Matter and Its Properties

Physics is the study of matter and its changes in motion. **Chemistry** is the study of matter and its changes in composition. Biology is the study of living matter and its changes. So, it is helpful to know a few things about matter.

Matter is anything that has mass and volume. **Mass** is the measure of the inertia in matter and **inertia** is the resistance to change. The greater the mass an object has the greater the inertia or resistance. **Volume** is the space that is occupied by matter. Thus, it is everywhere, and you should be able to recognize and describe matter.

Matter is described using its chemical and physical properties. Properties are just the characteristics of a substance. The **physical properties** are those properties that describe something without changing the composition of the material. The mass, volume, density, conductivity, malleability and hardness can be described without changing the composition. But **chemical properties** describe matter as its composition changes and are related to chemical changes. Being flammable, explosive, acidic or able to react with water are chemical properties.

Identify the following as a **(P)**hysical or **(C)**hemical properties.

_____ color	_____ flammable	_____ malleable
_____ corrosive	_____ soluble	_____ explosive

The Changes in Matter

The changes matter undergoes are classified as either chemical or physical. A **physical change** is a change in the form of a substance, but its chemical composition remains the same. A physical change does not result in a new substance. Cutting a wooden plank in half is an example of a physical change. The plank is in two pieces, but it is still wood. The melting of ice or the boiling of water changes the form of water, but it is still water. Thus, a physical change.

However, a **chemical change,** which is the result of a chemical reaction, occurs when a **new** substance with **new** properties is created. Burning a wooden plank would result in smoke, heat and ashes and it would no longer be wood; so, a chemical change has occurred.

Chemical reactions are the rearrangement of atoms and ions to create **new** substances. The starting substances are called **reactants** and the new substances are called **products**.

Identify the following as a **(P)**hysical or **(C)**hemical change.

_____ hydrogen peroxide decomposes

_____ an antacid tablet fizzing in water

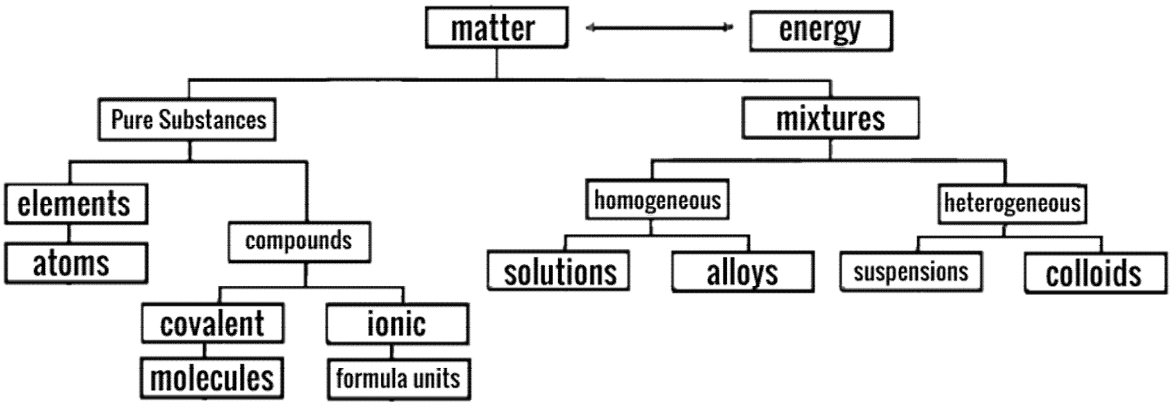
_____ the melting of a Popsicle

_____ burning a candle

_____ copper made into wire

_____ burning a log

The Divisions Matter



Matter is classified as either a pure substance or mixture. **Pure substances** have a fixed composition with definite properties and cannot be broken down into simpler substances by ordinary physical processes. Pure substances are divided into elements and compounds.

An **element** is the simplest form of a pure substance and cannot be broken down into simpler substances by chemical or physical means. The simplest form of an element is the atom. **Compounds** are chemical combinations of elements always in the same ratio and can be broken down by chemical processes. Compounds form either **molecules** (H_2O) or **formula units** (NaCl).

Mixtures are physical combinations of two or more substances with varying compositions, varying properties and can be separated by ordinary physical processes. Mixtures are divided into two main groups: homogeneous and heterogeneous.

Homogenous mixtures have the same composition throughout, consist of only one phase and do not have layers. The two kinds of homogeneous mixtures are solutions and alloys.

Solutions consist of a solute completely dissolved in a solvent. The **solute** is the minor substance that dissolves, and the **solvent** is the major substance that causes the dissolving. Saltwater, Kool-Aid™ and coffee are examples of solutions. An **alloy** is a solution of two or more elements, at least one of which is a metal, where the resulting

material has metallic properties. Alloys are usually made to improve on the properties of the elements that make them up. Steel for example, is much stronger than iron, which is its main component.

Heterogeneous mixtures are not equally mixed, separate into phases and tend to form layers. Heterogeneous mixtures are divided into suspensions and colloids. **Suspensions** contain large particles that settle when left alone. Italian salad dressing, blood and muddy water are suspensions. **Colloids** are like suspensions, except the particles don't settle. Instead, the particles remain suspended and scatter light causing the mixture to appear cloudy or opaque. This cloudiness is referred to as the Tyndall effect.

Types of Colloids

Name	Type	Example
Aerosols	liquid in gas	fog, clouds, insect spray
	solid in gas	smoke, dust, air pollution
Foams	gas in liquid	whipped cream, shaving cream
	gas in solid	marshmallows, Styrofoam, bath sponge
Emulsions	liquid in liquid	milk, mayonnaise, hair cream
Sols	solid in liquid	ink, liquid detergent, shampoo, paint
Gels	liquid in solid	gelatin, butter, cheese, jelly

Identify the following as (**hom)o**geneous, (**heter)o**geneous, (**col**)loid, (**com)p**ound or (**elem)**ents.

____ the copper in a penny _____ vinegar _____ table sugar

____ whole milk _____ oxygen _____ water

____ a hamburger _____ whipped cream _____ an orange

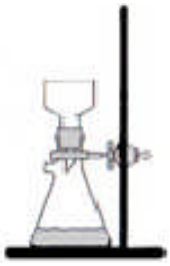
____ pencil _____ sulfur _____ air

Separating Mixtures

Separating pure substances is very difficult and requires large amounts of energy, but mixtures can be separated by physical means. Some of the techniques used to separate mixtures are:

- filtration – the use of a mesh such as filter paper to separate a solid and a liquid
- distillation – the use of heating and evaporation to separate a solution
- chromatography – the use of solubility and colors to separate a solution
- centrifugation – the use of spinning to separate solids
- extraction – the use of chemical to separate suspensions
- dialysis – the use of diffusion or osmosis to separate suspensions

Distillation



Filtration

Density and Specific Gravity

Mass, volume, temperature and density are physical properties used to help describe matter. **Density** is the ratio of mass to volume and is defined as the mass per unit volume. Densities are used to distinguish between two substances or help identify certain substances. The units for density are **g/ml** for fluids or **g/cm³** for solids.

Example: A 47.3 mL sample ethanol has a mass of 37.32 g. What is the density?

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{37.32\text{ g}}{47.3\text{ mL}} = 0.789\text{ g/mL}$$

If the density of a substance is greater than 1 g/mL, it will sink in water. But, if the density is less than 1 g/mL, it will float.

The **specific gravity** of a substance is the ratio of its density to the density of water, both at the same temperature. The density of water is 1.00 g/mL at 25 °C.

$$\text{Sp. Gr.} = \frac{D_{\text{substance}}}{D_{\text{water}}}$$

Note: the units cancel out.

Think About It

- Can you describe matter, mass, and volume?
- Do you know the divisions of matter?
- Do you know the different pure substances?
- Do you know the different mixtures?
- What is a colloid?
- Describe which is easier to separate, a homogeneous or heterogeneous mixture?
- Can you list at least 5 physical properties?
- Can you list at least 5 chemical properties?
- Can you recognize physical and chemical changes?
- Describe a chemical reaction.
- List the parts of a chemical reaction.
- What is the difference between an atom and a molecule?

"Creativity is allowing oneself to make mistakes; art is knowing which ones to keep."
-- Scott Adams