chapter 16

Properties of Atoms and the Periodic Table

section 1 Structure of the Atom

What You'll Learn

- the names and symbols of common elements
- what subatomic particles and quarks are
- how to describe the atom
- how electrons are arranged in an atom

Before You Read

You use symbols to make it easier to write certain things, such as $25.08 instead of twenty-five dollars and eight cents. On the following lines, write some symbols you may use to make writing easier.

_____

_____

Study Coach

Create a Quiz As you read this section, write a quiz question for each paragraph. After you finish reading the section, answer your quiz questions.

FOLDABLES™

A Organize Information
Make the following Foldable to help organize information about scientific shorthand, atomic components, and quarks.

Scientific Shorthand	Atomic Components	Quarks

Read to Learn

Scientific Shorthand

Do you have a nickname? Do you use abbreviations for long words or the names of states? Scientists also do this. In fact, scientists have developed their own shorthand, a way to shorten long, complicated names.

C, Al, Ne, and Ag are all chemical symbols for different elements. A chemical symbol is shorthand for the name of an element. Chemical symbols make writing names of elements easier. Chemical symbols are either one capital letter or a capital letter plus one or two small letters. The table shows the chemical symbols for some elements. For some elements, the symbol is the first letter of the element's name. For example, C is for carbon. For other elements, the symbol is the first letter plus another letter from its name. For example, Ca is for calcium. Some symbols come from the Latin names of elements. *Argentum* is Latin for "silver." Silver's symbol is Ag.

Symbols of Some Elements

Element	Symbol	Element	Symbol
Aluminum	Al	Iron	Fe
Calcium	Ca	Mercury	Hg
Carbon	C	Nitrogen	N
Chlorine	Cl	Oxygen	O
Gold	Au	Potassium	K
Hydrogen	H	Sodium	Na

How have elements been named?

Elements have been named in many different ways. Elements have been named to honor scientists, for places, or for the elements' properties. Other elements have been named using rules made by an international committee. No matter what the origin of the name, scientists worldwide use the same system of element names and chemical symbols. People everywhere know that H means hydrogen, O means oxygen, and H_2O means dihydrogen monoxide, or water.

Reading Check

1. **Identify** What is the symbol for dihydrogen monoxide?

_____

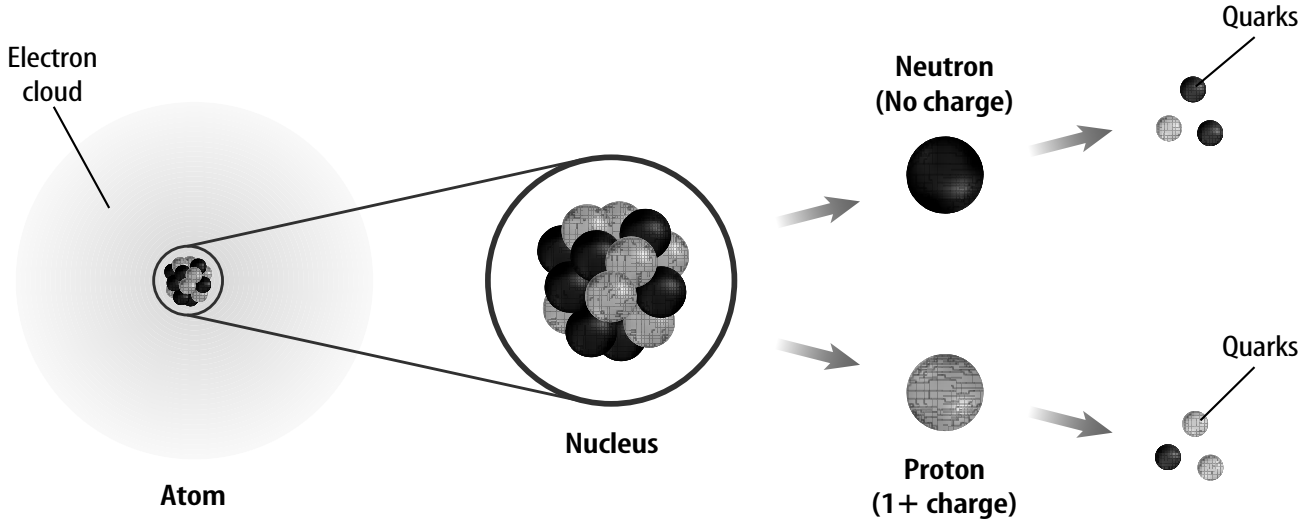
Atomic Components

An element is matter that is made up of one type of atom. An **atom** is the smallest piece of matter that still has the properties of the element. For example, the element silver is made up of only silver atoms. The element hydrogen is made up of only hydrogen atoms.

The figure below shows the structure of the atom. Atoms are made up of protons, neutrons, and electrons. **Protons** are particles with an electrical charge of 1+. **Neutrons** are particles with no electrical charge. **Electrons** are particles with an electrical charge of 1–. The **nucleus** is the small, positively charged center of the atom. It is made up of protons and neutrons. The nucleus is surrounded by a cloud containing electrons. The number of protons in an atom determines which element it is. For example, all atoms with 47 protons are silver atoms. All atoms with 1 proton are hydrogen atoms.

Picture This

2. **Label** Write a plus sign on each proton shown in the nucleus.



Quarks—Even Smaller Particles

Are protons, neutrons, and electrons the smallest particles that exist? Scientists hypothesize that electrons are not made up of smaller particles. If this is true, electrons are one of the most basic types of particles. But protons and neutrons are made up of smaller particles called **quarks**. So far, scientists have discovered six different quarks. Scientists theorize that protons are made up of three quarks. The quarks in a proton are held together with a force called the strong nuclear force. Neutrons are made up of another arrangement of three quarks. Scientists are still studying protons and neutrons to better understand them.

Reading Check

3. **Compare** Which is smaller, a proton or a quark?

_____

How do scientists find quarks?

To study quarks, scientists accelerate, or speed up, charged particles until they are moving extremely fast. Then they force the particles to collide with—or smash into—protons. The collision causes the protons to break apart. The Fermi National Accelerator Laboratory in Illinois has a machine that can accelerate particles fast enough to smash protons. This machine, called a Tevatron, is in a circular tunnel. The tunnel is 6.4 km in circumference. Scientists use electric and magnetic fields in the Tevatron to accelerate and smash particles.

How do scientists study quarks?

Scientists use different kinds of devices to detect the new particles that are made when particles are smashed together. Just as traffic investigators can tell what happened at an accident by looking at tire tracks and other clues, scientists gather information about the particles to find out what happened when they collided. One way to do this is by using a device called a bubble chamber. A bubble chamber is filled with liquid. The particles leave tracks of bubbles as they pass through the liquid—like tire tracks. Scientists examine the bubble tracks to determine what happened when the particles collided.

Think it Over

4. **Describe** How do scientists study the makeup of protons?

_____

_____

_____

_____

Why was it hard to find the sixth quark?

Finding evidence that quarks existed was not easy. Scientists found five quarks and hypothesized that a sixth quark existed. But it took a team of nearly 450 scientists from around the world several years to find the sixth quark. The tracks of the sixth quark were hard to detect. They were hard to detect because there was evidence of the sixth quark in only about one billionth of a percent of proton collisions. The sixth quark is called the *top* quark.

Models—Tools for Scientists

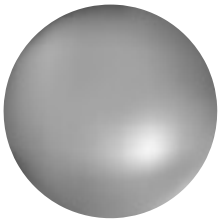
Scientists use models to represent things that are difficult to visualize—or picture in your mind. Scaled-down models let you visualize something that is too large to see. Models of buildings, the solar system, and airplanes are scaled-down models. Scaled-up models are used to represent things that are too small to see. Scientists have developed scaled-up models to help them study the atom. To give you an idea of how small the atom is, it would take about 50,000 atoms stacked on top of each other to equal the thickness of a sheet of aluminum foil.

For a model of the atom to be useful, it must accurately represent everything we know about matter and how the atom behaves. As they learn more about atoms, scientists must change their models to include the new information.

How has the atomic model changed?

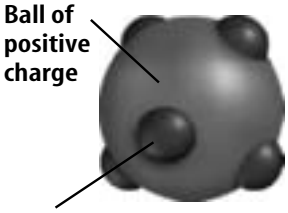
People have not always known that matter is made up of atoms. Around 400 B.C., a Greek philosopher named Democritus came up with the idea that atoms make up all substances. Another famous Greek philosopher, Aristotle, did not agree with Democritus' theory. Aristotle believed that each kind of matter was uniform, or the same all the way through, and not made of smaller particles. Aristotle's incorrect theory was accepted for about two thousand years. But in the 1800s, an English scientist named John Dalton was able to prove that atoms existed.

Dalton Model Dalton's model of the atom was a solid sphere, as shown in the first figure on the right. Dalton's model helped scientists explain why chemical reactions occur. Scientists then could use chemical symbols and equations to describe these reactions.



Dalton's Model

Thomson Model In 1904, English physicist Joseph John Thomson decided from his experiments that atoms contained small, negatively charged particles. He thought these "electrons" were spread out evenly throughout a positively charged sphere. His model, shown in the second figure, looks like a ball of chocolate chip cookie dough.



Thomson's Model

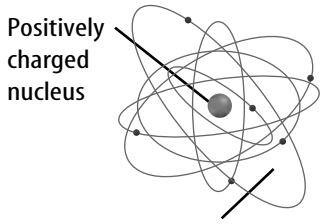
Think it Over

5. **Explain** Why have scientists developed scaled-up models to study the atom?

Picture This

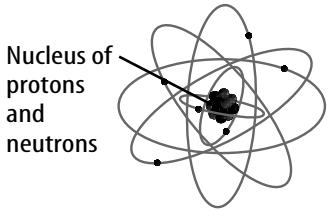
6. **Identify** What part of Thomson's model are represented by the "chocolate chips" in the ball of cookie dough?

Rutherford Model In 1911, another British physicist, Ernest Rutherford, thought that almost all the mass of an atom and all its positive charge were concentrated in the nucleus of an atom. He also thought the nucleus of an atom was surrounded by electrons, as shown in the first figure.



Rutherford's Model

Bohr Model In 1913, Danish physicist Neils Bohr hypothesized that electrons travel in fixed orbits around the nucleus of the atom, as the second figure shows. One of Bohr's students, James Chadwick, found that the nucleus contained positive protons and neutral neutrons.



Bohr's Model

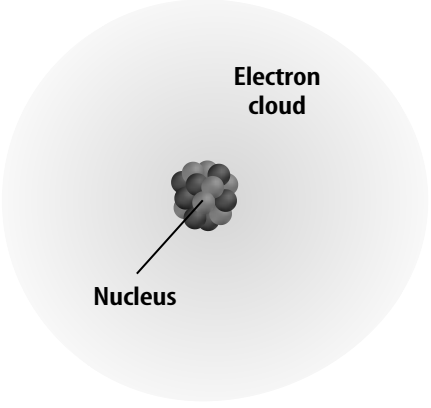
Reading Check

7. **Explain** What did Chadwick discover about the nucleus of an atom?

What is the electron cloud model?

The model of the atom has changed over time. By 1926, scientists had developed the electron cloud model of the atom in use today. An **electron cloud** is the area around the nucleus of an atom where its electrons are most likely found. The electron cloud is 100,000 times larger than the diameter of the nucleus. However, each electron in the cloud is much smaller than a single proton.

Scientists do not really know where in the electron cloud the electrons might be. Electrons move so fast and have such a small mass that it is impossible to describe exactly where they might be. It is best to describe their location as somewhere in the cloud. Think of the spokes on a spinning bicycle wheel. The spokes are moving so quickly that you can't tell exactly where any one spoke is. All you see is a blur. The spokes lie somewhere in the blur. An electron cloud is similar. It is a blur containing all of the electrons somewhere within it. The figure illustrates what an electron cloud might look like.



Electron Cloud Model

Picture This

8. **Compare and Contrast** How are Dalton's model (see figure on previous page) and electron cloud models of the atom similar? How are they different?

Similar:

Different:

After You Read

Mini Glossary

atom: the smallest piece of matter that still has the properties of the element

electron: particle with an electrical charge of 1–

electron cloud: the area around the nucleus of an atom where its electrons are most likely found

neutron: particle with no charge

nucleus: the small, positively charged center of the atom

proton: particle with an electrical charge of 1+

quark: smaller particle that makes up protons and neutrons

1. Review the terms and their definitions in the Mini Glossary. Write a sentence describing what parts make up an atom.

2. Below is a model of an atom. Label and describe each part of the atom. If any particles are made up of even smaller particles, list these also.

3. Study Coach As you read this section, you created a quiz question for each paragraph. Did answering these quiz questions after you read the section help you learn the material? Why or why not?

End of Section

Name Date Class

SECTION 1 Reinforcement

Structure of the Atom

Directions: *Answer the following questions on the lines provided.*

1. How is the chemical symbol of an element determined?

2. What are atoms composed of?

3. Are electrons, protons, or neutrons the smallest particles? If not, what are?

4. How many types of quarks are there and what is the name of one of them?

5. Why do scientists use models to study atoms?

6. Why has the atomic model changed over time?

7. Why is the current atomic model called the "Electron Cloud Model"?

Directions: *Match the term in Column I with the definition in Column II. Write the letter of the correct definition in the blank at the left.*

Column I

_____ **8.** electron

_____ **9.** neutron

_____ **10.** nucleus

_____ **11.** proton

_____ **12.** quark

Column II

a. positively charged particle

b. negatively charged particle

c. neutral particle

d. smaller particles that make up protons and neutrons

e. positively charged center of an atom