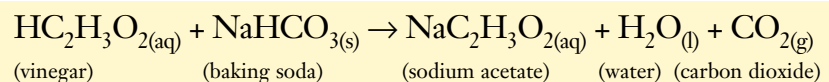
You learned in Topic 6 that chemists usually put symbols in parentheses behind the reactants and products to indicate the states of matter. For example, magnesium, a solid, is used to create bright light in fireworks and flash bulbs. The magnesium oxide formed is soft, grey in colour and easily crumbles into dust. The word equation for the reaction is

magnesium + oxygen → magnesium oxide

The chemical equation for the reaction of magnesium in oxygen is



When you studied the law of conservation of mass, you learned that atoms are neither lost nor created in a chemical reaction. The atoms just change partners as old substances are changed into new substances. For example, you have probably observed that when you mix vinegar and baking soda, a vigorous chemical reaction occurs (see Figure 2.50). The chemical equation may look complicated, but you now know how to understand each part:



**Figure 2.50** When vinegar is poured on baking soda (sodium hydrogen carbonate), bubbles of carbon dioxide gas form quickly. Water and sodium acetate are also formed.

What states of matter were the reactants in? What states of matter are the products in? Notice how the atoms have changed partners in the reaction as new substances were created.

### STRETCH Your Mind

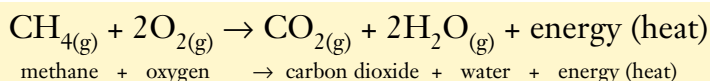
Notice the number 2 before Mg in the equation. This number is called a coefficient and is used to “balance” the equation. Count the number of Mg atoms on each side. Are they the same? Are the oxygen atoms balanced?

The equation  $\text{Ag} + \text{Br} \rightarrow \text{AgBr}$  is unbalanced, since bromine is a diatomic molecule and should be written as  $\text{Br}_2$ . How would you balance the equation?

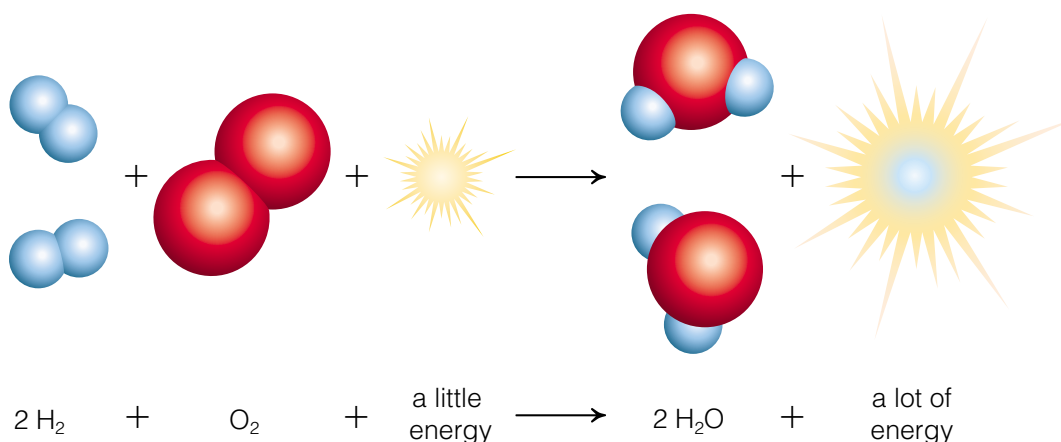
## Breaking Chemical Bonds

Chemical bonds are forces that cause a group of atoms to behave as a unit. Energy is stored in chemical bonds. To break bonds, energy must be added. When bonds form, energy is released.

All chemical reactions involve changes in energy. Energy is either produced or absorbed during a chemical reaction. For example, the burning of wood is a chemical reaction (see Figure 2.51). Cellulose and other substances in the wood combine with the oxygen from the air and produce carbon dioxide and water. Energy, light, and heat are also produced in this reaction. Chemical reactions that give off heat are called **exothermic** reactions. When methane in natural gas is burned in a furnace, energy in the form of heat is created as shown by the equation below:



What are the reactants in this equation? What are the products?



**Figure 2.52** It takes only a small amount of energy to start the reaction between hydrogen and oxygen to form water. The energy released by the reaction is much greater, so the reaction is exothermic.



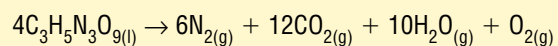
**Figure 2.51** Compounds in wood chemically combine with oxygen when they burn to form water and carbon dioxide.



Off the Wall

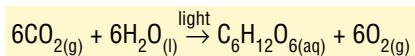
Nitroglycerine is used not only in explosives, it is also used as medicine for heart disease. Tiny amounts of nitroglycerin taken in pills dilate constricted blood vessels.

**Figure 2.53** An explosion is an exothermic reaction. During the reaction of nitroglycerin with the air, so much energy is released that an explosion occurs. Can you name the four gases produced by an explosion of nitroglycerin?



## Pause & Reflect

Do you recognize the following equation? The series of chemical reactions shown below takes place in the presence of chlorophyll.



The equation represents the process of photosynthesis. Is photosynthesis an endothermic or exothermic reaction? Why?

When you eat sugars and starches, you are eating molecules formed by endothermic reactions. Your cells break down these molecules in an exothermic process that supplies your body with energy. The exothermic process is called respiration. How is respiration related to photosynthesis? What do you think is the chemical equation for respiration?

Sometimes energy is absorbed during a chemical change. Chemical reactions that absorb energy are called **endothermic** reactions. Earlier you learned that electricity was necessary to decompose water into oxygen and hydrogen. The reaction does not occur unless energy in the form of an electric current is passed through the water. The absorbed energy is used to change the state of matter and change the forces holding the water together.

Chemical changes occur in all foods when they are cooked. For example, when baking soda ( $\text{NaHCO}_3$ ) is mixed into some kinds of cookie dough, and the dough is baked in a hot oven, a chemical reaction occurs. The baking soda absorbs energy and breaks down into carbon dioxide, water, and sodium carbonate ( $\text{Na}_2\text{CO}_3$ ). The  $\text{CO}_2$  gas and gaseous  $\text{H}_2\text{O}$  (steam) puff up the cookies. Figure 2.55 shows another endothermic reaction.



**Figure 2.54** Both hot and cold packs are available for treating sports injuries. Sometimes, the temperature change is produced by a solute dissolving in water. Hot packs generally use calcium chloride ( $\text{CaCl}_2$ ) and cold packs generally use ammonium nitrate ( $\text{NH}_4\text{NO}_3$ ). Which of these chemicals produces an endothermic reaction?




**Figures 2.55** When ammonium thiocyanate and barium hydroxide octahydrate are mixed, an endothermic reaction occurs. Heat is absorbed from the surroundings. The Erlenmeyer flask becomes very cold. If water is placed on the bottom of the flask, it will freeze the flask to a wooden block.

## Off the Wall

Make-up artists use many chemical reactions to provide special effects on television and in the movies. If an actor is to appear to have skin on his or her arm destroyed by acid, the make-up artist places a thin layer of baking soda in the make-up. When the acid (a mild solution of vinegar) is sprayed, a chemical reaction takes place. The actor's skin appears to melt away. The foaming skin is really carbon dioxide gas and make-up rolling off the actor's arm.

 Initiating and Planning

 Performing and Recording

 Analyzing and Interpreting

 Communication and Teamwork

# Hot Potato, Cold Potato

Hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) combines readily with substances that contain oxygen. Liver and potato both have oxygen in them. Design an investigation to determine the type of reaction that happens when hydrogen peroxide combines with liver and potatoes.

## Question

When hydrogen peroxide is combined with liver or potato slices, are the reactions endothermic or exothermic?

## Safety Precautions



- Hydrogen peroxide can irritate your eyes and skin.
- Be sure to wear protective equipment.
- If you accidentally spill hydrogen peroxide on your skin, wash it off with lots of cool water.

## Apparatus

thermometer  
other apparatus, as approved by your teacher

## Materials

3% hydrogen peroxide  
potato and beef liver slices of varying masses

## Skill

### FOCUS

To find out more about how to design your own investigation, turn to Skill Focus 6.

## Procedure

- 1 Brainstorm with your partners about how you might test whether each reaction is endothermic or exothermic.
- 2 As a group, make a prediction about each reaction. Give a reason why your prediction might be correct.
- 3 Decide what your manipulated variable will be. What will be your control variables? How much hydrogen peroxide will you add to each sample? How will you measure temperature change?

- 4 Create a data table for collecting your data.
- 5 Have your teacher approve your investigation method, data table, and safety precautions.
- 6 Conduct your investigation. Remember to regulate the controlled variables.
- 7 Repeat your investigation several times to collect more data.

## Analyze

1. (a) What was your manipulated variable?  
(b) What was the responding variable?
2. Is the reaction between a potato and hydrogen peroxide endothermic or exothermic? How do you know?
3. Is the reaction between liver and hydrogen peroxide endothermic or exothermic? How do you know?
4. Were your predictions correct? Explain why or why not.

## Conclude and Apply

5. What is the source of the energy for each reaction?
6. Graph your data. Extend your graph to include predictions for the reaction if you had used a stronger solution of hydrogen peroxide and larger pieces of potato or liver.
7. Evaluate the tools, techniques, and processes you used to gather evidence. What improvements could you make?

## Find Out **ACTIVITY**



### Exothermic or Endothermic?

Examine the dissolution of several common solids in water. Is energy produced or absorbed when each solid is dissolved?

#### Materials



5 test tubes  
test tube rack  
test tube brush  
thermometer  
stirring rod  
water  
various solids provided by your teacher  
electronic balance or metric measuring spoons

#### Procedure **Performing and Recording**

1. Measure 15 mL water into a test tube. Set a thermometer in the water. Allow it to come to the water's temperature. Record the temperature. Remove the thermometer from the water.
2. Add 5 g of one of the solids to the water. Stir with a stirring rod until dissolved. Put the thermometer into the solution. Record the temperature.

3. Dispose of the solution as directed by your teacher.
4. Repeat steps 1–3 for each of the solids to be tested.

#### What Did You Find Out? **Analyzing and Interpreting**

1. Which of the solids dissolved exothermically? Which dissolved endothermically?
2. Compare your results with those of other groups. How can you explain any differences in data?
3. Calculate the average of all groups' data for each substance. Display the averages as a graph.

#### Extension

4. Suppose you were designing a cold pack that could be used by medical personnel. Which of the solids you tested could be mixed with water in the pack? Why?

## TOPIC 7 **Review**

### Pause & Reflect

Hydrogen peroxide is often used to bleach colour out of hair. If you were to have your hair bleached blonde, would your head feel cold or hot as the hydrogen peroxide was applied? Why?

1. Describe six types of evidence that might indicate a chemical reaction has occurred.
2. Give two examples of a chemical equation using words. Restate the equations using chemical formulas.
3. What is the difference between an endothermic and an exothermic reaction? Give two examples of each.
4. On which side of the arrow in an equation are the products usually found? On which side are the reactants usually found?