<u>Chem 101 Lecture Notes</u>: Week 3 Chapter 4: "Properties of Matter" pgs. 61-77

2 Main Types of Properties

a. **Physical properties:** Characteristics of a substance (element or compound) that do not change and are useful in identifying the substance.
b. **Chemical properties:** Characteristics of a substance that indicate how the substance interacts or changes in the presence of other substances.

<u>**Examples**</u>: weight, mass, height, volume, color, density, specific gravity, size, shape, temperature, melting (freezing) point, boiling point, odor, etc. are all PHYSICAL properties

Flammable, explosive, bleaching, oxidizing, corrosive, caustic, unstable, reacts slowly, vigorously, color changing, or polymerizing are all terms that relate the possible CHEMICALproperties of a substance.

No two substances have exactly the same physical and chemical properties!

PHYSICAL VS. CHEMICAL CHANGE

Physical changes are those that do NOT result in a change in the identity of a substance; these changes simply result in a change in physical state (solid, liquid, gas, or plasma).

<u>**Examples**</u>: Ice melting, water boiling, water condensing, ice freezing, alcohol evaporating, iodine subliming (going directly from solid to gas)

Chemical changes are those that DO result in a change in the identity of the substance; these changes result in a new substance forming.

Examples: paper burning to form carbon dioxide and water vapor (combustion); sugar charring to produce carbon and water vapor (decomposition); steel rusting in air to produce iron (III) oxide (synthesis); chlorine replacing bromine from sea water (single replacement); hard water stains forming from calcium depositing (double displacement)

ALL OF THE ABOVE CHEMICAL CHANGES CAN BE DISPLAYED USING FORMULAS FOR EACH SUBSTANCE INVOLVED AND SHOWING REACTANTS AND PRODUCTS.

Reactants: In the above chemical change word equations, an example would be paper and oxygen (what undergoes chemical change).

Products: In the above, an example would be the carbon dioxide and water vapor produced from burning paper (what results from a chemical change).

When a chemical change occurs, the mass of the products produced always equals the mass of the reactants consumed. This is termed the LAW OF CONSERVATION OF MASS.

Example: *32 g of sulfur are burned with 16 g of oxygen (O_2), one would expect 48 g of sulfur dioxide (SO_2) to be produced.*

$$32 \text{ g of } S + 16 \text{ g of } O_2 \rightarrow 48 \text{ g of } SO_2$$

Hence, mass is neither gained nor lost.

Similarly, the LAW OF CONSERVATION OF ENERGY states that energy is neither gained nor lost during a chemical change. So, in the above equation, the heat content (enthalpy) of the reactants must equal the heat content of the product (sulfur dioxide). Since the heat content of sulfur dioxide is less than the combined heat contents of the 2 reactants, heat is released as sulfur burns to maintain equal amounts of kinetic and potential energy on both sides of the equation.

2 Types of Energy

a. Kinetic energy: This is energy possessed by moving particles of matter.

b. **Potential energy**: This is energy stored due to the position of an object. Gravity affects potential energy.

Examples:

A swinging baseball bat has kinetic energy; while a batter who is getting ready to swing at a ball has potential energy stored in his/her muscles.

A piece of paper has potential energy stored in its chemical bonds. When combined with oxygen, those bonds break and new bonds form which results in a lower potential energy and so heat (kinetic energy) and light is given off.

If we wanted to measure the heat given off by this reaction or heat required to cause a physical change such as melting to occur, the following equation is useful

$$\mathbf{Q = m \bullet C \bullet \Delta T}$$

Where Q = heat gained or lost, m is the mass of the substance (units = grams), C is the specific heat of the substance, and **ΔT is the measured change in temperature of the substance.**

The units of heat can be either calories (cal) or joules (J). To convert from calories to joules: 1 cal = 4.184 J. The specific heat of a substance is the amount of energy (calories or joules) needed to raise the temperature of 1 gram of the substance by 1^{o}C. *See Table 4.3 on p. 73 for some specific heats.* NOTE: You may see K (Kelvin) units used for temperature too.**Recall that K = ^{o}C + 273.15.**

Example problem: Using a bomb calorimeter (a device for measuring the heat of combustion), the temperature of 500 g of ethyl alcohol increased from 15°C to 28.7°C when a sample of cottonseed oil was burned. How much energy in joules and calories was given off?

Step 1: Write down given. m = 500g, c (specific heat) for ethyl alcohol = 2.138 J/g$^{\circ}$C or 0.511 cal/g$^{\circ}$C,ΔT = 28.7 $^{\circ}$C-15°C = 13.7 $^{\circ}$C

Step 2: Insert known values into equation

$$Q = m \bullet C \bullet \Delta T.$$

For joules, Q = (500g)(2.138J/g^{o}C)(13.7^{o}C) =

For calories, use C = 0.511 cal/g^{o}C,

Q = (500g)(0.511cal/g^{o}C)(13.7^{o}C) =