

NANOTECHNOLOGY
(CHE3242)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

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

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) In moving from 3D bulk material to quantum dots, the material bandgap shifts
 - (a) towards longer wavelengths
 - (b) towards higher energies
 - (c) towards infra-red region
 - (d) none of above
- (ii) The grain size below which the material will be a single magnetic domain is called
 - (a) supermagnetic diameter
 - (b) the critical diameter
 - (c) magnetization diameter
 - (d) none of above
- (iii) Phonons are responsible for
 - (a) acoustic energy propagation
 - (b) light energy propagation
 - (c) thermal energy propagation
 - (d) defect propagation
- (iv) Pulsed laser deposition is advantageous over other PVD methods because
 - (a) it is a relatively fast process
 - (b) the fabrication can be done on a large scale
 - (c) it is not an energy intensive process
 - (d) it uses lower temperature
- (v) Langmuir Blodgett films are formed
 - (a) by chemical reaction on a substrate
 - (b) by ordered arrangement of long chain molecules on a substrate
 - (c) by coating a colloidal gel on a substrate
 - (d) none of these
- (vi) The process of DNA ligation
 - (a) separates two nucleotides
 - (b) separates one DNA strand from the other
 - (c) forms a covalent bond to join two nucleotides
 - (d) none of these

- (vii) If V_{bias} and d are the bias voltage and distance between the tip and sample, the expression for probe current in STM is
- (a) $I_t = V_{bias} \exp(Cd)$ (b) $I_t = V_{bias} d$
 (c) $I_t = V_{bias} \exp(-Cd)$ (d) $I_t = d \exp(-CV_{bias})$
- (viii) The relation between absorbance and concentration of species is known as
- (a) Beer's law (b) Bragg's law
 (c) Moseley's law (d) Snell's law
- (ix) Dip pen lithography (DPL) require
- (a) a photoresist (b) an atomic force microscopic nib
 (c) a photomask (d) a stripping solution
- (x) Zeolites have a _____ structure
- (a) cylindrical (b) octagonal
 (c) tetrahedral (d) buckyball

Fill in the blanks with the correct word

- (xi) Fermi energy in a 1D nanomaterial is express by _____
- (xii) Excitons are _____
- (xiii) Silica gel is prepared by _____ process
- (xiv) The nearfield van der Waals force between the probe tip and sample in AFM is expressed as _____.
- (xv) Scherrer equation for calculating particle diameter in XRD is expressed as _____.

Group - B

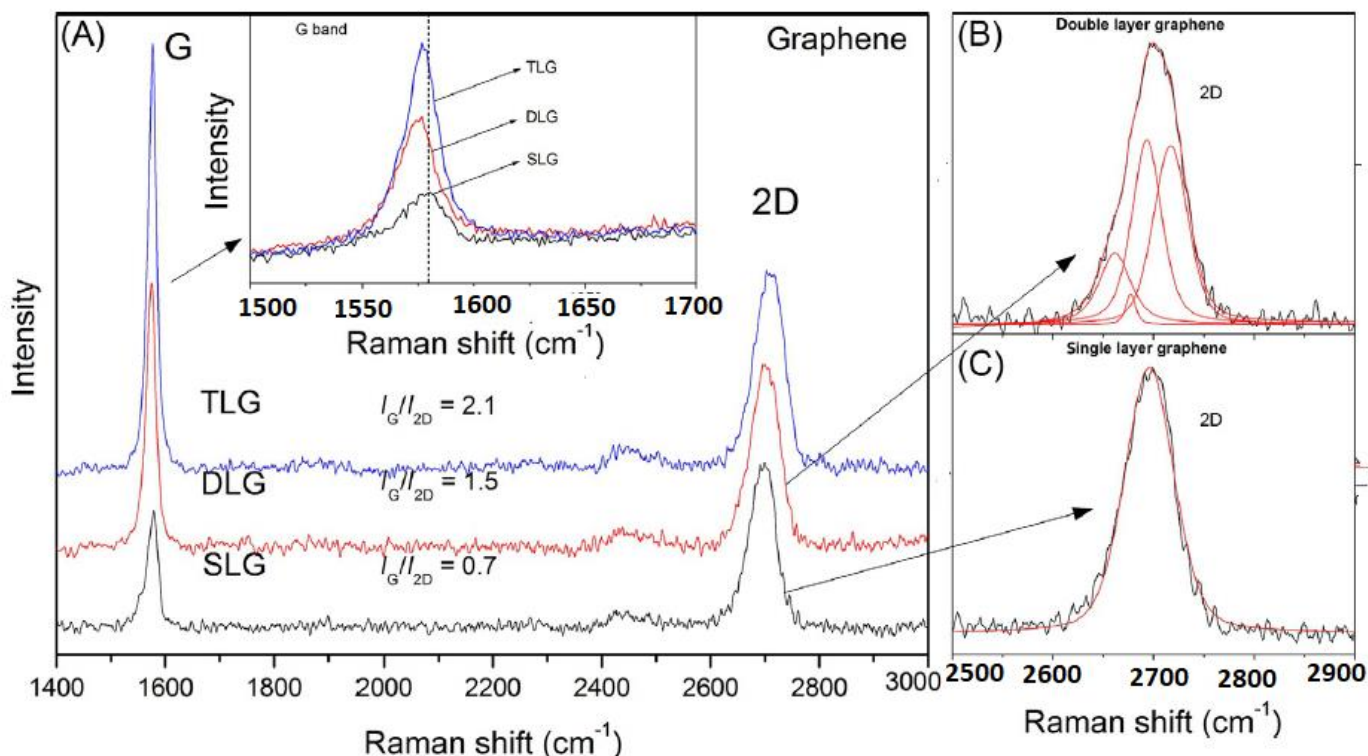
2. (a) Assume a rectangular solid of length, D , breadth $D/2$ and thickness $D/4$. Calculate the surface to volume ratio of this solid in terms of D . [[CO1](Analyse/HOCQ)]
- (b) With appropriate mathematical expression, explain why 10 nm Cu nanoparticle exhibit a higher melting point than bulk copper. [[CO1](Remember/IOCQ)]
- (c) Why is does the absorption edge shift towards blue as the confinement dimension is reduced? [[CO1](Remember/LOCQ)]
- 4 + 4 + 4 = 12**
3. (a) What are superparamagnetic nanoparticles? Explain in terms of critical magnetization diameter. [[CO1](Analyse/HOCQ)]
- (b) Vacancy concentration is affected by the curvature of the nanoparticle? Explain mathematically. [[CO1](Remember/LOCQ)]
- (c) Explain the process of photo emission. What are elastic and inelastic scattering? [[CO1](Apply/IOCQ)]
- 4 + 4 + 4 = 12**

Group - C

4. (a) Molecular beam epitaxy is used to deposit epitaxial layers. What is epitaxy? What are the factors controlling epitaxial growth? [[CO2](Analyse/HOCQ)]
 (b) Describe with a schematic the key components of a chamber where MBE is performed. [[CO2](Remember/LOCQ)]
 (c) Describe the reaction and mechanism by which porous Si is synthesized. [[CO2](Apply/IOCQ)]
4 + 4 + 4 = 12
5. (a) What is a microemulsion? What is a surfactant and a cosurfactant? [[CO2](Understand/LOCQ)]
 (b) Provide an example process where biomineralization occurs naturally and two examples of where this process is effectively utilized to remove contaminants. [[CO2](Remember/LOCQ)]
 (c) What is recombinant DNA? What is DNA ligation? Where are these processes used? [[CO2](Remember/LOCQ)]
4 + 4 + 4 = 12

Group - D

6. (a) Calculate the crystalline diameter of zinc oxide nanoparticles from the XRD data given below. Also compute the mean crystalline diameter. State the necessary equation required for finding the diameter.
- | Wavelength(Å) | Breadth angle of diffraction line(degree) | Bragg's angle of diffraction 2θ(degree) |
|---------------|---|---|
| 2.82 | 0.298 | 31.76 |
| 2.60 | 0.324 | 34.46 |
| 2.47 | 0.402 | 36.27 |
| 1.91 | 0.415 | 47.61 |
| 1.62 | 0.373 | 56.70 |
- [[CO3](Analyse/HOCQ)]
- (b) Discuss the various detectors used in XRF. [[CO3](Remember/LOCQ)]
 (c) Sketch and explain the X-ray spectrum of Molybdenum target as a function of applied voltage. [[CO3](Apply/IOCQ)]
 (d) For cubic NaCl crystal, if Bragg's angle of diffraction (2θ) is 46°, $d_{220} = 1.9707 \text{ Å}$, wavelength of incident Cu- $k\alpha$ line 1.54 Å, calculate the dimension of the cube. [[CO3](Apply/HOCQ)]
4 + 3 + 3 + 2 = 12
7. (a) Distinguish between X-ray photoelectron spectroscopy and Auger electron spectroscopy. [[CO3](Analyse/IOCQ)]
 (b) How does the Raman spectra shown below help draw conclusions on the graphene structure? [[CO3](Apply/HOCQ)]



- (c) Discuss the significance of HAADF detector in STEM with a diagram. [[C03](Apply/IOCQ)]
- (d) State the important applications of UV-Vis-NIR spectroscopy in characterization of nanomaterial. [[C03](Remember/LOCQ)]
- 3 + 4 + 2 + 3 = 12**

Group - E

8. (a) What do you mean by 'chirality' of carbon nano tube? How would you mathematically define the chiral vector? [[C04](Analyse/HOCQ)]
- (b) Explain the molecular structure of zeolites. What is the advantage of using nanocrystalline zeolite? [[C04](Remember/LOCQ)]
- (c) What are aerogels? State two properties of silica based aerogel. [[C04](Remember/LOCQ)]
- 4 + 4 + 4 = 12**
9. (a) Describe with schematics the process of soft lithography starting from mask development. [[C04](Remember/LOCQ)]
- (b) Why is etching done? Describe the process with a schematic. [[C04](Remember/LOCQ)]
- (c) Describe with schematics the process of microcontact printing. [[C04](Apply/IOCQ)]
- 4 + 4 + 4 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	47.92	25	27.08