Thermal Physics Exam 1 FORMULAS

$$g(N,s) = \frac{N!}{(\frac{1}{2}N+s)!(\frac{1}{2}N-s)!} = \frac{N!}{N_\uparrow! N_\downarrow!} \qquad g(N,s) \approx (2/\pi N)^{1/2} 2^N exp(-2s^2/N)$$

$$\langle s^2 \rangle = \int_{-\infty}^{\infty} ds \;\; s^2 g(N,s) / \int_{-\infty}^{\infty} ds \;\; g(N,s) = \frac{1}{4}N \qquad U(s) = -2smB$$

$$\langle X \rangle = \sum_s X(s)P(s) \qquad g(s) = \sum_{s_1} g_1(s_1) g_2(s-s_1) \qquad 1/\tau \equiv \left(\frac{\partial \sigma}{\partial U}\right)_{N,V}$$

$$\tau = k_B T \qquad P(\varepsilon_s) = exp(-\varepsilon_s/\tau)/Z \qquad Z = \sum_s exp(-\varepsilon_s/\tau)$$

$$p = -\left(\frac{\partial U}{\partial V}\right)_\sigma = \tau \left(\frac{\partial \sigma}{\partial V}\right)_U \qquad \sigma = -\left(\frac{\partial F}{\partial \tau}\right)_V \qquad p = -\left(\frac{\partial F}{\partial V}\right)_\tau$$

$$F = -\tau \ln(Z) \qquad Z_N = (n_Q V)^N / N! \qquad n_Q = (M\tau/2\pi\hbar^2)^{3/2}$$

$$pV = n\tau \qquad \sigma = N[\ln(n_Q/n) + \frac{5}{2}] \qquad C_V = \frac{3}{2}N$$

$$\langle s \rangle = \frac{1}{exp(\hbar\omega/\tau) - 1} \qquad \frac{U}{V} = \frac{\pi^2}{15\hbar^3 c^3}\tau^4 \qquad u_\omega = \frac{\hbar}{\pi^2 c^3} \frac{\omega^3}{exp(\hbar\omega/\tau) - 1}$$

$$J_U = \sigma_B T^4 \qquad C_V = \frac{12\pi^4 N k_B}{5}\left(\frac{T}{\theta}\right)^3 \qquad \theta = (\hbar v/k_B)(6\pi^2 N/V)^{1/3}$$

$$\mu(\tau,V,N) \equiv \mu = \left(\frac{\partial F}{\partial N}\right)_{\tau,V} \qquad \left(\frac{\partial U}{\partial N}\right)_{\sigma,V} = -\tau \left(\frac{\partial \sigma}{\partial N}\right)_{U,V}$$

$$\mu_{int} = \tau \ln(n/n_Q) \quad (n < n_Q) \qquad n_Q = (M\tau/2\pi\hbar^2)^{3/2} \qquad = \sum_{N=0}^{\infty} \sum_{s(N)} exp[(N\mu - \varepsilon_s)/\tau]$$

$$P(N,\varepsilon_s) = exp[(N\mu - \varepsilon_s)/\tau]/ \qquad \lambda \equiv exp(\mu/\tau) \qquad \langle N \rangle = \lambda \frac{\partial}{\partial \lambda} \ln(\quad)$$

$$f(\varepsilon) \approx \lambda exp(-\varepsilon/\tau) \qquad \lambda = \frac{N}{\sum_{\vec{n}} exp(-\varepsilon_{\vec{n}}/\tau)} \qquad \varepsilon_{\vec{n}} = \frac{\hbar^2}{2M}\left(\frac{\pi n}{V^{1/3}}\right)^2$$

$$\sum_{\vec{n}} exp(-\varepsilon_{\vec{n}}/\tau) = \tfrac{1}{2}\pi \int dn \;\; n^2 exp(-\varepsilon/\tau) \qquad \lambda = N/n_Q V \qquad n_Q = (M\tau/2\pi\hbar^2)^{3/2}$$

$$\mu = \tau \ln(n/n_Q) \qquad F = \int dN \;\; \mu(N,\tau,V) = N[\ln(n/n_Q) - 1]$$

$$p = -\left(\frac{\partial F}{\partial V}\right)_{\tau,N} = N\tau/V$$