Thermodynamics

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Heat Expansion

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

Heat

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

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

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

Critical Point

$$V_k = 3nb, \quad T_k = \frac{8a}{27Rb}, \quad p_k = \frac{a}{27b^2}$$

Molecule Radius

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

Vapor Pressure Curve

$$p = Ae^{-Ml_{\mathring{a}}/(RT)}$$

Reynolds Number

$$Re = \frac{\rho v d}{\eta}, \quad Re < 2300 \text{ laminar}$$

Volume Flow

$$\Phi = \frac{\mathrm{d}V}{\mathrm{d}t} = A_1 v_1 = A_2 v_2$$

Bernoullis Equation

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

Poiseuilles Law

$$\Phi = \frac{\pi R^4}{8\eta} \frac{(p_1 - p_2)}{L}$$

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

$$Q_{\text{net}} = W_{\text{net}} = \oint p dV$$

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

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

Averages

$$\langle v \rangle = \sqrt{\frac{8kT}{\pi m_{\text{en}}}}, \quad \langle v \rangle = 2\langle |v_x| \rangle$$
$$\langle W_{\text{kin}} \rangle = \left\langle \frac{m_{\text{en}} v^2}{2} \right\rangle = \frac{m_{\text{en}}}{2} \langle v^2 \rangle = \frac{3}{2} kT$$

Collision Number (per second and square meter)

$$n^* = \frac{n_o}{4} \langle v \rangle$$

Mean Free Path

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

Heat Conduction (General and Rod)

$$P = -\lambda A \frac{\mathrm{d}T}{\mathrm{d}x}, \quad P = \lambda A \frac{T_1 - T_2}{L}$$

Heat Transfer

$$P = \alpha A \Delta T$$

Radiation

$$P_{\text{ideal}} = \sigma A T^4, \quad P_{\text{real}} = e P_{\text{ideal}}$$

Tables

Saturation Pressure for Water

$t/^\circ$C	Water/kPa
-30	0.0381
-20	0.103
-15	0.165
-10	0.260
-5	0.401
0	0.610
5	0.872
10	1.23
15	1.70
20	2.34
25	3.17
30	4.24
35	5.64
40	7.37
50	12.3
60	19.9
70	31.2
80	47.3
90	70.1
100	101.3
110	143.2
120	198.4
130	270.0

Length expansion coefficient at 20 °C and normal air pressure.

Substance	$\alpha/(10^{-}6\mathrm{K}^{-}1)$	Substance	$\alpha/(10^{-}6\mathrm{K}^{-}1)$
Aluminum	23	Glass (typical)	6.0
Silver	19	Tungsten	4.3
Brass (Cu + Zn)	19	Marble (typical)	2.5
Copper	17	Invar (Fe + Ni)	2.0
Iron	12	Graphite	2.0
Steel	11	Diamond	1.2
Platinum	9.0	Quartz	0.4