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6 SEM TDC PHY M 2

2019

(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) Packing fraction of diamond structure is

(i) $\frac{\pi}{3\sqrt{2}}$

(ii) $\frac{\pi}{6}$

(iii) $\frac{\sqrt{3}\pi}{8}$

(iv) $\frac{\sqrt{3}\pi}{16}$

(Choose the correct answer)

(b) The energy versus wave vector relationship for a conduction electron in a semiconductor is

$$E = 5\frac{\hbar^2 k^2}{m_0}$$

(State True or False)

(c) Solids in which the outer electrons of the atom have a high degree of mobility and are free to move through the crystal is called

(i) ionic crystals

(ii) covalent crystals

(iii) metallic crystals

(iv) molecular crystals

(Choose the correct answer)

(d) If temperature increases, the current flowing in a semiconductor

(i) remains same

(ii) decreases

(iii) increases

(iv) first decreases then increases

(Choose the correct answer)

(e) The transition temperature of superconductor is related to the isotopic mass as

(i) $T_c \propto \frac{1}{\sqrt{M}}$

(ii) $T_c \propto \sqrt{M}$

(iii) $T_c \propto \frac{1}{M}$

(iv) $T_c \propto \frac{1}{M^2}$

(Choose the correct answer)

(f) The band theory of Kronig and Penny assumes that the potential experienced by an electron in a crystal is periodic with period equal to the length of the crystal.

(State True or False)

2. (a) What is the significance of Madelung constant and Madelung energy for a linear ionic crystal? 2

(b) Show the dependence of velocity of electron on wave vector k as predicted by the band theory. 2

(Turn Over)

(c) Define penetration depth for a superconductor. What is its value at critical temperature? 2

3. (a) Calculate the packing function (PF) for an f.c.c. lattice. 3

(b) If a is lattice constant of a cubic lattice, then calculate the spacing between (011) (101) (112) planes. 3

4. (a) What are Brillouin zones? Discuss the construction of the first two Brillouin zones for a square lattice. 1+4=5

(b) State the properties of reciprocal lattice. How does a reciprocal lattice construct from a direct lattice? 2+3=5

Or

Find the condition for strong diffraction of X-rays by crystal plane of separation d. Explain the principle of powder X-ray diffraction. 3+2=5

5. (a) What are electrical and thermal conductivities of metals? Establish the relation 2+3=5

$$\frac{k}{\sigma T} = \frac{\pi^2}{3}\left(\frac{kB}{e}\right)^2$$

where the symbols have their usual meanings.

(Continued)

Or

Define density of states. Why is the parameter very relevant to Sommerfeld theory? Discuss specific heat of electrons according to Sommerfeld theory.

(b) Show that average kinetic energy per electron for a three-dimensional free electron gas at 0 K is 4

$$\overline{E} = \left(\frac{3}{5}\right)E_{F0}$$

6. (a) Distinguish between a metal, an insulator and a semiconductor according to band theory. 2

(b) What is meant by the effective mass of an electron? What is its significance? 2

(c) State and prove Bloch theorem. Discuss its importance in the band theory. 4+2=6

7. (a) Give the expression for density of free electrons and holes in an intrinsic semiconductor. Show that Fermi level lies halfway between the valance band and the conduction band for an intrinsic semiconductor. 2+3=5

(Turn Over)

(b) Define mobility and conductivity. Obtain an expression for conductivity of doped semiconductors.

8. (a) What is Meissner effect? Explain the difference between type I and type II superconductors using the Meissner effect. 1+2=3

(b) What are high T_c superconductors? Give one example of a typical high temperature superconductor.

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