I. Chapter 10 Gases

A. 10.1 Characteristics of Gases

- Common compounds that are gases at room temperature of often composed entirely of nonmetals, have simple molecular formulas, and low molar masses.
- **Vapor**: the gaseous state of a substance which normally exist as a liquid or solid.
- A gas expands spontaneously to fill its container.
- The volume of a gas equals the volume of its container.
- Gases are highly compressible.
- Two or more gases form homogenous mixtures regardless of their identities or proportion.
- Characteristic properties of gases: expand to fill a container, being highly compressible, forming homogenous mixtures—arise because the molecules are relatively far apart.
- In any given volume of air, the molecules take up only about .1% of the total volume with the rest being made up of empty space.

B. 10.2 Pressure

- **Pressure P**: the force, F, that acts on a given area, A. $P = \frac{F}{A}$
- Gases exert pressure on any surface with which they are in contact.

1. Atmospheric Pressure and the Barometer

- Atmospheric pressure: the force exerted by the atmosphere on a given surface area.
- The force F, exerted by any object is the product of its mass, m, and its acceleration, a: $F = ma$
- The acceleration given by earth's gravitational force is $9.8\, m/s^2$
- 1 cross section of $1\, m^2$ of Earth's surface weighs 10,000kg.
- $F = (10{,}000\, kg)\left(9.8 \frac{m}{s^2}\right) = 1 \times 10^5\, kg \cdot \frac{m}{s^2} = 1 \times 10^5\, N$
- N is an abbreviation for *Newton*, the SI unit for force.
- 1 N= $1\, kg \cdot m/s^2$
- Magnitude of atmospheric pressure at sea level

  $$P = \frac{F}{A} = \frac{1 \times 10^5 N}{1 m^2} = 1 \times 10^5 Pa = 1 \times 10^2 kPa$$

- The SI unit of pressure is the Pascal (Pa); 1Pa= $1\, N/m^2$
- $1 ¿ 10^5 Pa = \frac{10^5 N}{m^2}$
- So the atmospheric pressure at sea level is equal to 1 bar.
- **Standard atmospheric pressure**: the typical pressure at sea level.
- $1\, atm = 760.\, mm\, Hg = 760\, torr = 1.01325 \times 10^5\, Pa = 101.325\, kPa = 1.01325 ¿$

C. 10.3 The Gas Laws

- Four variables are needed to define the physical condition, or state, of a gas: temperature, pressure, volume, and amount of gas, usually expressed as a number of moles.
- The equations that express the relationship between temperature, pressure, volume, and amount of a gas are known as *gas laws*.

1. The Pressure-Volume Relationship: Boyle's Law

- Gas volume increases, as the pressure exerted on the gas decreases.
- **Boyle's law**: *the volume of a fixed quantity of gas maintained at constant temperate is inversely proportional to the pressure.*
- Inversely proportional means as one gets larger, the other gets smaller.
- Boyle's Law equation: $V = constant \times \frac{1}{P}$ or PV= Constant
- The value of the constant depends on the temperature and amount of gas in the sample.

2. The Temperature-Volume Relationship: Charles's Law

- As temperature increases, volume increases.
- As temperature decreases, volume decreases.
- *The volume of a fixed amount of gas maintained at constant pressure is directly proportional to its absolute temperature.*
- Charles Law: $V = constant \times T$ or $\frac{V}{T} = constant$

3. The Quantity-Volume Relationship: Avogadro's Law

- *Law of combining volumes:* at a given temperature and pressure, the volumes of gases that react with one another are in ratios of small whole numbers.
- **Avogadro's hypothesis:** *equal volumes of gases at the same temperature and pressure contain equal numbers of molecules.*
- **Avogadro's Law:** *the volume of a gas maintained at constant temperature and pressure is directly proportional to the number of moles of the gas.*
- Avogadro's law: $V = constant \times n$ where n is number of moles.

D. 10.4 The Ideal-Gas Equation

- *Boyle's Law*: $V \propto \frac{1}{P}$ (constant n, T)
- *Charles's Law*: $V \propto T$ (constant n, P)
- *Avogadro's Law*: $V \propto n$ (constant P, T)
- *General Gas Law*: $V \propto \frac{nT}{P}$
- Naming the proportionality constant, R, $V = R(\frac{nT}{P})$
- **Ideal-Gas Equation** aka **Ideal-Gas Law**: $PV = nRT$ "pervnert"

- In deriving the ideal gas equation, we assume (a) that the molecules of an ideal gas do not interact with each other. As well as (b) that the combine volume of the molecules is much smaller than the volume the gas occupies.
- The term R in the ideal-gas law is the **gas constant.**
- The value and units for R depend on the units of P, V, n, and T.
- The value of T in the ideal gas law must *always* be the absolute temperature (in kelvins instead degrees Celsius).
- The quantity of gas, n, is normally expressed in moles.
- R is most often going to be equal to $0.08206\, L \cdot atm / mol \cdot K$ because pressure is mostly given in atmospheres.
- **Standard temperature and pressure (STP):** the conditions 0° C and 1 atm.
- The volume occupied by 1 mol of ideal gas at STP is 22.41 L.

1. Relating the Ideal-Gas Equation and the Gas Laws.

- At constant n and T, $P_1 V_1 = P_2 V_2$
- At constant n, $\frac{PV}{T} = nR = constant$
- Combined gas law: at constant n, $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

E. 10.5 Further Applications of the Ideal-Gas Equation

1. Gas Densities and Molar Mass

- Density of a gas can be expressed by: $d = \frac{nM}{V} = \frac{PM}{RT}$, where d is density and M is molar mass.
- Molar mass can be expressed by: $M = \frac{dRT}{P}$
- The higher the molar mass and pressure, the denser the denser the gas.
- The higher the temperature, the less dense the gas.

2. Volumes of Gasses in Chemical Reactions

- The coefficients in a balanced chemical equation tell us the relative amounts (in moles) of the reactants and products in a reaction
- The ideal gas equation relates the number of moles of a gas to P, V, and T.

F. 10.6 Gas Mixtures and Partial Pressures

- Dalton's Law The *total pressure of a mixture of gases equals the sum of the pressure that each would exert if it were present alone*.
- **Partial Pressure**: The pressure exerted by a particular component of a mixture of gases.
- If all the gases are at the same temperature and occupy the same volume, their total pressure equals: $P_t = (n_1 + n_2 + n_3 + \ldots)\left(\frac{RT}{V}\right) = n_t\left(\frac{RT}{V}\right)$