M. TECH. MET. AND MAT / M. E. MET. AND MAT
M.TECH. NANO SCIENCE AND TECHNOLOGY FIRST YEAR FIRST SEMESTER – 2024

SUBJECT: MATERIALS SCIENCE

Total Marks: 100   Time: 3 hours

Use separate sheets for answering each parts

Answer **TWO** questions from Part-I and **THREE** question from Part-II

Part-I

Answer any TWO questions   **20X2=40**

1.   (a) Define the following terms:

Primitive and non-primitive unit cell; Symmetry of crystal.

Find the allowed folds of rotational symmetry for a crystal lattice. Why do the five folds symmetry axes are absent in a crystal.

What are quasi crystals?

(b) Show that parallel planes have identical miller indices.

   Why do we need (h k i l) i.e. four indices convention for a hexagonal crystal system. Obtain the Miller-Bravais indices for a hexagonal crystal system,

                                                                    (10 + 10)

2.   (a) What are reciprocal lattice points?

By geometric construction show that the reciprocal points of a crystal planes really form a lattice.

(b) Show that a general reciprocal lattice vector $\overrightarrow{d^*_{hkl}} = \overrightarrow{h^*_a} + \overrightarrow{k^*_b} + \overrightarrow{l^*_c}$ is perpendicular to the (hkl) plane. What is the relation between the magnitudes of general reciprocal lattice vector to the inter-planar distance in direct lattice?

(c) The primitive translation vectors of the hexagonal space lattice are given as

$$\vec{a}_1 = \frac{\sqrt{3}}{2}a\,\hat{x} + \frac{a}{2}\,\hat{y}\ ; \quad \vec{a}_2 = -\frac{\sqrt{3}}{2}a\,\hat{x} + \frac{a}{2}\,\hat{y}\ ; \quad \vec{a}_3 = c\hat{z}$$

Show that the volume of the primitive cell is $\ \frac{\sqrt{3}}{2}a^2 c$

(7 + 8 + 5)

3 (a) Prove that the direction [h k l] is the normal to the plane (h k l) for a cubic lattice.

(b) Show the following planes and directions through a neat drawing for a cubic lattice

(2 2 2); (1 0 2); (0 1 3); and [1 1 2] ; [2 0 3]; [1 1 3]

(c) Find the Miller indices of a plane passing through the three points having coordinates   (0, 0, 1) (1,0, 0) and (1/2, 1/2, 1/4).

(d) Find the relations between the direct lattice and reciprocal lattice.

Show that reciprocal lattice of FCC is BCC.

(3 +6+ 3 + 8)

Part-II

Marks: 60

Answer any THREE questions 20X3=60

1. What is diffusion? Write about Interstitial Diffusion and Vacancy Diffusion and derive expression of *Diffusivity (D)* for both the cases. Derive Fick's 1st law of diffusion. with proper diagrams and mathematical expressions. 2+5+13

2. Explain Error function. Write about the Temperature dependence of diffusivity. Solve the Fick's 2nd law for steady and non-steady conditions. 2+5+13

3. Write about the different defects present in solids depending on their dimensionality. Write about Frenkel and Schottky defects and derive the equations for the equilibrium concentrations of those defects. Explain (with diagrams) the presence of edge dislocation in terms of half plane. 3+7+10

4. Write about the formation of Screw Dislocation. Write about Burgers circuit. Explain the presence of Edge dislocation as a "Boundary between slip and no-slip regions of a slip plane". A dislocation line cannot end abruptly inside a crystal-explain with diagrams.

3+3+7+7

5. Write about metals, insulators and semiconductors. Explain the doping process in semiconductors to make n type semiconductors. Explain direct and indirect bandgap semiconductors. Explain effective mass of electrons and derive mathematical expression for the same. 3+3+7+7