



# Indian Institute of Technology Patna

Patliputra Colony, Patna – 800 013, India

DEPARTMENT OF PHYSICS

MID-SEMESTER EXAMINATION DATE: 26-09-2018

Time: 2 hours

Full Marks: 30

COURSE NO: PH401

COURSE TITLE: Introduction to Nanomaterials Attempt all Questions

(Note: No explanation during the examination)

1. What is the length scale definition of nanomaterials? Is there engineering possible below  $10^{-10}\text{m}$ ? Justify your answer. [2]
2. Are molecular entities stable? Are quantum effects an obstacle to atomic manipulation? Is Brownian motion significant in nanocomponents? Are friction and wearing relevant for nanocomponents? [4]
3. Write a complete definition of "nanomaterials"? [2]

(or)

Why does the material strength increase with the decrease in grain size to nanometer scale?

4. Transparent polymer sections of 250 nm are floating in water. What will be the colour of the sections looking at  $90^\circ$ . Will the colour change, if somebody look it at angle of  $45^\circ$  to the surface of the water? If yes, write the colour. If no, justify. [4]  
[Refractive index: polymer ( $n_p$ )  $\cong 1.47$ , water ( $n_w$ )  $\cong 1.33$ , air ( $n_{air}$ )  $\cong 1.00$ ]
5. Write about self-cleaning and hydrophobicity nature of leaves and bird wings. [2]
6. What are low angle and high angle crystallographic grain boundaries? How is it related to nanotechnology? [2]

What is confinement in nanostructure semiconductors? Find the confinement lengths of nanostructure CdSe semiconductor. The effective mass of electron ( $m_e$ )  $\cong 0.13 m_0$  and hole ( $m_h$ )  $\cong 0.45 m_0$ . The effective velocity of electron and hole is  $V_e \cong V_h \cong 10^5 \text{ m/s}$ . What is the confinement length of electron in Cu metal? If effective mass of electron in Cu is  $\sim 10 m_0$  and velocity is  $10^5 \text{ m/s}$ . What are the differences between confinement in semiconductor and metal? Write advantages and disadvantages of both the cases. [6]

$[\hbar = \frac{h}{2\pi} = 1.054 \times 10^{-34} \text{ Js}, m_0 (\text{rest mass of electron}) = 9.1 \times 10^{-31} \text{ kg}]$

7. What are the magic numbers in nanostructure materials? Derive the expression to generate the magic numbers for FCC crystal symmetry. Calculate 10 magic numbers for FCC crystal structure. Sketch the graph between surface to volume ratio and size of the nanoparticle. Why the physical properties change along with decrease in size of the nanomaterial? [5]
8. Write a short note on "preparation of nanomaterials". [3]

(or)

What is the importance of quantum theory to understand the nanomaterials?

-----BEST OF LUCK-----