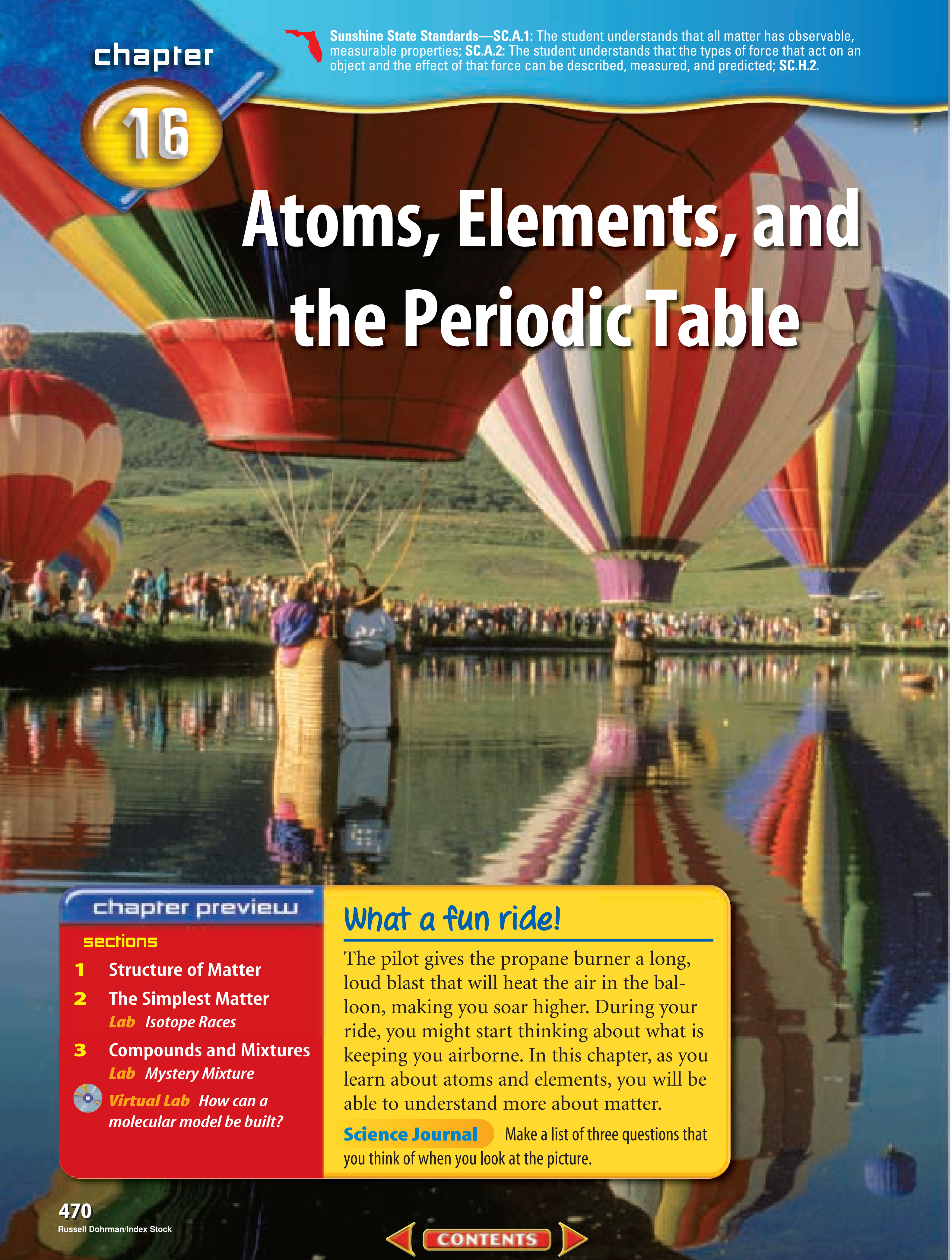


Sunshine State Standards—SC.A.1: The student understands that all matter has observable, measurable properties; **SC.A.2:** The student understands that the types of force that act on an object and the effect of that force can be described, measured, and predicted; **SC.H.2.**

chapter 16

Atoms, Elements, and the Periodic Table

chapter preview

sections

What a fun ride!

The pilot gives the propane burner a long, loud blast that will heat the air in the balloon, making you soar higher. During your ride, you might start thinking about what is keeping you airborne. In this chapter, as you learn about atoms and elements, you will be able to understand more about matter.

Science Journal Make a list of three questions that you think of when you look at the picture.

Russell Dohrman/Index Stock

Start-Up Activities

Launch LAB

SC.H.1.3.5

What is matter?

You've just finished playing basketball. You're hot and thirsty. You reach for your bottle of water and take a drink. Releasing your grip, you notice that the bottle is nearly empty. According to the dictionary, *empty* means "containing nothing." When you have finished the water in the bottle, is it really empty?

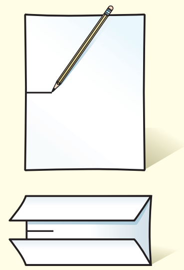
1. Complete a safety worksheet.
2. Inflate two balloons equally. Attach 6 cm of tape along the center of a meterstick. Attach one balloon to each end of the meterstick using tape.
3. Balance the meterstick and balloons on top of a ring stand. On the tape, mark the location where the meterstick is balanced.
4. Put a small hole in one balloon using a pin. Allow the balloon to deflate. Balance the meterstick. Mark the location where the meterstick balances.
5. **Think Critically** Describe your observations in your Science Journal. Explain your observations.

FOLDABLES™ Study Organizer

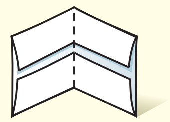
Atoms, Elements, and the Periodic Table Make the following Foldable to help you identify the main ideas about atoms, elements, compounds, and mixtures.

LA.A.1.3.4

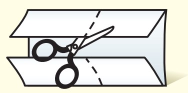
STEP 1 **Draw** a mark at the midpoint of a sheet of paper along the side edge. Then **fold** the top and bottom edges in to touch the midpoint.



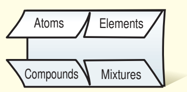
STEP 2 **Fold** in half from side to side.



STEP 3 **Open and cut** along the inside fold lines to form four tabs.



STEP 4 **Label** each tab as shown.



Read and Write As you read the chapter, list several everyday examples of atoms, elements, compounds, and mixtures on the back of the appropriate tab.

Science Online

Preview this chapter's content and activities at fl6.msscience.com

Russell Dohrman/Index Stock

CONTENTS

section 1

Benchmarks—SC.A.2.3.2 (pp. 472–479): The student knows the general properties of the atom (a massive nucleus of neutral neutrons and positive protons surrounded by a cloud of negative electrons) and accepts that single atoms are not visible.

Also covers: SC.D.1.3.5 (p. 475), SC.H.1.3.1 Annually Assessed (pp. 473–479), SC.H.1.3.5 Annually Assessed (p. 471), SC.H.1.3.6 (pp. 473–474), SC.H.3.3.4 (p. 474), SC.H.3.3.5 (pp. 473–478)

Structure of Matter

as you read

What You'll Learn

- **Describe** characteristics of matter.
- **Identify** what makes up matter.
- **Identify** the parts of an atom.
- **Compare** the models that are used for atoms.

Why It's Important

Matter makes up almost everything we see—and much of what we can't see.

Review Vocabulary

✹ **density:** the mass of an object divided by its volume

New Vocabulary

- ✹ **matter**
- ✹ **atom**
- ● law of conservation of matter
- ✹ **electron**
- ✹ **nucleus**
- ✹ **proton**
- ✹ **neutron**

✹ FCAT Vocabulary

What is matter?

Is a glass with some water in it half empty or half full? Actually, neither is correct. The glass is completely full—half full of water and half full of air. What is air? Air is a mixture of several gases, including nitrogen and oxygen, which are kinds of matter. **Matter** is anything that has mass and takes up space. So, even though you can't see it or hold it in your hand, air is matter. What about all the things you can see, taste, smell, and touch? Most are made of matter, too. Look at the things pictured in **Figure 1** and determine which of them are matter.

What isn't matter?

You can see the words on this page because of the light from the Sun or from a fixture in the room. Does light have mass or take up space? What about the warmth from the Sun or the heat from the heater in your classroom? Light and heat do not take up space, and they have no mass. Therefore, they are not forms of matter. Emotions, thoughts, and ideas are not matter either. Does this information change your mind about the items in **Figure 1**?

Reading Check *Why is air matter, but light is not?*

Figure 1 A rainbow is formed when light filters through the raindrops, a plant grows from a seed in the ground, and a statue is sculpted from bronze.
Identify *which are matter.*

Table 1 Early Beliefs About the Composition of Matter

Many Indian Philosophers (1,000 B.C.)	Kashyapa, an Indian Philosopher (1,000 B.C.)	Many Greek Philosophers (500–300 B.C.)	Democritus (380 B.C.)	Aristotle (330 B.C.)	Chinese Philosophers (300 B.C.)
• Ether—an invisible substance that filled the heavens • Earth • Water • Air • Fire	• Five elements broken down into smaller units called parmanu • Parmanu of earth elements are heavier than air elements	• Earth • Water • Air • Fire	• Tiny individual particles he called *atomos* • Empty space through which atoms move • Each substance composed of one type of *atomos*	• Empty space could not exist • Earth • Water • Air • Fire	• Metal • Earth • Water • Air • Fire

What makes up matter?

Suppose you cut a chunk of wood into smaller and smaller pieces. Do the pieces seem to be made of the same matter as the large chunk you started with? If you could cut a small enough piece, would it still have the same properties as the first chunk? Is there a limit to how small a piece can be? For centuries, people have asked questions like these and wondered what matter is made of. Studying how people have made these discoveries will help you understand the inquiry process.

An Early Idea Democritus, who lived from about 460 B.C. to 370 B.C., was a Greek philosopher who thought the universe was made of empty space and tiny bits of stuff. He believed that the bits of stuff were so small they could not be divided into smaller pieces. He called these tiny pieces *atomos*. The term *atom*, which is used today, comes from a Greek word that means "cannot be divided." An **atom** is a small particle that makes up most types of matter. An atom is too small to be seen even with a powerful microscope. **Table 1** shows Democritus's ideas and those of other early scientists and philosophers. Democritus thought that different types of atoms existed for every type of matter and that the atom's identity explained the characteristics of each type of matter. Democritus's ideas about atoms were a first step toward understanding matter. However, his ideas were not accepted for over 2,000 years. In the early 1800s, scientists built upon the concept of atoms to form the current atomic theory of matter.

INTEGRATE History

Atomism Historians note that Leucippus developed the idea of the atom around 440 B.C. He and his student, Democritus, refined the idea of the atom years later. Their concept of the atom was based on five major points: (1) all matter is made of atoms, (2) there are empty spaces between atoms, (3) atoms are complete solids, (4) atoms do not have internal structure, and (5) atoms are different in size, shape, and weight.

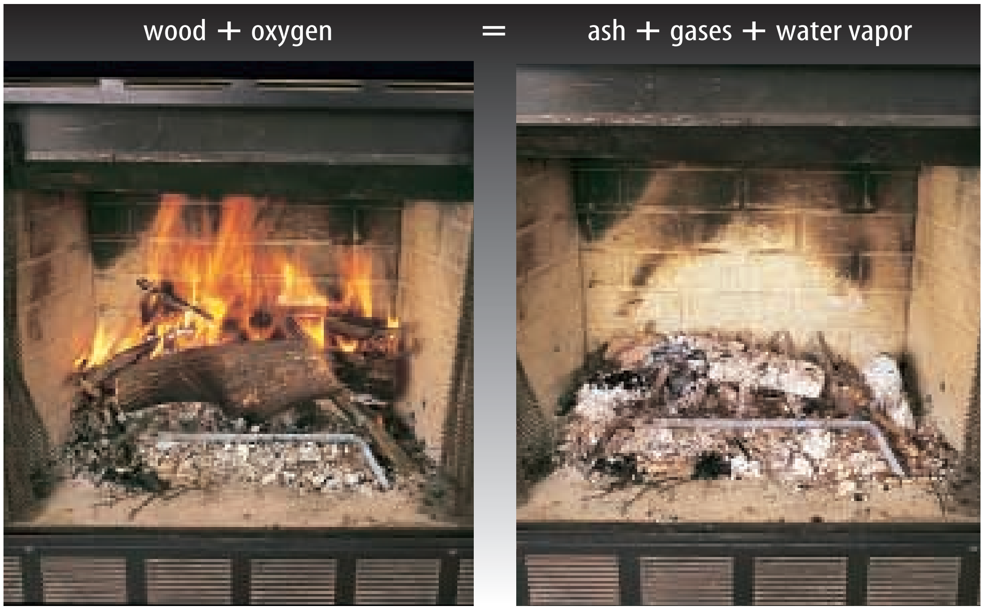


Figure 2 When wood burns, matter is not lost. The total mass of the wood and the oxygen it combines with during a fire equals the total mass of the ash, water vapor, carbon dioxide, and other gases produced.
Infer *When you burn wood in a fireplace, what is the source of oxygen?*

Lavoisier's Contribution Lavoisier (la VWAH see ay), a French chemist who lived about 2,000 years after Democritus, also was curious about matter—especially when it changed form. Before Lavoisier, people thought matter could appear and disappear because of the changes they saw as matter burned or rusted. You might have thought that matter can disappear if you've ever watched wood burn in a fireplace or at a bonfire. Lavoisier showed that wood and the oxygen it combines with during burning have the same mass as the ash, water vapor, carbon dioxide, and other gases that are produced, as shown in **Figure 2.** In a similar way, an iron bar, oxygen, and water have the same mass as the rust that forms when they interact. From Lavoisier's work came the **law of conservation of matter,** which states that matter is not created or destroyed—it only changes form.

Models of the Atom

Models often are used for things that are too small or too large to be observed or that are too difficult to be understood easily. One way to make a model is to make a smaller version of something large. If you wanted to design a new sailboat, would you build a full-sized boat and hope it would float? It would be more efficient, less expensive, and safer to build and test a smaller version first. Then, if it didn't float, you could change your design and build another model. You could keep trying until the model worked.

In the case of atoms, scientists use large models to explain something that is too small to be looked at. These models of the atom were used to explain data or facts that were gathered experimentally. As a result, these models also are theories.

SC.A.2.3.2

Mini LAB

Investigating the Unseen

Procedure

1. Complete a safety worksheet.
2. Your teacher will give you a **sealed shoe box** that contains **one or more items.**
3. What kinds of items are inside the box? You cannot look inside the box. The only observations you can make are by handling the box.

Analysis

1. How many items do you infer are in the box?
2. Compare your procedure with how scientists perform experiments.

Dalton's Atomic Model In the early 1800s, an English schoolteacher and chemist named John Dalton studied the experiments of Lavoisier and others. Dalton thought he could design an atomic model that explained the results of those experiments. Dalton's atomic model was a set of ideas—not a physical object. Dalton believed that matter was made of atoms that were too small to be seen by the human eye. He also thought that each type of matter was made of only one kind of atom. For example, gold atoms make up a gold nugget and give a gold ring its shiny appearance. Likewise, iron atoms make up an iron bar and give it unique properties, and so on. Because predictions using Dalton's model were supported by data, the model became known as the atomic theory of matter.

Sizes of Atoms Atoms are so small it would take about 1 million of them lined up in a row to equal the thickness of a human hair. For another example of how small atoms are, look at **Figure 3.** Imagine you are holding an orange in your hand. If you wanted to be able to see the individual atoms on the orange's surface, the size of the orange would have to be increased to the size of Earth. Then, imagine the Earth-sized orange covered with billions and billions of marbles. Each marble would represent one of the atoms on the skin of the orange. No matter what kind of model you use to picture it, the result is the same—an atom is an extremely small particle of matter.

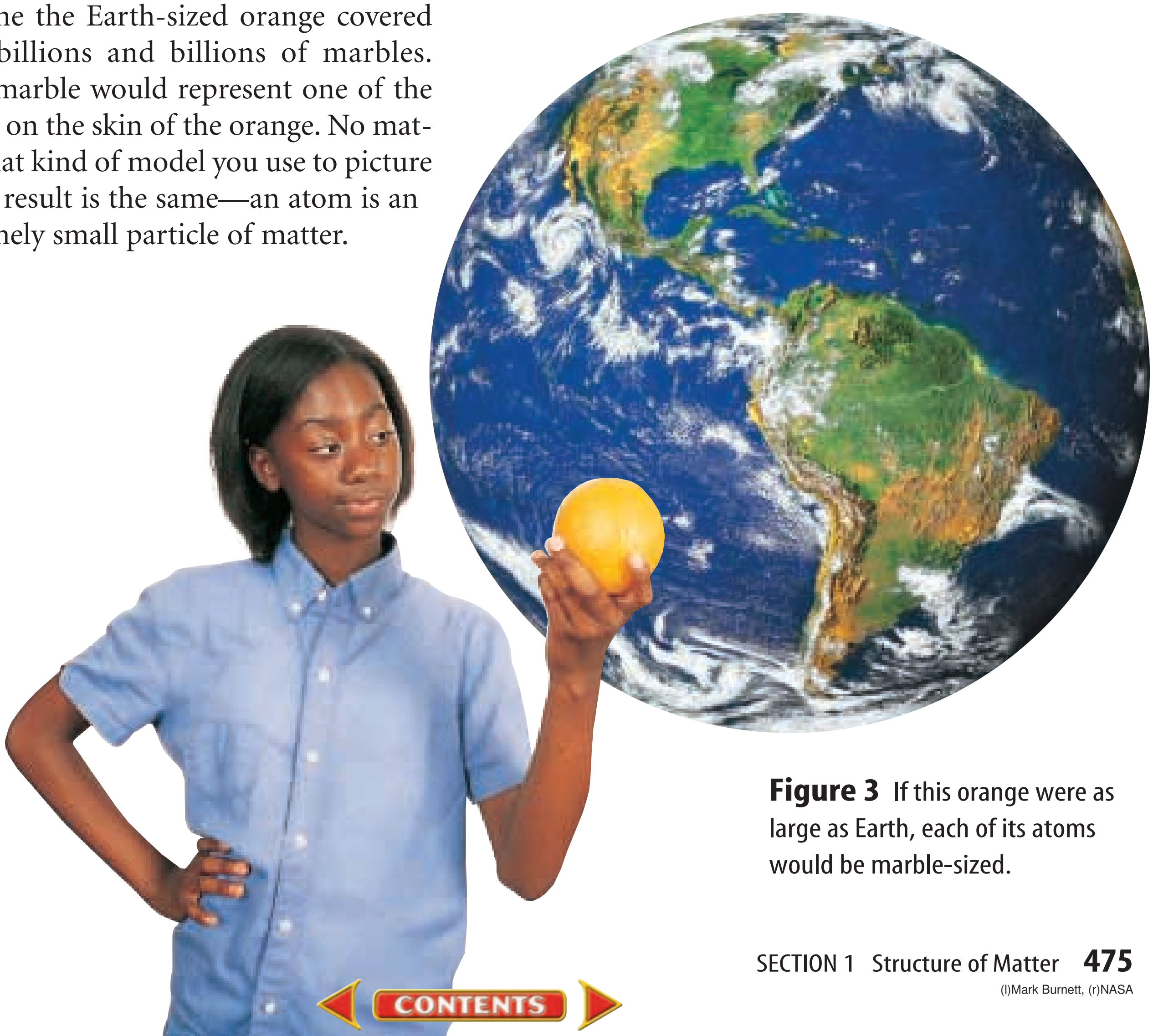
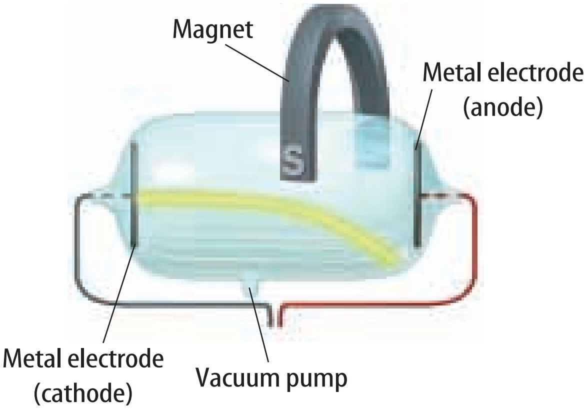


Figure 3 If this orange were as large as Earth, each of its atoms would be marble-sized.

(l)Mark Burnett, (r)NASA



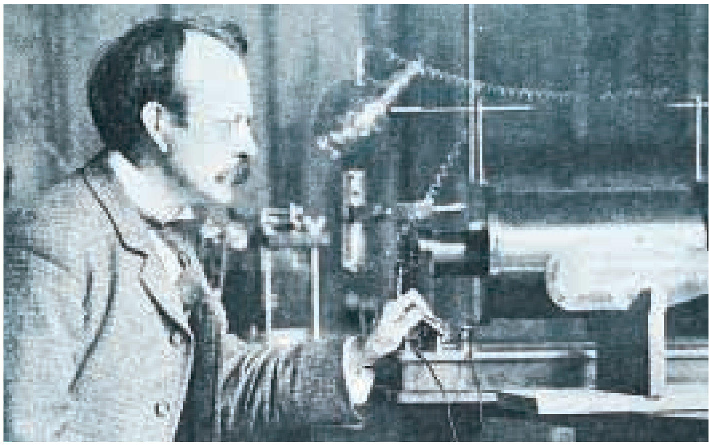


Figure 4 In Thomson's experiment, the magnet caused the cathode rays inside the tube to bend. **Describe** *what you think would happen to the cathode rays if the magnet were removed.*

LA.B.2.3.4

Science Online

Topic: Subatomic Particles
Visit fl6.msscience.com for Web links to information about particles that make up atoms.

Activity Can any of the particles be divided further? Display your data in a table.

Discovering the Electron One of the many pioneers in the development of today's atomic model was J.J. Thomson, an English scientist. He conducted experiments using a cathode-ray tube, which is a glass tube sealed at both ends, out of which most of the air has been pumped. Thomson's tube had a metal plate at each end. The plates were connected to a high-voltage electrical source that gave one of the plates—the anode—a positive charge and the other plate—the cathode—a negative charge. During his experiments, Thomson observed rays that traveled from the cathode to the anode. These cathode rays were bent by a magnet, as seen in **Figure 4,** showing that they were made up of particles that had mass and charge. Thomson knew that like charges repel each other and opposite charges attract each other. When he saw that the rays traveled toward a positively charged plate, he concluded that the cathode rays were made up of negatively charged particles. These invisible, negatively charged particles are called **electrons.**

Reading Check ***Why were the cathode rays in Thomson's cathode-ray tube bent by a magnet?***

Try to imagine Thomson's excitement at this discovery. He had shown that atoms are not too tiny to divide after all. Rather, they are made up of even smaller subatomic particles. Other scientists soon built upon Thomson's results and found that the electron had a small mass. In fact, an electron is 1/1,837 the mass of the lightest atom, the hydrogen atom. In 1906, Thomson received the Nobel Prize in Physics for his work on the discovery of the electron.

Matter that has an equal amount of positive and negative charge is said to be neutral—it has no net charge. Because most matter is neutral, Thomson pictured the atom as a ball of positive charge with electrons embedded in it. It was later determined that neutral atoms contained an equal number of positive and negative charges.

Thomson's Model Thomson's model, shown in **Figure 5,** can be compared to chocolate chips spread throughout a ball of cookie dough. However, the model did not provide all the answers to the questions that puzzled scientists about atoms.

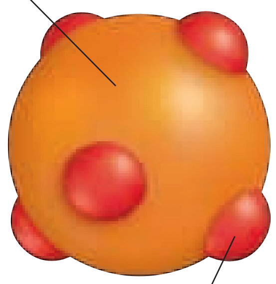


Figure 5 Thomson's model shows the atom as electrons embedded in a ball of positive charge.
Explain *how Thomson knew atoms contained positive and negative charges.*

Rutherford—The Nucleus Scientists still had questions about how the atom was arranged and about the presence of positively charged particles. In about 1910, a team of scientists led by Ernest Rutherford worked on these questions. In their experiment, they bombarded an extremely thin piece of gold foil with alpha particles. Alpha particles are tiny, high-energy, positively charged particles that he predicted would pass through the foil. Most of the particles passed straight through the foil as if it were not there at all. However, other particles changed direction, and some even bounced back. Rutherford thought the result was so remarkable that he later said, "It was almost as incredible as if you had fired a 15-inch shell at a piece of tissue paper, and it came back and hit you."

Positive Center Rutherford concluded that because so many of the alpha particles passed straight through the gold foil, the atoms must be made of mostly empty space. However, because some of the positively charged alpha particles bounced off something, the gold atoms must contain some positively charged object concentrated in the midst of this empty space. Rutherford called the positively charged, central part of the atom the **nucleus** (NEW klee us). He named the positively charged particles in the nucleus **protons**. He also suggested that electrons were scattered in the mostly empty space around the nucleus, as shown in **Figure 6.**

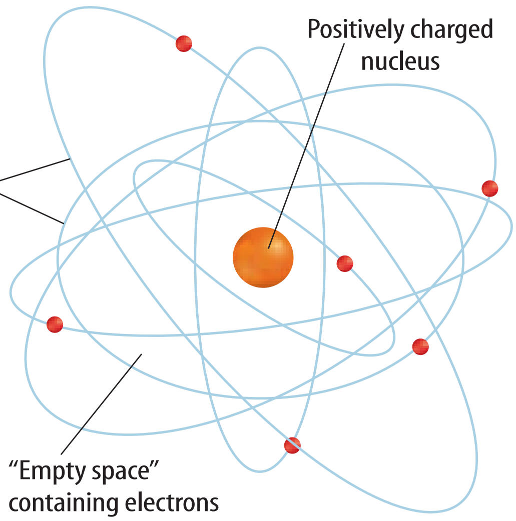


Figure 6 Rutherford concluded that the atom must be mostly empty space, in which electrons travel in random paths around the nucleus. He also thought the nucleus of the atom must be small and positively charged.
Identify *where most of the mass of an atom is concentrated.*

Discovering the Neutron Rutherford had been puzzled by one observation from his experiments with nuclei. After the collisions, the nuclei seemed to be heavier. Where did this extra mass come from? James Chadwick, a student of Rutherford's, answered this question. The alpha particles themselves were not heavier. The atoms that had been bombarded had given off new particles. Chadwick experimented with these new particles and found that, unlike electrons, the paths of these particles were not affected by an electric field. To explain his observations, he said that these particles came from the nucleus and had no charge. Chadwick called these uncharged particles **neutrons** (NEW trahnz). His proton-neutron model of the atomic nucleus is still accepted today.

Improving the Atomic Model

Early in the twentieth century, a scientist named Niels Bohr found evidence that electrons in atoms are arranged according to energy levels. The lowest energy level is closest to the nucleus and can hold only two electrons. Higher energy levels are farther from the nucleus and can contain more electrons. To explain these energy levels, some scientists thought that the electrons might orbit an atom's nucleus in paths that are specific distances from the nucleus, as shown in **Figure 7.** This is similar to how the planets orbit the Sun.

INTEGRATE Career

Physicists and Chemists Physicists generally study the physical atom. The physical atom includes the inner components of an atom, neutrons and protons. Chemists, on the other hand, study the chemical atom. The chemical atom refers to how different elements combine to form new substances.

The Modern Atomic Model As a result of continuing research, scientists now realize that because electrons have characteristics that are similar to waves and particles, their energy levels are not defined, planet-like orbits around the nucleus. Rather, it seems most likely that electrons move in what is called the atom's electron cloud, as shown in **Figure 8.**

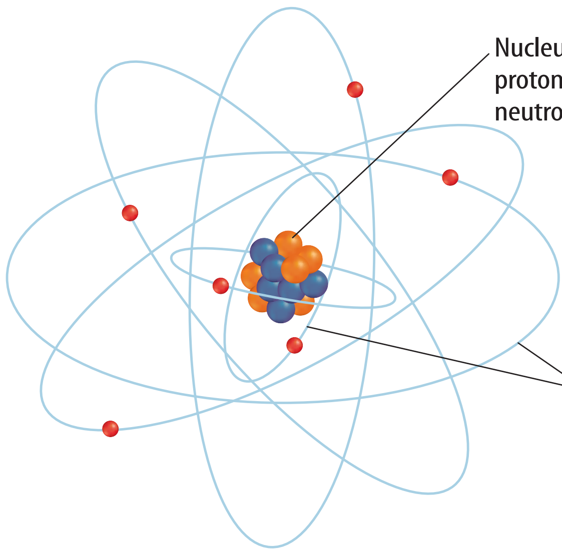


Figure 7 This simplified Bohr model shows a nucleus of protons and neutrons and electron paths based on energy levels. **Determine** *how many electrons this atom contains.*

The Electron Cloud A spherical cloud of varying density surrounding the nucleus is the electron cloud. The varying density shows where an electron is more or less likely to be. Atoms with electrons in higher energy levels have electron clouds of different shapes that also show where those electrons are likely to be. Generally, the electron cloud has a radius 10,000 times that of the nucleus.

Further Research By the 1930s, it was recognized that matter was made up of atoms. The mass of an atom is concentrated in its nucleus, which is made of protons and neutrons. Electrons, which exist in areas outside of the nucleus, account for only a very small fraction of an atom's mass. But scientists continued to study the basic parts of this atom. Today, they have succeeded in breaking down protons and neutrons into even smaller particles called quarks. Quarks have fractional electric charges of $+2/3$ or $-1/3$, unlike the $+1$ charge of a proton or the -1 charge of an electron. Research will continue as new discoveries are made about the structure of matter.

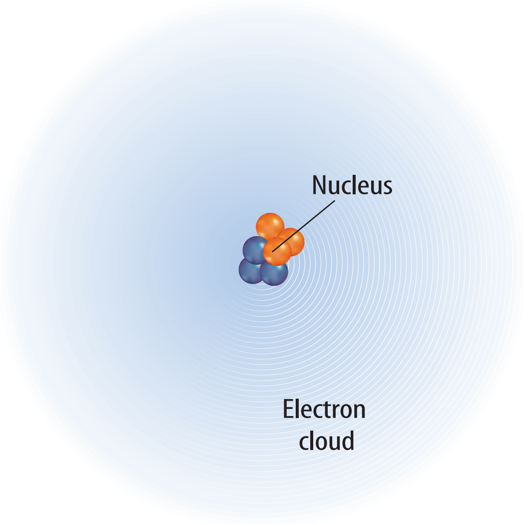


Figure 8 This model of the atom shows the electrons moving around the nucleus in a region called the electron cloud. The dark cloud of color represents the area where the electron is more likely to be found.
Infer *What does the intensity of color near the nucleus suggest?*

section 1 review

Summary

What is matter?

- Matter is anything that has mass and takes up space.
- Matter is composed of atoms.

Models of the Atom

- Democritus introduced the idea of an atom. Lavoisier showed matter is neither created nor destroyed, just changed.
- Dalton's ideas led to the atomic theory of matter.
- Thomson discovered the electron.
- Rutherford discovered protons exist in the nucleus.
- Chadwick discovered the neutron.

Improving the Atomic Model

- Niels Bohr suggested electrons move in energy levels.
- More recent physicists introduced the idea of the electron cloud and were able to break down protons and neutrons into smaller particles called quarks.

Self Check

1. **List** five examples of matter and five examples that are not matter. Explain your answers.
2. **Describe** and name the parts of the atom. SC.A.2.3.2
3. **Explain** why the word *atom* was an appropriate term for Democritus's idea.
4. **Describe** the conclusions that Rutherford obtained from the gold-foil experiment. SC.A.2.3.2
5. **Explain** the law of conservation of matter using your own examples.
6. **Think Critically** When neutrons were discovered, were these neutrons created in the experiment? How does Lavoisier's work help answer this question?

Applying Skills

7. **Classify** each scientist and his contribution according to the type of discovery each person made. Explain why you grouped certain scientists together. SC.H.3.3.5
8. **Evaluate Others' Data and Conclusions** Analyze, review, and critique the strengths and weaknesses of Thomson's "cookie dough" theory using the results of Rutherford's gold-foil experiment.

More Section Review fl6.msscience.com

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Benchmarks—SC.A.2.3.2 (pp. 483–484); SC.H.2.3.1 (pp. 480–482, 484–485): The student recognizes that patterns exist within and across systems.

section 2

Also covers: SC.A.1.3.1 Annually Assessed (pp. 483–485), SC.H.1.3.1 Annually Assessed (p. 482), SC.H.3.3.5 (p. 482)

The Simplest Matter

as you read

What You'll Learn

- **Describe** the relationship between elements and the periodic table.
- **Explain** the meaning of atomic mass and atomic number.
- **Identify** what makes an isotope.
- **Contrast** metals, metalloids, and nonmetals.

Why It's Important

Everything on Earth is made of the elements that are listed on the periodic table.

Review Vocabulary

✱ **mass:** a measure of the amount of matter an object has

New Vocabulary

- ✱ **element**
- atomic number
- isotope
- mass number
- atomic mass
- metal
- nonmetal
- metalloid

✱ FCAT Vocabulary

The Elements

Have you watched television today? TV sets are common, yet each one is a complex system. The outer case is made mostly of plastic, and the screen is made of glass. Many of the parts that conduct electricity are metals or combinations of metals. Other parts in the interior of the set contain materials that barely conduct electricity. All of the different materials have one thing in common: they are made up of even simpler materials. In fact, if you had the proper equipment, you could separate the plastics, glass, and metals into these simpler materials.

One Kind of Atom Eventually, though, you would separate the materials into groups of atoms. At that point, you would have a collection of elements. An **element** is matter made of only one kind of atom. At least 111 elements are known and about 90 of them occur naturally on Earth. These elements combine to form all living and most nonliving things. Examples of naturally occurring elements include the oxygen and nitrogen in the air you breathe and the metals gold, silver, aluminum, and iron. The other elements are known as synthetic elements. These elements have been made in nuclear reactions by scientists with machines called particle accelerators, like the one shown in **Figure 9.** Some synthetic elements have important uses in medical testing and are found in smoke detectors and heart pacemaker batteries.

Figure 9 The Tevatron has a circumference of 6.3 km—a distance that allows particles to accelerate to high speeds. These high-speed collisions can create synthetic elements.

Fermi National Accelerator Laboratory/Science Photo Library/Photo Researchers

Figure 10 When you look for information in the library, a system of organization called the Dewey Decimal Classification System helps you find a book quickly and efficiently.

Dewey Decimal Classification System	
000	Computers, information, and general reference
100	Philosophy and psychology
200	Religion
300	Social sciences
400	Languages
500	Science
600	Technology
700	Arts and recreation
800	Literature
900	History and geography

The Periodic Table

Suppose you go to a library, like the one shown in **Figure 10,** to look up information for a school assignment. How would you find the information? You could look randomly on shelves as you walk up and down rows of books, but the chances of finding your book would be slim. To avoid such haphazard searching, some libraries use the Dewey Decimal Classification System to categorize and organize their volumes to help you find books quickly and efficiently.

Charting the Elements Chemists have created a chart called the periodic table of the elements to help them organize and display the elements. **Figure 11** shows how scientists changed their model of the periodic table over time.

On the inside back cover of this book, you will find a modern version of the periodic table. Each element is represented by a chemical symbol that contains one to three letters. The symbols are a form of chemical shorthand that chemists use to save time and space—on the periodic table as well as in written formulas. The symbols are an important part of an international system that is understood by scientists everywhere.

The elements are organized on the periodic table by their properties. There are rows and columns that represent relationships between the elements. The rows in the table are called periods. The elements in a row have the same number of energy levels. The columns are called groups. The elements in each group have similar properties related to their structure. They also tend to form similar bonds.

LA.B.2.3.4

Science Online

Topic: New Elements
Visit **fl6.msscience.com** for Web links to information about new elements.

Activity Research physical properties of two synthetic elements.

VISUALIZING THE PERIODIC TABLE

NATIONAL GEOGRAPHIC

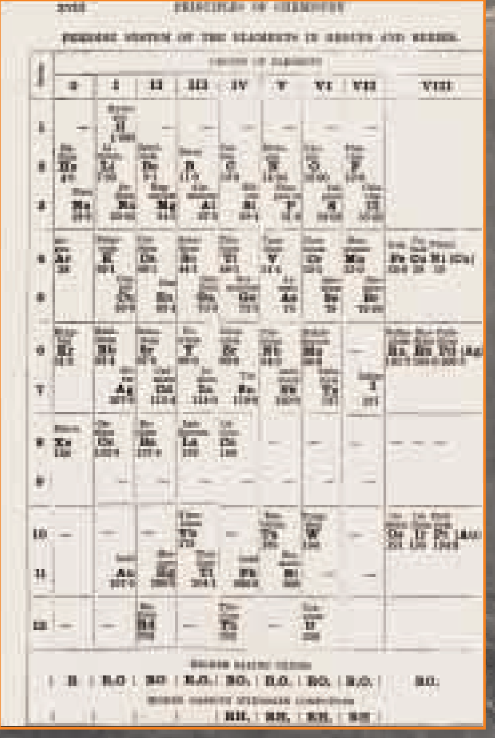
Figure 11

The familiar periodic table that adorns many science classrooms is based on a number of earlier efforts to identify and classify the elements. In the 1790s, one of the first lists of elements and their compounds was compiled by French chemist Antoine-Laurent Lavoisier, who is shown in the background picture with his wife and assistant, Marie Anne. Three other tables are shown here.

John Dalton (Britain, 1803) used symbols to represent elements. His table also assigned masses to each element.

An early alchemist put together this table of elements and compounds. Some of the symbols have their origin in astrology.

Dmitri Mendeleev (Russia, 1869) arranged the 63 elements known to exist at that time into groups based on their chemical properties and atomic weights. He left gaps for elements he predicted were yet to be discovered.



CONTENTS

Identifying Characteristics

Each element is different and has unique properties. These differences can be described in part by looking at the relationships between the atomic particles in each element. The periodic table contains numbers that describe these relationships.

Atomic Number and Protons Look at the element block for chlorine, shown in **Figure 12.** Cl is the symbol for chlorine. The number above the symbol, 17, is the element's atomic number. The **atomic number** of an element is the number of protons in each atom of that element. For example, every atom of chlorine has 17 protons. Its atomic number is 17. Every atom of uranium contains 92 protons. Its atomic number is 92.

Isotopes and Neutrons Atoms of the same element have the same number of protons. However, atoms of the same element might have different numbers of neutrons. For example, some chlorine atoms contain 18 neutrons while others contain 20 neutrons. Atoms of the same element that contain different numbers of neutrons are called **isotopes** (I suh tohps).

Mass Number An atom's **mass number** is the number of protons plus the number of neutrons it contains.

$$\text{mass number} = \text{protons} + \text{neutrons}$$

The mass number of a chlorine atom with 18 neutrons is 35 (18 neutrons + 17 protons). The mass number of a chlorine atom with 20 neutrons is 37 (20 neutrons + 17 protons). An isotope of an element is written with the element symbol followed by its mass number. The isotopes of chlorine are written as Cl-35 and Cl-37. **Table 2** shows the numbers of particles that make up these two isotopes.

Determining the Number of Neutrons If you know the mass number of an atom and the type of element it is, you can determine the number of neutrons in that atom using the following equation:

$$\text{neutrons} = \text{mass number} - \text{protons}$$

Likewise, the number of protons—and thus the element—can be determined if the number of neutrons and the mass number of an atom are known.

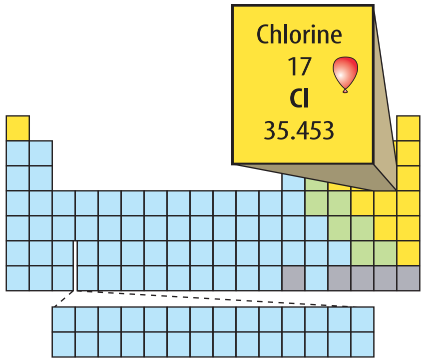


Figure 12 The periodic table block for chlorine shows its symbol, atomic number, and atomic mass.
Determine *if chlorine atoms are more or less massive than carbon atoms.*

Table 2 Chlorine Isotopes

Atomic Property	Cl-35	Cl-37
Mass number	35	37
Atomic number	17	17
Number of protons	17	17
Number of neutrons	18	20
Number of electrons in a neutral atom	17	17

Circle Graph Showing Abundance of Chlorine Isotopes

Average atomic mass = 35.45 u

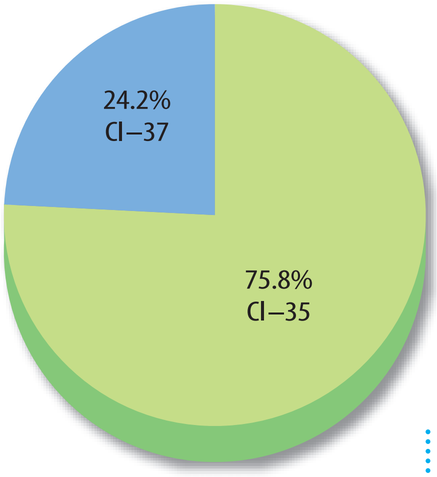


Figure 13 If you have 1,000 atoms of chlorine, about 758 will be chlorine-35 and have a mass of 34.97 u each. About 242 will be chlorine-37 and have a mass of 36.97 u each. The total mass of the 1,000 atoms is 35,454 u.
Calculate *the average mass of one chlorine atom.*

Atomic Mass The **atomic mass** is the weighted average mass of the isotopes of an element. The atomic mass is the number found below the element symbol in **Figure 12.** The unit that scientists use for atomic mass is called the atomic mass unit, which is given the symbol u. It is defined as 1/12 the mass of a carbon-12 atom.

The calculation of atomic mass takes into account the different isotopes of the element. Chlorine's atomic mass of 35.45 u could be confusing because there aren't any chlorine atoms that have that exact mass. About 76 percent of chlorine atoms are chlorine-35 and about 24 percent are chlorine-37, as shown in **Figure 13.** The weighted average mass of all chlorine atoms is 35.45 u.

Reading Check *Where is the atomic mass of each element located on the periodic table?*

Classification of Elements

Elements fall into three general categories—metals, metalloids (ME tuh loydz), and nonmetals. The elements in each category have similar properties.

Metals generally have a shiny or metallic luster and are good conductors of heat and electricity. All metals, except mercury, are solids at room temperature. Metals are malleable (MAL yuh bul), which means they can be bent and pounded into various shapes. The beautiful form of the shell-shaped basin in **Figure 14** is a result of this characteristic. Metals are also ductile, which means they can be drawn into wires without breaking. If you look at the periodic table, you can see that most of the elements are metals.

Figure 14 The artisan is chasing, or chiseling, the malleable metal into the desired form.

Other Elements **Nonmetals** are elements that usually are dull in appearance. Most are poor conductors of heat and electricity. Many are gases at room temperature, and bromine is a liquid. The solid nonmetals generally are brittle, meaning they cannot change shape easily without breaking. The nonmetals are essential to the chemicals of life. More than 97 percent of your body is made up of various nonmetals, as shown in **Figure 15.** You can see that, except for hydrogen, the nonmetals are found on the right side of the periodic table.

Metalloids are elements that have characteristics of metals and nonmetals. On the periodic table, metalloids are found between the metals and nonmetals. All metalloids are solids at room temperature. Some metalloids are shiny and many are conductors, but they are not as good at conducting heat and electricity as metals are. Some metalloids, such as silicon, are used to make the electronic circuits in computers, televisions, and other electronic devices.

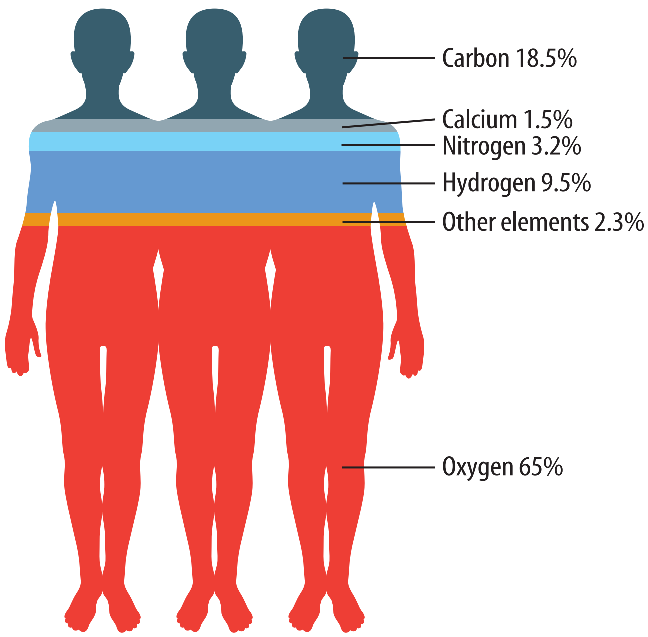


Figure 15 You are made up of mostly nonmetals.
Calculate *How many kilograms of oxygen are in a person that weighs 68 kg?*

Reading Check *What is a metalloid?*

section 2 review

Summary

The Elements

- An element is matter made of only one type of atom.
- Some elements occur naturally on Earth. Synthetic elements are made in nuclear reactions in particle accelerators.
- Elements are divided into three categories based on certain properties.

The Periodic Table

- The periodic table arranges and displays all known elements in an orderly way.
- Each element has a chemical symbol.

Identifying Characteristics

- Each element has a unique number of protons, called the atomic mass number.
- Isotopes of an element are important when determining the atomic mass of an element.

Self Check

1. **Explain** some of the uses of metals based on their properties. SC.A.1.3.1
2. **Describe** the difference between atomic number and atomic mass. SC.A.2.3.2
3. **Define** the term *isotope.* Explain how two isotopes of an element are different. SC.A.2.3.2
4. **Describe** how the periodic table is organized. SC.A.1.3.1
5. **Think Critically** Describe how to find the atomic number for the element oxygen. Explain what this information tells you about oxygen.

Applying Math

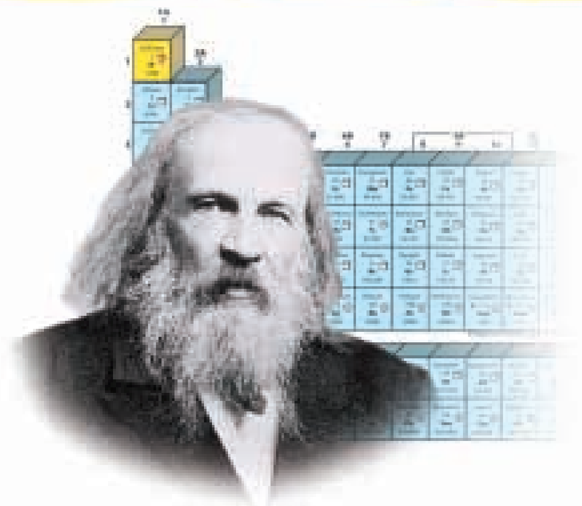
6. **Solve Simple Equations** An atom of niobium has a mass number of 93. How many neutrons are in the nucleus of this atom? An atom of phosphorus has 15 protons and 15 neutrons in the nucleus. What is the mass number of this isotope? SC.A.2.3.2

More Section Review fl6.msscience.com

Benchmark—SC.A.2.3.2: The student knows the general properties of the atom (a massive nucleus of neutral neutrons and positive protons surrounded by a cloud of negative electrons) and accepts that single atoms are not visible.

LAB

Isotope Races



Isotopes of the same element often have very different properties and therefore very different uses. This lab will introduce you to a number of isotopes used in science and the information available in the periodic table.

Real-World Problem

How can you use the periodic table to learn isotope information?

Goals

- **Practice** using the periodic table to find information.
- **Calculate** atomic number and neutron number from an isotope name.

Materials

periodic table
Science Journal
pen or pencil

Procedure

1. Divide into teams of four students and get in lines facing forward. The first one in line should have a periodic table.
2. Your teacher will show the first person in line an isotope name.
3. The first person in line will find the element on the periodic table and show the second person in line what it is.
4. The second person in line will find the atomic number of the isotope and show the third person in line both the element and the atomic number.
5. The third person in line will then calculate the number of neutrons in the isotope and tell the last person in line the element, atomic number, and number of neutrons.
6. The last person in line will report the element name, atomic number, number of neutrons, and mass number of the isotope.
7. Repeat this race with four more isotopes.

Conclude and Apply

1. **Calculate** the percentage of the atomic mass number of chlorine-35 that is composed of neutrons.
2. **Determine** the error in the following: Americium-241 has 146 neutrons and 98 protons.
3. **Identify** the isotope with a mass number of 60 and 33 neutrons.

Communicating Your Data

Prepare a graph of atomic number versus number of neutrons. Place the isotopes in the graph with stable and radioactive isotopes in different colors. Discuss any pattern you detect.

section 3

Benchmarks—SC.A.1.3.1 Annually Assessed (pp. 487–489): The student identifies various ways in which substances differ.

Also covers: SC.H.1.3.5 Annually Assessed (p. 488), SC.H.2.3.1 (p. 487), SC.H.3.3.5 (p. 494)

NASA

Compounds and Mixtures

Substances

Scientists classify matter in several ways that depend on what it is made of and its pattern of behavior. For example, matter that has the same composition and properties throughout is called a **substance.** Elements, such as a bar of gold or a sheet of aluminum, are substances. When different elements combine, other substances are formed.

Compounds What do you call the colorless liquid that flows from the kitchen faucet? You probably call it water, but maybe you've seen it written H_2O. The elements hydrogen and oxygen exist as separate, colorless gases. These two elements can combine, as shown in **Figure 16,** to form the compound water, which is different from the elements that make it up. A **compound** is a substance whose smallest unit is made up of atoms of more than one element bonded together.

Compounds often have properties that are different from the elements that make them up. Water is distinctly different from the elements that make it up. It also is different from another compound made from the same elements. Have you ever used hydrogen peroxide (H_2O_2) to disinfect a cut? This compound is a different combination of hydrogen and oxygen and has different properties from those of water.

Water is a nonirritating liquid that is used for bathing, drinking, cooking, and much more. In contrast, hydrogen peroxide carries warnings on its labels such as *Keep Hydrogen Peroxide Out of the Eyes.* Although it is useful in solutions for cleaning contact lenses, it is not safe for your eyes directly from the bottle.

Figure 16 A space shuttle is powered by the reaction between liquid hydrogen and liquid oxygen. The reaction produces a large amount of energy and the compound water.
Explain *why a car that burns hydrogen rather than gasoline would be friendly to the environment.*

as you read

What You'll Learn

- **Identify** the characteristics of a compound.
- **Compare and contrast** different types of mixtures.

Why It's Important

The food you eat, the materials you use, and all matter can be classified by compounds or mixtures.

Review Vocabulary
formula: shows which elements and how many atoms of each make up a compound

New Vocabulary
- substance
- ✹ mixture
- ✹ compound

✹ FCAT Vocabulary

Figure 17 The elements hydrogen and oxygen can form two compounds—water and hydrogen peroxide.
Compare and contrast *the formulas for hydrogen peroxide and water.*

Mini LAB

SC.A.1.3.1

Comparing Compounds

Procedure

1. Collect the following substances—**granular sugar, rubbing alcohol, salad oil,** and **spoons.**
2. Observe the color, appearance, and state of each substance. Note the thickness or texture of each substance.
3. Stir a spoonful of each substance into separate **containers** of **hot tap water** and observe.

Analysis

1. Compare the different properties of the substances.
2. The three substances are made of only carbon, hydrogen, and oxygen. Infer how they can have different properties.

Try at Home

Compounds Have Formulas What's the difference between water and hydrogen peroxide? H_2O is the chemical formula for water, and H_2O_2 is the formula for hydrogen peroxide. The formula tells you which elements make up a compound as well as how many atoms of each element are present. Look at **Figure 17.** The subscript number written below and to the right of each element's symbol tells you how many atoms of that element exist in one unit of that compound. For example, hydrogen peroxide has two atoms of hydrogen and two atoms of oxygen. Water is made up of two atoms of hydrogen and one atom of oxygen.

Carbon dioxide, CO_2, is another common compound. Carbon dioxide is made up of one atom of carbon and two atoms of oxygen. Carbon and oxygen also can form the compound carbon monoxide, CO, which is a gas that is poisonous to all warm-blooded animals. As you can see, no subscript is used when only one atom of an element is present. A given compound always is made of the same elements in the same proportion. For example, water always has two hydrogen atoms for every oxygen atom, no matter what the source of the water is. No matter what quantity of the compound you have, the formula of the compound always remains the same. If you have 12 atoms of hydrogen and six atoms of oxygen, the compound is still written H_2O, but you have six molecules of H_2O ($6\ H_2O$), not $H_{12}O_6$. The formula of a compound communicates its identity and makeup to any scientist in the world.

Reading Check ***Propane has three carbon and eight hydrogen atoms. What is its chemical formula?***

Mark Burnett

Mixtures

When two or more substances (elements or compounds) come together but don't combine to make a new substance, a **mixture** results. Unlike compounds, the proportions of the substances in a mixture can be changed without changing the identity of the mixture. For example, if you put some sand into a bucket of water, you have a mixture of sand and water. If you add more sand or more water, it's still a mixture of sand and water. Its identity has not changed. Air is another mixture. Air is a mixture of nitrogen, oxygen, and other gases, which can vary at different times and places. Whatever the proportion of gases, it is still air. Even your blood is a mixture that can be separated, as shown in **Figure 18,** by a machine called a centrifuge.

Reading Check *How do the proportions of a mixture relate to its identity?*

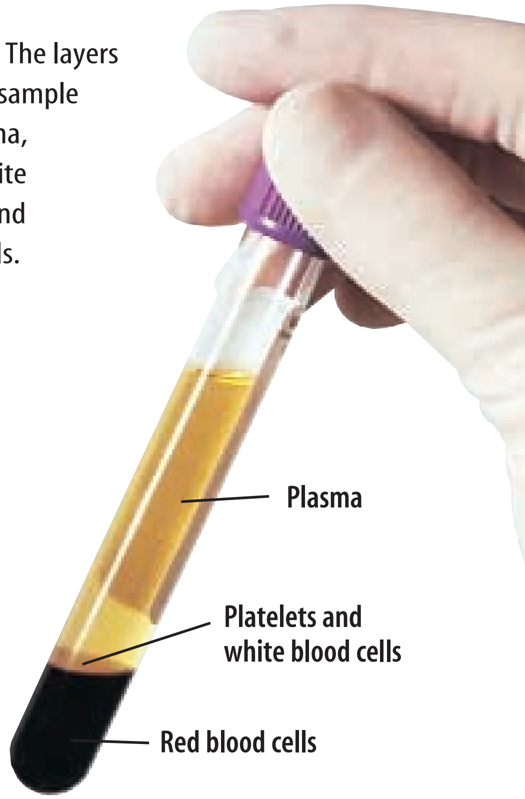


Figure 18 The layers in this blood sample include plasma, platelets, white blood cells, and red blood cells.

Applying Science

What's the best way to desalt ocean water?

You can't drink ocean water because it contains salt and other suspended materials. Or can you? In many areas of the world, drinking water is in short supply. Methods for getting the salt out of salt water are being used to meet the demand for freshwater. Use your problem-solving skills to find the best method to use in a particular area.

Methods for Desalting Ocean Water

Process	Amount of Water a Unit Can Desalt in a Day (m^3)	Special Needs	Number of People Needed to Operate
Distillation	1,000 to 200,000	lots of energy to boil the water	many
Electrodialysis	10 to 4,000	stable source of electricity	1 to 2 persons

Identifying the Problem

The table above compares desalting methods. In distillation, the ocean water is heated. Pure water boils off and is collected, and the salt is left behind. Electrodialysis uses an electric current to pull salt particles out of water.

Solving the Problem

1. What method(s) might you use to desalt the water for a large population where energy is plentiful?
2. What method(s) would you choose to use in a single home?

Figure 19 Mixtures are part of your everyday life.

INTEGRATE Life Science Your blood is a mixture made up of elements and compounds. It contains white blood cells, red blood cells, water, and a number of dissolved substances. The different parts of blood can be separated and used by doctors in different ways. The proportions of the substances in your blood change daily, but the mixture does not change its identity.

Separating Mixtures Sometimes you can use a liquid to separate a mixture of solids. For example, if you add water to a mixture of sugar and sand, only the sugar dissolves in the water. The sand then can be separated from the sugar and water by pouring the mixture through a filter. Heating the remaining solution will separate the water from the sugar.

At other times, separating a mixture of solids of different sizes might be as easy as pouring them through successively smaller sieves or filters. A mixture of marbles, pebbles, and sand could be separated in this way.

Science Online

Topic: Mixtures

Visit fl6.msscience.com for Web links to information about separating mixtures.

Activity Describe the difference between mixtures and compounds.

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Homogeneous or Heterogeneous Mixtures, such as the ones shown in **Figure 19,** can be classified as homogeneous or heterogeneous. *Homogeneous* means "the same throughout." You can't see the different parts in this type of mixture. In fact, you might not always know that homogeneous mixtures are mixtures because you can't tell by looking. Which mixtures in **Figure 19** are homogeneous? No matter how closely you look, you can't see the individual parts that make up air or the parts of the mixture called brass in the lamp shown. Homogeneous mixtures can be solids, liquids, or gases.

A heterogeneous mixture has larger parts that are different from each other. You can see the different parts of a heterogeneous mixture, such as sand and water. How many heterogeneous mixtures are in **Figure 19?** A pepperoni and mushroom pizza is a tasty kind of heterogeneous mixture. Other examples of this kind of mixture include tacos, vegetable soup, a toy box full of toys, or a toolbox full of nuts and bolts.

LA.A.2.3.5

INTEGRATE Earth Science

Rocks and Minerals Scientists called geologists study rocks and minerals. A mineral is composed of a pure substance. Rocks are mixtures and can be described as being homogeneous or heterogeneous. Research to learn more about rocks and minerals and note some examples of homogeneous and heterogeneous rocks in your Science Journal.

section 3 review

Summary

Substances

- A substance can be either an element or a compound.
- A compound contains more than one kind of element bonded together.
- A chemical formula shows which elements and how many atoms of each make up a compound.

Mixtures

- A mixture contains substances that are not chemically bonded together.
- There are many ways to separate mixtures based on their physical properties.
- Homogeneous mixtures are those that are the same throughout. These types of mixtures can be solids, liquids, or gases.
- Heterogeneous mixtures have larger parts that are different from each other.

Self Check

1. **List** three examples of compounds and three examples of mixtures. Explain your choices.
2. **Determine** A container contains a mixture of sand, salt, and pebbles. How can each substance be separated from the others? SC.A.1.3.1
3. **Think Critically** Explain whether your breakfast was a compound, a homogeneous mixture, or a heterogeneous mixture. SC.A.1.3.1

Applying Skills

4. **Compare and contrast** compounds and mixtures based on what you have learned from this section.
5. **Use a Database** Use a computerized card catalog or database to find information about one element from the periodic table. Include information about the properties and uses of the mixtures and/or compounds in which the element is frequently found.

More Section Review fl6.msscience.com

KS Studios

LAB

Benchmark—SC.A.1.3.1: The student identifies various ways in which substances differ (e.g., mass, volume, shape, density, texture, and reaction to temperature and light); SC.H.1.3.5: The student knows that a change in one or more variables may alter the outcome of an investigation.

Mystery Mixture

Goals
- **Test** for the presence of certain compounds.
- **Decide** which of these compounds are present in an unknown mixture.

Materials
test tubes (4)
cornstarch
powdered sugar
baking soda
small scoops (4)
dropper bottles (2)
iodine solution
white vinegar
hot plate
250-mL beaker
water (125 mL)
test-tube holder
small pie pan

Safety Precautions

Complete a safety worksheet before you begin.

WARNING: *Use caution when handling hot objects. Substances could stain or burn clothing. Be sure to point the test tube away from your face and your classmates while heating.*

Real-World Problem

You will encounter many compounds that look alike. For example, a laboratory stockroom is filled with white powders. It is important to know what each is. In a kitchen, cornstarch, baking powder, and powdered sugar are compounds that look alike. To avoid mistaking one for another, you can learn how to identify them. Different compounds can be identified by using chemical tests. For example, some compounds react with certain liquids to produce gases. Other combinations produce distinctive colors. Some compounds have high melting points. Others have low melting points. How can the compounds in an unknown mixture be identified by experimentation?

Procedure

1. Copy the data table below into your Science Journal. Record your results carefully for each of the following steps.
2. Place a small scoopful of cornstarch on the pie pan. Do the same for the sugar and baking soda, making separate piles. Add a drop of vinegar to each. Wash and dry the pan after you record your observations.
3. Place a small scoopful of cornstarch, sugar, and baking soda on the pie pan. Add a drop of iodine solution to each one. Wash and dry the pan after you record your observations.
4. Place a small scoopful of each compound in a separate test tube. Use only enough solid to fill the bottom, rounded portion of the test tubes. Hold the test tubes with the test-tube holder. Gently heat each test tube in a beaker of boiling water on a hot plate. Record your observations.
5. Follow steps 2 through 4 to test your mystery mixture for each compound.

Identifying Presence of Compounds

Substance to Be Tested	Fizzes with Vinegar	Turns Blue with Iodine	Melts when Heated
Cornstarch			
Sugar		Do not write in this book.	
Baking soda			
Mystery mix			

Analyze Your Data

Identify from your data table which compound(s) you have as your mystery mixture.

Conclude and Apply

1. **Describe** how you decided which substances were in your mystery mixture.
2. **Explain** how you would be able to tell if none of the three compounds were in your mystery mixture.
3. **Draw a Conclusion** What would you conclude if you tested baking powder from your kitchen and found that it fizzed with vinegar, turned blue with iodine, and did not melt when heated?
4. **Identify** possible sources of error in your results.

Communicating Your Data

Make a different data table to display your results in a new way. **For more help, refer to the Science Skill Handbook.**

Ancient Views of Matter

Two cultures observed the world around them differently

The world's earliest scientists were people who were curious about the world around them and who tried to develop explanations for the things they observed. This type of observation and inquiry flourished in ancient cultures such as those found in India and China. Read on to see how the ancient Indians and Chinese defined matter.

Indian Ideas

To Indians living about 3,000 years ago, the world was made up of five elements: fire, air, earth, water, and ether, which they thought of as an unseen substance that filled the heavens. Building upon this concept, the early Indian philosopher Kashyapa (kah SHI ah pah) proposed that the five elements could be broken down into smaller units called parmanu (par MAH new). Parmanu were similar to atoms in that they were too small to be seen but still retained the properties of the original element. Kashyapa also believed that each type of parmanu had unique physical and chemical properties.

Parmanu of earth elements, for instance, were heavier than parmanu of air elements. The different properties of the parmanu determined the characteristics of a substance. Kashyapa's ideas about matter are similar to those of the Greek philosopher Democritus, who lived centuries after Kashyapa.

Chinese Ideas

The ancient Chinese also broke matter down into five elements: fire, wood, metal, earth, and water. Unlike the early Indians, however, the Chinese believed that the elements constantly changed form. For example, wood can be burned and thus changes to fire. Fire eventually dies down and becomes ashes, or earth. Earth gives forth metals from the ground. Dew or water collects on these metals, and the water then nurtures plants that grow into trees, or wood.

This cycle of constant change was explained in the fourth century B.C. by the philosopher Tsou Yen. Yen, who is known as the founder of Chinese scientific thought, wrote that all changes that took place in nature were linked to changes in the five elements.

Research Write a brief paragraph that compares and contrasts the ancient Indian and Chinese views of matter. How are they different? Similar? Which is closer to the modern view of matter? Explain. LA.B.2.3.1

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Reviewing Main Ideas

Section 1 Structure of Matter

1. Matter is anything that occupies space and has mass.
2. Matter is made up of atoms.
3. Atoms are made of smaller parts called protons, neutrons, and electrons.
4. Many models of the atom have been created as scientists try to discover and define the atom's internal structure. Today's model has a central nucleus with the protons and neutrons, and an electron cloud surrounding it.

Section 2 The Simplest Matter

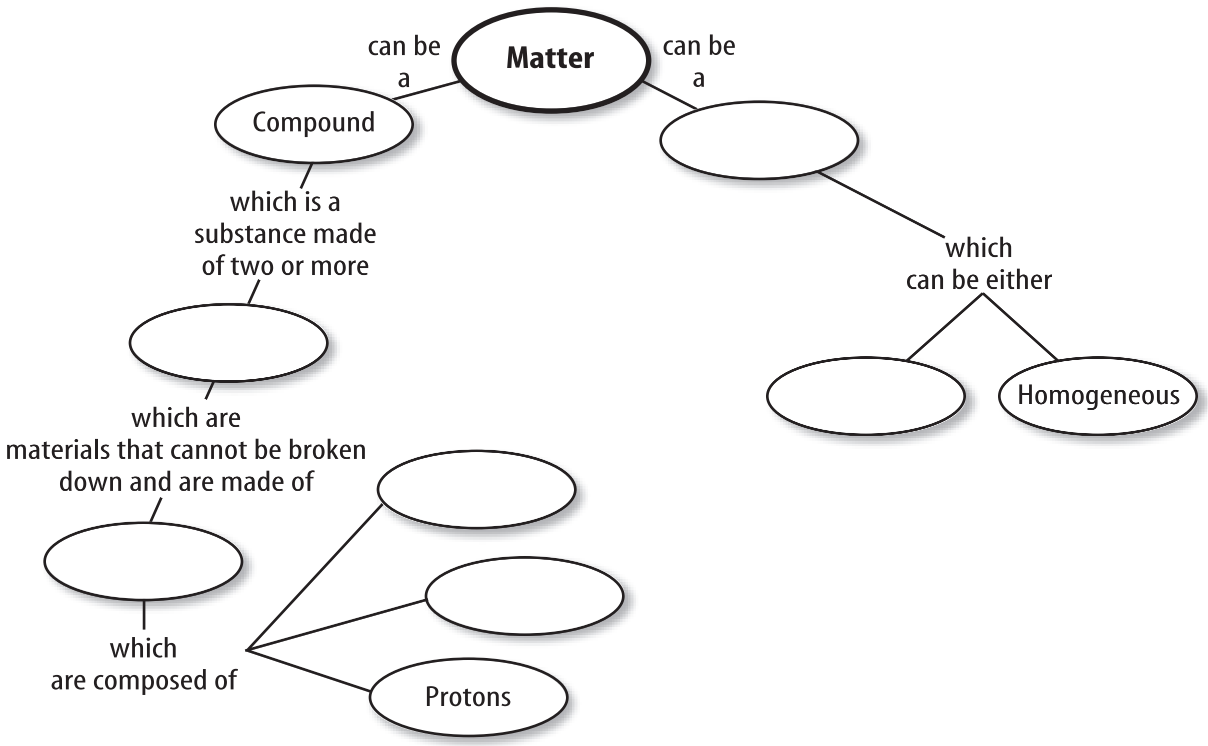
1. Elements are the building blocks of matter.
2. An element's atomic number tells how many protons its atoms contain, and its atomic mass tells the average mass of its atoms.
3. Isotopes are two or more atoms of the same element that have different numbers of neutrons.

Section 3 Compounds and Mixtures

1. Compounds are substances that are produced when elements combine. Compounds contain specific proportions of the elements that make them up.
2. Mixtures are combinations of compounds and elements that have not formed new substances. Their proportions can change.

Visualizing Main Ideas

Copy and complete the following concept map.



chapter 16 Review

Using Vocabulary

✸ **atom** p. 473	✸ **matter** p. 472
atomic mass p. 484	metal p. 484
atomic number p. 483	metalloid p. 485
✸ **compound** p. 487	✸ **mixture** p. 489
✸ **electron** p. 476	✸ **neutron** p. 478
✸ **element** p. 480	nonmetal p. 485
isotope p. 483	✸ **nucleus** p. 477
law of conservation of matter p. 474	✸ **proton** p. 477
mass number p. 483	substance p. 487

✸ FCAT Vocabulary

Fill in the blanks with the correct vocabulary word or words.

1. The ________ is the particle in the nucleus of the atom that carries a positive charge and is counted to identify the atomic number. SC.A.2.3.2

2. The new substance formed when elements combine chemically is a(n) ________.

3. Anything that has mass and takes up space is ________.

4. The particles in the atom that account for most of the mass of the atom are protons and ________. SC.A.2.3.2

5. Elements that are shiny, malleable, ductile, good conductors of heat and electricity, and make up most of the periodic table are ________. SC.A.1.3.1

Checking Concepts

Choose the word or phrase that best answers the question.

6. What is a solution an example of?
- **A)** element
- **B)** heterogeneous mixture
- **C)** compound
- **D)** homogeneous mixture

7. The nucleus of one atom contains 12 protons and 12 neutrons, while the nucleus of another atom contains 12 protons and 16 neutrons. What are the atoms? SC.A.1.3.1
- **A)** chromium atoms
- **B)** two different elements
- **C)** two isotopes of an element
- **D)** negatively charged

8. Copper (Cu) has 29 protons and 39 neutrons. What is the atomic number for copper? SC.A.2.3.2
- **A)** 10
- **B)** 29
- **C)** 39
- **D)** 68

9. What does the atom consist of? SC.A.2.3.2
- **A)** electrons, protons, and alpha particles
- **B)** neutrons and protons
- **C)** electrons, protons, and neutrons
- **D)** elements, protons, and electrons

10. In an atom, where is an electron located? SC.A.2.3.2
- **A)** in the nucleus with the proton
- **B)** on the periodic table of the elements
- **C)** with the neutron
- **D)** in a cloudlike formation surrounding the nucleus

11. How is matter defined?
- **A)** the negative charge in an atom
- **B)** anything that has mass and occupies space
- **C)** the mass of the nucleus
- **D)** sound, light, and energy

12. What are two atoms that have the same number of protons called? SC.A.2.3.2
- **A)** metals
- **B)** nonmetals
- **C)** isotopes
- **D)** metalloids

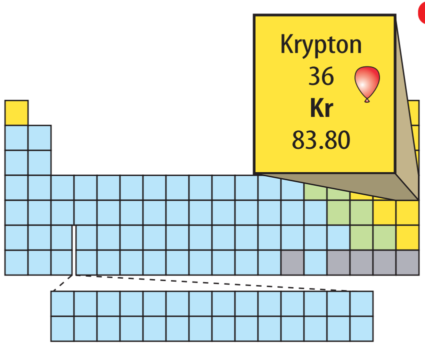
13. Which is a heterogeneous mixture? SC.A.1.3.1
- **A)** air
- **B)** brass
- **C)** a salad
- **D)** apple juice

Vocabulary PuzzleMaker fl6.msscience.com

CONTENTS

Use the illustration below to answer questions 14 and 15.

SC.A.2.3.2



14. Using the figure above, krypton has
A) an atomic number of 84.
B) an atomic number of 36.
C) an atomic mass of 36.
D) an atomic mass of 72.

15. From the figure, the element krypton is
A) a solid. **C)** a mixture.
B) a liquid. **D)** a gas.

Thinking Critically

16. Analyze Information A chemical formula is written to indicate the makeup of a compound. What is the ratio of sulfur atoms to oxygen atoms in SO_2?

17. Determine which element contains seven electrons and seven protons. SC.A.2.3.2

18. Determine Using the periodic table, what are the atomic numbers for carbon (C), sodium (Na), and nickel (Ni)? SC.A.2.3.2

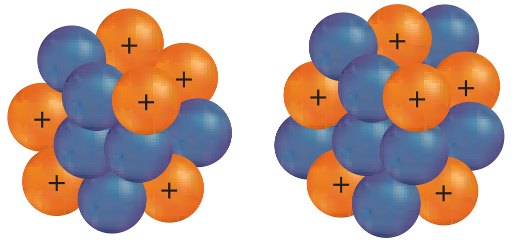
19. Explain how cobalt-60 and cobalt-59 can be the same element but have different mass numbers. SC.A.1.3.1

20. Analyze Information What did Rutherford's gold-foil experiment tell scientists about atomic structure?

21. Predict Suppose Rutherford had bombarded aluminum foil with alpha particles instead of the gold foil he used in his experiment. What observations do you predict Rutherford would have made? Explain your prediction.

22. Draw Conclusions You are shown a liquid that looks the same throughout. You're told that it contains more than one type of element and that the proportion of each varies throughout the liquid. Is this an element, a compound, or a mixture?

Use the illustrations below to answer question 23.



23. Interpret Scientific Illustrations Look at the two carbon atoms above. Explain whether or not the atoms are isotopes. SC.A.1.3.1

24. Explain how the atomic mass of krypton was determined. SC.A.2.3.2

Performance Activities

25. Newspaper Article As a newspaper reporter in the year 1896, you have heard about the discovery of the electron. Research and write a newspaper article about the scientist and the discovery.

Applying Math

SC.A.2.3.2

26. Atomic Mass Krypton (Kr) has six naturally occurring isotopes with atomic masses of 78, 80, 82, 83, 84, and 86. Make a table of the number of protons, electrons, and neutrons in each isotope.

27. Atomic Ratio A researcher is analyzing two different compounds, sulfuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2). What is the ratio of hydrogen to oxygen in sulfuric acid? What is the ratio of hydrogen to oxygen in hydrogen peroxide? SC.A.1.3.1

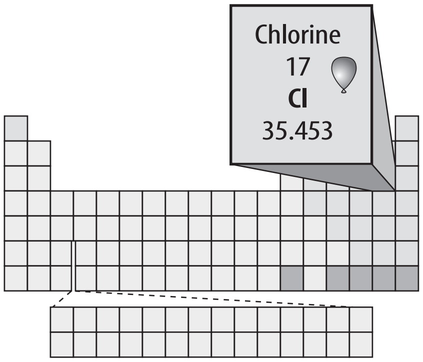
The assessed Florida Benchmark appears above each question.

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Multiple Choice

SC.A.2.3.2

1 The diagram below shows some properties of chlorine.



What does the number 35.453 represent?

A. the average atomic mass of a chlorine atom

B. the number of neutrons in every chlorine atom

C. the number of protons in every chlorine atom

D. the number of neutrons and protons in every chlorine atom

SC.A.1.3.1

2 Which characteristic is typical of a solid, nonmetal element?

F. shiny

G. brittle

H. good heat conductor

I. good electrical conductor

SC.H.2.3.1

3 How are the elements in the periodic table organized?

A. by atomic weight

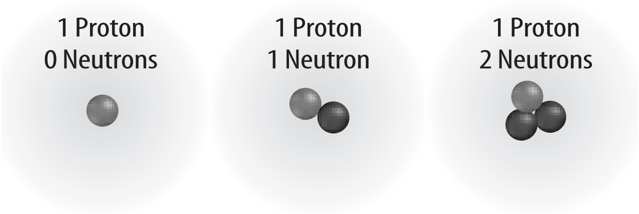
B. by their structures

C. by their properties

D. by name

SC.A.2.3.2

4 The illustration below shows three different atoms.



Which correctly identifies the three atoms shown in the diagram?

F. They are all isotopes of chlorine.

G. They are all isotopes of helium.

H. They are all isotopes of hydrogen.

I. They are all isotopes of lithium.

SC.A.1.3.1

5 What state of matter are metalloids at room temperature?

A. gas

B. liquid

C. plasma

D. solid

SC.H.1.3.2

6 Democritus first proposed that matter is made up of tiny particles called atoms. Which term **best** describes Democritus's proposal about matter?

F. It was an experiment.

G. It was a hypothesis.

H. It was a law.

I. It was a theory.

Gridded Response

SC.A.1.3.1

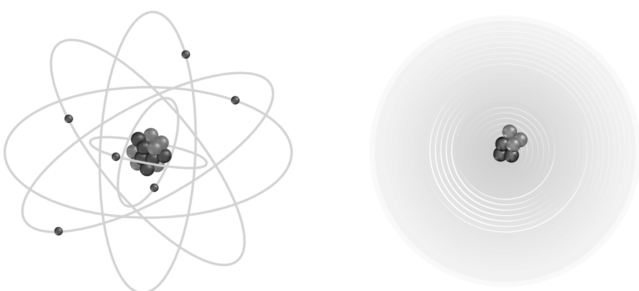
7 Carbon-14 is an isotope of the element carbon. How many protons does Carbon-14 have?

Short Response

READ INQUIRE EXPLAIN

SC.H.1.3.1

8 The diagram below shows examples of Bohr's atomic model and the modern atomic model. Explain how these two models are similar and how they are different.

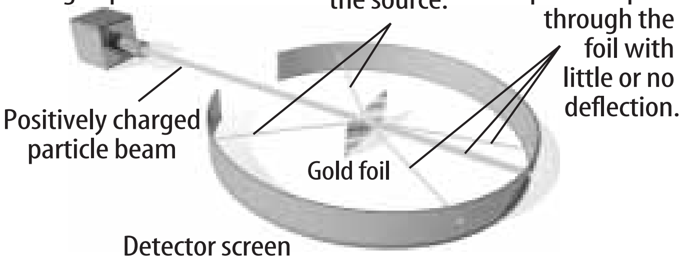


Extended Response

READ INQUIRE EXPLAIN

SC.H.1.3.5

9 The diagram below shows Ernest Rutherford's gold foil experiment.



PART A Describe the setup shown. What did Rutherford expect to happen in the experiment?

PART B What actually occurred during the experiment and what did Rutherford conclude?

FCAT Tip

Calculators When working with calculators, use careful and deliberate keystrokes. Calculators will display an incorrect answer if you press the wrong keys or press keys too quickly. Remember to check your answer to make sure that it is reasonable.