

Total number of printed pages-8

1 (Sem-4/FYUGP) CHE 41 MJ

2026

CHEMISTRY

(Major)

Paper : CHE4400104MJ

(Inorganic Chemistry-I)

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

- (i) Predict the symmetry point group of H_2S molecule.
- (ii) Write the electronic configuration of Fe in $[Fe(CN)_6]^{4-}$ in terms of t_{2g} and e_g in an octahedral field when $\Delta_o < P$.
- (iii) Write the most stable oxidation state in each of Cu , Ag and Au ?
- (iv) Which of the following elements does not show disproportion reaction?
 - (a) Mn
 - (b) Cu
 - (c) Cl
 - (d) K
- (v) How many α and β particles will be released when ${}_{92}U^{238}$ successfully disintegrates to be transformed to ${}_{82}Pb^{206}$?

2. Answer **any five** from the following questions :

2×5=10

- (i) Draw all the symmetry elements present in ammonia molecule.

- (ii) What is John Teller effect? Give the splitting of d orbitals in z-in and z-out pattern of distortion.

- (iii) What is zone refining? Which type of substances is purified by it?

- (iv) $FeSO_4$ solution is always prepared in dilute sulphuric acid. Explain.

- (v) Write the nuclear reaction involved in carbon dating.

- (vi) Actinoids have greater tendency to form complexes than actinoids. Explain.

- (vii) Calculate the bond order of $[Re_2Cl_8]^{2-}$ and give its magnetic property.

- (viii) Why is +3 the common oxidation state for lanthanides?

- (ix) The tendency of a metal ion to form compounds of high coordination numbers decreases across the first-row transition elements. Explain.

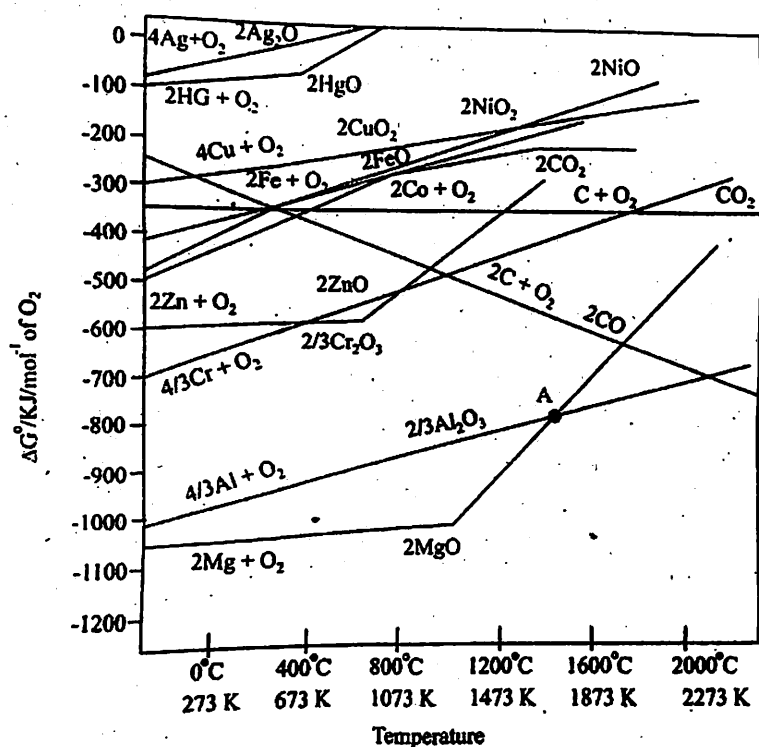
- (x) Show that $1 amu = 1.66 \times 10^{-27} Kg$
 $= 913.5 MeV$ of energy.

3. Answer **any four** from the following questions :

5×4=20

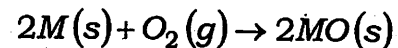
- (i) Find all the symmetry elements in an O_h point group.

- (ii) Calculate CFSE in terms of Δ_0 and P for high spin and low spin octahedral complexes of $Fe(II)$ and $Co(II)$. Predict whether the complexes will be paramagnetic or diamagnetic.
- (iii) Consider the following Ellingham diagram for oxides and answer the following questions :



- (a) What does the slope of the lines represent?

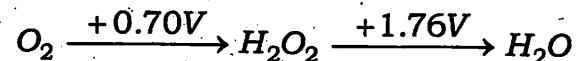
- (b) $\Delta G^\circ = RT \ln K$. What is the expression for K for the general reaction :



- (c) At what temperature can carbon reduce zinc oxide?

$$1+2+2=5$$

- (iv) (a) Using the Latimer diagram of oxygen given below :



Draw the Frost diagram of oxygen. From these diagrams indicate (a) which is the most stable species, and (b) which species would undergo disproportionation?

- (b) The mass defect for ${}^{14}_7N$ was found to be $0.112 amu$. Calculate the binding energy per nucleon.

$$3+2=5$$

- (v) (a) State why the elements of the second transition series show properties which are more similar to those of the third transition series than the first transition series.

- (b) Discuss the principles of extraction of nickel from its ore.

2+3=5

- (vi) (a) Half life period of a radioactive element is 1×10^{-6} sec. How long will it take for 90% disintegration?

- (b) What is a symmetry operation? How many symmetry operations can be performed by the operator C_3 on BF_3 molecule?

3+2=5

- (vii) (a) Square planar d^8 paramagnetic complexes are extremely rare. Account for this observation with a crystal field argument.

- (b) The second ionization energy of Cu and Cr are sufficiently high. Explain why.

3+2=5

- (viii) How many oxides of vanadium are known? Give preparation, properties and uses V_2O_5 .

2+3=5

4. Answer **any one** from the following questions:

10

- (i) (a) Why are transition metals capable of showing variable oxidation state? Give a brief description of stable and unstable oxidation states of V, Cr, Mn and Fe.

1+4=5

- (b) Describe Mond's process to purify Nickel.

5

- (ii) (a) What is an improper rotational axis of symmetry (S_n)? Give an example of a molecule with centre of inversion (i).

- (b) Give the factors affecting the magnitude of Δ_0 .

- (c) Define electrolytic reduction with an example.

- (d) Explain autoxidation with an example.

- (e) La^{4+} ion does not exist. Explain.

2+5=10

- (iii) (a) Discuss the bonding in an octahedral molecule with the help of molecular orbital theory considering σ -bond only.

5

- (b) Will Hg_2^{2+} ion disproportionate in aqueous solution into Hg^{2+} and Hg^0 ? Given that

$$E^0(Hg_2^{2+}/Hg^0) = 0.7960V$$

$$E^0(Hg^{2+}/Hg_2^{2+}) = 0.9110V$$

$$E^0(Hg^{2+}/Hg^0) = 0.8535V$$

5

- (iv) (a) Derive integrated form of equation for the decay of radioactive element. Deduce the expression for $t_{1/2}$. 3+2=5
- (b) Discuss the ion exchange method of separation of lanthanides.

5

Total number of printed pages-8

1 (Sem-4/FYUGP) CHE 42 MJ

2026

CHEMISTRY

(Major)

Paper : CHE4400204MJ

(Organic Chemistry-I)

Full Marks : 45

Time : 2 hours

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

1. Answer the following questions : $1 \times 5 = 5$

(A) Which one is the strongest acid among *o*-, *m*- and *p*-hydroxybenzoic acid?

(B) What happens when acetylene and H_2S is passed over Al_2O_3 at $400^\circ C$?

(C) Write the name and structure of *any one* basic amino acid.

(D) Heavy metal ions like _____ and _____ inhibit the activity of variety of enzymes. $\frac{1}{2} + \frac{1}{2} = 1$

(E) Draw the chemical structure and give IUPAC name of maleic acid. $\frac{1}{2} + \frac{1}{2} = 1$

2. Answer the following : (*any five*) $2 \times 5 = 10$

(a) By using Hoffmann degradation reaction, how can you prepare ethanamine?

(b) Define auxochromes. What is red-shift in connection with UV-visible spectroscopy? $1 + 1 = 2$

(c) How will you prepare malic acid from maleic acid?

(d) Define 'Zwitter ions'. Give *two* evidences in support of dipolar ionic structure of amino acids. $1 + 1 = 2$

(e) Carboxylic acids do not give characteristic reactions of carbonyl group. Explain.

(f) Explain briefly about the acidic character of pyrrole.

(g) What are the electronic transitions possible in the following compounds?

(i) Methane

(ii) Ethylbromide

(iii) Benzene

(iv) Formaldehyde

$$\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = 2$$

(h) What do you mean by enzyme inhibition?

(i) What happens when acetylene and hydrocyanic acid is passed through red hot iron tube? Write the chemical equation.

(j) What are the medicinal importances of Morphine?

3. Answer *any four* from the following :

$$5 \times 4 = 20$$

(a) What is Claisen Condensation reaction? Write the reaction for preparation of ethyl acetoacetate (EAA). Provide a mechanism for the reaction. $1 + 1 + 3 = 5$

(b) (i) How substituted pyrrole can be prepared by Hantzsch synthesis? 3

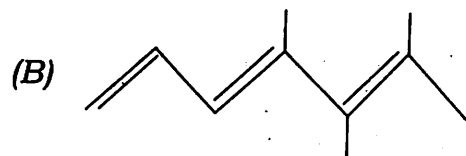
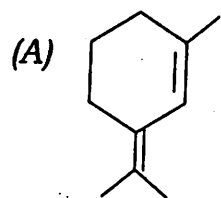
(ii) How will you prepare furan and thiophene derivatives from 1,4-dicarbonyl compound. 2

(c) (i) How primary aliphatic and aromatic amines can be distinguished by chemical reaction? 2

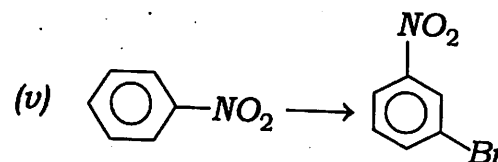
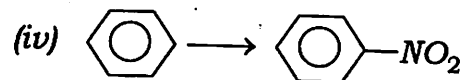
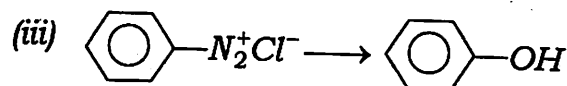
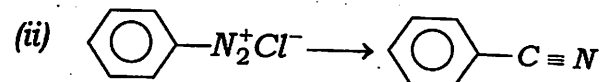
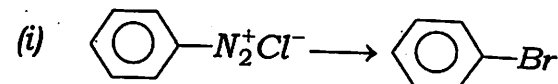
(ii) Explain Mannich reaction with mechanism. 3

(d) (i) What is the range of UV-visible light? 1

(ii) Using Woodward-Fieser rule calculate the λ_{max} of the following compounds— 2+2=4



(e) How can you carry out the following transformation? 1×5=5



(f) What are peptides? Write about peptide bond formation and its structure and geometry. 1+1+3=5

(g) Write short notes on : 2½×2=5

(i) Reformatsky reaction

(ii) Madelung synthesis

(h) What is Emde's modification? Write about the medicinal importance of Reserpine. 3+2=5

4. Answer **any one** from the following : 10

(a) (i) How will you prepare Malic acid and Tartaric acid from succinic acid? $2\frac{1}{2} \times 2 = 5$

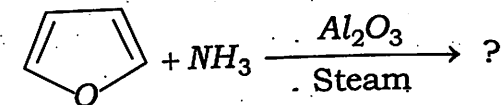
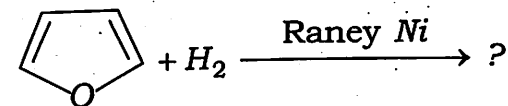
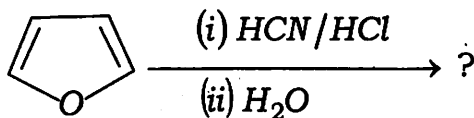
(ii) How will you distinguish between maleic acid and fumaric acid? 2

(iii) Which one is stronger acid between maleic acid and fumaric acid and why? Define Chelation effect. $2 + 1 = 3$

(b) (i) Write about Fischer Indole synthesis and give the mechanism. 4

(i) Electrophilic substitution of five membered heterocyclic compound like furan or thiophene usually takes place preferably at C-2 than C-3 position. Explain. 3

(iii) Complete the following reaction : $1 \times 3 = 3$



(c) (i) What are the different steps by which the primary structure of proteins can be determined? 3

(ii) What do you mean by specificity of enzyme? Elaborate with examples. 3

(iii) How amino acids can be synthesized from α -Halo acids? 2

(iv) Give the reaction involved in the preparation of amino acids by Gabriel synthesis. 2

(d) (i) How can the two geometric isomers of stilbene be identified from λ_{max} values? Values of UV-visible spectroscopy. 2

(ii) What do you mean by Fingerprint region in IR-spectroscopy? Explain its significance. 3

(iii) What are the two different types of vibrational modes of polyatomic molecule? 2

(iv) Find out the normal modes of vibration in CO_2 molecule. Among them which modes of vibrations are IR-active and why? 3

Total number of printed pages-8

1 (Sem-4/FYUGP) CHE 44 MJ

2026

CHEMISTRY

(Major)

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.

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

(a) What is Landé's 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 248.1×10^{-4} , 126.5×10^{-4} and $280.0 \times 10^{-4} \text{ Scm}^2\text{mol}^{-1}$ 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) $(6a, 3b, 3c)$ (ii) $(2a, -3b, -3c)$ 1+1=2

(f) KNO_3 crystallizes in orthorhombic system with the unit cell dimensions $a = 542\text{pm}$, $b = 917\text{pm}$ and $c = 645\text{pm}$. Calculate the diffraction angles for first order X-ray reflections from (111) planes using radiation with wave length = 154.1pm .

- (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 200MHz NMR spectrometer, if a proton resonates at 1460Hz downfield from TMS, calculate the chemical shift.
- (j) Can a solution of 1M CuSO_4 be stored in a vessel made of nickel metal? Given that $E^\circ_{\text{Ni}^{2+}/\text{Ni}} = -0.25\text{ volt}$ and $E^\circ_{\text{Cu}^{2+}/\text{Cu}} = +0.34\text{ volt}$.

3. Answer **any four** questions : $5 \times 4 = 20$

- (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 $\text{C}_4\text{H}_8\text{O}_2$ gave the following sets of NMR data :
triplet $\delta = 1.1(3H)$,
quartet $\delta = 2.3(2H)$;
singlet $\delta = 3.6(3H)$
Assign the structure to this compound. 3
- (ii) How will you differentiate Chlorobenzene from 1,2-Dichloroethane by NMR spectra? 2

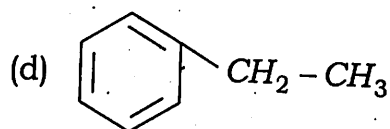
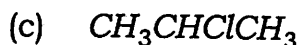
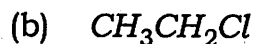
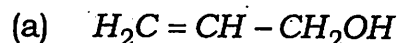
- (f) How will you distinguish among ethylamine, diethylamine and triethylamine on the basis of mass spectral studies?
- (g) What is meant by the term 'Chemical shift'? Write with examples the shielding and deshielding effects involved in NMR spectroscopy. Mention *two* important characteristics of solvents 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 $m/e = 46.4$. 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



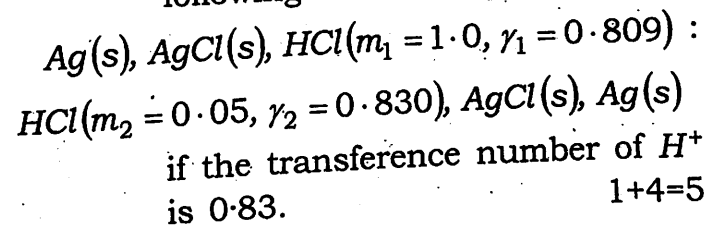
- (iii) Write the differences between first order and second order spectra. 3

- (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 :



(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+}
