# 2015

( 6th Semester )

## PHYSICS

### TWELFTH (A) PAPER

**( Solid-State Physics—II )**

*Full Marks* : 55

*Time* : 2½ hours

### ( PART : B—DESCRIPTIVE )

( *Marks* : 35 )

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

**1.** *(a)* Describe elastic vibrations of continuous media and obtain the wave equation. 4

*(b)* Compare the dispersion curves for elastic vibrations of continuous media and one-dimensional monoatomic linear lattice by plotting them together. Show that the two curves coincide in the long wavelength limit ($\lambda \to \infty$). 1½+1½=3

*Or*

Derive the vibrational modes of a diatomic linear lattice and draw the dispersion curves for the two branches of vibrations. What is the physical difference between the two branches? 4+2+1=7

**2.** What are diamagnetic materials? Describe the classical theory of diamagnetism. Obtain an expression for the diamagnetic susceptibility of material. 1+3+3=7

*Or*

Describe the formation and significance of the hysteresis loop. Show that the area under the hysteresis loop denotes the energy dissipated per unit volume of material during each magnetizing cycle. 3+4=7

**3.** Write short notes on *(a)* Lorentz field and *(b)* Clausius-Mossotti relation. 3½+3½=7

*Or*

What are various polarizabilities? Discuss the classical theory of electronic polarizability and obtain the corresponding dispersion relation. 2+5=7

**4.** Explain the basic assumption in Kronig-Penney model. Discuss the results of Kronig-Penney model for *(a)* small barrier strength $(P \to 0)$ and *(b)* extremely large barrier strength $(P \to \infty)$. 2+2½+2½=7

*Or*

Show that the effective mass of an electron in an energy band is given by $m^* = \dfrac{\hbar^2}{\left(\dfrac{d^2E}{dk^2}\right)}$.

Give the physical basis of effective mass and explain its physical significance. 4+3=7

**5.** *(a)* Discuss the distinction between type I and type II superconductors with the help of appropriate diagrams. 3½

*(b)* Calculate the penetration depth for a superconducting material having electron density $n = 4 \times 10^{26}$ per $m^3$. What happens to the penetration depth as the critical temperature is approached?

[$m = 9 \cdot 1 \times 10^{-31}$ kg
$\mu_0 = 4\pi \times 10^{-7}$ SI unit
$e = 1 \cdot 6 \times 10^{-19}$ C] 3½

*Or*

Give an elementary treatment of BCS theory of superconductivity. Explain how the superconducting energy gap varies with temperature. 4+3=7

★★★

**2015**

( 6th Semester )

**PHYSICS**

TWELFTH (A) PAPER

**( Solid-State Physics—II )**

( PART : A—OBJECTIVE )

( *Marks* : 20 )

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

SECTION—A

( *Marks* : 5 )

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×5=5

**1.** Phonon is a quantum of

*(a)* electromagnetic wave ( )

*(b)* polarization wave ( )

*(c)* magnetization wave ( )

*(d)* elastic wave ( )

**2.** The effective number of electrons available for electrical conduction is maximum when

*(a)* the energy band is completely filled ( )

*(b)* the energy band is filled to the inflection point of the $E$ vs. $k$ curve ( )

*(c)* the energy band is completely empty ( )

*(d)* the energy band is filled up to two-third of the maximum capacity ( )

**3.** Optical refractive index $n$ is related to electronic polarizability $\alpha$ as

*(a)* $\frac{n^2-1}{n^2+2}=\frac{N\alpha}{3\varepsilon_0}$ ( )

*(b)* $\frac{n^2+1}{n^2-2}=\frac{N\alpha}{3\varepsilon_0}$ ( )

*(c)* $\frac{n^2+1}{n^2-2}=\frac{3\varepsilon_0}{N\alpha}$ ( )

*(d)* $\frac{n^2-1}{n^2+2}=\frac{3\varepsilon_0}{N\alpha}$ ( )

**4.** All materials have

*(a)* paramagnetic property ( )

*(b)* diamagnetic property ( )

*(c)* ferromagnetic property ( )

*(d)* ferrimagnetic property ( )

**5.** Superconducting electron density

*(a)* at absolute zero is infinite ( )

*(b)* at absolute zero is zero ( )

*(c)* at absolute zero is finite ( )

*(d)* increases as temperature increases from absolute zero to transition temperature ( )

## SECTION—B

( *Marks* : 15 )

Answer the following questions briefly : 3×5=15

1. Compare the paramagnetic susceptibility as obtained from quantum theory of paramagnetism and Langevin's classical theory.

 

2. What are Brillouin zones? How are they related to the energy levels of an electron in a metal?

3. What are phase and group velocities?

 

4. What do you mean by depolarization field? How does it affect the electric field in the medium?

8. For a specimen of superconducting material, the critical fields are $1.4 \times 10^5$ and $4.2 \times 10^5$ ampere/meter respectively for 14 K and 13 K. Calculate the transition temperature.

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