INDIAN INSTITUTE OF TECHNOLOGY DELHI
PYL-102, MINOR-II
Total Marks: 20, Time: 1hr

Date: 05-10-2017

1. In which of the following cases electron-hole pairs are created?
   A. n-type semiconductors B. intrinsic semiconductors C. p-type semiconductors D. semiconductors with defects

   [1/2]

2. Which of the following statements is incorrect for effective density of state function for an intrinsic semiconductor?
   A. It is a function of temperature B. It depends on the band structure C. It is a function of doping concentration

   [1/2]

3. Consider an intrinsic semiconductor with $D_v(E)$ being the density of states in the valence band. If E_v is the valence band edge and $f(E)$ is the Fermi-Dirac probability function (for electrons), write an expression for concentration of holes in the valence band. Consider $D_v(E) = CE^{1/2}$.

   [1]

4. Draw a schematic energy box diagram for an intrinsic semiconductor. Also, show schematically the following in the same diagram:

   a) corresponding DOS. Assume electron and hole effective masses are equal.
   b) the Fermi Dirac distribution function for $T > 0$ and
   c) distribution of cariers in the corresponding energy bands.

   [1+1+1/2+1]

5. a) The intrinsic carrier concentration of GaAs at room temperature is 3.85×10^{10} cm^{-3}. If the effective masses of electrons and holes in GaAs are $0.067m_e$ and $0.48m_e$, respectively, what is the energy difference between the conduction and valence band edges for GaAs?
   b) Also, determine how the Fermi energy for this system changes as a fucntion of temperature. Show this with a schematic diagram by plotting Fermi energy for T=200 K, 300 K, 400 K, 500 K.

   [$2\frac{1}{2}$+2+1]

6. a) A semiconductor material is doped such that the $n > n_i$; where n is carrier concentration of electrons and n_i is the instrinsic carrier concentration. Show that holes are the minority carriers in this system.
   b) If N_d represents the donor concentration (1.5×10^{16}cm^{-3}), what is the density of electrons (n_d) occupying a donor state at $T = 300$ K ? Consider that the donor level and the Fermi level lie below 15 meV and 6[illegible]7 meV from conduction band edge, respectively. Negelect the modification of Fermi function due to spin degeneracy.
   c) What is the concentration of ionized donors at $T = 300$ K?

$n_i = np$

[1+2+1]

7. Consider a semiconductor p-n junction where p and n regions are unifromly doped. Show that the induced electric field in the space charge region is a linear function of distance. Consider that the space charge region abruptly ends in n and p side.

[3]

8. Show schematically the changes in the built-in potential by drawing the energy band diagrams of a p-n junction under the application of zero bias and reverse bias (V). Also identify the relevant Fermi energies in the diagrams.

[1+1]

$k_B = 1.38 \times 10^{-23}$ J/K, $m_e = 9.11 \times 10^{-31}$kg, $h = 6.626 \times 10^{-34}$J-s, $\hbar = 1.054 \times 10^{-34}$J-s