PHY 292S **Problem Set #3** **Winter 2008**

Due on Thursday, April 4th before the lecture.

1. Problem 6.30 on p. 237 of Schroeder. Note that this problem requires you to calculate the partition function numerically, by adding up the terms in the summation. As discussed in problem 6.28, you need to keep only 3-4 terms. However, you will need to calculate the partition function and energy as a function of temperature in order to obtain Cv by numerical differentiation. You can use numerical package (mathematica, maple, matlab, etc.) or spreadsheet such as Excel.

2. Problem 6.48 (a) on p. 255 of Schroeder. (The value of ε for oxygen is given in problem 6.24 on p.236: ε=0.00018 eV.)

3. Problem 6.17 on p. 231.

4. In the class, we considered an example of an ideal two-state paramagnet. Each microscopic magnetic dipole responds only to the external magnetic field. In the real world, however, atomic dipoles are influenced by their neighbors. In the well-known case of ferromagnetism, all the neighboring dipoles tend to align parallel to each other, even in the absence of the external magnetic field. In nature, however, more common type of magnetic order is known as antiferromagnetism, in which all the neighboring dipoles tend to align anti-parallel to each other in the absence of the external magnetic field. The simplest model proposed to describe antiferromagnetism is called nearest-neighbor Ising model, in which the interaction between the neighboring dipoles is given by the constant exchange energy. We will consider just two elementary dipoles in this problem. Specifically, the energy of these two dipoles are given by $U = \varepsilon S_1 S_2$, where S_1 takes +1 (-1) when the dipole 1 is pointing up (down), and the value of S_2 is similarly given for the dipole 2. The external magnetic field is zero.
   (a) Enumerate the (micro)states of this system and write down their Boltzmann factors.
   (b) Calculate the partition function.
   (c) Find the probabilities of finding the dipoles parallel and antiparallel, and plot these probabilities as a function of kT/ε.
   (d) At what temperatures are you more likely to find the dipoles antiparallel than parallel?