PHY 3107, Spring 2018, Homework #9

due Tuesday, Apr. 17

1.) Find: a) the Fermi energy in copper, assuming there is one free electron per ion for copper. [Copper has an atomic weight of 63.5u and a density of $\rho = 8.95 \times 10^3$ kg/m^3.] b) the Fermi temperature (defined as $T_F = E_F/k$), c) the Fermi velocity

2.) Electrons in a solid follow Fermi-Diract statistical distributions: $F_{FD} = \frac{1}{B_1 e^{E/kT}+1}$. Setting $B_1 = 1$ is equivalent to setting the Fermi energy to the top of the valence band. Find the relative number of electrons with energies of 0.1 eV, 1 eV and 10 eV above the valence band. [Note: you will get small numbers. To get an appreciable fraction, we would need to integrate this function between two limits. The point of this problem is to see the relative number at different energies.]

3.) This problem compares the classical and quantum models of conductivity. We use silver as a specific example, but you can compare to copper in example 12.1. Silver has a density $\rho = 10.5 \times 10^3\ \mathrm{kg}/m^3$ and a resistivity $\rho = 1.60 \times 10^{-8}\ \Omega \cdot m$. Take silver's atomic weight to be 108 moles/gram. Silver has an average of one conduction electron per atom. A) First calculate the lattice spacing: determine the number of silver atoms per cubic meter, and then assume each atom fits in a cube of side *d.* [E.g., invert and take the cube root.] B) At room temperature, find the rms thermal speed of electrons, $v_{rms} = \sqrt{3k_B T/m_e}$. C) Calculate the classical time between collisions. D) from example 12.1, find the mean free path. This is about 10-20 "lattice spacings" or the distance between nuclei you found in part A).

4.) This problem compares the classical and quantum models of conductivity. We use silver as a specific example, but you can compare to copper in example 12.1. Silver has a density $\rho = 10.5 \times 10^3\ \mathrm{kg}/m^3$ and a resistivity $\sigma = 1.60 \times 10^{-8}\ \Omega \cdot m$. Take silver's atomic weight to be 108 moles/gram. Silver has an average of one conduction electron per atom. A) Now replace v_{rms} with the Fermi speed and repeat the calculation of the mean free path, using $E_F = 5.48\ eV$.