PG – 232

III Semester M.Sc. Examination, January 2018
(CBCS Scheme)
CHEMISTRY
C301 IC : Solid State Chemistry

Time : 3 Hours Max. Marks : 70

***Instruction** : Answer question No. **1** and **any five** of the remaining.*

1. Answer **any ten** of the following. **(2×10=20)**

   a) Name the type of bond responsible for the cohesive forces in (i) Ice and (ii) Crystalline Li.

   b) Define the reciprocal lattice vector $\vec{k}$. What is its significance in the free electron theory ?

   c) Make a schematic plot of f(E) Vs E at (i) T = 0K and (ii) T > 0K.

   d) How many rotation axes of each kind are present in the point group 23 ?

   e) Using Euler's construction calculate the angles between the different axes of rotation in the point group 422.

   f) The vibration spectrum of a solid has two modes (i) 150 cm^{-1} which varies linearly with $\vec{q}$, and (ii) 1500 cm^{-1} independent of $\vec{q}$. Which of these is the optical mode ? Give reasons.

   g) Using a schematic diagram, show how a FCC crystal can transform to a body-centred tetragonal crystal (BCT) by a diffusionless mechanism. What is such a phase transition called ?

   h) Consider the crystals of KCl and LiCl. Which of the two point defects, Frenkel and Schottky would dominate in each of them ? Give reasons.

   i) Two extrinsic semiconductors are prepared : (I) In-doped Ge and (II) Sb-doped Ge.

      Draw the schematic energy level diagram for each and indicate the nature of charge carriers.

j) A X-ray of λ = 1.54 Å is scattered by an angle 2θ = 10°. Calculate the corresponding d-spacing.

k) Consider the two triclinic space groups : P1 and $P\bar{1}$. Which of these is likely to exhibit piezoelectricity ? Give reasons.

l) Write the Wierl equation and explain all the terms.

2. a) A crystal has the following cell parameters : a = 5.7 Å; b =7.8 Å, c = 17.8 Å; $\alpha = \beta = \gamma = 90°$. Find the crystal system. What are the Bravais lattices possible in this crystal system. Calculate the number of atoms per unit cell and specify the fractional coordinates of all the atoms in each cell.

b) Obtain an expression for the fermi energy, E_f, of a n-type semiconductor. **(6+4=10)**

3. a) Write the expression for the structure factor and explain all the terms. Derive an expression for the intensity of a Bragg's reflection.

b) Using the expression derived in (a) above, obtain the reflection conditions for a C – centred lattice. **(5+5=10)**

4. Find the crystal system, lattice type and the principal symmetry elements in the following space groups :

(i) $Fm\bar{3}m$, (ii) $P6_{3/m}cm$, (iii) $P\bar{1}$, (iv) Pnma. **(3+3+1+3=10)**

5. a) Show that a superconductor is thermodynamically more stable than a normal metal. Make a plot of the free energy G Versus applied magnetic field H.

b) What are the properties that discontinuously change with temperature during

i) Melting

ii) Glass transition and

iii) Metal superconductor transition.

Make a schematic plot for each and indicate the order of the transition. **(4+6=10)**

6. a) Write the Schrödinger equation for an electron in a weak periodic potential and give any one form of its solution. Explain all the terms involved.

b) Show that the solution given in (a) above is not an eigen function of the momentum operator. **(5+5=10)**

7. a) $BaTiO_3$ undergoes a first order ferroelectric transition at 393 K. An oxide MO undergoes a second order magnetic transition at the same temperature. Make schematic plots for the polarization and magnetization curves respectively for the two materials. Also make a schematic plot of the DSC measurements for the two cases. Provide a brief explanation for your answer.

   b) NiO is a face centred cubic antiferromagnetic insulator with a lattice dimension, 'a'. Plot schematically its X-ray diffraction pattern (Int V s θ) and compare it with the neutron diffraction pattern. **(5+5=10)**

8. A Ge crystal (E_g = 0.72ev) containing 10^{22} atoms/cc is doped with 1 ppm of As atoms. The As states lie 0.012 eV below the bottom of the conduction band.

   a) What type is the resultant semiconductor ?

   b) Where does the E_f of this semiconductor lie at 298 K ?

   c) What are the majority and minority carrier concentrations ?

   d) Show that n×p is independent of E_f. **10**
