



Indian Institute of Technology Patna

Bihta, Patna – 801103, India

DEPARTMENT OF PHYSICS

END-SEMESTER EXAMINATION

DATE: 23-11-2017

Time: 3 hours

COURSE NO: PH401 COURSE TITLE: Introduction to Nanomaterials

Full Marks: 50

Attempt all Questions

1. Can a stable structure possible with 65 number of carbon atoms? Justify your answer. How many carbon atoms are required to construct smallest fullerene structure? Write the structural parameters (No. of edges, faces, vertices etc.) for smallest fullerene structure. [5]

Or

Determine the diameter for the following nanotubes: (8,8), (8,5) (44,57) and (18,73). Identify the electrical nature of nanotubes.

2. What is the theoretical tensile strength σ , in gigapascals ($1\text{GPa} = 10^9\text{Nm}^{-2}$) of carbon – carbon bonds of different order? Assume that all bonds stretch to 2.5xtheir respective length before breaking. How much mass under earth's gravitational pull are these bonds able to hold without breaking? [4]

Bond	Bond length (nm)	Bond dissociation energy (kJ.mol^{-1})
C-C	0.154	348
C=C	0.142	480
C=C (both covalent)	0.134	614
C \equiv C	0.120	839

3. Write a short note on Materials classification. [4]
4. Why strength of material made up of nanocrystallites increases with the decrease in crystallite size? [4]
5. Which is/are the parameter/s responsible for the optical properties of the nanomaterials? Why colors of nanomaterials (<100 nm) depends upon its size? [2+2]
6. Suppose an engineer reduced the particle size (grain size) of gold from 20 μm to 20 nm. How much melting point will deviate? The melting point of 20 μm iron is $\sim 1810\text{ K}$. Verify the result if the particle size of Gold reduced to 1 nm. [Surface tension coefficient for solid-liquid interface = 1Nm^{-1} at 1343 K, Particle density of Gold is 1.25 g/cm^3 , Latent heat of fusion for Gold = 67 kJ/kg]. [4]
7. Write a short note on coulomb blockade. How is it applied to nanotransistors i.e. single electron transistor? Plot the V-I characteristic of nanoconductors. Discuss the operation of single-electron transistor. Two Cu nanoparticles of diameter 1 nm each combined and make a bigger nanoparticle. What is the net resistance of bigger Cu nanoparticle if the individual Cu nanoparticle (1 nm) resistance is 12 m Ω . [6]
8. What is the principle of recording of "magnetic recording media" and "magneto resistive recording media"? [5]

Or

How can magnetic nanoparticles be used in MRI technology, cancer treatment and drug delivery?

9. Write the working principle of AFM or STM with the schematic diagram of the equipment. Why this microscopy does not required an electromagnetic source for imaging? [4]
10. How can the BET surface area analyzer characterize the nanomaterials?

Or

Write a short note on Raman spectrometer focusing on nanomaterials characterization. [4]

11. XRD pattern of a nanocrystalline material is having the following data. Three numbers of peaks have been observed at 38.52° , 44.76° and 65.13° with FWHM at 1.8×10^{-3} , 1.2×10^{-3} and 1.6×10^{-3} radian respectively. The pattern has been recorded at 0.02 steps and scan rate is 1 sec per step. Calculate the crystallite size and maximum possible error on it. Take the instrumental broadening 0.015° for all peaks. [4]

Or

How can be thickness of 2-D materials determined by employing the X-ray reflectivity technique?

12. What is the most important information you gathered from this course? Explain your answer. [2]

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