Chapter 10

The Periodic Table

THE BIG IDEA

How is the periodic table used to classify and provide information about all known elements?

Inquiry What makes this balloon so special?

Things are made out of specific materials for a reason. A weather balloon can rise high in the atmosphere and gather weather information. The plastic that forms this weather balloon and the helium gas that fills it were chosen after scientists researched and studied the properties of these materials.

- What property of helium do you think makes the balloon rise through the air?
- How do you think the periodic table is a useful tool when determining properties of different materials?

Get Ready to Read

What do you think?

Before you read, decide if you agree or disagree with each of these statements. As you read this chapter, see if you change your mind about any of the statements.

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.
3. Fewer than half of the elements are metals.
4. Metals are usually good conductors of electricity.
5. Most of the elements in living things are nonmetals.
6. Even though they look very different, oxygen and sulfur share some similar properties.

Lesson 1

Using the Periodic Table

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

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

Vocabulary

periodic table p. 345

group p. 350

period p. 350

Multilingual eGlossary

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Inquiry Same Information?

You probably have seen a copy of a table that is used to organize the elements. Does it look like this chart? There is no specific shape that a chart of elements must have. However, the relationships among the elements in the chart are important.

Launch Lab

15 minutes

How can objects be organized?

What would it be like to shop at a grocery store where all the products are mixed up on the shelves? Maybe cereal is next to the dish soap and bread is next to the canned tomatoes. It would take a long time to find the groceries that you needed. How does organizing objects help you to find and use what you need?

1. Read and complete a lab safety form.
2. Empty the **interlocking plastic bricks** from the **plastic bag** onto your desk and observe their properties. Think about ways you might group and sequence the bricks so that they are organized.
3. Organize the bricks according to your plan.
4. Compare your pattern of organization with those used by several other students.

Think About This

1. Describe in your Science Journal the way you grouped your bricks. Why did you choose that way of grouping?
2. Describe how you sequenced the bricks.
3. **Key Concept** How does organizing things help you to use them more easily?

What is the periodic table?

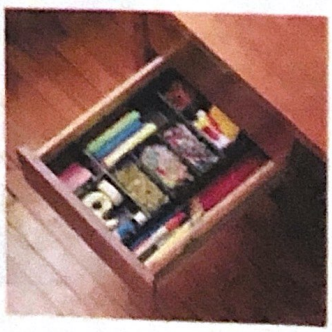
The "junk drawer" in Figure 1 is full of pens, notepads, rubber bands, and other supplies. It would be difficult to find a particular item in this messy drawer. How might you organize it? First, you might dump the contents onto the counter. Then you could sort everything into piles. Pens and pencils might go into one pile. Notepads and paper go into another. Organizing the contents of the drawer makes it easier to find the things you need, also shown in Figure 1.

Just as sorting helped to organize the objects in the junk drawer, sorting can help scientists organize information about the elements. Recall that there are more than 100 elements, each with a unique set of physical and chemical 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.* It can be used to determine the relationships among the elements.

In this chapter, you will read about how the periodic table was developed. You will also read about how you can use the periodic table to learn about the elements.

Figure 1 Sorting objects by their similarities makes it easier to find what you need.



Developing a Periodic Table

In 1869 a Russian chemist and teacher named Dimitri Mendeleev (duh MEE tree • men duh LAY uf) was working on a way to classify elements. At that time, more than 60 elements had been discovered. He studied the physical properties such as density, color, melting point, and atomic mass of each element. Mendeleev also noted chemical properties such as how each element reacted with other elements. Mendeleev arranged the elements in a list using their atomic masses. He noticed that the properties of the elements seemed to repeat in a pattern.

When Mendeleev placed his list of elements into a table, he arranged them in rows of increasing atomic mass. Elements with similar properties were grouped in the same column. The columns in his table are like the piles of sorted objects in your junk drawer. Both contain groups of things with similar properties.

Reading Check What physical property did Mendeleev use to place the elements in rows on the periodic table?

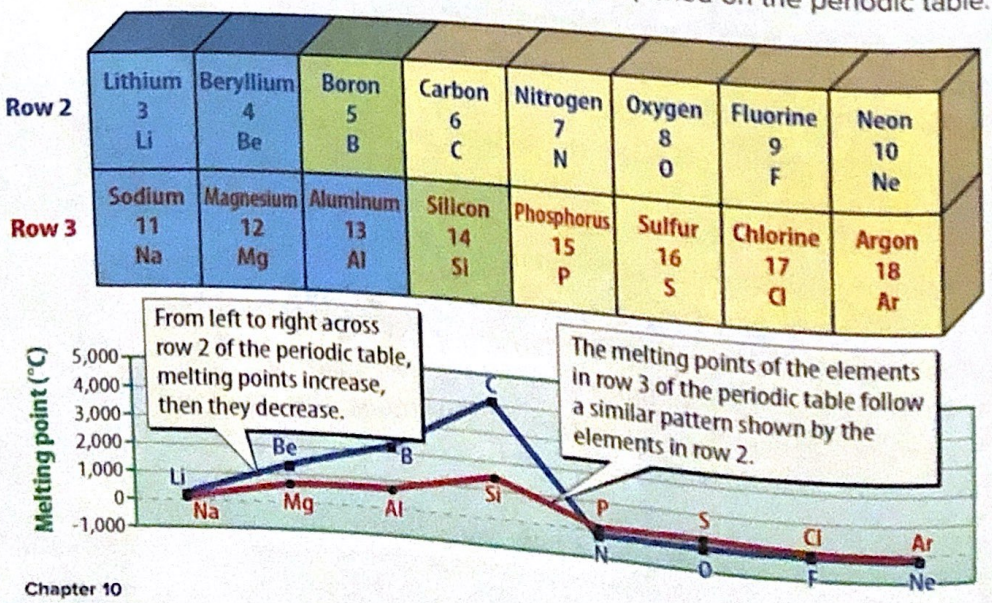
Patterns in Properties

The term *periodic* means "repeating pattern." For example, seasons and months are periodic because they follow a repeating pattern every year. The days of the week are periodic since 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. Recall that melting point is the temperature at which a solid changes to a liquid. The blue line in **Figure 2** represents the melting points of the elements in row 2 of the periodic table. Notice that the melting point of carbon is higher than the melting point of lithium. However, the melting point of fluorine, at the far right of the row, is lower than that of carbon. How do these melting points show a pattern? Look at the red line in **Figure 2.** This line represents the melting points of the elements in row 3 of the periodic table. The melting points follow the same increasing and then decreasing pattern as the blue line, or row 2. Boiling point and reactivity also follow a periodic pattern.

A Periodic Property

Figure 2 Melting points increase, then decrease, across a period on the periodic table.



Predicting Properties of Undiscovered Elements

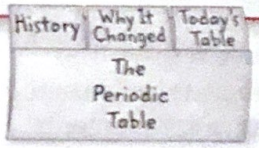
When Mendeleev arranged all known elements by increasing atomic mass, there were large gaps between some elements. He predicted that scientists would discover elements that would fit into these spaces. Mendeleev also predicted that the properties of these elements would be similar to the known elements in the same columns. Both of his predictions turned out to be true.

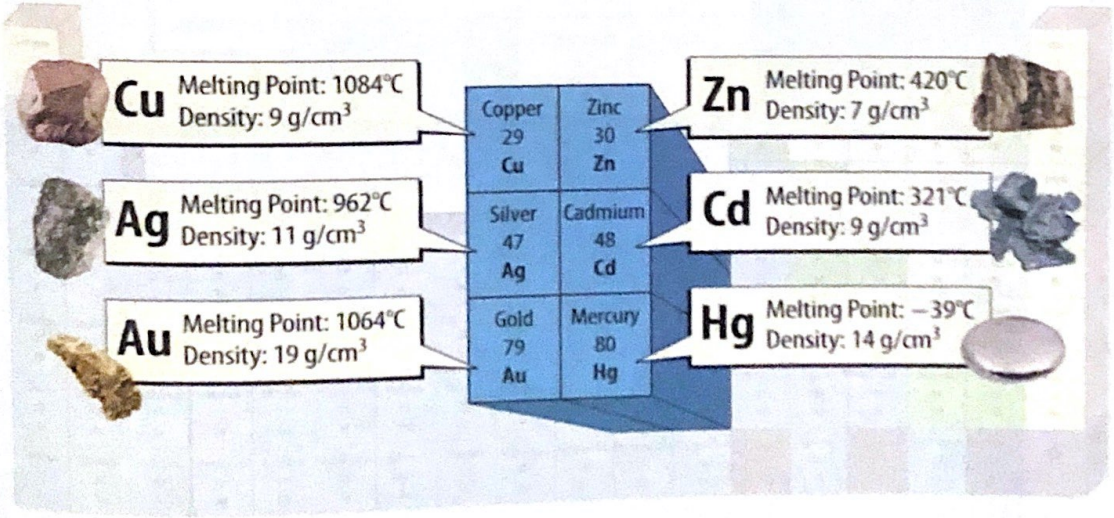
Changes to Mendeleev's Table

Mendeleev's periodic table enabled scientists to relate the properties of the known elements to their position on the table. However, the table had a problem–some elements seemed out of place. Mendeleev believed that the atomic masses of certain elements must be invalid because the elements appeared in the wrong place on the periodic table. For example, Mendeleev placed tellurium before iodine despite the fact that tellurium has a greater atomic mass than iodine. He did so because iodine's properties more closely resemble those of fluorine and chlorine, just as copper's properties are closer to those of silver and gold, as shown in **Figure 3.**

FOLDABLES

Use four sheets of paper to make a top-tab book. Use it to organize your notes about the development of the periodic table.





The Importance of Atomic Number

In the early 1900s, the scientist Henry Moseley solved the problem with Mendeleev's table. Moseley found that if elements were listed according to increasing atomic number instead of increasing atomic mass, columns would contain elements with similar properties. Recall that the atomic number of an element is the number of protons in the nucleus of each of that element's atoms.

Key Concept Check What determines where an element is located on the periodic table you use today?

Animation

Figure 3 On today's periodic table, copper is in the same column as silver and gold. Zinc is in the same column as cadmium and mercury.

SCIENCE USE V. COMMON USE

period

Science Use the completion of a cycle; a row on the periodic table

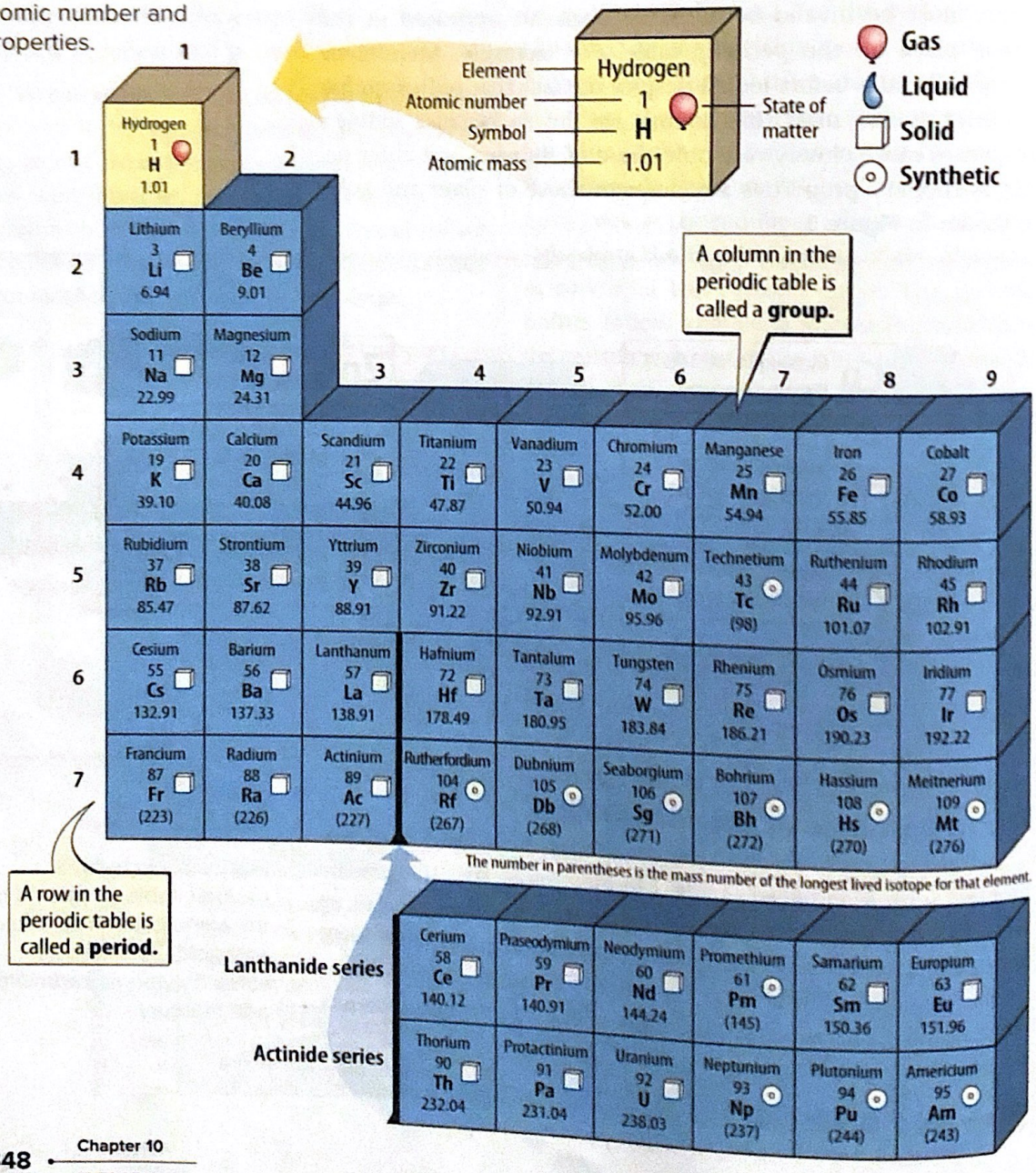
Common Use a point used to mark the end of a sentence; a time frame

Animation

Today's Periodic Table

You can identify many of the properties of an element from its placement on the periodic table. The table, as shown in Figure 4, 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 interpret the element's physical and chemical properties.

Figure 4 The periodic table is used to organize elements according to increasing atomic number and properties.



What is on an element key?

The element key shows an element's chemical symbol, atomic number, and atomic mass. The key also contains a symbol that shows the state of matter at room temperature. Look at the element key for helium in **Figure 5.** Helium is a gas at room temperature. Some versions of the periodic table give additional information, such as density, conductivity, or melting point.

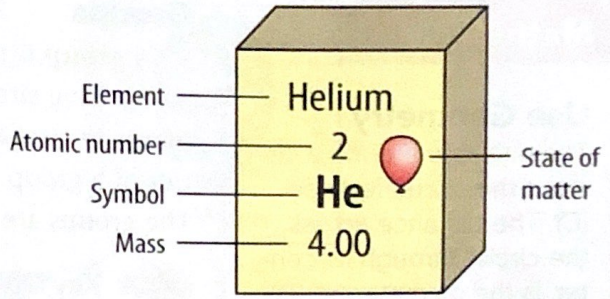
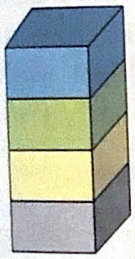


Figure 5 An element key shows important information about each element.

Visual Check What does this key tell you about helium?



10	11	12	13	14	15	16	17	18
								Helium 2 He 4.00
			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	Neon 10 Ne 20.18
			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	Argon 18 Ar 39.95
Nickel 28 Ni 58.69	Copper 29 Cu 63.55	Zinc 30 Zn 65.38	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	Krypton 36 Kr 83.80
Palladium 46 Pd 106.42	Silver 47 Ag 107.87	Cadmium 48 Cd 112.41	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	Xenon 54 Xe 131.29
Platinum 78 Pt 195.08	Gold 79 Au 196.97	Mercury 80 Hg 200.59	Thallium 81 Tl 204.38	Lead 82 Pb 207.20	Bismuth 83 Bi 208.98	Polonium 84 Po (209)	Astatine 85 At (210)	Radon 86 Rn (222)
Darmstadtium 110 Ds (281)	Roentgenium 111 Rg (280)	Copernicium 112 Cn (285)	Ununtrium * 113 Uut (284)	Flerovium 114 Fl (289)	Ununpentium * 115 Uup (288)	Livermorium 116 Lv (293)	Ununseptium * 117 Uus (294)	Ununoctium * 118 Uuo (294)

* The names and symbols for elements 113, 115, 117, and 118 are temporary. Final names will be approved by IUPAC (International Union of Pure and Applied Chemistry).

Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.93	Dysprosium 66 Dy 162.50	Holmium 67 Ho 164.93	Erbium 68 Er 167.26	Thulium 69 Tm 168.93	Ytterbium 70 Yb 173.05	Lutetium 71 Lu 174.97
Curium 96 Cm (247)	Berkelium 97 Bk (247)	Californium 98 Cf (251)	Einsteinium 99 Es (252)	Fermium 100 Fm (257)	Mendelevium 101 Md (258)	Nobelium 102 No (259)	Lawrencium 103 Lr (262)

Math Skills

Use Geometry

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 determining the circumference is:

$C = \pi d$ or $C = 2\pi r$

For example, an iron (Fe) atom has a radius of **126 pm** (picometers; 1 picometer = one-trillionth of a meter). The circumference of an iron atom is:

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

$C = 791\ \text{pm}$

Practice

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

Math Practice

Personal Tutor

Groups

A **group** *is a column on the periodic table.* Elements in the same group have similar chemical properties and 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, as shown in **Figure 4.**

Key Concept Check What can you infer about the properties of two elements in the same group?

Periods

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

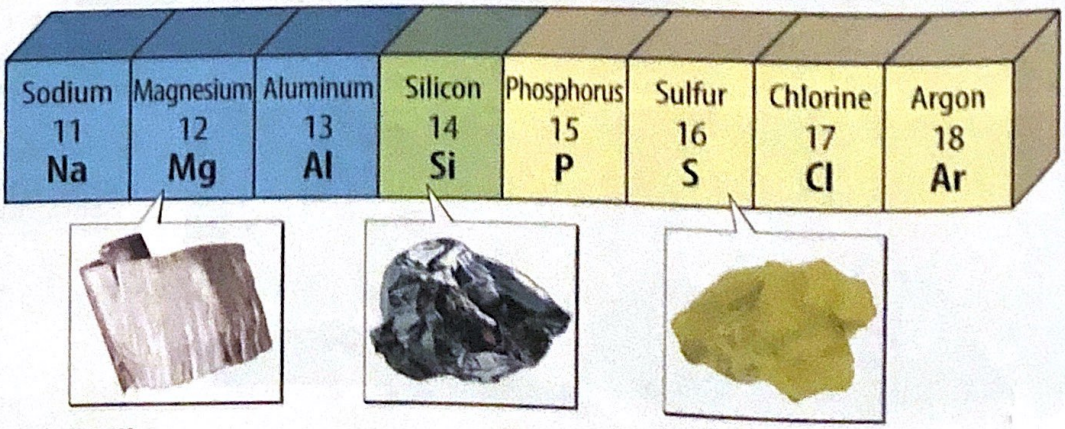
Metals, Nonmetals, and Metalloids

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. Individual metals have some properties that differ, but all metals are shiny and conduct thermal energy and electricity.

With the exception of hydrogen, nonmetals are located on the right side of the periodic table. The properties of nonmetals differ from the properties of metals. Many nonmetals are gases, and they do not conduct thermal energy or electricity.

Between the metals and the nonmetals on the periodic table are the metalloids. Metalloids have properties of both metals and nonmetals. **Figure 6** shows an example of a metal, a metalloid, and a nonmetal.

Figure 6 In period 3, magnesium is a metal, silicon is a metalloid, and sulfur is a nonmetal.



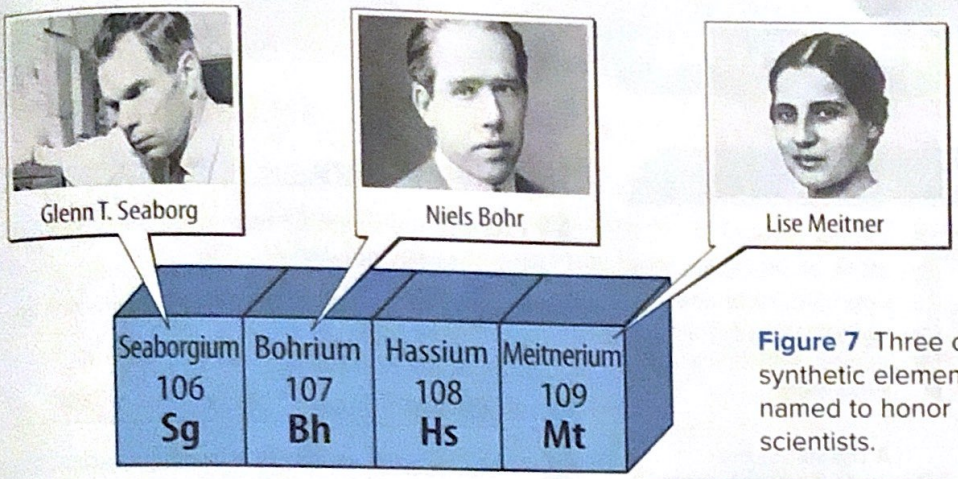


Figure 7 Three of these synthetic elements are named to honor important scientists.

How Scientists Use the Periodic Table

Even today, new elements are created in laboratories, named, and added to the present-day periodic table. Four of these elements are shown in **Figure 7.** These elements are all synthetic, or made by people, and do not occur naturally on Earth. Sometimes scientists can create only a few atoms of a new element. Yet scientists can use the periodic table to predict the properties of new elements they create. Look back at the periodic table in **Figure 4.** What group would you predict to contain element 119? You would probably expect element 119 to be in group 1 and to have similar properties to other elements in that group. Scientists hope to one day synthesize element 119.

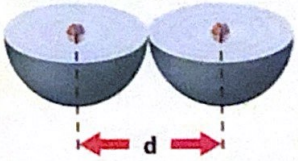
The periodic table contains more than 100 elements. Each element has unique properties that differ from the properties of other elements. But each element also shares similar properties with nearby elements. The periodic table shows how elements relate to each other and fit together into one organized chart. Scientists use the periodic table to understand and predict elements' properties. You can, too.

Reading Check How is the periodic table used to predict the properties of an element?

MiniLab 20 minutes

How does atom size change across a period?

One pattern seen on the periodic table is in the radius of different atoms. The figure below shows how atomic radius is measured.



Atomic radius = $\frac{1}{2}$d

1. Read and complete a lab safety form.
2. Using **scissors** and **card stock paper,** cut seven 2-cm × 4-cm rectangles. Using a **marker,** label each rectangle with the atomic symbol of each of the first seven elements in period 2. Obtain the radius for each atom from your teacher.
3. Using a **ruler,** cut **plastic straws** to the same number of millimeters as each atomic radius given in picometers. For example, if the atomic radius is 145 pm, cut a straw 145 mm long.
4. **Tape** each of the labeled rectangles to the top of its appropriate straw.
5. Insert the straws into **modeling clay** according to increasing atomic number.

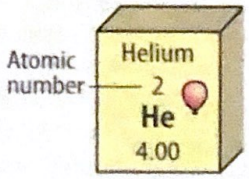
Analyze and Conclude

1. **Describe** the pattern you see in your model.
2. **Key Concept** Predict the pattern of atomic radii of the elements in period 4.

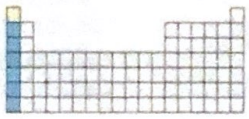
Lesson 1 Review

Online Quiz
Virtual Lab

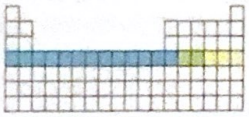
Visual Summary



On the periodic table, elements are arranged according to increasing atomic number and similar properties.



A column of the periodic table is called a group. Elements in the same group have similar properties.



A row of the periodic table is called a period. Properties of elements repeat in the same pattern from left to right across each period.

FOLDABLES

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

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.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1. **Identify** the scientific term used for rows on the periodic table.
2. **Name** the scientific term used for columns on the periodic table.

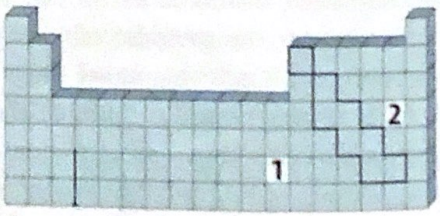
Understand Key Concepts

3. The _____ increases by one for each element as you move left to right across a period.
4. What does the decimal number in an element key represent?

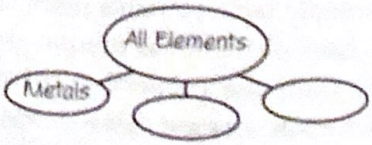
   A. atomic mass **C.** chemical symbol
   B. atomic number **D.** state of matter

Interpret Graphics

5. **Classify** each marked element, 1 and 2, as a metal, a nonmetal, or a metalloid.



6. **Identify** Copy and fill in the graphic organizer below to identify the color-coded regions of the periodic table.



Critical Thinking

7. **Predict** Look at the perioidic table and predict three elements that have lower melting points than calcium (Ca).

Math Skills

Math Practice

8. Carbon (C) and silicon (Si) are in group 4 of the periodic table. The atomic radius of carbon is 77 pm and sulfur is 103 pm. What is the circumference of each atom?

Skill Practice Identify Patterns

25 minutes

How is the periodic table arranged?

Materials

20 cards

What would happen if schools did not assign students to grades or classes? How would you know where to go on the first day of school? What if your home did not have an address? How could you tell someone where you live? Life becomes easier with organization. The following activity will help you discover how elements are organized on the periodic table.

Learn It

Patterns help you make sense of the world around you. The days of the week follow a pattern, as do the months of the year. **Identifying a pattern** involves organizing things into similar groups and then sequencing the things in the same way in each group.

Try It

1. Obtain cards from your teacher. Turn the cards over so the sides with numbers are facing up.
2. Separate the cards into three or more piles. All of the cards in a pile should have a characteristic in common.
3. Organize each pile into a pattern. Use all of the cards.
4. Lay out the cards into rows and columns based on their characteristics and patterns.

Apply It

5. Describe in your Science Journal the patterns you used to organize your cards. Do other patterns exist in your arrangement?
6. Are there gaps in your arrangement? Can you describe what a card in one of those gaps would look like?
7. **Key Concept** What characteristics of elements might you use to organize them in a similar pattern?