



DEPARTMENT OF PHYSICS
Indian Institute of Technology Patna
Bihta, Patna – 801106, India

END-SEMESTER EXAMINATION M.M. 50 DURATION: 24 hours (online)
COVID-19 PANDEMIC TIME (ONLINE EXAM)
COURSE: PH401 (INTRODUCTION TO NANOMATERIALS)
DATE: 22-11-2021

(If you feel the question is wrong, please describe why?)

1. Discuss the working principle of STM. What are modifications needed to be taken care of by an engineer to image the semiconductor materials (thin films) by using the STM? Can one get magnetic domain distribution by using STM? Justify your answer. [6]
2. Prove that the angle between the armchair and zigzag chiral vector is 30° . Calculate the angle of helicity and diameter of (4,12), (3,13), (18,18), and (14,0) carbon nanotube, and mention their nature of electrical conduction. [8]
3. An engineer got the XRD pattern of steel noted the following data:

2θ (deg)	Intensity (CPS)	FWHM (deg)
26.53	100	0.237
44.58	900	0.345
55.00	40	0.421
64.98	152	0.332
82.29	332	0.384

Identify the peaks that correspond to carbon and iron. Find the crystallite size of carbon and iron in the composite. Assume 4% carbon is added to the iron matrix. [6]

4. A company has asked an engineer to make a design and specification of a magnetic lens for a 200KV TEM machine. Discuss the design of the magnetic lens for the 200KV TEM machine. Plot focal length versus current (in the coil) which will help the mechanic to make the lens as well as it will help the operator for imaging. [8]
5. No electromagnetic radiation is used in AFM for imaging. Justify the statement. In AFM technique, one measures the force between AFM tip and sample forces. What kinds of forces can be measured here? How many minimum number of detectors (not the photodiode alone complete detector) are required in AFM for imaging? Justify your answer. Discuss the working principle of detectors in AFM. [8]
6. A particulate composite is made up of Fe and Co metals ($\text{Fe}_{1-x}\text{Co}_x$). The x varies from 0 to 1 as follows: $x = 0, 0.04, 0.06, 0.08, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.92, 0.94, 0.96, 0.98, 1.0$. Plot the tensile strength, Young modulus and magnetic moment per formula unit in μ_B versus composition of Fe and Co. The average crystallite size of both Fe and Co is 40nm. [Tensile strength of Fe = 540 MPa and Co = 800 MPa, Young modulus of Fe = 211 GPa and Co = 209 GPa, magnetic moment per formula unit of Fe = $2.7 \mu_B$ and Co = $2.3 \mu_B$]. [10]
7. What are the advantage and disadvantages between magnetic (magnetic memory device) and magnetoresistive (magnetoresistive memory device) recording media? [4]
8. What is/are the most important information/s you learn from this course? [no marks]

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