PHY/VI/CC/21a **Student's Copy**

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(CBCS)

(6th Semester)

PHYSICS

TWELFTH (A) PAPER

(Solid State Physics)

Full Marks : 75

Time : 3 hours

(Part : A—objective)

(*Marks* : 25)

The figures in the margin indicate full marks for the questions

Section—A

(*Marks* : 10)

Put a Tick ☑ mark against the correct alternative in the box provided : 1×10=10

1. Phonons obey

(a) Fermi-Dirac statistics ☐

(b) Bose-Einstein statistics ☐

(c) Maxwell-Boltzmann statistics ☐

(d) Boltzmann statistics ☐

2. In the vibrations of one-dimensional diatomic lattice the optical and acoustical branches coincide at $K \quad \frac{}{2a}$, if

(a) $m \quad M$ ☐

(b) $m \quad M$ ☐

(c) $m \quad M$ ☐

(d) $m \quad M$ ☐

Where m is the mass of the lighter atom and M is the mass of the heavier atom and a is interatomic distance.

3. All materials have

(a) diamagnetic property ☐

(b) paramagnetic property ☐

(c) ferrimagnetic property ☐

(d) ferromagnetic property ☐

4. The magnetic susceptibility of a material is independent of temperature. The material is

(a) diamagnetic ☐

(b) paramagnetic ☐

(c) ferrimagnetic ☐

(d) ferromagnetic ☐

5. The polarization $\vec{P}$ in a solid dielectric is related to the electric field $\vec{E}$ and electric flux density $\vec{D}$ by the relation

(a) $\vec{E} \quad {}_0\vec{D} \quad \vec{P}$ ☐

(b) $\vec{E} \quad {}_0\vec{P} \quad \vec{D}$ ☐

(c) $\vec{D} \quad {}_0\vec{P} \quad \vec{E}$ ☐

(d) $\vec{D} \quad {}_0\vec{E} \quad \vec{P}$ ☐

6. For a given dielectric the electronic polarizability

- *(a)* increases with temperature ☐
- *(b)* decreases with temperature ☐
- *(c)* is independent of temperature ☐
- *(d)* may increase or decrease with temperature ☐

7. The motion of electrons in a periodic crystal lattice gives rise to

- *(a)* energy bands ☐
- *(b)* phonons ☐
- *(c)* photons ☐
- *(d)* None of the above ☐

8. Bloch theorem is applicable to

- *(a)* constant potential ☐
- *(b)* variable potential ☐
- *(c)* infinite potential ☐
- *(d)* periodic potential ☐

9. Transition temperature T_c and critical field H_c for a superconductor are related as

- *(a)* $H_c \quad H_o (T_c \quad 1)$ ☐
- *(b)* $H_c \quad H_o (T_c \quad 1)$ ☐
- *(c)* $H_c \quad H_o \; 1 \quad \frac{T}{T_c}^{\,2}$ ☐
- *(d)* $H_c \quad H_o \; 1 \quad \frac{T_c}{T}^{\,2}$ ☐

10. In a superconductor the Fermi energy level lies

(a) midway between the ground state and the first excited state ☐

(b) below the ground state ☐

(c) at the first excited state ☐

(d) above the first excited state ☐

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. What are phonons? Write the wave vector conservation law for inelastic collision of photons accompanied by creation and absorption of phonons.

OR

2. Give two points each of similarity and dissimilarity between phonons and photons.

3. Mention two properties each of paramagnetic and ferromagnetic materials.

OR

4. Distinguish between classical theory and quantum theory of paramagnetism.

5. Show that $\vec{P} \quad {}_{o}\vec{E}(\; {}_{r} \quad 1)$, where symbols have their usual meanings.

OR

6. Explain the different polarization mechanisms in dielectrics.

7. Distinguish between metals, semiconductors and insulators on the basis of their energy band structure.

OR

8. Explain the concept of holes.

9. Discuss Meissner effect in superconductivity.

OR

10. What are type I and type II superconductors?

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. *(a)* Obtain the dispersion relation for a one-dimensional monoatomic lattice. Discuss the dispersion behaviour at low frequency and high frequency. 5+3=8

(b) Define phase velocity and group velocity. 2

OR

2. Deduce the dispersion relation for a one-dimensional diatomic lattice. Differentiate between optical and acoustical branches. Why are these branches named so? 5+3+2=10

3. *(a)* Describe the classical theory of diamagnetism and obtain an expression for diamagnetic susceptibility. 6

(b) What is hysteresis? Prove that the work done by a magnetising field per unit volume of a material for a complete cycle is equal to the area enclosed by the B-H curve. 1+3=4

OR

4. *(a)* Describe the quantum theory of paramagnetism and obtain Curie's law. 6

(b) Give a brief idea of Weiss's theory of ferromagnetism and explain domain formation. 4

5. *(a)* What do you mean by local field in a solid dielectric? Deduce an expression for the local field for structures possessing cubic symmetry and obtain the Clausius–Mosotti relation. 1+5+2=8

(b) Define dielectric constant. How is it related to electric susceptibility? 1+1=2

OR

6. *(a)* What do you mean by polarizability? Describe the classical theory of electronic polarizability. 1+5=6

(b) Define polarization in dielectrics. What is depolarization field and how does it affect the electric field in a medium? 1+1+2=4

7. Discuss the Kronig-Penny model for the motion of electrons in a periodic potential. Using the model show that the energy spectrum of electrons consists of a number of allowed energy bands separated by forbidden regions. 10

OR

8. What is meant by effective mass of an electron? Give its physical significance. Prove that the effective mass of an electron in crystal is given by

$$m \qquad \frac{\hbar^2}{d^2E \,/\, dk^2}$$

where symbols have their usual meanings. Discuss the conditions when the effective mass of the electron becomes positive, negative and infinity.

1+2+4+3=10

9. *(a)* Give a qualitative description of BCS theory of superconductivity. Explain how the superconducting energy gap varies with temperature.

4+3=7

(b) Explain the isotope effect in superconductivity. 3

OR

10. *(a)* Derive London equations and obtain an expression for London penetration depth. 3+3=6

(b) The critical fields at 6 K and 8 K for a superconducting alloy are 7·616 tesla and 4·284 tesla respectively. Find the critical temperature and critical field at 0 K. 4

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