# Unit 8: States of Matter

**Phases**

- Solids: rigid, definite volume (non-compressible)
- Liquids: fluid, definite volume (non-compressible)
- Gases: fluid, indefinite volume (compressible)

**Intermolecular Attractive Forces (weakest to strongest)**

- London dispersion forces (nonpolar molecule to nonpolar molecule)
- Dipole dipole forces (polar molecule to polar molecule)
- Hydrogen bonding (polar molecule to hydrogen attached to N, O, F)
- Metallic bonding (between atoms in a metallic lattice)
- Ionic bonding (between ions in a salt lattice)
- Covalent bonding (between atoms in a network solid)

**Properties of Liquids**

- Cohesion - attractive force between molecules of the same type
    - Viscosity: the resistance to flow
    - Surface tension: attraction between molecules at the surface that prevent surface penetration
- Adhesion - attraction of a molecule to a surface
    - Capillary action: the interaction between a liquid with a solid surface that causes the liquid to rise through narrow tubes

**Phase Changes**

- Solid --> Liquid = melting (endothermic)
- Liquid --> Solid = freezing (exothermic)
- Liquid --> Gas = boiling/vaporization (endothermic)
- Gas --> Liquid = condensation (exothermic)
- Solid --> Gas = sublimation (endothermic)
- Gas--> Solid = deposition (exothermic)

**Heating and Cooling Curves**

- Temperature vs. Time
- Temperature of a sample increases/decreases until a phase change (kinetic energy increases/decreases)
- Temperature remains constant during a phase change

**Phase Diagrams**

- AKA "Butt diagrams"
- Pressure vs. Temperature
- Triple point: conditions under which sample exists as three separate phases and undergoes many phase changes simultaneously
- Critical point: beyond the critical temperature, particles have too much kinetic energy and no amount of pressure can cause the gas to condense
- If the slope of the melting point line is negative (as it is for water), the liquid phase is more dense than the solid phase

**Variables Affecting Gases**

- Temperature - Average kinetic energy
    - Measured in °C or K
    - K = °C - 273
- Pressure - Force per unit area
    - Measured in atmospheres (atm)
    - 1 atm = 14.7 psi = 760 mmHg = 760 torr = 101.3 kPa
- Volume - amount of occupied space (container)
    - Measured in liters
    - 1 L = 1000mL = $1000cm^3$
- STP = Standard Temperature and Pressure = 0°C and 1 atm

**Kinetic Molecular Theory**

- Particles are in constant motion with speed determined by temperature
- Particles travel in a straight line until they collide with something
- Collisions with the container walls are measured as pressure
- (assume) Collisions are perfectly elastic
- (assume) Volume of the particles is negligible
- (assume) Interactions between particles are negligible
- A gas that meets all three assumptions is an ideal gas (as opposed to a real gas)

**Gas Laws**

- Boyle's Law
    - When T is constant, P is inversely proportional to V
    - $P_1V_1 = P_2V_2$
- Charles' Law
    - When P is constant, V is directly proportional to the Kelvin T
    - $V_1/T_1 = V_2/T_2$
- Gay-Lussac's Law
    - When V is constant, P is directly proportional to the Kelvin T
    - $P_1/T_1 = P_2/T_2$
- Combined Gas Law
    - $P_1V_1/T_1 = P_2V_2/T_2$
- Ideal Gas Law
    - PV = nRT
    - P is pressure in atm
    - V is volume in L
    - n is amount in mol
    - T is temperature in K
    - R is universal gas constant 0.0821 L*atm/mol*K
- Dalton's Law of Partial Pressures
    - The total pressure of a mixture of gases is equal to the sum of the partial pressures of the components
    - $P_1 + P_2 + ... P_n = P_{tot}$
- Graham's Law of Diffusion
    - The rate of diffusion of a gas to fill a container or effusion through a small opening is inversely related to the size of the particle
    - "Fat people run slow"

**Gas Stoichiometry**

- One mole of any gas at STP has a volume of 22.4 L