Lesson 2

The Structure of ATOMS

ESSENTIAL QUESTIONS

- Where are protons, neutrons, and electrons located in an atom?
- How is the atomic number related to the number of protons in an atom?
- What effect does changing the number of particles in an atom have on the atom's identity?

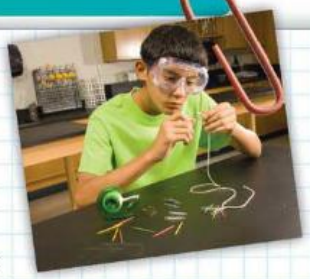
Vocabulary

nucleus p. 236
proton p. 236
neutron p. 236
electron p. 236
electron cloud p. 237
atomic number p. 238
isotope p. 239
ion p. 239

SC.8.P.8.7

Inquiry Launch Lab

20 minutes



How can you make different things from the same parts?

Atoms are all made of the same parts. Atoms can be different from each other because they have different numbers of these parts. In this lab, you will investigate how you can make things that are different from each other even though you use the same parts to make them.

Florida NGSSS

LA.8.2.2.3 The student will organize information to show understanding or relationships among facts, ideas, and events (e.g., representing key points within text through charting, mapping, paraphrasing, summarizing, or comparing/contrasting);

SC.8.P.8.5 Recognize that there are a finite number of elements and that their atoms combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.

SC.8.P.8.7 Explore the scientific theory of atoms (also known as atomic theory) by recognizing that atoms are the smallest unit of an element and are composed of sub-atomic particles (electrons surrounding a nucleus containing protons and neutrons).

SC.8.N.1.1 Define a problem from the eighth grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.8.N.3.1 Select models useful in relating the results of their own investigations.

Also covers: MA.6.A.3.6

Procedure

1. Read and complete a lab safety form.
2. Think about how you can join **paper clips, toothpicks**, and **string** to make different types of objects. You must use at least one of each item, but not more than five of any kind.
3. Make the object. Use **tape** to connect the items.
4. Plan and make two more objects using the same three items, varying the numbers of each item.
5. Describe below how each of the objects you made are alike and different.

Data and Observations

Think About This

1. **Observe** What do the objects you made have in common? In what ways are they different?

2. Key Concept What effect do you think increasing or decreasing the number of items you used would have on the objects you made?

The Parts of an Atom

Now that you have read about ways to classify matter, you can probably recognize the different types you see each day. You might see pure elements, such as copper and iron, and you probably see many compounds, such as table salt. Table salt is a compound because it contains the atoms of two different elements—sodium and chlorine—in a specific combination. You also probably see many mixtures. The silver often used in jewelry is a homogeneous mixture of metals that are evenly mixed, but not bonded together.

Inquiry What makes them different?

1. This ring is made of two of the most beautiful materials in the world—diamond and gold. Diamond is a clear, sparkling crystal made of only carbon atoms. Gold is a shiny, yellow metal made of only gold atoms. How can they be so different if each is made of just one type of atom? The structure of atoms makes significant differences in materials. Do you think a diamond could be used to make a ring band and gold be used to make a stone? Why or why not?

As you read in Lesson 1, the many types of matter are possible because there are about 115 different elements. Each element is made up of a different type of atom. Atoms can combine in many different ways. They are the basic parts of matter.

What makes the atoms of each element different? Atoms are made of several types of tiny particles. The number of each of these particles in an atom is what makes atoms different from each other. It is what makes so many types of matter possible.

Active Reading **2. Explain** What makes the atoms of different elements different from each other?

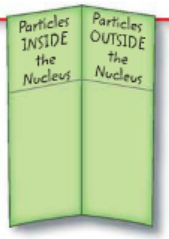
Active Reading **3. Write** As you read this lesson, use the table below to describe the parts of atoms including each part's location and charge.

Part	Description
Nucleus	
Proton	
Neutron	
Electron	

Active Reading

FOLDABLES® LA.8.2.2.3

Make a vertical two-column chart book. Label it as shown. Use it to organize information about the particles in an atom.



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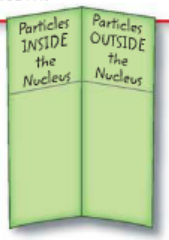


SCIENCE USE V. COMMON USE

charge

Science Use an electrical property of some objects that determines whether the object is positive, negative, or neutral

Common Use buying something with a credit card

WORD ORIGIN

proton

from Greek *protos*, means "first"

The Nucleus—Protons and Neutrons

The basic structure of all atoms is the same. As shown in **Figure 12,** an atom has a center region with a positive **charge.** One or more negatively charged particles move around this center region. *The* **nucleus** *is the region at the center of an atom that contains most of the mass of the atom.* Two kinds of particles make up the nucleus. *A* proton *is a positively charged particle in the nucleus of an atom. A* neutron *is an uncharged particle in the nucleus of an atom.*

Active Reading **4. Review** Underline the particles that make up the nucleus.

Click below.

abc

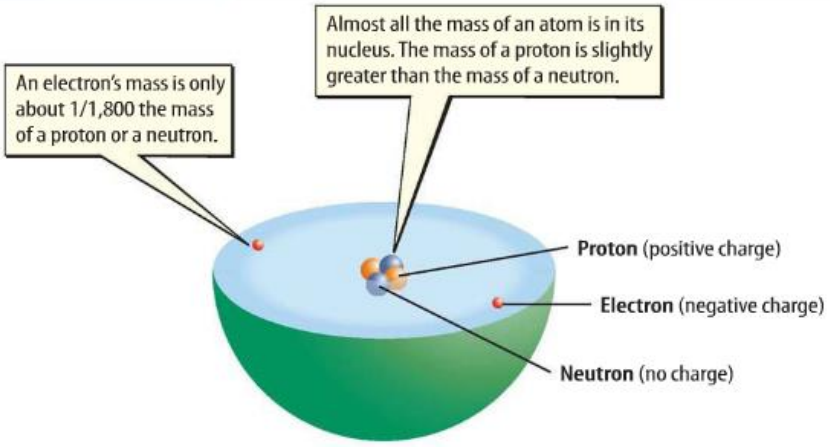
Electrons

Atoms have no electric charge unless they change in some way. There must be a negative charge that balances the positive charge of the nucleus. *An* **electron** *is a negatively charged particle that occupies the space in an atom outside the nucleus.* Electrons are so small and move so quickly that scientists are unable to tell exactly where a given electron is located at any specific time. Therefore, scientists describe their positions around the nucleus as a cloud rather than specific points. A model of an atom and its parts is shown in **Figure 12.**

Figure 12 All atoms have a positively charged nucleus surrounded by one or more electrons.

5. NGSSS Check **Summarize** Where are protons, neutrons, and electrons located in an atom? SC.8.P.8.7

Parts of an Atom



6. Visual Check **Determine** How many protons and how many electrons does this atom have?

An Electron Cloud Drawings of an atom, such as the one in **Figure 13,** often show electrons circling the nucleus like planets orbiting the Sun. Scientists have conducted experiments that show the movement of electrons is more complex than this. The modern idea of an atom is called the electron-cloud model. *An* **electron cloud** *is the region surrounding an atom's nucleus where one or more electrons are most likely to be found.* It is important to understand that an electron is not a cloud of charge. An electron is one tiny particle. An electron cloud is mostly empty space. At any moment in time, electrons are located at specific points within that area.

Electron Energy Electrons are constantly moving around the nucleus in a region called the electron cloud. However, some electrons are closer to the nucleus than others. Electrons occupy certain areas around the nucleus according to their energy, as shown in **Figure 13.** Electrons close to the nucleus are strongly attracted to it and have less energy. Electrons farther from the nucleus are less attracted to it and have more energy.

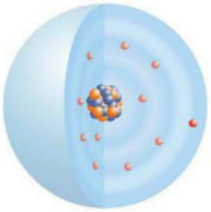


Figure 13 Electrons farther from the nucleus have more energy.

The Size of Atoms

As tiny as atoms are, electrons, protons, and neutrons are even smaller. The data in **Table 3** shows that protons and neutrons have about the same mass. Electrons have only about 1/2,000 the mass of a proton or a neutron. If you held a textbook and placed a paper clip on it, you wouldn't notice the added mass because the mass of a paper clip is small compared to the mass of the book. In a similar way, the masses of an atom's protons and neutrons are packed tightly into a tiny nucleus. Visualize the nucleus as the size of an ant. How large would the atom be? Amazingly, the atom would be the size of a football stadium.

Table 3 Properties of Atomic Particles

Particle	Charge	Mass (g)
Proton	+1	1.007316
Neutron	0	1.008701
Electron	−1	0.000549

Active Reading 8. **Infer** Do you think all atoms are the exact same size? Explain.

Math Skills MA.6.A.3.6

Use Scientific Notation
Scientists write very large and very small numbers using scientific notation. A gram of carbon has about 50,000,000,000,000,000,000 atoms. Express this in scientific notation.

1. Move the decimal until one nonzero digit remains on the left: 5.00000000000000000000
2. Count the places you moved. Here it is 19 left.
3. Show that number as a power of 10. The exponent is negative if the decimal moves right and positive if it moves left. Answer: 5×10^{19}
4. Reverse the process to change scientific notation back to a whole number.

Practice

7. The diameter of a carbon atom is 2.2×10^{-8} cm. Write this as a whole number.

Inquiry
LAB STATION
SC.8.N.1.1, SC.8.P.8.7
Try It!
MiniLab *How can you model atoms?* at connectED.mcgraw-hill.com

Apply It!
After you complete the lab, answer these questions.

Apply It! After you complete the lab, answer these questions.

1. If you know the number of protons in a neutral atom, what else do you know?

2. What element has 11 electrons and 12 neutrons?

SUBMIT SHOW ANSWERS CLEAR

Differences in Atoms

In some ways atoms are alike. Each has a positively charged nucleus surrounded by a negatively charged electron cloud. But atoms can differ from each other in several ways. Atoms can have different numbers of protons, neutrons, or electrons.

Protons and Atomic Number

Look at the periodic table in the back of this book. In each block, the number under the element name shows how many protons each atom of the element has. For example, each oxygen atom has eight protons. *The* **atomic number** *is the number of protons in the nucleus of an atom of an element.* If there are 12 protons in the nucleus of an atom, that element's atomic number is 12. Examine **Figure 14.** Notice that the atomic number of magnesium is the whole number above its symbol. The atomic number of carbon is 6. This means that each carbon atom has 6 protons.

Every element in the periodic table has a different atomic number. You can identify an element if you know either its atomic number or the number of protons its atoms have. If an atom has a different number of protons, it is a different element.

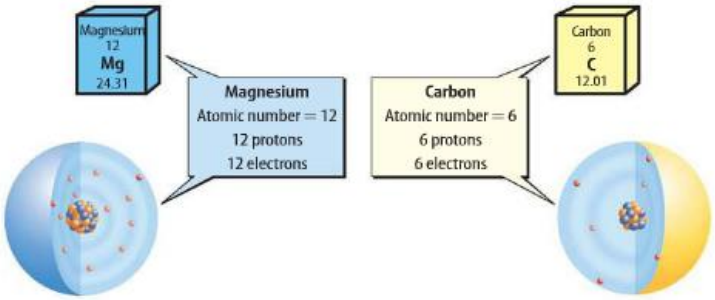
Active Reading **9. Describe** How is the atomic number related to the number of protons in an atom?

Active Reading **10. Locate** Circle the atomic number in the cube that represents the carbon atom.

Click below.

abc

Figure 14 An atomic number is the number of protons in each atom of the element.



Neutrons and Isotopes

Each atom of an element contains the same number of protons, but the number of neutrons can vary. *An* **isotope** (I suh tohp) *is one of two or more atoms of an element having the same number of protons, but a different number of neutrons.* Boron-10 and boron-11 are isotopes of boron, as shown in **Figure 15.** Notice that boron-10 has 10 particles in its nucleus. Boron-11 has 11 particles in its nucleus.

Click below.

abc

Active Reading **11. Differentiate** Underline how boron-10 and boron-11 are different.

Electrons and Ions

You read that atoms can differ by the number of protons or neutrons they have. **Figure 16** illustrates a third way atoms can differ—by the number of electrons. A neutral, or uncharged, atom has the same number of positively charged protons and negatively charged electrons. As atoms bond, their numbers of electrons can change. Because electrons are negatively charged, a neutral atom that has lost an electron has a positive charge. A neutral atom that has gained an electron has a negative charge. *An* **ion** (I ahn) *is an atom that has a charge because it has gained or lost electrons.* Because the number of protons is unchanged, an ion is the same element it was before.

Isotopes

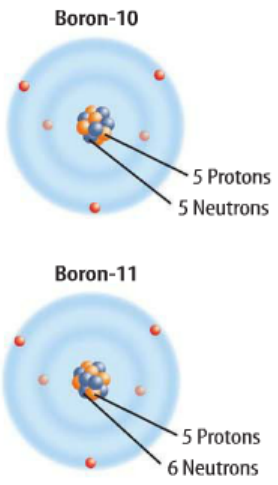
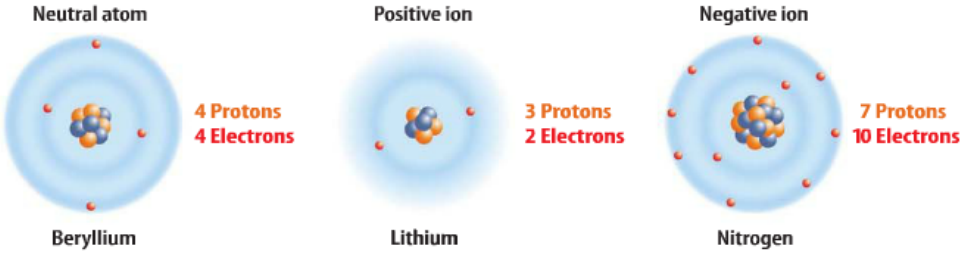


Figure 15 Boron-10 and boron-11 are isotopes. The number of protons is the same, but the number of neutrons is different.

In the previous lesson, you read that each particle of a compound is two or more atoms of different elements bonded together. One of the ways compounds form is when one or more electrons move from an atom of an element to an atom of a different element. This results in a positive ion for one element and a negative ion for the other element.

Figure 16 A positive ion has fewer electrons than protons. A negative ion has more electrons than protons.

Ions



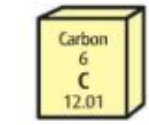
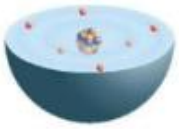
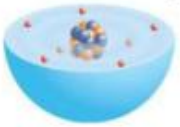
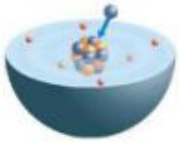
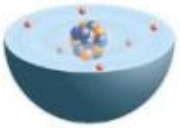
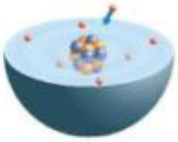
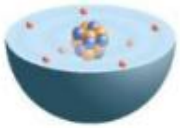
Click below.

abc

Active Reading **12. Determine** Highlight the element that has more protons than electrons.

SUBMIT SHOW ANSWERS CLEAR

Table 4 Possible Changes in Atoms

Neutral Atom	Change	Results
 • 6 protons • 6 neutrons • 6 electrons 	**Protons** add one proton 	**New element—nitrogen**  • ____ protons • 7 neutrons • 7 electrons
	Neutrons add one neutron 	**Isotope**  • 6 protons • ____ neutrons • 6 electrons
	Electrons add one electron 	**Ion**  • 6 protons • 6 neutrons • ____ electrons

13. **NGSSS Check** **Relate** Fill in the blanks in **Table 4** to show how changing the number of particles in an atom changes the atom's identity. SC.8.P.8.7 SUBMIT SHOW ANSWERS CLEAR

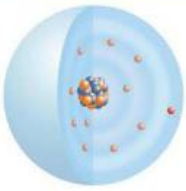
Atoms and Matter

You have now read that matter can be either a substance or a mixture. A substance has a composition that is always the same, but the composition of a mixture can vary. All types of matter are made of atoms. The atoms of a certain element always have the same number of protons, but the number of neutrons can vary. When elements combine to form compounds, the number of electrons in the atoms can change. The different ways in which atoms can change are summarized in **Table 4**.

Look back at the diamond and gold ring at the beginning of this lesson. Now can you answer the question of how they can be so different if each is made of just one type of atom? Each carbon atom in diamond has six protons. Each gold atom has 79 protons. The parts of an atom give an element its identity. The ways in which the atoms combine result in the many different kinds of matter.

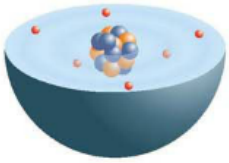
Lesson Review 2

Visual Summary



All matter is made of atoms. Atoms are made of protons, electrons, and neutrons.

An orange is about 100 million times wider than an atom.



Atoms of the same element can have different numbers of neutrons.

Inquiry LAB STATION SC.8.N.1.1, SC.8.N.3.1, SC.8.P.8.5 **Try It!**

MiniLab ***Balloon Molecules*** at connectED.mcgraw-hill.com

Use Vocabulary

1. **Distinguish** between a proton and a neutron.

2. An atom that has lost one or more electrons is a(n) _____ .

3. **Use the term** *isotope* in a complete sentence.

Understand Key Concepts

4. Which is located outside the nucleus of an atom? SC.8.P.8.7

   (A) electron (C) neutron
   (B) ion (D) proton

5. **Identify** the element that has nine protons. SC.8.P.8.7

6. **Explain** how atomic number relates to the number of particles in an atom's nucleus. SC.8.P.8.7

Interpret Graphics

7. **Organize** Summarize what you have learned about the parts, the sizes, and the differences of atoms. LA.8.2.2.3

Properties of Atoms	
Parts	
Size	
Differences	

Critical Thinking

8. **Decide** Can you tell which element an atom is if you know its charge and the number of electrons it has? Explain. SC.8.P.8.7

SUBMIT SHOW ANSWERS CLEAR

LESSON 2 The Structure of Atoms

- The center of an atom is the **nucleus**. The nucleus contains **protons** and **neutrons**. **Electrons** occupy the space in an atom outside the nucleus.
- The identity of an atom is determined by its **atomic number**. The atomic number is the number of protons in the atom.
- The identity of an atom stays the same if the number of neutrons or electrons changes.

nucleus p. 236
proton p. 236
neutron p. 236
electron p. 236
electron cloud p. 237
atomic number p. 238
isotope p. 239
ion p. 239