

section 16 The Periodic Table

● Before You Read

Many parts of our lives are affected by repeated patterns. For example, a calendar shows the patterns of weeks. Name some repeated patterns that you see happening all the time. How could you keep track of a pattern?

What You'll Learn

- the composition of the periodic table
- how to get information from the periodic table
- what metal, nonmetal, and metalloid mean

● Read to Learn

Organizing the Elements

When you look at the Moon, does it always appear the same? Each month, the Moon grows larger until it is full, then grows smaller until it seems to disappear. This type of change is called periodic. The word *periodic* means “repeated in a pattern.” The days of the week are periodic because they repeat every seven days. Think of the calendar as a periodic table of days and months.

Who was Dmitri Mendeleev?

In the late 1800s, a Russian chemist named Dmitri Mendeleev wanted to find a way to organize the elements. He organized the elements known at the time into a table. He placed the elements in the table in order of increasing atomic mass.

Mendeleev discovered a pattern in his table. The properties of some lighter elements seemed to repeat in heavier elements. Because this pattern repeated, the pattern was considered to be periodic. Today, this arrangement is called a periodic table of elements. In the **periodic table**, the elements are arranged by increasing atomic number and by changes in physical and chemical properties. ✓

Mark the Text

Identify the Main Point

Look for the main point of the paragraph or paragraphs under each heading in this section. When you have found the main point, write it down on a piece of paper. After you read the section, look over the main points again to help you learn the content of the section.

✓ Reading Check

1. **Determine** Who was the first person to organize the elements into a periodic table?

How did Mendeleev's table predict properties?

Mendeleev left blank spaces in his table so that he could line up the elements. He looked at the elements surrounding the blank spaces. He predicted the properties and atomic masses of unknown elements to fit in the blank spaces.

The table shows Mendeleev's predictions for the element germanium. He called the element *ekasilicon*. His predictions proved to be accurate. Scientists eventually found all of the elements that were missing from Mendeleev's periodic table. The properties of these "missing" elements turned out to be extremely close to what Mendeleev predicted.

Applying Math

2. **Use Decimals** Find the difference between the predicted density of germanium and its actual density.

Mendeleev's Predictions

Predicted Properties of Ekasilicon (Es)	Actual Properties of Germanium (Ge)
<i>Existence Predicted—1871</i>	<i>Actual Discovery—1886</i>
Atomic mass = 72	Atomic mass = 72.61
High melting point	Melting point = 938°C
Density = 5.5 g/cm ³	Density = 5.323 g/cm ³
Dark gray metal	Gray metal
Density of EsO ₂ = 4.7 g/cm ³	Density of GeO ₂ = 4.23 g/cm ³

How has the periodic table been improved?

Mendeleev's periodic table was very good for its time. However, scientists eventually found some problems with it. The elements on Mendeleev's table increased in atomic mass from left to right. Look at the modern periodic table at the back of this book. You will find examples, such as cobalt and nickel, that decrease in mass from left to right. However, notice that the atomic number always increases from left to right.

In 1913, the arrangement of the periodic table was changed. Instead of being arranged by increasing atomic mass, it was arranged by increasing atomic number. This change was due to the work of an English scientist named Henry G. J. Moseley. The new arrangement seemed to correct some of the problems of the old table. The current periodic table uses Moseley's arrangement and is shown in the back of this book. ✓

✓ Reading Check

3. **Observe** How did Moseley arrange the periodic table?

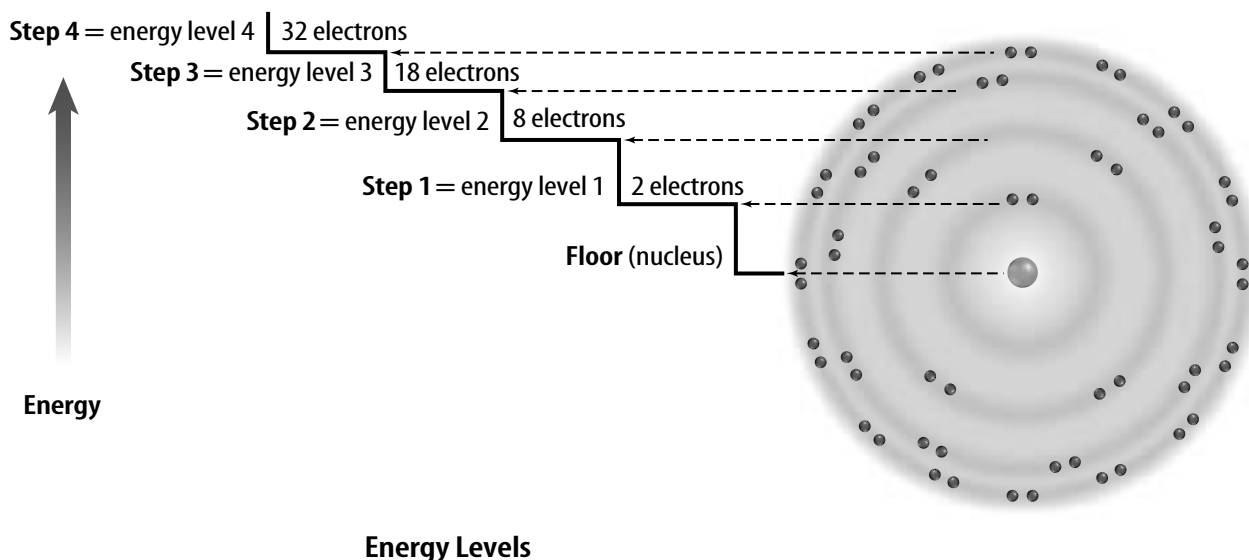
The Atom and the Periodic Table

Objects are often sorted or grouped according to the properties they have in common. Elements on the periodic table are grouped according to their chemical properties. The vertical columns on the periodic table are called **groups**. The groups are numbered 1 through 18. Sometimes they are called families. Elements in each group have similar properties. For example, in Group 11, copper, silver, and gold have similar properties. Each is a shiny metal. Each is a good conductor of electricity and heat. Why are the elements in a group similar? Look at the structure of the atom to answer this question.

What is the structure of the electron cloud?

Where are the electrons located in an atom? How many are there? In a neutral atom, the number of electrons is equal to the number of protons. Carbon has an atomic number of six, which means it has six protons and six electrons. These electrons are located in the electron cloud that surrounds the nucleus.

Scientists have found that electrons in the electron cloud have different amounts of energy. Look at the figure. It shows a model of the energy differences that scientists use. Electrons fill the energy levels from the inner levels to the outer levels. The inner levels are closer to the nucleus and the outer levels are farther from the nucleus. Inner levels have less energy than the outer levels. Imagine that the nucleus is like a floor. Each energy level is a step up a flight of stairs above the floor. Each stair step represents an increase in energy. The figure shows the maximum number of electrons that will fit in each energy level of an atom. Not all atoms will have all levels filled. This depends on the number of electrons in an atom of that element.



Think it Over

4. **Draw Conclusions** Neon is a gas. Do you think neon is an element in Group 11? Explain.

Picture This

5. **Apply** The element magnesium has 12 electrons. In how many energy levels are the electrons of magnesium?

Picture This

6. **Identify** What is hydrogen's outermost energy level?
- _____

How are electrons arranged in energy levels?

Elements that are in the same group have the same number of electrons in their outer energy level. The number of electrons in the outer energy level determines the chemical properties of the element. It is important to understand the link between the location on the periodic table, chemical properties, and the structure of the atom.

These energy levels are named using numbers one to seven. Electrons fill the energy levels starting with the inner level. For example, the element sulfur has 14 electrons. Two electrons will be in energy level 1 and eight electrons will be in energy level 2. The rest of the electrons will be in energy level 3.

Look again at the diagram on the previous page. Notice that energy levels 3 and 4 have increasingly large numbers of electrons. However, a stable outer energy level has eight electrons. How is this possible? In elements that have three or more energy levels, more electrons can be added to inner energy levels as long as the outer level contains eight electrons.

How are rows on the periodic table arranged?

Remember that the atomic number found on the periodic table is equal to the number of electrons in an atom. Look at the partial periodic table below.

Top Row The top row has hydrogen with one electron and helium with two electrons. Both of these electrons are in energy level 1. Energy level 1 is the outermost level in these elements. So, hydrogen has one outer electron and helium has two. Recall from the figure on the previous page that energy level 1 can hold only two electrons. Therefore, helium has a full outer energy level.

Hydrogen 1 H							Helium 2 He
Lithium 3 Li	Beryllium 4 Be						
		Boron 5 B	Carbon 6 C	Nitrogen 7 N	Oxygen 8 O	Fluorine 9 F	Neon 10 Ne
Sodium 11 Na	Magnesium 12 Mg	Aluminum 13 Al	Silicon 14 Si	Phosphorus 15 P	Sulfur 16 S	Chlorine 17 Cl	Argon 18 Ar

Second Row The second row of the periodic table begins with lithium. Lithium has three electrons, two in energy level 1, and one in energy level 2. Next is beryllium with two outer electrons and boron with three outer electrons. The pattern continues until you reach neon. Neon has eight outer electrons. Look at the figure on the previous page. Energy level 2 can hold eight electrons. So, neon has a full outer energy level. Notice how a row in the table ends when an outer energy level is filled. The third row of elements, electrons begin filling energy level 3. The row ends with argon, which has a stable outer energy level.

What are electron dot diagrams?

Elements in the same group have the same number of electrons in their outer energy level. Outer electrons are used to determine the chemical properties of an element.

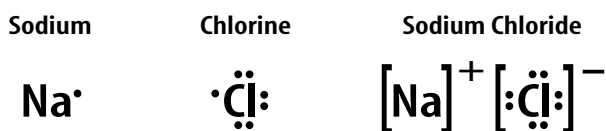
American chemist G. N. Lewis invented the electron dot diagram to show the outer electrons of an element. An **electron dot diagram** is the symbol of an element with dots representing the number of electrons in the outer energy level. The diagram for the elements sodium (Na) and chlorine (Cl) is shown below. These diagrams show how electrons in the outer energy level bond when elements combine to form compounds.

How are elements in the same group similar?

Elements in Group 17 are called halogens. They all have electron dot diagrams similar to chlorine, shown below. You can see that chlorine has seven electrons in its outer energy level. So do the other halogens. Since all elements in a group have the same number of electrons in their outer levels, those elements undergo chemical reactions in similar ways. ✓

How do halogens form compounds?

All halogens can form compounds with elements in Group 1. Group 1 elements, like sodium, all have one electron in their outer energy level. The figure shows an example of a compound formed by a reaction between sodium and chlorine. Sodium combines with chlorine to give each element a complete outer energy level. The result is the compound sodium chloride (NaCl), ordinary table salt.



Not all elements form compounds with other elements. Group 18 elements have completely filled outer energy levels. This makes group 18 elements unreactive.

Applying Math

- 7. Use Numbers** How many electrons would fluorine need to gain in order to have a stable outer energy level?

✓ Reading Check

- 8. Apply** What do all of the elements in a group have in common?

Picture This

- 9. Draw Conclusions** What seems to happen to the one electron in the outer level of sodium when it combines with chlorine to form sodium chloride?

Compare and Contrast

Divide your paper into four quarters to compare and contrast metals, nonmetals, and metalloids.

Metal:
Nonmetal:
Metalloid:



Think it Over

10. **Draw Conclusions** Silicon conducts electricity under some conditions but not under other conditions. In which region would you place silicon?

Picture This

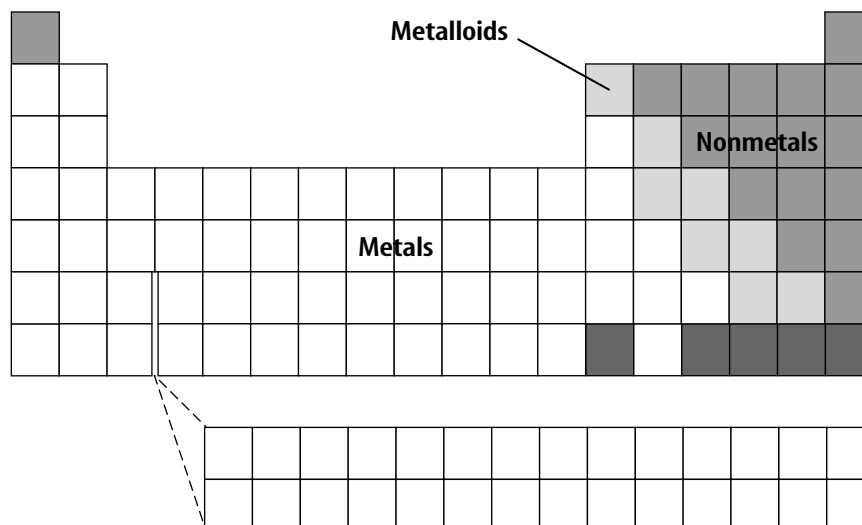
11. **Apply** On which side of the periodic table would you look for an element that definitely will not conduct electricity?

Regions on the Periodic Table

The periodic table has several regions with specific names. The horizontal rows of elements are called **periods**. Recall that the elements increase by one proton and one electron as you go from left to right across a period. Also, each period represents a higher electron energy level.

All of the elements in the white squares in the diagram are metals. Iron, zinc, and copper are some examples of metals. Most metals are solids at room temperature. They usually are shiny. They can be drawn into wires and pounded into sheets. They are good conductors of heat and electricity.

The elements on the right side of the diagram in dark gray are classified as nonmetals. Oxygen, bromine, and carbon are nonmetals. Most nonmetals are gases. The elements in this region that are solids are brittle. Nonmetals are also poor conductors of heat and electricity at room temperature. The elements in light gray are metalloids, or semimetals. They have some properties of metals and some properties of nonmetals. Boron and silicon are examples of metalloids.



Regions on the Periodic Table

Elements in the Universe

Scientists have found the same elements throughout the universe. Many scientists hypothesize that hydrogen and helium are the building blocks of other elements. Atoms join within stars to form elements with atomic numbers greater than those of hydrogen and helium. Exploding stars, called supernovas, spread their mixture of elements throughout the universe. Scientists have made new elements in laboratories. These elements may have life spans less than a second.

● After You Read

Mini Glossary

electron dot diagram: the symbol of an element with dots representing the number of electrons in the outer energy level

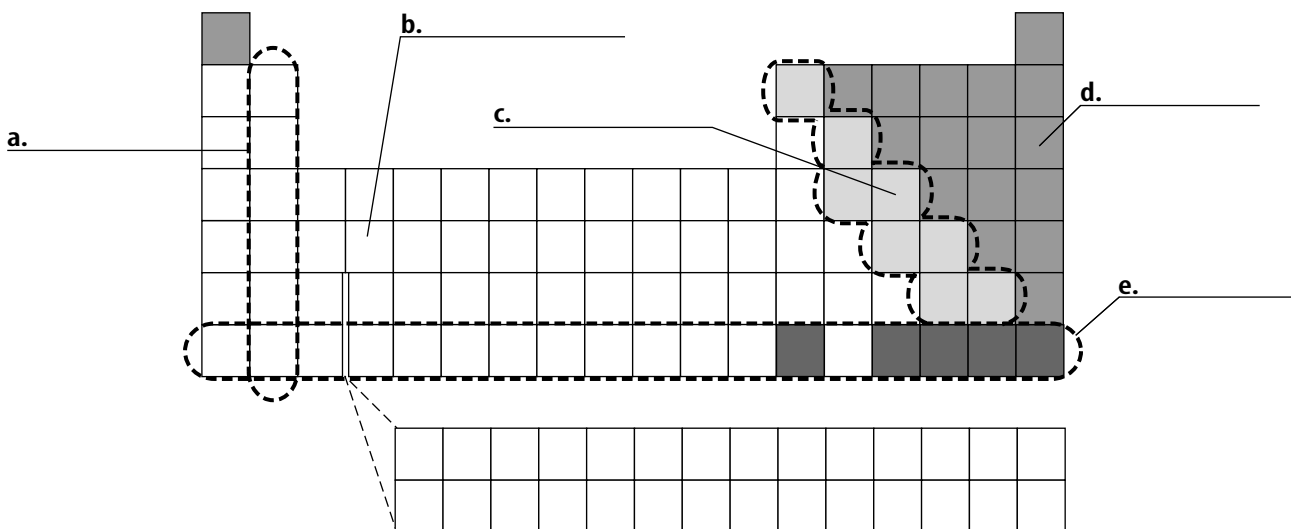
group: a vertical column of elements on the periodic table


period: a horizontal row of elements on the periodic table

periodic table: an arrangement of the elements by increasing atomic number and by changes in physical and chemical properties

1. Review the terms and their definitions in the Mini Glossary. Write a sentence using one of the terms that shows that you understand the term.

2. Below is a blank periodic table of elements. On this table, label the different sections as *metals*, *metalloids*, *nonmetals*, *period*, or *group*.



3.  **Mark the Text** Explain what is important about the rows and columns on the periodic table.
