1 (Sem–4) CHE 4

2025

CHEMISTRY

Paper : CHE0400404

(Magnetic Resonance Spectroscopy and Analytical Techniques)

Full Marks : 45

Time : Two 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 nuclei show magnetic properties for NMR spectrometry ?

   $^{2}H, ^{1}H, ^{14}N, ^{12}C$

   (b) State which of the following radiations is associated with NMR spectroscopy :

   X-ray, infrared, γ – ray, radiowave

(c) Name the crystal system with characteristics $a = b \neq c$; $\alpha = \beta = 90°$, $\gamma = 120°$.

(d) Which is the commonly used adsorbent in column chromatography ?

NH_4OH, H_2SO_4, $CuSO_4$, Silica gel

(e) In mass spectrometry, the sample that has to be analyzed is bombarded with which of the following ?

protons, electrons, neutrons, α-particles

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

(a) What are α-cleavage and induce cleavage in mass spectroscopy ?

(b) What is the basic difference between the principles of conventional chromatography and HPLC ?

(c) Write *two* reasons for using TMS as reference in non-aqueous solvents in ^1H NMR spectroscopy.

(d) Explain spin-spin coupling in case of 1, 1–dibromoethane.

(e) What is R_f value ? During a chromatography experiment, a pigment moved 3.4 *cm* and the solvent had moved 4.8 *cm*. Calculate the R_f value.

(f) What is McLafferty rearragement ?

(g) The edge length in *NaCl* crystal is 5.63×10^{-10} *m*. Find the distance between (111) planes.

(h) How the molar conductance of strong electrolyte changes with dilution ?

(i) Write briefly about redox electrode.

(j) How the metal-amalgam electrode is set up ? How is it represented ?

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

(a) What do you understand by adsorbent ? Give *two* classes of an adsorbent. Give examples of each class. 1+2+2=5

(b) Name the different ionization techniques in mass spectrometry. Explain *any two* techniques. 2+3=5

(c) What do you mean by ionic doublets ? Write briefly about asymmetry effect. 1+4=5

(d) What is metal-metal insoluble salt electrode ? How this electrode is represented ? Write the overall electrode reaction and electrode potential of metal–metal insoluble electrode. 1+1+3=5

(e) Write the principle of NMR spectroscopy and draw the block diagram of NMR spectrometer. 2+3=5

(f) The mass spectrum of 2-methyl-pentane shows two prominent peaks and m/z values of 71 and 43. Identify each species showing adequate fragmentation. Also identify the base peak. Distinguish between molecular ion peak and base peak in mass spectrometry. 2+1+2=5

(g) Draw a rough sketch of ^1H NMR spectrum of 1-bromoethane and predict the chemical shift positions of the protons. Name *two* factors that affect chemical shift. 3+2=5

(h) Why are liquid N_2 and *He* used in NMR spectrometers ? Name *one* solvent used in NMR spectroscopy. Calculate the chemical shift in ppm unit for a proton that shifted to 270 *Hz* downfield from the TMS in a 100*MHz* NMR spectrometer. 2+1+2=5

4. Answer ***any one*** question : 10×1=10

(a) (i) What are shielding and deshielding involved in NMR spectroscopy ? 3

(ii) How many signals will be shown by Br_2CHCH_2Br in NMR spectroscopy ? 3

(iii) How will you distinguish 1-propanol and 2-propanol using NMR spectroscopy ? 2

(iv) Write the structure of the compound with molecular formula $C_3H_6Cl_2$ which exhibits only one signal in the ^1H NMR spectrum. 2

(b) (i) Discuss the theory of electron spin resonance spectroscopy. 5

(ii) Taking example of hydrogen atoms, explain what is meant by hyperfine splitting in electron spin resonance spectroscopy ? 3

(iii) How many signals will be observed in the ESR spectrum of methyl radical ? 2

(c) (i) State Bragg's law and deduce the equation $n\lambda = 2d\sin\theta$ 3

(ii) The parameters of an orthorhombic unit cell are $a = 50pm$, $b = 100pm$, $c = 150pm$. Determine the spacing between the (123) planes. 3

(iii) Calculate the Miller indices of crystal plane which cut through the crystal axes at $(2a, 3b, c)$ and (a, b, c). 4

(d) (i) What is a concentration cell ? Write a short note on concentration cells without transference. 1+4=5

(ii) What is liquid junction potential ? Show that liquid junction potential depends upon the transference number of anions and cations. 1+4=5