

# RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FIFTH SEMESTER EXAMINATION, FEBRUARY 2022

THIRD YEAR [BATCH 2019-22]

PHYSICS (HONOURS)

Paper : XII [CC12]

Date : 28/02/2022

Time : 11 am – 1 pm

Full Marks : 50

Answer **any five** questions of the following:

[5×10]

1. a) Find an expression for the spacing between the successive (hkl) lattice planes in a lattice. [3]
- b) Compare the spacings between the successive (100), (110) and (111) lattice planes in a FCC lattice. [2]
- c) Find the position of Fermi level in intrinsic semiconductor. [3]
- d) Show that a crystalline solid can not possess a five-fold rotational symmetry. [2]

2. a) Find the relation between the frequency of vibration and wave vector K in a linear monatomic lattice.

Using this relation, deduce the expression for density of vibrational modes of the same lattice. [4+3]

- b) For a semiconductor with a band gap of 1eV, calculate the position of Fermi level at T=0K and at T=300K in  $m_h^* = 6m_e^*$  where  $m_h^*$ , and  $m_e^*$  are effective masses of hole and electron respectively. [3]
3. a) Using the Debye approximation, show that the lattice heat capacity of a solid at  $T \ll \Theta_D$  is proportional to  $T^3$ . Given  $g(\omega) = \frac{9N}{\omega_D^3} \omega^2$ , symbols have their usual significance. [4]
  - b) The primitive translation vectors of a two dimensional lattice are  $\vec{a} = 2\hat{x}, \vec{b} = \hat{x} + 2\hat{y}$ . Determine the primitive translation vectors of its reciprocal lattice. [2]
  - c) Derive an expression for the built-in-electric field in a pn junction by solving one-dimensional Poisson's equation. [4]
4. a) Show that in X-ray diffraction nth order reflection from (hkl) plane is considered as 1st order reflection from (nhnkn) plane. [2]
  - b) The energy near the valence band edge of a crystal is given by  $E = -AK^2$ , where  $A = 10^{-38} \text{ Jm}^2$ . An electron with wave vector  $\vec{K} = 10^{10} \hat{x} \text{ m}^{-1}$  is removed from an orbital in the completely filled valence band. Determine the effective mass, velocity, momentum and energy of the hole. [1+1+1+1]
  - c) Show that the structure factor for reflection(khl) can be written as

$$F(hkl) = \sum_j^N f_j e^{i(\vec{G} \cdot \vec{r}_j)}$$

where symbols have their usual meaning.

[4]

5. Write short note on the followings (i) Para-magnetism, diamagnetism and ferromagnetism, (ii) Classical Langevin Theory. [6+4]

6. a) Define polarization, dispersion and absorption. [4.5]  
b) If 'p' is a dipole moment of a dielectric under external field 'E', then define polarization, Clausius-Mosotti equation and Lorentz-Lorentz equation. [3]  
c) What is piezo-electric effect and skin effect? [2.5]
7. a) What is superconductivity?  
b) What is Meissner effect?  
c) Proof a superconductor is perfectly diamagnetic.  
d) Define type I and type II superconductor. [2.5+2.5+2.5+2.5]
8. a) Write usefulness of Maxwell and Reynold's equations.  
b) Using London equation define penetration depth of a superconductor.  
c) What is Cooper pair?  
d) Write a note on BCS theory. [3+3+1+3]

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