Total number of printed pages–8

1 (Sem–4/FYUGP) CHE 44 MJ

2026

CHEMISTRY

(Major)

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Acc. No.
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Paper : CHE4400404MJ

(Magnetic Resonance Spectroscopy and Analytical Techniques)

Full Marks : 45

Time : 2 hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions as directed : 1×5=5

(a) Which of the following electromagnetic radiation is used in ESR spectroscopy ?

(i) IR radiation

(ii) Radio waves

(iii) X-rays

(iv) Micro waves

(b) In mass spectroscopy the peak with 100% abundance is

(i) base peak

(ii) molecular ion peak

(iii) parent ion peak

(iv) None of the above

(c) The value of R_f is always

(i) Greater than 1

(ii) Equal to 1

(iii) Less than 1

(iv) Zero

(d) *Cs* metal crystallizes in a *bcc* lattice. How many atoms are present per unit cell ?

(e) Define Zeta potential.

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2. Answer ***any five*** questions : 2×5=10

(a) What is Landé'g-factor ? Calculate *g* value for Fe^{3+} ion. 1+1=2

(b) Write *two* advantages of Gas Chromatography.

(c) What is Nitrogen rule in Mass Spectroscopy ?

(d) For the strong electrolytes *NaOH*, *NaCl* and $BaCl_2$ the molar ionic conductances at infinite dilution are $248{\cdot}1 \times 10^{-4}$, $126{\cdot}5 \times 10^{-4}$ and $280{\cdot}0 \times 10^{-4}$ Scm^2mol^{-1} respectively. Calculate Λ_m^0 for $Ba(OH)_2$.

(e) Calculate the Miller indices of crystal planes which cut through the crystal axes at *(i)* (6*a*, 3*b*, 3*c*) *(ii)* (2*a*, −3*b*, −3*c*) 1+1=2

(f) KNO_3 crystallizes in orthorhombic system with the unit cell dimensions $a = 542pm$, $b = 917pm$ and $c = 645pm$. Calculate the diffraction angles for first order X-ray reflections from (111) planes using radiation with wave length = $154{\cdot}1pm$.

(g) Outline the method of detection and determination of components of a mixture by thin layer chromatography (TLC).

(h) Discuss the applications of mass spectrometry with suitable examples.

(i) For a 200*MHz* NMR spectrometer, if a proton resonates at 1460*Hz* downfield from TMS, calculate the chemical shift.

(j) Can a solution of 1*M* $CuSO_4$ be stored in a vessel made of nickel metal? Given that $E^{\circ}_{Ni^{2+}/Ni} = -0{\cdot}25\,volt$ and $E^{\circ}_{Cu^{2+}/Cu} = +0{\cdot}34\,volt$.

3. Answer ***any four*** questions : 5×4=20

(a) Describe Rotating Crystal method for the study of X-ray diffraction of crystals briefly.

(b) What is role of internal standard used in GLC techniques? Write down *two* main advantages of HPLC techniques. 3+2=5

(c) What is Law of rational indices? Define space lattice and unit cell. What is the nature of structural units in a molecular solids? 2+2+1=5

(d) Discuss the principle of ESR spectroscopy with the help of examples. Explain hyperfine-splitting in ESR spectra. 4+1=5

(e) (i) A compound of molecular formula $C_4H_8O_2$ gave the following sets of NMR data :

triplet $\delta = 1{\cdot}1(3H)$,

quartet $\delta = 2{\cdot}3\,(2H)$;

singlet $\delta = 3{\cdot}6\,(3H)$

Assign the structure to this compound. 3

(ii) How will you differentiate Chlorobenzene from 1,2-Dichloroethane by NMR spectra? 2

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(f) How will you distinguish among ethylamine, diethylamine and triethylamine on the basis of mass spectral studies?

(g) What is meant by the term 'Chemical shift'? Write with examples the shielding and deshielding effects involved in NMR spectroscopy. Mention *two* important characteristics of solvents used in NMR spectroscopy. 2+2+1=5

(h) In the mass spectrum of toluene, strong peaks are found at $m/e = 91$ and $m/e = 65$. Also a broad peak appears at $m/e = 46 \cdot 4$. Justify the origin of these signals.

4. Answer ***any one*** question : 10

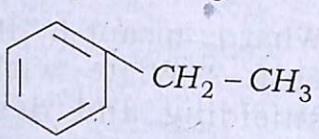
(a) (i) Explain the relationship between Larmor precessional frequency ω_0 and applied magnetic field B_0 with diagrams. 3

(ii) How many proton signals will be obtained in the PMR spectrum of the following compounds : 4

(a) $H_2C = CH - CH_2OH$

(b) CH_3CH_2Cl

(c) $CH_3CHClCH_3$

(d)  $CH_2 - CH_3$

(iii) Write the differences between first order and second order spectra. 3

(b) (i) Define ion exchange chromatography. What do you mean by cation exchangers and anion exchangers ? Give *one* example in each case. 2+2+1=5

(ii) What is the basic principle of potentiometric titration ? Explain with a schematic diagram a complete electrochemical cell used in potentiometric Acid-Base titration. Draw a potentiometric titration curve of an Acid *Vs* Base titration. 2+2+1=5

(c) (i) Describe briefly how Quinhydrone electrode can be used for determining pH for a solution. Write the limitations of this electrode. 4+1=5

(ii) What is liquid junction potential ? Calculate the liquid junction potential associated with the following cell :

$Ag(s), AgCl(s), HCl(m_1 = 1 \cdot 0, \gamma_1 = 0 \cdot 809)$:

$HCl(m_2 = 0 \cdot 05, \gamma_2 = 0 \cdot 830), AgCl(s), Ag(s)$

if the transference number of H^+ is 0·83. 1+4=5

(d) (i) An unknown hydrocarbon has a molecular peak at $m/z = 84$ with relative intensity of 31·3% and $(M+1)$ peak of intensity 2·06%, what is the molecular formula of the compound? 5

(ii) Determine the number of ESR peaks for the following ions : 2+2+1=5

(a) Mn^{2+}

(b) Cr^{3+}

(c) Cu^{2+}

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