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42022

M. Sc. (Physics) 4th Semester

Examination – May, 2019

PHYSICS OF NANO-MATERIALS

Paper : PHY(H)-402/4248

Time : Three Hours] *[Maximum Marks : 80*

Before answering the questions, candidates should ensure that they have been supplied the correct and complete question paper. No complaint in this regard, will be entertained after examination.

Note : Attempt ***five*** questions in all, selecting at least ***one*** question from each Unit. Question No. **1** is ***compulsory***.

1. (a) Show that effective mass (m^*) of electron can be represented as $m^* = \dfrac{h^2}{4\pi^2\left(\dfrac{d^2E}{dk^2}\right)}$, where E and k are energy and wave vector respectively. 4

(b) What are quantum wells, quantum wires and quantum dots ? Give the number of confinement and delocalization dimensions in each of these low dimensional systems. 4

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(c) Explain how micro-strain leads to broadening of x-ray diffraction peaks of Nanomaterials. 4

(d) Describe ion by ion and cluster by cluster deposition mechanism of nanomaterials in context of chemical bath deposition with a suitable example. 4

UNIT – I

2. (a) Describe the band formation in solids. In light of band theory, classify the solids in metals, semiconductors and insulators. 11

(b) If the energy dispersion relation for a two-dimensional electron system is given as $\varepsilon = u\hbar k$, where k is wave vector, for this system find the variation of density of states, $p(\varepsilon)$ with ε. 5

3. Discuss how band-gap and density of states varies with crystal size ? Also show that for semiconducting spherical nano-crystal of radius R (excluding exciton levels)

$$E_{g,nano} - E_{g,bulk} = \frac{h^2}{8\mu R^2}$$

Where μ is the reduced mass form for effective mass of e h pair and other symbols have their usual meaning ? 16

UNIT – II

4. (a) Write and solve Schrödinger equation for elect in a metallic specimen of volume $V = L_x \times L_y \times$

   (b) Draw density of states versus energy graph bulk, quantum well, wire and dot.

5. What do you mean by quantum wire ? Write and so Schrodinger equation to find Eigen values and El functions. Also find an expression for density of st of a quantum wire and plot it as a function of energy.

UNIT – III

6. (a) Explain Raman Effect and discuss the effect particle size on broadening of Raman peaks.

   (b) Describe the principle of photoluminescen spectroscopy (PL). How PL spectroscopy employed for the characterization of Nanomateria Nanostructures ?

7. (a) How to distinguish between bulk and nan crystalline materials using x-ray diffracti technique ? Find the separate expressions f FWHM of x-ray diffraction peaks due to fini size of nanomaterials and due to micro-strai Also explain the method of finding avera crystallite size and strain from Williamson's Ha Plot. 1

   (b) A PL experiment is performed on CdSe Quantum dots and it is found that emission takes place at 696nm. Find the radius of CdSe quantum dots, you are provided with $m_e^* = 0.13m_0, m_h^* = 0.45m_0$ and band gap of Bulk CdSe i.e. $E_g^{CdSe} = 1.74eV$. 5

UNIT – IV

8. (a) Describe cluster beam evaporation technique for synthesis of nano-materials. Also give the list of materials deposited by this technique and its drawbacks. 9

   (b) Discuss ball milling technique for synthesis of nano-particles. How contamination from milling tools and atmospheric gases is minimized ? 7

9. Write short notes on the following : 8 + 8 = 16

   (i) Chemical Bath Deposition

   (ii) Ion Beam Deposition