RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SIXTH SEMESTER EXAMINATION, MAY 2017

THIRD YEAR [BATCH 2014-17]

Date : 11/05/2017 **PHYSICS (Honours)**

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

Answer <u>any five</u> questions : [5×10]

1. a) Explain the idea of lattice and basis for describing crystal structure. What is a Bravais lattice? Can a honeycomb structure be considered as a Bravais lattice? [2+1+1]
   b) Are the planes (010) and (020) identical? Explain. [2]
   c) An element is cubic with lattice constant 4·28Å and with two of its atoms in the unit cube at (0,0,0) and $\left(\frac{1}{2},\frac{1}{2},\frac{1}{2}\right)$. How many nearest neighbours does each atom have in this element and how far away are they. Also find the atomic packing factor of this lattice. [1+2+1]

2. a) Considering suitable set of primitive vectors, show that the reciprocal lattice corresponding to a BCC lattice is a FCC lattice in reciprocal space. [2]
   b) Starting from Ewald sphere, prove the following form of Bragg's law $2\vec{K}.\vec{G}+G^2=0$. where K is the wave vector of the incident x-ray and G is the reciprocal lattice vector. [3]
   c) On an X-ray powder photograph of a cubic substance with Cu-K_α radiation $(\lambda = 1{\cdot}54\text{Å})$, lines are observed at the following Bragg angles (θ in degrees); 12·3, 14·1, 20·1, 24·1, 25·1, 29·3 and 32·2. Identify the crystal structure and assign Miller indices to the lines. Also calculate the unit cell dimension. [4+1]

3. 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) Using Born theory calculate the lattice energy of ionic crystal. [3]

4. a) What is the density of electronic state? How does the density of electronic state relate with the energy of electron in three dimensional metal. [1+3]
   b) Show that paramagnetic susceptibility due to free electrons is independent of temperature. [4]
   c) The lattice constant of copper is 3·6Å. Calculate the number of electrons per unit volume and Fermi velocity. [2]

5. a) Draw E-K diagram for free electron and electron in a solid. [1]
   b) What is the physical significance of effective mass of a carrier in a periodic lattice? [2]
   c) Sketch the distribution of space charge density and electric field across a p-n junction diode where p-side is lightly doped than n-side $(N_a < N_d)$. [3]
   d) Consider a silicon n-p-n transistor junction of $V_{eb} = 0{\cdot}814\,\text{eV}$ and $V_{cb} = 0{\cdot}635\,\text{eV}$ at T = 300K with doping concentrations of 10^{18}cm^{-3}, 10^{16}cm^{-3} and 10^{15}cm^{-3} in E, B and C region respectively. Calculate the emitter-base space charge width W_{EB}, and base-collector space charge width W_{BC}. [$\in_r = 11$ and $\in_0 = 8{\cdot}85\times10^{-14}\,\text{Fcm}^{-1}$]. [4]

6. a) Find the expression for the local field that is responsible for polarizing atoms of a solid dielectric of cubic symmetry. [5]
   b) Give Weiss theory of spontaneous magnetization and discuss its temperature dependence. [5]

7. a) What do you mean by carrier injection in a p-n junction diode? Under low-level injection approximation find the carrier injection at the edges of the p-n junction. [1+3]
   b) Derive the London equations for superconductivity and discuss the results. [4]
   c) Consider a silicon p-n junction at T = 300K with doping concentrations of $N_a = 10^{16}cm^{-3}$ and $N_d = 10^{15}cm^{-3}$. Calculate the built-in potential barrier in a p-n junction. [2]

8. a) What is Bloch theorem? Prove the Bloch theorem. [1+4]
   b) Kroning-Penny model gives a simplified solution of the form $P\frac{\sin\alpha a}{\alpha a}+\cos\alpha a=\cos Ka$, where the symbols have their usual significance. Discuss the formation of energy band and influence of P on the energy band. [5]

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