Van der Waals eqn: \[ P + \frac{a}{V_m^2} (V_m - b) = RT \]

Virial eqn: \[ Z = \frac{P V_m}{RT} = 1 + \frac{B(T)}{V_m} + \frac{C(T)}{V_m^2} + \ldots \]

Adiabatic expansion: \[ P V_1^\gamma = P_2 V_2^\gamma \] and \[ \frac{T_2}{T_1} = \left( \frac{V_1}{V_2} \right)^{\gamma - 1} \] where \( \gamma = \frac{C_{p,m}}{C_{v,m}} \)

Definition of ideal gas thermometer: \[ \frac{T_2}{T_1} = \lim_{P \to 0} \frac{(PV)_2}{(PV)_1} \]

Ideal gas law in terms of density: \[ \rho = \frac{PM}{RT} \] where \( M \) is the molar mass

Kinetic energy per molecule of an ideal gas: \[ \bar{E_k} = \frac{3}{2} k_B T \]

Graham’s Law of Effusion: \[ \frac{\text{rate (gas 1)}}{\text{rate (gas 2)}} = \sqrt{\frac{M(2)}{M(1)}} = \sqrt{\frac{\rho(2)}{\rho(1)}} \] where \( M \) is molar mass and \( \rho \) is density

Root-mean-square speed of a molecule in a gas: \[ \sqrt{u^2} = \sqrt{\frac{3k_B T}{m}} \]

Average speed of a molecule in a gas: \[ \bar{u} = \sqrt{\frac{8k_B T}{\pi m}} \]

Definitions of heat capacity: \[ C_{v,m} = \left( \frac{\partial U}{\partial T} \right)_v \] and \[ C_{p,m} = \left( \frac{\partial H}{\partial T} \right)_p \]

\[ \Delta H_2 = \Delta H_1 + \int_{T_1}^{T_2} \Delta C_p dT \] to obtain \( \Delta H \) at temperature \( T_2 \) from known value of \( \Delta H \) at \( T_1 \).

\[ C_{p,m} = C_{v,m} + R \] and \( \gamma = \frac{C_{p,m}}{C_{v,m}} \)

Fundamental physical constants and conversion factors:

| \( R \) | 8.3145 J mol\(^{-1}\) K\(^{-1}\) | 0.08206 L atm mol\(^{-1}\) K\(^{-1}\) | 1 atm = 101325 Pa |
| \( L \) | 6.022 × 10\(^{23}\) mol\(^{-1}\) | | 1 bar = 1 × 10\(^5\) Pa |
| \( k_B \) | 1.3806 × 10\(^{-23}\) J K\(^{-1}\) | | 1 L = 1 dm\(^3\) = 1000 cm\(^3\) = 1 × 10\(^{-3}\) m\(^3\) |