NANOTECHNOLOGY
(CHEN 3231)

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) Atomic Force Microscope tips are generally made of
(a) silicon   (b) germanium
(c) platinum   (d) none of above.

(ii) Langmuir-Schaeffer process involves the deposition of a monolayer on
(a) vertical plate   (b) plate inclined at 30 deg to subphase
(c) horizontal plate   (d) both a and c.

(iii) Electroluminescence is the process of
(a) generation of electricity from light
(b) generation of light by passing electric current
(c) spontaneous flow due to radioactive nature of the material
(d) flow under plasma discharge.

(iv) The process of soft lithography uses which of the following as raw material?
(a) Polydimethylsiloxane   (b) Silane
(c) Poly methyl methacrylate   (d) Both (a) and (c).

(v) The group velocity at the edge of the first Brillouin zone of a monoatomic linear lattice is
(a) $\sqrt{\dfrac{ka^2}{M}}$ (b) $\sqrt{\dfrac{ka}{M}}$ (c) 1   (d) 0.

(vi) Bragg's law in vector form can be represented as
(a) $2\vec{k}.\vec{G} = 0$ (b) $2\vec{k}.\vec{G} + G^2 = 0$
(c) $2\vec{k}.\vec{G} - G^2 = 0$ (d) $2\vec{k}.\vec{G} + G^2 = k^2$
Where $\vec{k}$ is the wave vector and $\vec{G}$ is the reciprocal lattice vector

(vii) Which of the following is considered as weak quantum confinement regime?
(a) $\dfrac{R}{\alpha_B^*} \approx 1$ (b) $\dfrac{R}{\alpha_B^*} > 1$
(c) $\dfrac{R}{\alpha_B^*} < 1$ (d) $\dfrac{R}{\alpha_B^*} << 1$
Where exciton's Bohr radius is α_B^* and radius of the sample is R

(viii) The condition for constructive interference from successive crystallographic planes is governed by
(a) Bragg's law   (b) laws of reflection
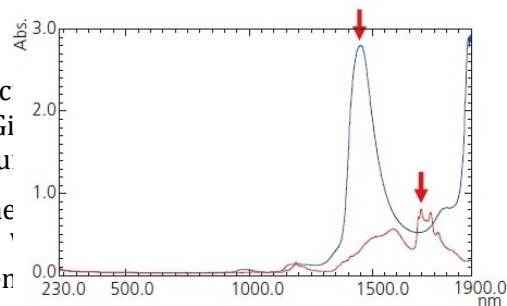(c) Scherrer equation   (d) laws of refraction.

(ix) Aerogel structures are obtained through a special drying process after gel formation. This special drying process is
(a) freeze drying   (b) calcination
(c) supercritical drying   (d) drying in an inert gas.

(x) Exciton is a quasi particle which
(a) is neutral
(b) carries charge through a semiconductor
(c) is obtained when an electron combines with a hole
(d) is the excited state of an electron

2. (a) List and desc[...] [...]ur deposition. Use a diagram. Gi[...] [...]VD. At what step of IC manufactu[...]

   (b) Describe one [...] and the associated equipment. [...] [...]cant components of the equipmen[...]

6 + 6 = 12

3. (a) Provide a schematic and explain how a monolayer is deposited through the Langmuir Blodgett process. What is X and Y type of deposition?

   (b) Draw the Π-Area curve for a typical L-B Process identifying zones of compactness at different stages of the process.

8 + 4 = 12

Group – C

4. (a) Explain molecular self assembly with an example. Why is molecular self-assembly preferred over conventional fabrication techniques?

   (b) Describe the alkanethiol bond. State its important properties? State one application where this bond is used in lithography.

6 + 6 = 12

5. (a) What are S layers ? Describe how S-layers are used in UV lithography.

   (b) What is DNA hybridization? How can DNAs be used as a connecting wire?

6 + 6 =12

Group – D

6. (a) What is an Auger electron? What type of characterization is done with Auger Electron Spectroscopy AES?

   (b) Describe how Auger Electrons are generated in a concentric hemispherical analyzer (CHA)?

4 + 8 = 12

7.(a) Describe the working principle of UV spectrophotometer with a diagram.

   (b) The figure given below shows the UV spectrum of two component mixture. What can you tell about the characteristic of the two components. We also know that ethanol absorption is maximum at 1400nm.
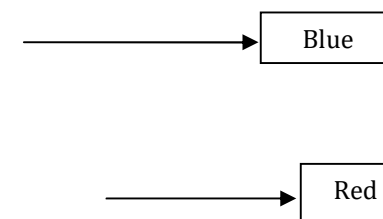
6 + 6 = 12

Group – E

8. (a) Potential energy of a diatomic molecule in terms of inter atomic distance R is given by.

$$U(R) = -\frac{A}{R^m} + \frac{A}{R^n}$$

   i) At what distance between the atoms potential energy will be minimum?

   ii) Under what condition the potential energy will be minimum ?

   (b) What is a quantum well? Starting from necessary Schrödinger equation estimate the energy eigen value in an one dimensional quantum well.

(3 + 3) +(1 + 5) = 12

9. (a) Are the physical and chemical properties of nanoparticles same as that of the bulk.-Comment.

   (b) Show that reciprocal lattice of fcc lattice is bcc.
   (c) What are Brillouin zones in a two-dimensional lattice.
   (d) How band structure of a semiconductor is different from that of metal? Differentiate between direct and indirect band gap semiconductor.

2+ 4 +2 +(1 + 3) = 12