Summary

3.1 Solids, Liquids, and Gases

Materials can be classified as solids, liquids, or gases, based on whether their shapes and volumes are definite or variable.

Solid is the state of matter in which materials have a definite shape and a definite volume. The term *definite* means that the shape and volume of a material do not easily change. Almost all solids have some type of orderly arrangement of particles at the atomic level.

Liquid is the state of matter in which a material has a definite volume but not a definite shape. A liquid always has the same shape as its container and can be poured from one container to another.

Gas is a state of matter in which a material has neither a definite shape nor a definite volume. A gas takes the shape and volume of its container.

On Earth, almost all matter exists in a solid, liquid, or gaseous state. But ninety-nine percent of all the matter in the universe exists in a state that is not common on Earth. At extremely high temperatures, matter exists as plasma. At extremely low temperatures, matter exists as a fifth state of matter called a Bose-Einstein condensate (BEC).

Kinetic energy is the energy an object has due to its motion. The faster an object moves, the greater its kinetic energy. The kinetic theory of matter says that all particles of matter are in constant motion.

The particles in a gas are never at rest. There are forces of attraction among the particles in all matter. In a gas, the attractions are too weak to have an effect. The constant motion of particles in a gas allows a gas to fill a container of any shape or size. The kinetic theory as applied to gases has three main points:

- Particles in a gas are in constant, random motion.
- The motion of one particle is unaffected by the motion of other particles unless the particles collide.
- Forces of attraction among particles in a gas can be ignored under ordinary conditions.

The particles in liquids also have kinetic energy. In a liquid, there is a kind of tug of war between the constant motion of particles and the attractions among particles. A liquid takes the shape of its container because particles in a liquid can flow to new locations. The volume of a liquid is constant because forces of attraction keep the particles close together.

Solids have a definite volume and shape because particles in a solid vibrate around fixed locations.

3.2 Gas Laws

Pressure is the result of a force distributed over an area. The SI unit of pressure is derived from SI units of force and area. When a force in newtons (N) is divided by an area in square meters (m^2), the unit of pressure is newtons per square meter (N/m^2). The SI unit for pressure, the pascal (Pa), is shorthand for newtons per square meter. One kilopascal (kPa) is equal to 1000 pascals.

Collisions between particles of a gas and the walls of the container cause the pressure in a closed container of gas. The more frequent the collisions, the greater the pressure of the gas is.

Factors that affect the pressure of an enclosed gas are its temperature, its volume, and the number of its particles.

- Raising the temperature of a gas will increase its pressure if the volume of the gas and the number of particles are constant, or the same.

- Reducing the volume of a gas increases its pressure if the temperature of the gas and the number of particles are constant.
- Increasing the number of particles will increase the pressure of a gas if the temperature and the volume are constant.

Charles's law states that the volume of a gas is directly proportional to its temperature in kelvins if the pressure and the number of particles of the gas are constant. Charles's law can be expressed mathematically with T_1 and V_1 representing the temperature and volume of a gas before a change occurs. T_2 and V_2 represent the temperature and volume after a change occurs.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

The temperatures must be expressed in kelvins.

Boyle's law states that the volume of a gas is inversely proportional to its pressure if the temperature and the number of particles are constant. Boyle's law can be expressed as follows:

$$P_1V_1 = P_2V_2$$

P_1 and V_1 represent the pressure and volume of a gas before a change occurs. P_2 and V_2 represent the pressure and volume of a gas after a change occurs.

Boyle's law and Charles's law can be combined into a single gas law that describes the relationship among the temperature, volume, and pressure of a gas when the number of particles is constant.

3.3 Phase Changes

When at least two states of the same substance are present, scientists describe each different state as a phase. A phase change is the reversible physical change that occurs when a substance changes from one state of matter to another. Melting, freezing, vaporization, condensation, sublimation, and deposition are six common phase changes.

One way to recognize a phase change is by measuring the temperature of a substance as it is heated or cooled. The temperature of a substance does not change during a phase change.

During a phase change, energy is transferred between a substance and its surroundings. During an endothermic change (for example, melting), the system absorbs energy from its surroundings. During an exothermic change (for example, freezing), the system releases energy to its surroundings.

The arrangement of molecules in water becomes less orderly as water melts and more orderly as water freezes.

The phase change in which a substance changes from a liquid into a gas is vaporization. Vaporization is an endothermic process. Scientists note the difference between two vaporization processes—boiling and evaporation. Evaporation takes place at the surface of a liquid and occurs at temperatures below the boiling point. Evaporation is the process that changes a substance from a liquid to a gas at temperatures below the substance's boiling point. The greater the surface area of a container of water, the faster the water evaporates.

Condensation is the phase change in which a substance changes from a gas or vapor to a liquid. Condensation is an exothermic change.

Sublimation is the phase change in which a substance changes from a solid to a gas or vapor without changing to a liquid first. Sublimation is an endothermic change.

Deposition is the phase change in which a gas or vapor changes directly into a solid without first changing to a liquid. Deposition is an exothermic change and is the reverse of sublimation.