

Total number of printed pages-7

63/1 (SEM-5) CC12/PHYHC5126

2023

PHYSICS

Paper : PHYHC5126

(Solid State Physics)

Full Marks : 60

Pass Marks : 24

Time : Three hours

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

1. Choose the correct answer : **(any five)** 1×5=5
- (a) The co-ordination number of an atom in a fcc lattice is
- (i) 8
 - (ii) 6
 - (iii) 12
 - (iv) 4

Contd.

(b) Miller indices of the plane parallel to x and y axes are

(i) (100)

(ii) (010)

(iii) (001)

(iv) (111)

(c) According to Dulong and Petit's law, the average energy of on atom of a solid at temperature T is

(i) $1/2 k_B T$

(ii) $k_B T$

(iii) $2 k_B T$

(iv) $3 k_B T$

(d) Which of the following material does not have permanent magnetic dipoles ?

(i) paramagnetic

(ii) diamagnetic

(iii) ferromagnetic

(iv) anti-ferromagnetic

(e) The torque induced on a dipole, placed in an electric field (\vec{E}) is given by

(i) $\vec{E} \sin \theta$

(ii) $\vec{P} \vec{E} \sin \theta$

(iii) $\vec{E} \cos \theta$

(iv) $\vec{P} \vec{E} \cos \theta$

(f) Ionic polarization

(i) increases with temperature

(ii) decreases with temperature

(iii) may increase or decrease with temperature

(iv) is independent of temperature

(g) The hysteresic phenomena in ferroelectric material exists

(i) below ferroelectric transition temperature

(ii) at transition temperature

(iii) above transition temperature

(iv) at all temperatures

(h) From Kronig-Penny model the energy discontinuity occurs in a one dimensional lattice when

(i) $k = \pm n\pi$

(ii) $k = \pm n\pi / a$

(iii) $k = \pm 2n\pi$

(iv) $k = \pm n\pi / 2a$

(i) 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

(j) The superconducting state is perfectly _____ in nature.

(i) diamagnetic

(ii) paramagnetic

(iii) ferromagnetic

(iv) antiferromagnetic

2. Answer the following questions : **(any five)**
2×5=10

(a) Show that the reciprocal lattice of a bcc lattice is a fcc lattice.

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

(c) How does the Debye model differ from Einstein model of lattice heat capacity?

(d) Draw hysteresis curve (100p) of a ferromagnetic material. What do you mean by coercivity?

(e) Define polarization and polarizability.

(f) What is ferroelectric Curie temperature? Write down the Curie-Weiss law.

(g) What do you mean by critical field in superconductivity?

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

(a) What is Meissner effect in a superconductor? What are the major conclusions that can be drawn from this effect?
3+2=5

- (b) Define mobility, conductivity and current density. Derive an expression for the conductivity of doped semiconductors. $1+1+1+2=5$
- (c) Discuss the theory of ferroelectricity and mention its applications. $4+1=5$
- (d) Write a short note on plasma oscillations.
5
- (e) Explain Ferrimagnetism. What are ferrites? $4+1=5$
- (f) What are the assumptions of Debye model of lattice specific heat? Discuss its predictions and limitations compared with Einstein model. $3+2=5$
- (g) What do you mean by packing fraction? Find the expression for packing fractions of body centred and face centred cubic lattice. $1+2+2=5$
- (h) Write a brief note on piezoelectricity and pyroelectricity. $2\frac{1}{2}+2\frac{1}{2}=5$
- (i) What do you mean by normal and anomalous dispersion, explain in detail.
5

4. Answer the following questions : **(any two)**
 $10 \times 2 = 20$

- (a) What is atomic scattering factor? Derive the general expression for the atomic scattering factor using spherical polar co-ordinates. $2+8=10$
- (b) Give an account of quantum theory of paramagnetism and derive an expression for susceptibility. $2+8=10$
- (c) What do you mean by Clausius-Mossotti relation?

Prove that $\frac{M\alpha}{3\epsilon_0} = \left(\frac{E_r - 1}{E_r + 2} \right) \frac{M}{d}$, where the symbols have their usual meaning. $2+8=10$

- (d) Write short notes of the following : $5 \times 2 = 10$
- (i) BCS theory of superconductivity
- (ii) Importance of Hall effect and its applications