2017-2018
M.TECH. AUTUMN SEMESTER (1 SEMESTER) EXAMINATION
(M. Tech and Advanced P.G. Diploma in Nanotechnology)
Fundamentals of Nanotechnology
(INC-610)
(Credits: 04)

Maximum Marks: 60
Duration: Two Hours

Note: Students of Adv. P. G. Diploma will be examined out of 75 marks and their obtained marks shall be proportionally raised.

Answer ALL the questions. Notations used have their usual meaning.

1. (a) How are nanomaterials defined? Write down its possible application in science and technology. [8]
   (b) What is self-assembly? What are the important parameters behind self-assembly? [4]

2. (a) Explain surface area of nanoparticles and why nanosized particles exhibit different properties than large particles of the same substance? [7]
   (b) What are Colloids? Explain with examples. [5]

3. (a) What are Genetic Codes? How does DNA indirectly determine a protein's function? [4]
   (b) Differentiate between Miscells and Vesicles. [4]
   (c) Write short note any one of the followings.
      (1) Biological Building blocks [4]
      (2) DNA Double Nanowires [4]

4. (a) Obtain the expressions and plot number of electrons N(E) versus energy, and density of states D(E) versus energy graph in:
     (i) 2D, and (ii) 1D. [6]
     (b) What is an exciton? Describe why exciton formation and diffusion is critical for the performance of a solar cell. [6]

5. (a) What is the band gap of C_{60} and what type of semiconducting behaviour usually C_{60} exhibits? Is it possible to change the behaviour to p-type? [4]
   (b) Describe structure of carbon nanotubes [8]
2017-2018
M.TECH. AUTUMN SEMESTER (I SEMESTER) EXAMINATION
M. Tech (Nanotechnology)
Quantum Mechanics
(INC-611)
(Credits: 04)

Maximum Marks: 60
Duration: Two Hours

Answer ALL the questions. Notations used have their usual meanings.

1. (a) State and explain the uncertainty principle. Using this principle show that electron cannot be inside the nucleus. [7.5]
   (b) Obtain the expressions for reflection and transmission coefficients for a particle incident on a potential step of height $V_0$. [7.5]

2. (a) Write down the Schrodinger equation for a particle in a three dimensional box, and find its eigen values and normalized eigen functions. [8]
   Or
   (a') Write down the Schrodinger equation for a one-dimensional Harmonic Oscillator and find its eigen values and eigen functions. [8]
   (b) Find the expectation value of $x^2$ for a particle in a one-dimensional infinite square well potential of width 2a which is symmetrical about $x = 0$. [8]

3. (a) The Hamiltonian of a system is given by the matrix: $H_0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 3 \end{bmatrix}$ and the eigen vectors by: $\phi_1 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$; $\phi_2 = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$; $\phi_3 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, find eigen values of $H_0$. [2]
   (b) If the perturbation to the system is given by the matrix: $H' = \begin{bmatrix} 0 & 0.6 & 0 \\ 0.6 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$, find new eigen values of the system. [3]
   (d) If the perturbation to the system is given by the matrix: $H' = \begin{bmatrix} 0 & 0 & 0.6 \\ 0 & 0 & 0 \\ 0.6 & 0 & 0 \end{bmatrix}$, find new eigen values of the system. [4]
   (e) How ground state energy of a system is calculated using Variational Method? [6]

4. Answer all the questions from the following:
   (a) Consider a two dimensional rectangular infinite potential well with the wave function:
   $$\varphi = \frac{2}{\sqrt{ab}} \sin \frac{n\pi x}{a} \sin \frac{n\pi y}{b}$$
   Calculate the first order energy correction with the following perturbation:
   $$V' = \frac{n^2 \hbar^2}{40 m \sqrt{ab}}$$
   for $(a/4 \leq x \leq 3a/4)$ and $(b/4 \leq y \leq 3b/4)$, $V' = 0$ everywhere else. [12]
   (b) Write three differences between a quantum computer and a classical computer. [3]
2017-2018
M.TECH. AUTUMN SEMESTER (I SEMESTER) EXAMINATION
(M. Tech and Advanced P.G. Diploma in Nanotechnology)
Physics and Chemistry of Solids
(INC-612)
(Credits: 04)

Maximum Marks: 60
Duration: Two Hours

Note: Students of Adv. P. G. Diploma will be examined out of 75 marks and their obtained marks shall be proportionally raised.

Answer ALL the questions. Notations used have their usual meanings.

1. (a) Define the terms; lattice, basis, crystal structure and unit cell. [4]
   (b) Assuming that lattice points of lattice parameter a in a bcc structure are occupied by spherical atoms of radius r, calculate the free volume per unit cell. [5]
   (c) Describe the two ways in which crystals may have closet packing of atoms. Workout the coordination number and packing factor for fcc structure. [6]
   OR
   (c') Derive Bragg’s law of x-rays diffraction in crystals. Give an account of power method of crystal structure analysis. [6]

2. (a) Explain the difference between ionic and covalent types of bonding. Give some examples. [4]
   (b) Electrons are accelerated by 844 volt and are reflected from a crystal. The reflection maximum occurs when the glancing angle is 58°. Determine the spacing of the crystal. [5]
   (c) What are the forces contributing to the binding of an ionic crystal? What do you understand by Madelung constant? Obtain an expression for the total lattice energy of an ionic crystal. [6]

3. (a) Based on electronic structure, differentiate between a metal and a semiconductor at 4K temperature. [5]
   (b) What is a polymer? Obtain the formula to calculate the side of a cubical polymer nanoparticle. [5]
   (c) Describe Eutectic temperature with the help of a phase diagram. [5]

4. (a) Derive the expression to estimate the ratio of critical shear stress ($\sigma_c$) to shear modulus (G) of a crystal. G of polycrystalline aluminium is $2.5 \times 10^{11}$ (dyn/cm$^2$) and $\sigma_c$ is $2.6 \times 10^3$ (dyn/cm$^2$). Calculate the ratio of $\sigma_c$/G and comment why is it different from the theoretically estimated value? [9]
   (b) Calculate the number of Schottky defects in the following cases:
   (i) $E_v = 0.5$ eV, and $T = 100$ K; (ii) $E_v = 0.5$ eV, and $T = 300$ K; and (iii) $E_v = 1$ eV, and $T = 300$ K. [6]
Answer ALL the questions. Notations used have their usual meanings.

1. (a) What do you mean by configuration and dissipative work? How much energy is needed if one mole undergoes a free expansion to triple its volume? [2] 
(b) Draw a neat and clean phase diagram for water and state the Phase rule. [3] 
(c) One kilogram of water is heated reversibly by an electric heating coil from 20 °C to 80 °C. Compute the change in entropy of the water and the Universe assuming the specific heat of water as a constant. [5] 
(d) What is reaction kinetics? Obtain rate equations in differential and integral form for a first order reaction. Give an example of second order reaction. [5] 

(a') Five indistinguishable particles are to be distributed among the four equally spaced energy levels with no restriction on the number of particles in each energy state. If the total energy is to be 12E, (i) Specify the occupation number of each level for each macrostate, and (ii) Find the number of microstates for each macrostate taking g_1, g_2, g_3 and g_4 as 1, 3, 4 and 5 respectively. [7] 
(b) Define various thermodynamic functions with their physical significances. [3] 
(c) What is phase space? State and prove Liouville's theorem. [5] 

3. (a) Describe one experimental method that is frequently used to investigate atomic level diffusion. [9] 
(b) What are the materials that can be used to make spacer wires in Kirkendall Effect observation setup? Consider an alloy with two metallic elements A and B (each 50% atomic concentration). The atomic size of element A is greater than that of B, comment on spacer markings, if the outside block is made from: i) metal A, and ii) metal B. [6] 

4. (a) What are order and disorder transformations? What may cause a superconducting metal to undergo a disordered transformation below the critical temperature? [9] 
(a') Describe the mechanism of phase transformation of a system to a metastable state with the help of a qualitative Gibbs free energy diagram. [9] 
(b) D_0 of Zn in copper is 0.3 cm²s⁻¹ and the required energy is 2 eV. Find the value of D at: (i) 150 K, and (ii) 450 K. (Assume K_B T = 25 meV at 300K) [6]
2017-2018
M.TECH. AUTUMN SEMESTER (I SEMESTER) EXAMINATION
(M. Tech and Advanced P.G. Diploma in Nanotechnology)
Synthesis and Characterization of Nanomaterials
(INC-614)
(Credits: 04)

Maximum Marks: 60 
Duration: Two Hours

Note: Students of Adv. P. G. Diploma will be examined out of 75 marks and their obtained marks shall be proportionally raised.

Answer ALL the questions. Notations used have their usual meanings.

1. Explain with examples the bottom-up and top-down techniques for synthesis of nanoparticles. What are their merits and demerits? [5]

2. Describe five chemical methods for synthesizing of nanoparticles. [10]

3. (a) Explain the process for fabrication of carbon supported nanoparticles. [5]
(b) Differentiate between physical, chemical and biological modes of nanoparticle synthesis. [5]
(c) What is the current status of research and development in Nanotechnology? [5]

4. (a) How the four point probe method overcomes the shortcomings of the two point probe method? Obtain the relation for the determination of energy band gap of a semiconductor by using this method. [3+3]
(b) What are the essential components of magnetic properties measurement system (MPMS)? Discuss in brief the operation of superconducting magnet in hysteresis mode. [5]
(c) Draw the neat and clean diagram of scanning tunneling microscope (STM). [2]
(d) The diffraction pattern of a metal is observed by using X-ray of the wavelength 1.54 Å having crystallite size of 10 nm. Determine the line broadening of most intense peak of the diffraction pattern, if it is obtained at an angle $(2\theta_B)$ of 60°. [2]

OR

4’. Give a detailed description of construction and working of a scanning electron microscope (SEM) with a neat and clean schematic diagram and also define interaction volume. [15]

5. (a) Give a detailed account of resist materials used in lithography. Why does negative resist get hardened when exposed to UV light? [3+4]
(b) Name at least three lithographic techniques and discuss about the basic steps involved in brief for one of them with suitable diagrams. [6]