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)   The reciprocal lattice of a fcc lattice is a
   (a) simple cubic lattice   (b) bcc lattice
   (c) fcc lattice   (d) hexagonal lattice

   (ii)   Electrons in fermi level will obey the following energy distribution
   (a) Bose Einstein distribution   (b) Fermi Dirac distribution
   (c) Maxwell Boltzmann distribution   (d) all

   (iii)   The process of melt-mixing involves
   (a) Rapid cooling of molten metals
   (b) Formation of crystalline layers of metal
   (c) Mixing two molten metals at high temperature
   (d) None of above

   (iv)   A Langmuir Blodgett film is
   (a) a solid amorphous layer deposited on a glass substrate
   (b) a thick polymer film
   (c) an extremely thin film with high structural order
   (d) none of above

   (v)   Biomineralization is the process
   (a) of mining of materials using biological active compounds
   (b) of production of minerals by living organisms
   (c) mineral utilization by living organisms
   (d) none of above

   (vi)   Porous silicon is
   (a) used in optoelectronic devices   (b) photo luminescent
   (c) is formed by an etching process   (d) all of above

(vii) Scanning probe microscopy involves
    (a) the imaging of the probe
    (b) recording the probe-surface interaction
    (c) capturing the digital image of the object
    (d) none of above

(viii) The Scherrer equation in X-ray diffraction and crystallography relates
    (a) the shape of the particle to the diffraction peak width
    (b) the size of the particle to the diffraction peak width
    (c) the number of particles to diffraction peak
    (d) none of above

(ix) Photoluminescence spectrometry excites the specimen with light and measures
    (a) the dissipation of the excess energy absorbed by electrons
    (b) the energy absorbed by the sample
    (c) all of above
    (d) none of above

(x) Soft lithography predominantly uses the following material
    (a) tetraethylorthosilicate   (b) polydimethylsiloxane
    (c) titanium tetra isopropoxide   (d) polymethylmethacrylate

Group – B

2. Explain the concepts of space lattice, basis and crystal structure.
How is a Wigner Seitz cell constructed ?
Write the energy expression and wave function for an electron following quantum free electron theory in one dimension.
What is the main cause of quantum free electron theory's failure?
What is energy band gap of a semiconductor?

$$(3 + 3 + 2 + 2 + 2) = 12$$

3. Find out reciprocal lattice vectors for a space lattice defined by the following primitive translation vectors : a=4i, b=4j, c=4k where i, j and k are the unit vectors along x, y and z axes.
What is Fermi Energy ?
Draw the energy level diagram for an n-type semiconductor and level it.
What are the differences between free electron gas and ideal gas ?
Why the spacing of the electronic levels increases with decreasing nanoparticle size ?

$$(3 + 2 + 2 + 3 + 2) = 12$$

Group – C

4. (a) What are the major steps involved in sol-gel synthesis? With the help of an example reaction, name and explain the two-step reaction process. Give relevant chemical equations.

(b)   The end product of the sol gel process is a xerogel or aerogel which is formed depending on conditions of the drying process. Explain the difference in drying process and the reason behind the formation of xerogels and aerogels respectively.

6 + 6 = 12

5.   (a)   Explain the concept of how a solid substrate can be coated with a non-fouling film using self-assembly of molecular structures. What type of bond is responsible for self-assembly? Give detailed characteristics of this bond.

(b)   What is DNA hybridization? Illustrate with an example how the process can be used as molecular wires for connecting nano electrodes.

6 + 6 = 12

Group – D

6.   (a)   State two differences in working principle of a scanning and transmission electron microscope. State the kind of samples that can be examined with each device.
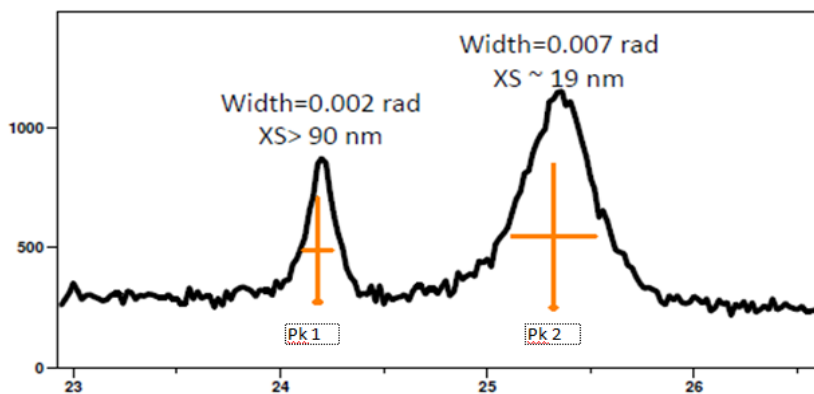
(b)

Fig. 1

Fig. 1 above shows the peaks when XRD is performed on a material containing nanocrystallites. Assuming that the incident X-ray wavelength is 0.154 nm and the peak widths are given in radians (Pk 1 width = 0.002 rad and Pk 2 width= 0.007 rad) as shown in figure, calculate the size of nanocrystallites present in the material.

6 + 6 = 12

7.   (a)   When electromagnetic waves are incident on matter, a part of it is absorbed by the material. State and explain the various forms of excitations, transitions that are triggered due to this process.

(b)   Explain the cause behind 'blue shift' of light observed as the nanoparticles are reduced in size. Why does 10 nm gold film become transparent where as bulk gold is not?

6 + 6 = 12

Group – E

8. (a) What makes certain polymers electrically conducting? Give two examples of a conducting polymer.

    (b) What is electrochemical oxidation ? How is this process used in the synthesis of a conducting polymer?

    6 + 6 = 12

9. (a) Explain the working principle of atomic force microscopy(AFM). Provide schematic if necessary. Give two examples of characterization performed with AFM.

    (b) Describe the process of nanosphere lithography. Provide an example of how a biotemplate can be used for nanolithography.

    6 + 6 = 12

Department & Section	Submission Link
CHE	https://classroom.google.com/u/1/w/Mjk5MzYwMjQwOTkw/tc/MzY4NzcxMTk4NDI4