Home Assignment (EE2187) 3

Due date of submission of assignment is **Monday 26 August.**

1. The energy near a valence band edge is given by $E = -2 \times 10^{-26} k^2$ ergs. An electron is removed from the state $k=1\times10^{7} cm^{-1}$, the band is otherwise full. Find

a) The sign and magnitude of the effective of the effective mass of the hole
b) The direction and magnitude of the wave vector of the hole
c) The crystal momentum
d) The velocity of the hole
e) The energy of the hole and
f) The electric current carried by the hole.

2. The most important semiconductors are germanium (Ge) and silicon (Si) their properties are complex as shown in the following table.

Properties of Ge and Si

	Mobility at 300° K (m^2/V-s)		Effective mass m^*/m_0	
	Electron	Hole	Electron	Hole
Ge	0.39	0.19	$m^*_l = 1.600$ $m^*_t = 0.082$	$m^*_{lh} = 0.04$ $m^*_{hh} = 0.30$
Si	0.15	0.06	$m^*_l = 0.970$ $m^*_t = 0.190$	$m^*_{lh} = 0.16$ $m^*_{hh} = 0.50$

Where the subscripts for the effective mass denote the following:
l = longitudinal, *t* = transverse, *lh* = light hole and *hh* = heavy hole

a) Calculate the relaxation times for Ge at 300oK for a longitudinal electron; a transverse electron; a light hole and a heavy hole. ($\mu = q\tau/m^*$)
b) Repeat (a) for Si and 300°K
c) For a carrier concentration of 1023 m-3, calculate the electrical conductivities for Ge at 300°K due to longitudinal electrons; transverse electrons; light holes and heavy holes.
d) Repeat (c) for Si at 300°K.

3. Find the density of states function g(ε) for 2-dimensional crystals.

4. The Maxwell-Boltzmann distribution of momentum is given by

$$f(p) = Bp^2 T^{-\frac{3}{2}} \exp\left(-\frac{p^2}{2mkT}\right)$$

Determine B; calculate <υ> and < υ2>. Can you identify the physical insight from the result?

5. Show that the Fermi function is symmetrical about ε_f

i.e., $f(\varepsilon_f + \varepsilon) = 1 - f(\varepsilon_f - \varepsilon)$

What do you infer from the result?

6. For Si, ni = $2x10^{10}cm^{-3}$ at T = 300K. Find ni at T = 500K.
Assume that εg = 1.12eV at 300K and does not vary much with temperature. Repeat if $\varepsilon_g(T) = \varepsilon_g(0) - \{\alpha T2/(T+\beta)\}$ where εg (0) = 1.17eV, $\alpha = 5.405x10^{-4}$eV/K and β = 204K.

7. For Silicon doped with 1015 phosphorous atoms per cm3 find the temperature at which (a) the material starts becoming intrinsic and (b) the carriers freeze out.
8. Find the position of the Fermi level at 0oK for a semiconductor doped with
a) Nd, (Na=0); b) Nd > Na; c) Nd = Na; d) Nd <Na; e) Nd = Na=0.
Write down all the reasons that made you arrive at the answer!