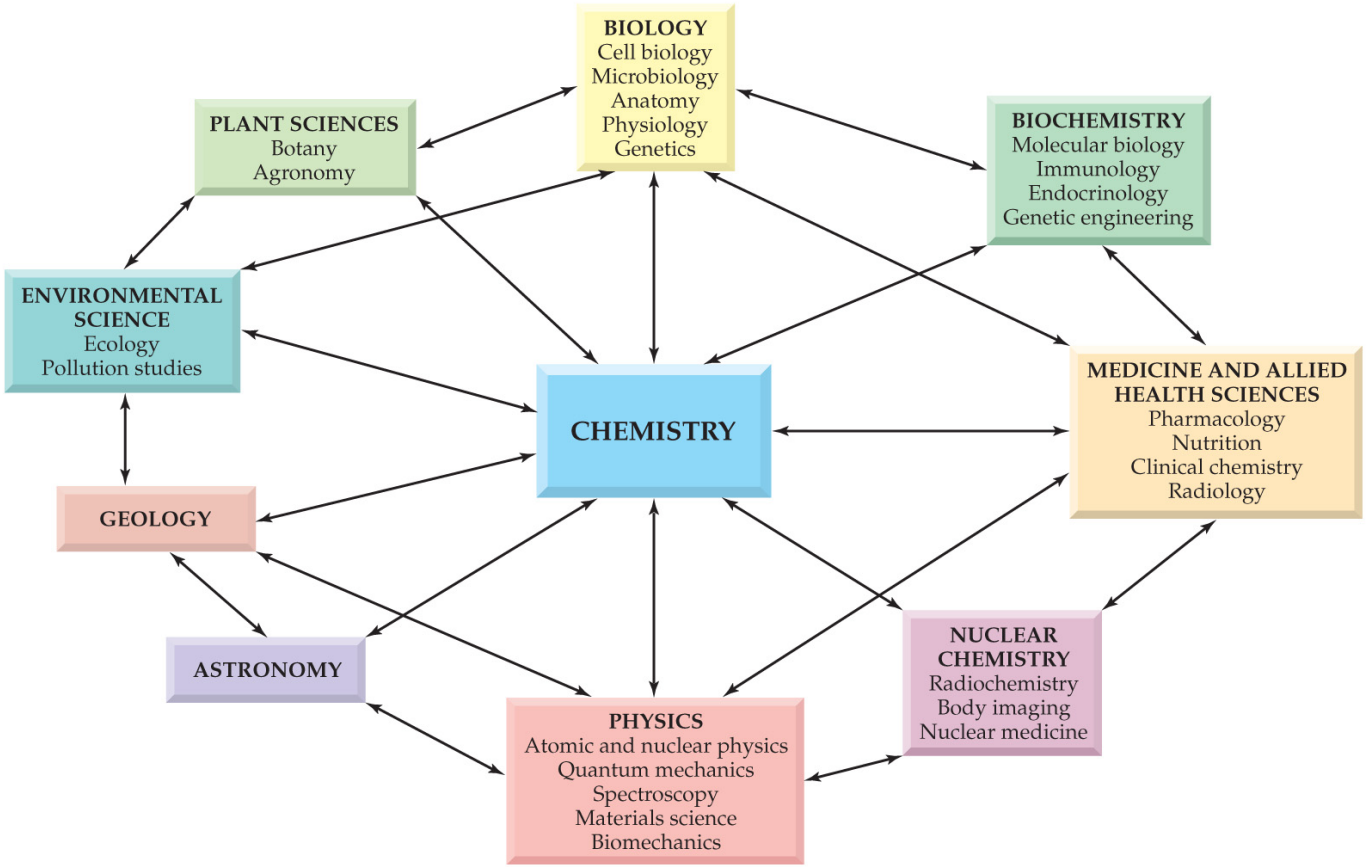
1.1 Chemistry: The Central Science

Chemistry is often referred to as "***The Central Science***"



Chemistry: The study of the properties and transformations of matter.

- **Matter:** Anything that has mass and occupies space – things you can see, touch, taste, or smell.
- **Property:** A characteristic that can be used to describe a substance. Substances have both physical and chemical properties.
- **Transformations:** A change in the properties of matter with time. There are physical changes and chemical changes.

Substances have both physical and chemical properties.

- **Physical Properties:** Density, color, and melting point are physical properties of matter. Observing a physical property can be done without altering the makeup of a substance.

- **Chemical Properties:** Chemical composition, what matter is made of, and chemical reactivity, how matter behaves, are chemical properties. Observing a chemical property alters the substance.

Physical Change: Does not alter the chemical makeup of a substance.

- Chemical reactivity is unchanged.
- Changes in state, changes in particle size, and the formation / separation of mixtures are all examples of physical change.
- Melting of ice to form liquid water is a physical change. In this case only a change in form takes place. The chemical makeup of the substance remains H_2O.

Chemical Change: Alters the makeup of a substance.

- Reactivity changes with the formation of new substances.
- Heat, light, or electrical energy is often emitted or absorbed.
- Potassium reacting with water is an example of a chemical change.

1.2 States of Matter

Common states of matter are: solid, liquid, and gas.

- **Solid:** A substance that has a definite shape and volume. Solids are rigid and dense.

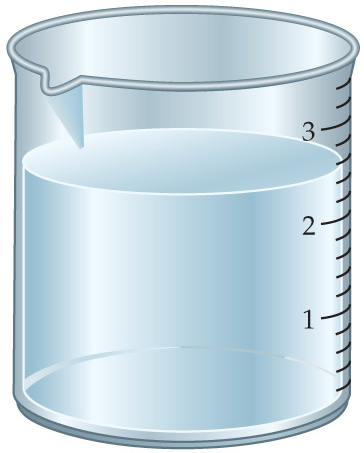
- **Liquid:** A substance that has a definite volume but that changes shape to fill the container. Liquids are dense and fluid.

Common states of matter are: solid, liquid, and gas.

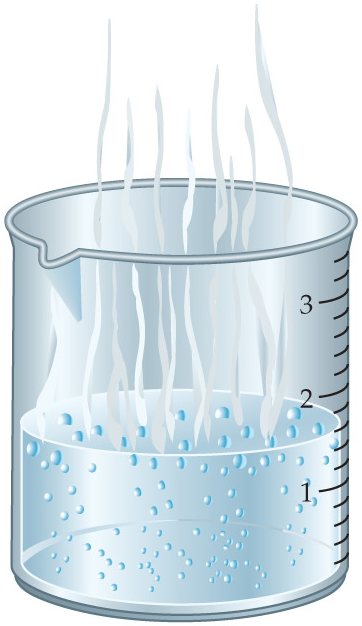
- **Gas:** A substance that has neither a definite volume nor a definite shape. Gases are low density fluids.
- Substances can exist in each of these three states depending on the pressure and the temperature. The conversion of a substance from one state into another is known as change of state.

The three states - the solid state, the liquid state, and the gaseous state - of water are shown below.

(a) Ice: A solid has a definite volume and a definite shape independent of its container.



(b) Water: A liquid has a definite volume but a variable shape that depends on its container.



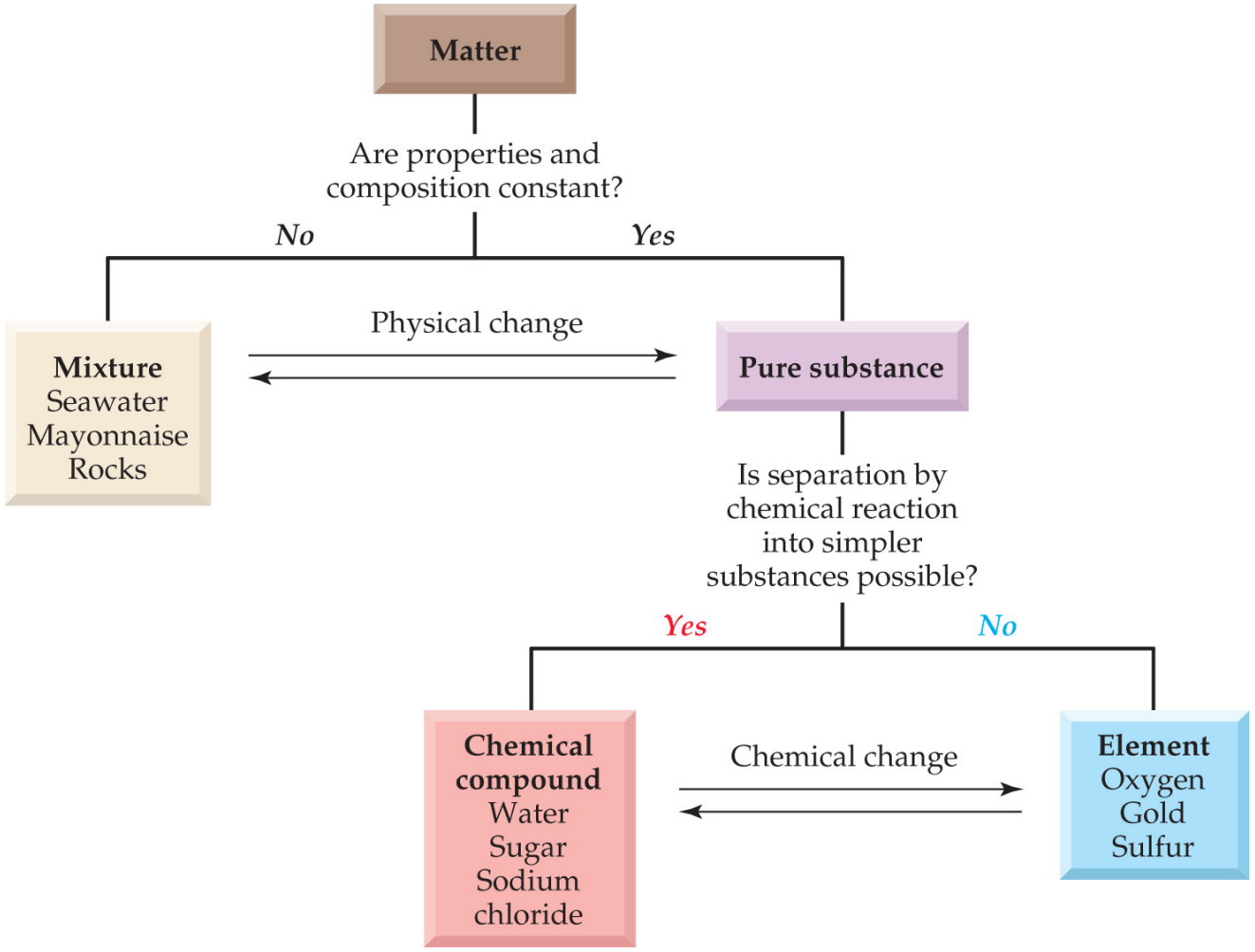
(c) Steam: A gas has both variable volume and shape that depend on its container.

1.3 Classification of Matter

- **Pure Substance**: Matter that is uniform in its chemical composition and properties. Sugar is a pure substance and water is a pure substance.
- **Mixture**: A blend of two or more pure substances in any ratio, each retaining their identity. Dissolving sugar in water creates a mixture.
- Physical changes can separate mixtures into one or more pure substances. Evaporation and condensation can separate water from sugar.

- **Element:** Pure substance that cannot be broken down chemically into simpler substances. Hydrogen and oxygen are examples of elements.
- **Chemical Compounds**: Two or more elements combined chemically in specific ratios to form a pure substance. Water is a compound composed of two parts hydrogen and one part oxygen.
- Chemical changes can separate chemical compounds into elements. Water can be broken down into hydrogen and oxygen by passing an electric current through it.

The classification of matter is summarized below.

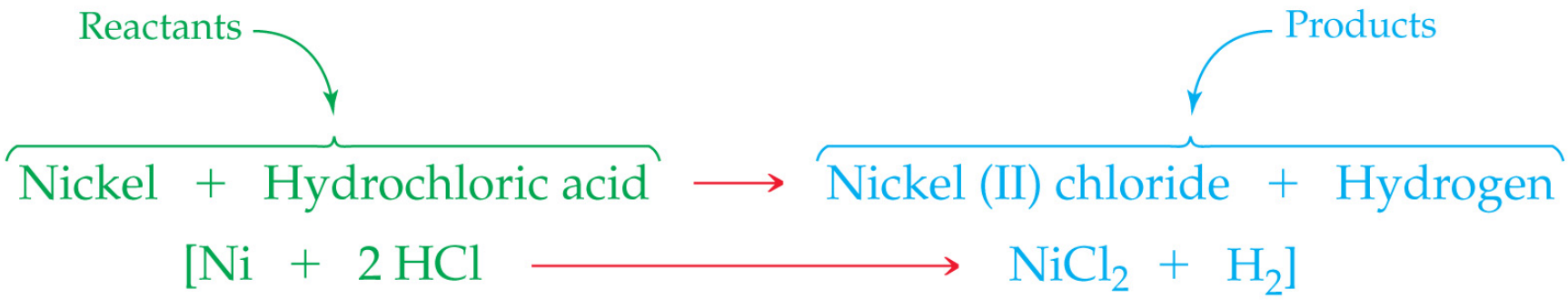


1.4 Example of a Chemical Reaction

- Nickel, a solid metal, is mixed with a colorless solution of hydrochloric acid in a test tube.

- The nickel is slowly eaten away, the colorless solution turns green, and a colorless gas bubbles out of the test tube.

- **Reactants:** One or more starting materials. Between reactants, the "+" can be read as "reacts with."
- **Products:** One or more substances formed as a result of a chemical reaction. Between products, the "+" can be read as "and."
- Between products and reactants, the "→" can be read as "to form."



1.5 Chemical Elements and Symbols

- 114 elements have been discovered.
- 90 occur naturally.
- 24 are produced artificially.
- Some familiar elements are iron, tin, carbon, oxygen, hydrogen, sulfur, etc.
- Some unfamiliar elements are niobium, rhodium, thulium, californium, etc.

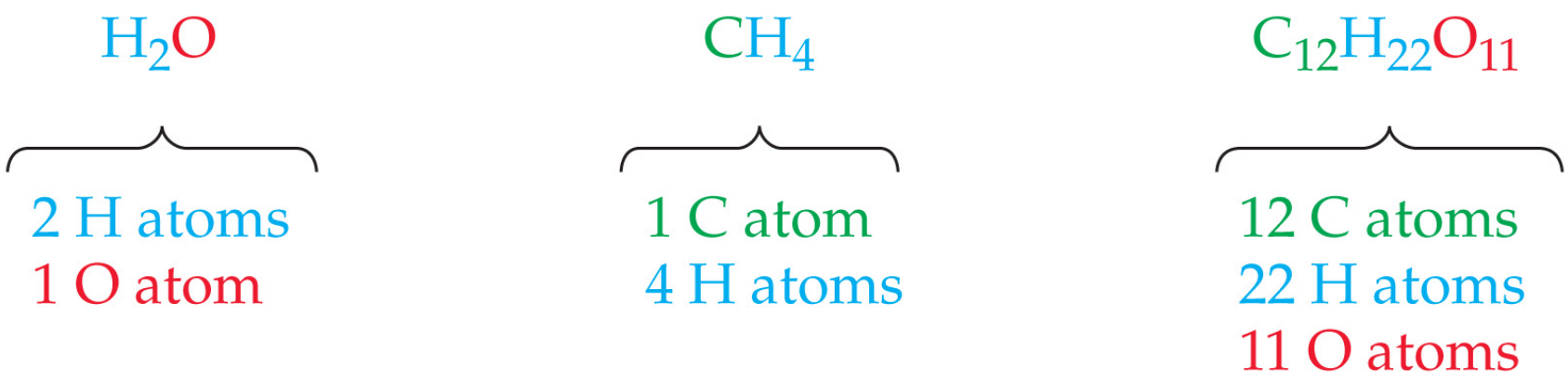
- Each element has its own unique symbol. One or two letter symbols are used to represent elements. The first letter is always capitalized and the second letter is always a lowercase. Examples: C, Cr, P, Pb

- Most symbols are derived from modern names and are easy to remember. Examples: “H” for hydrogen, “O” for oxygen, “N” for nitrogen, etc.

- A few symbols for elements are derived from their *Latin* names and are more difficult to learn. Examples: “Na” for sodium comes from its Latin name Natrium, “Pb” for lead comes from its Latin name Plumbum.

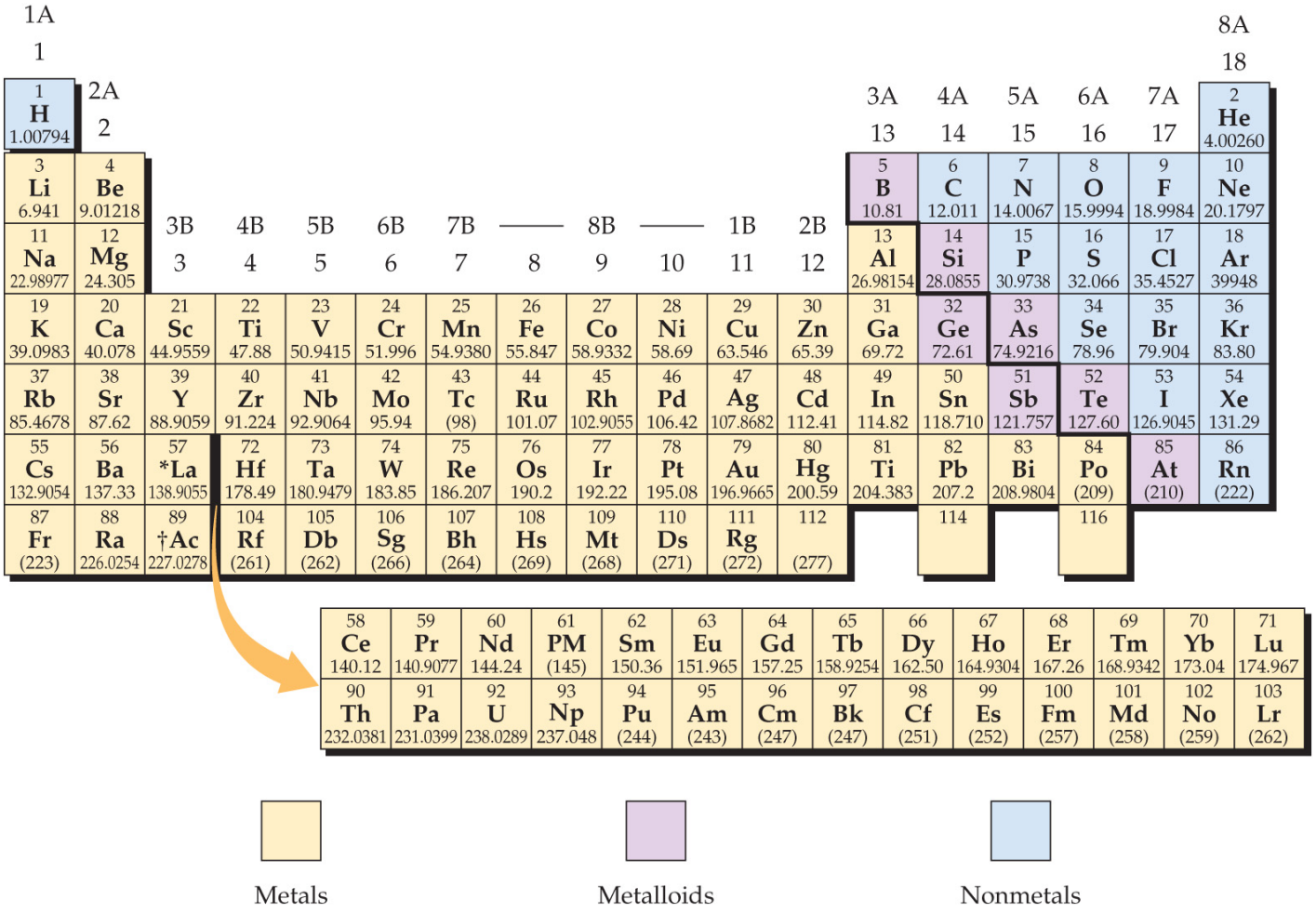
- All naturally occurring elements are not equally abundant. Oxygen and silicon together constitute 75% of the Earth’s crust.

Chemical Formula: A notation for a chemical compound using symbols and subscripts to show how many atoms of each element are present. When no subscript is given for an element a subscript of "1" is understood.



1.6 Elements and the Periodic Table

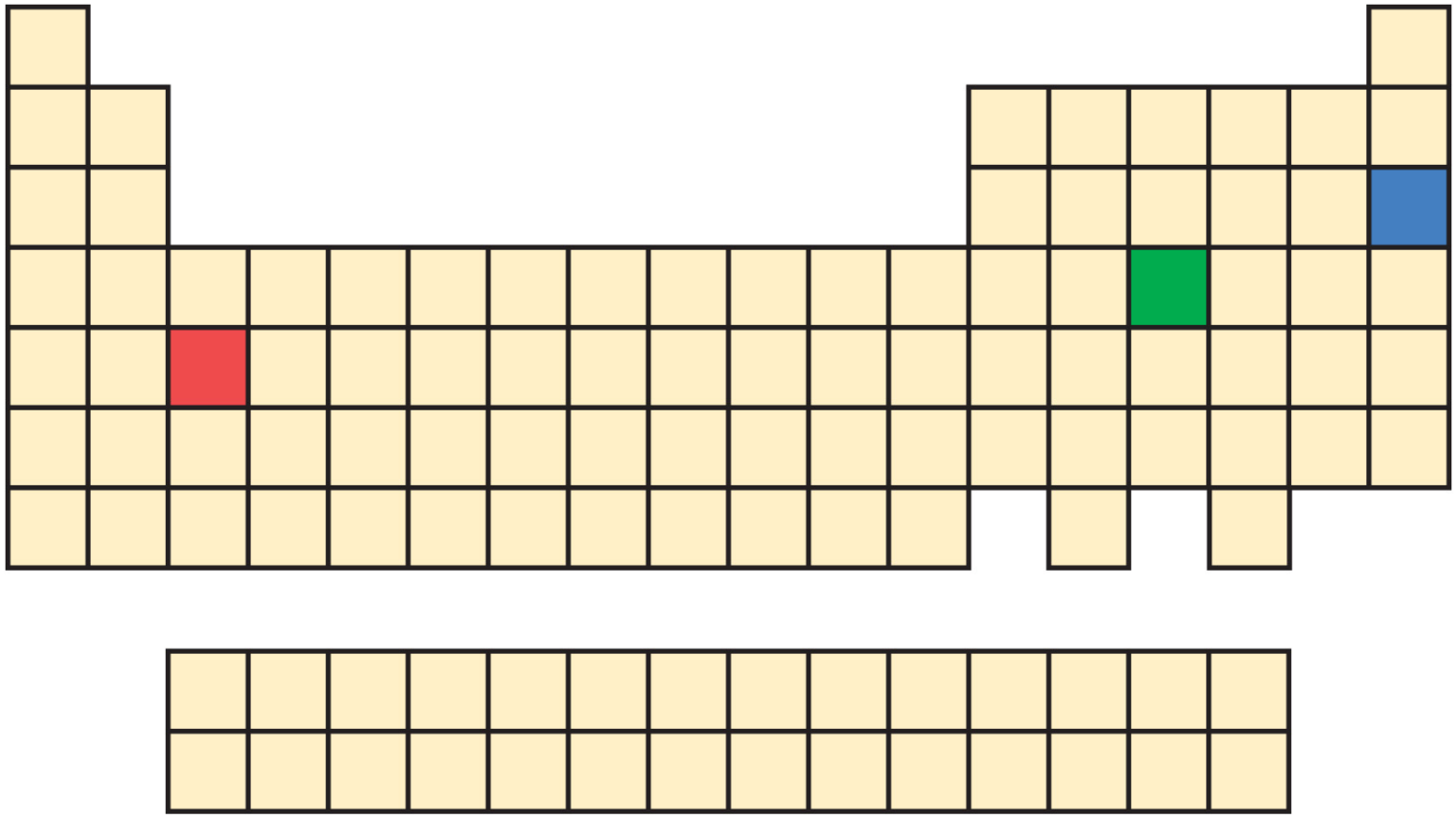
Periodic Table: 114 elements in tabular format.



Large amounts of information regarding the properties of elements are embedded in the periodic table. Elements are roughly divided into 3 groups:

- **Metals:** Found on the left side of the table.
- **Nonmetals:** Found on the right side of the table.
- **Metalloids:** Found along a diagonal line between metals and nonmetals.

A metal (red), a nonmetal (blue), and a metalloid (green) appear in distinct places on the periodic table



Metals: 90 of the 114 elements are metals. They appear on the left side of the periodic table.

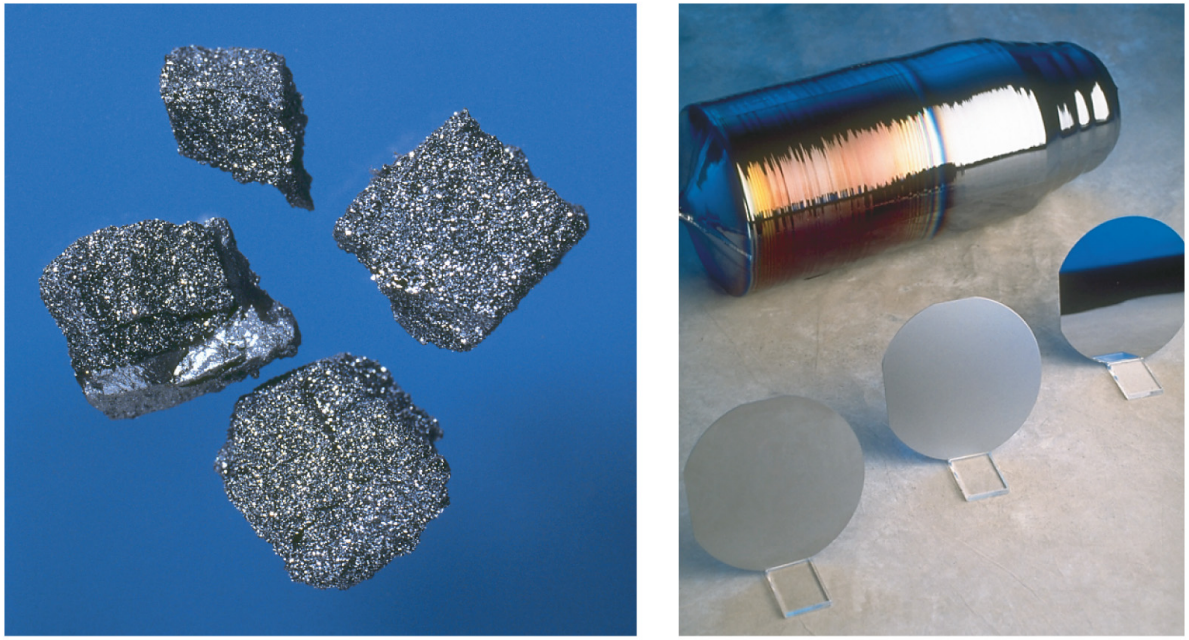
Some common properties of metals are:

- Solid at room temperature (except mercury which is a liquid)
- Good conductor of heat and electricity
- Lustrous on fresh surfaces
- Malleable and ductile

Nonmetals: Appear on the right side of the periodic table. 17 elements are nonmetals.

- Eleven are gases at room temperature (H, N, O, F, Ne, etc.).
- Five are solids (C, P, S, Se, I).
- One is a liquid (Br).
- Nonmetals are poor conductors of heat and electricity.

Metalloids: Seven elements are metalloids. Their properties are between those of metals and nonmetals. Metalloids are semiconductors and are important to the electronics industry. (a) Boron and (b) silicon are examples of metalloids.



(a) (b)