PHY 293F – WAVES AND PARTICLES
DEPARTMENT OF PHYSICS, UNIVERSITY OF TORONTO

PROBLEM SET #8

DUE: Monday 30 November 2009, by 5 PM in drop boxes in basement of Physics building. Problem sets submitted after 5:10 PM will not be accepted.

NOTES: Marks will be given for showing workings as well as for final answers. Provide sufficient detail to explain how you got your result to the marker.

1. Calculate the Helmholtz free energy of a photon gas, such as the one we used to investigate blackbody radiation by doing the following:

   a. Calculate the Helmholtz free energy directly from $F = U - TS$. Simplify your expression to get the most compact expression possible.

   b. Verify your answer in part (a) by calculating the entropy, S and comparing it to the result we got in class. To get a compact answer in terms of V and T, you can use $\alpha = 8\pi^5 k^4 / 15(hc)^3$.

   c. Differentiate F with respect to V to get the pressure of a photon gas. Again, present your answer as the most compact expression possible.

2. Problem 7.51 on page 303-304 of Schroeder (only parts (a) – (d)).

3. Problem 7.56 on page 307 of Schroeder.

4. In equation 7.116 (p.311), there are two contributions to the heat capacity of a solid. At what temperature, T_{eq}, are these contributions equal for a sample of solid copper. Use data from Figure 7.28 (plot of C/T versus T^2), where the slope is 5×10^{-5} J/K^4 and the intercept is 0.7 mJ/K^2 for solid copper, for your calculation. Name which contribution to the heat capacity is greater above T_{eq}?