 Attempt all questions

1. (a) What is meant by Self-Assembly? Describe the three mechanisms of semiconductors island formation. 14
   (b) Give general structure of a SAM of alkane thiol on gold. 5

2. (a) What are proteins and nucleic acids? What do you understand by "magic twenty"? 5
   (b) Explain the terms DNA and RNA and discuss their chemical structure. Describe the double stranded nature of DNA and base pairing in DNA and briefly explain the processes of transcription and translation. 14

3. (a) What do you understand by quantum confinement? 5
   (b) Define density of states. Describe the three dimensional, two dimensional and zero dimensional structures on the basis of DOS. 14

OR

3'. (a) What are quantum dots? Use Schrodinger equation to explain the relationship between band gap and the size of the dot and hence explain the different colours of the quantum dots. 12
   (b) Describe the colloidal growth of Nano crystals. 7

4. Write notes on any three of the following: 6+6+6
   (a) "There is plenty of room at the bottom"
   (b) Historical development of Nanotechnology
   (c) Micro contact printing.
   (d) Porous silicon.
   (e) Discovery of C60.
Q No. 1  
(a) If the uncertainty in the speed of an electron \((m = 9 \times 10^{-31} \text{ kg})\) is \(3 \times 10^9 \text{ m/sec}\), estimate the uncertainty in its position. \((\hbar = 6.63 \times 10^{-34} \text{ J.s})\)  
(b) Obtain the expression of energy levels, \(E_n\) for one dimensional square well potential of finite depth.  
(c) Find the probability that a particle trapped in a box \(L\) wide can be found between 0.45\(L\) and 0.55\(L\) for the ground and first excited states.  

Q No. 2  
(a) Elaborate the concept of wave particle duality. Discuss its physical significance.  
(b) Find the expectation value \(<x>\) for the two states of a harmonic oscillator.  
(c) A particle is in a cubic box with infinitely hard walls whose edges are \(L\) long. The wave functions of the particle are given by:  
\[
\Psi = A \sin \frac{n_x \pi x}{L} \sin \frac{n_y \pi y}{L} \sin \frac{n_z \pi z}{L} \quad n_x = 1, 2, 3, \ldots \quad n_y = 1, 2, 3, \ldots \quad n_z = 1, 2, 3, \ldots
\]

Find the value of the normalization constant \(A\).  

Q No. 3  
(a) Outline the probability interpretation of the wave function.  
(b) Solve steady state form of Schrödinger equation to obtain the eigen function and the energy eigen value for a particle in a three dimensional box.  
(c) A particle of varying energy \(E\) is incident on a rectangular potential barrier of height \(V_0 > E\) and width \(b\). Derive expressions for the reflection and transmission coefficients.  

Q No. 4  
(a) Discuss the time independent perturbation theory for the non-degenerate stationary state. Evaluate the first order eigen function and energy eigen value.  
(b) Obtain the secular equation by using the variational approximation method. Write at least two applications of this method.  

OR

Q No. 3  
(a) Discuss the time independent perturbation theory for the non-degenerate stationary state. Evaluate the first order eigen function and energy eigen value.  
(b) Obtain the secular equation by using the variational approximation method. Write at least two applications of this method.  

Q No. 4  
(a) Give the complete analytical treatment of general adiabatic perturbation method and write one of its applications.  
(b) Write short notes on:  
(i) Quantum computer (ii) Quantum Qbits.
Answer all the questions. The Symbols have their usual meaning

1. (a) What do you mean by crystal symmetry? Describe all the crystal symmetries in detail.  
(b) Calculate packing fraction in hcp structure by establishing the relation between c & a.  
(c) Obtain Bragg’s law. Name various X-ray diffraction methods to study crystal structures, giving details of one method only.  

2. (a) Explain the interaction which is responsible for holding atoms together in inert gas crystals and hence derive an expression for the interaction.  
   OR  
   (a’) What is Lennard-Jones potential? Apply it to obtain minimum energy of an inert gas crystal having bcc structure. Given $\sum p_i^{-12} = 9.11418, \sum p_i^{-6} = 12.2533$  
(b) Discuss in detail molecular orbital theory of hydrogen molecule.  

3. (a) What are different assumptions of Drude model? Use Drude model to obtain expressions for electrical and thermal conductivities in metals and hence write Wiedmann-Franz Law.  
   OR  
   (a’) What do you understand by effective mass of a charge carrier in a solid? Obtain an expression for effective mass and discuss its dependence on curvature of the band. Explain shifting of Fermi level with doping concentrations by using suitable expressions.  
(b) What are composites? Give their classification scheme and discuss one of the composite types in detail.  
(c) Calculate number of free electrons in monovalent Cu having lattice constant 3.62Å. If relaxation time for electron in Cu is $2.7 \times 10^{-14}$s, calculate electrical conductivity.  

4. (a) Categorize imperfections in solids on the basis of their dimensionality. How is Frenkel defect developed in a solid? Derive an expression for equilibrium concentration of Frenkel defects and discuss its dependence on temperature.  
(b) What are the possible reasons of low critical stress in pure metals? Discuss edge and screw dislocations with the help of suitable diagrams. Draw and discuss the role of grain boundaries in the growth of the crystals.

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2010-11

M. Tech. in Nanotechnology and Advanced P.G. Diploma in Nanotechnology Examination

(I SEMESTER)

ELEMENTS OF PHYSICAL CHEMISTRY

AP-513

Maximum Marks: 75

Duration: Three Hours

This question paper consists of five questions. However, there is an internal choice.

1. (a) What are the empirical and thermodynamical temperatures. Show that constant volume ideal gas thermometer very closely measure the actual temperature of a system. (4)
   (b) What do you understand by the order of a chemical reaction? Establish the rate equation for a second order chemical reaction? (4)
   (c) Define the term heat capacity and enthalpy of a system. (4)
   (d) Define the term “entropy” and also give its statistical interpretation (3)

2. (a) What are micro- and macro-states of a system? Discuss a possible statistics of a system obeying Bose-Einstein (B-E) statistics. (10)
   (b) Which distribution functions will suitably describe the systems containing:
       (i) cooper pairs (ii) electron gas (iii) gas molecules (iv) liquid helium at low temperature (v) neutron stars

OR

2' Obtain Bose-Einstein (B-E) distribution function. Show that B-E distribution function reduces to Maxwell-Boltzmann(M-B) distribution functions under appropriate conditions. (15)

3. (a) What are homogeneous and heterogeneous nucleation. (7.5)
   (b) What are electrochemical processes? Give some examples of electrochemical reactions. (7.5)

4. (a) State and explain the Fick’s laws of diffusion. (7)
   (b) State and prove Liouville’s theorem. (8)

5. (a) Describe the process of grain-growth. (7)
   (b) What is Kirkendal effect? (8)
Maximum Marks: 75
Note: Answer all the questions.

1. Describe any three of the following methods of synthesis of nanoparticles;
   (i) Metal nanocrystals by reduction
   (ii) Photochemical synthesis
   (iii) Sol-gel method
   (iv) Electro-chemical synthesis
   (v) Ball Milling
   (5+5+5)

2. (a) State the merits and demerits of the biological methods of nanoparticle synthesis over physical and chemical methods of synthesis.
   (b) Discuss the role of prokaryotic bacteria in nanoparticle synthesis with special reference to magnetotactic bacteria.
   (3+12)

3. (a) What are eukaryotes? Elaborate the process of semiconductor nanoparticle synthesis through the micro organism yeast.
   (b) Write a note on the nanoparticles synthesized by Fungi.
   (2+8)

4. (a) What do you mean by characterization of nanomaterials? What are primary probes and secondary effects in this regard? Describe in brief the basic principle involved in construction and working of transmission electron microscope (TEM)
   (3+5)
   (b) What is a spectrophotometer? Discuss in brief how this equipment can be used for determining the band gap of a semiconductor.
   (7)
   OR

4' Give an account of atomic force microscope clearly mentioning its various modes of operation and the range of force involved in each. Mention a few salient features that make this characterization technique grossly different from scanning tunneling (STM) technique.
   (11+4)

5. What is nanolithography? Describe in detail the direct write electron beam nanolithography (DWEB) technique and briefly point out how this technique is different from electron beam projection nanolithography (EPL).
   (15)