T.Y.B.Sc

IV

Subject: Physics P II
Solid State Physics (OLD)
(R-2016-17).

Expt. Solid State Physics.

QP Code : 77070

(2 $\frac{1}{2}$ Hours) [Total Marks : 75

N.B. (1) All questions are compulsory.
(2) Figures to the right indicate full marks
(3) Neat diagrams should be drawn wherever necessary.
(4) Use of calculators /log tables is allowed.
(5) Symbols have their usual meaning unless otherwise stated.

List of Constants:

Charge of an electron e = 1.6021×10^{-19} Coulomb

Mass of an electron m_e = 9.109×10^{-31} kg

Boltzmann constant k = 1.38054×10^{-23} Joule/Kelvin

Planck's constant h = 6.626×10^{-34} joule sec

Permeability of free space μ_0 = $4\pi \times 10^{-7}$ Henry/m

Q.1 A Attempt any ONE: 10

i) Explain and derive expressions for relaxation time, collision time and mean free path as applied to free electrons.

ii) Given $Z(E) = C\sqrt{E}$ where $C = 4\pi\left(\frac{2m}{h^2}\right)^{\frac{3}{2}}$ the number of states between energy E and $E + dE$ for electron in a solid. Hence derive an expression for average energy of electron in terms of Fermi energy.

B Attempt any ONE: 05

i) Calculate the number of energy states available for the electrons in a cubical box of side 1cm lying below an energy of 1eV.

ii) Show that the wavelength associated with an electron having an energy equal to the Fermi energy is given by, $\lambda_F = \left[\frac{8\pi}{3n}\right]^{\frac{1}{3}}$

Q.2 A Attempt any ONE: 10

i) What are Brillouin Zones? Discuss the formation of Brillouin Zones for a linear and two dimensional lattices.

ii) Give a brief account of the following properties of superconductivity
a) Meissner effect b) Transition temperature c) Critical Field

{TURNOVER

KS-Con.3643-16.

B Attempt any ONE:

i) Derive an expression for the number of wave functions per band.

ii) Calculate the critical current density for 1mm diameter wire of lead at a) 4.2 K and b) 7 K.

Given : Critical temperature for lead is 7.18 K and $H_0 = 6.5 \times 10^4$ A/m

Q.3 A Attempt any ONE:

i) Discuss Langevin's theory for a paramagnetic gas and obtain an expression for the paramagnetic susceptibility of the gas.

ii) Give an account of Weiss theory of ferromagnetism and derive Curie Weiss law.

B Attempt any ONE:

i) Discuss the origin of permanent magnetic dipole moments in a solid and obtain the relation between magnetic dipole moment and angular momentum of an orbiting electron.

ii) Define Neel temperature. The susceptibility of a substance is 1.02 at its Neel temperature of 68K. Find the value of the constant C.

Q.4 A Attempt any ONE:

i) Explain diffusion, drift and recombination processes in an extrinsic semiconductor. Hence derive the equation of continuity.

ii) Derive the law of junction assuming low level injection for a p-n junction diode.

B Attempt any ONE:

i) Explain in brief Hall effect. State its any two applications.

ii) A Ge p-n junction has reverse saturation current I_0 = 1μA at 37°C. Find its static and dynamic resistance for an applied bias of 0.3V at 37°C

Q.5 A Attempt any ONE :

i) The Fermi energy of silver is 5.51 eV. What is the average energy of the free electrons in silver at 0 K?

ii) Calculate the electronic contribution to specific heat of copper using quantum formulation at 300 K. Fermi energy of copper at 300 K is 7.05 eV.

Given : Avogadro's number = 6.023×10^{26} /kilomole

B Attempt any ONE : 04

i) The lead material works as a superconductor at a temperature of $T_c = 7.26$ K. If the constant characteristics field of the lead material at 0 K is $H_0 = 8 \times 10^5$A/m. Calculate the critical magnetic field in lead at 5 K.

ii) Consider a two dimensional square lattice of sides 0.3 nm. At what electron momentum values do the sides of the first Brillouin zone comes? Calculate the energy of the free electron with this momentum.

C Attempt any ONE : 04

i) A magnetic material has magnetization of 3300 A/m and flux density of 0.0044Wb/m^2.Calculate the magnetic field of the material.

ii) Estimate the diamagnetic susceptibility of solid argon which has atomic number 18 and its concentration at 4K is 2.66 x 10^{28} atoms/m^3.The root mean square distance of an electron from the nearest nucleus is 0.62AU.

D Attempt any ONE : 03

i) A bar of silicon 2cm long has a cross sectional area of 1cm^2. The crystal is n-type with a donor concentration of 10^{23}/m^3. If the resistance of the bar is 10 Ω, what is the electron mobility?

ii) A germanium p-n Junction diode has 10^{22}donor atoms/m^3 in the n region and 10^{21} acceptor atoms/m^3 in the p region. Find the value of the barrier potential developed across the unbiased junction at 27^0C.
Given $n_i = 10^{19}/m^3$

****