The Gas Laws

Chem1A, General Chemistry I

Gases are measured by: pressure (P), volume (V), amount (n), and temperature (T).

Temperature must always be in Kelvin (K) to avoid negative temperatures.

THE SIMPLE GAS LAWS

- Boyle's Law: When n and T are constant, P and V are inversely related.

$$P \cdot V = \textbf{constant} \qquad \text{OR} \qquad \mathbf{P_1V_1 = P_2V_2}$$

- Charles' Law: When n and P are constant, V and T are directly related.

$$\frac{V}{T} = \textbf{constant} \qquad \text{OR} \qquad \mathbf{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$$

- Avogadro's Law: When P and T are constant, V and n are directly related.

$$\frac{V}{n} = \textbf{constant} \qquad \text{OR} \qquad \mathbf{\frac{V_1}{n_1} = \frac{V_2}{n_2}}$$

- Gay-Lussac's Law: When n and V are constant, P and T are directly related.

$$\frac{P}{T} = \textbf{constant} \qquad \text{OR} \qquad \mathbf{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$$

THE IDEAL GAS LAW

- P = atmospheres (atm), V = Liters (L), n = moles (mols), T = Kelvin (K)

$$\mathbf{\frac{PV}{nT} = R} \qquad \text{OR} \qquad \mathbf{PV = nRT}$$

R = universal gas constant, 0.08206 (L·atm)/(mol·K)

- Density: of a gas in g/L

$$\textbf{Density}\ (g/L) = \frac{P \times (\text{molar mass})}{RT}$$

MIXTURES OF GASES

- Dalton's Law: The total pressure of a mixture of gases is equal to the sum of each of the partial pressures.

$$\mathbf{P_T} = P_1 + P_2 + \ldots P_n \qquad \text{OR} \qquad \mathbf{P_1} = \chi_1 P_T$$

mole fraction (χ_1) = mols of gas 1/total mols mixture

MOVEMENT OF GASES

- Root Mean Squared Speed: Typically the average speed a particle of gas travels, in m/s.

  $$u_{RMS} = \sqrt{\frac{3RT}{M}}$$

  R = universal gas constant, 8.314 J/(mol · K)
  T = absolute T, in K
  M = molar mass, in kg/mol
- Graham's Law: The rate of effusion is inversely proportional to the gas's molar mass.

  $$\sqrt{\frac{M_2}{M_1}} = \frac{r_1}{r_2}$$

  rate = inversely proportional to time

REAL GASES

- Van der Waals Equation: At high pressures and low temperatures, gases behave non-ideally. Individual particle volume increases V and intermolecular, attractive forces between particles and wall decrease P.

  $$(P + \frac{n^2a}{V^2})(V - nb) = nRT$$

  n = amount of particles
  a = experimentally derived constant individual to the gas
  b = experimentally derived constant individual to the gas