INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

AV212 Semiconductor Devices

Department of Avionics

Quiz #1 (15/09/2022)

Semester: III **Maximum Marks: 15**

Answer ALL questions

1. (a) Explain the concept of effective mass in semiconductors. Why do we use it? [2]
   (b) Given an E-k diagram, how will you find out the effective mass? [1]

2. (a) For a semiconductor, the band structure is represented by

$$E = \begin{cases} E_c + \frac{\hbar^2(k-3)^2}{2m_e} & \text{for conduction Band,} \\ E_v - \frac{\hbar^2 k^2}{2m_h} & \text{for valence Band} \end{cases}$$

   Given that electron effective mass m_e=0.15m_0 and hole effective mass m_h=0.73m_0, where m_0 is the free electron mass, and Eg=1.75eV.
   Draw the qualitative band structure for this semiconductor, and mark the relevant parameters. Is this semiconductor direct or indirect? Justify your answer. [3]

3. (a) Define the Fermi-Dirac distribution function, and explain its properties. [2]
   (b) Show that the probability of a state at energy ΔE above the Fermi level to be filled is the same as the probability of a state at an energy ΔE below the Fermi level to be vacant. [2]

4. (a) The DOS in the conduction band is given by

$$N(E) = 4\pi \left(\frac{2m_e}{h^2}\right)^{3/2} \sqrt{E - E_c}$$

   Using this expression and the Fermi distribution calculate the expression for the carrier concentration in conduction band in terms of Fermi integrals. Cleary show every steps and explain under what circumstances you can approximate the Fermi distribution with Boltzmann approximation. Using Boltzmann approximation, recalculate the electron carrier density in conduction band. [5]

GOOD LUCK TO YOU ALL!!!!!!