CHAPTER 4
LESSON 1

Elements and Chemical Bonds

Electrons and Energy Levels

Key Concepts

- How is an electron's energy related to its distance from the nucleus?
- Why do atoms gain, lose, or share electrons?

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	1. Elements rarely exist in pure form. Instead, combinations of elements make up most of the matter around you.	
	2. Chemical bonds that form between atoms involve electrons.	

Study Coach

Ask Questions Read the headings in this lesson. Write questions about the information given under each heading. Take turns with a partner asking and answering the questions. Use the questions as a study guide.

Read to Learn

The Periodic Table

The periodic table presents information about the elements in an organized way. A copy of the periodic table is on the inside back cover of this book. The table has more than 100 blocks. Each known element is a block. Each block describes basic properties of one element, such as its state of matter at room temperature, its atomic number, and its atomic mass. The atomic number is the number of protons in each atom of the element. The atomic mass is the average mass of all the different isotopes of an element.

Periods and Groups

You can learn about some properties of an element from its position on the periodic table. Elements are organized in periods (rows) and groups (columns). The periodic table lists elements in order of atomic number. The atomic number increases from left to right as you move across a period. Elements in each group have similar chemical properties and react with other elements in similar ways.

Reading Check

1. Explain How is the periodic table organized?

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Metals, Nonmetals, and Metalloids

There are three main regions of elements on the periodic table. The regions classify elements as metals, nonmetals, or metalloids.

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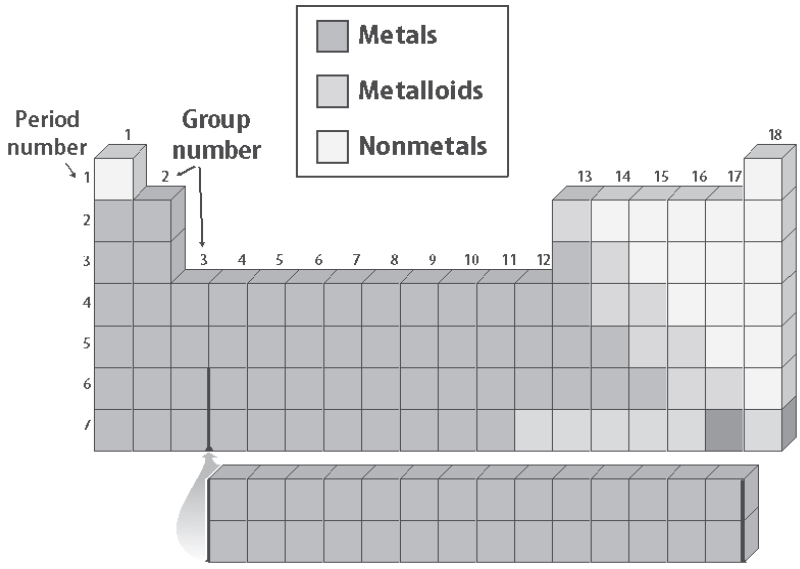

The table above shows the three main regions of the periodic table. Except for hydrogen, elements on the left side are metals. Metals are good conductors of electricity and thermal energy. Metals can easily be hammered into sheets.

Metalloids form a narrow stair-step pattern between the metals and nonmetals. Metalloids have properties in common with both metals and nonmetals. They are often used as semiconductors in electronic devices.

Nonmetals are on the right side of the table. Nonmetals do not conduct electricity or thermal energy well. Most nonmetals are gases at room temperature. Those that are solids tend to be brittle.

Atoms Bond

Elements rarely exist in pure form in nature. Instead, atoms of different elements chemically combine and form compounds. Compounds make up most of the matter around you, including living and nonliving things.

There are about 115 elements. These elements combine and form millions of compounds. Chemical bonds hold the compounds together. *A* **chemical bond** *is a force that holds two or more atoms together in a compound.*

Electron Number and Arrangement

Atoms contain protons, neutrons, and electrons, as shown at the top of the next page. A proton has a positive charge. A neutron has no charge. An electron has a negative charge. Each element's atomic number is the number of protons in each atom of that element. In a neutral (uncharged) atom, the number of protons equals the number of electrons.

Visual Check

2. Identify the metalloids in the figure and highlight them.

Reading Check

3. Locate Where are metals, nonmetals, and metalloids on the periodic table?

REVIEW VOCABULARY

compound
matter that is made up of two or more different kinds of atoms joined together by chemical bonds

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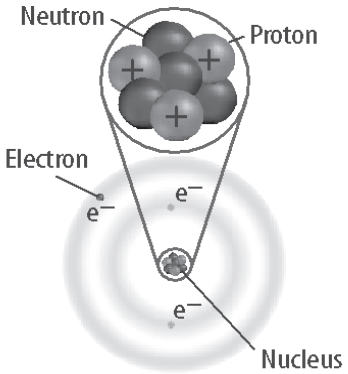
Visual Check

4. Highlight Use one color to highlight the protons in the lithium atom. Use a second color to highlight the neutrons. Use a third color to highlight the electrons.

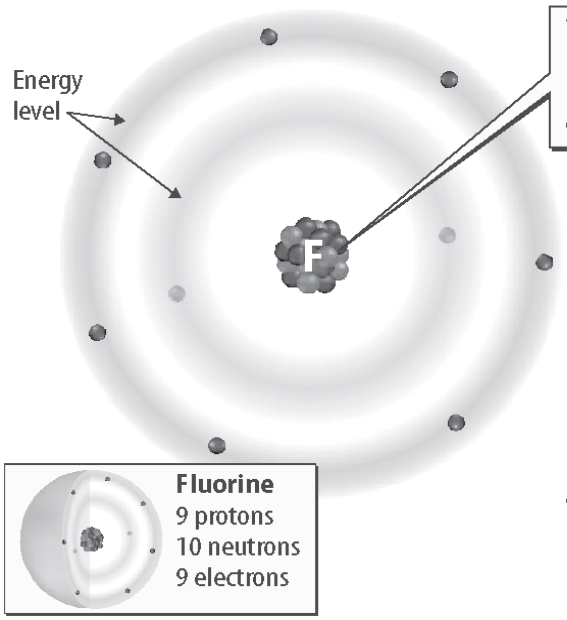
Positions of Electrons

The exact position of the electrons in an atom cannot be determined. Electrons constantly move around the nucleus. However, each electron is usually in a certain area around the nucleus. Some are in areas close to the nucleus and some are in areas farther away.



Lithium atom

Electrons and Energy



Different electrons in an atom have different amounts of energy. The areas in which electrons move around the nucleus are called energy levels. The figure on the right shows the energy levels of a fluorine atom. The amount of energy an electron has is related to its distance from the nucleus. Electrons closest to the nucleus are in the lowest energy level. These electrons have the least energy. Electrons farthest from the nucleus are in the highest energy level. These electrons have the most energy. Notice that the lowest energy level in the atom can hold only two electrons. The second energy level can hold up to eight electrons.

Visual Check

5. Identify Circle the electrons that have the greatest amount of energy.

Key Concept Check

6. Analyze How is an electron's energy related to its position in an atom?

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Electrons and Bonding Imagine two magnets. The closer they are to each other, the stronger the attraction of their opposite ends. Like magnets, the negatively charged electrons are attracted to the positively charged nucleus of an atom. Electrons close to the nucleus have a strong attraction to it. It is difficult for these electrons to interact with the electrons of atoms nearby. However, electrons far from the nucleus have a weak attraction to it. The nuclei of other atoms can easily attract these outer electrons. This attraction between the positive nucleus of one atom and the negative electrons of another atom creates a chemical bond.

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Valence Electrons

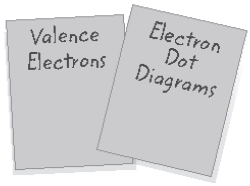
Electrons farthest from their nucleus are easily attracted to the nuclei of nearby atoms. These outermost electrons are the only electrons that form chemical bonds. Even atoms that have only a few electrons, such as hydrogen and lithium, can form chemical bonds. This is because these electrons are still the outermost electrons and are exposed to nuclei of other atoms. *A* **valence electron** *is an outermost electron of an atom that participates in chemical bonding.* Valence electrons have the most energy of all the electrons in an atom.

The number of valence electrons in an atom helps determine the type and number of bonds the atom can form. The periodic table can tell you the number of valence electrons an atom has. Except for helium, elements in certain groups have the same number of valence electrons. The figure below shows how to determine the number of valence electrons in the atoms of groups 1, 2, and 13–18.

The number of valence electrons in an atom equals the ones digit of the group number at the top of the column. Each of these digits is highlighted in the figure below. Helium is an exception. An atom of helium has two valence electrons. Finding the number of valence electrons for elements in groups 3–12 is more complicated. You will learn more about these groups in later chemistry courses.

FOLDABLES®

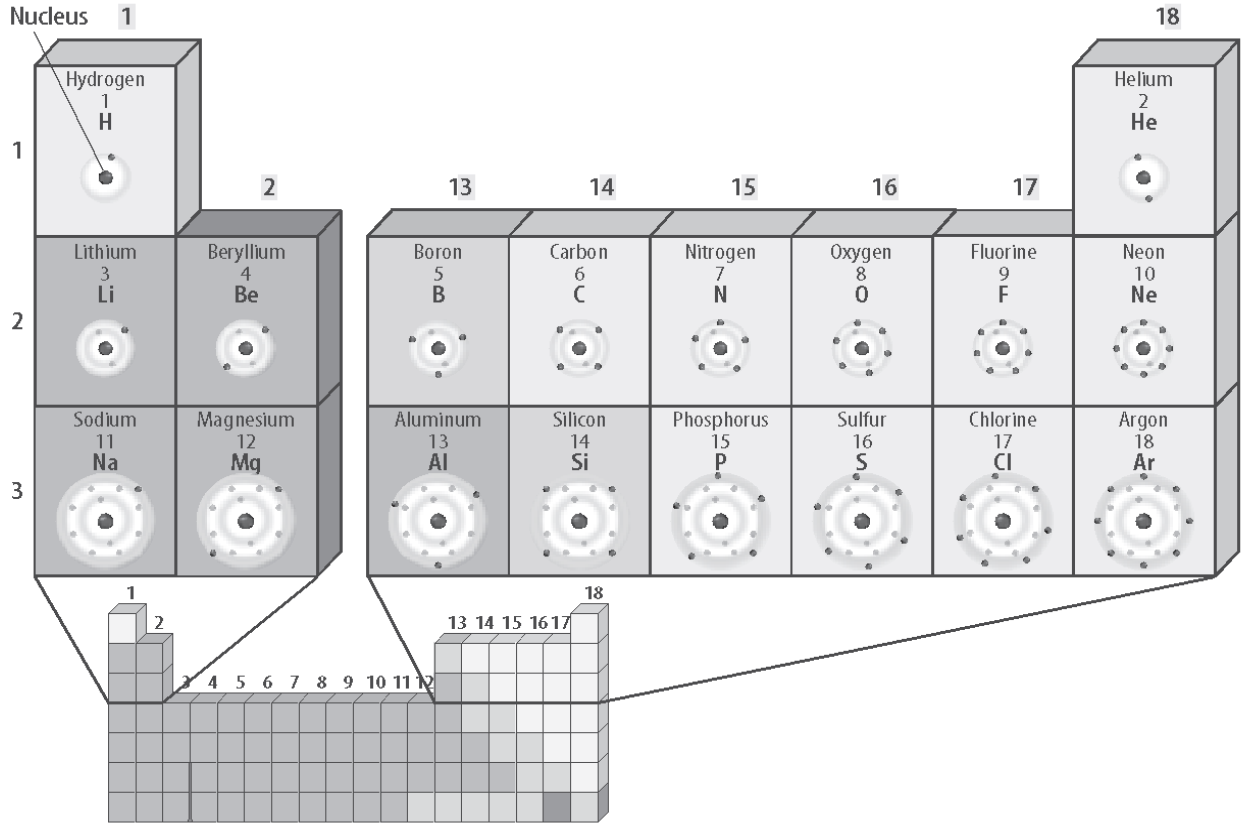
Make two quarter-sheet note cards to organize your notes on valence electrons and electron dot diagrams.



Visual Check

7. Interpret How many valence electrons does an atom of phosphorous (P) have? (Circle the correct answer.)

a. 1
b. 5
c. 15



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Electron Dot Diagrams

An electron dot diagram is a simple way to show an element's valence electrons. *An* **electron dot diagram** *is a model that represents valence electrons in an atom as dots around the element's chemical symbol.*

Electron dot diagrams can help you predict how an atom will bond with other atoms. Dots, representing valence electrons, are placed one-by-one on each side of an element's symbol. Then the dots are paired up until all the dots are used. The number of unpaired dots represents the number of bonds an atom can form.

The figure below shows the steps for writing electron dot diagrams. Period 2 elements are shown. Remember that every element in a group has the same number of valence electrons. As a result, every element in a group has the same number of dots in its electron dot diagram.

Notice that a neon atom, Ne, has eight valence electrons, or four pairs of dots. It has no unpaired dots. Atoms with eight valence electrons are chemically stable. They do not react easily with other atoms. Atoms with 1–7 valence electrons are chemically unstable. These atoms easily bond with other atoms and form chemically stable compounds.

Reading Check

8. Explain Why are electron dot diagrams useful?

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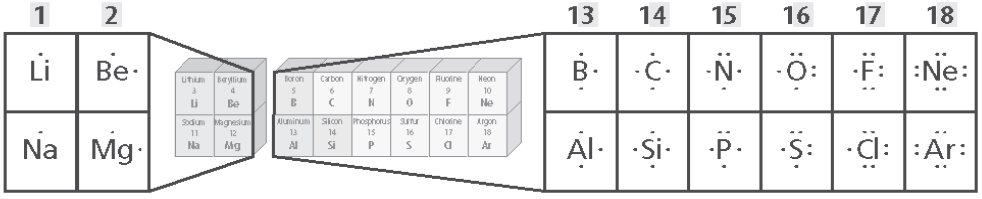
Visual Check

9. Conclude How many electron pairs does an atom of Argon, Ar, have? (Circle the correct answer.)

a. 1
b. 3
c. 4

Steps for writing a dot diagram	Beryllium	Carbon	Nitrogen	Neon
1 Identify the element's group number on the periodic table.	2	14	15	18
2 Identify the number of valence electrons. • This equals the ones digit of the group number.	2	4	5	8
3 Draw the electron dot diagram. • Place one dot at a time on each side of the symbol (top, right, bottom, left). Pair up the dots until all are used.	Be·	·C·	·N·	:Ne:
4 Determine if the atom is stable. • An atom is stable if all dots on the electron dot diagram are paired.	Unstable	Unstable	Unstable	Stable
5 Determine how many bonds this atom can form. • Count the dots that are unpaired.	2	4	3	0



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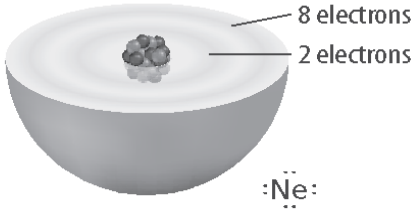
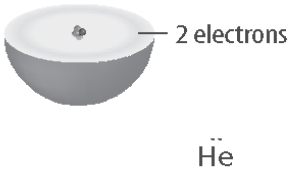
Noble Gases

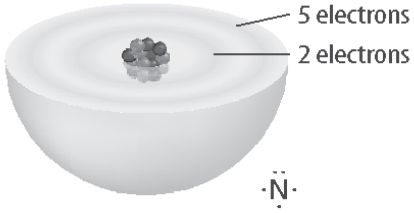
The elements in Group 18 are called noble gases. With the exception of helium, noble gases have eight valence electrons and are chemically stable. Stable atoms do not easily react, or form bonds, with other atoms. The figure below shows the electron structures of two noble gases—neon and helium. Notice that all dots are paired.



Neon has 10 electrons: 2 inner electrons and 8 valence electrons. A neon atom is chemically stable because it has 8 valence electrons. All dots in the dot diagram are paired.



Helium has 2 electrons. Because an atom's lowest energy level can hold only 2 electrons, the 2 dots in the dot diagram are paired. Helium is chemically stable.



Nitrogen has 7 electrons: 2 inner electrons and 5 valence electrons. Its dot diagram has 1 pair of dots and 3 unpaired dots. Nitrogen atoms become more stable by forming chemical bonds.

Stable and Unstable Atoms

Atoms with unpaired dots in their electron dot diagrams are reactive, or chemically unstable. For example, nitrogen, shown above at right, is reactive because it has three unpaired dots. Unstable atoms such as nitrogen become more stable by forming chemical bonds with other atoms.

When an atom forms a bond, it gains, loses, or shares valence electrons with other atoms. By forming bonds, atoms become more chemically stable. Recall that atoms are most stable with eight valence electrons. Therefore, atoms with less than eight valence electrons form bonds and become stable.

Visual Check

10. Analyze Can neon easily react, or form bonds, with other atoms? Explain.

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Key Concept Check

11. Discuss Why do atoms gain, lose, or share electrons?

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After You Read

Mini Glossary

chemical bond: a force that holds two or more atoms together in a compound

electron dot diagram: a model that represents valence electrons in an atom as dots around the element's chemical symbol

valence electron: an outermost electron of an atom that participates in chemical bonding

1. Review the terms and their definitions in the Mini Glossary. Write a sentence describing how the number of valence electrons is used to make an electron dot diagram.

2. Complete the table below about the three elements listed. Use a copy of the periodic table to help you.

Element	Metal, Nonmetal, or Metalloid	Group Number	Number of Valence Electrons
Sodium	metal	1	
Chlorine		17	7
Silicon	metalloid		4

3. How is the interaction of electrons with the nucleus of an atom similar to the interaction of two magnets?

What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

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END OF LESSON

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