The Periodic Table

Using the Periodic Table

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. The elements on the periodic table are arranged in rows in the order they were discovered.	
	2. The properties of an element are related to the element's location on the periodic table.	

Read to Learn

What is the periodic table?

There are more than 100 elements. Each element has a unique set of properties. Scientists use a table, called the periodic (pihr ee AH dihk) table, to organize elements. The **periodic table** *is a chart of the elements arranged into rows and columns according to their physical and chemical properties*. The periodic table can be used to determine the relationships among the elements.

This chapter describes the development of the periodic table. It will show you how to use the periodic table to learn about the elements.

Developing a Periodic Table

In 1869, a Russian chemist and teacher Dimitri Mendeleev (duh MEE tree · men duh LAY uf) put together an early periodic table. He studied the physical properties such as density, color, melting point, and atomic mass of each element. He also studied the chemical properties, such as how each element reacted with other elements. Mendeleev arranged the elements in rows of increasing atomic mass. He grouped elements with similar properties in the same column.

Key Concepts

- How are elements arranged on the periodic table?
- What can you learn about elements from the periodic table?

Study Coach

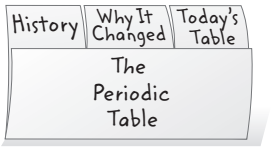
Create a Quiz As you study the information in this section, create questions about the information you read. Be sure to answer your questions. Refer to your questions and answers as you review the chapter.

Reading Check

1. Explain What physical property did Mendeleev use to place the elements in rows on the periodic table?

FOLDABLES®

Make a top-tab book to organize your notes about the development of the periodic table.



Patterns in Properties

The word *periodic* means "repeating pattern." Seasons and months are periodic because they follow a repeating pattern every year. The days of the week are periodic because they repeat every seven days.

What were some of the repeating patterns Mendeleev noticed in his table? Melting point is one property that shows a repeating pattern. Melting point is the temperature at which a solid changes to a liquid. In the periodic table, melting points increase and then decrease across a row. Boiling points and reactivity also follow a periodic pattern.

Predicting Properties of Undiscovered Elements

When all of the elements known in Mendeleev's time were arranged in a periodic table, there were large gaps between some elements. Mendeleev predicted that scientists would discover elements that would fit into these spaces. He also predicted that the properties of those elements would be similar to the known elements in the same columns. Both of Mendeleev's predictions turned out to be true.

Reading Check

2. Describe What did Mendeleev predict about the properties of the elements missing from his periodic table?

Changes to Mendeleev's Table

Mendeleev's periodic table made it possible for scientists to relate the properties of elements to their position on the table. However, the table had one big problem: some elements seemed to be out of place.

When elements were arranged in order of atomic mass, a few of the elements did not seem to belong in their columns. Their properties were similar to the properties of the elements in the next column on Mendeleev's table. What could be done to fix this problem on Mendeleev's table? The result is the periodic table we use today.

The Importance of Atomic Number

In the early 1900s, scientist Henry Moseley solved the problem with Mendeleev's table. Mendeleev had listed elements according to increasing atomic mass. Instead of listing elements according to increasing atomic mass, Moseley listed elements according to increasing atomic number.

The atomic number of an element is the number of protons in the nucleus of each of that element's atoms. When Mosely organized the table according to atomic number, he found that the columns contained elements with similar properties.

Key Concept Check

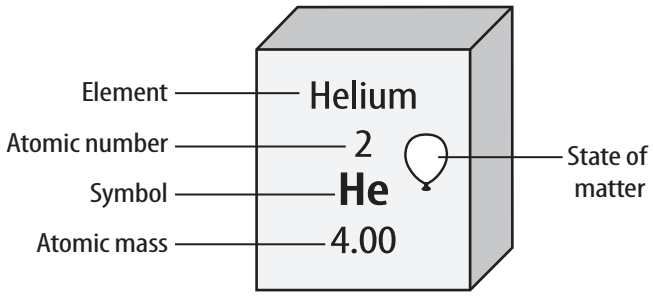
3. Identify What determines where an element is located on the periodic table you use today?

Today's Periodic Table

The periodic table is shown on the next two pages. You can identify many of the properties of an element from its placement on the periodic table. The table is organized into columns, rows, and blocks, which are based on certain patterns of properties. In the next two lessons, you will learn how an element's position on the periodic table can help you understand the element's physical and chemical properties.

What is on an element key?

Each element in the periodic table is represented by an element key. An element key shows important information about each element. The key shows the element's chemical symbol, atomic number, and atomic mass. The key also contains a symbol that shows the element's state of matter at room temperature. Look at the information given for helium in the figure on the right. It shows that helium is a gas at room temperature, it has the atomic number 2, its chemical symbol is He, and its atomic mass is 4.00.



Groups

A **group** *is a column on the periodic table*. Elements in the same group have similar chemical properties. This means that the elements in a group react with other elements in similar ways. There are patterns in the physical properties of a group, such as density, melting point, and boiling point. The groups are numbered 1–18 at the top of each column on the periodic table.

Periods

The rows on the periodic table are called **periods**. The atomic number of each element increases by 1 as you read from left to right across each period. The physical and chemical properties of the elements also change as you move from left to right across a period.

Math Skills

The distance around a circle is the circumference (C). The distance across the circle, through its center, is the diameter (d). The radius (r) is half of the diameter. The circumference divided by the diameter for any circle is equal to π (pi), or 3.14. The formula for finding the circumference is:

$$\mathbf{C} = \pi\mathbf{d} \text{ or } \mathbf{C} = 2\pi\mathbf{r}$$

Example: The circumference of an iron (Fe) atom is:

$$\mathbf{C} = 2 \times 3.14 \times \mathbf{126\ pm}$$

(picometers; 1 picometer = one-trillionth of a meter)

$$\mathbf{C} = \mathbf{791\ pm}$$

4. Use Geometry The radius of a uranium (U) atom is 156 pm. What is its circumference?

Visual Check

5. Determine What does the key in the figure tell you about helium?

Key Concept Check

6. Describe What can you infer about the properties of two elements in the same group?

Metals, Nonmetals, and Metalloids

Almost three-fourths of the elements on the periodic table are metals. Metals are on the left side and in the middle of the table. Metals can have different properties, but all metals are shiny and conduct thermal energy and electricity.

Nonmetals, except for hydrogen, are located on the right side of the periodic table. The properties of nonmetals are different from those of metals. Nonmetals do not conduct thermal energy or electricity. Many nonmetals are gases.

Between the metals and the nonmetals on the periodic table are the metalloids. Metalloids have properties of both metals and nonmetals.

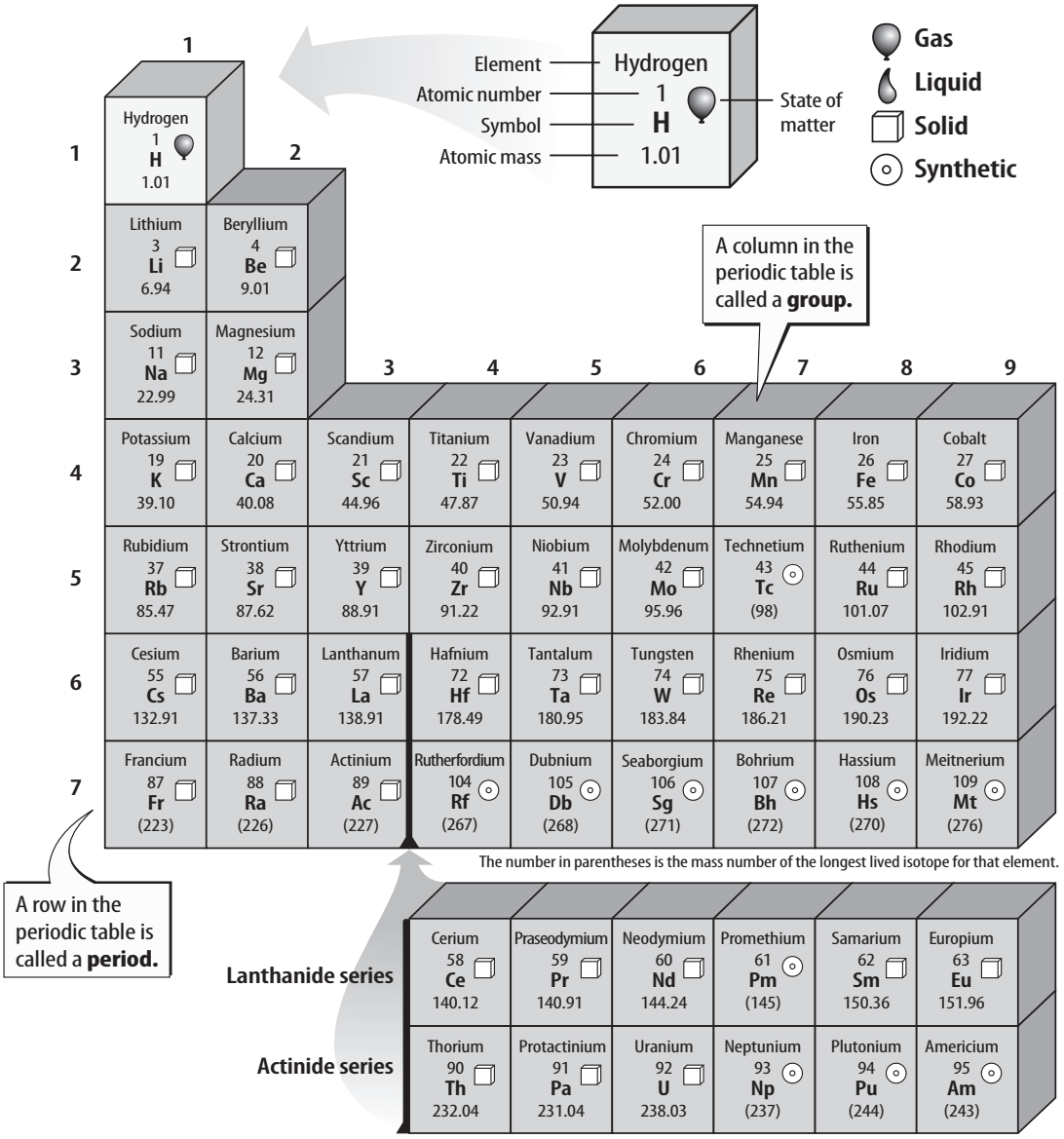
Visual Check

7. Identify How is the periodic table organized?

_____

_____

PERIODIC TABLE OF THE ELEMENTS



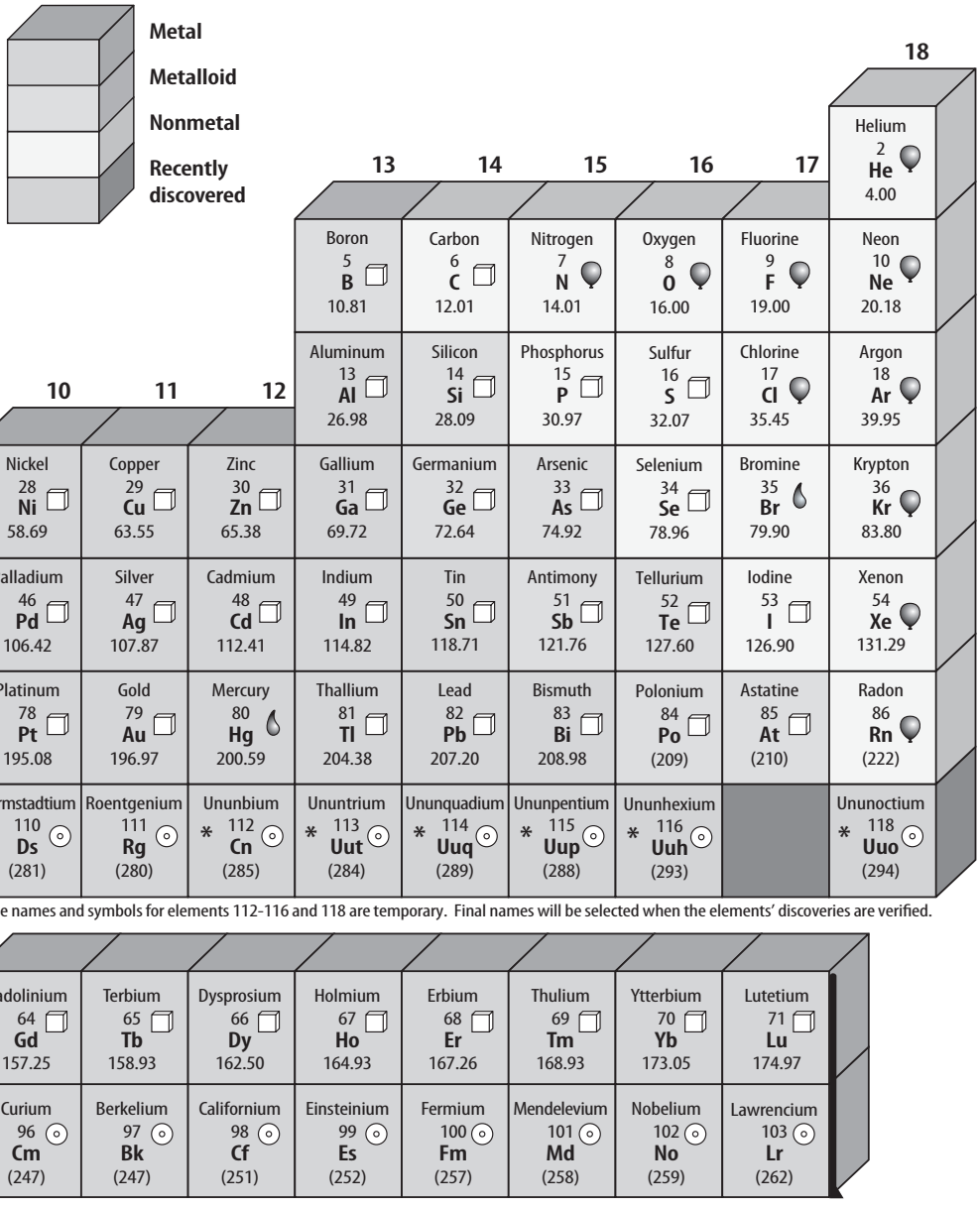
How Scientists Use the Periodic Table

More than 100 elements are known today. They are all listed on the periodic table. Each element has its own set of properties. It also has properties similar to the elements near it on the table. The periodic table shows how elements relate to each other and fit together into one organized chart. Scientists use the periodic table to understand and predict elements' properties.

The elements with the largest atomic masses are not found in nature. These are elements that can be made only by scientists in special laboratories. Elements that were created in laboratories are named to honor the scientists who created them or the laboratories in which they were created.

Reading Check

8. Explain How is the periodic table used to predict the properties of an element?



Mini Glossary

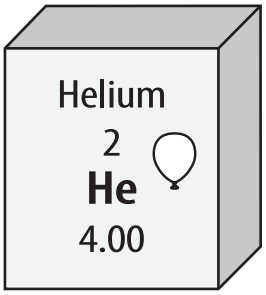
group: a column on the periodic table

period: a row on the periodic table

periodic (pihr ee AH dihk) table: a chart of the elements arranged into rows and columns according to their physical and chemical properties

1. Review the terms and their definitions in the Mini Glossary. Use all three words in the Mini Glossary to describe the periodic table and how it is arranged.

2. Examine the element key at right from the periodic table. From the element key, give all the information you can tell about the element shown.



3. How did preparing questions about the periodic table and the elements help you learn the information in the lesson?

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

The Periodic Table

Metals

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
	3. Fewer than half of the elements are metals.	
	4. Metals are usually good conductors of electricity.	

Read to Learn

What is a metal?

Metals are some of the most useful elements. Forks, knives, copper wire, aluminum foil, gold jewelry, and many other things are made of metal.

Most of the elements on the periodic table are metals. Except for hydrogen, all of the elements in groups 1–12 on the periodic table are metals. Some of the elements in groups 13–15 are metals also. To be a metal, an element must have certain properties.

Physical Properties of Metals

Recall that physical properties are characteristics used to describe or identify something without changing its makeup. All metals share certain physical properties. *A* **metal** *is an element that is generally shiny. It is easily pulled into wires or hammered into thin sheets. A metal is a good conductor of electricity and thermal energy*. Gold exhibits the properties of metal.

Luster and Conductivity People use gold for jewelry because of its beautiful color and metallic luster. **Luster** *is the ability of a metal to reflect light*. Gold is also a good conductor of thermal energy and electricity. However, gold is too expensive to use in normal electrical wires or metal cookware. Copper is often used instead.

Key Concepts

- What elements are metals?
- What are the properties of metals?

Mark the Text

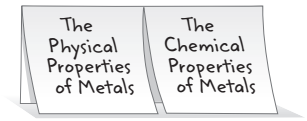
Underline Main Ideas As you read, underline the main ideas under each heading. After you finish reading, review the main ideas that you have underlined.

Key Concept Check

1. Explain How does the position of an element on the periodic table allow you to determine if the element is a metal?

FOLDABLES®

Make a two-tab book to record information about the physical and chemical properties of metals.



Ductility and Malleability Gold is the most ductile metal. **Ductility** (duk TIH luh tee) *is the ability of a substance to be pulled into thin wires*. A piece of gold with a mass the same as that of a paper clip can be pulled into a wire that is more than 3 km long.

Malleability (ma lee uh BIH luh tee) *is the ability of a substance to be hammered or rolled into sheets*. Gold is so malleable that it can be hammered into thin sheets. A pile of a million thin sheets of gold would be only as high as a coffee mug.

Other Physical Properties of Metals Metals have other physical properties. The density, strength, boiling point, and melting point of a metal are greater than those of other elements. Except for mercury, all metals are solid at room temperature. Many uses of a metal are determined by the metal's physical properties.

Key Concept Check

2. Identify What are some physical properties of metals?

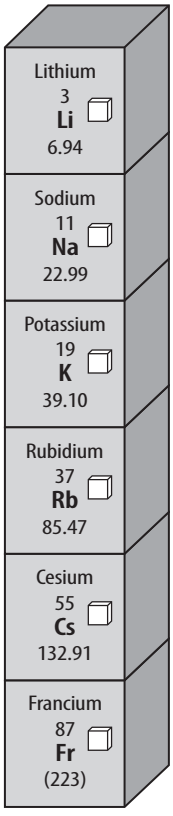
Chemical Properties of Metals

Recall that a chemical property is the ability or inability of a substance to change into one or more new substances. Most metals share similar physical properties. The chemical properties of metals, however, can vary greatly. Metals in the same group on the periodic table usually have similar chemical properties. The likelihood that one element will react with another is a chemical property.

Group 1: Alkali Metals

The elements in group 1 are called **alkali** (AL kuh li) **metals.** Group 1 elements are shown on the right. They include lithium, sodium, potassium, rubidium, cesium, and francium.

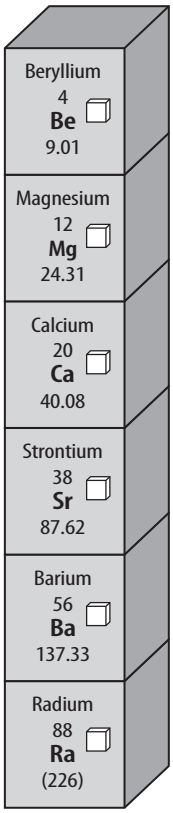
Because they are in the same group, alkali metals have similar chemical properties. Alkali metals are very reactive. Because they react quickly with other elements, alkali metals occur only in compounds in nature. Pure alkali metals must be stored so that they do not come into contact with oxygen and water vapor in the air. Alkali metals react violently with water. Alkali metals also have similar physical properties. Pure alkali metals have a silvery appearance and are soft enough to be cut with a knife. They also have the lowest densities of all metals. A block of pure sodium metal could float on water because of its very low density.



Visual Check

3. Identify What part of the periodic table is represented by the figure at right?

Group 2: Alkaline Earth Metals



The elements in group 2 are called **alkaline** (AL kuh lun) **earth metals.** Group 2 elements are shown on the right. They include beryllium, magnesium, calcium, strontium, barium, and radium.

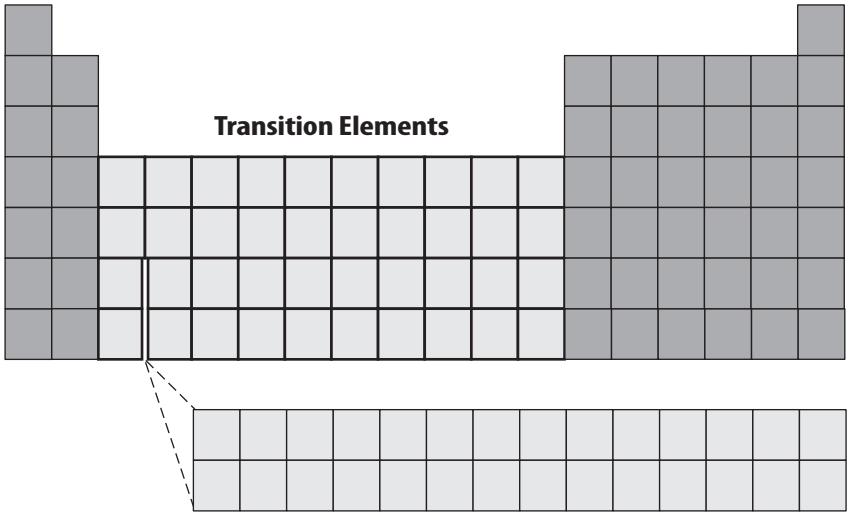
Like alkali metals, alkaline earth metals react quickly with other elements. But they do not react as quickly as alkali metals do. Like alkali metals, pure alkaline earth metals do not occur naturally. They combine with other elements and form compounds.

The physical properties of the alkaline earth metals are also similar to those of the alkali metals. Alkaline earth metals are soft and silvery. They have low densities, but their densities are greater than those of alkali metals.

Groups 3–12: Transition Elements

The elements in groups 3–12 are called **transition elements.** The transition elements are in two blocks on the periodic table. As shown below, one block is in the center of the periodic table. The other block is the two rows at the bottom of the periodic table.

Many colorful materials contain small amounts of transition elements. An emerald is green because it contains small amounts of chromium. A garnet is red because of the iron it contains.



Visual Check

4. Identify Circle the element in the figure with the highest atomic mass.

Reading Check

5. Identify Which element reacts faster with oxygen—barium or potassium?

_____

_____

_____

Visual Check

6. Identify How many periods of transition elements are there in the periodic table?

_____

Think it Over

7. Contrast Describe two differences between transition elements and alkali metals.

Properties of Transition Elements

All transition elements are metals. They have higher melting points, greater strength, and higher densities than the alkali metals and the alkaline earth metals. Transition elements also react less quickly with oxygen. Some transition elements can exist in nature as free elements rather than in compounds. Free elements occur in pure form.

Uses of Transition Elements

Transition elements in the middle block of the periodic table have many important uses. Because they are dense, strong, and resist corrosion, transition elements such as iron make good building materials. Copper, silver, nickel, and gold are used to make coins. Many transition elements can react with other elements and form many compounds.

Lanthanide and Actinide Series

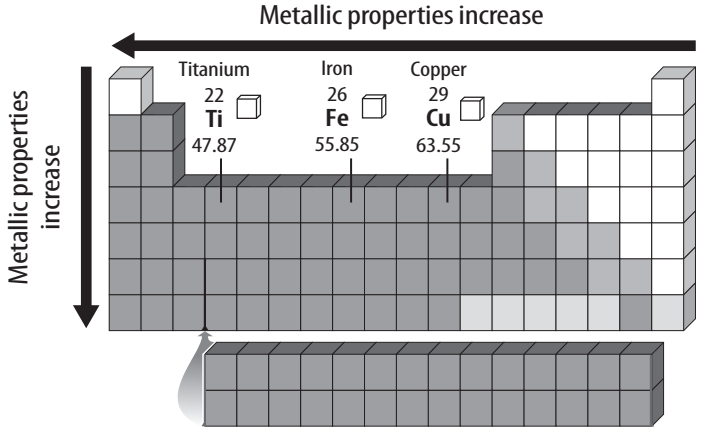
Two rows of transition elements are at the bottom of the periodic table. They are placed below the main table to keep the table from being too wide. Elements in the first row are called the lanthanide series, and elements in the second row are called the actinide series. Some elements from both series have valuable properties. Lanthanide series elements are used to make strong magnets. Plutonium, an actinide series element, is used as a fuel in some nuclear reactors.

Patterns in Properties of Metals

The properties of elements follow repeating patterns across the periods of the periodic table. The figure below shows these patterns. Potassium (K) has more luster, is the most malleable, and conducts electricity better than all the elements in period 4. All these properties decrease from left to right across the period. The elements on the far right have no metallic properties at all. There are also patterns within groups. Metallic properties tend to increase as you move down a group.

Reading Check

8. Locate Where on the periodic table would you expect to find elements with few or no metallic properties?



Visual Check

9. Identify Circle the most malleable metal: iron (FE), copper (Cu), or titanium (Ti).

After You Read

Mini Glossary

alkali (AL kuh li) metal: an element in group 1 on the periodic table

alkaline (AL kuh lun) earth metal: an element in group 2 on the periodic table

ductility (duk TIH luh tee): the ability of a substance to be pulled into thin wires

luster: the ability of a metal to reflect light

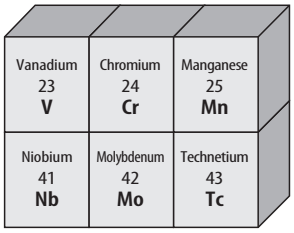
malleability (ma lee uh BIH luh tee): the ability of a substance to be hammered or rolled into sheets

metal: an element that is generally shiny, is easily pulled into wires or hammered into thin sheets, and is a good conductor of electricity and thermal energy

transition element: an element in groups 3–12 on the periodic table

1. Review the terms and their definitions in the Mini Glossary. Use three terms to tell what properties metals tend to have.

2. Examine the section of the periodic table at right. Which element has properties most similar to those of chromium (Cr)? Why?



3. How did underlining the main ideas help you review the material?

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

CHAPTER 11
LESSON 3

The Periodic Table

Nonmetals and Metalloids

Key Concepts

- Where are nonmetals and metalloids on the periodic table?
- What are the properties of nonmetals and metalloids?

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
	5. Most of the elements in living things are nonmetals.	
	6. Even though they look very different, oxygen and sulfur share some similar properties.	

Mark the Text

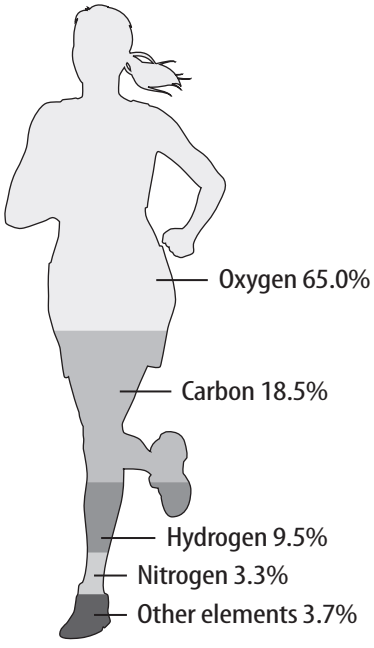
Underline Terms As you read this lesson, underline the names of important nonmetals. Highlight information about them. Use this information to review the lesson.

Read to Learn

The Elements of Life

More than 96 percent of the mass of your body comes from just four elements. They are shown in the figure. All four of these elements—oxygen, carbon, hydrogen, and nitrogen—are nonmetals. **Nonmetals** *are elements that have no metallic properties.*

Of the remaining elements in your body, the two most common are also nonmetals—phosphorus and sulfur. These six elements (oxygen, carbon, hydrogen, nitrogen, phosphorus, and sulfur) form the compounds in proteins, fats, nucleic acids, and other large molecules in your body. These elements also form the compounds in all other living things.



Visual Check

1. Identify Which three elements make up most of the mass of your body?

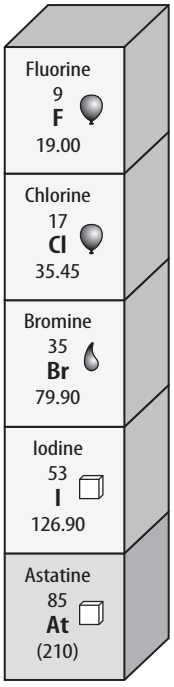
_____

_____

How are nonmetals different from metals?

Recall that metals have luster. They are ductile, malleable, and good conductors of electricity and thermal energy. All metals except mercury are solids at room temperature.

The properties of nonmetals are different from those of metals. Nonmetals do not conduct electricity or thermal energy well. Those that are solid at room temperature have no luster. Many of the nonmetals are gases at room temperature.



Nonmetals in Groups 14–16

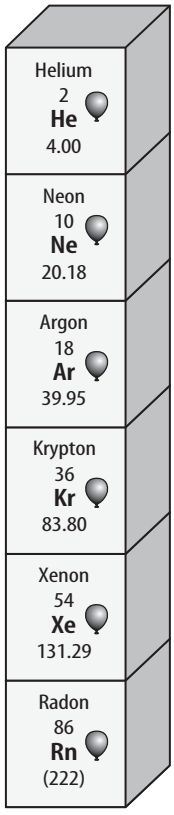
Look at the periodic table in this chapter or in the back of this book. Notice that groups 14–16 contain metals, nonmetals, and metalloids. The chemical properties of the elements in each group are similar. However, the physical properties of the elements can be different. Nonmetals in the groups include carbon, nitrogen, phosphorus, oxygen, sulfur, and selenium.

Group 17: The Halogens

Group 17 of the periodic table is above on the right. *An element in group 17 of the periodic table is called a* **halogen** (HA luh jun). Halogens can react with a metal and form a salt. For example, chlorine gas reacts with solid sodium and forms sodium chloride, or table salt. All halogens react readily with other elements and form compounds. In fact, they can occur naturally only in compounds. They do not exist as free elements.

Group 18: The Noble Gases

Group 18 of the periodic table is shown at right. *The elements in group 18 are known as the* **noble gases.** The elements helium, neon, argon, krypton, xenon, and radon are the noble gases. Unlike the halogens, the only way noble gases react with other elements is under special conditions in a laboratory. They do not form compounds naturally.

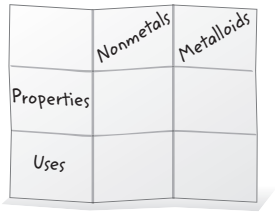


Key Concept Check

2. Identify What properties do nonmetals have?

FOLDABLES®

Make a chart with three columns and three rows to organize information about nonmetals and metalloids.



Reading Check

3. Predict Will bromine (Br) react with sodium (Na)? Explain your answer.

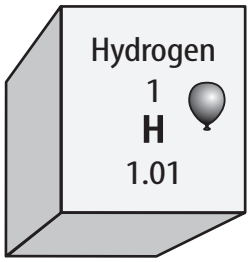
Visual Check

4. Identify Label each figure on the left with the correct group number from the periodic table.

Visual Check

5. Identify What can you tell about the element hydrogen from looking at the element key on the right?

Hydrogen



The element key for hydrogen is shown at right. Hydrogen has the smallest atomic mass of any of the elements. Hydrogen is the most common element in the universe.

Hydrogen is most often classified as a nonmetal because it has many of the properties of nonmetals. For example, it is a gas at room temperature. However, hydrogen shares properties with the alkali metals in group 1. In liquid form, hydrogen conducts electricity just like a metal does. In some chemical reactions, hydrogen reacts like an alkali metal. However, under conditions on Earth, hydrogen usually behaves like a nonmetal. More than 90 percent of all the atoms in the universe are hydrogen atoms.

Metalloids

Between the metals and the nonmetals on the periodic table are elements known as metalloids. The elements boron, silicon, germanium, arsenic, antimony, tellurium, polonium, and astatine are metalloids. *A* **metalloid** (MEH tul oyd) *is an element that has physical and chemical properties of both metals and nonmetals.* Silicon is the most abundant metalloid in the universe. The metalloids are shown in the figure below.

Key Concept Check

6. Identify Where are metalloids on the periodic table?

Visual Check

7. Identify Circle the portion of the figure at right that contains the metalloid elements.

Boron 5 **B** 10.81	Carbon 6 **C** 12.01	Nitrogen 7 **N** 14.01	Oxygen 8 **O** 16.00	Fluorine 9 **F** 19.00
Aluminum 13 **Al** 26.98	Silicon 14 **Si** 28.09	Phosphorus 15 **P** 30.97	Sulfur 16 **S** 32.07	Chlorine 17 **Cl** 35.45
Gallium 31 **Ga** 69.72	Germanium 32 **Ge** 72.64	Arsenic 33 **As** 74.92	Selenium 34 **Se** 78.96	Bromine 35 **Br** 79.90
Indium 49 **In** 114.82	Tin 50 **Sn** 118.71	Antimony 51 **Sb** 121.76	Tellurium 52 **Te** 127.60	Iodine 53 **I** 126.90
Thallium 81 **Tl** 204.38	Lead 82 **Pb** 207.20	Bismuth 83 **Bi** 208.98	Polonium 84 **Po** (209)	Astatine 85 **At** (210)

Semiconductors

Recall that metals are good conductors of thermal energy and electricity. Nonmetals are poor conductors of thermal energy and electricity. But they are good insulators. A property of metalloids is the ability to act as a semiconductor. *A* **semiconductor** (seh mee kun DUK tur) *is an element that conducts electricity at high temperatures, but not at low temperatures*. At high temperatures, metalloids act like metals and conduct electricity. But at lower temperatures, they act like nonmetals and do not conduct electricity. This property is useful in electronic devices such as computers and televisions.

Properties and Uses of Metalloids

Silicon is one of the most abundant elements on Earth. Sand, clay, and many rocks and minerals are made of silicon compounds. Pure silicon is used in semiconductor devices for computers and other electronic products. Germanium is also used as a semiconductor. Semiconductors are an important use of metalloids. Metalloids also have other uses. Boron is used in water softeners and laundry products. Boron also glows bright green in fireworks.

Metals, Nonmetals, and Metalloids

You have read that all metallic elements have common characteristics, such as malleability, conductivity, and ductility. However, each metal has unique properties that make it different from other metals. The same is true for nonmetals and metalloids. How can knowing the properties of an element help you understand how to use it?

Look at the periodic table. An element's position on the periodic table tells you a lot about the element. By knowing that sulfur is a nonmetal, for example, you know that it breaks easily and does not conduct electricity. You would not choose sulfur to make a wire. You would not try to use oxygen as a semiconductor or sodium as a building material. You know that transition elements are strong, malleable, and do not react easily with oxygen or water. These elements make good building materials because they are strong and malleable. They are less reactive than other elements. Being familiar with the properties of metals and other elements can help you understand how they are used in different situations.

Think it Over

8. Explain What property makes semiconductors useful in electronic equipment?

Reading Check

9. Explain Why would you not use an element on the right side of the periodic table as a building material?

Mini Glossary

halogen (HA luh jun): an element in group 17 of the periodic table

metalloid (MEH tul oyd): an element that has physical and chemical properties of both metals and nonmetals

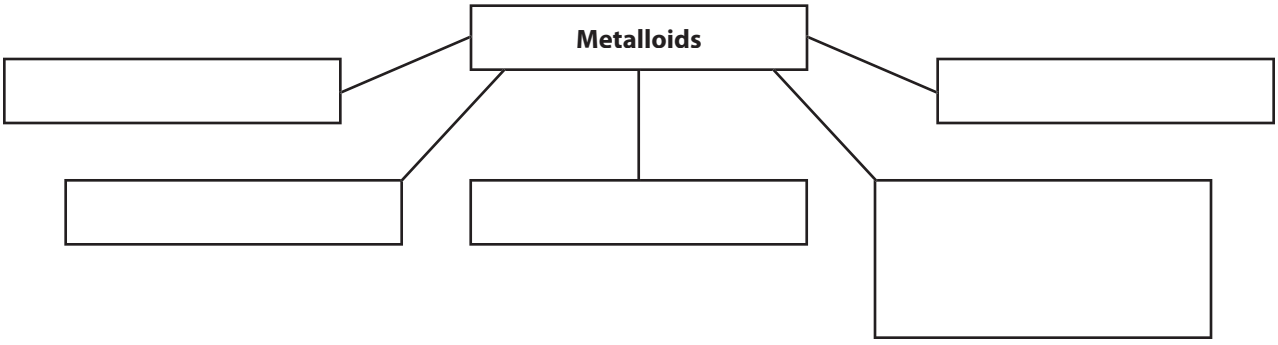
noble gas: an element in group 18 of the periodic table

nonmetal: an element that has no metallic properties

semiconductor (seh mee kun DUK tur): an element that conducts electricity at high temperatures, but not at low temperatures

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that compares nonmetals and metalloids.

2. In the graphic organizer below, write the names of five metalloids. In the largest box, write the name of the metalloid that is one of the most abundant elements on Earth.



3. Review the names of the nonmetals that you underlined and the information that you highlighted. How did this strategy help you learn about nonmetals?

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