PROBLEM SET 8

1) **Text, problem 7.8**

2) A system has a series of evenly spaced, non-degenerate energy levels with energies $\varepsilon_o=0$, $\varepsilon_1=\varepsilon$, $\varepsilon_2=2\varepsilon$, $\varepsilon_3=3\varepsilon$, etc. It is desired to fill these levels with a total of 4 particles. Consider three different cases: (1) the particles are *distinguishable*, (2) the particles are *bosons*, and (3) the particles are *fermions*. (*Hint:* for each part make an energy level diagram, to explicitly describe the possible configurations)

a) The ground state of a system is the multi-particle state which has the lowest possible energy (NOT necessarily ZERO). For each case above, what is the total energy of this ground state? For each case, how are the 4 particles distributed among the various energy levels in the ground state?

b) Now suppose that the system of 4 particles has a total energy ε **above** the ground state energy. For each case above, make a diagram that shows the possible distributions of the 4 particles in the various energy levels for this total energy and then determine how many micro-states there are for each such distribution.

c) Repeat part b if the total energy **above** the ground state energy is 2ε, rather than ε.

3) For a temperature T=300 K, determine the equilibrium number of indistinguishable particles per state ($\bar{n}_{FD}$ or $\bar{n}_{BE}$) for an energy level with energy ε if

a) the particles are *bosons* and (i) $\varepsilon-\mu=0.001$ eV and (ii) $\varepsilon-\mu=0.1$ eV.

b) the particles are *fermions* and (i) $\varepsilon-\mu=-0.1$ eV and (ii) $\varepsilon-\mu=+0.1$ eV.

4) Suppose that at temperature $T=3T_F$, the chemical potential of a system of fermions has the value $\mu=-5.6\ \varepsilon_F$. For each of the energies below, calculate the Fermi-Dirac function $\bar{n}_{FD}(\varepsilon)$.

a) $\varepsilon=0$

b) $\varepsilon=\varepsilon_F/2$

c) $\varepsilon=\varepsilon_F$

d) $\varepsilon=2\varepsilon_F$

5) **Text Problem 7.9** – in the first part, compare the quantum volume with the volume per molecule of the gas at a temperature of 20ºC and a pressure of 1 atm. In the second part, you should assume that as the temperature is lowered, the pressure is also lowered so that the volume per molecule stays constant. Then find the temperature at which the volume per molecule and the quantum volume become equal.

6) **TextProblem7.12**