



भारतीय प्रौद्योगिकी संस्थान पटना  
Indian Institute of Technology Patna  
Mid Semester Examination (Mid-Sem) (Aug-Nov-2011)

COURSE NO: PH401

COURSE TITLE: Introduction to Nanomaterials

Duration: 2 hours

Full Marks: 30

1. How many 10 nm nanocubes are required to produce the same surface area as a one cubic meter cube? How much volume do they occupy? [2]
2. Calculate the ratio of surface atoms to volume atoms by a simple procedure for a  $R = 10$  nm gold colloid. Assume that the surface atoms occupy a thickness of one atomic diameter ( $d_{\text{gold}} = 0.288$  nm) and that the packing fraction for gold is at a volume efficiency ( $V_{\text{volume}}/\text{Total volume}$  ( $\frac{4}{3}\pi R^3, R = 10\text{nm}$ )) of 0.740 and surface efficiency (=Volume available for surface gold atoms/ $V_{\text{layer}}$ ) of 0.91. [3]
3. Explain the following nano-phenomena with one example from each phenomena: (i) Super hydrophobicity, (ii) Self cleaning, and (iii) Localized surface Plasmon. [3]
4. Explain the working principle of AFM with ray diagram. Discuss the advantage and disadvantage of contact mode and non contact mode in a AFM technique. [3]
5. Determine the angular resolution of a 200kV electron microscope with 50 semi-angle of collection of the magnifying lense (refractive index=1.5). Calculate the special resolution for a lense of focal length 10cm. [2]
6. Discuss about the advantage and disadvantage of TEM technique to characterize nanoparticles. [2]
7. Calculate the crystallite size using Sherrer's formulae from the following XRD data: (i) Bragg's position ( $\theta$ ) =  $17.4^\circ$ , (ii) FWHM =  $0.743^\circ$  and (iii)  $\text{Cu } K_\alpha$  radiation,  $\lambda = 1.5418\text{\AA}$ . [2]
8. What do you mean by magic numbers in nanoscience? [2]
9. A nanoparticle with mass  $5 \times 10^{-27}$  g exist in a 1-nm, one dimensional box. What is the wave length of radiation that is emitted when the nanoparticle loses energy from the  $n = 3$  level to the  $n = 2$  level? [2]
10. A material (melting point =  $3000^\circ\text{C}$ ) has been milled (ball milling) to make a 2nm size particle. Calculate the melting point of nano particle. (particle density =  $11340\text{kg/m}^3$ , Latent heat of fusion =  $67 \times 10^3\text{J/kg}$ , Surface tension coefficient for a liquid – solid interface =  $2.2\text{ N/m}$ ). [2]
11. Why ferromagnetic materials exhibit superparamagnetic nature below 100nm. [2]
12. Write short notes on LASER ablation and Electron beam lithography method to grow nanomaterials. [5]

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BEST OF LUCK