Physics 308: Assignment 7

Due in class Thursday, March 20, 2008

1. (10-10, classical conduction) Find (a) the current density and (b) the drift velocity if there is a current of 1 mA in a No. 14 copper wire. (The diameter of No. 14 wire, which is often used in household wiring, is 0.163 cm).

2. (10-19, quantum conduction) What is the Fermi speed, i.e., the speed of a conduction electron whose energy is equal to the Fermi energy E_F, for (a) Na, (b) Au, and (c) Sn? (See Table 10-3.)

3. The resistivities of Na, Au, and Sn at $T = 273\,\mathrm{K}$ are $4.2\,\mu\Omega\,\mathrm{cm}$, $2.04\,\mu\Omega\,\mathrm{cm}$, and $10.6\,\mu\Omega\,\mathrm{cm}$, respectively. Use these values and the Fermi speed calculated in Problem 2 to find the mean free paths for the conduction electrons in these elements.

4. (10-28; band theory of solids) A photon of wavelength $3.35\,\mu\mathrm{m}$ has just enough energy to raise an electron from the valence band to the conduction band in lead sulfide crystal. (a) Find the energy gap between these bands in lead sulfide. (b) Find the temperature T for which $k_B T$ equals this energy gap.

5. (10-30; impurity semiconductors) Arsenic has five valence electrons. If arsenic is used as a dopant in silicon, compute (a) the ionization energy and (b) the orbit radius of the fifth arsenic electron. The effective mass for electrons in silicon is $0.2\,m_e$. (c) What is the ratio of the ionization energy of the fifth electron to the energy gap is silicon?