Section 3: Mixed Groups

MAINIDEA

Some groups on the periodic table contain metalloids—elements that have some properties of metals and some properties of nonmetals.

K *What I Know*	**W** *What I Want to Find Out*	**L** *What I Learned*

Essential Questions

- What are the differences between metals, nonmetals, and metalloids?
- How are the allotropes of carbon similar, and how are they different?
- What does the term *semiconductor* mean?
- What is the difference between natural and synthetic elements?

Vocabulary

Review

- substance

New

- metalloid
- allotrope
- semiconductor
- transuranium element

Properties of Metalloids

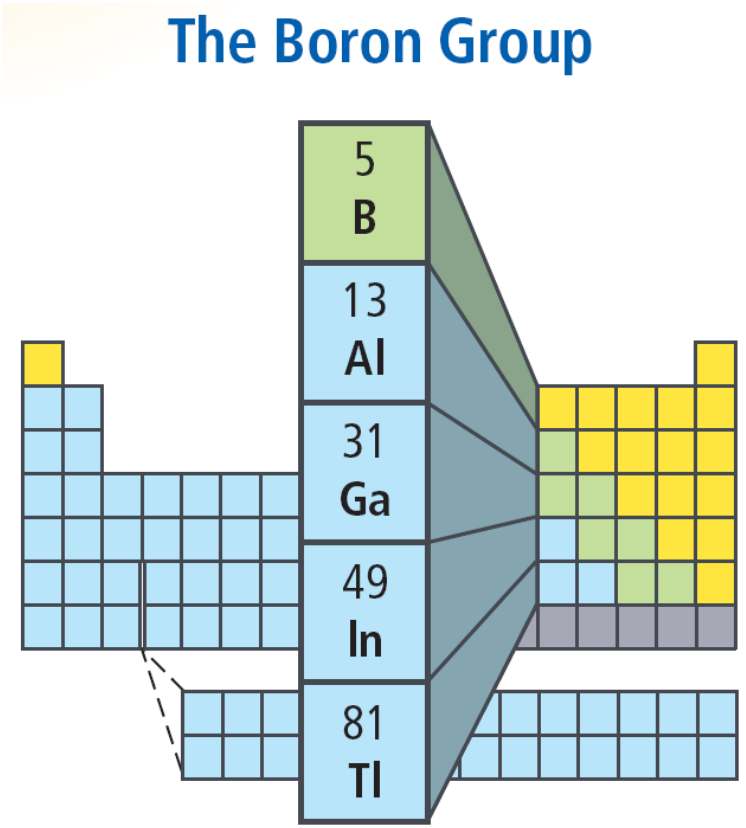
Metalloids can form ionic and covalent bonds with other elements and can have metallic and nonmetallic properties.

- 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 the elements in the periodic table that are located along the stair-step line.

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.

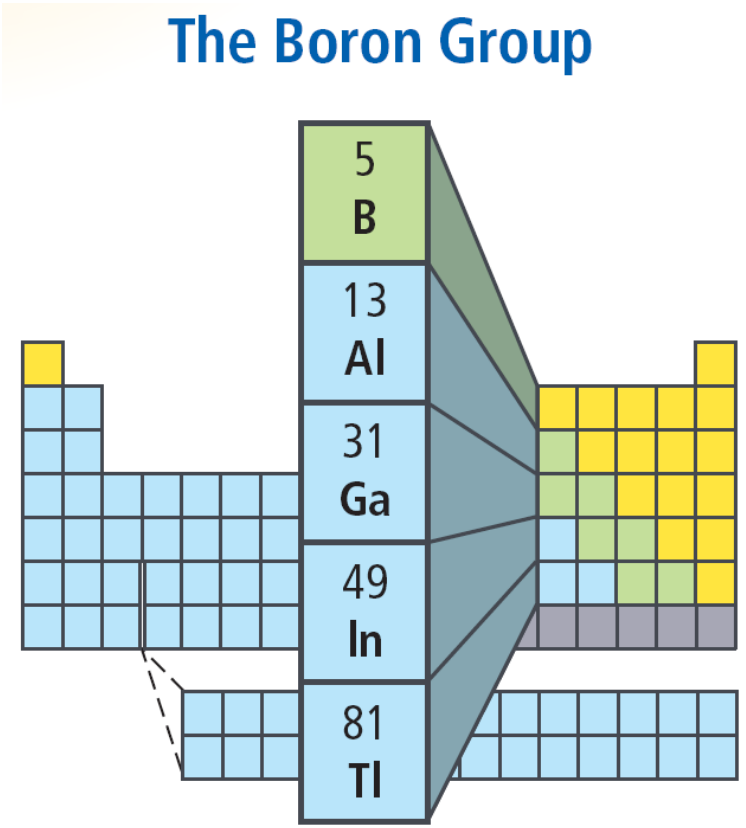
- One of these is borax, which is used in some laundry products to soften water.
- The other is boric acid, a mild antiseptic.
- Boron is also used to make heat-resistant glassware.



The Boron Group

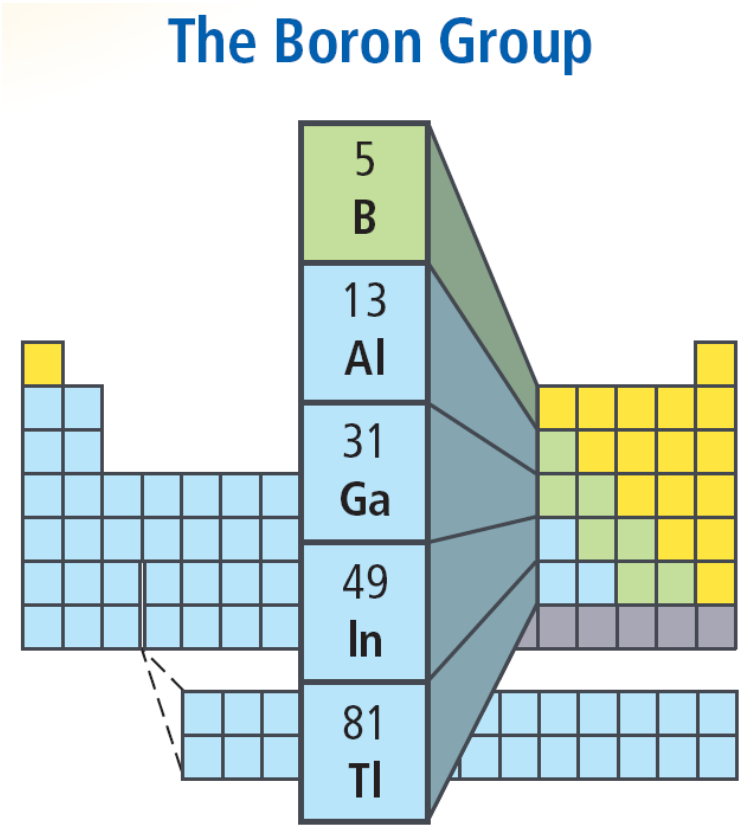
Aluminum, a metal in Group 13, is the most abundant metal in Earth's crust.

- Aluminum is strong and light and is used in the construction of airplanes.
- It is used in soft-drink cans, foil wrap, cooking pans, and as siding.



The Boron Group

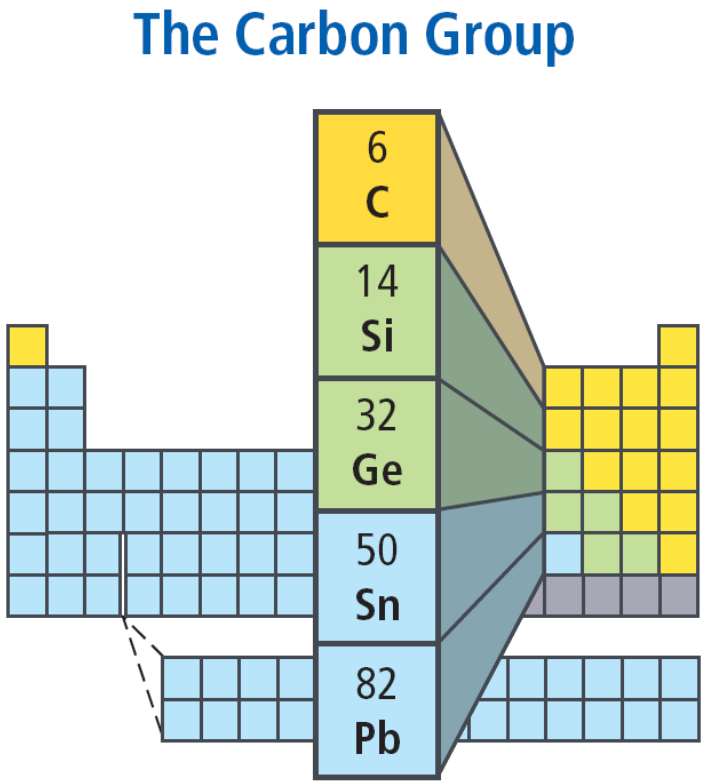
- Gallium is a metal use in electronic components.
- Indium and thallium are rare metals.



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.

- Carbon is a nonmetal.
- Silicon and germanium are metalloids.
- Tin and lead are metals.



Carbon

- 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.

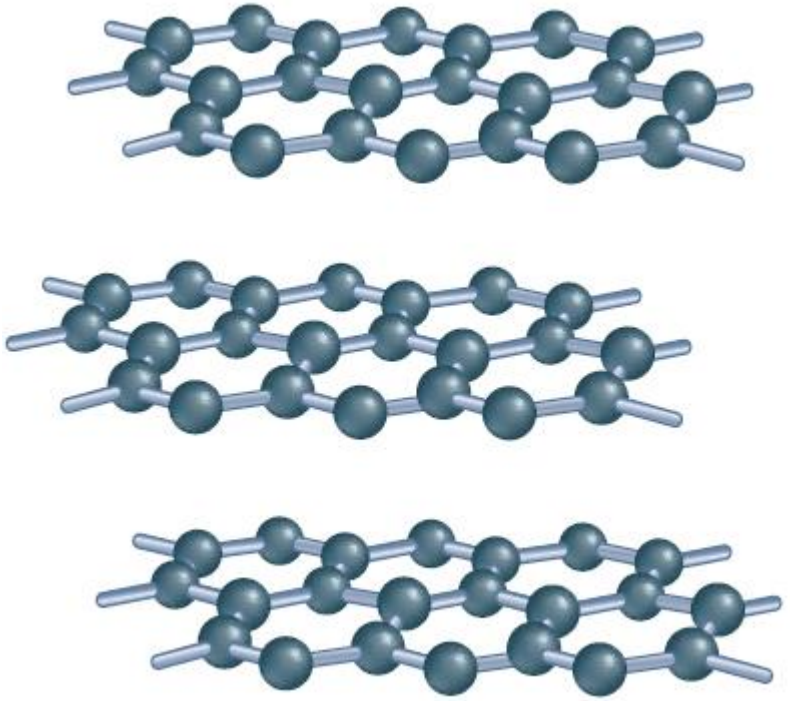
Allotropes

Different molecular structures of the same element are called **allotropes**.

- Carbon can form different molecular structures.
- Diamond, graphite, and buckminsterfullerene are allotropes of carbon.

Graphite

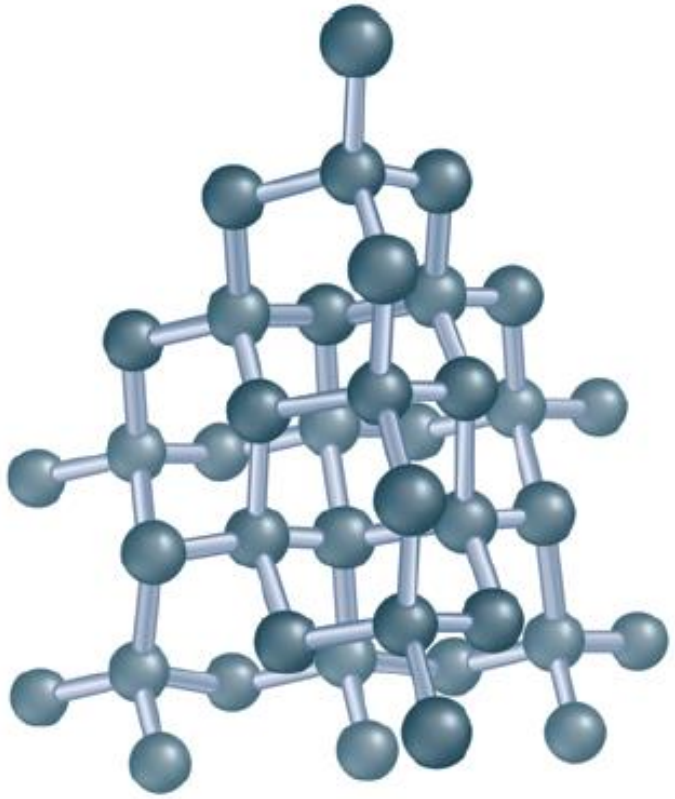
- Graphite is a black powder made up of layers of hexagonal structures of carbon atoms.
- The layers of hexagons are weakly bonded and can slide easily over each other.
- This structure makes graphite a good lubricant.



Graphite

Diamond

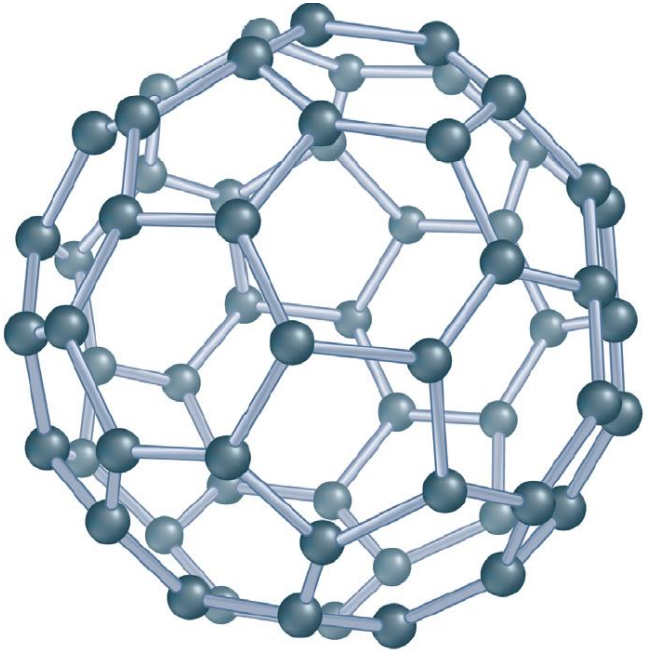
- In a diamond, each carbon atom is bonded to four other carbon atoms at the vertices, or corner points, of a tetrahedron.
- In turn, many tetrahedrons join together to form a giant molecule in which the atoms are held tightly in a strong crystalline structure.



Diamond

Buckyballs

- 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.
- In 1991, scientists were able to use the buckyballs to synthesize extremely thin, graphite-like tubes.
- These tubes, called nanotubes, are about 1 billionth of a meter in diameter.



Buckyball

Silicon and germanium

Silicon is the main component in **semiconductors**—elements that conduct an electric current under certain conditions.

- 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.
- Germanium, the other metalloid in the carbon group, is used along with silicon in making semiconductors.

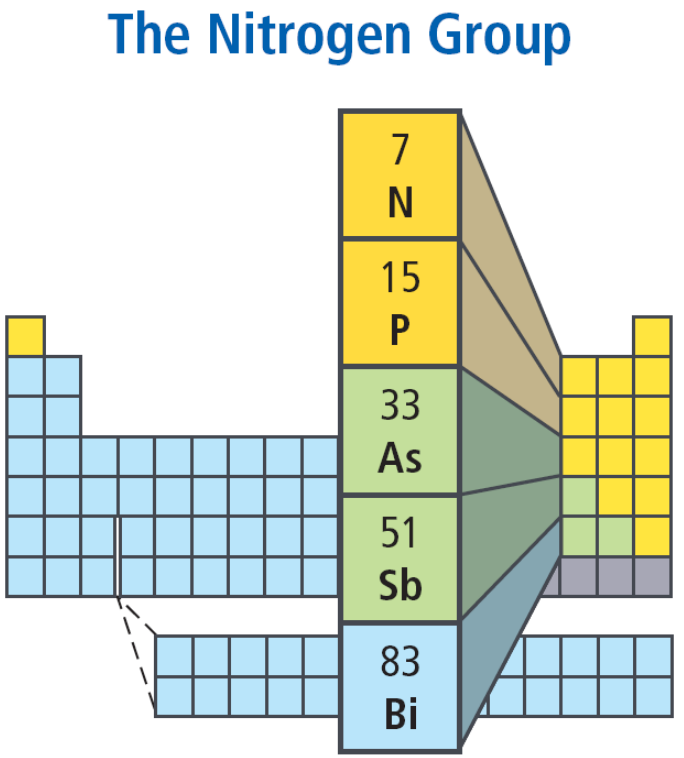
Tin and lead

- 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, it is no longer used.

The Nitrogen Group

The nitrogen family makes up Group 15.

- 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.
- Each element has five electrons in its outer energy level.
- These elements tend to share electrons and to form covalent compounds with other elements.



Nitrogen and phosphorus

- Phosphorus is a nonmetal that has three allotropes.
- Phosphorus is used in match heads, fertilizers, and fine china.

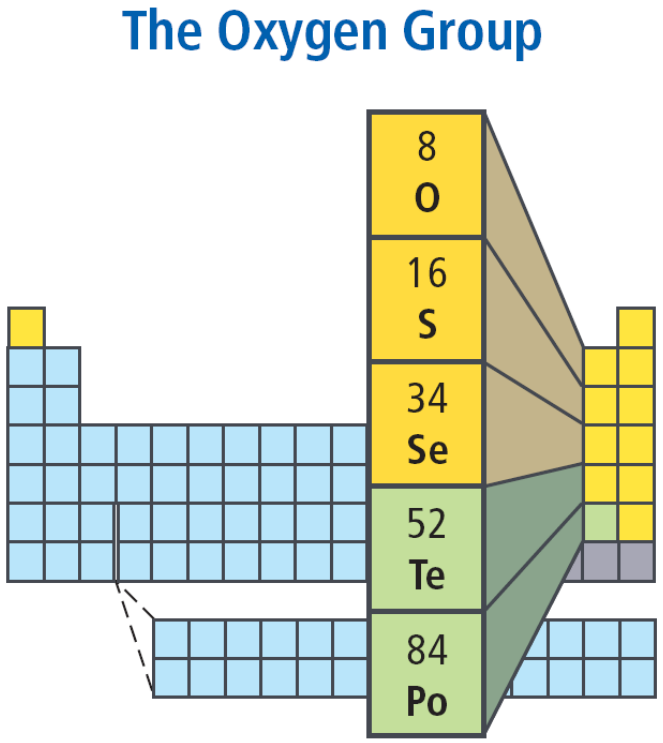
Arsenic, antimony, and bismuth

- Antimony is a metalloid, and bismuth is a metal.
- Both antimony and bismuth are used with other metals to lower their melting points.

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.
- During electrical storms, some oxygen molecules, O_2, change into ozone molecules, O_3.
- Water (H_2O) is an oxygen compound needed by living organisms.



Other group 16 elements

- Sulfur is a nonmetal that exists in several allotropic forms.
- Sulfur exists as different-shaped crystals and as a noncrystalline solid.
- The nonmetal selenium and two metalloids tellurium and polonium are the other Group 16 elements.
- Selenium is the most common of these three.
  - It is one of several elements that you need in trace amounts in your diet.
  - It is toxic if too much of it gets into your system.

Synthetic Elements

The most recently discovered elements are synthetic.

- 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.

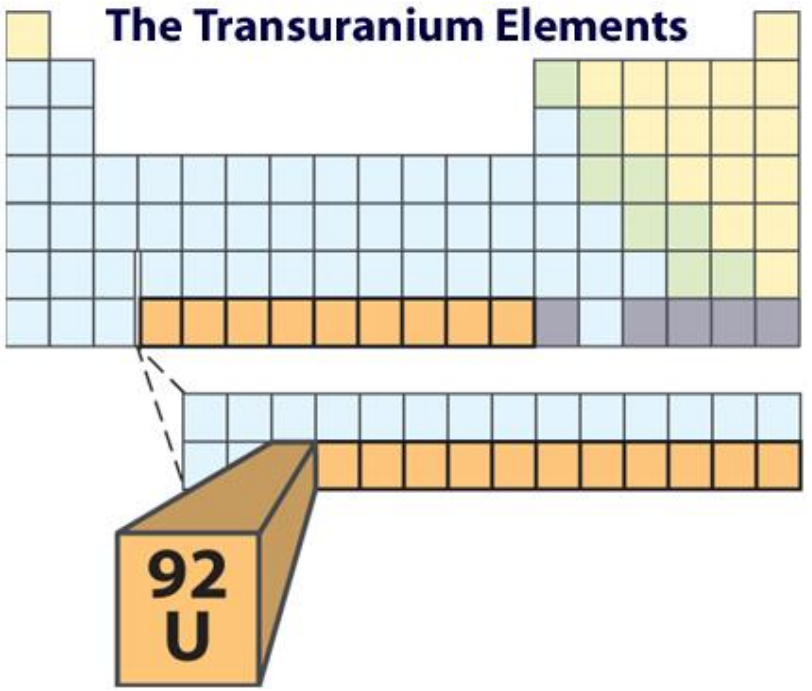
Why make elements?

- Synthetic elements are useful because they are radioactive.
- Technetium’s radioactivity, make it ideal for many medical applications.
- By studying how the synthesized elements form and disintegrate, you can gain an understanding of the forces holding the nucleus together.

Transuranium Elements

Elements having more than 92 protons, the atomic number of uranium, are called **transuranium elements**.

- These elements do not belong exclusively to the metal, nonmetal, or metalloid group.
- All of the transuranium elements are synthetic and unstable, and many of them disintegrate quickly.



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