**2 0 2 3**

( CBCS )

( 6th Semester )

**PHYSICS**

TWELFTH (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 monatomic one-dimensional lattice vibration, the lattice wave behaves like a standing wave without transfer of energy when

*(a)* $2\sqrt{m/}$ ( )

*(b)* $2\sqrt{/m}$ ( )

*(c)* $v$ $\sqrt{m/}$ ( )

*(d)* $v$ $\frac{1}{}\sqrt{/m}$ ( )

**2.** In a diatomic one-dimensional linear chain of atoms, the first Brillouin zone ranges from $k$ $\frac{}{2a}$ to $k$ $\frac{}{2a}$, where $a$ is the nearest neighbour distance. The smallest possible wavelength in this zone will be

*(a)* $a$ ( ) *(b)* $2a$ ( )

*(c)* $4a$ ( ) *(d)* $a/2$ ( )

**3.** The spontaneous magnetisation of ferromagnetic material at Curie temperature is

*(a)* 0 ( ) *(b)* 1 ( )

*(c)* ( ) *(d)* 1/2 ( )

**4.** The internal Weiss field, which arises due to the overlapping of the wave function of two neighbouring atoms in ferromagnetic material, is of the order of

*(a)* 500 *T* ( ) *(b)* 1000 *T* ( )

*(c)* 1500 *T* ( ) *(d)* 5000 *T* ( )

**5.** Which of the following is the fastest polarisation process?

*(a)* Electronic polarisation ( )

*(b)* Ionic polarisation ( )

*(c)* Space charge polarisation ( )

*(d)* Orientation polarisation ( )

**6.** When a dielectric is placed in external electric field, the induced dipole moment develops per unit volume is called

*(a)* polarisation ( )

*(b)* polarisability ( )

*(c)* permeability ( )

*(d)* susceptibility ( )

**7.** Valence band comprises of

*(a)* electrons that are freely moving inside the solid ( )

*(b)* electrons that are in the outermost orbit of the atom ( )

*(c)* mobile electrons ( )

*(d)* It contains no electron ( )

**8.** The K-electron of copper atom is lightly bound to nucleus. Its effective mass is

*(a)* $m_e$ 0 ( )

*(b)* $m_e$ ( )

*(c)* $m_e$ $m_e$ ( )

*(d)* 0 $m_e$ ( )

**9.** The magnetic susceptibility of a superconductor

*(a)* has a positive value ( )

*(b)* 0 as $T$ $T_c$ ( )

*(c)* as $T$ $T_c$ ( )

*(d)* has a negative value ( )

**10.** According to BCS theory, the zero resistance of superconductors arises due to

*(a)* presence of phonon scattering ( )

*(b)* increase of phonon scattering ( )

*(c)* decrease of phonon scattering ( )

*(d)* absence of phonon scattering ( )

## ( SECTION : B—SHORT ANSWER )

( *Marks* : 15 )

Answer the following questions : 3×5=15

### UNIT—I

**1.** Show that group and phase velocities are equal in vibration of monatomic linear lattice for long wavelength.

**OR**

**2.** What are phonons? Give two points each of similarity and dissimilarity between phonons and photons.

### UNIT—II

**3.** Explain how in diamagnetic material the induced magnetic flux is opposite to the inducing applied magnetic field.

**OR**

**4.** What is Curie-Weiss law? What is the significance of Curie temperature?

UNIT—III

**5.** Write a short note on anomalous dispersion.

**OR**

**6.** Find a relation between relative permittivity and susceptibility of a dielectric.

UNIT—IV

**7.** State Bloch theorem. What is the outcome of the theory?

**OR**

**8.** What is forbidden energy gap?

UNIT—V

**9.** Explain Cooper pair and coherence length.

**OR**

**10.** Describe the isotope effect in superconductors.

## ( SECTION : C—DESCRIPTIVE )

( *Marks* : 50 )

Answer the following questions : 10×5=50

UNIT—I

**1.** Discuss the lattice vibration of one-dimensional linear monatomic chain. Show that the state of vibration of the lattice corresponding to the wave vectors $k$ and $k \frac{2m}{a}$ are the same (where $m$ is an integer and $a$ is the nearest neighbour distance). Also show that at the boundary of first Brillouin zone, the alternate atoms are in the opposite phase and form a standing wave. 5+2+3=10

**OR**

**2.** Discuss the lattice vibrations of a lattice with two atoms per primitive cell. What are the optical and acoustical branch? Find the values of angular frequencies at the first Brillouin zone boundary. 6+2+2=10

UNIT—II

**3.** Discuss the saturation phenomenon in paramagnets quantum mechanically under strong magnetic field and low temperature conditions. 10

**OR**

**4.** Explain classical Langevin theory of diamagnetism and derive the expression for its susceptibility. 10

UNIT—III

**5.** *(a)* What are the various components of the local electric field at an atom in a crystal? Obtain the Lorentz relation for the local electric field. When is this relation valid? 2+5+1=8

*(b)* What do you mean by dielectric polarisation? 2

**OR**

**6.** *(a)* Define electronic polarisability. Show that electronic polarisability is given by

$$e \quad \frac{0 ( r \quad 1)}{N}$$

where $N$ is the number density of the dielectric. 2+4=6

*(b)* Obtain the Clausius-Mosotti relation. 4

UNIT—IV

**7.** Solve the Schrödinger equation for motion of electrons through periodic potential (Kronig-Penney potential). Discuss the results for *(a)* small barrier strength ($P$ 0) and *(b)* extremely large barrier strength ($P$ ). 10

**OR**

**8.** *(a)* How does the band theory of solid lead to the classification of solids into conductors, semiconductors and insulators? 4

*(b)* Explain the concept of effective mass of an electron. Explain how effective mass of electron varies with the wave vector. 2+4=6

UNIT—V

**9.** Derive London equations and discuss how it helps in explaining the superconducting state. Obtain an expression for London penetration depth. 5+1+4=10

**OR**

**10.** Define superconductivity. Explain the types of superconductor. What are the critical temperature, critical magnetic field, Meissner effect? 1+3+6=10

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