(b) Discuss the effects of nano-particle size on Raman peaks. 4

7. (a) List the factors responsible for broadening of X-ray diffraction peaks of nano materials. Discuss how this finite width of X-ray diffraction peaks is used for determination of particle size and strain in nano-materials. 11

(b) Discuss the effect of nano-particle size on photoluminescence peak at a fix temperature. 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. (a) Draw schematic diagram of chemical bath deposition technique. Explain the deposition mechanism by taking example of any particular material. Also mention its merits and demerits. 8

(b) Describe ion beam deposition technique along with its advantages and disadvantages. 8

M.Sc. 4th Semester (New) Examination, May–2016
PHYSICS
Paper–XVI
Physics of Nano-materials (New)

Time allowed : 3 hours] *[Maximum marks : 80*

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

1. (a) Discuss how the density of states varies with crystal size. Show that for simple cubic crystal density of states is proportional to cube of the lattice constant (a). 4

(b) Explain why absorption & emission does not take place in $Al_{0.3}Ga_{0.7}As/GaAs/Al_{0.3}Ga_{0.7}As$ quantum well structure at $h\nu = E_g$ (GaAs), although it happens in bulk GaAs. 4

(c) What is Raman Effect ? Why Stokes emission is much favoured over anti-Stokes at relatively lower temperatures ? 4

(d) Describe the cluster formation in context of cluster beam evaporation technique and mention the conditions under which optimum size clusters are formed. 4

Unit–I

2. (a) Experimentally, it is proven fact that band-gap of a semiconductor nano-crystal increases with size reduction. Prove this experimental fact theoretically i.e.

$$E_{g,nano} = E_{g,bulk} + \frac{h^2}{2}\left(\frac{1}{m_{e,eff}} + \frac{1}{m_{h,eff}}\right)\left(\frac{\pi}{R}\right)^2$$

Where R is the radius of the nano-crystal and other symbols have their usual meanings. 10

(b) Explain the metallic character shown by divalent metals like Be, Ca, etc. Which are insulators as per predictions of the one dimensional band theory. 6

3. (a) Derive the expression for density of states for free electron i.e. three dimensional case. Plot and explain density of states versus energy graph in an energy band. 11

(b) Give qualitative idea and features of free electron theory. 5

Unit–II

4. (a) What do you mean by quantum confined structures and quantum confinement limit ? How many dimensions are confined and free in bulk, quantum well, wire and dot respectively ? Also draw the density of states versus energy graph for each one. 7

(b) Write and solve Schrödinger equation for an electron confined in one and two dimensional infinite square well potential. 9

5. Discuss how a practical quantum well structure is formed. Write the condition under which this quantum well is treated as a finite well or an infinite well for an electron inside it. Solve the Schrödinger equation for the electron under infinite well approximation. Also plot its E-k diagram and density of states. 16

Unit–III

6. (a) Describe the basic principal and instrumentation involved in photoluminescence spectroscopy. Discuss how photoluminescence spectroscopy is used in determination of alloy composition in compound semiconductors ($Al_xGa_{1-x}As$ etc.) and in finding the well width of $Al_xGa_{1-x}As/GsAs/Al_xGa_{1-x}As$ quantum well structure. 12