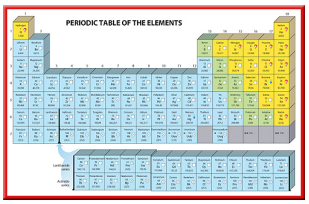
Elements and Their Properties

Chapter 19

Section 19.1: Metals

- Metals are found to the **left** of the staircase



Properties of Metals

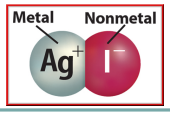
- **Metals** usually have common properties
  - they are good conductors of heat and electricity
  - all but **Mercury** are solid at room temperature
  - they have **luster** (reflect light)
  - they are **malleable** (hammered or rolled into sheets)
  - they are **ductile** (can be drawn into wire)

Ionic Bonding in Metals

- atoms of metals have one to three electrons in their outer shell
  - look at their group number
- metals tend to give up electrons easily in chemical reactions because of the strength of charge of the protons in the nucleus
  - we'll call them losers

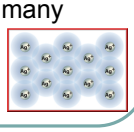
Ionic Bonding in Metals

- when metals combine with nonmetals, they lose their electrons to the nonmetal
  - this is an ionic bond
- metals and nonmetals become more chemically stable when they form ions



Metallic Bonding

- in **metallic bonding**, positively charged metallic ions are surrounded by a cloud of electrons
- outer-level (valence) electrons are not held tightly to the nucleus of an atom
- electrons move freely among many positively charged ions



Metallic Bonding

- metallic bonding explains 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

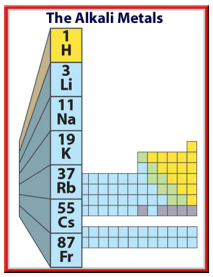
Metallic Bonding

- metals are good conductors of electricity because the outer-level (valence) electrons are weakly held

The Alkali Metals

- the elements in Group 1 of the periodic table are the **Alkali Metals**
  - they are shiny, malleable, and ductile
- they are good conductors of heat and electricity
- they are softer than most metals

The Alkali Metals



The Alkali Metals

- they are the most reactive of all the metals
- react violently with oxygen and water
- do not occur in nature in their elemental form
- they are stored in unreactive substances, such as oil

The Alkali Metals

- each atom of an alkali metal has one electron in its outer energy level
  - this electron is given up, or lost
- the alkali metal becomes a positively charged ion in a compound such as sodium chloride

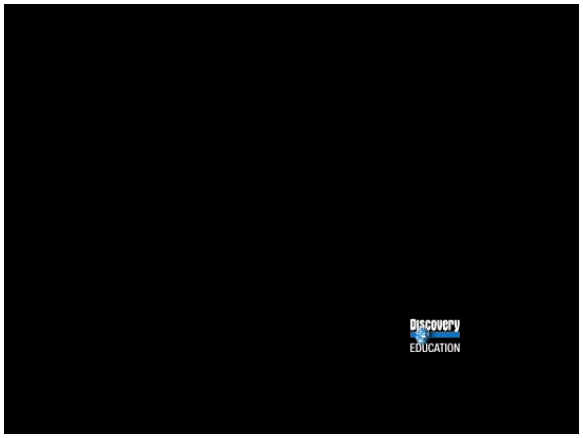
The Alkali Metals: Uses

- Lithium
  - used to treat mental disorders as lithium carbonate
  - Found in lubricants, batteries, glass, and alloys (mixtures of metals)

- Sodium
  - 6th most abundant element on the Earth's surface
  - found in the ocean as sodium chloride
  - found in crustal rocks as sodium chloride, sodium carbonate, sodium sulfate, and sodium borate

The Alkali Metals

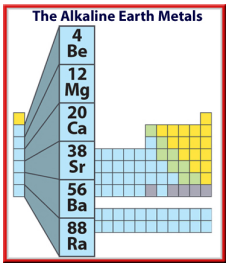
- Francium
  - the last element in Group 1 is extremely rare and radioactive
- **radioactive element**
  - one in which the nucleus breaks down and gives off particles and energy



The Alkaline Earth Metals

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

Alkaline Earth Metals



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
- the alkaline earth metal becomes a positively charged ion in a compound such as calcium fluoride, CaF_2

The Alkaline Earth Metals

- magnesium metal is one of the metals used to produce the brilliant white color in fireworks
- compounds of strontium produce the bright red flashes

The Alkaline Earth Metals

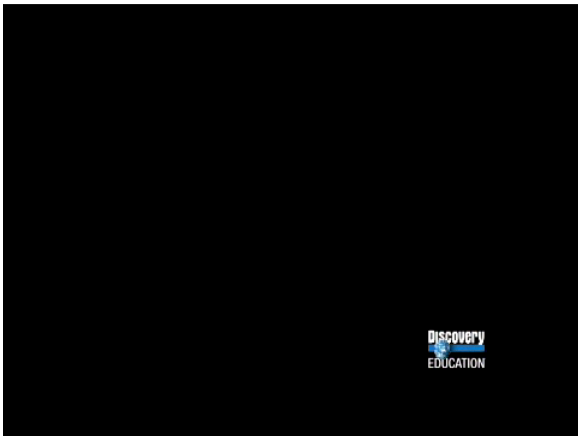
- Magnesium's lightness and strength account for its use in cars, planes, and spacecraft
- Magnesium also is used in compounds to make such things as household ladders, and baseball and softball bats

The Alkaline Earth Metals and Your Body

- Calcium compounds are needed for life
  - Calcium phosphate in your bones helps make them strong.
- Barium sulfate $BaSO_2$ is used to diagnose some digestive disorders because it absorbs X-ray radiation well

The Alkaline Earth Metals

- the last element in Group 2 is radioactive and is found associated with uranium
- once used to treat cancer
  - Radium



Transition Elements

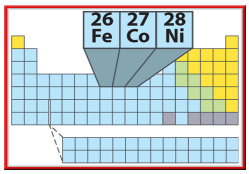
- **Transition elements**
  - elements in Groups 3 through 12 in the periodic table (Group B)
- called transition elements because they are considered to be elements in transition between Groups 1 and 2 and Groups 13 through 18

Transition Elements

- often occur in nature as uncombined
- often form color compounds
- gems show brightly colored compounds containing chromium

Iron, Cobalt and Nickel

- these are called the Iron Triad
- all three elements are used in the process to create steel and other metal mixtures (alloys)

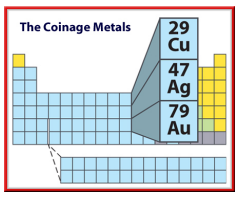


Iron, Cobalt and Nickel

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

Copper, Silver and Gold

- found free in nature
  - Why?
- once used widely to make coins
- known as the coinage metals

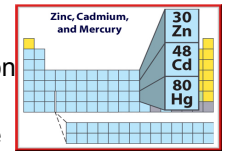


Copper, Silver and Gold

- Copper often is used in electrical wiring
  - great conductor & low cost
- Silver iodide and silver bromide
  - Used for photographic film and paper

Zinc, Cadmium and Mercury

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



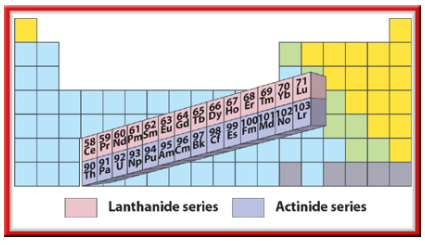
Zinc, Cadmium and Mercury

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

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.

Inner Transition Metals



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

The Lanthanides

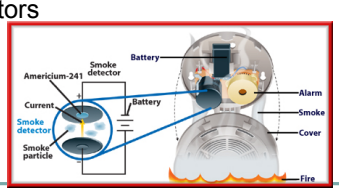
- 1st row (58-71)
- called the lanthanide series because they follow the element lanthanum

Synthetic Elements

- by smashing existing elements with particles accelerated in a heavy ion accelerator, scientists have been successful in creating elements not typically found on Earth
- except for technetium-43 and promethium-61, each synthetic element has more than 92 protons

Synthetic Elements

- Plutonium also can be changed to americium, element 95
- this element is used in home smoke detectors



Transuranium Elements

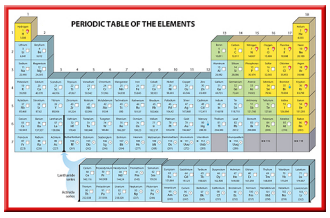
- elements having more than 92 protons, the atomic number of uranium, are called **transuranium elements**
- they are synthetic and unstable, and many of them disintegrate quickly

The Actinides

- 2nd row (90-103)
- 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

Section 19.2: Nonmetals

- Nonmetals are found to the **right** of the staircase (except hydrogen)

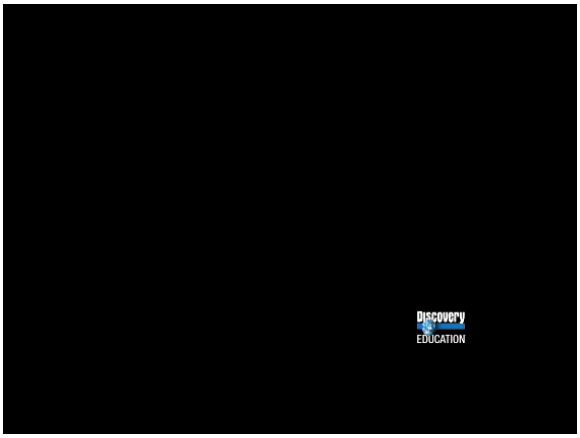


Properties of Nonmetals

- **Nonmetals**
  - elements that usually are gases or brittle solids at room temperature
    - do not conduct heat or electricity well
    - they are not shiny
    - they are brittle solid

Bonding in Nonmetals

- electrons in nonmetals are strongly attracted to the nucleus
  - poor conductors
- most nonmetals can form ionic and covalent compounds



Hydrogen

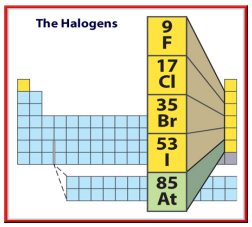
- Hydrogen is a diatomic molecule
  - **diatomic molecule**
    - consists of two atoms of the same element in a covalent bond
  - H_2
- There are 7 diatomic elements on the periodic table
  - H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

Hydrogen

- is highly reactive
- a hydrogen atom has one 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
  - these are called hydrides
  - LiH, NaH, BaH_2

The Halogens

- halogen lights contain small amounts of bromine or iodine
- they are very reactive in their elemental form



The Halogens

- they have **7** valence electrons (group VIIA)
- they only need 1 more to be stable
- if a halogen gains an electron from a metal, an ionic compound, called a **salt** is formed.
  - Halogen means "salt producer"
- **Fluorine** is the most chemically active of all elements

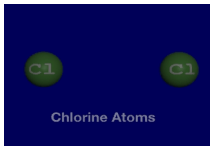
The Halogens

- halogens form reactive **diatomic covalent molecules** in their gaseous form
- can be identified by their distinctive colors
- Chlorine Cl_2 is greenish yellow, gas
- Bromine Br_2 is reddish orange liquid
- Iodine I_2 is a violet solid
  - Will sublime (solid → gas)

The Halogens

- Astatine is the last member of Group 7
- it is radioactive and rare, but has many properties similar to those of the other halogens

The Halogens

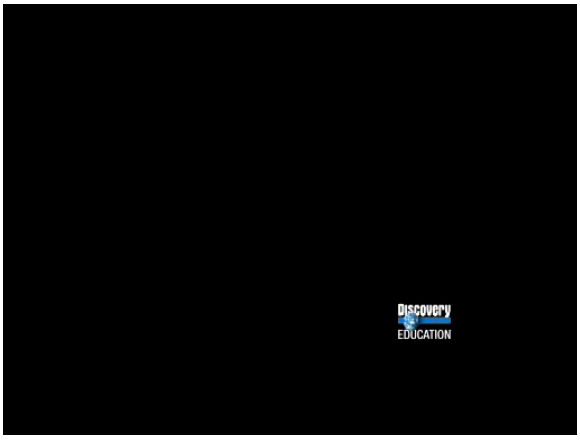


The Halogens

- 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

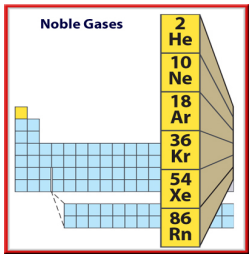
Uses of Halogens

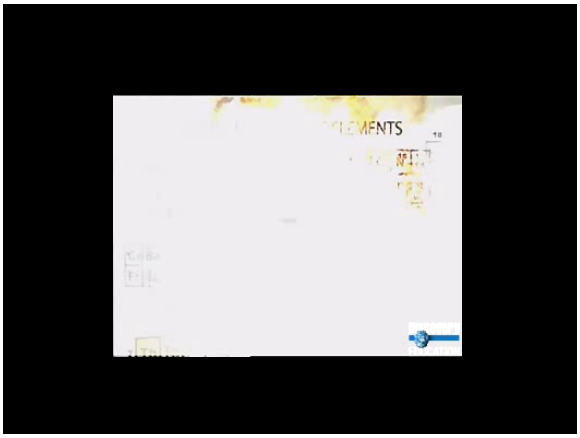
- Chlorine compounds are used to disinfect water.
- Chlorine, the most abundant halogen, is obtained from seawater at ocean-salt recovery sites.



The Noble Gases

- they are stable because their outermost energy levels are full
- no naturally occurring noble gas compounds are known
- elements will gain or lose electrons to be like the Noble gases



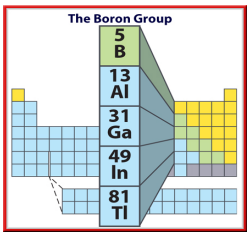


Metalloids

- **Metalloids**
  - can form ionic and covalent bonds with other elements and can have metallic and nonmetallic properties
- 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 found along the staircase
  - B, Si, Ge, As, Sb, Te, and sometimes Po and At

The Boron Group

- Boron, a metalloid, is the first element of Group 3
  - Borax – used in laundry detergent to soften water



The Boron Group

- Aluminum
  - metal
  - most abundant in the Earth's crust
  - soft drink cans, siding, foil wrap, cooking pans
  - strong and light; used to construct airplanes

The Carbon Group

- Carbon
  - in coal and as a compound in oil, natural gas, and foods
  - carbon compounds are essential to life
- Silicon is second only to oxygen in abundance in Earth's crust
  - crystal structure of silicon dioxide is similar to the structure of diamond
  - occurs as two allotropes

The Boron Group

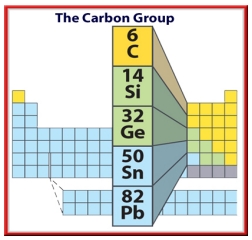
- **Allotropes**
  - different forms of the same element, have different molecular structures
- Silicon is the main component in **semiconductors**
  - elements that conduct an electric current under certain conditions

The Carbon Group

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

The Carbon Group

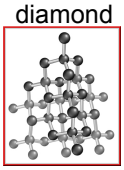
- each element has 4 valence electrons
- Carbon is a nonmetal, silicon and germanium are metalloids, and tin and lead are metals



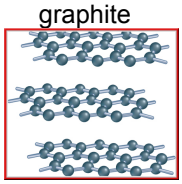
Allotropes of Carbon

- graphite and diamond have the same formula, but different molecular structures

diamond

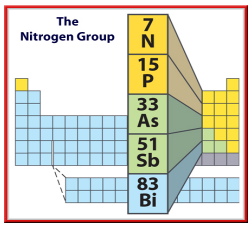


graphite



The Nitrogen Group

- each element has 5 valence electrons
- Nitrogen
  - the fourth most abundant element in your body
  - diatomic – N_2



The Nitrogen Group

- Phosphorus
  - a nonmetal that has three allotropes
- Antimony
  - a metalloid, and bismuth is a metal

The Oxygen Group

- Oxygen, a nonmetal, exists in the air as diatomic molecules, O_2
- during electrical storms, some oxygen molecules, O_2, change into ozone molecules, O_3