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?

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GROUP 1: ALKALI METALS

3 Li Lithium
11 Na Sodium
19 K Potassium
37 Rb Rubidium
55 Cs Cesium
87 Fr Francium

Group contains: metals
Electrons in the outer level: 1
Reactivity: very reactive
Other shared properties: softness, color of silver, shininess, low density

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.

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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?

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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?

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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?

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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.

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READING CHECK

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

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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.

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.

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

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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.

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.

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

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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?

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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?

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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?

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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?

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GROUP 18: NOBLE GASES

2 He Helium	**Group contains:** nonmetals
10 Ne Neon	**Electrons in the outer level:** 8 (except helium, which has 2)
18 Ar Argon	**Reactivity:** unreactive
36 Kr Krypton	**Other shared properties:** colorless odorless gas at room temperature
54 Xe Xenon	
86 Rn Radon	

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

1
H
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?

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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?

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