2022

(CBCS)

(6th Semester)

PHYSICS

NINETEENTH (A) PAPER

(Solid State Physics)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. In a one-dimensional monoatomic lattice vibration, the phase and the group velocities are the same when the wave vector K is such that

(a) K $\frac{}{2}$ ( )

(b) K 0 ( )

(c) K ( )

(d) K $\frac{}{2}$ ( )

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

(a) m M ( )

(b) m M ( )

(c) m M ( )

(d) m M ( )

3. Above a certain critical temperature, all magnetic materials become

(a) diamagnet ( )

(b) paramagnet ( )

(c) ferromagnet ( )

(d) ferrimagnet ( )

4. The magnetic susceptibility of a material is small and negative. The material is

(a) paramagnet ( )

(b) diamagnet ( )

(c) ferrimagnet ( )

(d) ferromagnet ( )

5. The electric displacement vector $\vec{D}$ for an isotropic medium is

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

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

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

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

6. A dielectric material is placed in an external electric field $\vec{E}$. The polarization $\vec{P}$ produced in the material is given by

(a) $\vec{P}$ $_0\vec{E}$ ( )

(b) $\vec{P}$ $_e\vec{E}$ ( )

(c) $\vec{P}$ $_0$ $_e\vec{E}$ ( )

(d) $\vec{P}$ $\dfrac{_0\vec{E}}{e}$ ( )

7. Bloch theorem is applicable to

(a) constant potential ( )

(b) variable potential ( )

(c) periodic potential ( )

(d) infinite potential ( )

8. A solid having a certain number of energy bands completely filled and all other bands completely empty is a/an

(a) conductor ( )

(b) semiconductor ( )

(c) insulator ( )

(d) good conductor ( )

9. Below a critical field H_c, type I superconductor exhibits

(a) perfect paramagnetism ( )

(b) perfect diamagnetism ( )

(c) perfect ferromagnetism ( )

(d) perfect ferrimagnetism ( )

10. The energy gap in a superconductor is

(a) minimum at 0 K ( )

(b) maximum at 0 K ( )

(c) independent of temperature ( )

(d) All of the above ( )

(SECTION : B—SHORT ANSWER)

(*Marks* : 15)

Answer the following questions (any *three*) : 5×3=15

UNIT—I

1. Define phase velocity and group velocity.

OR

2. What are Brillouin zones?

UNIT—II

3. Define the following terms :

(a) Magnetic susceptibility

(b) Magnetic flux density

OR

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

UNIT—III

5. What are the different sources of polarizability of a dielectric material?

OR

6. Show that

$$\vec{P} \quad {}_0\vec{E}(\ _r \quad 1)$$

where the symbols have their usual meanings.

UNIT—IV

7. Explain the concept of forbidden energy bands.

OR

8. Explain the concept of holes.

UNIT—V

9. Describe the isotope effect in superconductors.

OR

10. Explain the concept of BCS ground state.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

UNIT—I

1. Derive the dispersion relation for a one-dimensional monoatomic lattice. Discuss the dispersion behaviour at low and high frequencies. 6+4=10

OR

2. Deduce the dispersion relation for a one-dimensional diatomic lattice. Discuss the nature of acoustic and optical modes. 6+4=10

UNIT—II

3. *(a)* Explain the origin of diamagnetism in materials. 3

(b) Obtain an expression for diamagnetic susceptibility using Langevin's classical theory. 7

OR

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

(b) Give an account of Weiss theory of ferromagnetism. 4

UNIT—III

5. *(a)* What do you mean by local field in a dielectric? Obtain an expression for local electric field at an atom in a dielectric material. 1+6=7

(b) Write a short note on complex dielectric constant. 3

OR

6. *(a)* Discuss the classical theory of electric polarizability and obtain Clausius-Mossotti relation. 4+4

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

UNIT—IV

7. Prove that the motion of electrons through the periodic potential in solids gives rise to the band structure. 10

OR

8. What is meant by the effective mass of an electron? What is its significance? Show that the effective mass of an electron in a crystal is inversely proportional to the second derivative of E k curve. Discuss the conditions when the effective mass of an electron becomes positive, negative and infinity. 1+2+4+3

UNIT—V

9. *(a)* What are superconductors? What is the difference between a conductor cooled to 0 K and a superconductor? 1+2

(b) Give a qualitative description of BCS theory of superconductivity. How does it account for the superconducting state? 4+3

OR

10. *(a)* Derive London equations and obtain an expression for London penetration depth. 4+3

(b) Explain the term critical magnetic field in a superconductor. 3

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