Unit 3

“Matter and Change”
Matter

- Matter is anything that: a) has mass, and b) takes up space

- Mass = a measure of the amount of “stuff” (or material) the object contains (don’t confuse this with weight, a measure of gravity)

- Volume = a measure of the space occupied by the object
Describing Matter

- Properties used to describe matter can be classified as:
  1) **Extensive** – depends on the *amount* of matter in the sample
     - Mass, volume, calories are examples
  2) **Intensive** – depends on the *type* of matter, not the amount present
     - Hardness, Density, Boiling Point
Properties are...

- Words that describe matter (adjectives)
- **Physical Properties** - a property that can be observed and measured without changing the material’s composition.
  - Examples - color, hardness, m.p., b.p.
- **Chemical Properties** - a property that can only be observed by changing the composition of the material.
  - Examples - ability to burn, decompose, ferment, react with, etc.
States of matter

1) **Solid** - matter that can not flow (definite shape) and has definite volume.

2) **Liquid** - definite volume but takes the shape of its container (flows).

3) **Gas** - a substance without definite volume or shape and can flow.
   - **Vapor** - a substance that is currently a gas, but normally is a liquid or solid at room temperature. (Which is correct: “water gas”, or “water vapor”?)
## States of Matter

<table>
<thead>
<tr>
<th></th>
<th>Definite Volume?</th>
<th>Definite Shape?</th>
<th>Result of a Temperature Increase?</th>
<th>Will it Compress?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>YES</td>
<td>YES</td>
<td>Small Expans.</td>
<td>NO</td>
</tr>
<tr>
<td>Liquid</td>
<td>YES</td>
<td>NO</td>
<td>Small Expans.</td>
<td>NO</td>
</tr>
<tr>
<td>Gas</td>
<td>NO</td>
<td>NO</td>
<td>Large Expans.</td>
<td>YES</td>
</tr>
</tbody>
</table>
4th state: Plasma - formed at high temperatures; ionized phase of matter as found in the sun.
Three Main Phases

(a) Particles in a solid  
(b) Particles in a liquid  
(c) Particles in a gas
Solid > Melt > Liquid > Condense > Gas

Solid > Melt > Liquid > Evaporate > Gas

Solid > Melt > Liquid > Sublimation > Gas

Solid > Deposition > Liquid > Condense > Solid

Solid > Deposition > Liquid > Evaporate > Gas

Solid > Deposition > Liquid > Sublimation > Gas
Physical vs. Chemical Change

- **Physical change** will change the visible appearance, without changing the composition of the material.
  - Boil, melt, cut, bend, split, crack
  - Is boiled water still water?

- Can be **reversible**, or **irreversible**

- **Chemical change** - a change where a new form of matter is formed.
  - Rust, burn, decompose, ferment
Mixtures are a physical blend of at least two substances; have variable composition. They can be either:

1) **Heterogeneous** – the mixture is not uniform in composition
   - Chocolate chip cookie, gravel, soil.

2) **Homogeneous** - same composition throughout; called “solutions”
   - Kool-aid, air, salt water

Every part keeps its own properties.
Solutions are Homogeneous Mixtures

- Mixed molecule by molecule, thus too small to see the different parts.
- Can occur between any state of matter: gas in gas; liquid in gas; gas in liquid; solid in liquid; solid in solid (alloys), etc.
- Thus, based on the distribution of their components, mixtures are called homogeneous or heterogeneous.
Phase?

- The term “phase” is used to describe any part of a sample with uniform composition of properties.
- A homogeneous mixture consists of a single phase.
- A heterogeneous mixture consists of two or more phases.
Separating Mixtures

- Some can be separated easily by physical means: rocks and marbles, iron filings and sulfur (use magnet)
- Differences in physical properties can be used to separate mixtures.
- **Filtration** - separates a solid from the liquid in a heterogeneous mixture (by size). Coffee Maker
Separation of a Mixture

Components of dyes such as ink may be separated by paper chromatography. Has a mobile phase that moves across the surface of another material, which is called a stationary phase.
Separation of a Mixture

- **Distillation:** takes advantage of different boiling points. (liquid in a liquid)
Separation of a Mixture

- **Crystallization** – separation technique that results in the formation of pure solid particles of a substance from a solution containing dissolved substance. (solid in a liquid) ex. Rock Candy
Substances: Element or Compound

Substances are either:

a) Elements

OR

b) Compounds
- **Elements** - simplest kind of matter
  - cannot be broken down any simpler and still have properties of that element!
  - all one kind of atom.

- **Compounds** are substances that can be broken down only by chemical methods
  - when broken down, the pieces have completely different properties than the original compound.
  - made of two or more atoms, chemically combined (not just a physical blend!)
## Compound vs. Mixture

<table>
<thead>
<tr>
<th>Compound</th>
<th>Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made of one kind of material</td>
<td>Made of more than one kind of material</td>
</tr>
<tr>
<td>Made by a chemical change</td>
<td>Made by a physical change</td>
</tr>
<tr>
<td>Definite composition</td>
<td>Variable composition</td>
</tr>
</tbody>
</table>

- **Compound**
  - Made of one kind of material
  - Made by a chemical change
  - Definite composition

- **Mixture**
  - Made of more than one kind of material
  - Made by a physical change
  - Variable composition
Which is it?

Element

Compound

Mixture
Elements vs. Compounds

- Compounds **can** be broken down into simpler substances by chemical means, but **elements cannot**.
- A “chemical change” is a change that produces matter with a **different composition** than the original matter.
Chemical Change

A change in which one or more substances are converted into different substances.

Heat and light are often evidence of a chemical change.
Properties of Compounds

- Quite different properties than their component elements.
- Due to a CHEMICAL CHANGE, the resulting compound has new and different properties:
  - Table sugar – carbon, hydrogen, oxygen
  - Sodium chloride – sodium, chlorine
  - Water – hydrogen, oxygen
Classification of Matter

Matter

Can it be separated by physical means?

Yes

Mixtures

Is the composition uniform?

Yes

Homogeneous mixtures
(air, sugar in water, stainless steel)

No

Heterogeneous mixtures
(granite, wood, blood)

No

Pure Substances

Can it be decomposed by ordinary chemical means?

Yes

Compounds
(water, NaCl, sucrose)

No

Elements
(Gold, aluminum, oxygen, chlorine)
Chemical Changes

- The ability of a substance to undergo a specific chemical change is called a chemical property.
  - iron plus oxygen forms rust, so the ability to rust is a chemical property of iron

- During a chemical change (also called chemical reaction), the composition of matter always changes.
Chemical Reactions are...

- When one or more substances are changed into new substances.
- **Reactants** - the stuff you start with
- **Products** - what you make
- The products will have NEW PROPERTIES different from the reactants you started with
- Arrow points from the reactants to the new products. Ex. $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$
Recognizing Chemical Changes

1) **Energy** is absorbed or released (temperature changes hotter or colder)

2) **Color** changes

3) **Gas** production (bubbling, fizzing, or odor change; smoke)

4) formation of a **precipitate** - a solid that separates from solution (won’t dissolve)

5) **Irreversibility** - not easily reversed

But, there are examples of these that are not chemical – boiling water bubbles, etc.
Conservation of Mass

- During any chemical reaction, the mass of the products is always equal to the mass of the reactants.

- All the mass can be accounted for:
  - Burning of wood results in products that appear to have less mass as ashes; where is the rest?

- Law of conservation of mass
43.43 g Original mass = 43.43 g Final mass

reactants

= 

product
Percent by Mass

% = \frac{\text{Mass of Element}}{\text{Mass of Compound}} \times 100

Ex. Sucrose

<table>
<thead>
<tr>
<th>Element</th>
<th>Grams</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>8.4 g</td>
<td>8.4/20(100) = 42%</td>
</tr>
<tr>
<td>H</td>
<td>1.3 g</td>
<td>1.3/20(100) = 6.5%</td>
</tr>
<tr>
<td>O</td>
<td>10.3 g</td>
<td>10.3/20(100) = 51.5%</td>
</tr>
<tr>
<td>Total</td>
<td>20.0 g</td>
<td>100%</td>
</tr>
</tbody>
</table>