PG/IIS/PHS-202/15

M.Sc. 2nd Semester Examination, 2015

PHYSICS

PAPER— PHS-202 (A & B)

Full Marks : 40

Time : 2 hours

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

PHS-202(A)

[*Marks* : 20]

1. Answer any *two* of the following : 2×2

(*a*) A superconducting tin has a critical temperature of 3·7 K in zero magnetic field and a critical field of 0·0306 *T* at OK. Find the critical field at 2 K.

(*b*) Draw the variation of *B* and *M* with *H* for a superconductor.

(*c*) What is Josephson effect ?

2. Answer any *two* of the following : 3 × 2

(*a*) Explain what do you mean by complex dielectric constant.

(*b*) The space between a parallel plate capacitor is filled with a dielectric having dielectric constant $\epsilon'_r = 2{\cdot}5$ when subjected to a 2 volt alternating voltage at 1 MHz. The loss tangent at this frequency is 4×10^{-4} calculate the imaginary part of dielectric constant (ϵ''_r) at this frequency.

(*c*) What is Meissner effect ? Show how London equations lead to this effect.

3. Answer any *one* of the following : 10 × 1

(*a*) Consider the total current in a superconductor as the superposition of the contributions to the current from the superconducting electron pairs and from the normal electron, hence determine the propagation characteristics at finite temperature of a superconductor in an

electromagnetic field. Derive the expression for $\epsilon'(w)$ and $\epsilon''(w)$ for electronic polarizability in presence of an ac field. Show the variation $\epsilon'(w)$ and $\epsilon''(w)$ with frequency for electronic polarizability. 5 + 3 + 2

(*b*) Derive the expression for current density for cooper pair tunneling. Explain a.c. Josephson effect and show how the value of $\frac{\hbar}{2e}$ can be measured from a.c. Josephson effect. 3 + 5 + 2

PHS-202(B)

[*Marks* : 20]

Answer **Q. No. 1** & **2** and any **one** from the rest

1. Answer any *two* questions : 2 × 2

(*a*) A semiconductor is lightly doped with *p* type impurity. Prove that value of minimum conductivity is $2qn_i\sqrt{\mu_n\mu_p}$ where n_i is the intrinsic carrier concentration and μ_n, μ_p are electron and hole mobilities.

(*b*) Show the variation of $\ln \sigma$ *vs* $\frac{1}{T}$ plot (from low temperature to high temperature range) for a non-degenerate semiconductor. Also explain the different portions of the plot.

(*c*) What is meant by Direct recombination and indirect recombination ?

2. Answer any *two* questions : 3×2

(*a*) An abrupt junction diode has a capacitance of 30 pF when reverse biased at 6 V. What is the decrease in capacitance if the voltage is increased by 2 V ?

(*b*) Explain population inversion for lasing action in *p-n* junction under forward bias (using band diagram).

(*c*) A semiconductor contains acceptor and hole concentration is $10^{22}/m^3$. Assume that effective density of states in the valence band is $10^{25}/m^3$. How far above the valence band in eV the Fermi energy E_F lies at 300 K ?

(*Continued*)

3. (*a*) Derive Einstein relation assuming a *p-n* junction under equilibrium condition.

   (*b*) Find also the expression of barrier potential in a *p-n* junction under equilibrium condition.

   (*c*) Explain what is meant by Varicaps. 5 + 3 + 2

4. (*a*) Describe in details photoconductivity in a semiconductor and hence find an expression of growth of current.

   (*b*) What is meant by quadratic recombination and hence find an expression of carrier density when light is switched off ? 6 + 4