2014-15
M.TECH. II SEMESTER (WINTER SEMESTER) EXAMINATION
NANOTECHNOLOGY
NANOBIOTECHNOLOGY
AP-615

Maximum Marks: 60 Credits: 04 Duration: Three Hours

Answer all the questions.

Q.No. Question M.M.
1(a) What are cell surface receptors? Explain the induced fit interaction of antigens and antibodies with the help of a neat diagram. [05]
1(b) Explain the cellular organization of a typical animal cell with the help of neat and labelled diagram. [05]
1(c) Describe the protocol of nanoparticles/ nanomaterials toxicity assessment using the Ames Salmonella/ mutagenicity assay. [05]
2(a) Define and discuss natural nanomaterials. Write examples of inorganic and organic world. [05]
2(b) What is spider silk? Discuss formation of spider silk and explain its formation. OR [05]
2(b') Discuss the concept of tissue engineering and how can nanotechnology be used for developing implants? [05]
2(c) Differentiate between collagen, cartilage, bone, aspidine and teeth. Does the bone have piezoelectric properties? [05]
3(a) Give a detailed account of therapeutic action of nanoparticles and nanodevices. [06]
3(b) How the nanostructures can enhance the fidelity of antibiotics? [06]
3(c) What is hyperthermia? Explain the role of nanoparticles in ‘cooking of cancer’. [03]
4(a) Write the basic principle of NMR and explain the detailed procedure of MRI. [06]
4(b) What are Quantum dots? Why are they used as molecular labels? [05]
4(c) What are the advantages of biosynthesis of nanoparticles/nanomaterials? [04]
Answer all questions. Symbols have their usual meanings.

1(a) What are the characteristic features occurring in the material on changing it from bulk to nano regime?  

OR

1(a') Show that $L_p$ is the average distance a hole diffuses before recombination.

1(b) Discuss quantum Hall effect in a two dimensional channel. Also obtain quantum condition of Hall resistance in the channel.

2(a) Taking into account ballistic conductor in between two contacts, obtain an expression for current and discuss the role of modes in the contact resistance.  
(b) What is the effect on current when a conductor is connected through the ballistic conductors in between two contacts? Use current equations to get the Landauer formula.

3(a) Derive an expression for orientational polarization in the case of poly atomic molecules. Discuss its dependence on temperature.  

OR

3(a') Obtain an expression for complex electronic polarizability in the presence of an alternating field and discuss the behaviour of real and imaginary parts with frequency with the help of dispersion curves.

3(b) A solid contains $5 \times 10^{28}$ identical atoms/m$^3$, each with polarizability of $3 \times 10^{-40}$ F.m$^2$. Assuming that internal field is given by Lorentz relation, calculate ratio of the internal field to the applied field. Also calculate relative permittivity of the material.  
(Given: $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m)

4(a) Discuss with examples the spin arrangements in ferromagnetic, anti ferromagnetic and ferrimagnetic materials.

4(b) The magnetic field in a diamagnetic material is $1.2 \times 10^5$ A/m$^{-1}$. Calculate the magnetization and flux density in it, if its magnetic susceptibility is $-4.2 \times 10^{-6}$. Also, compute the relative permeability of the material.

4(c) Explain Nanocarbon ferromagnetism and plot the magnetization curve (hysteresis loops) for iron particles on the tips of aligned nanotubes at the temperature of 5 and 320 K.

Continued.........
5 (a) What are lattice vibration and phonons?  
5(b) Calculate the specific heat of lead at 10 K if its Debye temperature is 105 K. Also determine the highest frequency that the sample allows to propagate through it.  
5(c) How did the Einstein theory explain the failure of Dulong and Petit law?

OR

5' (a) Work out expression for the specific heat of solids following Einstein model. How does specific heat depend on temperature and to what extent does this model agree with experimental results?  
5' (b) For copper, specific heat at low temperature has behavior of $C_v \approx 4.6 \times 10^{-2} T^3$ J/kmol.K. Estimate the Debye temperature for copper.

6 (a) Discuss the fundamental optical absorption process in direct and indirect semiconductors. Explain the phenomenon of photoconductivity.  
6(b) Explain the terms fluorescence and phosphorescence. Discuss and plot the curves of fluorescence spectra for two samples of CdS nanoparticles and photoluminescence excitation spectra for seven CdSe quantum dots.

Useful Physical constants:

Given $k_B = 1.38 \times 10^{-23}$ JK$^{-1}$, $N = 6.02 \times 10^{26}$ k mol$^{-1}$, $h = 6.624 \times 10^{-34}$ Js, $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m and $\mu_0 = 4\pi \times 10^{-7}$
NOTE: Answer ALL the questions.

1(a) What do you mean by nanocomposite materials? Explain their importance. [03]
(b) Discuss the ceramic-metal nanocomposites in detail and mention its potential applications. [07]

OR

(b') Describe synthesis of nanocomposites by mechanical alloying method and name the silica-based aerogel matrices. [07]

(c) What is the thermal spray technique for the synthesis of nanocomposites? Give its critical parameters. [05]

2(a) Differentiate between hard, superhard and ultrahard nanocomposites. [03]
(b) Explain the design methodology and mechanical properties of superhard nanocomposites. With the help of suitable example discuss the mechanism of hardness enhancement of nanocomposites. [12]

3 What are fractal based glass metal nanocomposites? How are they synthesized? Discuss their electrical properties. [15]

4 Explain various methods for the synthesis of carbon nanotube/polymer nanocomposites. Discuss in detail their mechanical and electrical properties. Mention some industrial applications of carbon nanotube/polymer nanocomposites. [15]

4' Write notes on
(i) Graphene/polymer nanocomposites and their advantages
(ii) Carbon nanotube/ceramic composites
(iii) Challenges in the processing of polymer nanocomposites and their possible remediation
NOTE: Answer ALL the questions. Notations used have their usual meanings.

1(a) Discuss the importance of clusters and explain two discoveries associated with them. [4.0]

1(b) Explain the principle, construction and working of MBE technique and mention its attributes and drawbacks. [6.0]

1(c) Describe any TWO of the following methods for nanoparticles synthesis [5.0]
   (i) Template based synthesis
   (ii) Electrochemical deposition
   (iii) Spray pyrolysis

2(a) Explain Coulomb Blockade in quantum dots. Obtain the necessary conditions for the observation of this phenomenon. [7.0]

OR

2(a') Explain the role of cohesive energy on melting temperature of nanoparticles and derive the equation $T_m = T_{mb}(1 - 6\sigma r/D)$. [7.0]

2(b) What do you understand by solid-state phase transformation? With the help of suitable diagrams, discuss homogeneous and heterogeneous nucleation. [8.0]

3(a) Write the importance of optical properties of semiconductor nanoparticles. Explain UV-visible and photoluminescence properties of CdSe and ZnS nanoparticles. [9.0]

OR

3(a') What do you mean by non-linear optical properties? Explain these properties in semiconductor nanoparticles with suitable examples. [9.0]

3(b) Give the applications of semiconductor nanomaterials in optical filters and LEDs. Also mention the shortcomings of nanoparticle LEDs. [6.0]

4(a) Describe any two synthesis mechanism and methods of semiconductor nanowires. [6.0]

4(b) Write short notes on any THREE of the following [9.0]
   (i) Porous Silicon (PoSi)
   (ii) Nanoribbons
   (iii) Nanobelts
   (iv) Nanosprings