
Chapter 1: $T_K = T_C + 273.15$ $pV = nRT = NkT$ $R = N_A k$ $v_{\text{rms}} = \sqrt{\frac{3kT}{m}}$

$U_{\text{thermal}} = N \frac{f}{2} kT$ $\Delta U = Q + W$ $dU = dQ + dW$ $W = - \int_{V_i}^{V_f} p dV$

$p_1 V_1^\gamma = p_2 V_2^\gamma$ $V_1 T_1^{f/2} = V_2 T_2^{f/2}$ $\gamma = \frac{C_p}{C_V} = \frac{f+2}{f}$ $C = \frac{Q}{\Delta T} = \frac{\Delta U - W}{\Delta T}$

$Q = mc\Delta T$ $C_V = \left(\frac{\partial U}{\partial T} \right)_V = n \left(\frac{f}{2} \right) R$ $C_p = C_V + nR$ $Q = mL$

$H = U + pV$

Chapter 2: $\Omega(N, m) = \binom{N}{n} = \frac{N!}{n!(N-n)!}$ $\Omega(N, q) = \binom{q+N-1}{q} = \frac{(q+N-1)!}{q!(N-1)!}$

$\Omega(N, N_\uparrow) = \frac{N!}{N_\uparrow!(N-N_\uparrow)!}$ $N! \approx N^N e^{-N} \sqrt{2\pi N}$ $\ln N! \approx N \ln N - N$

$\Omega(N, U, V) = \frac{1}{N!} \frac{V^N}{h^{3N}} \frac{\pi^{3N/2}}{(3N/2)!} (\sqrt{2mU})^{3N}$ $S \equiv k \ln \Omega$ $S = Nk \left[\ln \left(\frac{V}{N} \left(\frac{4\pi mU}{3Nh^2} \right)^{3/2} \right) + \frac{5}{2} \right]$

Chapter 3: $\frac{1}{T} = \left(\frac{\partial S}{\partial U} \right)_{N,V}$ $C_V = \left(\frac{\partial U}{\partial T} \right)_{N,V}$ $dS = \frac{C_V dT}{T}$ $U = \mu B (N_\downarrow - N_\uparrow)$

$M = \mu (N_\uparrow - N_\downarrow)$ $p = T \left(\frac{\partial S}{\partial V} \right)_{U,N}$ $\mu = -T \left(\frac{\partial S}{\partial N} \right)_{U,V}$ $dU = TdS - pdV + \mu dN$

Chapter 4: $e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H} \leq 1 - \frac{T_C}{T_H}$ $\text{COP} = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C} \leq \frac{T_C}{T_H - T_C}$

Chapter 5: $H = U + pV$ $F = U - TS$ $G = U - TS + pV$ $dF = -SdT - pdV + \mu dN$

$dG = -SdT + Vdp + \mu dN$ $\frac{dp}{dT} = \frac{L}{T\Delta V}$

Chapter 6: $\mathcal{P}(s) = \frac{1}{Z} e^{-E(s)/kT}$ $Z = \sum_s e^{-E(s)/kT}$ $\beta = \frac{1}{kT}$ $\bar{E} = -\frac{1}{Z} \frac{\partial Z}{\partial \beta}$

$\bar{X} = \frac{1}{Z} \sum_s X(s) e^{-\beta E(s)}$ $\mathcal{D}(v) = \left(\frac{m}{2\pi kT} \right)^{3/2} 4\pi v^2 e^{-mv^2/2kT}$ $F = -kT \ln Z$

$Z_{\text{total}} = Z_1 Z_2 \dots Z_N$ noninteracting, distinguishable

$Z_{\text{total}} = \frac{1}{N!} Z_1^N$ noninteracting, indistinguishable $\ell_Q \equiv \frac{h}{\sqrt{2\pi m kT}}$ $v_Q = \ell_Q^3$

$Z = \frac{1}{N!} \left(\frac{V Z_{\text{int}}}{v_Q} \right)^N$ $\ln Z = N [\ln V + \ln Z_{\text{int}} - \ln N - \ln v_Q + 1]$

Chapter 7: $\mathcal{P}(s) = \frac{1}{Z} e^{-[E(s) - \mu N(s)]/kT}$ $Z = \sum_s e^{-[E(s) - \mu N(s)]/kT}$

$\bar{n}_{\text{FD}} = \frac{1}{e^{(\epsilon - \mu)/kT} + 1}$ $\bar{n}_{\text{BE}} = \frac{1}{e^{(\epsilon - \mu)/kT} - 1}$ $\bar{n}_{\text{Boltzmann}} = \frac{1}{e^{(\epsilon - \mu)/kT}}$

$$\epsilon_F = \frac{h^2}{8m} \left(\frac{3N}{\pi V} \right)^{2/3} \quad U = \frac{3}{5} N \epsilon_F \quad p = \frac{2}{3} \frac{U}{V} \quad g(\epsilon) = \frac{\pi(8m)^{3/2}}{2h^3} V \sqrt{\epsilon}$$

$$N = \int_0^\infty g(\epsilon) \bar{n}_{FD}(\epsilon) d\epsilon \quad U = \int_0^\infty \epsilon g(\epsilon) \bar{n}_{FD}(\epsilon) d\epsilon \quad u_\lambda(\lambda) d\lambda = V(8\pi hc) \frac{\lambda^{-5}}{e^{hc/\lambda kT} - 1} d\lambda$$

$$u_\epsilon(\epsilon) d\epsilon = V \frac{8\pi}{(hc)^3} \frac{\epsilon^3}{e^{\epsilon/kT} - 1} d\epsilon \quad \lambda_{\text{peak}} T = 2.89777 \times 10^6 \text{ nm K} \quad \text{power} = \sigma_{\text{SB}} e A T^4$$

Constants: $1 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$ $R = 8.3145 \text{ J mol}^{-1} \text{ K}$ $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
 $e = 1.602 \times 10^{-19} \text{ C}$ $k = 1.381 \times 10^{-23} \text{ J/K} = 8.617 \times 10^{-5} \text{ eV/K}$

$$\mu_B = \frac{eh}{4\pi m_e} = 9.274 \times 10^{-24} \text{ J/T} = 5.788 \times 10^{-5} \text{ eV/T} \quad \sigma_{\text{SB}} = 5.67 \times 10^{-8} \text{ W/m}^2/\text{K}^4$$

Math: $e^x \approx 1+x$ for $|x| \ll 1$ $(1+x)^n \approx nx$ for $|x| \ll 1$ $\ln(1+x) \approx x$ for $|x| \ll 1$

$$\sinh(x) = \frac{e^x - e^{-x}}{2} \quad \cosh(x) = \frac{e^x + e^{-x}}{2} \quad \tanh(x) = \frac{\sinh(x)}{\cosh(x)} = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

$\tanh(x) \approx x$ for $|x| \ll 1$

$$\int_0^\infty \frac{x}{e^x - 1} dx = \frac{\pi^2}{6} \quad \int_0^\infty \frac{x^2}{e^x - 1} dx = 2.404 \quad \int_0^\infty \frac{x^3}{e^x - 1} dx = \frac{\pi^4}{15}$$