M.Sc. 2nd Semester Examination, 2023

PHYSICS

PAPER – PHS-202.1 & 202.2

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

PAPER – PHS 202.1

(*Solid State-II*)

[*Marks* : 20]

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

   (*a*) What is the fundamental property of a super-conductor, perfect conductivity or perfect diamagnetism ? Justify your answer.

   (*b*) What will be the maximum wavelength of a

photon which can break a copper pair of a superconductor with an energy band gap of 2.73 eV ?

(*c*) Draw the variation of resistivity with temperature for a perfect conductor and a superconductor.

(*d*) What do you mean by dielectric loss ?

2. Answer any *two* of the following questions : 4×2

(*a*) What do you mean by penetration depth in a type-I superconductor ? Determine the penetration of a superconductor having a super-electron density of 4×10^{-28} m^{-3}. 2 + 2

(*b*) Determine the percentage of ionic polarizability in sodium chloride crystal which has the optical index of refraction and the static dielectric constant as 1.5 and 5.6 respectively. 2 + 2

(*c*) Derive second London equation 4

$$\nabla \times \vec{J}s = -\frac{\vec{B}}{\Lambda_s c}.$$

(*d*) For lead, superconductivity ensures at 7.19K, when there is a zero applied magnetic field. When the magnetic field of 0.074T is applied at temperature 2.0K superconductivity will stop. Find the magnetic field that should be applied so that superconductivity will not occur at any temperature ? Also calculate the penetration depth of lead at 5.2 K, if the London Penetration depth at 0K is 37 mm. 4

3. Answer any *one* of the following questions : 8×1

(*a*) Obtain the expression for the difference of entropy between normal and superconducting states of a specimen. Hence discuss the discontinuity in the heat capacity at T_c. 8

(*b*) (*i*) Explain polarizability of atoms and molecules. Discuss what are its sources.

(*ii*) Derive the expression for Debye equation in connection with dipolar polarizability. 3 + 5

PAPER – PHS 202.2

(*Solid State-II*)

[*Marks* : 20]

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

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

   (*b*) Clearly distinguish nondegenerate and degenerate semiconductor.

   (*c*) Explain what is meant by Varicaps ?

   (*d*) What is meant by quadratic recombination ?

5. Answer any *two* of the following : 4×2

   (*a*) Show that electric field is maximum for a p-n junction just at the junction.

   (*b*) What is diffusion capacitance ? Find an expression of diffusion capacitance in a p-n junction.

(*c*) Find an expression of ionization energy of the impurity atom in Ge.

(*d*) Using band diagram describe the principle of the generation of photovoltage in a p-n junction and hence find an expression of open circuit voltage.

6. Answer any *one* of the following : 8×1

(*a*) (*i*) What is meant by diffusion length ? Find an expression of diffusion length of hole when a p-n junction is in forward biased ? $1 + 5$

(*ii*) Show the variation of $\ln \sigma V_s . \frac{1}{T}$ plot (from low temperature to high temperature) for a non degenerate semiconductor. Also explain the different portion of the plot. 2

(*b*) Describe in details photoconductivity in a semiconductor and hence find an expression of growth of current. How lifetime of a carrier can be determined ? $2 + 4 + 2$
