4 Nonmetals and Metalloids

Objectives

After this lesson, students will be able to

K.3.4.1 Describe the properties of nonmetals.

K.3.4.2 Tell how metalloids are useful.

Target Reading Skill

Using Prior Knowledge Explain that using prior knowledge helps students connect what they already know to what they are about to read.

Answers

Sample answers:

What You Know

1. Nonmetals are not shiny.

2. Nonmetals are not magnetic.

What You Learned

1. Nonmetals are dull and brittle.

2. Metalloids have characteristics of metals and nonmetals.

All in One Teaching Resources

- Transparency K28

Preteach

Build Background Knowledge L2

Experience With Chlorine

Ask: **What do you know about chlorine?** *(Sample answer: Chemical used in swimming pools, part of bleach)* Encourage students to build on their experiences with chlorine in swimming pools and share their observations. Point out the position of chlorine in the periodic table. Invite students to share any knowledge they may have about elements near chlorine.

Section 4

Nonmetals and Metalloids

Reading Preview

Key Concepts

- What are the properties of nonmetals?
- How are the metalloids useful?

Key Terms

- nonmetal
- diatomic molecule
- halogen
- noble gas
- metalloid
- semiconductor

Target Reading Skill

Using Prior Knowledge Before you read, write what you know about the properties of nonmetals and metalloids in a graphic organizer like the one below. As you read, write what you learn.

What You Know
1. Nonmetals are not shiny. 2.

What You Learned
1. 2.

Lab zone Discover Activity

What Are the Properties of Charcoal?

1. Break off a piece of charcoal and roll it between your fingers. Record your observations.
2. Rub the charcoal on a piece of paper. Describe what happens.
3. Strike the charcoal sharply with the blunt end of a fork. Describe what happens.
4. When you are finished with your investigation, return the charcoal to your teacher and wash your hands.

Think It Over

Classifying Charcoal is a form of the element carbon. Would you classify carbon as a metal or a nonmetal? Use your observations from this activity to explain your answer.

Life on Earth depends on nonmetals. All organisms are made from compounds of carbon. The air you and other living things breathe contains mostly nitrogen and oxygen. Water, a key compound in living cells, consists of hydrogen and oxygen. Yet, while many compounds made with nonmetals are essential to life, some nonmetals themselves are poisonous and highly reactive. Still others are completely unreactive. Compared to metals, nonmetals have a much wider variety of properties. However, nonmetals do have several properties in common.

These bears, the grass behind them, and all life on Earth is based on carbon, a nonmetal.

Lab zone Discover Activity

Skills Focus Classifying L1

Materials activated charcoal, paper, fork

Time 5 minutes

Tips Activated charcoal is available where aquarium supplies are sold. You may substitute charcoal briquettes, but tell students that the charcoal has been mixed with clay to keep its shape.

Expected Outcome The charcoal breaks easily, rubs off on fingers and paper, and shatters when hit with a fork.

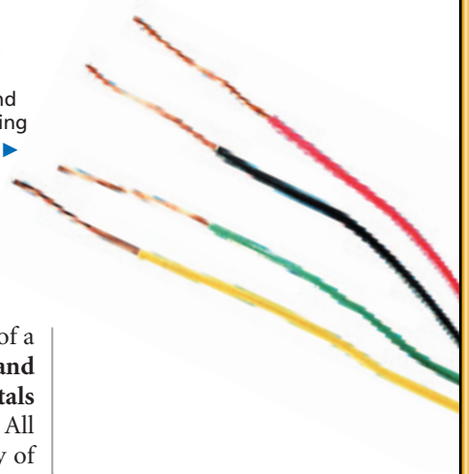
Think It Over Sample answer: Carbon is brittle, dull, not malleable, and not lustrous. Carbon is not a metal.

FIGURE 20
Physical Properties of Nonmetals

Nonmetals have properties that are the opposite of metals. **Comparing and Contrasting** *Contrast the properties of these nonmetals with those of metals.*

▲ The helium filling this blimp is a gas at room temperature.

◀ Sulfur crumbles into a powder.



Nonmetals are good insulators. Carbon compounds are found in the plastic insulating these copper wires. ▶

Properties of Nonmetals

A **nonmetal** is an element that lacks most of the properties of a metal. **Most nonmetals are poor conductors of electricity and heat and are reactive with other elements. Solid nonmetals are dull and brittle.** Look at the periodic table in Section 2. All of the elements in green-tinted boxes are nonmetals. Many of the nonmetals are common elements on Earth.

Physical Properties Ten of the 16 nonmetals are gases at room temperature. The air you breathe is mostly a mixture of two nonmetals, nitrogen (N) and oxygen (O). Other nonmetal elements, such as carbon (C), iodine (I), and sulfur (S), are solids at room temperature. Bromine (Br) is the only nonmetal that is liquid at room temperature.

Look at examples of nonmetals in Figure 20. In general, the physical properties of nonmetals are the opposite of those of the metals. Solid nonmetals are dull, meaning not shiny, and brittle, meaning not malleable or ductile. If you hit most solid nonmetals with a hammer, they break or crumble into a powder. Nonmetals usually have lower densities than metals. And nonmetals are also poor conductors of heat and electricity.

Differentiated Instruction

English Language Learners/ Beginning L1

Comprehension: Key Concept Rewrite the boldfaced sentences on this page as a list of nonmetal properties. Have students construct a cluster diagram with "Properties of Nonmetals" in the center and each property connected to it by a line. Allow students to list properties using English synonyms or native words.
learning modality: visual

English Language Learners/ Intermediate L2

Comprehension: Key Concept Have students complete the activity at left, but do not allow them to use native words.
learning modality: visual

Instruct

Properties of Nonmetals

Teach Key Concepts L2

Contrasting Nonmetals and Metals

Focus Tell students that nonmetals are most often described as anything that is not a metal.

Teach List the properties of metals discussed in *Metals*. Then, list properties of nonmetals, opposite the corresponding metal property. Ask: **Are nonmetals good conductors of heat and electricity?** *(No)* **In what state are most nonmetals found at room temperature?** *(Most are gases, some are solids, only one is a liquid.)* Explain that most solid nonmetals are brittle. Ask: **What properties of metals are the opposite of *brittle*?** *(Malleable and ductile)*

Apply Ask: **What properties of oxygen make it a nonmetal?** *(Sample answer: It is a gas at room temperature and a poor conductor of electricity and heat.)* **learning modality: verbal**

Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Nonmetals and Metalloids*

Student Edition on Audio CD

Monitor Progress L2

Writing Instruct students to write down one characteristic that most nonmetals have.

Answer

Figure 20 Sulfur is brittle, helium is a gas, and plastics do not conduct electricity. Metals are bendable, good conductors of electricity, and usually solid at room temperature.

Use Visuals: Figure 21 L2

Electrons and Reactivity

Focus Remind students that metals react with other elements by losing electrons and nonmetals react by gaining or sharing electrons.

Teach Direct students to look at Figure 21. Ask: **Which element will gain an electron?** *(Chlorine)* **Which element will lose an electron?** *(Sodium)*

Apply Explain that the reactivity of elements depends on electrons. Ask: **Why do the nonmetals in Group 18 rarely react with other elements to form compounds?** *(They do not readily lose or share electrons.)*

learning modality: visual

Families of Nonmetals

Teach Key Concepts L2

Nonmetal Groups

Focus Point out that Group 18 is the one group that consists only of nonmetals. However, nonmetals in mixed groups do share similar properties with the metals in their group.

Teach Begin a table on the board with properties of nonmetals as you did with metals. Again, keep track of the properties of each nonmetal family as students study them. Record the properties of that group, including the number of electrons lost when reacting with other elements. Also include examples of each.

Apply Ask: **What property do elements in mixed groups share?** *(They all gain, lose, or share the same number of electrons.)*

learning modality: visual

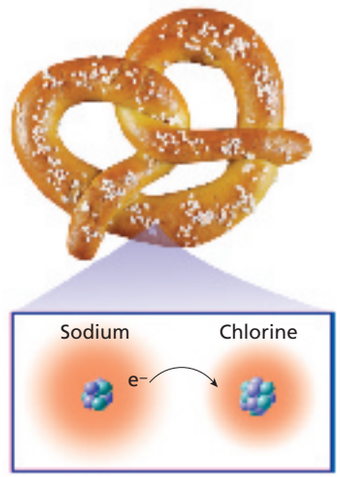


FIGURE 21
Reactions of Nonmetals
The table salt on a pretzel is mined from deposits found on Earth. The same compound can also be formed from a reaction between the metal sodium and the nonmetal chlorine.

Chemical Properties Most nonmetals are reactive, so they readily form compounds. In fact, fluorine (F) is the most reactive element known. Yet, Group 18 elements hardly ever form compounds.

Atoms of nonmetals usually gain or share electrons when they react with other atoms. When nonmetals and metals react, electrons move from the metal atoms to the nonmetal atoms, as shown by the formation of salt, shown in Figure 21. Another example is rust—a compound made of iron and oxygen (Fe_2O_3). It's the reddish, flaky coating you might see on an old piece of steel or an iron nail.

Many nonmetals can also form compounds with other nonmetals. The atoms share electrons and become bonded together into molecules.

Reading Checkpoint **In which portion of the periodic table do you find nonmetals?**

Families of Nonmetals

Look again at the periodic table. Notice that only Group 18 contains elements that are all nonmetals. In Groups 14 through 17, there is a mix of nonmetals and other kinds of elements.

The Carbon Family Each element in the carbon family has atoms that can gain, lose, or share four electrons when reacting with other elements. In Group 14, only carbon is a nonmetal. What makes carbon especially important is its role in the chemistry of life. Compounds made of molecules containing long chains of carbon atoms are found in all living things.

Most of the fuels that are burned to yield energy contain carbon. Coal, for example, is mostly the element carbon. Gasoline is made from crude oil, a mixture of carbon compounds with chains of 5 to 50 or more carbon atoms in their molecules.

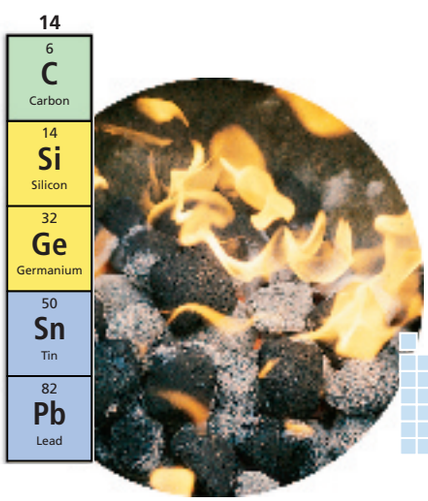


FIGURE 22
Carbon
Charcoal is one form of carbon, the only nonmetal in Group 14.

The Nitrogen Family Group 15, the nitrogen family, contains two nonmetals, nitrogen and phosphorus. These nonmetals usually gain or share three electrons when reacting with other elements. To introduce yourself to nitrogen, take a deep breath. The atmosphere is almost 80 percent nitrogen gas (N_2). Nitrogen does not readily react with other elements, so you breathe out as much nitrogen as you breathe in.

Nitrogen is an example of an element that occurs in nature in the form of diatomic molecules, as N_2. A **diatomic molecule** consists of two atoms. In this form, nitrogen is not very reactive. Although living things need nitrogen, most of them are unable to use nitrogen from the air. However, certain kinds of bacteria can use this nitrogen to form compounds. This process is called nitrogen fixation. Plants can then take up these nitrogen compounds formed in the soil by the bacteria. Farmers also add nitrogen compounds to the soil in the form of fertilizers. Like all animals, you get the nitrogen you need from the food you eat—from plants, or from animals that ate plants.

Phosphorus is the other nonmetal in the nitrogen family. Phosphorus is much more reactive than nitrogen, so phosphorus in nature is always found in compounds. A compound containing phosphorus is used to make matches, because it can react with oxygen in the air.

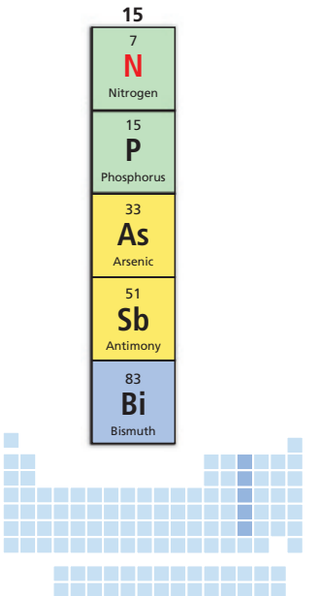


FIGURE 23
The Nitrogen Family
Nitrogen and phosphorus are grouped in the same family of the periodic table, Group 15. **Making Generalizations** *How do atoms of both these elements change when they react?*

▼ Nitrogen is a key ingredient of fertilizers.

▲ Match heads contain a highly reactive phosphorus compound that ignites easily.

Help Students Read L2

Vocabulary: Word Part Analysis Write the word *diatomic* on the board and ask: **What is the root word of this word?** *(Atom)* Explain that the prefix *di-* means "two" or "double." The suffix *-ic* means "of," or "pertaining to." Say that this suffix changes a noun to an adjective. Ask: **Since you know that an atom is a particle of matter, what does "diatomic molecule" mean?** *(A molecule formed of two atoms)*

Lab zone Build Inquiry L2

Reading Fertilizer Bags

Materials labels from various types of fertilizers

Time 15 minutes

Focus Tell students that nitrogen and phosphorus are two of the key ingredients in fertilizers.

Teach Have students find the guaranteed analysis of chemicals on the fertilizer label. Ask: **In what form is the nitrogen present in the fertilizer?** *(Sample answer: Nitrates and ammonium compounds)* **In what form is the phosphorus?** *(Sample answer: Phosphates)*

Apply Ask: **Why aren't nitrogen and phosphorus present as pure elements in the fertilizer?** *(As part of a compound, nitrogen and phosphorus are more stable and in a form that plants can easily use.)* **learning modality: verbal**

Differentiated Instruction

Special Needs L3

Interpreting Visuals Have students look at the column of symbols for the Group 15 elements shown in Figure 23. Then have them locate the same column in the large periodic table shown earlier and compare the two. Point out that, except for atomic mass, both illustrations list the same information for each element in the group. Ask: **What do the different colors of the boxes represent?** *(Green indicates a nonmetal, yellow is a metalloid, and blue is a metal.)* Then have students create a chart with the headings *Metal, Nonmetal,* and *Metalloid.* Direct students to write in the chart the names of the Group 15 elements that fit into each category. Have students identify and circle the name of the only element in the group that is a gas. *(Nitrogen)* **learning modality: visual**

Monitor Progress L2

Oral Presentation Have students give the number of electrons that elements in the carbon family and elements in the nitrogen family usually lose, gain, or share.

Answers

Figure 23 Both gain or share three electrons.

Reading Checkpoint To the right of the metalloids

Lab zone Build Inquiry

L2

Finding Nonmetals

Materials none

Time 15 minutes

Focus Tell students that nonmetals have many different uses.

Teach Invite student groups to look for nonmetals in the classroom and around the school building and grounds. Have them list the nonmetals they observe and describe their uses. When students return to the classroom, make a class list of the observed nonmetals. Then, challenge students to identify the nonmetal elements.

Apply Ask: **Why are most nonmetals found as part of a compound?** *(Sample answer: Nonmetals are very reactive.)*
learning modality: visual

Lab zone Try This Activity

Show Me the Oxygen

How can you test for the presence of oxygen?

1. Pour about a 3-cm depth of hydrogen peroxide (H_2O_2) into a test tube.
2. Add a pea-sized amount of manganese dioxide (MnO_2) to the test tube.
3. Observe the test tube for about 1 minute.
4. When instructed by your teacher, set a wooden splint on fire.
5. Blow the splint out after 5 seconds and immediately plunge the glowing splint into the mouth of the test tube. Avoid getting the splint wet.

Observing Describe the change in matter that occurred in the test tube. What evidence indicates that oxygen was produced?

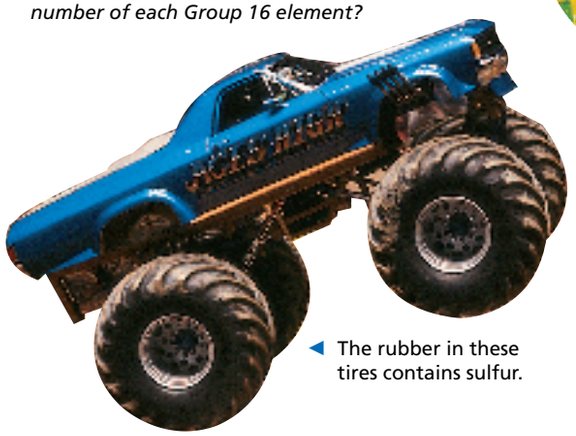
The Oxygen Family Group 16, the oxygen family, contains three nonmetals—oxygen, sulfur, and selenium. These elements usually gain or share two electrons when reacting with other elements.

You are using oxygen right now. With every breath, oxygen travels into your lungs. There, it is absorbed into your bloodstream, which distributes it all over your body. You could not live without a steady supply of oxygen. Like nitrogen, the oxygen you breathe is a diatomic molecule (O_2). In addition, oxygen sometimes forms a triatomic (three-atom) molecule, which is called ozone (O_3). Ozone collects in a layer in the upper atmosphere, where it screens out harmful radiation from the sun. However, ozone is a dangerous pollutant at ground level because it is highly reactive.

Because oxygen is highly reactive, it can combine with almost every other element. It also is the most abundant element in Earth's crust and the second-most abundant element in the atmosphere. (The first is nitrogen.)

Sulfur is the other common nonmetal in the oxygen family. If you have ever smelled the odor of a rotten egg, then you are already familiar with the smell of some sulfur compounds. Sulfur is used in the manufacture of rubber for rubber bands and automobile tires. Most sulfur is used to make sulfuric acid (H_2SO_4), one of the most important chemicals used in industry.

▲ Some of the oxygen needed by a frog enters through its skin.



◀ The rubber in these tires contains sulfur.

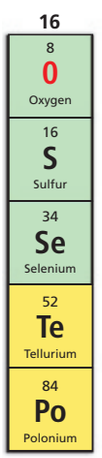


FIGURE 24
The Oxygen Family
Oxygen and sulfur are the most common of the three nonmetals in Group 16.
Interpreting Tables *What is the atomic number of each Group 16 element?*

Lab zone Try This Activity

Skills Focus Observing

L2

Materials 3% hydrogen peroxide solution, manganese dioxide, test tube, wooden splint, matches

Time 15 minutes

Tips Substitute wooden coffee stirrers for splints.

Expected Outcome Bubbles form in the H_2O_2 after the addition of MnO_2. The glowing splint relights and burns brightly. Sample answer: A gas was produced from the reaction of a solid and a liquid. The splint relit, indicating the presence of oxygen.

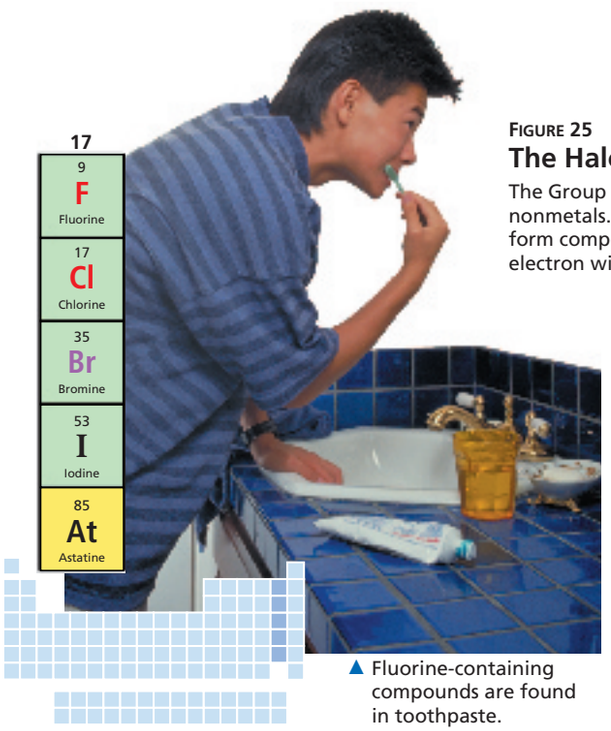
Extend Test for the presence of carbon dioxide. Add a small amount of hydrochloric acid to a test tube containing crushed shells or limestone (calcium carbonate). After the reaction, light a splint and insert it into the test tube. It will be extinguished by the carbon dioxide gas. **learning modality: visual**

The Halogen Family Group 17 contains fluorine, chlorine, bromine, iodine, and astatine. These elements are also known as the **halogens,** which means "salt forming." All but astatine are nonmetals, and all share similar properties. A halogen atom typically gains or shares one electron when it reacts with other elements.

All of the halogens are very reactive, and the uncombined elements are dangerous to humans. Fluorine is so reactive that it reacts with almost every other known substance. Even water and powdered glass will burn in fluorine. Chlorine gas is extremely dangerous, but it is used in small amounts to kill bacteria in water supplies.

Though the halogen elements are dangerous, many of the compounds that halogens form are quite useful. Compounds of carbon and fluorine make up the nonstick coating on cookware. Small amounts of fluorine compounds that are added to water supplies help prevent tooth decay. Chlorine is one of the elements in ordinary table salt (the other is sodium). Another salt of chlorine, calcium chloride, is used to help melt ice on roads and walkways. Bromine reacts with silver to form silver bromide, which is used in photographic film.

Go Online SCILINKS NSTA
For: Links on nonmetals
Visit: www.SciLinks.org
Web Code: scn-1134



▲ Fluorine-containing compounds are found in toothpaste.

FIGURE 25
The Halogens
The Group 17 elements are the most reactive nonmetals. Atoms of these elements easily form compounds by sharing or gaining one electron with atoms of other elements.

◀ Bromine is highly reactive, and will burn skin on contact.

Go Online SCILINKS NSTA
For: Links on nonmetals
Visit: www.SciLinks.org
Web Code: scn-1134
Download a worksheet that will guide students' review of Internet resources on nonmetals.

Lab zone **Build Inquiry** L3

Contrasting Halogens and Noble Gases

Materials art supplies, paper
Time 15 minutes

Focus Tell students that halogens are highly reactive and noble gases are very unreactive.

Teach Challenge students to create a cartoon that contrasts the reactivity of halogens and noble gases. Cartoons can be a single panel or a short series, color or black and white. Encourage students to be creative.

Apply Ask: **What causes the difference between the reactivity of halogens and noble gases?** *(Halogens easily gain or share one electron when reacting with other elements. Noble gases do not usually gain, lose, or share any electrons.)* **learning modality: kinesthetic**

Monitor Progress L2

Oral Presentation Call on students at random to give the group number and one characteristic of the oxygen family and the halogens.

Answer
Figure 24 Oxygen, 8; sulfur, 16; selenium, 34; tellurium, 52; and polonium, 84

The Metalloids

Teach Key Concepts L2

Properties of Metalloids

Focus Show students the location of metalloids in the periodic table.

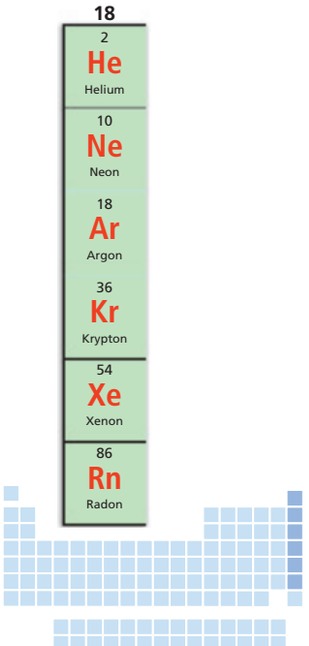
Teach Ask: **What are some properties of metalloids?** *(They have some properties of both metals and nonmetals. They are all solids at room temperature. They are brittle, hard, and somewhat reactive.)* **What is the most useful property of metalloids?** *(Their varying ability to conduct electricity)*

Apply Explain that silicon and germanium are metalloids used to make semiconductors. Ask: **What is a semiconductor?** *(A substance that can conduct electricity under some conditions but not under others.)* **What are semiconductors used for?** *(To make computer chips, transistors, and lasers)* **learning modality: verbal**

Integrating Physics L2

Have students find silicon on the periodic table. Ask: **Is silicon a metal, nonmetal, or metalloid?** *(Metalloid)* Explain that besides being used to make computer chips, silicon is also used to make solar cells. When light strikes the junction between two semiconductors or between a metal and a semiconductor, an electron moves from one atom to another. Ask: **What is the charge of an atom that has gained an electron?** *(Negative)* **What is the charge of an atom that has lost an electron?** *(Positive)* Explain that this transfer of charge can power a small appliance or charge a battery. **learning modality: verbal**

FIGURE 26
The Noble Gases
Electricity makes the Group 18 elements glow brightly inside glass tubes. **Applying Concepts** *Why are neon and the other noble gases so unreactive?*



The Noble Gases The elements in Group 18 are known as the **noble gases.** They do not ordinarily form compounds because atoms of noble gases do not usually gain, lose, or share electrons. As a result, the noble gases are usually unreactive. Even so, scientists have been able to form some compounds of the heavy noble gases (Kr, Xe) in the laboratory.

All the noble gases exist in Earth's atmosphere, but only in small amounts. Because they are so unreactive, the noble gases were not discovered until the late 1800s. Helium was discovered by a scientist who was studying not the atmosphere but the sun.

Have you made use of a noble gas? You have if you have ever purchased a floating balloon filled with helium. Noble gases are also used in glowing electric lights. These lights are commonly called neon lights, even though they are often filled with argon, xenon, or other noble gases.

Hydrogen Alone in the upper left corner of the periodic table is hydrogen—the element with the simplest and smallest atoms. Each hydrogen atom has one proton and one electron. Some hydrogen atoms also have neutrons. Because the chemical properties of hydrogen differ very much from those of the other elements, it really cannot be grouped into a family. Although hydrogen makes up more than 90 percent of the atoms in the universe, it makes up only 1 percent of the mass of Earth's crust, oceans, and atmosphere. Hydrogen is rarely found on Earth as a pure element. Most hydrogen is combined with oxygen in water (H_2O).

Reading Checkpoint **Why were the noble gases undiscovered until the late 1800s?**

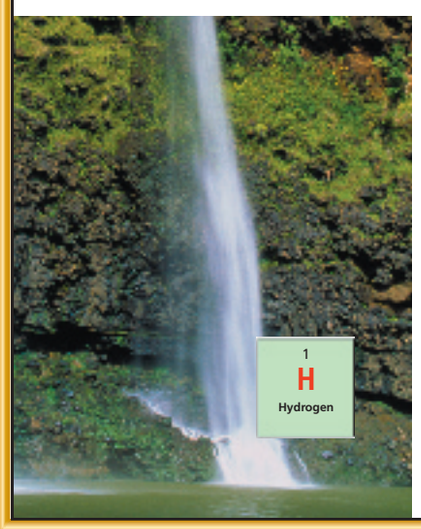


FIGURE 27
Importance of Hydrogen
Water is a compound of hydrogen and oxygen. Without liquid water, life on Earth would be impossible.

The Metalloids

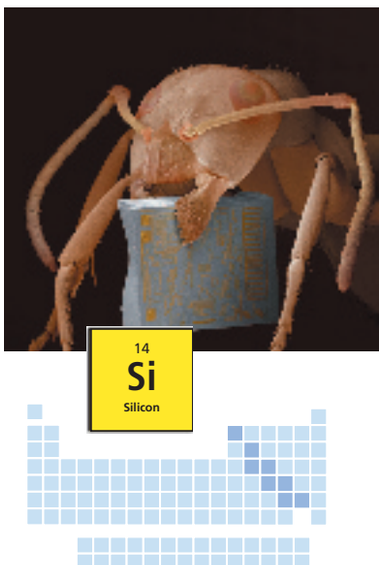
Along the border between the metals and the nonmetals are seven elements called metalloids. These elements are shown in the yellow squares in the periodic table in Section 2. The **metalloids** have some characteristics of both metals and nonmetals. All are solids at room temperature. They are brittle, hard, and somewhat reactive.

The most common metalloid is silicon (Si). Silicon combines with oxygen to form silicon dioxide (SiO_2). Ordinary sand, which is mostly SiO_2, is the main component of glass. A compound of boron (B) and oxygen is added during the process of glassmaking to make heat-resistant glass. Compounds of boron are also used in some cleaning materials.

The most useful property of the metalloids is their varying ability to conduct electricity. Whether or not a metalloid conducts electricity can depend on temperature, exposure to light, or the presence of small amounts of impurities. For this reason, metalloids such as silicon, germanium (Ge), and arsenic (As) are used to make semiconductors. **Semiconductors** are substances that can conduct electricity under some conditions but not under other conditions. Semiconductors are used to make computer chips, transistors, and lasers.

Reading Checkpoint **What is the most common metalloid, and where is it found?**

FIGURE 28
Silicon
A silicon computer chip is dwarfed by an ant, but the chip's properties as a semiconductor make it a powerful part of modern computers.



Section 4 Assessment

Target Reading Skill **Using Prior Knowledge** Review your graphic organizer about nonmetals and metalloids, and revise it based on what you learned in the section.

Reviewing Key Concepts

1. a. **Reviewing** What physical and chemical properties are found among the nonmetals?
   b. **Making Generalizations** What happens to the atoms of most nonmetals when they react with other elements?
   c. **Comparing and Contrasting** How do the physical and chemical properties of the halogens compare with those of the noble gases?
2. a. **Identifying** Where in the periodic table are the metalloids found?
   b. **Describing** What are three uses of metalloids?
   c. **Applying Concepts** What property makes certain metalloids useful as "switches" to turn a small electric current on and off?

Lab zone At-Home Activity

Halogen Hunt Identify compounds in your home that contain halogens. Look at labels on foods, cooking ingredients, cleaning materials, medicines, and cosmetics. The presence of a halogen is often indicated by the words *fluoride, chloride, bromide,* and *iodide* or the prefixes *fluoro-, chloro-, bromo-,* and *iodo-*. Show your family these examples and describe properties of the halogens.

Monitor Progress L2

Answers

Figure 26 Atoms of noble gases do not usually gain, lose, or share electrons.

Reading Checkpoint Because they are unreactive and scarce

Reading Checkpoint Silicon; in sand

Assess

Reviewing Key Concepts

1. a. Some nonmetals are gases at room temperature, while others are dull, brittle solids. In general, nonmetals have lower densities than metals and are poor conductors of heat and electricity. Except for Group 18 elements, most nonmetals react readily to form compounds. **b.** Atoms of nonmetals usually gain or share electrons when they react with other elements. **c.** At room temperature, fluorine and chlorine are gases, bromine is a liquid, iodine and astatine are solids, and all the noble gases are gases. While all the halogens are very reactive, the noble gases are usually stable and unreactive.

2. a. The metalloids are found along the border between the metals and nonmetals in the periodic table. **b.** Sample answer: As components of glass, cleaning materials, computer chips, transistors, and lasers **c.** Some metalloids, called *semiconductors,* conduct electricity under some conditions but not under other conditions.

Reteach L1

Have students make a table that compares and contrasts the properties of nonmetals and metalloids.

Performance Assessment L2

Writing Have students write a paragraph that explains why some metalloids are used to make semiconductors.

All in One Teaching Resources

- Section Summary: *Nonmetals and Metalloids*
- Review and Reinforce: *Nonmetals and Metalloids*
- Enrich: *Nonmetals and Metalloids*

Lab zone At-Home Activity

Halogen Hunt L1 Suggest students make a chart to list halogens they find. Examples include toothpaste (fluorine), table salt (chlorine), flour (bromine), tincture of iodine (iodine), and pesticides (fluorine and chlorine). Students might know about halogen light fixtures. Caution students not to touch pesticides or halogen light bulbs.

Lab zone Chapter Project

Keep Students on Track Allow students to begin testing their metal samples after you have approved their experimental plans. Suggest that students use descriptive means (e.g., *well, somewhat, poorly, not at all*) to rate a property if they cannot measure it exactly. When students test for conductivity, they might also test nonmetals (e.g., plastics, wood) for comparison.

Lab zone Skills Lab

Alien Periodic Table L2

Prepare for Inquiry

Key Concept
In the periodic table, elements are classified according to their properties.

Skills Objective
After this lab, students will be able to
- draw conclusions about the Earth names of the alien elements based on atomic number.
- classify elements based on their properties.
- interpret data on the properties of elements.
- infer the position of the elements on the periodic table.

Prep Time 5 minutes
Class Time 30 minutes

Advance Planning
Remind students to bring their textbooks to lab.

Alternative Materials
Give students index cards to rearrange the elements until they find the correct order. Or provide extra copies of the alien periodic table.

All in One **Teaching Resources**
- Lab Worksheet: *Alien Periodic Table*

Guide Inquiry

Invitation
Challenge students to find specific elements on the periodic table using clues. Ask: **What metal in Period 3 is slightly heavier than sodium?** *(Magnesium)*

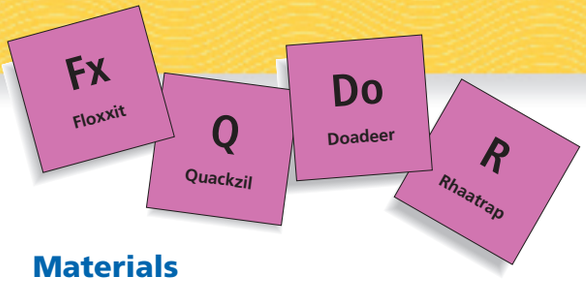
Introduce the Procedure
Refer students to the data for the alien elements and suggest that they work on the clues in order. Emphasize that they will need more than one clue to identify some elements.

Troubleshooting the Experiment
- Suggest that students work in pencil.
- Allow students to work in pairs.

Expected Outcome
See the sample data table on the next page.

Lab zone Skills Lab

Alien Periodic Table



Problem
Imagine that inhabitants of another planet send a message to Earth that contains information about 30 elements. However, the message contains different names and symbols for these elements than those used on Earth. Which elements on the periodic table do these "alien" names represent?

Skills Focus
drawing conclusions, classifying, interpreting data, inferring

Materials
- ruler
- periodic table from text for reference

Procedure
1. Copy the blank periodic table on page 107 into your notebook.
2. Listed below are data on the chemical and physical properties of the 30 elements. Place the elements in their proper position in the blank periodic table.

Alien Elements

The noble gases are **bombal** (Bo), **wobble** (Wo), **jeptum** (J), and **logon** (L). Among these gases, wobble has the greatest atomic mass and bombal the least. Logon is lighter than jeptum.

The most reactive group of metals are **xtalt** (X), **byyou** (By), **chow** (Ch), and **quackzil** (Q). Of these metals, chow has the lowest atomic mass. Quackzil is in the same period as wobble.

Apstrom (A), **vulcania** (V), and **kratt** (Kt) are nonmetals whose atoms typically gain or share one electron. Vulcania is in the same period as quackzil and wobble.

The metalloids are **ernst** (E), **highho** (Hi), **terriblum** (T), and **sississ** (Ss). Sississ is the metalloid with the greatest atomic mass. Ernst is the metalloid with the lowest atomic mass. Highho and terriblum are in Group 14. Terriblum has more protons than highho. **Yazzer** (Yz) touches the zigzag line, but it's a metal, not a metalloid.

The lightest element of all is called **pfsst** (Pf). The heaviest element in the group of 30 elements is **eldorado** (El). The most chemically active nonmetal is apstrom. Kratt reacts with byyou to form table salt.

The element **doggone** (D) has only 4 protons in its atoms.

Floxxit (Fx) is important in the chemistry of life. It forms compounds made of long chains of atoms. **Rhaatrap** (R) and **doadeer** (Do) are metals in the fourth period, but rhaatrap is less reactive than doadeer.

Magnificon (M), **goldy** (G), and sississ are all members of Group 15. Goldy has fewer electrons than magnificon.

Urrp (Up), **oz** (Oz), and **nuutye** (Nu) all gain 2 electrons when they react. Nuutye is found as a diatomic molecule and has the same properties as a gas found in Earth's atmosphere. Oz has a lower atomic number than urrp.

The element **anatom** (An) has atoms with a total of 49 electrons. **Zapper** (Z) and **pie** (Pi) lose two electrons when they react. Zapper is used to make lightweight alloys.

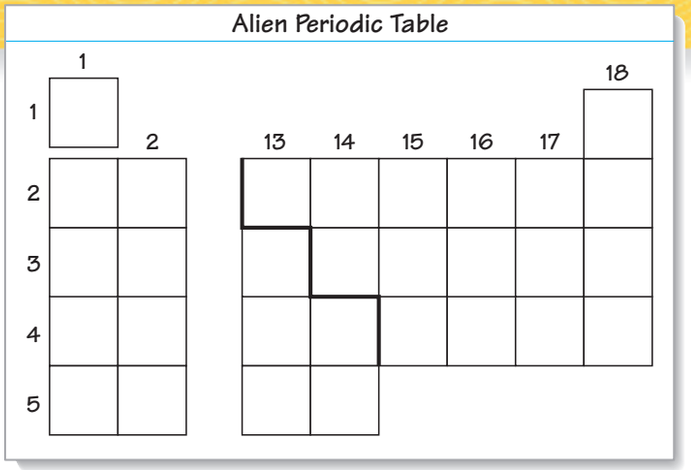
Analyze and Conclude
1. See the column on the next page.

2. Yes. Some clues identified a characteristic belonging to only one element, such as doggone having 4 protons, pfsst being the lightest element, and anatom having 49 electrons.

3. Some clues apply to several elements, such as clues about a group, so you need more information to identify specific elements.

4. Although there are some exceptions to the pattern, the atomic mass of elements usually increases as the atomic number increases.

5. The alien periodic table does not include transition metals, lanthanides, actinides, and elements beyond atomic number 50. Sample answer: It is not likely that certain groups of elements would be missing in a place where so many other elements are present.



Analyze and Conclude

1. **Drawing Conclusions** List the Earth names for the 30 alien elements in order of atomic number.
2. **Classifying** Were you able to place some elements within the periodic table with just a single clue? Explain using examples.
3. **Interpreting Data** Why did you need two or more clues to place other elements? Explain using examples.
4. **Inferring** Why could you use clues about atomic mass to place elements, even though the table is now based on atomic numbers?
5. **Communicating** Write a paragraph describing which groups of elements are not included in the alien periodic table. Explain whether or not you think it is likely that an alien planet would lack these elements.

More to Explore

Notice that Period 5 is incomplete on the alien periodic table. Create names and symbols for each of the missing elements. Then, compose a series of clues that would allow another student to identify these elements. Make your clues as precise as possible.

▼ **Radio telescopes in New Mexico**

1.

Earth	Alien Planet
hydrogen	pfsst
helium	bombal
lithium	chow
beryllium	doggone
boron	ernsst
carbon	floxxit
nitrogen	goldy
oxygen	nuutye
fluorine	apstrom
neon	logon
sodium	byyou
magnesium	zapper
aluminum	yazzer
silicon	highho
phosphorus	magnificon
sulfur	oz
chlorine	kratt
argon	jeptum
potassium	quackzil
calcium	doadeer
gallium	rhaatrap
germanium	terriblum
arsenic	sississ
selenium	urrp
bromine	vulcania
krypton	wobble
rubidium	xtalt
strontium	pie
indium	anatom
tin	eldorado

Extend Inquiry

More to Explore Sample answer: Democritus (De), boyle (Bo), avogadro (Av), and heisenberg (Hb) could be the names and symbols of the missing elements (though students will likely choose others). Sample clues: All the missing elements are in the fifth period. Hb and Bo are both metalloids, but Hb has a smaller mass. De is an unreactive gas. Av tends to gain one electron when it reacts.