

Physics 301 Formula Sheet

$$dE = \left. \frac{\partial E}{\partial S} \right|_{V,N} dS + \left. \frac{\partial E}{\partial V} \right|_{S,N} dV + \left. \frac{\partial E}{\partial N} \right|_{S,V} dN = TdS - pdV + \mu dN \quad (1)$$

$$F = U - TS = -kT \ln Z \quad (2)$$

$$dF = \left. \frac{\partial F}{\partial T} \right|_{V,N} dT + \left. \frac{\partial F}{\partial V} \right|_{T,N} dV + \left. \frac{\partial F}{\partial N} \right|_{T,V} dN = -S dT - pdV + \mu dN \quad (3)$$

$$H = U + pV \quad (4)$$

$$dH = \left. \frac{\partial H}{\partial S} \right|_{p,N} dS + \left. \frac{\partial H}{\partial p} \right|_{S,N} dp + \left. \frac{\partial H}{\partial N} \right|_{S,p} dN = T dS + V dp + \mu dN \quad (5)$$

$$G = U + pV - TS \quad (6)$$

$$dG = \left. \frac{\partial G}{\partial T} \right|_{p,N} dT + \left. \frac{\partial G}{\partial p} \right|_{T,N} dp + \left. \frac{\partial G}{\partial N} \right|_{T,p} dN = -S dT + V dp + \mu dN \quad (7)$$

$$\left. \frac{\partial T}{\partial V} \right|_S = - \left. \frac{\partial p}{\partial S} \right|_V \quad \left. \frac{\partial T}{\partial p} \right|_S = \left. \frac{\partial V}{\partial S} \right|_p \quad \left. \frac{\partial S}{\partial V} \right|_T = \left. \frac{\partial p}{\partial T} \right|_V \quad \left. \frac{\partial S}{\partial p} \right|_T = - \left. \frac{\partial V}{\partial T} \right|_p \quad (8)$$

$$\begin{matrix} V & F & T \\ E & & G \end{matrix} \quad (9)$$

$$\begin{matrix} E & & G \\ -S & H & -P \end{matrix} \quad (10)$$

$$\begin{matrix} -S & H & -P \end{matrix} \quad (11)$$

$$(12)$$

$$\sinh(x) = \frac{e^x - e^{-x}}{2} \quad \cosh(x) = \frac{e^x + e^{-x}}{2} \quad \tanh(x) = \frac{\sinh(x)}{\cosh(x)} \quad (13)$$

$$\text{Stirling's formula } N! \approx N^N e^{-N} \sqrt{2\pi N} \quad \sum_{n=0}^{\infty} x^n = \frac{1}{1-x} \quad (\text{for } x < 1) \quad (14)$$

$$\sigma_{SB} = \frac{\pi^2 k^4}{60 \hbar^3 c^2} = 5.67 \times 10^{-8} \text{ W/m}^2 \text{K}^4$$

$$\hbar = 1.05 \times 10^{-34} \text{ J s} = 6.6 \times 10^{-16} \text{ eV s}$$

$$k = 1.38 \times 10^{-23} \text{ J/K} = 8.63 \times 10^{-5} \text{ eV/K}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$G = 6.67 \times 10^{-11} \text{ m}^3/\text{s}^2 \text{ kg}$$

$$\text{Bohr magneton} = 9.27 \times 10^{-24} \text{ J/T} = 5.79 \times 10^{-5} \text{ eV/T}$$

$$\text{Proton mass} = 1.67 \times 10^{-27} \text{ kg or } 939 \text{ MeV} \quad \text{Electron mass} = 9.11 \times 10^{-31} \text{ kg or } 511 \text{ keV}$$

$$\text{Solar mass} = 1.99 \times 10^{33} \text{ kg} \quad \text{Solar radius} = 6.96 \times 10^8 \text{ m}$$

$$\text{Earth mass} = 5.98 \times 10^{24} \text{ kg} \quad \text{Earth radius} = 6.37 \times 10^6 \text{ m}$$

$$\text{Earth Sun distance} = 1.5 \times 10^{11} \text{ m}$$

It may be useful to know that 300 K corresponds to 1/40 eV.