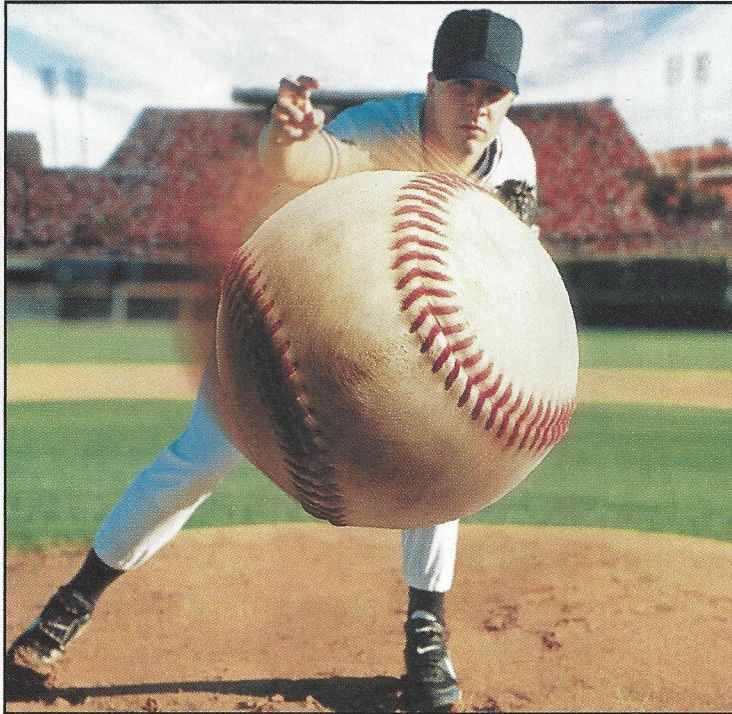


Chapter 14 The Properties of Matter

Chapter 15 Energy and Matter

Chapter 16 Force and Motion

Chapter 17 Machines at Work



*A pitcher throws a baseball very fast. He wants it to cross home plate before the batter can hit it.*

When a pitcher throws a baseball, energy is passed from the pitcher to the ball. The speed of the ball depends partly on how much energy is passed along. The table shows the speed of pitches and the time it takes for each one to get to home plate. Use the table to help you answer the questions.

1. How fast is a ball moving if it takes 1.0 second to travel from the pitcher to home plate?
2. How soon will a ball reach home plate if it is traveling at 50 feet per second?

**Speed and Time for a Ball to Get to Home Plate**

Speed	Time
88 feet per second	0.7 second
65 feet per second	1.0 second
50 feet per second	1.3 seconds



*The large stone in this necklace is called the Hope diamond. It has been valued and admired for hundreds of years. How is the Hope diamond different from the diamonds that surround it?*

## Learning Objectives

- Compare chemistry and physics, the two branches of physical science.
- Identify elements.
- Describe an atom and identify its parts.
- Use properties to identify matter and its three states.
- Explain how density affects mass.
- Compare and contrast compounds, mixtures, and solutions.
- LAB ACTIVITY: Explore how some substances will form solutions and some will not.
- ON-THE-JOB SCIENCE: Relate working with mixtures to making concrete.

## Words to Know

<b>property</b>	a way to describe matter, such as color, shape, odor, and hardness
<b>chemistry</b>	the scientific study of what matter is made of and how it reacts when it comes into contact with other matter
<b>physics</b>	the scientific study of what energy is and how it interacts with matter
<b>electron</b>	a part of an atom that has a negative electrical charge and is found outside the atom's nucleus
<b>neutron</b>	a part of an atom that has no electrical charge and is found inside the atom's nucleus
<b>proton</b>	a part of an atom that has a positive electrical charge and is found inside the atom's nucleus
<b>density</b>	the measure of how much mass something has for its size
<b>solid</b>	matter that has a definite shape and volume
<b>liquid</b>	matter that has a definite volume but no definite shape
<b>gas</b>	matter that has no definite shape or volume
<b>compound</b>	a substance that is formed when the atoms of two or more elements join together chemically
<b>mixture</b>	a substance made of two or more elements or compounds that are mixed together but not chemically joined
<b>solution</b>	a kind of mixture in which one substance dissolves, or seems to disappear, into another substance

## Words to Know

<b>property</b>	a way to describe matter, such as color, shape, odor, and hardness
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<b>proton</b>	a part of an atom that has a positive electrical charge and is found inside the atom's nucleus

## What Is Physical Science?

What do you have in common with a sandwich? How about sand, a race car, a tree, a pig, or the air you breathe? Not much, you might say. Well, you have one important thing in common with all these things. You are made of matter, along with everything on Earth that takes up space.

Matter has properties. A **property** is a way to describe matter. Some properties of matter are color, shape, odor, and hardness. The scientific study of the properties of matter is *physical science*.

✓ **What is the study of the properties of matter called?**

### Remember

Matter is made up of tiny units called atoms. Atoms join to make molecules.

## Physics and Chemistry

There are two branches of physical science. Some physical scientists study what matter is made of and how it reacts when it comes into contact with other matter. This field of study is called **chemistry**. Other scientists focus on energy. They try to understand what energy is and how it interacts with matter. This field of study is called **physics**.

Chemists must understand a lot about physics, however. Physicists must also understand a lot about chemistry. As you read on, you will see that the study of matter and energy go together.

### ✓ How are chemistry and physics related?

## The Elements

All matter is made up of elements. There are at least 112 known elements. Eighty-eight of these elements are found in nature. The rest of the elements have been made in laboratories. Gold, silver, helium, oxygen, and nitrogen are examples of elements found in nature.

Elements are substances that cannot be broken down into simpler substances. Chemists use symbols to write about elements. A symbol is a shorthand way of writing a name. The chart on this page lists some of the elements and their symbols. For example, the symbol for the element hydrogen is H. The symbol for oxygen is O. See the Periodic Table of Elements in Appendix B for the symbols for all the elements.

There are two main groups of elements, *metals* and *nonmetals*. Gold and silver are metals. Helium, oxygen, and nitrogen are nonmetals.

Within the two main groups of elements are smaller groups called *families*. Families of elements share certain characteristics. In the Periodic Table of Elements, different colors show the different families.

Element	Symbol
Aluminum	Al
Arsenic	As
Calcium	Ca
Carbon	C
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Fluorine	F
Gold	Au
Helium	He
Hydrogen	H
Iron	Fe
Lead	Pb
Mercury	Hg
Oxygen	O
Platinum	Pt
Silver	Ag
Sulfur	S
Tin	Sn
Zinc	Zn

Figure 14-1  
*Common elements and symbols*



## Science Fact

Several hundred years ago, a group of scientists called *alchemists* insisted they could turn some common elements into gold. They never did it. For every new discovery in science, there are always many more experiments that fail.

Not all substances that are made of the same element have the same properties. A diamond is one form of the element carbon. A diamond is the hardest natural substance known. Diamonds are used to make cutting tools and, of course, jewelry. Graphite is another form of the element carbon. It is black, soft, and slippery. It is used in the moving parts of machines to help them work more smoothly. It is also what is used in pencils.

✓ **Why are elements considered the simplest substances on Earth?**

## The Structure of an Atom

Elements are made up of atoms. Atoms have four main parts: a nucleus, electrons, neutrons, and protons. This is true for all elements except hydrogen, which has no neutrons.

### The Nucleus

One part of an atom is its central core. This core is called a *nucleus*. A cell has a nucleus, too. However, this nucleus is different from the nucleus of an atom.

### Electrons

An atom has one or more electrons. An **electron** is a part of an atom that has a negative electrical charge. Electrons are found outside the atom's nucleus. Clouds of electrons actually circle around the nucleus. Different elements have different numbers of electrons. A hydrogen atom has only one electron. A uranium atom has 92 electrons. Electrons travel at very high speeds.

### Neutrons and Protons

An atom has neutrons and protons. A **neutron** is a part of an atom that has no electrical charge. Neutrons are found inside the atom's nucleus. A **proton** is also found inside the nucleus. However, protons have a positive electrical charge.

Every atom has the same number of protons as it has electrons. The number of neutrons varies.

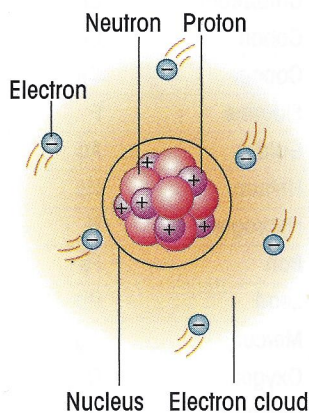


Figure 14-2 *An atom of carbon has six electrons.*

Electrons and protons have opposite electrical charges. They attract each other. This attraction is what holds electrons close to the nucleus of the atom.

✓ What are the four main parts of an atom?

## Lesson Review

1. What are some properties of matter?
2. What are the two branches of physical science?
3. What are the two main groups of elements? Into what smaller groups are they broken down?
4. **CRITICAL THINKING** An atom has 12 protons. How many electrons does the atom have?

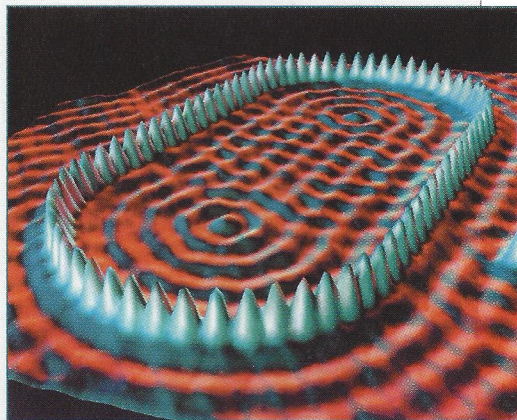
## On the Cutting Edge

### LOOKING AT ATOMS

Everything around you is made up of atoms. However, to see atoms themselves, you need a computer and special microscopes. One such microscope is called the scanning tunneling microscope, or STM.

An STM uses beams of electrons instead of beams of light. The electron beams move over, or scan, a surface. Signals are sent from the microscope to a computer. Then the computer shows an image of the atoms on the surface. The atoms appear as bumps on the surface. Scientists have used STMs to view metals, human tissue, and the twisted-ladder shape of a DNA molecule.

**CRITICAL THINKING** How would it be helpful to see images of atoms?



*Individual atoms appear as bumps or peaks in this computer image from an STM.*

## Words to Know

<b>density</b>	the measure of how much mass something has for its size
<b>solid</b>	matter that has a definite shape and volume
<b>liquid</b>	matter that has a definite volume but no definite shape
<b>gas</b>	matter that has no definite shape or volume
<b>compound</b>	a substance that is formed when the atoms of two or more elements join together chemically
<b>mixture</b>	a substance made of two or more elements or compounds that are mixed together but not chemically joined
<b>solution</b>	a kind of mixture in which one substance dissolves, or seems to disappear, into another substance

## Telling Things Apart

The properties of a substance make it possible to tell it apart from another substance. A few properties of matter are color, shape, odor, and hardness. You could describe an element such as mercury as silver-colored and a liquid. It also does not have a strong smell.

Another property of a substance is its mass. Mass is the amount of matter in something. For example, a volleyball is about the same size as a bowling ball. However, there is much more matter in a bowling ball than in a volleyball. It has a greater mass.

Another property of matter is **density**. Density is the measure of how much mass something has for its size. Scientists define density as the *measure of mass per unit volume*. The meaning of *per unit volume* is “for any given space.” So, density is the amount of mass in a given space.

### Science Fact



Iron pyrite is often called “fool’s gold.” It has many of the same properties as gold. However, a few drops of acid will dissolve iron pyrite and give off a bad smell. Real gold will not change under “the acid test.”



Think of a loaf of bread. Imagine balling it up and squeezing it together as tightly as possible. The balled-up bread would take up less space than the original loaf. It would have a smaller volume than it did before you balled it up. The amount of bread would be the same. The mass per volume, or density, however, would be greater.

Now think of a cork in water. The cork is less dense than water. This causes the cork to float. Lead, however, is denser than water. It sinks to the bottom.

### ✓ How are mass and density related?

## The Three States of Matter

Matter has three different states, or ways of existing. These states are solid, liquid, and gas. A **solid** is matter that has a definite shape and volume. A **liquid** is matter that has a definite volume but no definite shape. A **gas** is matter that has no definite shape or volume.

Matter can change between the different states. For example, water is usually in liquid form. If you freeze water, it becomes a solid, as ice. When a solid melts, it turns back into a liquid. When you heat water, it turns to a colorless gas called water vapor and then disappears. This is called *evaporation*. A gas changes back to liquid during *condensation*. When a cold window fogs up, the fog is water vapor that has turned back into a liquid.

Like solids, liquids have a definite volume. However, they do not have a definite shape. Think of a glass of water. If you poured that water into a bowl, the volume of water would still be the same. It would take up the same amount of space. The shape of the water would change, though. It would take on the shape of the bowl. Now think about moving a solid, such as a peach, from a glass to a bowl. The peach would not change shape or volume.

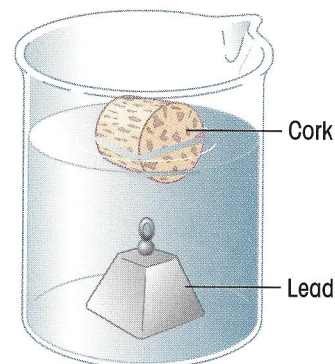


Figure 14-3  
Cork floats in water while lead sinks.

Gas is also matter. That is, it takes up space. However, it does not have a definite shape or a definite volume. A gas will spread out over a container of any size or any shape.

Think of a small bathroom after a hot shower. The water vapor fills the whole bathroom. Suppose you took a shower in a much bigger bathroom. The same amount of water vapor would spread out in the bigger room. Air, hydrogen, helium, oxygen, and carbon dioxide are all gases.

The molecules in all substances are constantly moving. However, the molecules in solids are packed very tightly together. They move very little. The molecules in liquids have more room. They move around more freely. The molecules in gases have even more room to move.

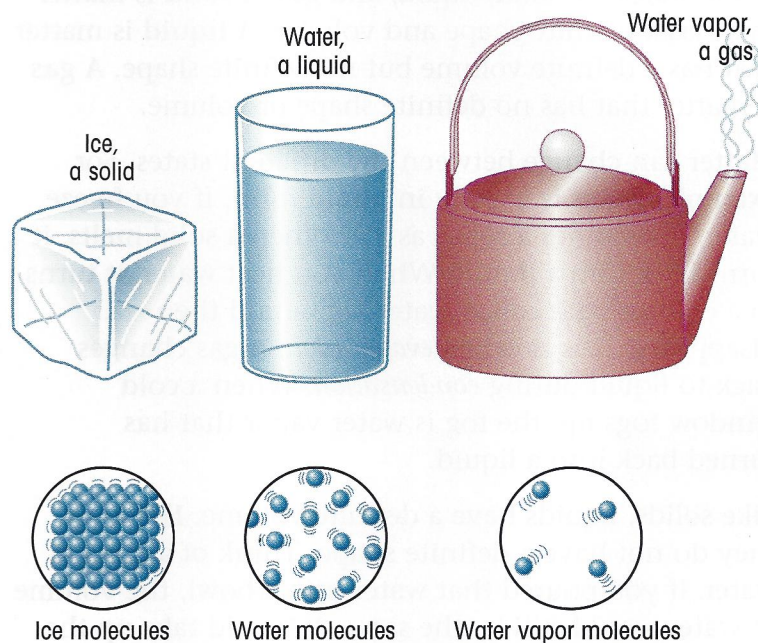


Figure 14-4 *The three states of matter are solid, liquid, and gas.*

✓ What are the three states of matter?

## Compounds, Mixtures, and Solutions

A substance that is formed when the atoms of two or more elements join together chemically is called a **compound**. The elements in a compound have a chemical connection, or *bond*. In most chemical bonds, atoms share electrons. Water is a compound made of oxygen and hydrogen. The oxygen and hydrogen atoms share electrons. Rust is a compound made by a chemical bond of iron and oxygen. Sugar, salt, and soap are also compounds.

A **mixture** is different from a compound. A mixture is a substance made of two or more elements or compounds that are mixed together but not chemically joined. For example, if you mix soil and water, they are still separate. You can pour the mixture through a filter. The soil will stay on the filter, and water will come out the other end.

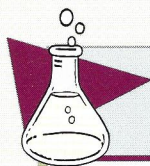
A **solution** is a special kind of mixture. In a solution, one substance *dissolves*, or seems to disappear, when it is put into another. However, it is not gone. It has only spread out evenly throughout the other substance.

Salt water is a solution. If you put a small amount of salt in water, the salt will dissolve. However, if you let the salt water stand in a sunny place for several days, the water will evaporate. You will be left with the salt.

✓ How can different elements join together?

### Lesson Review

1. Which of the three states of matter have a definite volume?
2. How is a mixture different from a compound?
3. **CRITICAL THINKING** Which has greater density, a jar filled with air or a jar filled with water? Explain your answer.



## LAB ACTIVITY

### Part of the Solution

#### BACKGROUND

A mixture can be separated by a filter. A solution cannot. You must use evaporation to separate a solution.

#### PURPOSE

You will add solids to water. Then you will test to see if you have a mixture or solution.

#### MATERIALS

paper, pencil, 4 plastic cups, water, teaspoons, salt, chalk dust, 2 coffee filter papers, 2 saucers

	Does It Dissolve in Water?	Contents of Filter Paper	Contents of Saucer
Solid			
Salt			
Chalk			

#### WHAT TO DO

1. Copy the chart to the right.
2. Fill two of the plastic cups halfway with water.
3. Add a teaspoon of salt to one cup and stir. Then add a teaspoon of chalk dust to the other cup and stir. Record your observations in the second column of the chart.
4. Place one coffee filter paper in the top of another cup. Pour the water-salt mixture into the filter paper.
5. Save the filter paper with any contents in it. Label it. Pour some of the filtered liquid from the cup into a saucer. Let it sit overnight or until the water evaporates.
6. Repeat Steps 4 and 5 on the water-chalk mixture.
7. The next day, compare the contents of the two filter papers and the two saucers. Complete the chart.

#### DRAW CONCLUSIONS

- Which solid dissolved in water and which did not?
- Which solid formed a mixture with the water?
- Which formed a solution with the water?

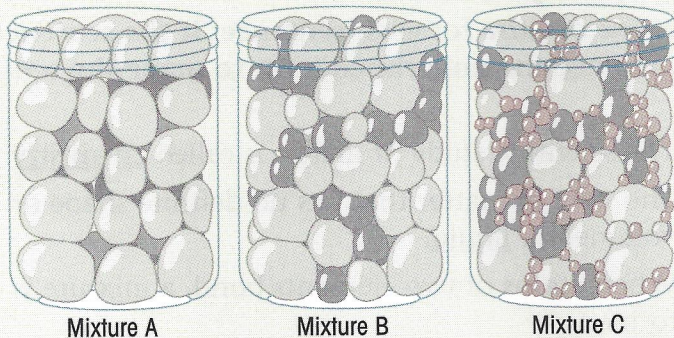
## ON-THE-JOB SCIENCE

### Concrete Worker

Al Hernandez is a concrete worker. He mixes cement, sand, gravel, and water to make a thick, wet mixture of concrete. He then pours the concrete into a mold. The cement in the concrete causes the mixture to harden.

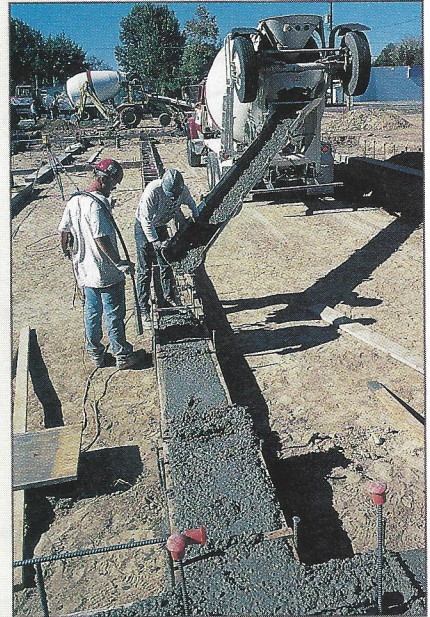
Concrete must contain the correct type and amount of each ingredient. If the wrong type of cement is used, the concrete might not harden correctly. If the concrete contains too much water, sand, or gravel, it might not be strong enough.

Look at the drawings. Note the differences among concrete Mixtures A, B, and C. Concrete will be stronger if the sand and gravel mixture is very dense.



Answer these questions, using the drawings.

1. Which mixture has the most amount of space between particles?
2. Which mixture is most tightly packed? Why?
3. Which mixture above would make the strongest concrete? Why?



*Concrete must have the right mix of ingredients to be strong.*

#### Critical Thinking

When too much water is added to concrete, small holes form in the concrete as it dries. What do you think these holes will do to the concrete?

**Summary**

Properties are used to identify matter. Properties of matter include mass, density, and state.

**Lesson 14.1**

Chemistry and physics are two branches of physical science. Elements are made up of atoms. Atoms contain a nucleus, electrons, neutrons, and protons.

**Lesson 14.2**

The state of matter can be solid, liquid, or gas. When the atoms of elements bond, they form a compound. When they mix but do not bond, they form a mixture. A solution is one kind of mixture.

**Vocabulary Review**

Write *true* or *false* for each sentence. If the sentence is false, replace the underlined term to make the sentence true.

1. The scientific study of matter is called chemistry.
2. The state of matter that has no definite shape or volume is a liquid.
3. When atoms of two elements bond, a mixture is formed.
4. The particle that has no electrical charge and is found in the nucleus of the atom is an electron.
5. A property can be used to identify matter.
6. The scientific study of energy is called physics.
7. Matter with a definite volume and shape is a liquid.
8. The positively charged particle in an atom is a proton.

## Chapter Quiz

Write your answers on a separate sheet of paper.

1. You are studying the properties of an apple. Are you studying chemistry, or are you studying physics? Explain.
2. What are three properties of a pumpkin?
3. What are the four main parts of an atom? Where are they located?
4. What keeps electrons close to the nucleus?
5. What is density a measure of?
6. What happens to a gas when it is moved from a small container into a big container?
7. Are the molecules farther apart in water, steam, or ice? Explain.
8. Iron and oxygen atoms bond to form rust. Is rust a compound or a mixture? Explain.
9. Why is muddy water a mixture and not a compound?
10. What happens to salt when it dissolves in water?

### Test Tip

To study for the test, review the titles of the sections in the chapter. Turn each title into a question. Then read quickly through the section to find the answer to the question.

### Research Project

The breakfast you ate this morning, the clothes you wear, and the book in front of you are all made of compounds. These compounds are made up of elements. Choose an element listed in the Periodic Table of Elements found in Appendix B. Find out all you can about the element's properties. For example, find out its boiling point, melting point, density, and any other properties. The Internet and reference books are good sources of information.