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6 SEM TDC PHY M 2

2018

(May)

PHYSICS

(Major)

Paper : 602

(Condensed Matter Physics)

Full Marks : 60

Pass Marks : 24/18

Time : 3 hours

The figures in the margin indicate full marks for the questions

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

(a) If N_i, N_f, N_c denote the numbers of lattice points present inside, at the face centre and at the corner of a cubic cell respectively, the effective number of lattice points belonging to a unit cell is

(i) $N = N_i + N_f + N_c$

(ii) $N = N_i + 2N_f + 3N_c$

(iii) $N = \frac{N_i}{2} + \frac{N_f}{3} + \frac{N_c}{5}$

(iv) $N = N_i + N_f/2 + N_c/8$

(Choose the correct answer)

(b) What is the coordination number of the diamond lattice?

(c) A simple cubic lattice is self-reciprocal but with different cell dimensions.

(State True or False)

(d) The average kinetic energy per electron for a three-dimensional free-electron gas at 0 K is

(i) $\bar{E}_0 = \left(\frac{2}{3}\right) E_{F_0}$ (ii) $\bar{E}_0 = \left(\frac{2}{5}\right) E_{F_0}$

(iii) $\bar{E}_0 = \left(\frac{3}{5}\right) E_{F_0}$ (iv) $\bar{E}_0 = 5E_{F_0}$

(Choose the correct answer)

(e) In diffraction, the expression for the amplitude of the wave scattered through a given angle was first calculated by

(i) Bragg
(ii) Born
(iii) Broglie
(iv) Madelung

(Choose the correct answer)

(f) In a pure or intrinsic semiconductor, electrons and holes are thermally generated and are not equal in number.

(State True or False)

(Continued

2. (a) How does hcp structure differ from bcc structure? 2

(b) How does the Fermi energy of a metal depend on temperature, concentration of electrons and the total number of electrons present in the metal? 2

(c) Lead in the superconducting state has critical temperature of 6·2 K at zero magnetic field and critical field of 0·064 MA m^{-1} at 0 K. Determine the critical field at 4 K. 2

3. (a) Show that for a cubic lattice, the distance between the successive plane of Miller indices (hkl) is given by the expression $d_{hkl} = a/(h^2 + k^2 + l^2)^{1/2}$. 4

(b) What do you mean by packing fraction and Brillouin zone? 1½+1½=3

4. (a) State Bragg's law of diffraction and discuss its importance in crystal structure analysis. 1+3=4

(b) Discuss how the concept of reciprocal lattice helps in the Ewald's construction and determination of crystal structure. 4

Or

The primitive translation vectors of a two-dimensional lattice are

$$a = 2\hat{i} + \hat{j} \; ; \quad b = 2\hat{j}$$

Determine the primitive translation vectors of its reciprocal lattice. 4

(Turn Over)

5. *(a)* How does the classical free-electron theory lead to Ohm's law? What is Wiedemann-Franz law?

   (b) What is Fermi energy? Derive expressions for the Fermi energy and density of states for a free-electron gas in one dimension. 1+6

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

7. Give the qualitative interpretation of the band structure of electronic energy levels in a semiconductor.

8. *(a)* Explain the difference between type-I and type–II superconductors.

   (b) What is London equation? Show that London equation leads to the Meissner effect.

9. *(a)* Derive an expression for electron concentration for an intrinsic semiconductor.

   Or

   What is an extrinsic semiconductor? Discuss the variation of the Fermi level with temperature for an *n*-type semiconductor.

   (b) Define penetration depth related to superconductor when it is placed in an external magnetic field.

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