# Homework #4

## Due: Wednesday, February 22, 2017

## Solids

1. Griffiths Problem 5.16

2. Griffiths Problem 5.17

3. A container filled with $H_2$ gas has a pressure of 1 atmosphere ($1.013\times10^5$ Pa) at room temperature (20°C). To what temperature must the gas be cooled for quantum effects to become important? Estimate this temperature by equating the thermal de Broglie wavelength to the inter-particle spacing. Use the ideal gas law to estimate the density.

   Repeat this calculation for the conduction electrons in a metal for which the average inter-electronic spacing is fixed at 0.1 nm.

Hint: You might want to review problem 1.18 in Griffiths to get a perspective on this problem.

4. Suppose you have 20 particles that can be arranged in 5 systems (i.e., an ensemble of 5) where each system has just <u>four</u> energy levels. Assume that all the energy levels are degenerate, so, this is just a counting exercise where the number of particles are conserved.

   a. Calculate the number of microstates for the configuration $(N_1, N_2, N_3, N_4) = (5, 5, 5, 5)$ if the particles are distinguishable.

   b. Calculate the number of microstates for the configuration $(N_1, N_2, N_3, N_4) = (5, 5, 5, 5)$ if the particles are fermions. You should be able to do this without any "heavy" calculation.

   c. Calculate the number of microstates for the configuration $(N_1, N_2, N_3, N_4) = (5, 5, 5, 5)$ if the particles are bosons.

5. In the photosphere of a star, there are neutral *He* atoms in thermodynamic equilibrium at a temperature of 5800K. Using the Maxwell-Boltzmann distribution calculate the fraction of atoms where one of the two electrons is in the *n=2* state (the other electron in the n=1 state) compared to *He* atoms where both electrons are in the ground state, $|100\rangle$.

$$\frac{n_2}{n_1} = \rule{3cm}{0.4pt}$$