

**Physics 418**  
**Homework 4 - Due Feb. 20, 2009**

Problem 1: Patheria 1.7. Check that these results are consistent with the equations of state for an ideal photon gas, described by the equations of state  $PV = U/3$  and  $U = \sigma VT^4$  (the Stefan-Boltzmann law), where  $\sigma$  is a constant. N.B. These results must be interpreted with care because for the photon gas,  $C_p$  does not even exist, because one cannot vary the temperature at constant pressure for a photon gas.

Problem 2: Patheria 2.7. In addition, derive the exact number of ways in which the energy can be divided among the  $N$  oscillators (before taking the asymptotic limit). Calculate the entropy for this system in the thermodynamic limit. Express the internal energy  $E$  in terms of the temperature  $T$  and oscillator number  $N$ , and plot this function versus  $T$ . Also, plot the heat capacity versus temperature. Find the asymptotic limits of the energy for large and small temperature.

Problem 3: In the above problem 2, calculate the number of states  $\tilde{\Omega}(E)$  with energy less than (or equal to) the energy  $E$ . Find the number of states with energies between  $E - \Delta$  and  $E$ , where  $\Delta < E$ . Show that for  $N \gg 1$  (i.e.  $\sim 10^{23}$ ) that  $\Omega(E) = \tilde{\Omega}(E) - \tilde{\Omega}(E - \Delta) \approx \tilde{\Omega}(E)$ . How can this be? What does it imply for statistical mechanics calculations?