HOMEWORK 8, THERMAL PHYSICS (PHY306)

1.Metals can be approximated by an ideal Fermi gas of valence electrons. For metallic cupper Cu, using their density

$$n_e = 9 * 10^{28} \times m^{-3} = 90 \times nm^{-3}, \;\; n(ano)m = 10^{-9}m$$

calculate the Fermi momentum p_F and the Fermi energy E_F (express the latter in Joules and electron-volts eV).

2. Using the $O(T^2)$ term in the Sommerfeld formula (30.38), calculate the thermal correction to the electron density and energy (at fixed μ), for room temperature $T = 300K$.

3.Large nuclei can be approximated by an ideal Fermi gas of protons and neutrons (each having spin 1/2 and thus 2 spin states, so the total number of states is 4). The gas is located in a homogenous attractive mean potential V_{mean}. The so called "symmetric nuclear matter" contains equal number of protons and neutrons, and their combined density is

$$n_p + n_n = n_N = 0.16 * 10^{45} \times m^{-3} = 0.16 \times fm^{-3}, \;\; f(emto)m = 10^{-15}m$$

(a) calculate the Fermi momentum p_F and the Fermi energy E_F (express the latter in Joules and mega-electronvolts $MeV = 10^6\, eV$).
(b) Repeat the same calculation for the pure neutron matter, of the same total density. Unlike the symmetric nuclear matter, this one is unbound and would emit nucleons if created. What does it tell us about the mean potential energy V_{mean}?

4.A photon of energy $\Delta E = 10\, MeV$ is absorbed by a heavy nucleus with $A = 200$ nucleons. After certain relaxation process, thermal equilibrium is reached. Approximating the nucleus by a drop of homogenous symmetric nuclear matter with n_N given in problem 3, and using the $O(T^2)$ term in the Sommerfeld formula (30.38) for the total energy of the Fermi gas, estimate the resulting temperature T of the excited nucleus. (Hint: remember that μ also gets thermal correction: it must be obtained from the normalization to the total number of nucleons A and included in the energy calculation, as was discussed at the lecture.)