

States of Matter

I. Solids, Liquids and Gases

a. **States of Matter** – matter can be classified as solid, liquid or gas based on whether shapes and volumes are definite or variable

i. Solids

1. Definite shape AND definite volume
2. Particles within a solid are close together and usually are ordered
3. Examples: pencil, quarter, book

ii. Liquids

1. Definite volume, but not a definite shape (liquids take the shape of their container – think of a glass of juice)
2. Particles in liquids are close together but disordered (random)
3. Examples: juice, water

iii. Gases

1. Not definite shape, not definite volume (gases take the shape and volume of their container – think of a balloon)
2. Particles in a gas are far apart and disordered (random)
3. Examples: air, helium

iv. Plasma

1. Exists at extremely *high* temperatures (sun and other stars)
2. It is a partially ionized gas

v. Bose-Einstein Condensate

1. Exists at extremely *low* temperatures – close to absolute zero (or -273°C)
2. Groups of atoms in this state behave as if they are a single particle

b. Kinetic Theory

- i. **Kinetic energy**: energy an object has due to its motion
- ii. Example: a baseball thrown at 85 miles per hour has more kinetic energy than one thrown at 70 miles per hour
- iii. Kinetic theory states that all particles of matter are in constant motion – this helps explain the behavior of different states of matter
- iv. Particles of matter in an object are attracted to each other, and this attraction increases as they get close together

c. Behavior of Gases

- i. Particles in a gas are far apart and move fast; therefore, the forces of attraction between them are weak and can be ignored
- ii. The fast, constant motion of gas particles allows them to fill a container of any shape or size
- iii. 3 Main points of Kinetic Theory of Gases:
 1. Gas particles move constantly in random directions

2. Motion of one particle doesn't affect another until they collide
3. Forces of attraction between gas particles can usually be ignored
- d. Behavior of Liquids**
 - i. Liquid particles have lower speed (less kinetic energy) than those of a gas
 - ii. Liquid particles are close together, so forces of attraction affect their behavior
 - iii. A liquid takes the shape of its container because of particle motion, but has definite volume because of forces of attraction
- e. Behavior of Solids**
 - i. Solid particles are very close together, so motion is limited
 - ii. This limited motion means solids have definite volume and shape
- II. The Gas Laws** – behavior of gases is related to pressure, temperature and volume of gas particles
 - a. Pressure**
 - i. Pressure is the force distributed over an area (snowshoes help keep you from sinking in the snow – they reduce pressure by increasing the area supporting your weight)
 - ii. Pressure is caused by gas particles hitting the walls of the container holding the gas
 - b. Factors that Affect Gas Pressure (P)**
 - i. *Temperature (T)* – as temperature goes up, pressure goes up if volume and number of particles are constant
 - ii. *Volume (V)* – as volume increases, pressure decreases if temperature and number of particles are constant
 - iii. *Number of Particles (n)* – as the number of gas particles increases, pressure goes up if temperature and volume are constant
 - iv. Charles's Law**
 1. Volume of a gas is directly proportional to temperature (as T increases, V increases if n and P are constant)
 2.
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
 - v. Boyle's Law**
 1. Volume of a gas is inversely proportional to pressure (as P increases, V decreases if n and T are constant)
 2.
$$P_1V_1 = P_2V_2$$
 - vi. Ideal Gas Law**
 1. Combines Charles's Law and Boyle's Law
 2. Relates gas pressure, temperature, volume and number of particles in one equation
 3.
$$PV = nRT$$
- III. Phase Changes**
 - a. Reversible physical change that occurs when a substance changes from one state to another

- b. Six common phase changes: (*also see figure below*)
- Melting*: solid → liquid
 - Freezing*: liquid → solid
 - Vaporization*: liquid → gas
 - Condensation*: gas → liquid
 - Sublimation*: solid → gas
 - Deposition*: gas → solid
- c. The temperature of a substance **DOES NOT CHANGE** during a phase change because *all of the energy is going to break up attractions between particles instead of to increasing particle motion*
- d. Phase changes are either *exothermic* (energy is released to surroundings) or *endothermic* (energy is absorbed from surroundings) – see figure below

