1 Heat and Temperature

Temp. scales: $F = 32 + \frac{9}{5}C$, $K = C + 273.16$

Ideal gas equation: $pV = nRT$, $n$ : number of moles

van der Waals equation: $(p + \frac{n^2a}{V^2})(V - b) = nRT$

Thermal expansion: $L = L_0(1 + \alpha \Delta T)$, $A = A_0(1 + \beta \Delta T)$, $V = V_0(1 + \gamma \Delta T)$, $\gamma = 2\beta = 3\alpha$

Thermal stress of a material: $\frac{F}{A} = Y\Delta L$

2 Kinetic Theory of Gases

General: $M = mN_A$, $k = R/N_A$

Maxwell distribution of speed:

![Maxwell distribution of speed](image)

RMS speed: $v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M}}$

Average speed: $\bar{v} = \sqrt{\frac{8kT}{\pi m}} = \sqrt{\frac{8RT}{\pi M}}$

Most probable speed: $v_p = \sqrt{\frac{2kT}{m}}$

Pressure: $p = \frac{1}{3}\rho v_{rms}^2$

Equipartition of energy: $K = \frac{1}{2}kT$ for each degree of freedom. Thus, $K = \frac{3}{2}kT$ for molecule having $f$ degrees of freedoms.

Internal energy of $n$ moles of an ideal gas is $U = \frac{3}{2}nRT$.

3 Specific Heat

Specific heat: $s = \frac{Q}{m\Delta T}$

Latent heat: $L = Q/m$

Specific heat at constant volume: $C_v = \frac{\Delta Q}{n\Delta T}\bigg|_V$

Specific heat at constant pressure: $C_p = \frac{\Delta Q}{n\Delta T}\bigg|_p$

Relation between $C_p$ and $C_v$: $C_p - C_v = R$

Ratio of specific heats: $\gamma = C_p/C_v$

Relation between $U$ and $C_v$: $\Delta U = nC_v\Delta T$

Specific heat of gas mixture:

$$C_v = \frac{n_1C_{v1} + n_2C_{v2}}{n_1 + n_2}, \quad \gamma = \frac{n_1C_{p1} + n_2C_{p2}}{n_1C_{v1} + n_2C_{v2}}$$

Molar internal energy of an ideal gas: $U = \frac{1}{2}RT$, $f = 3$ for monatomic and $f = 5$ for diatomic gas.

4 Thermodynamic Processes

First law of thermodynamics: $\Delta Q = \Delta U + \Delta W$

Work done by the gas:

$$\Delta W = p\Delta V, \quad W = \int_{V_1}^{V_2} pdV$$

$W_{\text{isothermal}} = nRT \ln\left(\frac{V_2}{V_1}\right)$

$W_{\text{isobaric}} = p(V_2 - V_1)$

$W_{\text{adiabatic}} = \frac{p_1V_1 - p_2V_2}{\gamma - 1}$

$W_{\text{isochoric}} = 0$

Efficiency of the heat engine:

$$\eta = \frac{\text{work done by the engine}}{\text{heat supplied to it}} = \frac{Q_1 - Q_2}{Q_1}$$

$\eta_{\text{carnot}} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$

Coeff. of performance of refrigerator:

$$\text{COP} = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$$

Entropy: $\Delta S = \frac{\Delta Q}{T}$, $S_f - S_i = \int^T_s \frac{\Delta Q}{T}$

Const. $T$: $\Delta S = Q/T$, Varying $T$: $\Delta S = ms \ln \frac{T_i}{T_f}$

Adiabatic process: $\Delta Q = 0$, $pV^\gamma = \text{constant}$

5 Heat Transfer

Conduction: $\frac{\Delta Q}{\Delta T} = -KA\frac{dT}{dx}$

Thermal resistance: $R = \frac{x}{kA}$

$$R_{\text{series}} = R_1 + R_2 = \frac{1}{\frac{x_1}{K_1} + \frac{x_2}{K_2}}$$

$$\frac{1}{R_{\text{parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{x} \left(K_1A_1 + K_2A_2\right)$$

Kirchhoff’s Law:

$$\text{emissive power} = \frac{E_{\text{emissivity}}}{A_{\text{body}}} = E_{\text{blackbody}}$$

Wien’s displacement law: $\lambda_m T = b$

Stefan-Boltzmann law: $\frac{\Delta Q}{\Delta T} = \sigma e A T^4$

Newton’s law of cooling: $\frac{dT}{dt} = -bA(T - T_0)$