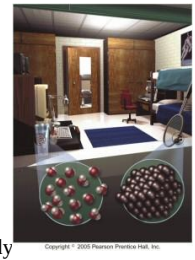
Introductory Chemistry, 2nd Edition
Nivaldo Tro

Chapter 3
Matter and Energy



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What is Matter?

- **Matter** is defined as anything that occupies space and has mass

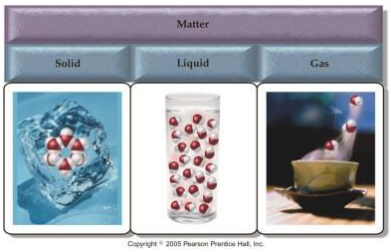
Matter is composed of a lot of tiny little pieces we call **atoms** and **molecules**

Visible/measurable properties

State	*Shape*	*Volume*	*Compress*	*Flow*
Solid	Fixed	Fixed	No	No
Liquid	Indef.	Fixed	No	Yes
Gas	Indef.	Indef.	Yes	Yes

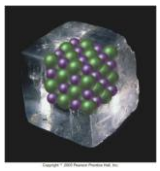
"Room temperature"

The motion and arrangement of the atoms or molecules determine the physical state of matter.



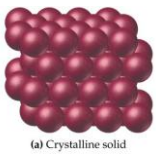
Solids

- the particles in a solid are packed *close together* and are *fixed in position*

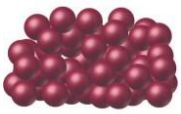


Solids

- **crystalline solids**
  - ✓salt and diamonds



- **amorphous solids**
  - ✓plastic and glass



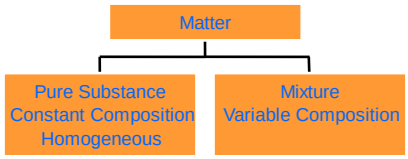
Liquids

- the particles are *closely packed*, *move around* and have a *random* arrangement.

Gases

- the particles are *widely separated*, *rapidly moving*, *random*.

Classification of Matter

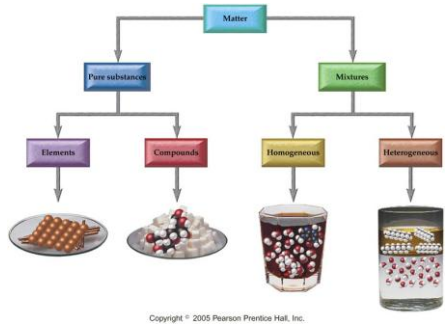


- **Pure Substance** = all samples are made of the same atoms or molecules in the same percentages
  - ✓ salt
- **Mixtures** = different samples may have the same pieces in different percentages
  - ✓ salt water

Copper – a Pure Substance

Brass – a Mixture

Classifying Matter



Atoms & Molecules

- Smallest piece of an element is called an **atom**
  - ✓there are subatomic particles, but these are no longer the element
- Smallest piece of a compound is called a **molecule**
  - ✓molecules are made of atoms
  - ✓all molecules of a compound are identical
  - ✓each molecule has the same number and type of atoms

Properties of Matter

- **Physical Properties** are the characteristics of matter that can be changed without changing its composition
  - ✓characteristics that are directly observable
- **Chemical Properties** are the characteristics that determine how the composition of matter changes as a result of contact with other matter or the influence of energy
  - ✓characteristics that describe the behavior of matter

Some Physical Properties

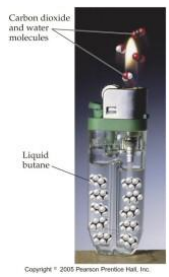
mass	volume	density
solid	liquid	gas
melting point	boiling point	volatility
taste	odor	color
texture	shape	solubility
electrical conductance	thermal conductance	magnetism
malleability	ductility	specific heat capcity

Some Chemical Properties

Acidity	Basicity (aka Alkalinity)
Causticity	Corrosiveness
Reactivity	Stability
Inertness	Explosiveness
(In)Flammability	Combustibility
Oxidizing Ability	Reducing Ability

3.6 Changes in Matter

Changes in Matter

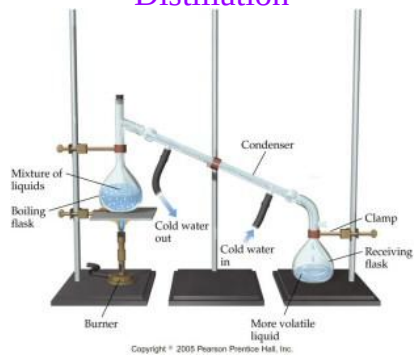


Is it a Physical or Chemical Change?

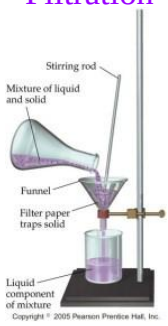
Phase Changes are Physical Changes

Separation of Mixtures

Distillation



Filtration



3.7 Law of Conservation of Mass

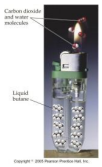
- *"Matter is neither created nor destroyed in a chemical reaction"*

Conservation of Mass

- butane + oxygen → carbon dioxide + water

58 grams + 208 grams → 176 grams + 90 grams

266 grams = 266 grams



3.8 Energy

- Energy is anything that has the capacity to do work

Law of Conservation of Energy

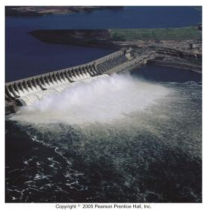
- "*Energy can neither be created nor destroyed*"

Matter Possesses Energy

- all chemical and physical changes result in the matter changing energy

Kinds of Energy Kinetic and Potential

- **Kinetic Energy** is energy of motion, or energy that is being transferred from one object to another
- **Potential Energy** is energy that is stored



Some Forms of Energy

Units of Energy

- **calorie (cal)** is the amount of energy needed to raise one gram of water by 1°C
  - ✓kcal = energy needed to raise 1000 g of water 1°C
  - ✓food Calories = kcals

Energy Conversion Factors

1 calorie (cal)	=	4.184 joules (J)
1 Calorie (Cal)	=	1000 calories (cal)
1 kilowatt-hour (kWh)	=	3.60 x 10^6 joules (J)

Example 3.5: Conversion of Energy Units

Example:

- A candy bar contains 225 Cal of nutritional energy. How many joules does it contain?

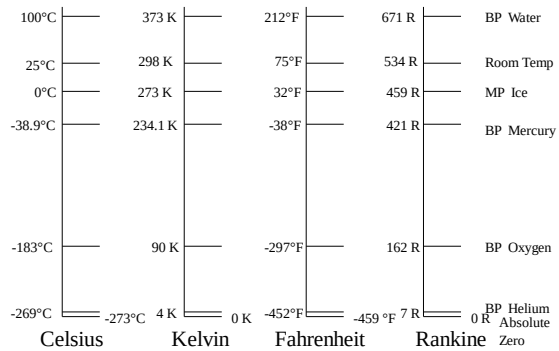
Heat

kinetic energy of the molecules in a sample

3.9 Temperature

- Temperature is a **measure** of the average kinetic energy of the molecules in a sample
- Not all molecules have in a sample the same amount of kinetic energy
- a higher temperature means a larger average kinetic energy

Temperature Scales



Example 3.8: Converting Between Fahrenheit and Kelvin Temperature Scales

Example:

- Convert 310 K to Fahrenheit

3.10 Energy and the Temperature of Matter

- The amount the temperature of an object increases depends on the amount of heat energy added (q).
- The amount the temperature of an object increases depends on its mass

Heat Capacity

- **heat capacity** is the amount of heat a substance must absorb to raise its temperature 1°C
  - ✓cal/°C or J/°C
  - ✓metals have low heat capacities, insulators high
- **specific heat** = heat capacity of 1 gram of the substance
  - ✓cal/g°C or J/g°C
  - ✓waters specific heat = 4.184 J/g°C for liquid
    - ➢or 1.000 cal/g°C
    - ➢less for ice and steam

Specific Heat Capacity

- Specific Heat is the amount of energy required to raise the temperature of one gram of a substance by one Celsius degree

Specific Heat Capacities

Substance	*Specific Heat J/g°C*
Aluminum	0.895
Calcium	0.656
Carbon (dia)	0.508
Carbon (gra)	0.708
Copper	0.377
Gold	0.129
Iron	0.448
Lead	0.129
Silver	0.712
Water (l)	4.184
Water (s)	2.03
Water (g)	2.02

Heat Gain or Loss by an Object

- the amount of heat energy gained or lost by an object depends on 3 factors – how much material there is, what the material is, and how much the temperature changed

Amount of Heat = Mass x Heat Capacity x Temperature Change

$$q = m \times C \times \Delta T$$

Example 3.9: Relating Heat Energy to Temperature Change

Example:

- Gallium is a solid metal at room temperature, but melts at 29.9°C. If you hold gallium in your hand, it melts from body heat. How much heat must 2.5 g of gallium absorb from your hand to raise its temperature from 25.0°C to 29.9°C? The heat capacity of gallium is 0.372 J/g°C