RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2016

THIRD YEAR [BATCH 2013-16]

Date : 07/05/2016 **PHYSICS (Honours)**

Time : 11 am – 1 pm **Paper :** VIII Full Marks : 50

***Answer <u>any five</u> of the following* :** [5×10]

1. a) Find an expression for the spacing between the successive (hkl) lattice planes in a lattice. [4]
   b) Compare the spacings between the successive (100), (110) and (111) lattice planes in a fcc lattice. [3]
   c) Calculate the Hall coefficient of sodium on the free electron model, given that sodium has bcc structure of cell side 4·28Å. [3]

2. a) Derive Bragg's equation in X-ray diffraction. [2]
   b) Write down Laue's equation for x-ray diffraction. How does Laue's approach differ from Bragg's approach? [1+2]
   c) In a powder diffraction experiment using $Cu-K_\alpha$ radiation of wave-length 1·54Å, the first four lines are observed from a monoatomic cubic crystal when the angle 2θ are 22·2°, 31·6°, 38·9° and 45·3°. Determine the crystal structure and the lattice parameter. [4+1]

3. a) What do you mean by the cohesive energy of a crystal? Calculate it for NaCl crystal explaining its various terms clearly. [1+4]
   b) Derive the Clausius-Mosotti relation expressing the relationship between dielectric constant and atomic polarisability. [5]

4. a) Find the dispersion relation of a one-dimensional monoatomic lattice of lattice constant 3·6Å. Using this relation find the limiting value of wavelength λ for which the material can be treated as non-dispersive medium. [4+1]
   b) What are the basic differences between the models of Einstein and Debye for determination of lattice heat capacity of a solid? [2]
   c) Assuming a solid of volume v, the number of modes of vibration having angular frequency between ω and $\omega+d\omega$ is given by $dN=\frac{v\omega^2 d\omega}{2\pi^2 c^3}$ where c is the velocity of sound in solid. Calculate the Debye cut-off Frequency and write its physical significance. [3]

5. a) Using free electron theory, derive an expression for the electrical conductivity of a metal in terms of Fermi velocity and mean free path of electrons. How does the conductivity relate with Fermi surface. [5+1]
   b) The internal energy of the free electron gas in thermal equilibrium at
   $$U=\frac{3}{5}NE_{F0}\left[1+\frac{5\pi^2}{12}\left(\frac{T}{T_F}\right)^2\right]$$
   Using this relation calculate the molar specific heat due to electron at constant volume in metal silver of $E_{F0}=5\cdot5\,eV$ at 100K. [4]

6. a) Discuss the concept of "effective mass" for an electron moving in a periodic potential. [2]
   b) Calculate the effective mass (m*) as a function of wave vector (k) for a one-dimensional crystal of lattice constant 'a' having dispersion relation $E(k)=E_0-\alpha-4\beta\cos(ka)$ where, E_0, α,β are constants. Also find the width of the energy band and the value of 'k' at which the velocity of the electron is maximum. [2+2+2]
   c) Argue that the effective mass of the hole is opposite to that of an electron. [2]

7. a) Derive an expression for the built-in-electric field in a pn junction by solving one-dimensional Poisson's equation. Hence find the width of the space charge region. [4+2]
   b) Show that at thermal equilibrium the Fermi level must be constant throughout the pn diode.. [3]
   c) Draw clearly the energy band diagram of a npn transistor. [1]

8. a) Derive the Curie-Weiss law of ferromagnetism. [5]
   b) Explain why diamagnetism is an inherent property of an atom. [1]
   c) What are the difference between perfect conductor and super conductor. [2]
   d) What is Meissner effect? [2]

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