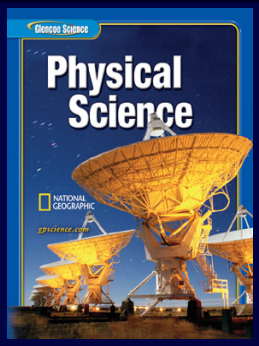
19



CHAPTER RESOURCES END

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Unit 5: Diversity of Matter

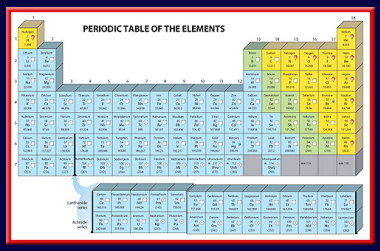
CHAPTER RESOURCES END

Metals

19.1

Properties of Metals

- In the periodic table, metals are elements found to the left of the stair-step line.



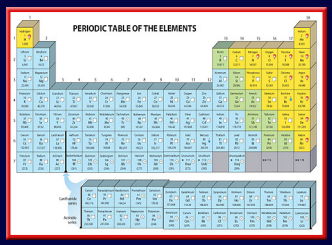
CHAPTER RESOURCES END

Metals

19.1

Properties of Metals

- **Metals** usually have common properties—they are good conductors of heat and electricity, and all but one are solid at room temperature.



CHAPTER RESOURCES END

Metals

19.1

Properties of Metals

- Metals also reflect light. This is a property called luster.
- Metals are **malleable** (MAL yuh bul), which means they can be hammered or rolled into sheets.
- Metals are also **ductile**, which means they can be drawn into wires.

CHAPTER RESOURCES END

Metals

19.1

Ionic Bonding in Metals

- The atoms of metals generally have one to three electrons in their outer energy levels.
- In chemical reactions, metals tend to give up electrons easily because of the strength of charge of the protons in the nucleus.

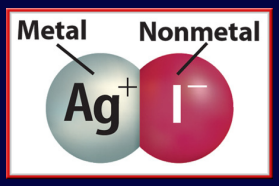
CHAPTER RESOURCES END

Metals

19.1

Ionic Bonding in Metals

- When metals combine with nonmetals, the atoms of the metals tend to lose electrons to the atoms of nonmetals, forming ionic bonds.
- Both metals and nonmetals become more chemically stable when they form ions.



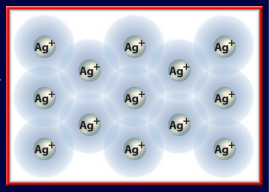
CHAPTER RESOURCES END

Metals

19.1

Metallic Bonding

- In **metallic bonding**, positively charged metallic ions are surrounded by a cloud of electrons.
- Outer-level electrons are not held tightly to the nucleus of an atom. Rather, the electrons move freely among many positively charged ions.



CHAPTER RESOURCES END

Metals

19.1

Metallic Bonding

- The idea of metallic bonding explains many of the properties of metals.
- When a metal is hammered into a sheet or drawn into a wire, it does not break because the ions are in layers that slide past one another without losing their attraction to the electron cloud.
- Metals are also good conductors of electricity because the outer-level electrons are weakly held.

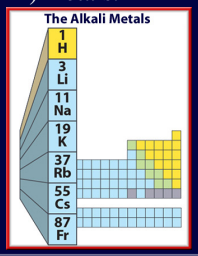
CHAPTER RESOURCES END

Metals

19.1

The Alkali Metals

- The elements in Group 1 of the periodic table are the alkali (AL kuh li) metals.
- Group 1 metals are shiny, malleable, and ductile.
- They are also good conductors of heat and electricity. However, they are softer than most other metals.



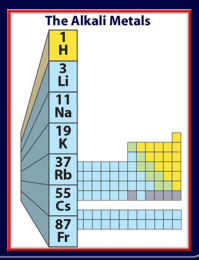
CHAPTER RESOURCES END

Metals

19.1

The Alkali Metals

- The alkali metals are the most reactive of all the metals. They react rapidly—sometimes violently—with oxygen and water.
- Alkali metals don't occur in nature in their elemental form and are stored in substances that are unreactive, such as an oil.



CHAPTER RESOURCES END

Metals

19.1

The Alkali Metals

- Each atom of an alkali metal has one electron in its outer energy level.
- This electron is given up when an alkali metal combines with another atom.
- As a result, the alkali metal becomes a positively charged ion in a compound such as sodium chloride.

CHAPTER RESOURCES END

Metals

19.1 The Alkali Metals

- Alkali metals and their compounds have many uses.
- Doctors use lithium compounds to treat bipolar depression.

CHAPTER RESOURCES END

Metals

19.1 The Alkali Metals

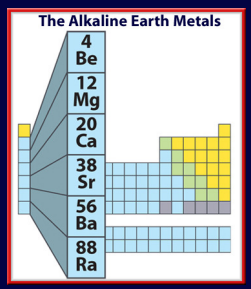
- The operation of some photocells depends upon rubidium or cesium compounds.
- Francium, the last element in Group 1, is extremely rare and radioactive.
- A **radioactive element** is one in which the nucleus breaks down and gives off particles and energy.

CHAPTER RESOURCES END

Metals

19.1 The Alkaline Earth Metals

- Each atom of an alkaline earth metal has two electrons in its outer energy level.



CHAPTER RESOURCES END

Metals

19.1 The Alkaline Earth Metals

- The alkaline earth metals make up Group 2 of the periodic table.
- These electrons are given up when an alkaline earth metal combines with a nonmetal.
- As a result, the alkaline earth metal becomes a positively charged ion in a compound such as calcium fluoride, CaF_2.

CHAPTER RESOURCES END

Metals

19.1 Fireworks and Other Uses

- Magnesium metal is one of the metals used to produce the brilliant white color in fireworks.
- Compounds of strontium produce the bright red flashes.

CHAPTER RESOURCES END

Metals

19.1 Fireworks and Other Uses

- Magnesium's lightness and strength account for its use in cars, planes, and spacecraft.
- Magnesium also is used in compounds to make such things as household ladders, and baseball and softball bats.

CHAPTER RESOURCES END

Metals

19.1

The Alkaline Earth Metals and Your Body

- Calcium is seldom used as a free metal, but its compounds are needed for life.
- Calcium phosphate in your bones helps make them strong.

CHAPTER RESOURCES

Metals

19.1

The Alkaline Earth Metals and Your Body

- The barium compound $BaSO_4$ is used to diagnose some digestive disorders because it absorbs X-ray radiation well.
- Radium, the last element in Group 2, is radioactive and is found associated with uranium. It was once used to treat cancers.

CHAPTER RESOURCES

Metals

19.1

Transition Elements

- **Transition elements** are those elements in Groups 3 through 12 in the periodic table.
- They are called transition elements because they are considered to be elements in transition between Groups 1 and 2 and Groups 13 through 18.

CHAPTER RESOURCES

Metals

19.1

Transition Elements

- Transition elements are familiar because they often occur in nature as uncombined elements.
- Transition elements often form colored compounds.
- Gems show brightly colored compounds containing chromium.

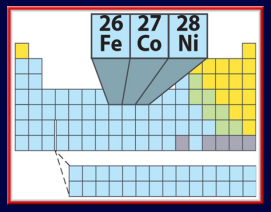
CHAPTER RESOURCES

Metals

19.1

Iron, Cobalt, and Nickel

- The first elements in Groups 8, 9, and 10—iron, cobalt, and nickel—form a unique cluster of transition elements.
- These three sometimes are called the iron triad.
- All three elements are used in the process to create steel and other metal mixtures.



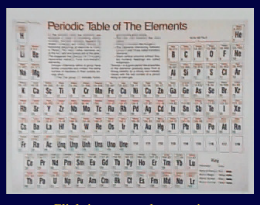
CHAPTER RESOURCES

Metals

19.1

Iron, Cobalt, and Nickel

- Iron—the main component of steel—is the most widely used of all metals.
- Nickel is added to some metals to give them strength.



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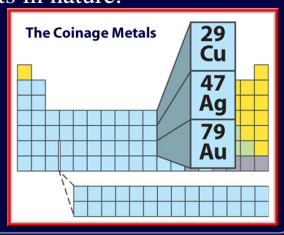
CHAPTER RESOURCES

Metals

19.1

Copper, Silver, and Gold

- Copper, silver, and gold—the three elements in Group 11—are so stable that they can be found as free elements in nature.
- These metals were once used widely to make coins.
- For this reason, they are known as the coinage metals.



CHAPTER RESOURCES END

Metals

19.1

Copper, Silver, and Gold

- Copper often is used in electrical wiring because of its superior ability to conduct electricity and its relatively low cost.
- Silver iodide and silver bromide break down when exposed to light, producing an image on paper.
- Consequently, these compounds are used to make photographic film and paper.

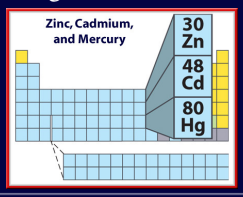
CHAPTER RESOURCES END

Metals

19.1

Zinc, Cadmium, and Mercury

- Zinc, cadmium, and mercury are found in Group 12 of the periodic table.
- Zinc combines with oxygen in the air to form a thin, protective coating of zinc oxide on its surface.
- Zinc and cadmium often are used to coat, or plate, other metals such as iron because of this protective quality.



CHAPTER RESOURCES END

Metals

19.1

Zinc, Cadmium, and Mercury

- Mercury is a silvery, liquid metal—the only metal that is a liquid at room temperature.
- It is used in thermometers, thermostats, switches, and batteries.
- Mercury is poisonous and can accumulate in the body.

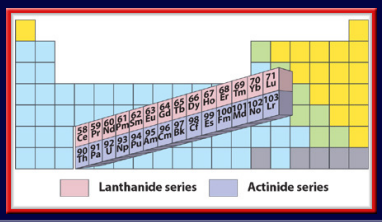
CHAPTER RESOURCES END

Metals

19.1

The Inner Transition Metals

- The two rows of elements that seem to be disconnected from the rest on the periodic table are called the inner transition elements.



CHAPTER RESOURCES END

Metals

19.1

The Inner Transition Metals

- They are called this because like the transition elements, they fit in the periodic table between Groups 3 and 4 in periods 6 and 7, as shown.

CHAPTER RESOURCES END

Metals

19.1

The Lanthanides

- The first row includes a series of elements with atomic numbers of 58 to 71.
- These elements are called the lanthanide series because they follow the element lanthanum.

CHAPTER RESOURCES END

Metals

19.1

The Actinides

- The second row of inner transition metals includes elements with atomic numbers ranging from 90 to 103.
- These elements are called the actinide series because they follow the element actinium.
- All of the actinides are radioactive and unstable.
- Thorium and uranium are the actinides found in the Earth's crust in usable quantities.

CHAPTER RESOURCES END

Metals

19.1

Metals in the Crust

- Earth's hardened outer layer, called the crust, contains many compounds and a few uncombined metals such as gold and copper.
- Most of the world's platinum is found in South Africa.
- The United States imports most of its chromium from South Africa, the Philippines, and Turkey.

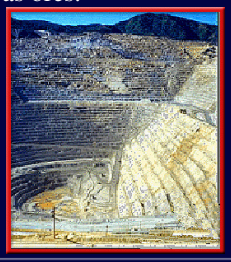
CHAPTER RESOURCES END

Metals

19.1

Ores: Minerals and Mixtures

- Metals in Earth's crust that combined with other elements are found as ores.
- Most ores consist of a metal compound, or mineral, within a mixture of clay or rock.



CHAPTER RESOURCES END

Metals

19.1

Ores: Minerals and Mixtures

- After an ore is mined from Earth's crust, the rock is separated from the mineral.
- Then the mineral often is converted to another physical form.
- This step usually involves heat and is called roasting.

CHAPTER RESOURCES END

Section Check

19.1

Question 1

What are common properties of metals?

Answer

Metals are good conductors of heat and electricity, reflect light, are malleable and ductile, and, except for Mercury, are solid at room temperature.

CHAPTER RESOURCES END

Section Check

19.1

Question 2

Which of these best describes electrons in metallic bonding?

A. electron acceptor
B. electron cloud
C. electron donor
D. electrons in fixed orbits

CHAPTER RESOURCES END

Section Check

19.1

Answer

The answer is B. In metallic bonding, positively charged metallic ions are surrounded by a cloud of electrons.

CHAPTER RESOURCES END

Section Check

19.1

Question 3

How do alkaline earth metals differ from alkali metals?

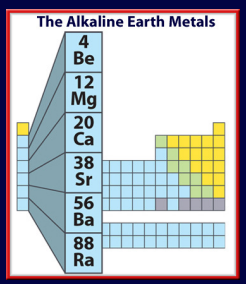
CHAPTER RESOURCES END

Section Check

19.1

Answer

Alkali metals have one electron in the outer energy level of each atom. Each atom of alkaline earth metals has two electrons in its outer energy level.



CHAPTER RESOURCES END

Nonmetals

19.2

Properties of Nonmetals

- Most of your body's mass is made of oxygen, carbon, hydrogen, and nitrogen.
- Calcium, a metal, and other elements make up the remaining four percent of your body's mass.

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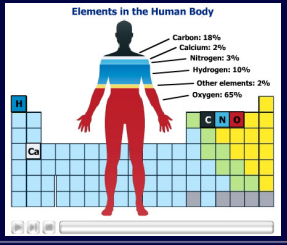


CHAPTER RESOURCES END

Nonmetals

19.2

Properties of Nonmetals

- Phosphorus, sulfur, and chlorine are among these other elements found in your body.
- These elements are classified as nonmetals.
- **Nonmetals** are elements that usually are gases or brittle solids at room temperature.

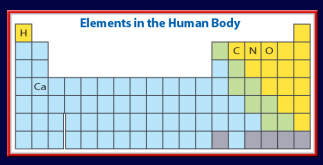
CHAPTER RESOURCES END

Nonmetals

19.2

Properties of Nonmetals

- Most nonmetals do not conduct heat or electricity well, and generally they are not shiny.
- In the periodic table, all nonmetals except hydrogen are found at the right of the stair-step line.



CHAPTER RESOURCES

END

Nonmetals

19.2

Properties of Nonmetals

- The noble gases, Group 18, make up the only group of elements that are all nonmetals.
- Group 17 elements, except for astatine, are also nonmetals.

CHAPTER RESOURCES

END

Nonmetals

19.2

Bonding in Nonmetals

- The electrons in most nonmetals are strongly attracted to the nucleus of the atom. So, as a group, nonmetals are poor conductors of heat and electricity.
- Most nonmetals can form ionic and covalent compounds.

CHAPTER RESOURCES

END

Nonmetals

19.2

Bonding in Nonmetals

- When nonmetals gain electrons from metals, the nonmetals become negative ions in ionic compounds.
- When bonded with other nonmetals, atoms of nonmetals usually share electrons to form covalent compounds.

CHAPTER RESOURCES

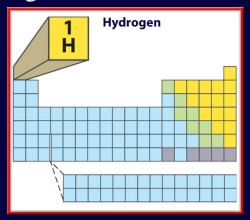
END

Nonmetals

19.2

Hydrogen

- If you could count all the atoms in the universe, you would find that about 90 percent of them are hydrogen.
- When water is broken down into its elements, hydrogen becomes a gas made up of diatomic molecules.



CHAPTER RESOURCES

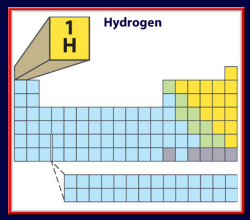
END

Nonmetals

19.2

Hydrogen

- A **diatomic molecule** consists of two atoms of the same element in a covalent bond.



CHAPTER RESOURCES

END

Nonmetals

19.2 **Hydrogen**

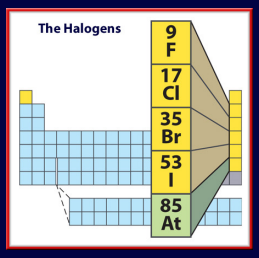
- Hydrogen is highly reactive.
- A hydrogen atom has a single electron, which the atom shares when it combines with other nonmetals.
- Hydrogen can gain an electron when it combines with alkali and alkaline earth metals.
- The compounds formed are hydrides.

CHAPTER RESOURCES END

Nonmetals

19.2 **The Halogens**

- Halogen lights contain small amounts of bromine or iodine.
- These elements, as well as fluorine, chlorine, and astatine, are called halogens and are in Group 17.

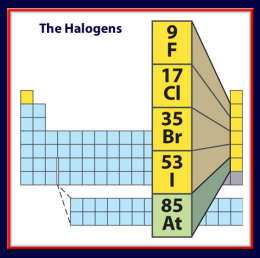


CHAPTER RESOURCES END

Nonmetals

19.2 **The Halogens**

- They are very reactive in their elemental form, and their compounds have many uses.



CHAPTER RESOURCES END

Nonmetals

19.2 **The Halogens**

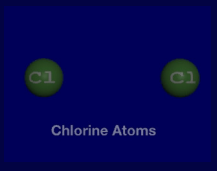
- Because an atom of a halogen has seven electrons in its outer energy level, only one electron is needed to complete this energy level.
- If a halogen gains an electron from a metal, an ionic compound, called a **salt** is formed.

CHAPTER RESOURCES END

Nonmetals

19.2 **The Halogens**

- In the gaseous state, the halogens form reactive diatomic covalent molecules and can be identified by their distinctive colors.



- Chlorine is greenish yellow, bromine is reddish orange, and iodine is violet.

CHAPTER RESOURCES END

Nonmetals

19.2 **The Halogens**

- Fluorine is the most chemically active of all elements.

- Hydrofluoric acid, a mixture of hydrogen fluoride and water, is used to etch glass and to frost the inner surfaces of lightbulbs and is also used in the fabrication of semiconductors.

CHAPTER RESOURCES END

Nonmetals

19.2 Uses of Halogens

- Chlorine compounds are used to disinfect water.
- Chlorine, the most abundant halogen, is obtained from seawater at ocean-salt recovery sites.

CHAPTER RESOURCES END

Nonmetals

19.2 Uses of Halogens

- Household and industrial bleaches used to whiten flour, clothing, and paper also contain chlorine compounds.

CHAPTER RESOURCES END

Nonmetals

19.2 Uses of Halogens

- Bromine, the only nonmetal that is a liquid at room temperature, also is extracted from compounds in seawater.
- Bromine compounds are used as dyes in cosmetics.

CHAPTER RESOURCES END

Nonmetals

19.2 Uses of Halogens

- Iodine, a shiny purple-gray solid at room temperature, is obtained from seawater.
- When heated, iodine changes directly to a purple vapor.
- The process of a solid changing directly to a vapor without forming a liquid is called **sublimation**.

CHAPTER RESOURCES END

Nonmetals

19.2 Uses of Halogens

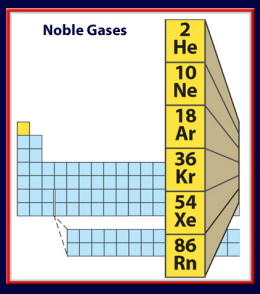
- Astatine is the last member of Group 17. It is radioactive and rare, but has many properties similar to those of the other halogens.
- There are no known uses due to its rarity.

CHAPTER RESOURCES END

Nonmetals

19.2 The Noble Gases

- The noble gases exist as isolated atoms.
- They are stable because their outermost energy levels are full.
- No naturally occurring noble gas compounds are known.



CHAPTER RESOURCES END

Section Check

19.2

Question 1

Which elements exist primarily as gases or brittle solids at room temperature?

A. metals
B. metalloids
C. nonmetals
D. synthetics

CHAPTER RESOURCES END

Section Check

19.2

Answer

The answer is C. Solid nonmetals are brittle or powdery and not malleable or ductile.

CHAPTER RESOURCES END

Section Check

19.2

Question 2

A(n) _____ molecule consists of two atoms of the same element in a covalent bond.

A. actinide
B. allotropic
C. diatomic
D. lanthanide

CHAPTER RESOURCES END

Section Check

19.2

Answer

The answer is C. When water is broken down into its elements, hydrogen becomes a gas made up of diatomic molecules.

CHAPTER RESOURCES END

Section Check

19.2

Question 3

Which of the following accounts for 90 percent of the atoms in the universe?

A. carbon
B. hydrogen
C. nitrogen
D. oxygen

CHAPTER RESOURCES END

Section Check

19.2

Answer

The answer is B. Hydrogen makes up 90 percent of the atoms in the universe. On Earth, most hydrogen is found in the compound water.

CHAPTER RESOURCES END

Nonmetals

19.2

The Noble Gases

- The stability of noble gases is what makes them useful.
- The light weight of helium makes it useful in lighter-than-air blimps and balloons.
- Neon and argon are used in "neon lights" for advertising.

CHAPTER RESOURCES END

Mixed Groups

19.3

Properties of Metalloids

- Metalloids share unusual characteristics.
- **Metalloids** can form ionic and covalent bonds with other elements and can have metallic and nonmetallic properties.

CHAPTER RESOURCES END

Mixed Groups

19.3

Properties of Metalloids

- Some metalloids can conduct electricity better than most nonmetals, but not as well as some metals, giving them the name semiconductor.
- With the exception of aluminum, the metalloids are the elements in the periodic table that are located along the stair-step line.

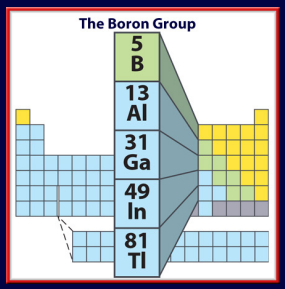
CHAPTER RESOURCES END

Mixed Groups

19.3

The Boron Group

- Boron, a metalloid, is the first element in Group 13.
- If you look around your home, you might find two compounds of boron.



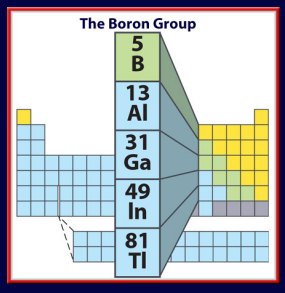
CHAPTER RESOURCES END

Mixed Groups

19.3

The Boron Group

- One of these is borax, which is used in some laundry products to soften water.
- The other is boric acid, a mild antiseptic.



CHAPTER RESOURCES END

Mixed Groups

19.3

The Boron Group

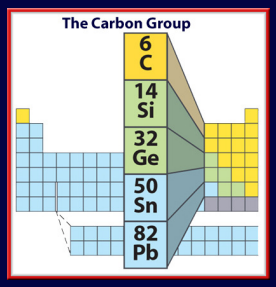
- Aluminum, a metal in Group 13, is the most abundant metal in Earth's crust.
- It is used in soft-drink cans, foil wrap, cooking pans, and as siding.
- Aluminum is strong and light and is used in the construction of airplanes.

CHAPTER RESOURCES END

Mixed Groups

19.3 The Carbon Group

- Each element in Group 14, the carbon family, has four electrons in its outer energy level, but this is where much of the similarity ends.

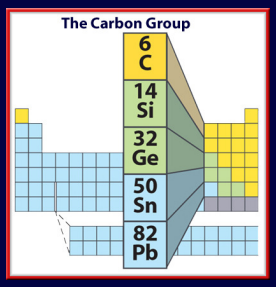


CHAPTER RESOURCES END

Mixed Groups

19.3 The Carbon Group

- Carbon is a nonmetal, silicon and germanium are metalloids, and tin and lead are metals.



CHAPTER RESOURCES END

Mixed Groups

19.3 The Carbon Group

- Carbon occurs as an element in coal and as a compound in oil, natural gas, and foods.
- Carbon compounds, many of which are essential to life, can be found in you and all around you.

CHAPTER RESOURCES END

Mixed Groups

19.3 The Carbon Group

- Silicon is second only to oxygen in abundance in Earth's crust.
- The crystal structure of silicon dioxide is similar to the structure of diamond.
- Silicon occurs as two allotropes. **Allotropes**, which are different forms of the same element, have different molecular structures.

CHAPTER RESOURCES END

Mixed Groups

19.3 The Carbon Group

- Silicon is the main component in **semiconductors**—elements that conduct an electric current under certain conditions.
- Germanium, the other metalloid in the carbon group, is used along with silicon in making semiconductors.

CHAPTER RESOURCES END

Mixed Groups

19.3 The Carbon Group

- Tin is used to coat other metals to prevent corrosion.
- Tin also is combined with other metals to produce bronze and pewter.
- Lead was used widely in paint at one time, but because it is toxic, lead no longer is used.

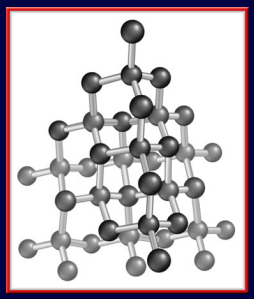
CHAPTER RESOURCES END

Mixed Groups

19.3

Allotropes of Carbon

- Diamond, graphite, and buckminsterfullerene are allotropes of an element.
- In a diamond, each carbon atom is bonded to four other carbon atoms at the vertices, or corner points, of a tetrahedron.



CHAPTER RESOURCES

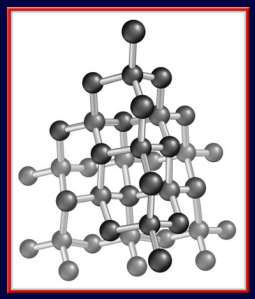
END

Mixed Groups

19.3

Allotropes of Carbon

- In turn, many tetrahedrons join together to form a giant molecule in which the atoms are held tightly in a strong crystalline structure.



CHAPTER RESOURCES

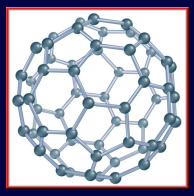
END

Mixed Groups

19.3

Allotropes of Carbon

- In the mid-1980s, a new allotrope of carbon called buckminsterfullerene was discovered. This soccer-ball-shaped molecule, informally called a buckyball, was named after the architect-engineer R. Buckminster Fuller, who designed structures with similar shapes.



CHAPTER RESOURCES

END

Mixed Groups

19.3

Allotropes of Carbon

- In 1991, scientists were able to use the buckyballs to synthesize extremely thin, graphitelike tubes.
- These tubes, called nanotubes, are about 1 billionth of a meter in diameter.
- Nanotubes might be used someday to make computers that are smaller and faster and to make strong building materials.

CHAPTER RESOURCES

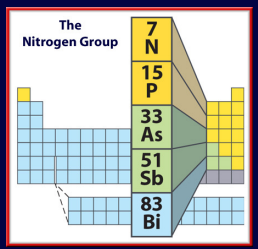
END

Mixed Groups

19.3

The Nitrogen Group

- The nitrogen family makes up Group 15.
- Each element has five electrons in its outer energy level.
- These elements tend to share electrons and to form covalent compounds with other elements.



CHAPTER RESOURCES

END

Mixed Groups

19.3

The Nitrogen Group

- Nitrogen is the fourth most abundant element in your body.
- Each breath you take is about 80 percent gaseous nitrogen in the form of diatomic molecules, N_2.

CHAPTER RESOURCES

END

Mixed Groups

19.3

Uses of the Nitrogen Group

- Phosphorus is a nonmetal that has three allotropes.
- Antimony is a metalloid, and bismuth is a metal.
- Both elements are used with other metals to lower their melting points.

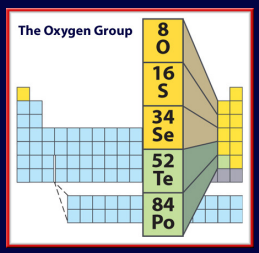
CHAPTER RESOURCES END

Mixed Groups

19.3

The Oxygen Group

- Group 16 on the periodic table is the oxygen group.
- Oxygen, a nonmetal, exists in the air as diatomic molecules, O_2.



CHAPTER RESOURCES END

CHAPTER RESOURCES END

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