[This question paper contains 2 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 7300 **L**

Unique Paper Code : 2513010027

Name of the Paper : Nanomaterials Characterization

Name of the Course : **B.Sc. (Hons.) Electronics (DSE)**

Semester : VII

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. There are **seven** questions in all, out of which you have to attempt any **five** questions.
3. **First** question is Compulsory.
4. **All** questions carry equal marks.
5. Use of Scientific Calculator is allowed.

Q1	a)	What is the quantum confinement effect? Explain 3D, 2D, 1D and 0D materials	3
	b)	What are secondary electrons in scanning electron microscopy (SEM)? What type of information about nanomaterials can be obtained from them?	3
	c)	State the Beer–Lambert law and explain its importance in UV–Visible absorption spectroscopy.	3
	d)	What is Raman scattering? Distinguish between Stokes and Anti-Stokes lines in Raman spectra.	3
	e)	Define electrical resistivity and state its SI unit. Why is resistivity an important parameter in electrical characterisation of materials?	3
	f)	What is magnetic anisotropy? Briefly explain why it is important in magnetic nanomaterials.	3
Q2	a)	Explain the difference between bulk materials and nanomaterials, highlighting the characteristic size range and general features of each. Discuss why materials exhibit different physical and chemical properties at the nanoscale.	6
	b)	Describe the top-down approach for synthesis of nanomaterials, giving suitable examples. Discuss its major advantages and limitations.	6
	c)	Explain the principle of X-ray diffraction (XRD) and discuss how it is used to determine the crystal structure and lattice parameters of nanomaterials.	6
Q3	a)	Describe the working principle of Scanning Electron Microscopy (SEM) with the help of a neatly labelled diagram. Explain how SEM images are used to determine the morphology and particle size of nanomaterials.	6
	b)	Explain the basic principle of Transmission Electron Microscopy (TEM) and mention the type of information that can be determined from TEM images.	6
	c)	A nanocrystalline sample shows an XRD peak at $2\theta=40^\circ$ using Cu Kα radiation of wavelength $\lambda=0.154$ nm. The full width at half maximum (FWHM) of this peak is $\beta=0.01$ rad. Assume the shape factor $K=0.9$. (i) Using Bragg's law, calculate the interplanar spacing 'd' corresponding to the peak. (ii) Using the Scherrer equation, estimate the crystallite size 'D' of the sample.	6

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Q4	a)	Explain the principle of UV–Visible spectroscopy with the help of a neatly labelled block diagram of a UV–Visible spectrophotometer. Describe how UV–Visible spectroscopy is used to estimate the optical band gap of nanomaterials.	6
	b)	Describe the working principle of Fourier Transform Infrared (FTIR) spectroscopy.	6
	c)	Two samples of the same semiconductor nanomaterial show absorption edges at 620 nm and 540 nm respectively in UV–Visible spectroscopy. (i) Calculate the optical band gap energy Eg corresponding to each absorption edge. (ii) Briefly explain which sample is likely to have smaller particle size?	6
Q5	a)	Briefly describe the basic components of a Raman spectrometer and the role of each component. Explain how Raman spectroscopy is useful in studying nanomaterials, giving two examples of the type of information it provides.	6
	b)	Describe the principle of photoluminescence (PL) spectroscopy and explain how it is used to study electronic and defect states in nanomaterials.	6
	c)	What is Atomic Force Microscopy (AFM)? Briefly explain how AFM is used to study the surface topography of nanomaterials.	6
Q6	a)	Explain the four-probe method for measuring electrical resistivity of materials and discuss its advantages over the two-probe method. In a four-probe measurement performed on a nanomaterial sample, the following values are recorded: Current I = 20 mA, Voltage V=10 mV and Probe spacing s = 2 mm (i) Write the expression for electrical resistivity using the four-probe method, and calculate the electrical resistivity of the sample. (ii) If the probe spacing is doubled while the measured voltage and current remain unchanged, determine how the calculated resistivity will change.	6
	b)	How can you distinguish single crystal, polycrystalline and amorphous materials with help of transmission electron microscope?	6
	c)	What contributes to the peak broadening in the X-ray diffraction pattern? Explain with help of diagrams.	6
Q7	a)	Explain the phenomenon of magnetoresistance in materials. Discuss the importance and technological applications of magnetoresistance in magnetic nanomaterials.	6
	b)	Describe the working principle of a Vibrating Sample Magnetometer (VSM) and explain how it is used to measure magnetic properties of materials.	6
	c)	What is the Magneto Optical Kerr Effect (MOKE)? Briefly explain how it is used to study magnetic materials	6