that the Fermi level lies halfway between the valence bond and the conduction bond. 10

(b) Explain the (V-I) characteristics of a p-n junction diode in forward and reverse bias. 4

8. (a) Explain the formation of depletion layer across a p-n junction. Obtain the expression for the width of the depletion layer in terms of impurity concentration and barrier potential. 9

(b) What is Hall effect? Show that for a p-type semiconductor the Hall co-efficient R_H is given by $R_H = {}^1/_{\rho e}$. 5

UNIT - V

9. (a) Explain the term critical magnetic field in a superconductor. How does the critical magnetic field vary with termperature in Type I and Type II superconductor? What is Meissner effect. 8

(b) Derive the London equations and explain the term coherence length. 6

10. (a) Explain d.c. Josephson's effect. Show that the supercurrent of superconducting pairs across the junction depends on the phase difference. 7

(b) How are cooper pair formed? Explain the BCS theory of superconductivity and discuss the energy gap based on this theory. 7

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PG (CBCS) ODD SEMESTER EXAMINATION, 2022

PHYSICS

3rd Semester

Course No. : PHYCC - 303

(Solid State Physics)

Full Marks : 70

Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

(Answer any five questions, taking one from each unit)

UNIT - I

1. (a) Describe the seven system of crystals with suitable diagrams. 7

(b) Draw the crystal planes (110) and (112) in an FCC lattice. 5

(c) Find the Miller indices of a plane having intercepts of 8a, 4b and 2c on the a - , b - and c - axes respectively. 2

2. (a) Derive Bragg's law of X-ray diffraction in crystal. Give an account of powder method of crystal structure analysis. 9

(b) Prove that the reciprocal lattice to BCC lattice is an FCC lattice. 5

UNIT - II

3. (a) Show that the repulsive forces must be shorter range than the attractive ones for the formation of a chemical bond. 6

(b) Show that the total lattic energy of an ionic crystal assuming a repulsive interaction of the form $Xe^{-R/\rho}$ operating between nearest neighbours only is given by

$$U = \frac{-1}{4\pi\epsilon_0}\ \frac{N\alpha e^2}{R_0}\left(1 - \frac{\rho}{R_0}\right)$$

where 2N is the number of ions in the crystal, Ro is the equilibrium separation between nearest neighbours and α is the Madelung constant. 8

4. (a) The PE of a pair of atom is

$$v = -A/r^4 + B/r^{12}$$

where 'r' is the interatomic distance. Find the value of 'r' where a stable bond is formed. Also calculate the energy released when the atoms form a stable bond. 6

(b) Obtain the dispersion relation for one-dimensional monatomic lattice. Show that the phase velocity is equal to the group velocity at law frequency. 8

UNIT - III

5. (a) What are the main drawbacks of classical free electron theory? 3

(b) Explain Fermi-Dirac distribution of electrons in a metal. Obtain a general expression for the Fermi Energy of electrons in a solid at zero degree Kelvin. Show that at the same temperature the average energy of the electron is $(3/5)th$ of the Fermi energy. 11

6. (a) Solve the equation for an electron moving in the following potential field
$u(x) = 0$ for $0<x<a$; $u(x) = v_0$ for $a<x<b$ and periodically repeated outside the interval. Show that for $E < V_0$ it leads to the following equation

$$\left[\frac{\beta^2 - \alpha^2}{2\alpha\beta}\right] \text{Sinh}\beta b\ \text{Sin}\alpha a + \text{Cosh}\beta b\ \text{Cos}\alpha a = \text{Cosk}\,(a+b)$$

where $\alpha^2 = 2mE/\hbar^2$; $\beta^2 = 2m(V_0 - E)/\hbar^2$
Discuss the motion of an electron in a periodic potential and show from (E-K) graph, that materials can be classified into conductors, insulators and semiconductors. 10

(b) Define (a) Crystal momentum (b) Effective mass of electron. 4

UNIT - IV

7. (a) Derive expression for density of free electrons and holes in an intrinsic semiconductor. Show