

Matter has mass and occupies space.

Chemists organize matter on the Periodic Table of the Elements (See Week 1 Handout).

### 3 states of matter

#### Solid

Matter tightly packed

Definite shape

Incompressible

Definite volume

Least energy

#### Liquid

Matter loosely packed and moves past itself

Indefinite shape that assumes shape of container

Incompressible

Definite volume

Intermediate energy

#### Gas

Matter is far apart and uniformly distributed in container

Indefinite shape that assumes shape of container

Compressible

Indefinite volume

Most energy

Substances change state with increasing temperature. For example, water is a solid  $\leq 0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ), a gas  $\geq 100^{\circ}\text{C}$  ( $212^{\circ}\text{F}$ ), and a liquid in between those temperatures.

Descriptions of state changes (changes in physical state of matter)

Melting (solid to liquid)

Freezing (liquid to solid)

Vaporization or boiling (liquid to gas)

Condensing (gas to liquid)

Subliming (solid to gas)

Depositing (gas to solid)

Increasing the temperature of a solid causes melting, then vaporization (or subliming).

Decreasing the temperature of a gas causes condensing, then freezing (or depositing).

### Two classifications of matter

Mixtures – can be physically separated into pure substances. 2 types are:

Homogeneous mixtures – the same throughout, like salt dissolved in water

Heterogeneous mixtures – different throughout, like sand and water

Pure substances – made up of one substance that cannot be physically separated. 2 types are:

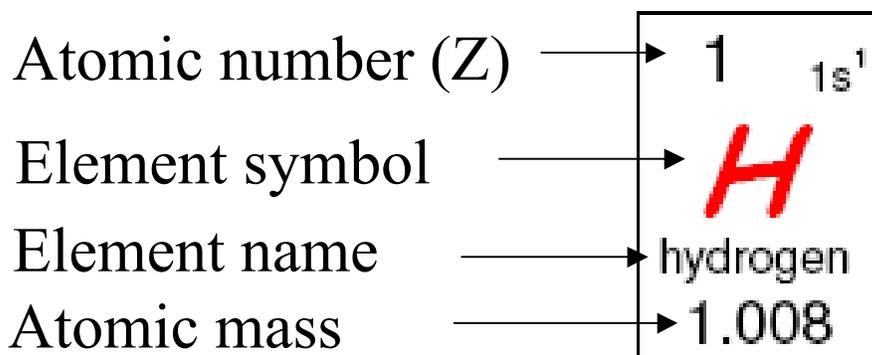
Compounds – can be chemically separated into elements

Elements – can not be broken down by chemical reactions. All known elements appear on the Periodic Table of the Elements (See Week 1 Handout).

Elements on the periodic table have an atomic number ( $Z$ ), where hydrogen has  $Z=1$ , helium has  $Z=2$ , and so on. The periodic table is arranged by atomic number.

Elements on the periodic table have a name and a symbol. The symbol is 1, 2, or 3 letters long where the first letter is capitalized and the remaining letters are lowercase.

Elements on the periodic table have an atomic mass (it is an average value for all isotopes of the same element)



Facts about elements:

Of the more than 100 elements, 81 are stable.

About 10 elements account for 95% of the mass of the Earth's crust

Oxygen accounts for about 50% of the mass of the Earth's crust and about 65% of the mass of the human body

### Classes of Elements

**Metalloids:** appear with an edge of their box on the stepped line of the periodic table and include B, Si, Ge, As, Sb, Te, Po, and At. Note that Al also appears on the stepped line (See Week 1 handout), but Al is an exception. Al is a metal.

**Metals** appear to the left of the metalloids and include aluminum (Al)

1. Some physical properties of metals include high density, high luster, high melting point, good conductors of heat and electricity, malleable (can be hammered into sheets), and ductile (can be drawn into wires).
2. A chemical property of metals is that they tend to become positively charged in compounds.

**Nonmetals** appear to the right of the metalloids

1. Some physical properties of metals include low density, dull, low melting point, poor conductors of heat and electricity, not malleable, not ductile, and 11 nonmetals occur in the gaseous state.
2. A chemical property of nonmetals is that they tend to become negatively charged in compounds.

**Metalloids** have physical and chemical properties in between metals and nonmetals.

On the Periodic Table of the Elements (See Week 1 handout), gaseous elements have symbols with an italic font, liquid elements have symbols with an outline font, and solids have symbols with a Times-Roman font.

The Law of Definite Composition states that compounds always contain the same proportions of elements by mass. For example, sodium chloride is always 39.3% sodium and 60.7% chlorine by mass. Also, water is always 11.2% hydrogen and 88.8% oxygen by mass.

A molecule is made up of two or more nonmetal atoms. A chemical formula tells the number and type of atoms in a molecule. For example,  $\text{H}_2\text{SO}_4$  (sulfuric acid) is the formula for a molecule because it consists of only nonmetals. The molecule is made up of 2 hydrogen atoms, 1 sulfur atom, and 4 oxygen atoms (and 7 total atoms). Subscripts indicate the number of atoms in the formula (when only one atom of a given type is present, no '1' is written).

The chemical formula can be written from a description of the composition. For example, the molecule niacin consists of 6 carbon atoms, 6 hydrogen atoms, 2 nitrogen atoms, and 1 oxygen atom. The chemical formula is  $\text{C}_6\text{H}_6\text{N}_2\text{O}$ . As before, subscripts indicate the number of atoms in the formula (when only one atom of a given type is present, no '1' is written).

Some chemical formulas use parenthesis to indicate more than one of a particular unit. For instance, the formula for antifreeze is  $\text{C}_2\text{H}_4(\text{OH})_2$ , which consists of 2 OH units. The atom count is 2 carbon atoms, 6 hydrogen atoms, and 2 oxygen atoms (a total of 10 atoms).

### **Physical properties**

Examples of physical properties include color, odor, boiling point, density, conductivity, and physical state. A physical property does not change the chemical composition of a substance.

**Chemical properties** describe the chemical reactions that a substance could undergo (or not undergo), meaning that the composition of elements changes.

**Physical Change** means to change the physical state or shape of a substance without changing its chemical composition.

**Chemical Change** means that a chemical reaction occurred. A chemical property means that the reaction could occur, whereas a chemical change means it did occur.

In the lab, formation of a precipitate, a color change, gas bubbles, or a release of heat are evidence of chemical change. Note that physical changes can give the same evidence as chemical change (for example, boiling makes gas bubbles), so it takes practice and experience to recognize the difference.