Total No. of printed pages = 6

63/2 (SEM-2) PHY 204

2022

PHYSICS

(Theory Paper)

Paper Code : PHY 204

(Condensed Matter Physics-I)

Full Marks – 80

Time – Three hours

The figures in the margin indicate full marks for the questions.

1. Choose the correct option of the following : 1×5=5

(a) The interplanar spacing for the lattice plane of Miller indices (201) for a cubic lattice with a = 5.62 Å is

(i) 1.50Å

(ii) 2.51Å

(iii) 3.25Å

(iv) 4.50Å

(b) The velocity of an electron in the energy band is maximum at

(i) $k = \frac{\pi}{2a}$ (ii) $k = \frac{\pi}{a}$

(iii) $k = -\frac{\pi}{a}$ (iv) $k = 0$

(c) The position of the Fermi level in p–type semiconductor is

(i) Near the conduction band

(ii) Near the valence band

(iii) In the middle of the conduction and valance band

(iv) None of the above

(d) A ferromagnetic material is heated above its curie temperature. Choose the correct statement :

(i) Ferromagnetic domains are perfectly arranged

(ii) Ferromagnetic domains become random

(iii) Ferromagnetic domains are not influenced

(iv) Ferromagnetic material changes to diamagnetic material

(e) Thermal breakdown occurs when the heat generated inside the insulating material is

(i) equal to or greater than the heat dissipated

(ii) less than that heat generated from the surface

(iii) only under AC voltage application

(iv) None of the above.

2. Answer the following questions : 2×5=10

(a) What are symmetry elements in a crystal ? Mention the various symmetry elements present in a cubic crystal.

(b) What is meant by dispersive and non-dispersive medium ?

(c) Explain how the paramagnetic susceptibility of a substance varies with temperature.

(d) Explain the difference between soft and hard magnetic materials.

(e) What is dielectric breakdown ? Explain how it can be prevented.

3. Answer any *five* of the following questions : 5×5=25

(a) Show that reciprocal lattice of a *bcc* cubic lattice is a *fcc* lattice. 5

(b) Derive an expression for the effective mass of an electron in the periodic crystal and draw the m*–k diagram. What is the physical significance of negative mass ? 4+1=5

(c) What is an extrinsic semiconductor ? Show that typical variation of carrier concentration with temperature for an extrinsic semiconductor and explain their different region. 1+4=5

(d) Discuss the Langevin's theory of diamagnetism and obtain an expression for diamagnetic suceeptibility. 5

(e) Explain the electronic polarization in atoms and hence obtain the expression for electronic polarizability in terms of radius of atom. 5

(f) Mention the various forms of dielectric breakdown and explain each one of them in details. 5

4. Answer any *four* of the following questions : 10×4=40

(a) (i) Explain the Bloch theorem. Discuss the different zone scheme of energy vs. wave vector (E-k) diagram. 2+5=7

(ii) What are Brillouin zones ? Illustrate the three Brillouin zones for a two-dimensional square lattice. 1+2=3

(b) Derive an expression of the density of electrons and holes in intrinsic semiconductor and show that 10

$$E_F = \frac{E_C + E_V}{2} + \frac{3}{4} kT \ln\left(\frac{m_h^*}{m_e^*}\right)$$

(c) What is reciprocal lattice ? Obtain the primitive reciprocal lattice vectors and their dot product with direct lattice vectors. Show that the direction of the reciprocal vector $\vec{\sigma}_{hkl}$ is perpendicular to the plane (h k l) and the length is $|\vec{\sigma}_{hkl}| = \frac{1}{d_{hkl}}$. 1+4+5=10

(d) (i) Deduce the Clausius-Mosotti equation and explain how it can be used to determine the dipole moment of a molecule. 7

(ii) Silicon has the dielectric constant 12 and edge-length of the conventional cubic cell of silicon lattice is 5.43Å. Calculate the electronic polarizability of silicon atoms. 3

(e) (i) Discuss the Weiss theory of ferromagnetism and show from the plot of Langevin function, spontaneous magnetization exists below the Curie temperature and vanishes above the Curie temperature. 6

(ii) What are ferromagnetic domains ? Explain the hysteresis loop on the basis of domains. 1+3=4