Your Roll No.....

Sr. No. of Question Paper : 10271

Unique Paper Code : 2223010035

Name of Paper : Nanoscience (DSE Paper)

Name of Course : **B.Sc. (Prog.) Physics_NEP: UGCF-2022**

Semester : VII

Duration : 3 Hours Maximum Marks: 60

Instructions for candidates

1. Write your Roll. No. on the top immediately on receipt of this question paper.
2. Attempt any **four** questions in all.
3. Question No. 1 is compulsory.
4. Symbols have their usual meanings.

Q.1. Answer any ***five*** questions. Each carry 3 marks.

a. How does the quantum confinement effect in semiconductors modify the electronic and optical properties of semiconductors? Give an example of a nanoscale semiconductor where you have a practical experience of this effect?

b. Differentiate graphically the density of states as a function of energy in 3D and 2D semiconductors.

c. Explain Coulomb Blockade effect in 0D semiconductors.

d. In GaAs, effective mass of electron is 0.067 times the rest mass of electron, difference between energy of electron in conduction band and conduction band edge is 0.10 eV. Calculate the density of states at E = 0.10 eV in 3D and 2D.

e. What are top-down and bottom-up approaches for synthesising the nanomaterials? Name the approach in which the ball milling method lies.

f. Explain briefly the impact of size on the energy levels of 1D and 0D nanomaterials in different dimensions.

Q.2. (a) Explain briefly the conductance quantization in 1D structures using split gate in 2DEG system formed at the interface of semiconductor hetrostructures such as GaAs and AlGaAs. (5)

(b) Explain the properties of a 2DEG system which are essential to observe conductance quantization in Hall effect measurements. (7)

(c) In 1D quantum system, find the energies for n=1, 2 levels of an electron confined in an infinite potential well of length 5 nm. [$\hbar = 1.0545 \times 10^{-34}$ J.s; $m_e = 9.109 \times 10^{-31}$ kg; 1 eV = 1.602×10^{-19} J] (3)

Q.3. (a) Derive the expression of the mean free path for elastic collision. How does it change with decreasing dimension of material? (7)

(b) Differentiate between diffusive and ballistic transport of charge carriers in nanoparticles. (5)

(c) Calculate the drift velocity of charge carrier across the nanowire having length 500 nm, cross section 50 nm^2, carrier concentration of 10^{19} cm^{-3}. If a voltage of 0.1 V across nanowire is applied and mobility of around 150 $cm^2/(V.s)$. (3)

Q.4. (a) What is physical vapor deposition technique? Explain the basic principle and working of sputtering technique with labelled diagram. (5)

(b) How sputtering technique can be used to prepare thin films of any metal oxide (like ZnO or SnO_2). (5)

(c) Give five advantages of sputtering system for thin film deposition in comparison to spin coating technique. (5)

Q.5. (a) Briefly explain the difference between micro electromechanical systems (MEMS) and nanoelectromechanical systems (NEMS). Describe briefly an example of NEMS technology. (5)

(b) Give five practical applications of nanoparticles in technology. (5)

(c) What is ball milling technique? Explain with clear diagram. (5)