Five Year Integrated M.Sc. Examination, 2024
Semester - VII
Paper: PH-4-7-2

Time: Four Hours | Subject: Material Science | Full Marks: 80

Questions are of values as indicated in the margin

GROUP -A

Answer any **ten** questions from Group -A

$10 \times 2 = 20$

1. (a) State and briefly explain Bloch's Theorem.

   (b) Explain the construction of Wigner-Seitz unit cell with the help of appropriate diagram.

   (c) Suppose the dispersion relation of waves is $\omega^2 = gk + hk^3$, where, g and h are constants. Calculate phase and group velocities of the waves.

   (d) Using appropriate diagram prove that two adjacent lattice points on a honeycomb lattice are not equivalent. Hence identify two equivalent points on this lattice.

   (e) Determine the Miller indices of a plane whose intercepts on x, y and z axis are $2a$, $-a$ and ∞, respectively.

   (f) Briefly discuss the origin of diamagnetism and paramagnetism.

   (g) Starting from the same precursors, how can you synthesize hollow and dense particles?

   (h) Discuss the application of Zeta Potential in pharmaceutical and paint industry.

   (i) What are the different categories of nanocatalysts based on their composition?

   (j) Is color a size dependent property? – Explain.

   (k) Illustrate the role of capping agents in the synthesis of nanomaterials using appropriate example.

   (l) What are the drawbacks of using titanium and stainless-steel alloys in medical implantations?

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GROUP -B

Answer any **twelve** questions from Group-B

$12 \times 5 = 60$

2. Define lattice, unit cell, primitive unit cell, reciprocal lattice with appropriate diagrams.

(1+1+1+2)=5

3. (a) State the basic assumptions of Drude model.
   (b) Use Drude model to obtain the general equation of motion for electron under a time varying force $f(t)$.

2+3=5

4. Derive Laue's condition for constructive interference. Use appropriate diagram to explain the construction.

5

5. (a) Consider a diatomic chain in one dimension. Write the equations of motion for two different types of atoms (No need to solve these). Clearly explain all the terms.
   (b) Draw the dispersion relation diagram for the optic and acoustic modes of a diatomic linear chain.

3+2=5

6. Show that the reciprocal lattice of a fcc (face-centred cubic) lattice is a bcc (body-centred cubic) lattice. Correspondingly, show that the reciprocal lattice of a bcc lattice is an fcc lattice. If an fcc lattice has conventional unit cell with lattice constant a, what is the lattice constant for the conventional unit cell of the reciprocal bcc lattice?

(2+2+1)=5

7. Prove the equivalence between Bragg's law and Laue's condition.

5

8. Dispersion relation of electrons moving in a periodic lattice of N sites, is given by

$$\cos(Ka) = \cos(pa) + \beta \frac{\sin(pa)}{pa},$$

where, a is the lattice constant, p is wave vector, β is a constant, and $K = \frac{2\pi n}{Na}$ with, $n = (0, \pm 1 \pm 2, \dots)$. Using proper plot, qualitatively discuss the solutions of this equation and show that the solutions of this equation exist for certain discrete ranges of p.

5

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9. (a) Illustrate with an appropriate model that the surface to volume ratio increases when a bulk material is broken down into smaller particles.
   (b) Discuss about the working principle of scanning tunneling microscopy.

2+(1+2)=5

10. (a) Explain the DLVO theory with appropriate illustrations.
    (b) What are prerequisites of sample preparation prior to collection of images using transmission and scanning electron microscopy and why?

3+2=5

11. What is Molecular Beam Epitaxy (MBE)? What are the two Epitaxy techniques? Write down the working principle in MBE. Give example of two different types of materials that can be made by MBE.

(1+1+2+1)=5

12. What are micelles? With appropriate illustration show the formation of different types of micelles. Discuss the application of micelles in nanoparticle synthesis with a suitable diagram and specific example.

(1+2+2)=5

13. In IGCT technique explain how inert gas type and inert gas pressure influence the synthesis? What is the effect of reactive gases on the synthesis? Write two advantages and two disadvantages of the IGCT technique.

(2+1+2)=5

14. (a) What is Ostwald's Ripening? Draw the La Mer model for monodisperse colloid growth.
    (b) Write down the basic principle of energy dispersive X-ray spectroscopy.
    (c) Name two cosmetic products where nanomaterials are used. Also mention the name of the compounds giving rise to the properties.

(1+1)+2+1=5

15. (a) Write down Scherrer's equation explaining the various terms appearing in it. What is SAXS and what information can be obtained from such study?
    (b) What are colloids? Identify the two phases in following colloidal systems: (i) liquid soap, (ii) opal, (iii) styrofoam and (iv) smoke.

(1+2)+2=5