Name _____ Class _____ Date _____

CHAPTER 7 The Periodic Table

SECTION 1

Arranging the Elements

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How are elements arranged on the periodic table?
- What are metals, nonmetals, and metalloids?
- What patterns are shown by the periodic table?

California Science Standards

8.3.f, 8.7.a, 8.7.b, 8.7.c

What Are Patterns of Elements?

By the 1860s, scientists had discovered more than 60 different elements. As they studied these elements, the scientists discovered that some elements had properties that were similar. For example, sodium and potassium are both metals that react violently with water. On the other hand, gold and silver are stable metals that react very slowly with water.

To understand the elements, chemists needed a way to organize what they knew about them. If they could find a pattern to these properties, it would help them understand how elements interact. A Russian chemist, Dmitri Mendeleev, discovered such a pattern in 1869. ☑

Mendeleev wrote the names of the elements and their properties on cards. When he arranged the cards in order of increasing atomic mass, he found that a pattern developed. He put elements that had similar properties in the same vertical column, as in the table below.

Arranging the Elements in a Table

Hydrogen 1						
Lithium 7	Beryllium 9	Boron 11	Carbon 12		Oxygen 16	Fluorine 19
Sodium 23	Magnesium 24	Aluminum 27	Silicon 28		Sulfur 32	Chlorine 35
Potassium 39	Calcium 40					

The elements were placed in order by atomic mass. Sodium is similar to lithium and potassium, so they are in the same column. The same is true for elements in the other columns.

STUDY TIP

Clarify Concepts Take turns reading this section out loud with a partner. Stop to discuss ideas that seem confusing.

READING CHECK

1. Describe What discovery allowed Mendeleev to organize the elements?

_____

_____

_____

TAKE A LOOK

2. Predict Look at the pattern of atomic masses of the elements. Predict where elements X (atomic mass 31) and element Y (atomic mass 14) should be placed. Write them in the empty boxes in the table.

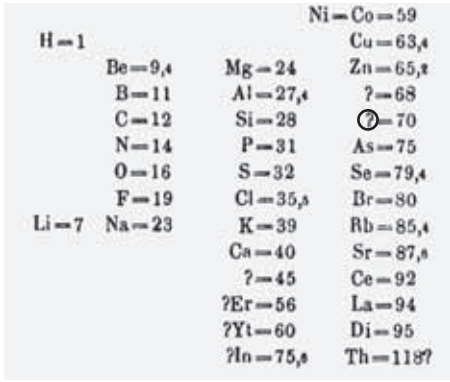
Say It

Discuss Many things occur in patterns that are periodic. In groups of three or four, discuss things in everyday life that occur at regular intervals. How many different types of patterns can you think of?

How Were the Patterns Used?

Mendeleev found that the pattern repeated several times. He started a new line with each element whose properties were similar to those of lithium. The result was that all the elements in the first column reacted in a similar way. All the elements in the second row also had similar properties. The pattern continued across the table—a periodic pattern. **Periodic** means "happening at regular intervals."

Mendeleev found that the pattern of elements repeated after every seven elements. His table became known as the periodic table of the elements. The figure below shows part of a chart that Mendeleev made using his periodic table. Notice that there are several question marks beside atomic masses.



			Ni = Co = 59
H = 1			Cu = 63,4
	Be = 9,4	Mg = 24	Zn = 65,2
	B = 11	Al = 27,4	? = 68
	C = 12	Si = 28	? = 70
	N = 14	P = 31	As = 75
	O = 16	S = 32	Se = 79,4
	F = 19	Cl = 35,5	Br = 80
Li = 7	Na = 23	K = 39	Rb = 85,4
		Ca = 40	Sr = 87,6
		? = 45	Ce = 92
		?Er = 56	La = 94
		?Yt = 60	Di = 95
		?In = 75,6	Th = 118?

Mendeleev used question marks to note elements that he thought would be found later.

TAKE A LOOK

3. Identify Look at Mendeleev's chart. How many new elements did he predict would be discovered later?

_____

When all the known elements were placed on the chart, there were places that did not line up. Mendeleev left several blank spots in his periodic table. He predicted that elements would be discovered that would fill those blanks.

By 1886, the gaps in the table had been filled by newly discovered elements. These elements had the properties that Mendeleev had predicted. The table below compares one of Mendeleev's predictions with the actual element, germanium, discovered in 1871.

Math Focus

4. Compare Mendeleev predicted an atomic mass for the element that was later discovered and named germanium. How much does germanium's actual atomic mass differ from his prediction?

_____

_____

Properties of Germanium		
	Mendeleev's predictions (1869)	**Actual properties**
Atomic mass	70 amu	72.6 amu
Density*	5.5 g/cm^3	5.3 g/cm^3
Appearance	dark gray metal	gray metal
Melting point*	high	937°C

* at room temperature and pressure

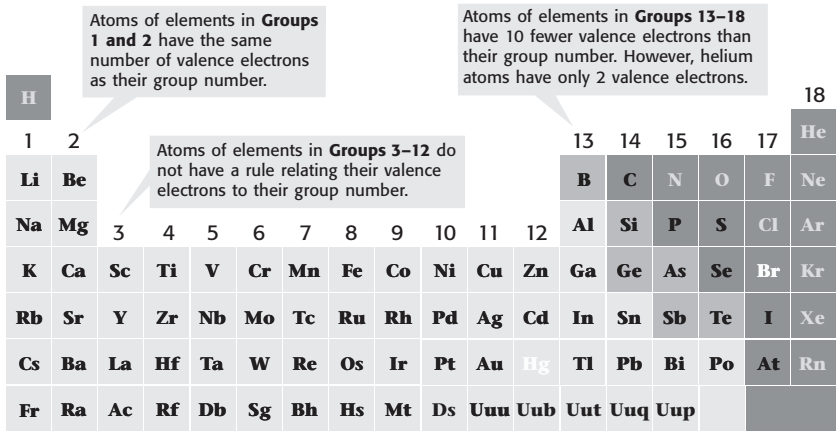
What Does the Modern Periodic Table Look Like?

The first periodic table included only 63 elements. Today, scientists know about more than 100 elements, although some of them are very rare. The modern periodic table contains information that is similar to Mendeleev's, but there are some differences.

The original periodic table displayed the elements in order of atomic mass. A few of the elements did not seem to be in the right order. Mendeleev placed them where he thought they should be, based on their properties. He thought that better atomic mass measurements would correct the problem.

In 1914, scientists began using *atomic numbers*. An atomic number is the number of protons in an atom. All of the elements fell into place when they were put in order by atomic number instead of atomic mass. The figure below shows a modern periodic table. ☑

Each horizontal row of elements, from left to right, is called a **period**. The physical and chemical properties of elements in a period follow the same pattern as those of the periods above and below. Each vertical column of elements (top to bottom) is called a **group**. Elements in a group tend to have similar chemical and physical properties. Groups are sometimes called families.



READING CHECK

5. Explain What property did Mendeleev use to sort the elements? What property has been used since 1914?

_____

_____

_____

_____

TAKE A LOOK

6. Describe How many groups and how many periods does the modern periodic table have? (Hydrogen and helium should be counted as the first period.)

_____

_____

How Are the Elements on the Table Classified?

When you look at the elements on the periodic table, three classes of elements are found. Usually, the classes of elements are related to the number of electrons in the outer energy level—the valence electrons. The number of valence electrons increases from left to right in a period. Based on their properties, the elements are classified as follows:

- metals—shown by darker shading to the left and center of the periodic table
- nonmetals—shown by lighter shading to the right side of the table
- metalloids—the region shown on either side of a zigzag line between the metals and nonmetals

The inert gases, Group 18 on the periodic table, are in the nonmetal group.

CALIFORNIA STANDARDS CHECK

8.7.a Students know how to identify regions corresponding to metals, nonmetals, and inert gases.

Word Help: identify
to point out or pick out

7. Compare How does the number of elements that are metals compare with the number of elements that are nonmetals?

_____

_____

_____

METALS

When you look at the periodic table, you can see that most of the elements are metals. Most metal atoms have few electrons in their outer energy levels. Except for mercury, which is a liquid, metals are solid at room temperature. The figure below shows some of the properties of metals.

Properties of Metals

Metals tend to be shiny, such as the reflective surface of this mirror.

Most metals are ductile, which means they can be drawn into thin wires like these copper wires. All metals are good conductors of electric current.

Most metals are malleable, which means they can be flattened without being shattered, as aluminum can be made into foil.

Most metals are good conductors of heat (thermal energy), like the iron in this griddle.

TAKE A LOOK

8. Identify Give five properties of metals that can be used to identify them as metals rather than nonmetals.

_____

_____

_____

_____

NONMETALS

Nonmetals are found on the right-hand side of the table. Atoms of most nonmetals have a nearly full outer energy level. Many of the nonmetal elements are gases at room temperature. In general, the properties of nonmetals are the opposite of the properties of metals. Some properties of nonmetals are described in the figure below. ☑

READING CHECK

9. Compare How are the outer energy levels of nonmetals different from the outer energy levels of metals?

_____

_____

_____

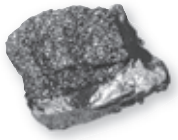
METALLOIDS

Metalloids are the elements found on either side of the zigzag line between metals and nonmetals. Their outer energy levels are about half filled. Metalloids have some of the properties of metals and some of the properties of nonmetals. Some of the properties of metalloids are described in the figure below.

Properties of Nonmetals and Metalloids

Nonmetals are not malleable or ductile. Solid nonmetals, such as carbon in the graphite of pencil lead, are brittle and will break or shatter when hit with a hammer.

Boron, a metalloid, is almost as hard as a diamond and is also very brittle. At high temperatures, it is a good conductor of electric current.



TAKE A LOOK

10. Identify Circle the word in the figure's text that describes how a metalloid responds to a hammer blow.

What Information Is on the Periodic Table?

On the next page is a more detailed look at parts of the periodic table. It includes the two groups on the left-hand side of the table and the six groups on the right-hand side. Each block in the table gives information about one element. This information includes the element's name, its atomic number, and its atomic mass.

Each block also shows the chemical symbol of the element. The symbol is one or two letters that abbreviate the name of the element. These symbols are used in the chemical formulas for compounds. If you see an unfamiliar symbol in a formula, you can use the periodic table to identify the element. ☑

READING CHECK

11. Describe What is a chemical symbol?

_____

_____

_____

TAKE A LOOK

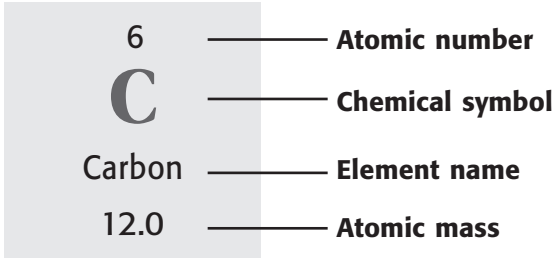
12. List What are the four pieces of information about an element that are shown on the periodic table?

_____

_____

_____

_____



Each square on the periodic table of elements includes the element's name, chemical symbol, atomic number, and atomic mass.

	Group 1	Group 2	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
Period 1	1 H Hydrogen 1.0							2 He Helium 4.0
Period 2	3 Li Lithium 6.9	4 Be Beryllium 9.0	5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
Period 3	11 Na Sodium 23.0	12 Mg Magnesium 24.3	13 Al Aluminum 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
Period 4	19 K Potassium 39.1	20 Ca Calcium 40.1	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
Period 5	37 Rb Rubidium 85.5	38 Sr Strontium 87.6	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
Period 6	55 Cs Cesium 132.9	56 Ba Barium 137.3	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
Period 7	87 Fr Francium (223)	88 Ra Radium (226)	113 Uut Ununtrium (284)	114 Uuy Ununquadium (289)	115 Uup Ununpentium (288)			

A row of elements is called a *period*.

A column of elements is called a *group* or *family*.

Critical Thinking

13. Analyze Relationships Scientists can make atoms of large elements never known before. Identify an element that would have properties like those of an atom with 118 protons.

_____

How Do You Read the Table?

On the previous page, the top figure shows how to read a block on the periodic table. The symbol for the element is generally the largest item in a block. The atomic number is above the symbol. The name of the element and the atomic mass are below the symbol.

Notice that for elements with one-letter symbols, the symbol is always capitalized. For elements with two-letter symbols, the first letter is capitalized, and the second letter is lowercase. Three-letter symbols represent elements with temporary names. ☑

The bottom figure on the previous page shows part of the periodic table. It shows only eight groups of elements so it can fit onto the page. All of the elements follow the **periodic law**. The periodic law states that the repeating chemical and physical properties change periodically with the elements' atomic numbers. An atomic number is the number of protons in an atom of the element.

The atomic number increases from left to right in every period. However, the atomic mass does not always do so. There are several pairs of elements in which the atomic mass is greater for the element on the left. An example is tellurium and iodine in Period 5.

Most tellurium atoms have at least two more neutrons than iodine atoms have. That is why the atomic mass of tellurium is higher than the atomic mass of iodine, even though iodine has one more proton.

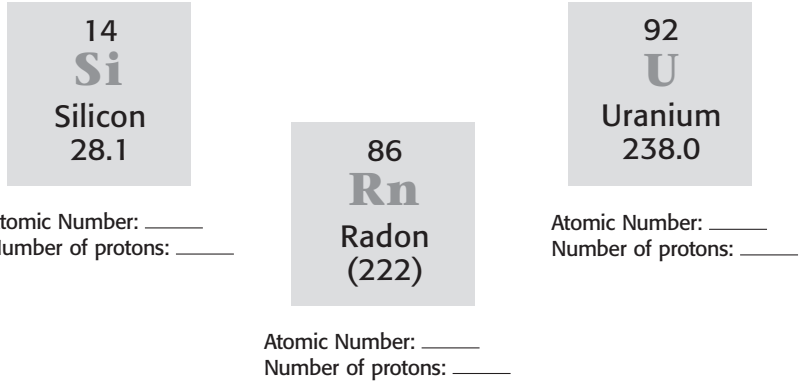
READING CHECK

14. Identify What does a three-letter chemical symbol show?

_____

_____

Finding the Atomic Number



TAKE A LOOK

15. Identify Fill in the blanks in the figure with the atomic number and the number of protons for each element. Use the information from the periodic table boxes.

Name _____ Class _____ Date _____

Section 1 Review

8.3.f, 8.7.a, 8.7.b, 8.7.c

SECTION VOCABULARY

group a vertical column of elements in the periodic table; elements in a group share chemical properties

period in chemistry, a horizontal row of elements in the periodic table

periodic describes something that occurs or repeats at regular intervals

Wordwise The suffix *-ic* means "pertaining to."

periodic law the law that states that the repeating chemical and physical properties of elements change periodically with the atomic numbers of the elements

1. **Compare** Which pair of elements is more likely to have similar properties: two elements in the same group or two elements in the same period?

2. **Organize** Fill in the table below with the correct classifications of the elements.

Location	Classification
Left-hand side and center of the periodic table	
Right-hand side of the periodic table	
Near the zigzag line toward the right-hand side of the periodic table	

3. **Identify Relationships** Use the periodic table to answer this question: Are the properties of rubidium (Rb) more similar to those of cesium (Cs) or those of strontium (Sr)? Explain your answer.

4. **Apply Concepts** Use the last periodic table in this section to identify the elements in the following compounds: PbS, KBr, and RaO.

5. **Apply Concepts** Use the periodic table to determine whether each of the following elements is a metal or a nonmetal: sodium (Na), krypton (Kr), and phosphorus (P).

Name _____ Class _____ Date _____

CHAPTER 7 The Periodic Table

SECTION 1

Arranging the Elements

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How are elements arranged on the periodic table?
- What are metals, nonmetals, and metalloids?
- What patterns are shown by the periodic table?

California Science Standards

8.3.f, 8.7.a, 8.7.b, 8.7.c

What Are Patterns of Elements?

By the 1860s, scientists had discovered more than 60 different elements. As they studied these elements, the scientists discovered that some elements had properties that were similar. For example, sodium and potassium are both metals that react violently with water. On the other hand, gold and silver are stable metals that react very slowly with water.

To understand the elements, chemists needed a way to organize what they knew about them. If they could find a pattern to these properties, it would help them understand how elements interact. A Russian chemist, Dmitri Mendeleev, discovered such a pattern in 1869. ☑

Mendeleev wrote the names of the elements and their properties on cards. When he arranged the cards in order of increasing atomic mass, he found that a pattern developed. He put elements that had similar properties in the same vertical column, as in the table below.

Arranging the Elements in a Table

Hydrogen 1						
Lithium 7	Beryllium 9	Boron 11	Carbon 12		Oxygen 16	Fluorine 19
Sodium 23	Magnesium 24	Aluminum 27	Silicon 28		Sulfur 32	Chlorine 35
Potassium 39	Calcium 40					

The elements were placed in order by atomic mass. Sodium is similar to lithium and potassium, so they are in the same column. The same is true for elements in the other columns.

STUDY TIP

Clarify Concepts Take turns reading this section out loud with a partner. Stop to discuss ideas that seem confusing.

READING CHECK

1. Describe What discovery allowed Mendeleev to organize the elements?

_____

_____

_____

TAKE A LOOK

2. Predict Look at the pattern of atomic masses of the elements. Predict where elements X (atomic mass 31) and element Y (atomic mass 14) should be placed. Write them in the empty boxes in the table.

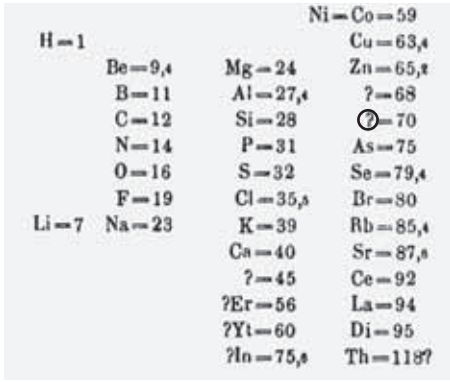
Say It

Discuss Many things occur in patterns that are periodic. In groups of three or four, discuss things in everyday life that occur at regular intervals. How many different types of patterns can you think of?

How Were the Patterns Used?

Mendeleev found that the pattern repeated several times. He started a new line with each element whose properties were similar to those of lithium. The result was that all the elements in the first column reacted in a similar way. All the elements in the second row also had similar properties. The pattern continued across the table—a periodic pattern. **Periodic** means "happening at regular intervals."

Mendeleev found that the pattern of elements repeated after every seven elements. His table became known as the periodic table of the elements. The figure below shows part of a chart that Mendeleev made using his periodic table. Notice that there are several question marks beside atomic masses.



			Ni = Co = 59
H = 1			Cu = 63,4
	Be = 9,4	Mg = 24	Zn = 65,2
	B = 11	Al = 27,4	? = 68
	C = 12	Si = 28	? = 70
	N = 14	P = 31	As = 75
	O = 16	S = 32	Se = 79,4
	F = 19	Cl = 35,5	Br = 80
Li = 7	Na = 23	K = 39	Rb = 85,4
		Ca = 40	Sr = 87,6
		? = 45	Ce = 92
		?Er = 56	La = 94
		?Yt = 60	Di = 95
		?In = 75,6	Th = 118?

Mendeleev used question marks to note elements that he thought would be found later.

TAKE A LOOK

3. Identify Look at Mendeleev's chart. How many new elements did he predict would be discovered later?

_____

When all the known elements were placed on the chart, there were places that did not line up. Mendeleev left several blank spots in his periodic table. He predicted that elements would be discovered that would fill those blanks.

By 1886, the gaps in the table had been filled by newly discovered elements. These elements had the properties that Mendeleev had predicted. The table below compares one of Mendeleev's predictions with the actual element, germanium, discovered in 1871.

Math Focus

4. Compare Mendeleev predicted an atomic mass for the element that was later discovered and named germanium. How much does germanium's actual atomic mass differ from his prediction?

_____

_____

Properties of Germanium		
	Mendeleev's predictions (1869)	**Actual properties**
Atomic mass	70 amu	72.6 amu
Density*	5.5 g/cm^3	5.3 g/cm^3
Appearance	dark gray metal	gray metal
Melting point*	high	937°C

* at room temperature and pressure

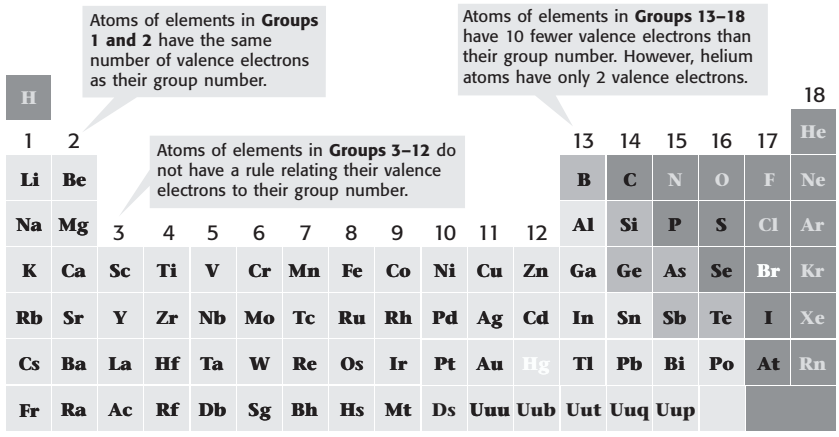
What Does the Modern Periodic Table Look Like?

The first periodic table included only 63 elements. Today, scientists know about more than 100 elements, although some of them are very rare. The modern periodic table contains information that is similar to Mendeleev's, but there are some differences.

The original periodic table displayed the elements in order of atomic mass. A few of the elements did not seem to be in the right order. Mendeleev placed them where he thought they should be, based on their properties. He thought that better atomic mass measurements would correct the problem.

In 1914, scientists began using *atomic numbers*. An atomic number is the number of protons in an atom. All of the elements fell into place when they were put in order by atomic number instead of atomic mass. The figure below shows a modern periodic table. ☑

Each horizontal row of elements, from left to right, is called a **period**. The physical and chemical properties of elements in a period follow the same pattern as those of the periods above and below. Each vertical column of elements (top to bottom) is called a **group**. Elements in a group tend to have similar chemical and physical properties. Groups are sometimes called families.



READING CHECK

5. Explain What property did Mendeleev use to sort the elements? What property has been used since 1914?

_____

_____

_____

_____

TAKE A LOOK

6. Describe How many groups and how many periods does the modern periodic table have? (Hydrogen and helium should be counted as the first period.)

_____

_____

How Are the Elements on the Table Classified?

When you look at the elements on the periodic table, three classes of elements are found. Usually, the classes of elements are related to the number of electrons in the outer energy level—the valence electrons. The number of valence electrons increases from left to right in a period. Based on their properties, the elements are classified as follows:

- metals—shown by darker shading to the left and center of the periodic table
- nonmetals—shown by lighter shading to the right side of the table
- metalloids—the region shown on either side of a zigzag line between the metals and nonmetals

The inert gases, Group 18 on the periodic table, are in the nonmetal group.

CALIFORNIA STANDARDS CHECK

8.7.a Students know how to identify regions corresponding to metals, nonmetals, and inert gases.

Word Help: identify
to point out or pick out

7. Compare How does the number of elements that are metals compare with the number of elements that are nonmetals?

_____

_____

_____

METALS

When you look at the periodic table, you can see that most of the elements are metals. Most metal atoms have few electrons in their outer energy levels. Except for mercury, which is a liquid, metals are solid at room temperature. The figure below shows some of the properties of metals.

Properties of Metals

Metals tend to be shiny, such as the reflective surface of this mirror.

Most metals are ductile, which means they can be drawn into thin wires like these copper wires. All metals are good conductors of electric current.

Most metals are malleable, which means they can be flattened without being shattered, as aluminum can be made into foil.

Most metals are good conductors of heat (thermal energy), like the iron in this griddle.

TAKE A LOOK

8. Identify Give five properties of metals that can be used to identify them as metals rather than nonmetals.

_____

_____

_____

_____

NONMETALS

Nonmetals are found on the right-hand side of the table. Atoms of most nonmetals have a nearly full outer energy level. Many of the nonmetal elements are gases at room temperature. In general, the properties of nonmetals are the opposite of the properties of metals. Some properties of nonmetals are described in the figure below. ☑

READING CHECK

9. Compare How are the outer energy levels of nonmetals different from the outer energy levels of metals?

_____

_____

_____

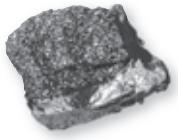
METALLOIDS

Metalloids are the elements found on either side of the zigzag line between metals and nonmetals. Their outer energy levels are about half filled. Metalloids have some of the properties of metals and some of the properties of nonmetals. Some of the properties of metalloids are described in the figure below.

Properties of Nonmetals and Metalloids

Nonmetals are not malleable or ductile. Solid nonmetals, such as carbon in the graphite of pencil lead, are brittle and will break or shatter when hit with a hammer.

Boron, a metalloid, is almost as hard as a diamond and is also very brittle. At high temperatures, it is a good conductor of electric current.



TAKE A LOOK

10. Identify Circle the word in the figure's text that describes how a metalloid responds to a hammer blow.

What Information Is on the Periodic Table?

On the next page is a more detailed look at parts of the periodic table. It includes the two groups on the left-hand side of the table and the six groups on the right-hand side. Each block in the table gives information about one element. This information includes the element's name, its atomic number, and its atomic mass.

Each block also shows the chemical symbol of the element. The symbol is one or two letters that abbreviate the name of the element. These symbols are used in the chemical formulas for compounds. If you see an unfamiliar symbol in a formula, you can use the periodic table to identify the element. ☑

READING CHECK

11. Describe What is a chemical symbol?

_____

_____

_____

TAKE A LOOK

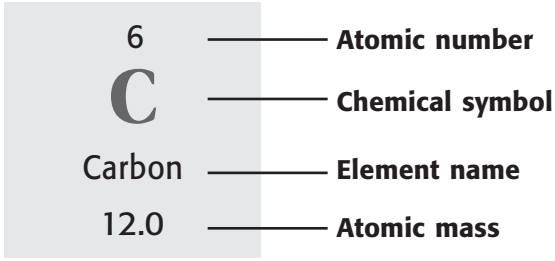
12. List What are the four pieces of information about an element that are shown on the periodic table?

_____

_____

_____

_____



Each square on the periodic table of elements includes the element's name, chemical symbol, atomic number, and atomic mass.

	Group 1	Group 2	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
Period 1	1 H Hydrogen 1.0							2 He Helium 4.0
Period 2	3 Li Lithium 6.9	4 Be Beryllium 9.0	5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
Period 3	11 Na Sodium 23.0	12 Mg Magnesium 24.3	13 Al Aluminum 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
Period 4	19 K Potassium 39.1	20 Ca Calcium 40.1	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
Period 5	37 Rb Rubidium 85.5	38 Sr Strontium 87.6	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
Period 6	55 Cs Cesium 132.9	56 Ba Barium 137.3	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
Period 7	87 Fr Francium (223)	88 Ra Radium (226)	113 Uut Ununtrium (284)	114 Uuy Ununquadium (289)	115 Uup Ununpentium (288)			

A row of elements is called a *period*.

A column of elements is called a *group* or *family*.

Critical Thinking

13. Analyze Relationships Scientists can make atoms of large elements never known before. Identify an element that would have properties like those of an atom with 118 protons.

_____

How Do You Read the Table?

On the previous page, the top figure shows how to read a block on the periodic table. The symbol for the element is generally the largest item in a block. The atomic number is above the symbol. The name of the element and the atomic mass are below the symbol.

Notice that for elements with one-letter symbols, the symbol is always capitalized. For elements with two-letter symbols, the first letter is capitalized, and the second letter is lowercase. Three-letter symbols represent elements with temporary names. ☑

The bottom figure on the previous page shows part of the periodic table. It shows only eight groups of elements so it can fit onto the page. All of the elements follow the **periodic law**. The periodic law states that the repeating chemical and physical properties change periodically with the elements' atomic numbers. An atomic number is the number of protons in an atom of the element.

The atomic number increases from left to right in every period. However, the atomic mass does not always do so. There are several pairs of elements in which the atomic mass is greater for the element on the left. An example is tellurium and iodine in Period 5.

Most tellurium atoms have at least two more neutrons than iodine atoms have. That is why the atomic mass of tellurium is higher than the atomic mass of iodine, even though iodine has one more proton.

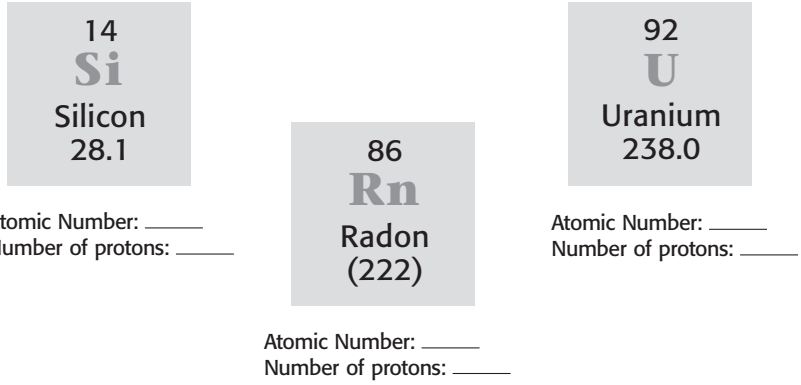
READING CHECK

14. Identify What does a three-letter chemical symbol show?

_____

_____

Finding the Atomic Number



TAKE A LOOK

15. Identify Fill in the blanks in the figure with the atomic number and the number of protons for each element. Use the information from the periodic table boxes.

Name _____ Class _____ Date _____

Section 1 Review

8.3.f, 8.7.a, 8.7.b, 8.7.c

SECTION VOCABULARY

group a vertical column of elements in the periodic table; elements in a group share chemical properties

period in chemistry, a horizontal row of elements in the periodic table

periodic describes something that occurs or repeats at regular intervals

Wordwise The suffix *-ic* means "pertaining to."

periodic law the law that states that the repeating chemical and physical properties of elements change periodically with the atomic numbers of the elements

1. **Compare** Which pair of elements is more likely to have similar properties: two elements in the same group or two elements in the same period?

2. **Organize** Fill in the table below with the correct classifications of the elements.

Location	Classification
Left-hand side and center of the periodic table	
Right-hand side of the periodic table	
Near the zigzag line toward the right-hand side of the periodic table	

3. **Identify Relationships** Use the periodic table to answer this question: Are the properties of rubidium (Rb) more similar to those of cesium (Cs) or those of strontium (Sr)? Explain your answer.

4. **Apply Concepts** Use the last periodic table in this section to identify the elements in the following compounds: PbS, KBr, and RaO.

5. **Apply Concepts** Use the periodic table to determine whether each of the following elements is a metal or a nonmetal: sodium (Na), krypton (Kr), and phosphorus (P).

Name _____ Class _____ Date _____

CHAPTER 7 The Periodic Table

SECTION 2

Grouping the Elements

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- Why do elements in a group often have similar properties?
- What are the characteristic properties of the groups on the periodic table?
- How does hydrogen differ from other elements?

California Science Standards

8.7.a, 8.7.c

Why Are Elements in a Group Similar?

The elements in a group on the periodic table often—but not always—have similar properties. The properties are similar because the elements within a group have the same number of electrons in their outer energy level. Atoms often take, give, or share electrons with other atoms. Elements whose atoms have similar outer energy levels tend to react in similar ways. ☑

STUDY TIP

Organize Make a Venn Diagram for metals and nonmetals. As you read, indicate for each group whether it includes all metals, all nonmetals, or a both.

READING CHECK

1. Explain Why do the elements within a group of the periodic table have similar chemical properties?

_____

_____

_____

_____

GROUP 1: ALKALI METALS

3 Li Lithium	**Group contains:** metals **Electrons in the outer level:** 1 **Reactivity:** very reactive **Other shared properties:** softness, color of silver, shininess, low density
11 Na Sodium	
19 K Potassium	
37 Rb Rubidium	
55 Cs Cesium	
87 Fr Francium	

Alkali metals are elements in Group 1 of the periodic table. Alkali metals are the most reactive metals, which means they form compounds with other elements most easily. Their atoms tend to give away one of their outer-level electrons when they form compounds.

Alkali metals react with water and with oxygen in the air. In fact, they can cause a violent explosion when put into water. Alkali metals are so reactive that, in nature, they are found only in compounds with other elements. Compounds formed from alkali metals have many uses. One such compound, sodium chloride (table salt), is necessary in your diet.

TAKE A LOOK

2. List Write the names and atomic numbers of the alkali metal elements.

_____

_____

_____

_____

_____

_____

GROUP 2: ALKALINE-EARTH METALS

4 Be Beryllium
12 Mg Magnesium
20 Ca Calcium
38 Sr Strontium
56 Ba Barium
88 Ra Radium

Group contains: metals
Electrons in the outer level: 2
Reactivity: very reactive but less reactive than alkali metals
Other shared properties: color of silver, higher densities than alkali metals

Alkaline-earth metals are less reactive than alkali metals. Atoms of alkaline-earth metals have two outer-level electrons. It is more difficult for atoms to lose two electrons than to lose one. That means alkaline-earth metals tend to react more slowly than alkali metals, but they are still very reactive. ☑

Group 2 elements and their compounds have many uses. For example, magnesium can be mixed with other metals to make low-density parts for airplanes. Compounds of calcium are found in chalk, cement, and even in your bones and teeth.

READING CHECK

3. Explain Why are the alkaline-earth metals less reactive than the alkali metals?

_____

_____

_____

_____

GROUPS 3 TO 12: TRANSITION METALS

21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn
39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd
57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg
89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Uuu	112 Uub

TAKE A LOOK

4. Identify How many protons does the largest transition metal have in its nucleus?

_____

Group contains: metals
Electrons in the outer level: 1 or 2
Reactivity: less reactive than alkaline-earth metals
Other shared properties: shininess, good conduction of thermal energy and electric current, higher densities and melting points than elements in Groups 1 and 2 (except for mercury)

Elements of Groups 3 to 12 are called transition metals. The atoms of transition metals do not give away their electrons as easily as atoms of Group 1 or Group 2 metals.

PROPERTIES OF TRANSITION METALS

The number of outer-level electrons in atoms of transition metals varies. The properties of these metals also vary widely. For example, iron forms rust when exposed to air and water. Gold and platinum, however, are very unreactive. Jewelry and other gold objects that are thousands of years old still look new.

Because they are metals, transition metals all share the common properties of metals. They tend to be shiny, malleable, and ductile. They conduct thermal energy and electric current well. Many of the transition metals have very high melting points compared with other elements. One exception is mercury, which is a liquid at room temperature. Many of the transition metals are familiar as structural materials, coins, and jewelry. ☑

READING CHECK

5. Identify Which transition metal has the lowest melting point?

_____

GROUP 13: BORON GROUP

5 B Boron
13 Al Aluminum
31 Ga Gallium
49 In Indium
81 Tl Thallium
113 Uut Ununtrium

Group contains: one metalloid and five metals
Electrons in the outer level: 3
Reactivity: reactive
Other shared properties: solid at room temperature

The most common element from Group 13 is aluminum. In fact, aluminum is the most common metal in Earth's crust. Until the 1880s, however, aluminum was considered a precious metal. Today, making pure aluminum is easier and cheaper than it was in the 1800s.

Aluminum is useful because it is such a lightweight, but strong, metal. It is used in aircraft parts parts, lightweight automobile parts, foil, cans, and garage doors. ☑

Like other elements in the boron group, aluminum is reactive. However, when aluminum reacts with oxygen in the air, a thin layer of aluminum oxide quickly forms on aluminum's surface. This layer prevents it from reacting further.

TAKE A LOOK

6. List Write the atomic numbers of the elements in Group 13.

_____

_____

READING CHECK

7. Explain Why is aluminum a good choice of metal for airplane bodies?

_____

_____

_____

GROUP 14: CARBON GROUP

6 C Carbon
14 Si Silicon
32 Ge Germanium
50 Sn Tin
82 Pb Lead
114 Uuq Ununquadium

Group contains: one nonmetal, two metalloids, and three metals
Electrons in the outer level: 4
Reactivity: varies among elements
Other shared properties: solid at room temperature

Group 14 includes several well-known and useful elements. The nonmetal carbon can be found uncombined in nature, as diamond and as soot from burning wood, oil, or coal.

Carbon also forms a wide variety of compounds. Some of these compounds, such as proteins, fats, and carbohydrates, are necessary for all living things.

TAKE A LOOK
8. Identify Which element in Group 14 is classified as a nonmetal?

_____

Silicon and germanium are metalloids. They are used in semiconductors. These are important components of computers and other electronic devices. Tin and lead are soft, relatively unreactive metals. A layer of tin keeps steel cans from rusting. Lead is used in automobile batteries.

GROUP 15: NITROGEN GROUP

7 N Nitrogen
15 P Phosphorus
33 As Arsenic
51 Sb Antimony
83 Bi Bismuth
115 Uup Ununpentium

Group contains: two nonmetals, two metalloids, and two metals
Electrons in the outer level: 5
Reactivity: varies among elements
Other shared properties: solid at room temperature (except for nitrogen)

Nitrogen, which is a gas at room temperature, makes up about 80% of the air that you breathe. In general, nitrogen is fairly unreactive. Nitrogen can be made to react with hydrogen to make ammonia for fertilizers.

TAKE A LOOK
9. Identify What are the chemical symbols for the elements nitrogen and phosphorus?

_____

Phosphorus is an extremely reactive nonmetal. In nature, it is always found combined with other elements. Because it is so reactive, phosphorus is used to make matches. The heat of friction against the box provides the energy to cause phosphorus to start burning.

GROUP 16: OXYGEN GROUP

8 O Oxygen
16 S Sulfur
34 Se Selenium
52 Te Tellurium
84 Po Polonium

Group contains: three nonmetals, one metalloid, and one metal
Electrons in the outer level: 6
Reactivity: reactive
Other shared properties: solid at room temperature (except oxygen)

About 20% of the air is oxygen. Oxygen is necessary for anything to burn. It is also important to most living things. Dissolved oxygen in water is necessary for fish to live.

Sulfur is another common member of Group 16. Sulfur can be found in natural deposits as a brittle, yellow solid. It is used to make sulfuric acid, which is the most widely used compound in the chemical industry. ☑

READING CHECK

10. Describe What are the physical properties of the element sulfur?

_____

_____

GROUP 17: HALOGENS

9 F Fluorine
17 Cl Chlorine
35 B Bromine
53 I Iodine
85 At Astatine

Group contains: nonmetals
Electrons in the outer level: 7
Reactivity: very reactive
Other shared properties: poor conduction of electric current, violent reaction with alkali metals to form salts, never in uncombined form in nature

Halogens are very reactive nonmetal elements that need to gain only one electron to have a complete outer level. The atoms of the halogens combine readily with other atoms, especially metals, to gain the extra electron. The reaction of a halogen with a metal makes a salt, such as sodium chloride.

Both chlorine and iodine are used as disinfectants. Chlorine is used to treat water for drinking and swimming. Iodine mixed with alcohol makes a germ killer used in hospitals.

Although the chemical properties of halogens are similar, their physical properties can be quite different. For example, at room temperature, fluorine and chlorine are gases, bromine is a liquid, and iodine is a solid. Astatine is a very rare element.

TAKE A LOOK

11. List What are the names and atomic numbers of the halogens?

_____

_____

_____

_____

_____

CALIFORNIA STANDARDS CHECK

8.7.a Students know how to identify regions corresponding to metals, nonmetals, and inert gases.

Word Help: identify
to point out or pick out

12. Explain What evidence do scientists have that the inert gases are not completely inert?

_____

_____

_____

Critical Thinking

13. Evaluate Models According to the current model of the atom, the atoms are most stable when they have filled outer energy levels. How do the properties of noble gases support this model?

_____

_____

_____

_____

_____

_____

_____

GROUP 18: NOBLE GASES

2 **He** Helium
10 **Ne** Neon
18 **Ar** Argon
36 **Kr** Krypton
54 **Xe** Xenon
86 **Rn** Radon

Group contains: nonmetals
Electrons in the outer level: 8 (except helium, which has 2)
Reactivity: unreactive
Other shared properties: colorless odorless gas at room temperature

Noble gases are unreactive gases found in Group 18 of the periodic table. The atoms of the noble gases have completely filled outer levels. This means that they do not need to gain or lose electrons to become stable.

Under normal conditions, these elements do not react with other elements. In fact, they are sometimes called inert gases because scientists once believed that they do not react at all. However, scientists have made compounds with some of the Group 18 elements. This is why they are usually called noble gases instead of inert gases.

Because the noble gases are so unreactive, they are very difficult to detect chemically. None of them was known when Mendeleev put together his first periodic table. In fact, the first noble gas was not discovered on Earth, but in the sun. Helium was first detected by its effect on light from the sun. *Helios* is the Greek word for "sun."

Argon is the most common noble gas on Earth, making up about 1% of the atmosphere. All of the noble gases are found in small amounts.

The unreactivity of the Group 18 elements makes them useful. For example, ordinary light bulbs last longer when they are filled with argon. Because argon is unreactive, it does not react with the hot metal filament of the bulb. A more reactive gas could react with the filament and cause the bulb to burn out sooner.

Noble gases are also used in colorful light tubes. They glow in bright colors when exposed to a strong electric charge. These lights are often called "neon lights." This is because the first tubes used neon to produce a bright red glow.

HYDROGEN

Electrons in the outer level: 1
Reactivity: reactive
Other properties: colorless, odorless gas at room temperature; low density; explosive reaction with oxygen

Hydrogen is the most abundant element in the universe. It is found in large amounts in stars. Atoms of hydrogen can give away one electron when they join with other atoms. Hydrogen reacts with many elements and is found in many familiar compounds. Hydrogen is so reactive that it can be used as fuel for rockets.

The properties of hydrogen do not match those of any group of the periodic table. Therefore, hydrogen is set apart from the rest of the elements on the table. It is shown above Group 1 because the atoms of alkali metals also lose one electron when they combine with other atoms. However, the physical properties of hydrogen are more like those of nonmetals than of metals. Hydrogen is in a group all by itself. ☑

READING CHECK

14. Explain Why is hydrogen not included in any group of the periodic table?

_____

_____

_____

_____

LANTHANIDES AND ACTINIDES

These metals are part of the transition metals. They are not shown on the periodic table in this chapter. However, many periodic tables show them as two rows at the bottom of the table. Each row has 15 metal elements, which tend to have very similar properties. The lanthanides are often mixed with other metals to make them stronger. The best known actinide is uranium, which is used in nuclear power plants.

SYNTHETIC (MAN-MADE) ELEMENTS

Many of the very large elements are not found naturally on Earth. Elements with atomic numbers greater than 92 (uranium) are made by forcing nuclear particles together. For example, uranium (#92) and carbon (#6) nuclei join to make californium (#98). After a new element is made, it is placed on the periodic table. It is given a temporary name and symbol until scientists agree on a permanent name for the new element.

Critical Thinking

15. Apply Concepts Scientists can make new elements by forcing particles together. How do you know that all of the new elements will be larger than uranium?

_____

_____

_____

_____

_____

Name _____ Class _____ Date _____

Section 2 Review

8.7.a, 8.7.c

SECTION VOCABULARY

alkali metal one of the elements of Group 1 of the periodic table (lithium, sodium, potassium, rubidium, cesium, and francium)

alkaline-earth metal one of the elements of Group 2 of the periodic table (beryllium, magnesium, calcium, strontium, barium, and radium)

halogen one of the elements of Group 17 of the periodic table (fluorine, chlorine, bromine, iodine, and astatine); halogens combine with most metals to form salts

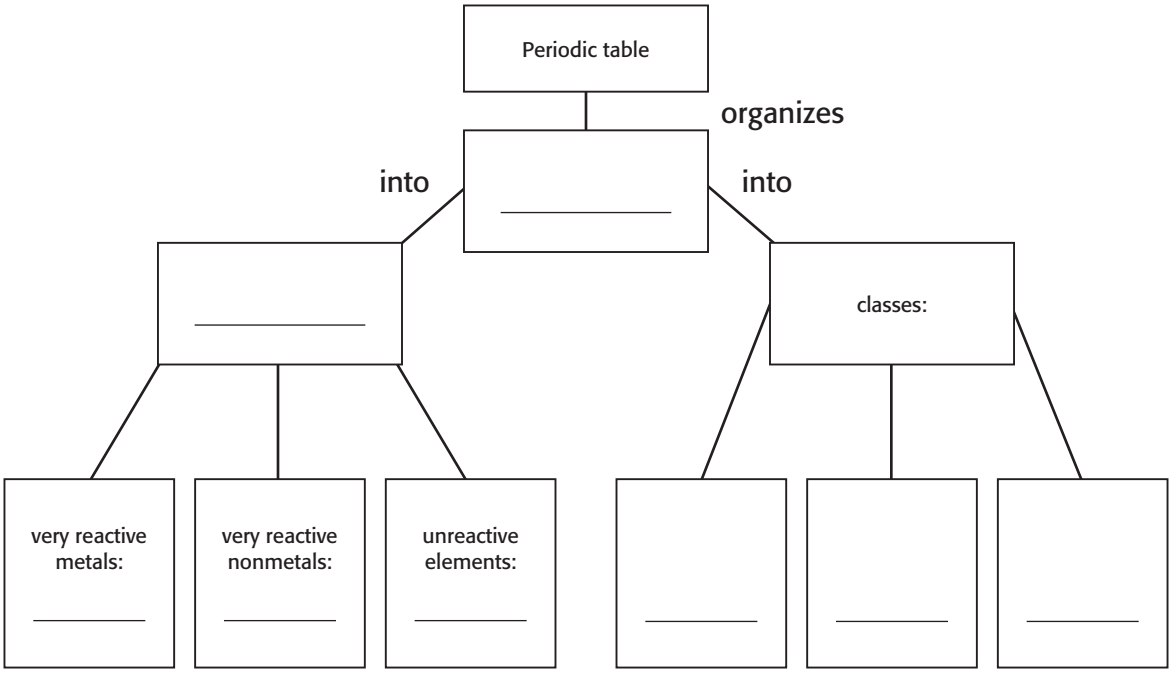
noble gas one of the elements of Group 18 of the periodic table (helium, neon, argon, krypton, xenon, and radon); noble gases are unreactive

1. Explain Why are the alkali metals and the halogens among the most reactive elements on the periodic table?

_____

_____

2. Recall Complete the Concept Map below with words from this section.



3. Apply Concepts Why were the noble gases among the last of the naturally occurring elements to be discovered?

_____

_____

4. Identify Relationships How are all of the nonmetal elements on the periodic table related, in terms of ability to lose electrons?

_____

_____