NANOTECHNOLOGY
(CHEN 3233)

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)   Fermi energy level for intrinsic semiconductors lies
          (a) at middle of the band gap   (b) close to conduction band
          (c) close to valence band   (d) none.

   (ii)   The band gap between conduction and valance band in an insulator is
          (a) low   (b) very low
          (c) high   (d) moderate.

  (iii)   A single monoloyer of a liquid film is to be deposited on a substrate. This is done with the help of special molecules called
          (a) amphiphiles   (b) polymers
          (c) polar molecules   (d) organometallic complex.

   (iv)   Sputter deposition is similar to pulsed laser in the following manner
          (a) both are used to deposit thin films
          (b) both used heated targets
          (c) both bombard the target to dislodge material
          (d) both use charge targets.

   (v)   The sol gel process occurs through a process of
          (a) dissolution and condensation   (b) hydrolysis and condensation
          (c) coagulation   (d) solidification of sol network

   (vi)   An example of a bio template is
          (a) red blood cell   (b) s layers
          (c) single strand DNA   (d) none of above.

  (vii)   Atomic Force Microscopy is capable of collecting information
          (a) about the surface of sample   (b) about bulk composition of sample
          (c) measure film thickness of sample   (d) measure film growth rate.

(viii) Dichromatic mirrors are used in
(a) scanning probe microscope
(b) atomic force microscope
(c) scanning electron microscope
(d) confocal microscope.

(ix) Electrostatic lenses are used in the following instruments
(a) scanning probe microscope
(b) atomic force microscope
(c) scanning electron microscope
(d) confocal microscope.

(x) Aerogels are used as construction material because they
(a) are lightweight and strong
(b) are good thermal conductors
(c) have high porosity
(d) are transparent.

Group- B

2. (a) Draw (100) plane for bcc lattice. Also calculate the planer packing density on this (100) plane. (Given, $a_0 = 3.536 \times 10^{-8}$ cm). [(CO1)(HOCQ)]
   (b) Draw the first Brillouin zone for a 2D square reciprocal lattice. [(CO1)(IOCQ)]
   (c) Write down the vector form of Bragg's equation. [(CO1)(LOCQ)]
   (d) What is n-type semiconductor? Give an example. Draw the energy level diagram of n-type semiconductor. [(CO1)(LOCQ)]
   (e) Write down the differences between intrinsic and extrinsic semiconductor.
   [(CO1)(LOCQ)]
   (1 + 2) + 2 + 1 + (1 + 1 + 2) + 2 = 12

3. (a) What is the density of states? [(CO1)(LOCQ)]
   (b) What is meant by Quantum confinement of a nanoparticles (NP)-Explain is details. [(CO1)(IOCQ)]
   (c) Mention some effects of size reduction of nanoparticles (NPs)? Briefly explain effect of size on melting point of NPs. [(CO1)(LOCQ)]
   (d) How does size change affect the optical properties of NPs? [(CO1) (IOCQ)]
   (e) Mention some chemical properties that change with change of size of NPs.
   [(CO4)(IOCQ)]
   2 + 2 + (2 + 2) + 2 + 2 = 12

Group - C

4. (a) What are Knudsen cells? What arrangements are made so that vaporized metal is free of contamination in the cells? [(CO2, CO3)(Remember/LOCQ)]
   (b) Draw a labelled schematic of the reactor in which tungsten is deposited on a silicon wafer through chemical vapour deposition. [(CO2)(Remember/LOCQ)]
   (c) What types of surface phenomena occurs during the heterogenous reaction with gas phase precursors on a substrate? [(CO3)(Understand/LOCQ)]
   5 + 4 + 3 = 12

5. (a) What are S-layers? With a sketch explain how S-layers can be used for lithography. [(CO2)(Apply/IOCQ)]

(b) Give two examples of nano particle synthesis from plants.

[(CO2)(Remember/LOCQ)]

(c) Give two examples of nano particle synthesis from fungi.

[(CO2)(Remember/LOCQ)]

6 + 3 + 3 = 12

Group - D

6. (a) Fig. 1 given below plots the absorbance vs concentration of dispersions containing 1 to 5 layers of graphene in $KMnO_4$ solution. Which instrument is used to get this type of graph? [(CO4)(Apply/IOCQ)]
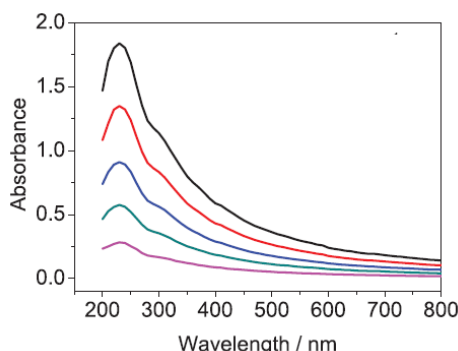

Fig. 1

(b) Draw a schematic to explain the working principle of the instrument.

[(CO4)(Remember/LOCQ)]

(c) Based on Fig. 1, describe the process of evaluating the number of layers in a dispersion containing unknown layers of graphene. [(CO4)(Analyze/IOCQ)]

2 + 5 + 5 = 12

7. (a) Describe the salient features in sample preparation of Transmission Electron Microscope. [(CO4)(Remember/LOCQ)]

(b) What are the differences between contact and non-contact mode of operation in atomic force of microscopy? [(CO4)(Remember/LOCQ)]

(c) Electrostatic lenses are used in Scanning Electron Microscope. What are electrostatic lenses and how are they used in this measuring instrument?

[(CO4)(Understand/LOCQ)]

4 + 4 + 4 = 12

Group – E

8. (a) State and explain the sequential process steps involved in feature development in photolithography starting from substrate cleaning.

[(CO2)(Remember/LOCQ)]

(b) Describe one lithographic technique which uses a direct write process. State one application. [(CO2)(Apply/IOCQ)]

6 + 6 = 12

9. (a) What are core shell nanoparticles? Describe the process used in any particular example of core shell NP synthesis? [(CO2,CO3)(Remember/LOCQ)]

(b)   Describe the structure of hydrogel. State two examples with applications.

[(CO2)(Understand/LOCQ)]

7 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	68.75	28.15	3.1

Course Outcome (CO):

After the completion of the course students will be able to the objective of the course is to provide an elaborated concept of different unit operations that are required in an industry. After completion of the course students will be able to:
1. Exhibit knowledge of the fundamentals of solid state physics, lattice and atomic structure, energy bands and different types of bonding in matter.
2. Classify the various types of process used in nano-manufacturing of 1D, 2D and 3D nanostructures.
3. Exhibit knowledge of the relevant physical, chemical, mechanical, electrical and optical properties of materials in nano configuration.
4. Exhibit understanding and decide on measurements and instruments used for characterizing nanomaterial.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question