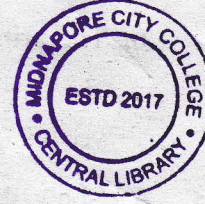# 2023

5th Semester Examination

PHYSICS (Honours)

Paper : C 12-T

[Solid State Physics]

[CBCS]

Full Marks : 40   Time : Two Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.

Group - A

Attempt any *five* questions : $2 \times 5 = 10$

1. Show that, for a simple cubic lattice, $d_{100} : d_{110} : d_{111} = \sqrt{6} : \sqrt{3} : \sqrt{2}$, where d_{hkl} is the separation between adjacent (*hkl*) parallel planes.

2. Taking the origin at the bottom of the conduction band, calculate the crystal momentum for free electron of energy 0.015 eV. Given that the effective mass of electron = $0.25 m_0$ where m_0 is the free electron mass.

3. Explain the Hall field and Hall voltage.

4. What is Pauli paramagnetism?

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Unknown

5. If an ionic crystal is subjected to an electric field of $1000\ Vm^{-1}$ and the resulting polarization 4.3×10^{-8} $C.m^{-2}$, calculate the relative permittivity of NaCl.

6. The primitive translation vectors of space lattice are $\vec{a} = 2\hat{i} + \hat{j}$, $\vec{b} = 2\hat{j}$, $\vec{c} = \hat{k}$. Find the primitive translation vectors of the reciprocal lattice.

7. Show that for a 1D mono-atomic lattice the group velocity at the zone boundary is zero.

8. Write down the differences between type I and type II superconductors.

Group - B

Attempt any *four* questions : 5×4=20

9. (a) What is local field in dielectrics? Taking the expression of the local field deduce the Clausius-Mossotti relation in dielectrics. 1+3

(b) What is the significance of complex dielectric constant in the case of a dielectric? 1

10. (a) Show that the total magnetic flux threading the circuit cannot change so long as the circuit remains resistanceless. 2

(b) The density and the atomic number of Niobium are $8.57\times10^{3}\ kg/m^3$ and 93, respectively. It has one conduction electron per atom. Calculate the penetration depth of Niobium. 2

(c) What is the isotope effect in superconductors? 1

11. (a) What is transition temperature in ferroelectricity? Comment on the structural phase transition in ferroelectrics. 1+2

(b) What symmetry element must be absent for a material to be ferroelectric? 1

(c) What is plasmon? 1

12. (a) Discuss the basic features of the Kronig-Penny model. 3

(b) A silicon plate of thickness 1 mm, breadth 10 mm and length 100 mm is placed in a magnetic field of $0.5\ Wb/m^2$ acting perpendicular to its thickness. If 10 mA current flows along its length, calculate the Hall voltage developed, if the Hall coefficient is $3.66\times10^{-4}\ m^3/C$. 2

13. (a) Define atomic scattering factor and geometrical structure factor. How the factors are related? 2+1

(b) The Bragg angle for first order reflection from (111) plane in a crystal is 60°. Calculate the interatomic spacing, if X-ray of 1.8Å are used. 2

14. Describe the Langevin's theory of paramagnetism and obtain an expression for paramagnetic susceptibility. 5

Group - C

Attempt any *one* question : 10×1=10

15. (a) What is depolarization field? 2

P.T.O.

(b) Derive the dispersion relation for a one-dimensional diatomic lattice and explain the acoustics and optical branches.   4+1+1

(c) What are Normal Dispersion and Anomalous Dispersion?   2

16. (a) What is the packing fraction in crystals? Find out the value of the packing factor for the FCC structure.   1+2

(b) Explaining the assumptions clearly, derive an expression for the lattice specific heat according to Debye Model. Discuss the low temperature limit and define Debye's T_3 law.   1+4+2

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