



1 FOCUS

Objectives

- 5.2.1** Describe the arrangement of elements in the modern periodic table.
- 5.2.2** Explain how the atomic mass of an element is determined and how atomic mass units are defined.
- 5.2.3** Identify general properties of metals, nonmetals, and metalloids.
- 5.2.4** Describe how properties of elements change across a period in the periodic table.

Reading Focus

Build Vocabulary

L2

Vocabulary Knowledge Rating Chart

Have students construct a chart with four columns labeled Term, Can Define or Use It, Heard or Seen It, and Don't Know. Have students copy the terms *period*, *group*, *periodic law*, *atomic mass unit*, *metals*, *transition metals*, *nonmetals*, and *metalloids* into column 1 and rate their term knowledge by putting a check in one of the other columns. Ask how many students actually know each term. Have them share their knowledge. Ask focused questions to help students predict text content based on the term, thus enabling them to have a purpose for reading. After students have read the section, have them rate their knowledge again.

Reading Strategy

L2

a. and b. Students might ask the meaning of the term *atomic mass*, why two series of elements are placed below the main body of the table, why there are two numbering systems for the columns, or why Period 7 is incomplete. (Student answers will vary depending on questions asked.)

Reading Focus

Key Concepts

- How is the modern periodic table organized?
- What does the atomic mass of an element depend on?
- What categories are used to classify elements on the periodic table?
- How do properties vary across a period in the periodic table?

Vocabulary

- ◆ period
- ◆ group
- ◆ periodic law
- ◆ atomic mass unit (amu)
- ◆ metals
- ◆ transition metals
- ◆ nonmetals
- ◆ metalloids

Reading Strategy

Previewing Copy the table below. Before you read, write two questions about the periodic table on pages 132 and 133. As you read, write answers to your questions.

Questions About the Periodic Table	
Question	Answer
a. _____ ? _____	b. _____ ? _____
c. _____ ? _____	d. _____ ? _____

Figure 5 shows a synthesizer keyboard with labels for the notes that correspond to the white keys. If you strike the key labeled middle C and then play the white keys in order from left to right, you will hear the familiar do-re-mi-fa-sol-la-ti scale. The next white note is a C that is an octave above middle C. An octave is the interval between any two notes with the same name. (The prefix *octa-* means “eight.”) Because the scale repeats at regular eight-note intervals, the scale is an example of a periodic pattern.

The sounds of musical notes that are separated by an octave are related, but they are not identical. In a similar way, elements in the same column of the periodic table are related because their properties repeat at regular intervals. But elements in different rows are not identical. You can use the modern periodic table of elements to classify elements and to compare their properties.

Figure 5 On this synthesizer keyboard, there is a repeating pattern of notes. The eight-note interval between any two notes with the same name is an octave. **Observing** How many octaves are visible on the keyboard?



Section Resources

Print

- **Laboratory Manual**, Investigation 5A
- **Reading and Study Workbook With Math Support**, Section 5.2 and **Math Skill: Calculating Average Atomic Mass**
- **Transparencies**, Section 5.2

Technology

- **Probeware Lab Manual**, Lab 2
- **Interactive Textbook**, Section 5.2
- **Presentation Pro CD-ROM**, Section 5.2
- **Go Online**, NSTA SciLinks, Periodic law

Use Visuals



Figure 7 Begin by having students compare the layouts in Figures 6 and 7. Ask, **What is the major difference in the layouts?** (Some elements from Periods 6 and 7 have been placed below the table.) **How are the layouts alike?** (Elements are arranged in order of atomic number. Elements with similar properties are in the same group and properties repeat in a predictable way from period to period.) Return to Figure 7 when atomic masses are discussed on p. 134, and when ways to classify elements on the periodic table are introduced on p. 135. (The table shows two classification systems: the 1–18 numbering system approved by the International Union of Pure and Applied Chemistry (IUPAC), and a system in which two sets of groups numbered 1–8 are distinguished by A and B labels. Unless students ask, you may want to let students wonder about the A and B classification system, which will be addressed in the introduction to Section 5.3.)

Visual, Logical

FYI

Placement of the lanthanides and actinides below the main body of the table also serves to emphasize the similarities among these elements related to their electron configurations.

Periodic Table of the Elements

Figure 7 In a modern periodic table of the elements, elements are arranged in order of increasing atomic number.

1A		2A		3B		4B		5B		6B		7B		8B	
1 H Hydrogen 1.0079															
3 Li Lithium 6.941	4 Be Beryllium 9.0122														
11 Na Sodium 22.990	12 Mg Magnesium 24.305														
19 K Potassium 39.098	20 Ca Calcium 40.08	21 Sc Scandium 44.956	22 Ti Titanium 47.90	23 V Vanadium 50.941	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.933							
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.22	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91							
55 Cs Cesium 132.91	56 Ba Barium 137.33	71 Lu Lutetium 174.97	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.21	76 Os Osmium 190.2	77 Ir Iridium 192.22							
87 Fr Francium (223)	88 Ra Radium (226)	103 Lr Lawrencium (262)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (264)	108 Hs Hassium (265)	109 Mt Meitnerium (268)							
		57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.4								
		89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)								

Nonmetals	Metals	Metalloids	
C	Li	B	Solid
Br	Hg		Liquid
H			Gas
	Tc		Not found in nature

For: Activity on the periodic table
Visit: PHSchool.com
Web Code: ccp-1052

Atomic number		6		C		Element symbol		Carbon		Element name		Atomic mass		12.011			
10		11		12		13		14		15		16		17		18	
1B		2B		3A		4A		5A		6A		7A		8A		2	
28		29		30		31		32		33		34		35		36	
Ni		Cu		Zn		Ga		Ge		As		Se		Br		Kr	
Nickel 58.71		Copper 63.546		Zinc 65.38		Gallium 69.72		Germanium 72.59		Arsenic 74.922		Selenium 78.96		Bromine 79.904		Krypton 83.80	
46		47		48		49		50		51		52		53		54	
Pd		Ag		Cd		In		Sn		Sb		Te		I		Xe	
Palladium 106.4		Silver 107.87		Cadmium 112.41		Indium 114.82		Tin 118.69		Antimony 121.75		Tellurium 127.60		Iodine 126.90		Xenon 131.30	
78		79		80		81		82		83		84		85		86	
Pt		Au		Hg		Tl		Pb		Bi		Po		At		Rn	
Platinum 195.09		Gold 196.97		Mercury 200.59		Thallium 204.37		Lead 207.2		Bismuth 208.98		Polonium (209)		Astatine (210)		Radon (222)	
110		111		112		*113		*114		*115		*116				*118	
Ds		Rg		Cn		*Uut		*Uuq		*Uup		*Uuh				*Uuo	
Darmstadtium (269)		Roentgenium (272)		Copernicium (277)		Ununtrium (284)		Ununquadium (289)		Ununpentium (288)		Ununhexium (293)				Ununoctium (299)	
63		64		65		66		67		68		69		70			
Eu		Gd		Tb		Dy		Ho		Er		Tm		Yb			
Europium 151.96		Gadolinium 157.25		Terbium 158.93		Dysprosium 162.50		Holmium 164.93		Erbium 167.26		Thulium 168.93		Ytterbium 173.04			
95		96		97		98		99		100		101		102			
Am		Cm		Bk		Cf		Es		Fm		Md		No			
Americium (243)		Curium (247)		Berkelium (247)		Californium (251)		Einsteinium (252)		Fermium (257)		Mendelevium (258)		Nobelium (259)			

*Name not officially assigned

Integrate Language Arts

L2

Elements 110, 111, 112, and 114 have not been named yet. Scientists can propose names for new elements, but the International Union of Pure and Applied Chemistry has final approval. Until new elements receive official names, chemists refer to them by their Latin-based atomic numbers. For example, element 114 is called ununquadium, Latin for one-one-four. Increase students' familiarity with the periodic table by having them identify some of the strategies used to name elements (scientists, geographic locations, mythological characters).

Verbal, Portfolio

Build Science Skills

L2

Comparing and Contrasting For this activity, use a periodic table displayed in the classroom, or make copies of a periodic table that is a few years old to distribute to students. To illustrate the dynamic nature of science, have students compare Figure 7 to the older periodic table. Ask, **What differences do you notice between the two periodic tables?** (Depending on when the older table was printed, the number of elements may vary and some elements in Period 7 may not have assigned names. Some values for atomic mass are likely to vary. A periodic table may include electron configurations for each element.) Make a list of responses on the board. Then ask, **How will the periodic table change in the future?** (Unnamed elements will be assigned official names and more elements may be discovered.)

Visual, Verbal, Group

FYI

Although plutonium is classified as a synthetic element, traces of plutonium isotopes Pu-238 and Pu-239 appear at low concentrations (about one part per 1011) in pitchblende, a uranium ore. In 1971, Darlene Hoffman, a scientist at Los Alamos National Laboratory, discovered traces of Pu-244 in Precambrian rocks. Because this isotope has a half-life of about 82 million years, it probably existed when Earth formed.

For: Activity on the periodic table
Visit: PHSchool.com
Web Code: ccp-1052

Students can learn more about the elements by interacting with a clickable periodic table online.

Atomic Mass

Address Misconceptions

L2

Students may not realize that all atoms of an element are isotopes. In other words, students may think that there is one “regular” atom and several variations called isotopes. Explain that a sample of an element found in nature contains a mixture of the different isotopes of that element. The symbols on the periodic table represent “average” atoms of elements. In fact, atoms with the atomic masses listed on the table do not exist. For example, there are no carbon atoms with an atomic mass of 12.011 amu. This value is a weighted average of the atomic masses of stable carbon isotopes. The value is close to the assigned value for carbon-12 because about 99% of a carbon sample is carbon-12 atoms.

Verbal, Logical

FYI

An atomic mass given in parentheses in Figure 7 is the mass number of the longest-lived isotope of an element that has no stable isotopes and for which the abundance of isotopes in nature shows great variability (or a complete absence in the case of technetium or promethium). Technetium and promethium have been detected in the spectra of stars.

Atomic number	17
Element symbol	Cl
Element name	Chlorine
Atomic mass	35.453

Figure 8 This box provides four pieces of information about the element chlorine: its symbol, its name, its atomic number, and its atomic mass.

Atomic Mass

There are four pieces of information for each element in Figure 7: the name of the element, its symbol, its atomic number and its atomic mass. 📌 **Atomic mass is a value that depends on the distribution of an element’s isotopes in nature and the masses of those isotopes.** You will use atomic masses when you study chemical reactions in Chapter 7.

Atomic Mass Units The mass of an atom in grams is extremely small and not very useful because the samples of matter that scientists work with contain trillions of atoms. In order to have a convenient way to compare the masses of atoms, scientists chose one isotope to serve as a standard. Recall that each isotope of an element has a different number of neutrons in the nuclei of its atoms. So the atoms of two isotopes have different masses.

Scientists assigned 12 atomic mass units to the carbon-12 atom, which has 6 protons and 6 neutrons. An **atomic mass unit** (amu) is defined as one twelfth the mass of a carbon-12 atom.

Isotopes of Chlorine In nature, most elements exist as a mixture of two or more isotopes. Figure 8 shows that the element chlorine has the symbol Cl, atomic number 17, and an atomic mass of 35.453 atomic mass units. (The unit for atomic mass is not listed in the periodic table, but it is understood to be the amu.) Where does the number 35.453 come from? There are two natural isotopes of chlorine, chlorine-35 and chlorine-37. An atom of chlorine-35 has 17 protons and 18 neutrons. An atom of chlorine-37 has 17 protons and 20 neutrons. So the mass of an atom of chlorine-37 is greater than the mass of an atom of chlorine-35.

Weighted Averages Your teacher may use a weighted average to determine your grade. In a weighted average, some values are more important than other values. For example, test scores may count more heavily toward your final grade than grades on quizzes or grades on homework assignments.

Figure 9 lists the atomic masses for two naturally occurring chlorine isotopes. If you add the atomic masses of the isotopes and divide by 2, you get 35.967, not 35.453. The value of the atomic mass for chlorine in the periodic table is a weighted average. The isotope that occurs in nature about 75% of the time (chlorine-35) contributes three times as much to the average as the isotope that occurs in nature about 25% of the time (chlorine-37).

Distribution of Chlorine Isotopes in Nature		
Isotope	Percentage	Atomic Mass
Chlorine-35	75.78%	34.969
Chlorine-37	24.22%	36.966

Figure 9 This table shows the distribution and atomic masses for the two natural isotopes of chlorine. **Using Tables** Which isotope occurs more often in nature?



What is an atomic mass unit?

Facts and Figures

Atomic Mass Units From the mid-1800s to 1960, oxygen was the standard for atomic masses. (Oxygen was likely chosen because it forms compounds with many elements.) After the discovery of isotopes, physicists and chemists began to use different standards. Physicists assigned the value 16.000 amu exclusively to oxygen-16. Other oxygen isotopes had different values. Chemists continued to use 16.000 amu as the average


for all oxygen atoms. Although the differences between the standards were small, the situation was potentially confusing.

In 1961, chemists and physicists agreed on a unified standard based on the carbon-12 isotope, which is assigned a value of 12.000 amu. (Although the SI abbreviation for atomic mass unit was changed to u for unified when scientists adopted the unified atomic mass unit, the amu notation is still widely used.)

Classes of Elements

The periodic table in Figure 7 presents three different ways to classify elements. First, elements are classified as solids, liquids, or gases, based on their states at room temperature. The symbols for solids are black. The symbols for liquids are purple. The symbols for gases are red.

Second, elements are divided into those that occur naturally and those that do not. All but two elements with atomic numbers 1 through 92 occur on Earth. Elements with atomic numbers of 93 and higher do not occur naturally. The symbols for these elements are white. In Chapter 10, you will find out how elements that do not occur in nature are produced.

The third classification system puts elements into categories based on their general properties.  **Elements are classified as metals, nonmetals, and metalloids.** In the periodic table, metals are located on the left, nonmetals are on the right, and metalloids are in between.

Metals The majority of the elements on the periodic table are classified as metals. In Figure 7, they are represented by blue boxes. **Metals** are elements that are good conductors of electric current and heat. Except for mercury, metals are solids at room temperature. Most metals are malleable. Many metals are ductile; that is, they can be drawn into thin wires.

Some metals are extremely reactive and some do not react easily. One way to demonstrate this difference is to compare the behavior of gold and the behavior of magnesium when these metals are exposed to the oxygen in air. Gold remains shiny because it does not react with the oxygen. Magnesium reacts with the oxygen and quickly dulls. Figure 10A shows one magnesium coil that is dull and one that is shiny. Figure 10B shows one use for a metal with a shiny surface.

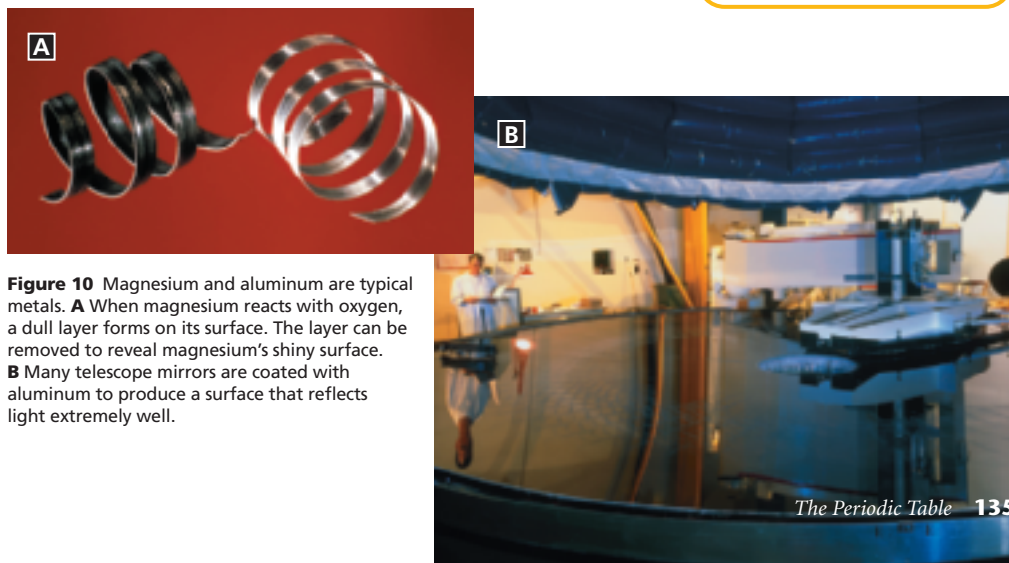


Figure 10 Magnesium and aluminum are typical metals. **A** When magnesium reacts with oxygen, a dull layer forms on its surface. The layer can be removed to reveal magnesium's shiny surface. **B** Many telescope mirrors are coated with aluminum to produce a surface that reflects light extremely well.

Expected Outcome

Element	Observation
Magnesium	Bubbles, test tube becomes hot, reaction complete in about 30 seconds, final solution clear.
Sulfur	No visible reaction
Aluminum	Slight bubbling in 5 minutes, test tube becomes warm after about 15 minutes, final mixture slightly cloudy with powdery gray precipitate.
Silicon	No visible reaction

Analyze and Conclude

1. Aluminum and magnesium are metals. Sulfur is a nonmetal and silicon is a metalloid.
2. Only the metals react with the acid.
3. A metal is a substance that reacts with HCl.

Logical

Quick Lab

Defining a Metal

Procedure

1. Use forceps to put a piece of magnesium into a test tube in a test tube rack. Using a graduated cylinder, add 5 mL of hydrochloric acid to the test tube.
CAUTION *Wear plastic gloves because the acid can burn skin or clothing. Record your observations.*
2. Repeat Step 1 with sulfur, aluminum, and silicon.

Analyze and Conclude

1. **Classifying** Based on their locations in the periodic table, classify the four elements as metals, metalloids, or nonmetals.
2. **Comparing and Contrasting** Compare the behavior of the metals with the acid to the behavior of the other elements with the acid.
3. **Forming Operational Definitions** Use your observations to write a definition of a metal.

Classes of Elements

Quick Lab

Defining a Metal

L2

Objective

After completing this activity, students will be able to

- use a chemical property to distinguish metals.

Skills Focus Forming Operational Definitions



Prep Time 20 minutes

Materials forceps; magnesium; test tubes; test-tube rack; graduated cylinder; 20 mL 2 M HCl; small pieces of sulfur, aluminum, and silicon

Advance Prep Prepare 1 L of 2 M HCl: add 200 mL of 10 M HCl to a 1-L volumetric flask containing 750 mL of water and swirl gently to mix. Add water to bring the volume to 1 L. **CAUTION** *Wear safety goggles, a lab apron, and neoprene gloves. Use concentrated HCl in a fume hood or other well-ventilated area. Never add water to acid.* Polish the magnesium lightly with steel wool to remove any magnesium oxide.

Class Time 20 minutes

Safety Remind students to use care in adding the acid and to rinse any acid off skin or clothing with water. **CAUTION** *The reaction of Mg in HCl will make the test tube hot. Keep spill-control materials (baking soda or citric acid) nearby to clean up spills. Repeat as necessary to remove all acid contamination. Elemental sulfur may emit H₂S when dispersed in HCl. Test the sulfur beforehand in a fume hood or other well-ventilated area. Supply silicon as chips, not in powdered form, which is flammable. Neutralize the acid solutions with baking soda and wash them down the drain with excess water.*

Teaching Tips

- Caution students not to get fingerprints on the Mg and Al samples.
- The complete reaction of Al and HCl will require more than 45 minutes. However, the results after 15 minutes will indicate how the materials react.

Answer to . . .

Figure 9 Chlorine-35



One-twelfth the mass of a carbon-12 atom

Integrate Health

L2

People who work under fluorescent lights or spend a lot of time viewing a computer screen sometimes choose pink lenses. Athletes participating in high-speed winter sports often use pink lenses because they help to increase contrast and depth perception when the available light is limited. Gray lenses are very common; they reduce the amount of light without changing its color. Have students research situations in which lenses with colors other than pink are used.

Verbal, Portfolio

Build Reading Literacy

L1

Summarize Refer to page 598D in Chapter 20, which provides the guidelines for summarizing.

Have students write a summary of the text on pp. 135–136. Summaries should include information about each of the vocabulary terms on these pages. Ask, **Based on your summary, which class of elements has properties that fall between the properties of two other classes of elements?** (*Metalloids*)

Verbal, Portfolio

FYI

The important role metalloids play as semiconductors is addressed in Chapter 6.



Figure 11 A compound of erbium (Er) and oxygen is used to tint glass pink.

Figure 12 Toothpaste contains a compound that helps to protect teeth from tooth decay. The compound is formed from the nonmetal fluorine and the metal sodium.



136 Chapter 5

The metals in groups 3 through 12 are called transition metals. **Transition metals** are elements that form a bridge between the elements on the left and right sides of the table. Transition elements, such as copper and silver, were among the first elements discovered. One property of many transition metals is their ability to form compounds with distinctive colors. The How It Works box on page 137 describes the use of transition elements in the production of colored glass.

Some transition elements have more properties in common than elements in other groups. This is especially true of elements in the lanthanide and actinide series. These elements are so similar that chemists in the 1800s had difficulty separating them when they were found mixed together in nature. A compound of erbium and oxygen was used to tint the lenses shown in Figure 11.

Nonmetals In Figure 7, nonmetals are represented by yellow boxes. As their name implies, nonmetals generally have properties opposite to those of metals. **Nonmetals** are elements that are poor conductors of heat and electric current. Because nonmetals have low boiling points, many nonmetals are gases at room temperature. In fact, all the gases in the periodic table are nonmetals. The nonmetals that are solids at room temperature tend to be brittle. If they are hit with a hammer, they shatter or crumble.

Nonmetals vary as much in their chemical properties as they do in their physical properties. Some nonmetals are extremely reactive, some hardly react at all, and some fall somewhere in between. Fluorine in Group 17 is the most reactive nonmetal. It even forms compounds with some gases in Group 18, which are the least reactive elements in the table. The toothpaste in Figure 12 contains a compound of the nonmetal fluorine and the metal sodium. This compound helps to protect your teeth against decay.

Metalloids In the periodic table in Figure 7, metalloids are represented by green boxes. **Metalloids** are elements with properties that fall between those of metals and nonmetals. For example, metals are good conductors of electric current and nonmetals are poor conductors of electric current. A metalloid's ability to conduct electric current varies with temperature. Pure silicon (Si) and germanium (Ge) are good insulators at low temperatures and good conductors at high temperatures.

Reading
Checkpoint

Which type of metals tend to form compounds with distinctive colors?

Facts and Figures

Fluoride in Toothpaste According to FDA regulations, toothpaste can contain sodium fluoride, sodium monofluorophosphate, or stannous fluoride at concentrations of 850 to 1150 ppm total fluorine. A package of toothpaste sold commercially cannot contain more than 276 mg of fluorine. Because too much fluoride can have adverse affects on health,

people should rinse away excess toothpaste. There must be a warning on toothpaste packages to keep the product out of the reach of children under 6 years of age. Young children need to be supervised when they brush their teeth until they have learned how to minimize ingestion of the toothpaste.

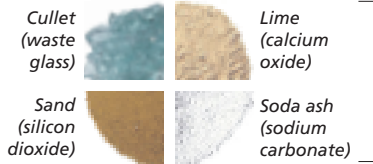
Making Glass

For more than 4500 years, people have made glass from sand. The float-glass process shown below is used to make large sheets of glass for windows, while molds are used to make glass bottles. **Interpreting Diagrams** *How is air used in making glass bottles?*



Colored glass

Metallic elements are mixed with the raw ingredients to produce colored glass. Iron or chromium is added for green, copper or gold for red, and cobalt for blue.

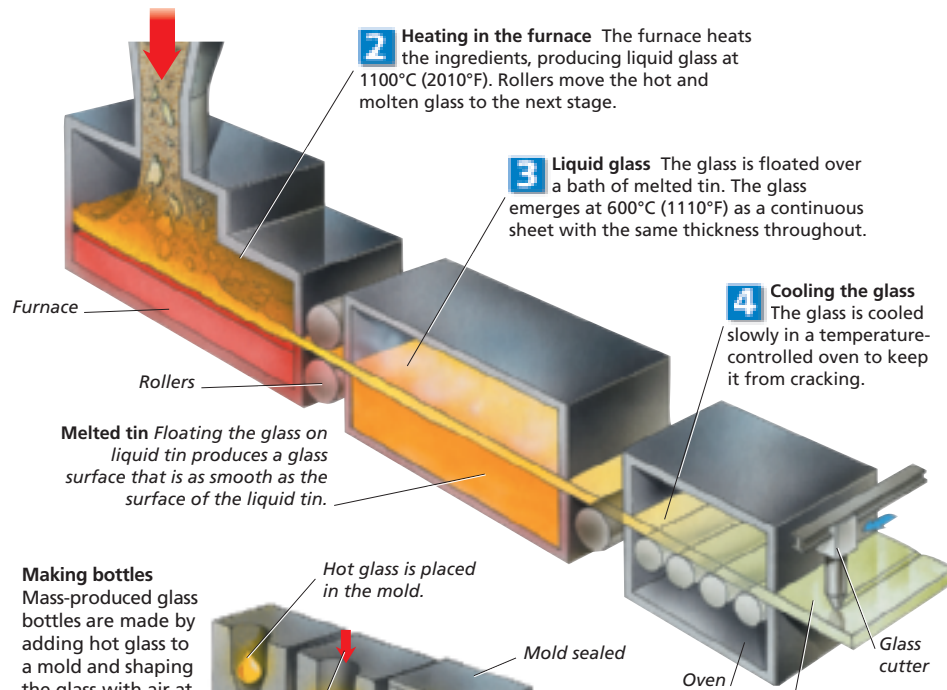


1 Adding the raw ingredients Sand, lime, and soda ash are poured into the furnace and heated to 1500°C (2730°F). Recycled waste glass, called cullet, is also added, to reduce the cost of raw materials.

2 Heating in the furnace The furnace heats the ingredients, producing liquid glass at 1100°C (2010°F). Rollers move the hot and molten glass to the next stage.

3 Liquid glass The glass is floated over a bath of melted tin. The glass emerges at 600°C (1110°F) as a continuous sheet with the same thickness throughout.

4 Cooling the glass The glass is cooled slowly in a temperature-controlled oven to keep it from cracking.

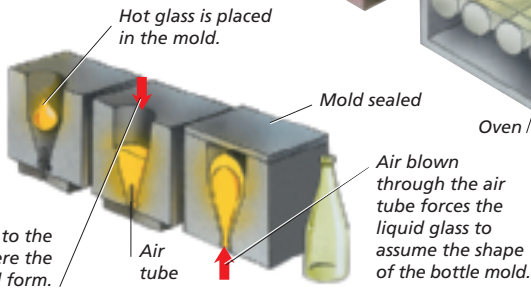


Melted tin Floating the glass on liquid tin produces a glass surface that is as smooth as the surface of the liquid tin.

Making bottles

Mass-produced glass bottles are made by adding hot glass to a mold and shaping the glass with air at high pressure.

Air pushes the glass to the bottom of the mold, where the neck of the bottle will form.



5 Cutting the glass A diamond-tipped cutter is used to cut the cooled glass.

Making Glass

L2

Float-glass plants are among the largest buildings in the world. Giant bins hold the raw materials for making glass. Huge roof ventilators and stacks release the intense heat needed to produce the liquid glass. The glassmaking operation is continuous, with the fires burning constantly. Often a glass plant will produce various tints of glass that are used in different applications.

Interpreting Diagrams Air at high pressure is used to force the liquid glass to take the shape of the mold.

Visual, Verbal

For Enrichment

L3

Interested students can research and report on the work of glassblowers and compare their techniques for shaping glass with the molding process that is described on p. 137. Have students use the library to find books, magazine articles, and videos to help in their research.

Verbal, Portfolio

FYI

Tell students that showing the raw ingredients of glass as four equal segments of a pie is not meant to reflect their actual percentages in the mixture. Adding soda ash saves energy because sodium carbonate lowers the melting temperature of the mixture. Running the glass over rollers instead of the molten tin produces an uneven surface.

Answer to . . .



Transition metals

Section 5.2 (continued)

Variation Across a Period

Teacher Demo

Period 3 Properties

L2

Purpose Students observe differences in electrical conductivity among three Period 3 elements.

Materials 6-volt battery, flashlight bulb with holder, 3 pieces of insulated wire with the ends stripped, 2.5-cm aluminum strip, small silicon chip, 2.5-cm piece of sulfur

Advance Prep Use the battery, flashlight bulb with holder, and the wires to make an open circuit.

Procedure Touch the free ends of the two wires to each end of the aluminum strip. Have students observe the bulb. Repeat for silicon and sulfur.

Expected Outcome The material used to complete the circuit determines the brightness of the light. For aluminum, the bulb is bright; for silicon, the bulb is dim; for sulfur, the bulb does not light. Students should conclude that the Period 3 elements become less metallic from left to right across the period.

Visual, Logical

3 ASSESS

Evaluate Understanding

L2

Ask students to identify the general properties of metals, nonmetals, and metalloids.

Reteach

L1

Use Figure 13 to illustrate how the properties of elements change from left to right across a period in the periodic table.

Writing in Science

Student answers should reflect the fact that all the isotopes of an atom occupy the same place on the periodic table, despite their different mass numbers.



If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 5.2.

Answer to . . .

Figure 13 Chlorine

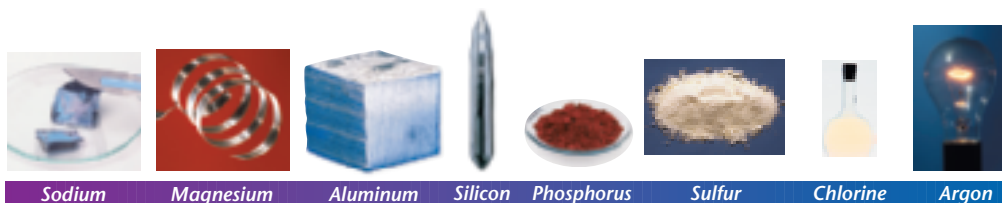


Figure 13 From left to right across Period 3, there are three metals (Na, Mg, and Al), one metalloid (Si), and four nonmetals (P, S, Cl, and Ar). Many light bulbs are filled with argon gas.

Observing Which other element in Period 3 is a gas?

Variation Across a Period

The properties within a period change in a similar way from left to right across the table, except for Period 1. **Across a period from left to right, the elements become less metallic and more nonmetallic in their properties.** The most reactive metals are on the left side of the table. The most reactive nonmetals are on the right in Group 17. The Period 3 elements shown in Figure 13 provide an example of this trend.

There are three metals, a metalloid, and four nonmetals in Period 3. If you were unwise enough to hold a piece of sodium in your hand, it would react quickly and violently with the water on your moist skin. But magnesium will not react with water unless the water is hot. Aluminum does not react with water, but it does react with oxygen.

Silicon is the least reactive element in Period 3 (except for argon). Under ordinary conditions, phosphorus and sulfur do not react with water, but they do react with oxygen. They also react with chlorine, which is a highly reactive nonmetal. Chlorine must be handled with as much care as sodium. Argon hardly reacts at all.

Section 5.2 Assessment

Reviewing Concepts

- What determines the order of the elements in the modern periodic table?
- Describe the periodic law.
- What two factors determine the atomic mass of an element?
- Name three categories that are used to classify the elements in the periodic table.
- What major change occurs as you move from left to right across the periodic table?

Critical Thinking

- Formulating Hypotheses** The atomic mass of iodine (I) is less than the atomic mass of tellurium (Te). But an iodine atom has one more proton than a tellurium atom. Explain how this situation is possible.

- Applying Concepts** Explain how you know that no new element with an atomic number less than 100 will be discovered.
- Comparing and Contrasting** Compare the reactions with water of the elements sodium and magnesium.

Writing in Science

Explanatory Paragraph The word *isotope* comes from the Greek words *isos*, meaning “equal,” and *topos*, meaning “place.” Write a paragraph explaining how the isotopes chlorine-35 and chlorine-37 occupy the same place in the periodic table.

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Section 5.2 Assessment

- In the modern periodic table, elements are arranged by increasing atomic number.
- Properties of elements repeat in a predictable way when atomic numbers are used to arrange elements into groups.
- Atomic mass is a value that depends on the distribution of an element's isotopes in nature and the masses of those isotopes.
- Metals, nonmetals, and metalloids
- The elements become less metallic and more nonmetallic in their properties.
- Answers may include that the tellurium isotopes that are most abundant have many neutrons in their nuclei or that all tellurium atoms have more neutrons than iodine atoms.
- The atomic number of an element corresponds to the number of protons in the element's atoms. The atomic number must be a whole number. All the places between 1 and 100 are already filled with existing elements.
- Sodium reacts quickly and violently with water at room temperature. Magnesium will not react unless the water is hot.