Formulae for Final

$$k = 1.381 \cdot 10^{-23} \text{ J/K} = 8.617 \cdot 10^{-5} \text{ eV/K} \qquad h = 6.626 \cdot 10^{-34} \text{ Js} = 4.136 \cdot 10^{-15} \text{ eVs}$$

$$N_A = 6.022 \cdot 10^{23} \qquad c = 2.998 \cdot 10^8 \text{ m/s}$$

$$\Delta U = Q + W_{\text{on}} \qquad \text{where} \qquad W_{\text{on}} = -\int p \, dV$$

$$pV = NkT \qquad pV^\gamma = \text{const.}, \text{ where } \gamma = (f+2)/f$$

$$U = \tfrac{f}{2}NkT \qquad \tfrac{1}{2}kT \text{ for each quadratic degree of freedom}$$

$$\Omega = \begin{pmatrix} q + N - 1 \\ q \end{pmatrix} \qquad \Omega = \begin{pmatrix} N \\ n \end{pmatrix} = \frac{N!}{n!(N-n)!}$$

$$\ln N! \approx N \ln N - N \qquad \ln(1+x) \approx x$$

$$S = Nk \left[\ln \left(\frac{V}{N} \left(\frac{4\pi mU}{3Nh^2} \right)^{3/2} \right) + \frac{5}{2} \right]$$

$$C_V = T \left(\frac{\partial S}{\partial T} \right)_{V,N} \qquad C_p = T \left(\frac{\partial S}{\partial T} \right)_{p,N} \qquad C_V = \left(\frac{\partial U}{\partial T} \right)_{V,N} \qquad \Delta S = \int \frac{C \, dT}{T}$$

$$dU = TdS - pdV + \mu dN$$

$$H = U + pV \qquad F = U - TS \qquad G = U - TS + pV$$

$$S = k \ln \Omega \qquad dS \geq 0 \qquad dS \geq \frac{Q}{T}$$

$$G = \mu N \qquad p = \frac{NkT}{(V-bN)} - a\frac{N^2}{V^2}$$

$$\epsilon = \frac{W}{Q_h} = \frac{W_{\text{by}}}{Q_h} \qquad \text{COP} = \frac{Q_c}{W} \qquad \frac{dp}{dT} = \frac{\Delta S}{\Delta V} = \frac{L}{T\Delta V}$$

$$\cosh(x) = \frac{e^x + e^{-x}}{2} \qquad \sinh(x) = \frac{e^x - e^{-x}}{2} \qquad \tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \qquad \frac{d \tanh(x)}{dx} = \frac{1}{\cosh^2(x)}$$

$$\overline{X} = \sum_s X(s) P(s)$$

Canonical: $\qquad P(s) = \frac{e^{-E(s)/(kT)}}{Z} \qquad \overline{X} = \frac{\sum_s X(s) e^{-E(s)/(kT)}}{Z} \qquad Z = \sum_s e^{-E(s)/(kT)}$

$$\overline{E} = -\frac{1}{Z}\frac{\partial}{\partial \beta}(Z) \qquad \beta = \frac{1}{(kT)} \qquad F = -kT \ln Z$$

$$D(v) = \left(\frac{m}{2\pi kT} \right)^{3/2} 4\pi v^2 e^{-mv^2/(2kT)}$$

$$Z_{\text{idealgas}} = \frac{1}{N!} \left(\frac{V Z_{\text{int}}}{v_Q} \right)^N \text{ where } v_Q = \left(\frac{h}{\sqrt{2\pi mkT}} \right)^3$$

$$\int_0^\infty e^{-ax^2} dx = \frac{1}{2}\sqrt{\frac{\pi}{a}} \qquad \int_0^\infty x^2 e^{-ax^2} dx = \frac{\sqrt{\pi}}{4} a^{-3/2} \qquad \int_0^\infty x^4 e^{-ax^2} dx = \frac{3}{8}\sqrt{\frac{\pi}{a^5}} \qquad \sum_{n=0}^\infty x^n = \frac{1}{1-x}$$

Grand Can.: $\quad P(s) = \frac{e^{-[E(s)-\mu N(s)]/(kT)}}{\mathcal{Z}} \qquad \overline{X} = \frac{\sum_s X(s) e^{-[E(s)-\mu N(s)]/(kT)}}{\mathcal{Z}} \qquad \mathcal{Z} = \sum_s e^{-[E(s)-\mu N(s)]/(kT)}$

$$\overline{n}_{\text{FD}} = \frac{1}{e^{(\epsilon-\mu)/(kT)} + 1} \qquad \overline{n}_{\text{BE}} = \frac{1}{e^{(\epsilon-\mu)/(kT)} - 1} \qquad \text{sphere: } A = 4\pi R^2 \qquad V = \frac{4\pi}{3}R^3$$