PRABHAT KUMAR COLLEGE, CONTAI

M. Sc. 3rd Semester Examination-2021

Subject: Physics Paper: PHS 303A Full Marks: 50 Time: 2 hr

Solid State Physics-I (Special Paper)

Answer any FOUR questions

Q1. a) Explain the consequences of the substitutional defects in case of ionic crystals. b) What is meant by work hardening to enhance the mechanical properties of the solids? (2+2)

c) Explain why low temperature is required to appear Landau levels in De-Haas-Van Alphen effect and describe the flux quantization and landau levels in case of metal placed in a magnetic field at low temperature 6

Q2. a) Find the bandwidth in a simple cubic crystal along [110] direction according to tight binding approximation. 2

b) Derive the LST relation assuming photon-phonon interaction in an ionic crystal. 8

Q3. a) What is point defects in solids? Derive equilibrium concentration of Schottky defects in case of ionic crystals at any temperature T. b) If a copper rod is heated from 0 K to 1250 K and there is an increase in length of 2% of original length. What fraction of this increase in length is due to formation of the vacancies? Given activation energy for vacancy formation is E_V = 1.2 x 10^5 J/mole and R = 8.314 J/mole/K, Copper is FCC structured crystal. (4+3)

c) Find the expression of elastic energy per unit length of screw dislocation considering a region of crystal of radius r about the screw dislocation with Burgers vector b 3

Q4. a) The energy band relation in a linear chain with interatomic distance 'a' is given by $E(k) = E_o - Tcoska$. When the width of the band gap is increased by 20%, calculate the effective mass of the electron at the band top. b) Derive the energy dispersion relation of electron in solid according to Tight Binding Approximation (TBA) (3+ 7)

Q5. a) Find the electron plasma frequency considering the motions of positive ions imbedded in an electron sea. b) What is soft optical phonon mode? c) Derive Thomas Fermi dielectric function considering electrostatic screening in metal. (2+2+6)

Q6. a) What is meant by reduced Zone scheme? b) Derive the energy dispersion relation for an electron in solid according to the nearly free electron approximation subject to a weak potential of U(x) = Ucos2πx/a, where a is lattice constant c) Assuming simple cubic crystals show that effective mass, $m^* = \frac{\hbar^2}{2\gamma a^2}$, where γ is the overlapping integral. (2 +4+2)

d) For copper n_o = 8.5 x 10^{22} cm^{-3}, E_{Fo} = 3.2 eV. Calculate the Thomas Screening length. 2

Q7. a) Write down the Boltzmann transport equation in relaxation time approximation. 3

b) Prove that dielectric loss is related to imaginary part of the dielectric constant. c) Derive the Debye equations in case of non-interacting molecular diploes in presence of alternating external electric field. Discuss the characteristics of the Debye equations. (2+5)

Q8. a) Treat F-centre as free electron of mass m moving in the field of a point charge e in NaCl crystal with the dielectric constant of 2.25. What is the 1s-2p energy difference of F-centre in NaCl? b) Deduce the theoretical estimation of shear stress for slip of plane to be occurred in solids. c) Derive the Einstein relation for ionic diffusion. (2+3+2)

d) Explain why dielectric constant at optical frequency arises from electronic polarizability. Draw frequency dependency of the real part of total polarizability. 3

Internal Assesment-10