2.S: The Physical and Chemical Properties of Matter (Summary)

- A **compound** is defined as a substance that results from the combination of two or more elements in a constant ratio. In a compound such as water, we show the ratio of the elements (hydrogen and oxygen) by using *subscripts* on the chemical symbols for each element. Thus, water (two hydrogens and one oxygen) is written using the **chemical formula** H_2O. In a **molecule**, the atoms are not only bonded together in a constant ratio, but they are also bonded in a *specific geometric arrangement*.
- A **pure substance** contains only one kind of matter;it can be a single element or a single chemical compound. Two or more pure substances mixed together constitute a mixture;you can always separate a mixture by simple physical means.
- A **heterogeneous mixture** is not uniform and different samples of the mixture will have a different compositions. A **homogeneous mixture**, is uniform and any sample that you examine will have *exactly* the same composition as any other sample. Within chemistry, the most common type of homogeneous mixture is a **solution**.
- Any pure substance, under appropriate conditions, can exist in three different **states**: solids, liquids and gases. States of matter are examples of **physical properties** of a substance. Other physical properties include appearance (shiny, dull, smooth, rough), odor, electrical conductivity, thermal conductivity, hardness and density, etc.
- **Solids** have both a definite shape and volume. **Liquids** have a definite volume, but take on the shape of their container. **Gasses** have neither a definite shape nor volume, and both of these are defined by the shape and volume of their container.
- The **kinetic molecular theory (KMT)** is generally used to explain physical states of matter. The KMT suggests that atoms and molecules are *always* in motion and are loosely bound to each other by attractive called **intermolecular forces**. In a **solid**, the kinetic energy (energy of motion) associated with the atoms or molecules is insufficient to break these forces and the particles are essentially fixed in place, adjacent to each other. In a **liquid**, there is enough kinetic energy to break some of the attractive forces, allowing the particles to “slip and slide” next to each other, but there is not enough energy to allow them to escape. In a **gas**, there is sufficient kinetic energy to totally overcome the forces and the particles have no interactions with each other.
- A change of state from a solid to a liquid occurs at a defined temperature (which) called the **melting point** (or freezing point);this temperature is a unique physical property of the substance. The transition from a liquid to a gas, likewise, occurs at the **boiling point**. A direct transition from a solid to a gas is called **sublimation**.
- An **intensive property** is defined as a property that is *inherent* to the substance and is not dependent on the sample size. **Density**, the ratio of mass-to-volume for a substance, is a classic example of an intensive property.
- **Density** is calculated by taking the **mass** of a sample of a substance, and dividing that by the **volume** of that sample. Density for solids is typically expressed using units of grams per cubic centimeter ($g\ cm^{-3}$);liquids as grams per milliliter ($g\ mL^{-1}$) and gasses as grams per liter ($g\ L^{-1}$), although any mixture of mass and volume units may be used. Remember, a mL has the same volume as a cm^3, and a L is simply 1000 mL.
- **Physical changes** are changes in outward appearances that do not alter the chemical nature of the substance and produce no new substance. When a **chemical change** occurs, a new substance is produced. Just like physical properties describe the appearance or intensive properties of a substance, **chemical properties** describe the set of chemical changes that are possible for that substance.
- The **law of mass conservation** (conservation of mass) simply states, that there is no detectable change in the total mass of materials when they react chemically (undergo a chemical change) to form new substances.