(b) Why the barrier potential in a depletion region of a p-n junction cannot be measured by an usual electronic meter ? (2)

(c) Show how the Fermi level varies for a p-type semiconductor from low temperature to high temperature. Find an expression of depletion temperature for such semiconductor. (3)

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(Internal Assessment – 10)

2018

M.Sc.

2nd Semester Examination

PHYSICS

PAPER – PGS-202 (Gr. – A + B)

Full Marks : 50

Time : 2 Hours

The figures in the right hand margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

(Gr. A –*Solid State-II*)
Answer Q1 and any one from Q2 and Q3.

1. Answer any five bits: 5 X 2 = 10

(i) The critical magnetic field for Al is 7.9 X 10^3 A/m. Calculate the critical current which can flow through a long thin superconducting wire of Al of diameter 10^{-4} m.

(ii) Show that the total magnetic flux threading the circuit cannot change so long as the circuit remains resistanceless.

(iii) The penetration depths for lead are 396Å and 1730 Å at 3K and 7.1K respectively. Calculate the critical temperature for Lead.

(iv) How the value of $\hbar/2e$ can be measured from superconductor – superconductor tunneling effect - Explain.

(v) It is required to break up a Cooper pair in lead which has the energy gap of 2.73 eV. What is the maximum wavelength of photon which will accomplish the job?

(vi) Explain the origin of surface energy for a Type-I superconductor.

(Turn over)

(vii) How the permanent dipole moment of a polar molecule can be measured by using Clausius – Mossotti relation?

(viii) What is the physical significance of isotope effect?

2. (a) Deduce Debye equations in case of a dielectric in the presence of an ac field. Show the variations of real and imaginary parts of dielectric constant with frequency. (4+1)

(b) Show the variation of different polarizabilities with the frequency of applied ac field and explain. (2)

(c) Discuss the tunneling between two superconductors with necessary band diagrams and current-voltage characteristics. (3)

3. (a) Deduce Rutger's formula for the specific heat of a superconductor. Calculate the discontinuity in heat capacity per unit volume at T_C for a Type–I superconductor with B_0 = 0.08T and T_C = 7K. Comment on the related phase transition. How other type of phase transition occurs – explain. (2+1+1+2)

(b) Write down the free energy expression of a superconductor considering it a mixture of two fluids. Then derive the London penetration depth on the basis of two-fluid model. (1+3)

(Gr. B – *Semiconductor Physics*)

Answer Q1 and any one from Q2 and Q3.

1. Answer any five bits: 2 X 5 = 10

(i) Calculate the energy difference between the intrinsic energy level and Fermi energy level in an intrinsic Si sample at T = 300K. Given m_e^* = 1.1 m and m_h^* = 0.55m, where m is electron mass.

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(ii) Explain the mechanism of generation of photocurrent in a solar cell.

(iii) Write down advantages and disadvantages of the junction capacitance.

(iv) What are meant by equilibrium and non-equilibrium carriers in case of semiconductors?

(v) How does population inversion occur in a p-n junction laser diode?

(vi) What do you mean by Schottky contact? Draw the band diagram of a Schottky contact.

(vii) Draw the energy band diagram for a doped semiconductor (p-type and n-type separately).

(viii) Clearly explain the difference between operation mechanisms of LED and photodiode.

2. (a) Derive the expression for density of electrons in the conduction band of n-type non-degenerate semiconductor at extremely low temperature and extremely high temperature region . (4+3)

A hypothetical semiconductor has an intrinsic carrier concentration of 1.0 x 10^{10} /cm^3 at 300K, it has conduction band and valence band effective densities of states N_c and N_v both equal to $10^{19}/cm^3$. (3)

i) Find the band gap E_g of the semiconductor.

ii) If the semiconductor is doped with N_d = 1.0 x 10^{16} donors/cm^3, what is the equilibrium electron concentration at 300K?

3. (a) What do you meant by diffusion length? Find an expression of diffusion length of hole when a p-n junction is forward biased. (5)

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