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

$$U_{\rm thermal} = N\frac{f}{2}kT \qquad \Delta U = Q + W \qquad dU = đQ + đW \qquad W = -\int_{V_i}^{V_f} p\,dV$$

$$p_1V_1^\gamma = p_2V_2^\gamma \qquad V_1T_1^{f/2} = V_2T_2^{f/2} \qquad \gamma = \frac{C_p}{C_V} = \frac{f+2}{f} \qquad C = \frac{Q}{\Delta T} = \frac{\Delta U - W}{\Delta T}$$

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

$$H = U + pV$$

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

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

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

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

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

Chapter 4: $e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H} \le 1 - \frac{T_C}{T_H}$ $\qquad \mathrm{COP} = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C} \le \frac{T_C}{T_H - T_C}$

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

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

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

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

$Z_{\rm total} = Z_1 Z_2 \ldots Z_N$ noninteracting, distinguishable

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

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

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

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

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

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

$u_\epsilon(\epsilon)d\epsilon = V\frac{8\pi}{(hc)^3}\,\frac{\epsilon^3}{e^{\epsilon/kT}-1}d\epsilon$ $\lambda_{\text{peak}}T = 2.897\,77\times10^6\,\text{nm K}$ $\text{power} = \sigma_{SB}eAT^4$

Constants: $1\,\text{atm} = 1.013\times10^5\,\text{Pa}$ $R = 8.3145\,\text{J mol}^{-1}\,\text{K}$ $N_A = 6.022\times10^{23}\,\text{mol}^{-1}$

$e = 1.602\times10^{-19}\,\text{C}$ $k = 1.381\times10^{-23}\,\text{J/K} = 8.617\times10^{-5}\,\text{eV/K}$

$\mu_B = \frac{eh}{4\pi m_e} = 9.274\times10^{-24}\,\text{J/T} = 5.788\times10^{-5}\,\text{eV/T}$ $\sigma_{\text{SB}} = 5.67\times10^{-8}\,\text{W/m}^2/\text{K}^4$

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

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

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

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