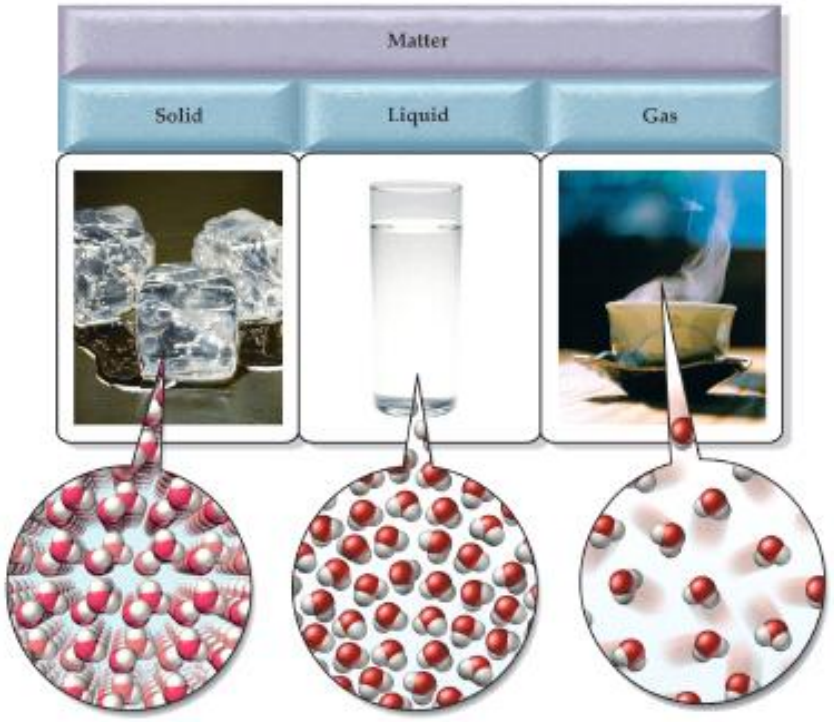
Chapter 3: Matter and Energy

Chemistry - the study of matter

- Matter is anything that has mass and occupies space

Physical States of Matter



Matter can exist in all three states

→ The state of matter observed for a substance is dependent on the temp. and pressure

- Oxygen and nitrogen can be liquids
- Iron can be vaporized

Elements and Compounds

Pure substance: a form of matter composed of a single chemical - either an element or a compound.

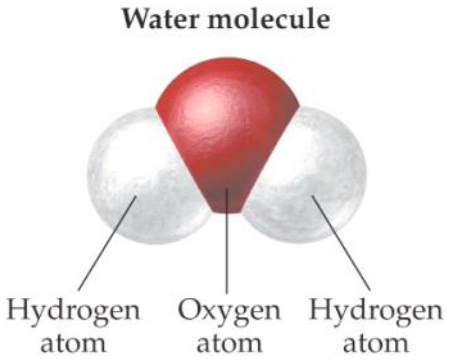
Element - a pure substance composed of just **one type of atom.**

- Elements CAN NOT be broken down into simpler substances by ordinary chemical means.

Compounds - a pure substance composed of *more than one type of atom* with the **atoms present in fixed ratios.**

Ex. In all samples of pure water there are 2 hydrogen atoms for every oxygen atom:

H_2O

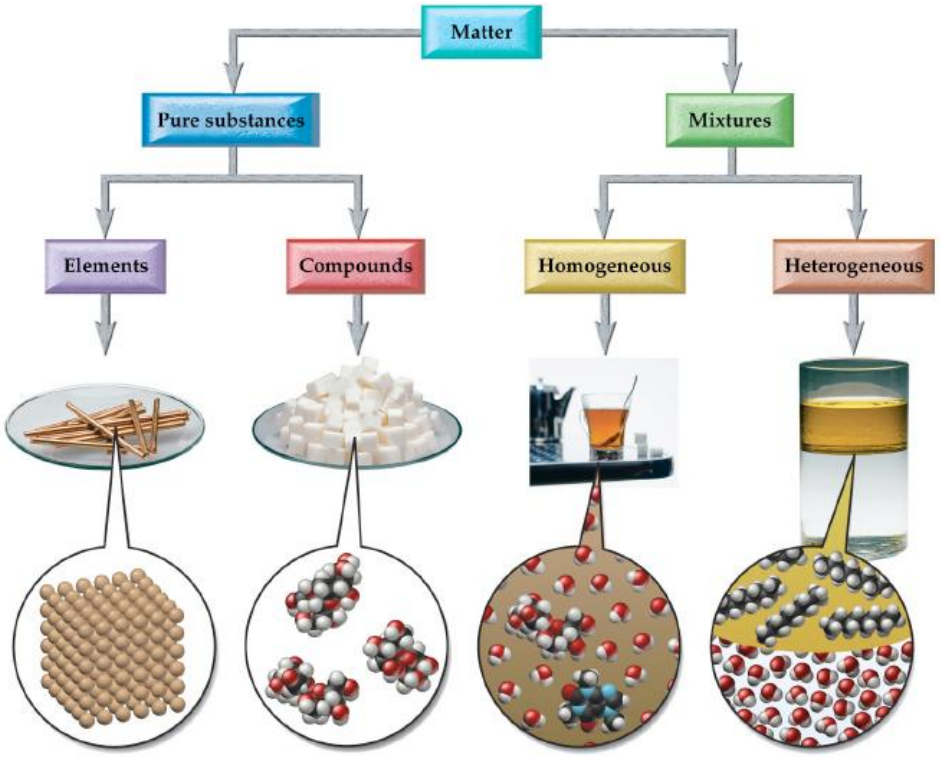


A compound **CAN** be broken down into 2 or more simpler substances by chemical means.

Ex. Electrolysis of Water

$2\ H_2O \longrightarrow 2\ H_2 + O_2$

Pure Substances and Mixtures



A pure substance always has a *definite* and *constant composition*.

A MIXTURE is a physical combination of 2 or more substances. The composition of a mixture can vary from sample to sample and its components can be separated by physical means.

Types of Mixtures

Heterogeneous

Contains visibly different parts or phases, each of which has different properties.

Homogeneous

Contains only one physically distinct phase which has uniform properties throughout - a **SOLUTION**

Classify the following as a pure substance or a homogeneous or heterogeneous mixture

a) a cup of coffee b) 24 carat gold bar c) green paint

d) chocolate chip cookie e) Kool Aid f) mercury

Physical and Chemical Properties and Changes

We recognize various chemicals by:

a) odor and color
b) density
c) boiling point and melting point
d) how they react with other chemicals, etc..

Physical Properties can be observed **without** changing a substance into another substance

Chemical Properties are properties that matter exhibits as it undergoes changes in chemical composition

A chemical property of iron is that it reacts with oxygen to form iron(III) oxide - RUST!

$$2\ Fe + 3\ O_2 \longrightarrow 2\ Fe_2O_3$$

The failure of a substance to react is also considered a chemical property: $CCl_4 + O_2 \longrightarrow$ NO RXN (does not burn)

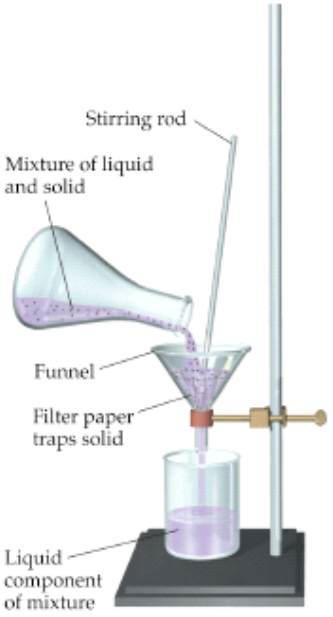
Physical change is a process that does NOT alter the basic nature (chemical composition) of a substance but only changes the form or appearance of the substance. (A new substance is not formed, only its state has changed).

Types of Physical Changes

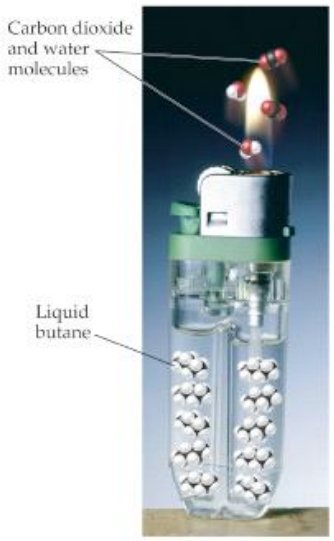
- Phase changes are physical changes (between solid, liquid, and gas)

Solid ice ⟷ Liquid Water ⟷ Gaseous Water
(Water Vapor or Steam)

- Changes in size and shape are physical changes
  ie pulverizing an aspirin
  tearing paper into smaller pieces
- Dissolving one substance into another is a physical change
- Filtration, distillation, and other methods of separating mixtures into pure substances are physical changes.



Chemical change:
- A new type of matter is formed
- A new chemical formula is written
- Also known as a chemical reaction



$C_4H_{10} + O_2 \longrightarrow CO_2 + H_2O$
(butane)

Clues that a chemical change has occurred (all of these are evidence that a new substance has formed)
- Color change
- Odor, gas evolved (but not just from boiling)
- Flame, burning
- Temperature change on its own

A Chemical equation represents a chemical reaction

Reactant(s) $\xrightarrow{\text{chemical reaction}}$ Product(s)

Classify these as physical or chemical changes:
a) Water evaporating
b) Smoking a cigarette
c) Dissolving salt in water
d) Crushing a piece of charcoal
e) Gasoline being used in your car engine
f) Boiling an egg (cooking it)
g) Boiling water

Law of the Conservation of Mass

In any chemical reaction mass is neither created nor destroyed.

OR

The products of a chemical reaction have the same total mass as the reactants

ENERGY

Behavior of matter is driven by energy, so understanding energy is critical in the study of chemistry

Law of the Conservation of Energy

Energy can not be created nor destroyed

- However, we can transfer energy from one place to another and we can change its form

Hydroelectric Dam

Types of Energy

Kinetic Energy: energy of motion (translational, rotational, vibrational)

Potential Energy: stored energy an object possesses due to its *position* or *chemical composition*

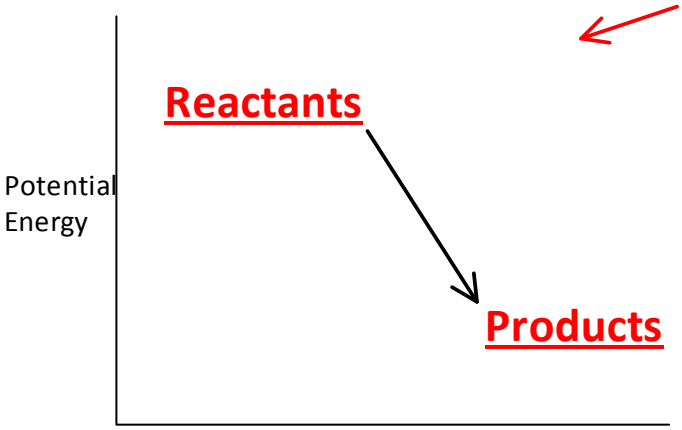
Common forms of energy

heat, light, electrical, mechanical and **chemical energy**

Energy

Common Energy Units
SI Unit = Joule (J)
calorie (cal)= amt of energy required to raise one gram of water by 1°C
Calorie (food calorie) = 1000 cal
1 cal = 4.184 J

- In most chemical reactions the chemical potential energy of the products is **LOWER** than that of the reactants



During such a chemical change energy is released. If the energy released is heat energy, the reaction is said to be EXOTHERMIC

If heat energy is absorbed during a chemical change the reaction is said to be **ENDOTHERMIC**

Q: If energy is released during an exothermic chemical reaction, don't we lose energy?

A: In an exothermic chemical reaction the energy released was *originally* stored as potential energy in the chemical bonds of the reactants. Consequently, during that reaction the **total energy** *does not change* but a transformation between forms of energy occurs - the stored potential energy is converted to heat (or other forms of energy).

Temperature

Temperature is a measure of atomic or molecular motion - as temp increases, molecular motion_____

- as temp decreases, molecular motion _____

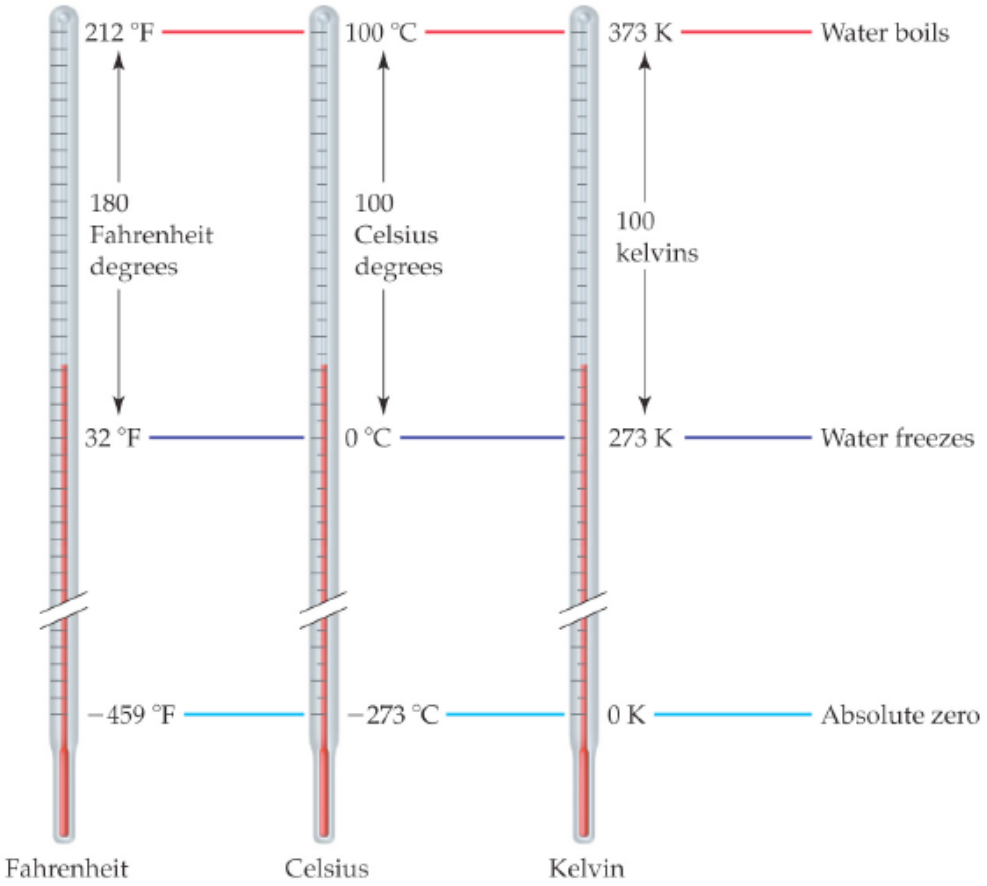
Temperature Scales

Fahrenheit scale (°F) - used in the U.S.

Celcius scale (°C)- used in the rest of the world and in science

Kelvin scale (K) - SI Unit; used in scientific calculations

- the absolute scale ("Absolute zero")



Temperature Conversions

$K = °C + 273.15$ $°F = \frac{9}{5} °C + 32$ or $°C = \frac{5}{9} (°F - 32)$

47.0 °C = ? K

68 °F = ? °C

68 °F = ? K