Five Year Integrated M.Sc. Examination 2022

Semester - VII

Course: CH-4-7-2

(Chemistry)

Time: Four Hours **Full Marks: 80**

Questions are of value as indicated in the margin

Group-A

1. Answer ***any ten*** questions: $10 \times 2 = 20$

(a) Primitive lattice vectors of a two-dimensional lattice are given by

$$\vec{a}_1 = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}, \quad \vec{a}_2 = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath},$$

where θ is a constant. Find the reciprocal lattice vectors.

(b) Calculate the minimum distance between two lattice points of a FCC lattice with lattice constant a.

(c) Draw the lattice planes represented by the Miller indices (1, 2, 1) and $(\bar{1}, 1, 1)$.

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

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

(f) State the assumptions of the Debye model of heat capacity of a solid.

(g) What are the main aims of chemical modification of nanoparticle surface?

(h) Discuss the role of nanoparticles in targeted drug delivery.

(i) Sketch the set-up of a spray pyrolysis system.

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

(k) What is zeta potential? Show its relationship with surface potential using a suitable plot.

(l) Draw a schematic representation of the working of a transmission electron microscope.

Group-B

Answer ***any twelve*** questions

2. Define lattice, unit cell and primitive unit cell with appropriate diagrams. 5

3. Calculate the specific heat of solids in three dimensions following Einstein's theory. 5

4. Consider a diatomic chain in one dimension. Write the equations of motion for atoms and find the dispersion relation. 5

5. We apply a magnetic field along the *z*-direction to a planar (two-dimensional) sample that sits in the *xy* plane. The sample has width W in the *y*-direction, length L in the *x*-direction and we apply a current I along the *x*-direction. 5

Suppose we measure a Hall voltage V_H. Express the Hall resistance $R_{xy} = V_H/I$ as a function of magnetic field. Does R_{xy} depend on the geometry of the sample? Also express R_{xy} in terms of the Hall coefficient R_H.

6. State Bloch theorem for periodic potential. Consider an electron moving through a one-dimensional periodic lattice of periodicity a. For which value of n, $\psi(x) = A \exp\left(i\left[\frac{\pi x}{a} + cos\left(\frac{n\pi x}{a}\right)\right]\right)$ represents an energy eigen function of this system that is consistent with the Bloch's theorem? 5

7. Assume a scattering time τ and use Drude theory to derive an expression for the conductivity of a metal. 5

8. Consider the motion of an electron in periodic potential given by 2+3

$$V(x) = \alpha \sum_{n=-\infty}^{n=\infty} \delta(x - na),$$

where $V(x + a) = V(x)$ and $\delta(x)$ is Dirac delta function.
(a) Write down the Schrödinger equation for the electron in the aforesaid periodic potential.
(b) If $\psi(x)$ represents a single electron wave-function, show that

$$\lim_{\epsilon \to 0} \left[\frac{d\psi}{dx}\right]_{0+\epsilon} - \lim_{\epsilon \to 0} \left[\frac{d\psi}{dx}\right]_{0-\epsilon} = \frac{2m\alpha}{\hbar^2}\psi(0)$$

9. (a) Illustrate with an appropriate model that the surface to volume ratio increases when a bulk material is broken down into smaller particles. 2
(b) Outline a synthetic route for the preparation of dendrimer. How can they be used to synthesize nanoparticles? 2+1

10. (a) Explain quantum confinement effect. 2
(b) What are the cell parameters of cubic and hexagonal crystals? Write down the expression for $\frac{1}{d^2}$ for these crystal classes. 1+2

11. (a) Briefly discuss about carbon based nanomaterials. 2
(b) What is Ostwald's Ripening? Draw the La Mer model for monodisperse colloid growth. 1+2

12. (a) What is molecular beam epitaxy (MBE)? What are the two epitaxy techniques? 1+1
(b) Write down the working principle in MBE. Give example of two different types of materials that can be prepared by MBE. 2+1

13. (a) What are colloids? Identify the two phases in following colloidal systems: (i) smoke, (ii) shaving cream, (iii) styrofoam and (iv) butter. 1+2
(b) Illustrate the role of capping agents in the synthesis of nanomaterials using appropriate example. 2

14. (a) Briefly describe a methodology for the synthesis of size-controlled ZnS nanoparticles. 2
(b) In inert gas condensation technique explain the role of inert gas (i) type, (iii) pressure and (iii) flow rate on the size of the resulting particles. 3

15. (a)What are the drawbacks of using titanium and stainless steel alloys in medical implantations? 2
(b) Write down the basic principle of energy dispersive X-ray spectroscopy. 2
(c) Write down Scherrer's equation explaining the various terms appearing in it. 1