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6 SEM TDC PHY M 2

2015

(May)

PHYSICS

(Major)

Course : 602

(Condensed Matter Physics)

Full Marks : 60
Pass Marks : 24

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following as directed : 1×6=6

(a) Lattice constant of a b.c.c. lattice is 5·96 Å. What is the distance between a corner atom and the body-centred atom in the cubic cell?

(b) What are the Miller indices of a plane that make intercepts of 1 Å, 2 Å and 3 Å on the coordinate axes of an ortho-rhombic crystal with $a : b : c = 3 : 2 : 1$?

(c) Average kinetic energy of an electron at absolute zero temperature ($\bar{E}_0$) is equal to

(i) $\frac{1}{2}E_{F_0}$

(ii) $\frac{1}{3}E_{F_0}$

(iii) $\frac{3}{5}E_{F_0}$

(iv) $\frac{2}{3}E_{F_0}$ (Choose the correct answer)

(d) If an electron is missing from the state of wave vector k_e, what will be the wave vector of the hole, thus formed?

(e) *P*-type semiconductor can be obtained by doping pure silicon with

(i) phosphorous

(ii) boron

(iii) antimony

(iv) germanium (Choose the correct answer)

(f) The forbidden energy gap between the valence band and the conduction band of a semiconductor is of the order of

(i) 1 MeV

(ii) 0·1 MeV

(iii) 1 eV

(iv) 5 eV (Choose the correct answer)

2. *(a)* What is packing fraction? Obtain the packing fraction for an f.c.c. lattice. 2

(b) State and explain Wiedemann-Franz law. 2

(c) What do you mean by mobility of a carrier? How does it depend on temperature and doping concentration? 2

3. *(a)* How can you construct a reciprocal lattice? Show that the reciprocal lattice vector is normal to the crystal plane. 2+2=4

(b) Derive an expression for the binding energy of an ionic crystal and obtain the expression for the Madelung constant. Evaluate Madelung constant for a linear ionic crystal. 3+1+1=5

4. *(a)* Draw the primitive cell corresponding to a b.c.c. cell. 2

(b) Obtain the vector form of Bragg's law using the concept of reciprocal lattice.

The spacing of the planes in a crystal is 1·2 Å and the angle for the first-order reflection is 30°. Determine energy in eV of the X-ray used. 2+3=5

5. *(a)* Write the expression for the Fermi-Dirac distribution function and discuss its behaviour with change in temperature. Show with diagram, the distribution of electrons among the energy levels present inside a box at 0 K. 4+2=6

(b) State and prove the Bloch theorem. Discuss its importance in the band theory. 4

6. *(a)* Describe periodic zone scheme, extended zone scheme and reduced zone scheme for representing the E-K relationship. 6

(b) Using the Kronig-Penny model, show that the energy of the lowest energy band is

$$E = \frac{\hbar^2 p}{ma^2} \text{ for } p \ll 1$$ 4

Or

Explain how the atomic energy levels split into bands when a number of atoms are brought close together to form a crystal.

7. (a) Derive an expression for electron concentration of intrinsic semiconductor in terms of band gap. How does band gap affect the probability of electrons to be found in the conduction band of an intrinsic semiconductor?

5+1=6

(b) What is Meissner effect? Discuss the behaviour of a superconductor in a magnetic field and compare it with a perfect conductor. 1+5=6

Or

What are type I and type II superconductors? Discuss the diamagnetic behaviour of type II superconductors.

2+4=6

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