PHYS 485 Materials Physics **Spring 2019**

Read: Chapters 7

Homework 10

Due date: Not collected; solutions in binder.

Work problems 7.5, 7.6, 7.7, 7.11, 8.2, 8.6 (a,b), 9.1, 9.3, 9.8, 9.9 in the text.

AQ 1: Give a plausible explanation of the origin of energy bands in solids. Distinguish between semiconductor, conductors, and insulators.

AQ2: Using the Fermi-Dirac distribution function, determine the values of energy corresponding to $f = 0.9$ and $f = 0.1$ at $300K$. This is approximately the region on either side of E_F that deviates from a parabola in figure 7.5 of the text. Use this to estimate the number of valence electrons available for conduction. Assume $E_F = 3.22\ eV$ and that the number of valence electrons per unit volume (which is equal to the number of atoms per unit volume multiplied by the valence of the atom) is $n = 2.65 \times 10^{28}\ m^{-3}$ (you should be able to actually estimate this latter number!), the values for Na.

AQ3: In AQ2 you found that the probability of occupation of 0.9 corresponds to an energy of $E_F - 2.2\ k_BT$. The number of electrons with energies greater than this is given by

$$N_C = \int_{E_F - 2.2k_BT}^{\infty} f(E)g(E)dE$$

As this integral is not easy to perform, we will assume that the number of electrons with energies greater than the Fermi energy is approximately equal to the number between $E_F - 2.2\ k_BT$ and E_F. Thus, we can write

$$N_C \approx \int_{E_F - 2.2k_BT}^{E_F} g(E)dE$$

Solve this integral and determine the proportion of valence electrons that participate in electrical conduction in a sample of Na at 300K.

AQ4: Distinguish between intrinsic and extrinsic semiconductors. Distinguish between direct gap and indirect gap semiconductors. Distinguish between p-type and n-type semiconductors. What are typical dopants for each? What kinds of concentrations of impurities are typically used?

AQ5: What is the Hall effect? How do we explain it classically?