



**M.E/M.TECH DEGREE EXAMINATIONS: NOV/DEC 2023**

(Regulation 2018)

First Semester

**CHEMISTRY**

P18CHE0003: Physical Methods in Chemistry

**COURSE OUTCOMES**

**CO1:** To understand the principle and Instrumentation of analytical and Spectroscopic techniques

**CO2:** To identify the functional groups for molecular interactions and to elucidate the structure and properties of compounds

**CO3:** To analyze the Surface Morphology and inner structure of the compounds

**CO4:** To identify and quantify the unknown and known compounds using mass spectrometry

**Time: Three Hours**

**Maximum Marks: 100**

**Answer all the Questions:-**

**PART A (10 x 1 = 10 Marks)**

1. Sequence the following functional groups in increasing wavenumber ( $\text{cm}^{-1}$ ) as observed in IR spectra. CO2 [K<sub>4</sub>]  
(i) O-H stretch (ii) C=O stretch (iii) C=C stretch (iv) C-H stretch  
a) (i) < (ii) < (iii) < (iv) b) (ii) < (iii) < (i) < (iv)  
c) (iii) < (iv) < (ii) < (i) d) (iv) < (ii) < (iii) < (i)
2. Which of the following solvent is not used in NMR spectroscopic technique? CO1 [K<sub>1</sub>]  
a) D<sub>2</sub>O b) CHCl<sub>3</sub>  
c) CCl<sub>4</sub> d) CDCl<sub>3</sub>
3. Identify the NMR inactive atom from the following? CO1 [K<sub>3</sub>]  
a) <sup>15</sup>N b) <sup>11</sup>B  
c) <sup>19</sup>F d) <sup>31</sup>P
4. Match the following with List I (functional groups/ transitions) with their List II CO1 [K<sub>4</sub>]  
(frequencies/ nm)

List I	List II
A. $\pi$ - $\pi^*$ transitions	i. 400-800 nm
B. Hydroxyl group (O-H)	ii. 1600-1650 $\text{cm}^{-1}$
C. Aromatic ring (C=C)	iii. 3200-3600 $\text{cm}^{-1}$

D. d-d transitions	iv. 200-400 nm
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- a) A-ii B-i C-iii D-iv                      b) A-iii B-iv C-ii D-i
- c) A-iv B-iii C-ii D-i                        d) A-iii B-iv C-i D-ii
5. Which among the following helps us in getting a three-dimensional picture of the specimen? CO3 [K<sub>2</sub>]
- a) Compound Microscope                      b) Simple Microscope
- c) Transmission Electron Microscope      d) Scanning Electron Microscope
6. Examine the two statements carefully and select the answer using the codes given below: CO3 [K<sub>4</sub>]
- Assertion (A): Transmission Electron Microscope provides two dimensional images.
- Reason (R): Scanning Electron Microscope (SEM) provides three dimensional images
- a) Both A and R are true, and the R is the correct explanation of the Assertion      b) Both A and R are true, and the R is not the correct explanation of the Assertion
- c) A is true but R is false                      d) Both A and R are false
7. Choose the appropriate systems that applies to Kramer's degeneracy. CO3 [K<sub>3</sub>]
- (i) Isolated systems (ii) Closed quantum systems (iii) Quantum systems with spin  
(iv) Quantum systems with time-reversal symmetry
- a) (i) and (ii)                                      b) (ii) and (iii)
- c) (iii) and (iv)                                    d) (i) and (iv)
8. The number of EPR signals observed for octahedral Ni(II) complexes is/are CO1 [K<sub>2</sub>]
- a) 1    b) 2
- c) 3    d) 4
9. Select the component in mass spectrometry that is responsible for separating ions based on their mass-to-charge ratio (m/z)? CO4 [K<sub>2</sub>]
- a) Ion source                                      b) Analyzer
- c) Electron Gun                                    d) Detector
10. The Isotopic abundance in mass spectrometry refers to CO4 [K<sub>1</sub>]
- a) The presence of only one isotope in a sample      b) The abundance of ions with identical mass-to-charge ratios
- c) The concentration of isotopes in the ion source      d) The ratio of different isotopes of an element in a sample

**PART B (10 x 2 = 20 Marks)**

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|--|-----|-------------------|
| 11. State the principle in "Photometric titrations".                               | CO1 | [K <sub>1</sub> ] |
| 12. Relate Fingerprint region in functional groups identification.                 | CO1 | [K <sub>1</sub> ] |
| 13. Compare ABC and ABX type of spectrum in NMR Spectroscopy.                      | CO2 | [K <sub>5</sub> ] |
| 14. Mention the influence of Resonance effect in NMR spectra.                      | CO3 | [K <sub>5</sub> ] |
| 15. Differentiate the Electron Microscopy with Optical Microscopy.                 | CO3 | [K <sub>4</sub> ] |
| 16. Organize the quantitative applications of STEM microscopy.                     | CO3 | [K <sub>3</sub> ] |
| 17. List the uses of derivative curves, in analyzing EPR spectra                   | CO3 | [K <sub>1</sub> ] |
| 18. How is the free radicals identified using ESR spectra?                         | CO3 | [K <sub>3</sub> ] |
| 19. List the different types of mass spectrometer.                                 | CO4 | [K <sub>4</sub> ] |
| 20. Explain the concept of molecular weight determination using mass spectrometry. | CO4 | [K <sub>2</sub> ] |

**PART C (6 x 5 = 30 Marks)**

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|--|---|-----|-------------------|
| 21. Predict the important spectral signals which you would expect in the IR and <sup>1</sup> H-NMR spectra of the following compounds:<br>i) Ethyl ethanoate<br>ii) Benzoic acid   | 5 | CO1 | [K <sub>1</sub> ] |
| 22. Compare and contrast the geminal and Vicinal coupling in NMR Spectroscopy.   | 5 | CO1 | [K <sub>5</sub> ] |
| 23. Using the given spectroscopic data determine the structure of compound A, which has a molecular formula, C <sub>5</sub> H <sub>9</sub> O <sub>2</sub> Cl,<br>IR, cm <sup>-1</sup> : 1735, 1275, 1200<br>NMR, δ: 4.23 (q), 4.39 (q), 1.68 (d), 1.31 (t)<br>Mass, m/z: 136, 29, 91, 63 | 5 | CO2 | [K <sub>4</sub> ] |
| 24. Differentiate the Atomic Force Microscopy with Magnetic Force Microscopy.  | 5 | CO3 | [K <sub>2</sub> ] |
| 25. Apply the hyperfine splitting in EPR spectra and enumerate its effects. Illustrate how this phenomenon assists in identifying and characterizing paramagnetic species in inorganic complexes.  | 5 | CO2 | [K <sub>3</sub> ] |
| 26. Describe the Metastable peak and nitrogen rule key features in mass  | 5 | CO4 | [K <sub>2</sub> ] |

spectrometry.

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

27. State the principles and discuss the instrumentation of IR Spectroscopy. 10 CO1 [K<sub>1</sub>]
28. Describe under which conditions each of the types of NMR spectroscopy techniques be used. 10 CO2 [K<sub>2</sub>]
29. Describe the various components of Transmission electron microscope (TEM) and List when TEM,STEM,could be used. 10 CO3 [K<sub>3</sub>]
30. Explain the concept of 'g' shift in EPR spectroscopy, Elucidate the factors influencing 'g' shift and significance of 'g' shift in the analysis of organic and inorganic systems exhibiting paramagnetic properties. 10 CO2 [K<sub>5</sub>]
31. Consider a metal complex of your choice and elucidate how the different instrumentation techniques could be used in order to arrive at the composition and structure of the complex. 10 CO2 [K<sub>4</sub>]

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