Thermodynamics

Heat Expansion

$$\frac{\Delta L}{L} = \alpha \Delta T, \quad \frac{\Delta V}{V} = \beta \Delta T, \quad \beta = 3\alpha$$

Heat

$$Q = mc\Delta T, \quad l_s = \frac{Q_s}{m}, \quad l_{å} = \frac{Q_{å}}{m}$$

Fluid Pressure

$$p_{tot} = p_{\text{fluid}} + p_{\text{air}} = \rho g h + p_{\text{air}}$$

Ideal Gas Law

$$pV = NkT \quad \text{or} \quad pV = nRT$$

$$\text{where} \quad n = \frac{m_{tot}}{M} = \frac{N}{N_A} \quad \text{and} \quad R = kN_A$$

Gas Density and Particle Density

$$\rho = \frac{m_{tot}}{V} = \frac{pM}{RT}, \quad n_o = \frac{N}{V} = \frac{p}{kT}$$

Barometric Height Formula

$$p = p_0 e^{-\rho_0 g h / p_0}, \quad h = \frac{p_0}{\rho_0 g} \ln \frac{p_0}{p}$$

Relative Moisture

$$R_M = \frac{p_{\text{water}}}{p_{\text{saturation}}}$$

Van der Waal's Equation

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

Molecule Radius

$$r = \left(\frac{3b}{16\pi N_A}\right)^{1/3}$$

Bernoullis Equation

$$p_1 + \frac{\rho v_1^2}{2} + \rho g y_1 = p_2 + \frac{\rho v_2^2}{2} + \rho g y_2$$

Pressure (Microscopic)

$$p = \frac{2}{3} n_o \frac{m_{\text{en}}}{2} \langle v^2 \rangle = \frac{2}{3} n_o \langle W_{\text{kin}} \rangle_{\text{en}}$$

Temperature (Microscopic)

$$\langle W_{\text{kin}} \rangle_{\text{en}} = \frac{3}{2} kT$$

Inner Energy (change)

$$\Delta U = \frac{f}{2} Nk\Delta T = \frac{f}{2} nR\Delta T$$

First Theorem

$$Q = \Delta U + W \quad \text{with} \quad W = \int_1^2 p\,dV$$

Isokor

$$W \equiv 0$$

Isobar

$$W = p\,(V_2 - V_1)$$

Isotherm

$$W = nRT \ln\left(\frac{V_2}{V_1}\right)$$

Adiabat

$$W = -\Delta U$$

Molar Heat Capacity

$$C = Mc, \quad C_V = \frac{f}{2} R, \quad C_p = C_V + R$$

Adiabat(Poissons Equations)

$$T_1 V_1^{(\gamma-1)} = T_2 V_2^{(\gamma-1)}$$
$$p_1 V_1^{\gamma} = p_2 V_2^{\gamma}$$

Quotient

$$\gamma \equiv \frac{C_p}{C_V} = \frac{c_p}{c_V} = 1 + \frac{2}{f}$$

Circuit Process

$$Q_{\text{net}} = W_{\text{net}} = \oint pdV$$

Efficiency

$$\eta = \frac{W_{\text{net}}}{Q_{\text{in}}} = \frac{Q_{\text{in}} - |Q_{\text{out}}|}{Q_{\text{in}}} = 1 - \frac{|Q_{\text{out}}|}{Q_{\text{in}}}$$

Ideal Efficiency

$$\eta = \frac{T_{\text{warm}} - T_{\text{cold}}}{T_{\text{warm}}} = 1 - \frac{T_{\text{cold}}}{T_{\text{warm}}}$$

Cold Factor (def. and Ideal)

$$K_f \equiv \frac{Q_{\text{in}}}{|W_{\text{net}}|}, \quad K_f = \frac{T_{\text{cold}}}{T_{\text{warm}} - T_{\text{cold}}}$$

Heat Factor (def. and Ideal)

$$V_f \equiv \frac{Q_{\text{out}}}{|W_{\text{net}}|}, \quad V_f = \frac{T_{\text{warm}}}{T_{\text{warm}} - T_{\text{cold}}}$$

Gauss Distribution

$$f(v_z) = \sqrt{\frac{m_{\text{en}}}{2\pi kT}} e^{-m_{\text{en}} v_z^2/(2kT)}$$

Maxwell–Boltzmann Distribution

$$f(v) = 4\pi v^2 \left(\frac{m_{\text{en}}}{2\pi kT}\right)^{3/2} e^{-m_{\text{en}} v^2/(2kT)}$$

Average energy

$$\langle W_{\text{kin}} \rangle = \left\langle \frac{m_{\text{en}} v^2}{2} \right\rangle = \frac{m_{\text{en}}}{2} \langle v^2 \rangle = \frac{3}{2} kT$$

Maxwell-Boltzmann velocities

$$v_{rms} = \sqrt{\langle v^2 \rangle} = \sqrt{\frac{3kT}{m}}$$

$$v_{max} = \sqrt{\frac{2kT}{m}}$$

$$\langle v \rangle = \int_0^\infty f_{MB} \cdot v \cdot dv = \sqrt{\frac{8kT}{\pi m}}$$

Mean Free Path

$$l = \frac{1}{n_o \pi d^2 \sqrt{2}}$$

Heat Conduction

$$P = k \cdot A \cdot \left|\frac{\mathrm{d}T}{\mathrm{d}x}\right|, R = \frac{\Delta x}{kA}$$

Thermal resistance

$$\Delta T = R_{therm} \cdot P \;\; if \;\; R_{therm} = \frac{\Delta x}{kA}$$

Heat Transfer

$$P = \alpha \cdot A \cdot |\Delta T|, \; R = \frac{1}{\alpha A}$$

Stefan-Boltzmann's law

$$P = A\sigma \left(T^4 - T_0^4\right), \sigma = 5.67 \cdot 10^{-8} \mathrm{W/m^2K^4}$$

$$P_{real} = \varepsilon \cdot P_{ideal}$$

Wien's law

$$\lambda_{max} \cdot T = 2.898 \cdot 10^{-3} \mathrm{K \cdot m}$$

Planck's law

$$\rho(f)df = \frac{8\pi h f^3}{c^3} \cdot \frac{1}{e^{hf/kT} - 1} df$$

The solar constant

$$\text{Average value} \approx 1380 \; W/m^2$$