KUMARAGURU college of technology
character is life

Register Number:……..…

M.E DEGREE EXAMINATIONS: NOV/DEC 2023

(Regulation 2018)

First Semester

PHYSICS

P18PHT0002 **:** Advanced Materials Characterization Techniques

COURSE OUTCOMES

CO1: To understand the basic physics, mechanisms and applications of the characterization methods commonly used in materials engineering.

CO2: To demonstrate the understanding of principle and working of microscopes, spectroscopy and X-ray radiation-based instruments and ability to study material properties using them.

CO3: To gain knowledge about the characterization techniques available to study the mechanical properties of nano materials.

CO4: To identify appropriate technique for specific material characterization.

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Arrange the following steps involved in X-ray diffraction in the correct order: CO1 [K_3]

   I. Incident X-ray beam passes through a crystal sample.

   II. X-rays interact with the crystal lattice, leading to constructive and destructive interference.

   III. Monochromatic X-rays are generated.

   IV. Crystal orientation is adjusted for optimal diffraction.

   a) iii – i – iv – ii b) i – iv – ii -iii

   c) iv – ii - iii – i d) ii - iii – i-iv

2. In X-ray diffraction, what does the term "d-spacing" refer to? CO1 [K_2]

   a) The distance between the X-ray source and the crystal b) The wavelength of the incident X-ray beam

   c) The distance between adjacent crystal planes in a crystal lattice d) The intensity of the diffracted X-rays

3. In Scanning Electron Microscopy (SEM), the primary purpose of the electron beam is CO2 [K_2]

to:

a) Generate X-rays for compositional analysis

b) Interact with the specimen to produce secondary electrons for surface imaging

c) Transmit through the specimen to create detailed internal images

d) Produce a high-resolution, 3D image of the specimen

4. Match THE item with List I with List II CO2 [K_3]

List I	List II
A. X-ray Diffraction	i. Atomic Force Microscopy (AFM)
B. Microscopy Techniques	ii. Differential Scanning Calorimetry
C. Compositional Characterization	iii. D-spacing determination
D. Thermal Analysis	iv. Electron Microprobe Analysis

a) A-ii; B-i; C – iv; D-iii

b) A-i; B-iii; C – iv; D-ii

c) A-iii; B-i; C – iv; D-ii

d) A-iv; B-i; C – iii; D-ii

5. In X-ray compositional characterization techniques, which method involves the analysis of X-rays emitted when inner-shell electrons are ejected and outer-shell electrons transition to fill the vacancies? CO2 [K_2]

a) Electron Microprobe Analysis (EMPA)

b) Energy Dispersive X-Ray Analysis (EDS)

c) X-ray Photoelectron Spectroscopy (XPS)

d) Wavelength-dispersive X-ray spectroscopy (WDS)

6. Which technique is commonly used to determine the elemental composition of a sample by measuring the energies of X-rays emitted when inner-shell electrons are ejected? CO4 [K_2]

a) X-ray Fluorescence (XRF)

b) UV-Visible Spectroscopy

c) Atomic Force Microscopy (AFM)

d) Infrared (IR) Spectroscopy

7. The following items consist of two statements, one labeled as the "Assertion (A)" and other as "Reason(R)". Examine these two statements and select the answers from the following codes. CO4 [K_3]

Assertion (A): In Infrared (IR) spectroscopy, different functional groups in a molecule absorb characteristic frequencies of infrared radiation.

Reason (R): This is due to the vibrations of specific chemical bonds, and the resulting spectrum provides information about the molecular structure.

a) Both A and R individually true and R is not correct explanation of A

b) Both A and R individually true and R is correct explanation of A

c) A is true but R is false

d) A is false but R is true

8. In Differential Scanning Calorimetry (DSC), what does an endothermic peak on the thermogram indicate? CO4 [K_3]

a) Release of heat from the sample

b) No thermal changes occurring in the sample

c) Increase in temperature due to a chemical reaction

d) Absorption of heat by the sample

9. Select the characterization techniques commonly used for investigating electrical, magnetic, and dielectric properties: CO4 [K_3]

A. Hall Measurement

B. Dielectric measurements

C. Atomic Force Microscopy (AFM)

D. Vibrating Sample Magnetometer (VSM)

E. UV-Visible Spectroscopy

a) A, B & D

b) A, B & C

c) B, C & D

d) A, C & D

10. In Hall Effect measurements, the sign of the Hall voltage can provide information about: CO4 [K_3]

a) The resistivity of the material

b) The temperature dependence of the material

c) The type of charge carriers (electrons or holes) in the material

d) The magnetic susceptibility of the material

PART B (10 x 2 = 20 Marks)

11. Describe the factors that influence the intensities of diffracted beams in X-ray diffraction methods under non-ideal conditions. CO1 [K_2]

12. What do you understand from geometrical structure factors. CO1 [K_1]

13. Define the resolving power of a transmission electron microscope (TEM). CO1 [K_2]

14.	Highlight, how Scanning Transmission Electron Microscopy (STEM) differs from traditional Transmission Electron Microscopy (TEM)	CO2	[K_3]
15.	What is the principle of XPS?	CO2	[K_2]
16.	How can you define fluorescence?	CO2	[K_2]
17.	Differentiate micro-Raman and laser Raman spectroscopy.	CO2	[K_3]
18.	Define photo luminescence.	CO4	[K_2]
19.	What is the purpose of vibrating sample magnetometer?	CO3	[K_2]
20.	What do you infer from Vickers hardness number?	CO3	[K_2]

PART C (6 x 5 = 30 Marks)

21.	Briefly explain the principle of X-ray diffraction based on Bragg's Law. Discuss the factors influencing the intensities of diffracted beams.	CO2	[K_2]
22.	Explain the fundamental differences between Bright Field (BF) and Dark Field (DF) imaging modes in Transmission Electron Microscopy (TEM).	CO2	[K_3]
23.	Outline the key steps involved in preparing the sample for AFM imaging and describe how the AFM technique can provide high-resolution images of the material's surface features. Discuss the specific advantages of AFM over other microscopy techniques in studying nanoscale structures.	CO2	[K_3]
24.	Compare and contrast X-Ray Photoelectron Spectroscopy (XPS) and X-ray Fluorescence (XRF) Spectroscopy.	CO1	[K_3]
25.	Explain the basic principles of UV-Visible spectroscopy. Describe the interaction of light with molecules results in electronic transitions and the absorption of specific wavelengths.	CO2	[K_2]
26.	Explain the I-V curve ad provide insights into the electrical behavior of the semiconductor.	CO4	[K_3]

Answer any FOUR Questions
PART D (4 x 10 = 40 Marks)

27.	Describe the principles of X-ray diffraction and the factors influencing diffracted beam intensities allow for the determination of atomic and geometrical structure factors in materials? Discuss the practical applications of this technique in material characterization.	CO1	[K_2]
28.	Analyze and explain the key principles of image formation in a Scanning Electron Microscope (SEM), considering the interaction of electrons with matter and the various modes of operation and discuss the strengths and limitations.	CO2	[K_3]
29.	What is Thermo gravimetric analysis (TGA) and how does it differ from Differential Thermal Analysis (DTA)? Eloborate the fundamental concept behind Differential Scanning Calorimetry (DSC).	CO4	[K_2]
30.	Define Energy Dispersive X-Ray Analysis (EDS) and explain its basic operating	CO2	[K_2]

principle.
List the types of information that can be obtained from EDS analysis.
Explain the difference between Energy Dispersive X-Ray Analysis (EDS) and Wavelength Dispersive X-Ray Analysis (WDS).

31. Explain how interferograms are transformed into FTIR spectra and describe the significance of the resulting spectra. CO2 [K_3]
Summarize the concept of wavenumber and its importance in FTIR spectra interpretation.

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