Physics Department

EPL-336: Semiconductor Optoelectronics

Attempt **any 8** questions & All questions carry 5 marks each

Max. Marks 40 Max. time 2 hr.

1. The E-k diagrams of three semiconductors (A, B and C) are well approximated by the parabolas at the bottom of the respective conduction band and at the top of the respective valence band. The relative varietion of conduction band and valence band are shown in the Figure 1.
   (e) Write the nature of band gaps with explanation.
   (b) Which semiconductor is likely to be best light emitting source and why?
   (c) Mention the relative locations of the Fermi energies.

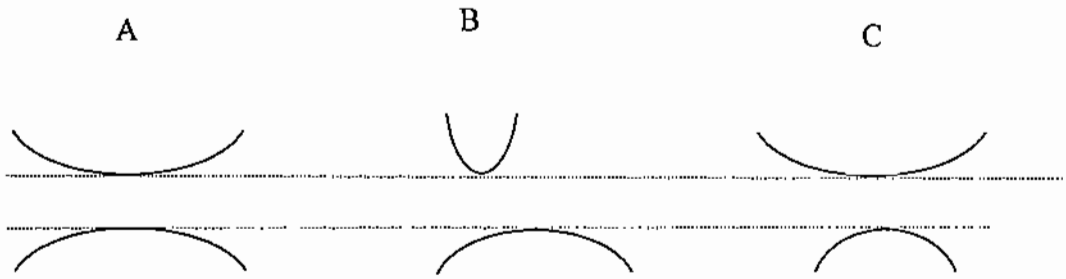

Figure 1

2. Assuming that a semiconductor is in quasi-equilibrium state, sketch energy *vs.* carrier concentration profiles in the conduction and valence bands and also show the levels corresponding to the conduction band edge, valence band edge and Fermi energies. Give appropriate reasons based on which the curves are drawn.

3. Explain briefly : (a) Brillouin scattering
   (b) Energy bands overlapping
   (c) Negative effective mass

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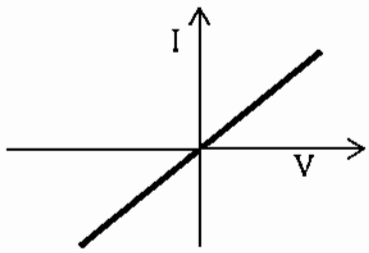
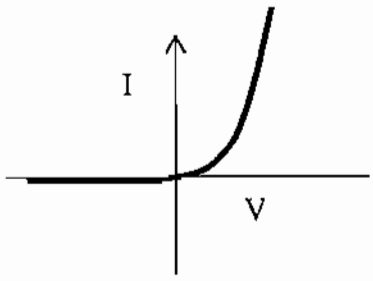
4. Two metal films (A and B) are deposited on a surface of a doped semiconductor. The current *vs.* voltage (I vs V) characteristics of the resultant junctions, recorded after making suitable contacts, are shown in the figures below. (a) Find the relative Fermi energies of three materials, (b) Draw the energy level diagrams which can explain the measured I vs. V curves and (c) mention the type of dopants in the semiconductors. Give reasons for your answer.





5. (a) Explain the working principle of double hetero-junction based laser diode
   (a) List the device design parameters which influence the light amplification gain and explain

6. Explain briefly: (a) k selection rule
   (b) Threshold current density (in laser)
   (c) Confinement factor

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7. (a) Write the *I vs. V curves* of a typical solar cell when it is illuminated with light sources having intensities I_0 W and $2I_0$ W with same spectral variation.
   (b) Define short circuit current, open circuit voltage, fill factor and conversion efficiency.
   (c) Mention two mechanisms which can enhance the optical energy conversion efficiency with brief explanation.

8. Explain the working principles of a typical APD and a typical PIN photo-detector with appropriate diagrams. Assuming that the incident light is pulsed and the both detectors are made of the same semiconductor, which detector is likely to give better response and why.

9. Explain briefly : (a) Shot noise
   (b) Ramo theorem
   (c) Responsivity