in the path of 1·0 cm length. What should be the concentration of the solution in order to abosrb 90% of the same radiation? What are bathochromic and hypochromic shifts? (3+2+3+2)

2. Discuss any two factors affecting the position of UV-vis absorption band. What are the sources for UV and visible light in UV-Visible spectrophotometer? Explain basic principle of Raman spectroscopy. (4+2+4)

3. Sketch the optical path of double beam instrument used in FTIR spectroscopy. What are the factors necessary in a molecule to absorb IR radiation? What is "fingerprint zone" in IR spectroscopy? (4+3+3)

4. Define chemical shift. What are the common solvents used in NMR spectroscopy? Why is TMS used as internal reference in NMR spectroscopy? Which of the following are NMR active and why? C^{12}, O^{16}, F^{19}, N^{14}, H^{2}, and C^{13}. (3+2+2+3)

5. What do you mean by retention factor (R_f) in paper chromatography? Describe its significance. Describe the working principle and usefulness of permeation chromatography. (3+3+4)

6. Describe the basic principles of gas chromatography. Briefly write down different factors which affect gas chromatographic separation. (4+6)

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MASTER OF SCIENCE EXAMINATION, 2024

(Second Year, First Semester)

INSTRUMENTATION SCIENCE

(Analytical Instrumentation)

Time : 4 *Hours* *Full Marks* : 80

PART—I

Answer **two** questions from each Section : Section—I and Section—II :

SECTION—I

1. What are the advantages of electrons compared to photon for microscopy? Where do the imaging electrons in an electron microscope come from?

What voltage is typically used in Transmission electron microscopes? What kinds of electron wavelengths does this correspond to?

What are three types of electron guns EM used in? What are the advantages and disadvantages of each? (2+2+1+2+1+2=10)

2. What is defining property of a lens? How do optical lenses focus light? How do electron lenses focus electrons? What are the four main components of an electron lens system? What does each do? (1+2+4+1+2=10)

3. What current is controlled by the filament, spot size, brightness, focus, and magnification knob?

What parts of instrument are common to all these SEM, TEM & EPMA? What are the functions of these common parts? (5+5=10)

4. How are Auger electron produced? Why is AES surface sensitive? How is depth profiling performed by AES? What kinds of problems are best tackled by AES? (2+2+3+3=10)

SECTION—II

5. *(a)* Show the schematic diagram of various transitions of X-ray emissions from different energy levels. Define $K\alpha_1$ and $K\alpha_2$ X-ray lines and show them in your diagram.

(b) Derive the Bragg equation for the X-ray diffraction from a crystal.

(c) The K and L_{II} absorption edges wavelength of Cu(Z=29) are respectively 1·3774 Å and 12·9 Å. Find the wavelength of $CuK\alpha_2$ X-ray line. (4+3+3=10)

6. *(a)* What is Moseley's law? Show the graphical representation of this law.

(b) In an X-ray tube there are Molybdenum (Z=42) target along with an impurity element. The emitted X-rays from this tube have one $MoK\alpha_2$ of wavelength 1·43603 Å and another X-ray line of 0·53832 Å from the impurity element. Find the atomic number of this impurity element using Moseley's law. What is this element?

(c) Derive the Scherrer formula for crystallite size from the diffraction. (4+3+3=10)

7. *(a)* Describe the various steps for operating "*Rigaku Miniflex*" XRD system and show a flowchart of its operation.

(b) Briefly describe the various methods of X-ray detection techniques. (5+5=10)

8. *(a)* What is X-Ray Photoelectron Spectroscopy (XPS)? State the basic principle of XPS analysis.

(b) What information can be obtained from XPS analysis?

(c) Describe an XPS system mentioning various components and their functions.

(d) Show using diagram a 1s photoelectron emission from a transition element. Show also the Auger electron emission in this experiment. (2+2+3+3=10)

PART—II

Answer ***any four*** questions.

1. State Lambert-Beer's law. What are the limitations of Lambert-Beer's law? A substance when dissolved in water at 10^{-3} M concentration absorb 10% of the incident radiation