(ii) A *n*-type silicon sample is exposed to light such that $10^{13}/cm^3$ electron-hole pairs (EHP) are created per microsecond. Equilibrium electron concentration in the sample no is 10^{14} cm^{-3} and $\tau_n = \tau_p = 2\,\mu sec$. Find out the steady state excess electron (or hole) concentration. Find out the position of quasi-Fermi level relative to the position of intrinsic energy level. (2)

(iii) What do you mean by indirect recombination? (1)

4. (i) Find an expression of density of states in the conduction band of a semiconductor. (2)

(ii) Find the density of holes in the valance band for a non-degenerate semiconductor. (4)

(iii) A Si sample is doped with 10^{17} Arsenic atoms/cm^3. What is the equilibrium hole concentration at 300 K? Given intrinsic carrier concentration $n_i = 1.5 \times 10^{10}$ cm^{-3}. (2)

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(Internal Assessment – 10)

2019

M.Sc.

2nd Semester Examination

PHYSICS

PAPER – PHS-202 (Gr. – 202.1 & 202.2)

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.
Use separate answer scripts for Group 202.1 and Group 202.2.

(*Solid State Physics -II – PHS 202.1*)
Answer Q1, Q2 and any one from Q3 and Q4

1. Answer any two bits: 2 X 2 = 4

(i) Discuss on the isotope effect in case of superconductor. What is indicated by this effect?

(ii) The optical index of refraction and the static dielectric constant for NaCl are 1.5 and 5.6 respectively. Determine the percentage contribution of ionic polarizability.

(iii) How can you use a Type-I superconductor as a 'thermal switch'?

(iv) Estimate the surface energy of a Type-I superconductor whose intrinsic coherence length, London penetration depth and critical magnetic field are 83 nm, 37 nm and 0.074 T.

2. Answer any two bits: 2 X 4 = 8

(i) (a) The critical field and critical temperature of Lead are 6.5 X 10^4 A/m and 7.18K respectively. To what temperature it must be cooled to become a superconductor in a magnetic field of 2 X 10^4 A/m.

(b) Discuss about the features that a non-ideal superconductor specimen may show. (2+2)

(ii) (a) What is orientational polarization?

(b) There are 1.6 X 10^{20} molecules / m^3 in NaCl vapour. Determine the orientational polarization at room temperature (300K) if the vapour is subjected to a field of 5 X 10^6 V/m. Assume that the NaCl molecule consists of Na^+ and Cl^- ions separated by a distance 2.5Å. (1+3)

(iii) What is demagnetizing factor in a ferromagnetic sample? Explain how a non-zero demagnetizing factor in a superconducting sample plays an important role in an intermediate state. (1+3)

(iv) Give a short account of Cooper Pair on the basis of Frohlich interaction. Given that the maximum wavelength of photon to break up Cooper pair in tin is 1.08×10^{-3} m, calculate the energy gap. (3+1)

3. (i) Prove that dielectric loss by an ac field driven dielectric material is proportional to the frequency of the field. (3)

(ii) Deduce the expression of tunneling current across the junction in case of ac Josephson effect. (4)

(iii) An ac current of frequency 1GHz is observed through a Josephson junction. Calculate the applied dc voltage. (1)

4. (i) Deduce the expression of conductivity when an ac field is applied on a superconductor. Define inductive impedance from the expression. How you can differentiate ac resistivity from dc resistivity in case of superconductors? (2+1+1)

(ii) Empirically it is found that the temperature dependence of the critical field B_c of a type-I superconductor is given by $B_c = B_0\left[1-\left(T/T_c\right)^2\right]$. Use this to show that the entropy (s_s) per unit volume of the superconducting state is lower than that of the normal state (s_n). Furthermore, show that $s_n - s_s = aT - bT^3$, where 'a' and 'b' are constants, and that $s_n = s_s$ when $T = T_c$. (2+2)

…….Continued

(*Semiconductor Physics PHS 202.2*)
Answer Q1, Q2 and any one from Q3 and Q4

1. Answer any two bits: 2 X 2 = 4

(i) Find the expression of barrier potential of a pn-junction which is under equilibrium.

(ii) Find out an expression of open circuit voltage of a solar cell.

(iii) Find an expression for carrier concentration in terms of band gap of an intrinsic semiconductor.

(iv) What do you mean by direct and indirect bandgap semiconductors.

2. Answer any two bits: 2 X 4 = 8

(i) Deduce the Einstein relation for electron considering a pn-junction under equilibrium.

(ii) The minority carrier lifetime in p-type material is 10^{-7} sec. Mobility of electron in silicon is 0.15 $m^2\ V^{-1}\ s^{-1}$ at 300 K. If 10^{20} /m^3 electrons are injected at $x = 0$ what is the diffusion current density just at the junction (i.e. at $x = 0$)

(iii) What do you mean by Schottky contact? Write the condition for a *n*-type and a *p*-type semiconductor to form Schottky contact and explain with necessary band diagram.

(iv) Find the expression of growth of excess carriers in a semiconductor material when light falls on it.

3. (i) Find out the expression of junction capacitance for abrupt junction and explain how you could measure barrier potential experimentally. (5)

(*Turn over*)