B.Sc. 5th Semester (Honours) Examination, 2022 (CBCS)

Subject : Physics

Course : CC-XII

(Solid State Physics)

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as applicable.

Symbols and abbreviations have their usual meanings.

Group-A

1. Answer *any five* questions: 2×5=10

(a) Electrons are accelerated under 344V and then reflected from a crystal. The first reflection maxima occurs at the glancing angle 60°. Determine the interplanar spacing of the crystal plane.

(b) The primitive vectors, in an orthorhombic cell are 1·27Å, 2·14Å and 1·51Å. Deduce the intercepts of y and z-axes if the (213) plane cuts an intercepts of 0·635Å along the x-axis.

(c) Using the Kronig-Peuny model, show that for P<<1, the energy of the lowest energy band at K = 0 is given by $E = \frac{h^2 P}{4\pi^2 m a^2}$.

(d) Calculate the penetration depth for lead at 5·2K if the London penetration depth at 0K is 37nm. (Given T_c = 7·19K).

(e) The static dielectric constant of a crystal is 5·6 and its refractive index is 1·5. Calculate the % contribution of ionic polarizability.

(f) State some distinguishing characteristics of a ferromagnetic material.

(g) Why are X-rays used for crystal structure analysis?

(h) What are phonons and what are the evidence of existence of phonons?

Group-B

2. Answer *any two* questions: 5×2=10

(a) Calculate the areal density on (100) and (111) planes of a simple cubic lattice for spherical atoms of radius 0·16nm. A second type of spherical atom just fits into the centre of each cubic cell, find the radius and packing fraction of the modified lattice. 2+2+1=5

(b) (i) Derive the Clausius-Mossotti relation expressing the relationship between dielectric constant and atomic polarisability.

(ii) Discuss the origin of antiferromagnetism. 3+2=5

(c) (i) What is Meissner effect? Which type of superconductors does not follow the Meissner effect strictly?

(ii) The critical field at 6K and 8K for an alloy for 7·616 and 4·248 MAm^{-1} respectively. Determine the transition temperature.

(iii) Estimate the intrinsic coherence length of Aluminium, if the size of the energy gap is $3{\cdot}4 \times 10^{-4}$eV. ($\gamma_F = 2{\cdot}02 \times 10^6$m/s). 1+1+3=5

(d) What is atomic scattering factor? Derive the general expression for the atomic scattering factor using spherical polar co-ordinates. 1+4=5

Group-C

3. Answer *any two* questions: 10×2=20

(a) What is paramagnetism? Describe Langevin's classical theory of paramagnetism and obtain an expression for paramagnetic susceptibility. Discuss the limitations of this theory. 2+6+2=10

(b) (i) Find an expression for the concentration of holes of an intrinsic semiconductor in the valence band.

(ii) A semiconducting crystal of 12mm long, 5mm wide and 1mm thick has a magnetic flux density of 0·5 Wb/m^2 applied from front to back perpendicular to largest faces. When a current of 20mA flows lengthwise through the specimen, the voltage measured across its width is 37μV. Find the Hall coefficient of the semiconductor. 7+3=10

(c) (i) Show that the Einstein's relation for the heat capacity per kmol of a solid reduces to the classical value of 3R when $KT \geq h\gamma$.

(ii) Calculate the number of possible wavefunctions in a band of 1d crystal. 7+3=10

(d) (i) What are superconductors? Distinguish between a Type-I and Type-II superconductors. Derive London's equation and obtain the expression of penetration depth.

(ii) Show that reciprocal of a bcc lattice is a fcc lattice. 7+3=10