"Statistical Physics" Spring 2002
Formula and Fact Sheet (Version of 25 February 2002)
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$k_B = 1.381 \times 10^{-23}$ J/K $= 8.617 \times 10^{-5}$ eV/K $\quad$ 1 eV $= 1.602 \times 10^{-19}$J $\quad k_B = \frac{R}{N_A}$

$V(r) = 4\,\epsilon \left[\left(\frac{d}{r}\right)^{12} - \left(\frac{d}{r}\right)^{6} \right] \qquad \ln(M!) \approx M\,\ln(M) - M$

$\sinh u = \frac{1}{2}(e^u - e^{-u}) \qquad \sinh u = u + \frac{u^3}{3!} + \frac{u^5}{5!} + ... + \frac{u^{2n+1}}{(2n+1)!} + ... \qquad |u| < \infty$

$\cosh u = \frac{1}{2}(e^u + e^{-u}) \qquad \cosh u = 1 + \frac{u^2}{2!} + \frac{u^4}{4!} + ... + \frac{u^{2n}}{(2n)!} + ... \qquad |u| < \infty$

$\tanh u = \frac{(e^u - e^{-u})}{(e^u + e^{-u})} \qquad \tanh u = u - \frac{1}{3}u^3 + \frac{2}{15}u^5 - \frac{17}{315}u^7 + \frac{62}{2835}u^9 - ... \qquad |u| < \frac{\pi}{2}$

$\int_0^\infty x^{2n+1}\, e^{-ax^2}\, dx = \frac{n!}{2a^{n+1}} \qquad \sum_{n=0}^{\infty} e^{-nx} = \frac{1}{1-e^{-x}} \qquad \int_{-\infty}^{\infty} e^{-ax^2} dx = \sqrt{\frac{\pi}{a}}$

$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + ... = \sum_{n=0}^{\infty} \frac{x^n}{n!}$

$\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + ... , \quad |x| < 1 , x = 1 \qquad \int_0^\infty e^{-x^2} dx = \frac{\sqrt{\pi}}{2}$

$\overline{v} = \int_0^\infty v\, f(v)\, dv \qquad \overline{v^2} = \int_0^\infty v^2\, f(v)\, dv \qquad v_{rms} = \sqrt{\overline{v^2}}$

$\Phi = \frac{1}{4}\, n\, \overline{v} \qquad P = \frac{1}{3}\, n\, m\, \overline{v^2} \qquad PV = \frac{1}{3}\, N\, m\, \overline{v^2}$

$\frac{3}{2} k_B T = \frac{1}{2} m \overline{v^2} \qquad \overline{\epsilon} = \frac{f}{2} k_B T$

$p_i = \frac{1}{W} \qquad \sum_i p_i = 1 \qquad p_i = \lim_{N\to\infty} \left(\frac{n_i}{N}\right) \qquad p_{(i+j)} = p_i + p_j \qquad p_{i,j} = p_i\, p_j$

${}^nP_r = \frac{n!}{(n-r)!} \qquad {}^nC_r = \frac{n!}{r!(n-r)!} \qquad W = \frac{N!}{n_1! \times n_2! \times n_3! \times ...}$

$\overline{x} = \frac{\sum_i n_i\, x_i}{N} \qquad \overline{x} = \sum_i p_i\, x_i \qquad (\Delta x)^2 = \sum_i p_i (x_i - \overline{x})^2$

$$P_G(x) = \frac{e^{-(x-\overline{x})^2/[2\Delta x^2]}}{(2\pi)^{\frac{1}{2}}\Delta x} \qquad P_L(x) = \frac{1}{\pi} \frac{\Gamma/2}{(x-\overline{x})^2 + (\Gamma/2)^2}$$

$$P_P(x) = \frac{\overline{x}}{x!} e^{-\overline{x}} \qquad P_B(x) = \frac{n!}{x!(n-x)!}\, p^x\, (1-p)^{n-x}$$

$S = \phi(W) \qquad S = k_B\, \ln(W) \qquad M = \frac{\mu(n_+ - n_-)}{V} = \frac{\mu N}{V} \tanh\left(\frac{\mu B}{k_B T}\right)$

$\Delta U_A^2 = -\frac{k_B}{S''} = k_B T^2 C_A \qquad M_z = -\frac{1}{V} \sum_i p_i \left(\frac{\partial E_i}{\partial B_z}\right)_V$

$Z = \sum_j e^{-E_j/k_B T} \qquad Z = \sum_n g_n e^{-E_n/k_B T} \qquad p_i = \frac{e^{-E_i/k_B T}}{Z} \qquad F = -k_B T \ln Z$

$\overline{U} = k_B T^2 \left(\frac{\partial \ln Z}{\partial T}\right)_V \qquad \overline{U} = -\frac{\partial \ln Z}{\partial \beta} \qquad \beta = \frac{1}{k_B T} \qquad dF = -SdT - PdV$

$P = -\left(\frac{\partial F}{\partial V}\right)_T \qquad P = k_B \left(\frac{\partial (T \ln Z)}{\partial V}\right)_T$

$S = -\left(\frac{\partial F}{\partial T}\right)_V \qquad S = k_B \left(\frac{\partial (T \ln Z)}{\partial T}\right)_V \qquad S = \frac{\overline{U}}{T} + k_B \ln(Z)$

$d'Q = \sum_i dp_i E_i \qquad \overline{U} = \sum_i p_i E_i \qquad d\overline{U} = \sum_i dp_i E_i + \sum_i p_i dE_i$

$\lambda = \left(\frac{2\pi\hbar^2}{m\, k_B T}\right)^{1/2} \qquad Z = Z_{trans} \times Z_{vib} \times Z_{rot}$

$$Z = \frac{1}{h} \int_{-\infty}^{\infty} dx \int_{-\infty}^{\infty} dp_x\ e^{-E(p_x,x)/k_B T} \qquad Z = \frac{1}{h^3} \int_{-\infty}^{\infty} d^3\vec{r} \int_{-\infty}^{\infty} d^3\vec{p}\ e^{-E(\vec{p},\vec{r})/k_B T}$$