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Physics 404 **HOMEWORK ASSIGNMENT #11** **Spring 2009**

Due date: Tuesday, May 12 **Deadline: Thursday, May 14, <u>2pm</u>**

B means a problem in Blundell & Blundell's text; GT means a problem in Gould & Tobochnik.

1. B29.2, a short problem

2. Consider a Fermi gas in 2 rather than 3 dimensions. (Such 2D electron gases can be found on the surface of some semiconductors, for example.)

a) Find the Fermi energy in terms of number of fermions N and area A

b) Show that the density of states is independent of ϵ and write it in terms of ϵ_F and N.

c) Show that the average energy of the fermions is $\epsilon_F/2$.

d) One can show (but you do not have to) that $\mu(T) = k_B T \ln(e^{\epsilon_F/k_B T} - 1)$.

Find the limits of $\mu(T)$ as i) T goes to 0 and ii) when $k_B T \gg \epsilon_F$ and iii) show that they make sense.

e) One can also show (but you do not have to) that for low temperature $U/N - \epsilon_F/2 = (\pi^2/6)(k_B T)^2/\epsilon_F$.

Find the associated specific heat and compare to the result in 3D.

3. B30.5 Note that $Li_1(z) \to \infty$ as $z \to 1$. (In Mathematica, $Li_1(z)$ is PolyLog[1,z].) The problem should take you only a few lines to do.

NOT assigned B29.6, which is long and involved, but I will provide solutions. Note that in eqs. (29.31) and (29.32), n_j should be $n_j!$, so that the denominators in both cases are $n_j!\,(g_j-n_j)!$. Furthermore, in eq. (29.35), there is this same error along with another in the term with parentheses: the denominator should be $n_j!\,(g_j-1)!$ In going from eq. (29.35) to (29.36), you should assume that $g_j \gg 1$ so that you can replace g_j-1 by g_j

The expression to be maximized is

$$\frac{S}{k_B} + \alpha\left(N - \sum_j g_j \bar{n}_j\right) + \beta\left(E - \sum_j g_j \bar{n}_j E_j\right)$$

This is, I believe the source of using β for $1/k_B T$.