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Group – E

- 8. (a) What is electron tunnelling current? What instrument uses this to measure nano scale features and how is this used?
 - (b) Explain with the help of Bragg's law, how it is possible to obtain information about the crystal structure. Why are X-rays used in diffractometer?

6 + 6 = 12

- 9. (a) Define the band-structure of solid materials with reference to the behaviour of metals (conductors), semiconductors and insulators.
 - (b) Derive the expression relating the energy of a harmonic oscillator to the natural frequency of the oscillator.

6 + 6 = 12

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Time Allotted : 3 hrs

Full Marks: 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A (Multiple Choice Type Questions)

1. Choose the correct alternative for the following:

10 × 1 = 10

- (i) Colloidal lithography
 - (a) precipitates solute phase of colloids
 - (b) uses sol particles in colloids as masks
 - (c) uses colloids to imprint a structure on the surface
 - (d) uses UV light.
- (ii) Inverse micelles are
 - (a) biological cells
 - (b) microemulsions of oil and water
 - (c) deposited during the Langmuir-Schaefer method
 - (d) used in photochemical synthesis.
- (iii) The condition for constructive interference from successive crystallographic planes is given by
 (a) Bragg's law
 (b) laws of reflection
 - (c) Scherrer equation (d) laws of refraction.
- (iv) Auger electron spectrometer is used
 - (a) to detect inorganic material
 - (b) for thin film analysis
 - (c) to detect luminescence of the material
 - (d) to measure the thickness of material.
- (v) Soft lithography
 - (a) is used to build microfluidic devices
 - (b) uses inorganic compounds as raw material
 - (c) is used to grow thin films on silicon substrate
 - (d) is used to build soft structures in photolithography.

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- (vi) An example of ordered porous material is
 - (a) porous silicon
 - (b) mesoporous silica MCM 41
 - (c) polycrystalline silicon
 - (d) zeolites.
- (vii) What exactly is a quantum dot?
 - (a) A semiconductor nanostructure that confines the motion of conduction band electrons, valence band holes, or excitons in all three spatial directions.
 - (b) The sharpest possible tip of an Atomic Force Microscope.
 - (c) A fictional term used in science fiction for the endpoints of wormholes.
 - (d) Unexplained spots that appear in electron microscopy images of nanostructures smaller than 1 nanometer.
- (viii) Monolayer deposition of a liquid film on a solid substrate is achieved by
 - (a) chemical vapour deposition process.
 - (b) Langmuir-schaffer process.
 - (c) soft lithography
 - (d) sol-gel process.
- (ix) Which one of these statements is NOT true?
 - (a) Gold at the nanoscale is red.
 - (b) Aluminium at the nanoscale is highly combustible.
 - (c) Silicon at the nanoscale is an insulator.
 - (d) Copper at the nanoscale is transparent.
- (x) Ferritin is
 - (a) an iron alloy
 - (b) an iron compound
 - (c) an intracellular protein
 - (d) used as a template in soft-lithograpy.

Group – B

- 2. (a) Explain the quantum confinement effect. Give an example of how a particular property of a material is affected when the material goes from bulk to the nano phase.
 - (b) What are plasmons and excitons? Describe the two different kinds of paramagnetism observed in materials?

6 + 6 = 12

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- 3. (a) What is epitaxial growth? What is the difference between epitaxial growth and epitaxial deposition? Explain with examples.
 - (b) Describe the low pressure chemical vapour deposition chamber with a detailed schematic. Give an example of one chemical reaction that is being carried out in the LPCVD chamber.

5 + 7 = 12

Group – C

- 4. (a) Silica aerogels are manufactured through hydrolysis and condensation process. Write out the reaction for the two steps. Explain the process of synthesizing silica aerogel.
 - (b) What is supercritical drying? How is it different from freeze drying?

6 + 6 = 12

- 5. (a) Provide a schematic of how a monolayer is deposited through the Langmuir Blodgett process. What is X and Y type of deposition?
 - (b) Draw the Π -a curve for a typical L-B Process identifying zones of compactness at different stages of the process.

8 + 4 = 12

Group – D

- 6. (a) How is the diameter of a carbon nanotube calculated? Illustrate with a diagram how you would get an armchair and a zigzag arrangement? Give two examples of application of carbon nano tubes.
 - (b) What is the process of large scale generation of carbon nano tubes? Describe the process with details on operating parameters.

6 + 6 = 12

7. (a) Aluminium gallium arsenide (AlGaAs) is a semiconductor with a lattice structures similar to that of gallium arsenide, but with a bigger band gap. These properties are advantageous when making a GaAs quantum dot surrounded by AlGaAs. At what temperature can electrons from the AlGaAs overcome the coulomb blockade that exists in a spherical GaAs quantum dot 10 nm in diameter?

[Given that the permittivity of AlGaAs, ϵ = 1.16 x 10 $^{-19}$ Farad/meter & K_B = 1.38 x 10 $^{-23}$ J/K].

(b) Estimate the melting point of nano gold particles (Diameter \sim 15 nm) while that of the bulk gold is 1337 K.

6 + 6 = 12

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