HW 9 Due May 9 2013 (Thursday)

This HW will be graded 20 points. 1.5 points for each problem and 2 extra points for handing in. Attempts to solve the problems even if unsuccessful will give you 1 point.

This is the last set of HW problems. It will be due on the last day of class. Only the book problems (i.e. problems that start with 6 or 7) will be part of the graded HW. The extra problems will be reviewed in the review session that will take place before the exam.

Problem 6.33
Problem 6.37
Problem 6.38
Problem 6.45
Problem 6.47 ("freeze out" occurs when kT is comparable to the spacing between the lowest energy levels. To calculate energy levels, you can assume a 1D box of width 1cm)
Problem 6.52
Problem 7.8
Problem 7.9
Problem 7.10
Problem 7.12
Problem 7.15
Problem 7.19

Extra (non book) problems, not to be handed in to be graded:

1.-Consider a mixture of Hydrogen and Helium at T=300 K. Find the speed at which the Maxwell distributions for these gases have the same value.

2.-Consider an ideal gas of atoms with mass m at temperature T.
   (a) Using the Maxwell-Boltzmann distribution for the speed v, find the corresponding distribution for the kinetic energy ε (don’t forget to transform dv into dε).
   (b) Find the most probable value of the kinetic energy.
   (c) Does this value of energy correspond to the most probable value of speed? Explain.
Calculate the partition function of an ideal gas of \( N=3 \) identical fermions in equilibrium with a thermal reservoir at temperature \( T \). Assume that each particle can be in one of four possible states with energies \( \varepsilon_1, \varepsilon_2, \varepsilon_3, \) and \( \varepsilon_4 \). (Note that \( N \) is fixed).

Calculate the grand partition function of an ideal gas of fermions in equilibrium with a thermal and particle reservoir \((T, \mu)\). Fermions can be in one of four possible states with energies \( \varepsilon_1, \varepsilon_2, \varepsilon_3, \) and \( \varepsilon_4 \). (Note that \( N \) is not fixed).

When the copper atoms form a crystal lattice with the density of atoms of \( 8.5 \cdot 10^28 \) m\(^{-3}\), each atom donates 1 electron in the conduction band.

(a) Assuming that the effective mass of the conduction electrons is the same as the free electron mass, calculate the Fermi energy. Express your answer in eV.

(b) The electrons participate in the current flow if their energies correspond to the occupancy \( n(\varepsilon) \) that is not too close to 1 (no empty states available for the accelerated electrons) and not too small (no electrons to accelerate). At \( T=300K \), calculate the energy interval that is occupied by the electrons that participate in the current flow, assuming that for these electrons the occupancy varies between 0.1 and 0.9.

(a) Calculate the critical temperature for BE condensation of diatomic hydrogen \( H_2 \) if the density of liquid hydrogen is 60 kg/m\(^3\). Would you expect superfluidity in liquid hydrogen as well? Hydrogen liquefies around 20K and solidifies at 14K.

(b) Above \( T_c \), the pressure in a degenerate Bose gas is proportional to \( T \). Do you expect the temperature dependence of pressure to be stronger or weaker at \( T < T_c \) ? Explain and draw a qualitative graph of the temperature dependence of pressure over the temperature range \( 0 < T < 2 T_c \).