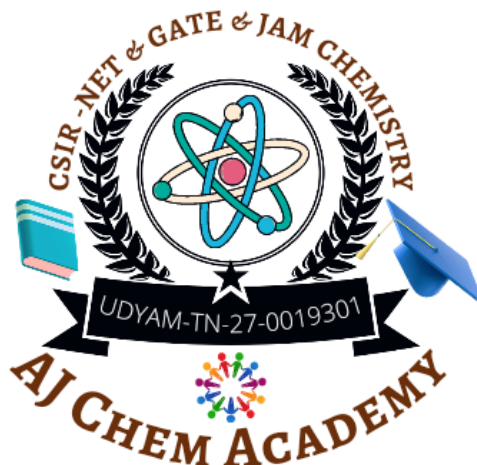


## GATE – 2000 – Chemistry



[www.csircoaching.com](http://www.csircoaching.com)

- ✓ CSIR-NET & SLET | SET Chemistry Coaching
- ✓ University Chemistry Entrance (PhD | PG)
- ✓ GATE Chemistry Coaching
- ✓ CUET-PG & JAM Chemistry Coaching

### Features

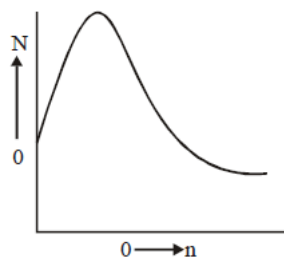
- |                               |                                  |
|-------------------------------|----------------------------------|
| ➤ 300 ++ Live Classes         | ➤ A Well-Defined Curriculum      |
| ➤ 200 ++ Concept Wise Tests   | ➤ A Strong Subject Foundation    |
| ➤ 50 ++ Chapter Wise Tests    | ➤ A Refined Learning Methodology |
| ➤ 50 ++ Model Tests           | ➤ Updated Study materials        |
| ➤ 2000 ++ Problem Discussions | ➤ Freshers Can easily understand |
| ➤ Recorded Videos             | ➤ Question banks                 |



**Q.1 – Q.50 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).**

- Which among the following molecules belong to point group  $C_{4v}$  ?  
 (a)  $[\text{BF}_4]^- \text{Na}^+$  (b)  $\text{XeOF}_4$  (c)  $\text{XeF}_4$  (d)  $[\text{PtCl}_4]^{2-}$
- The  $^{19}\text{F}$ -NMR spectrum of  $\text{PCl}_2\text{F}_3$  (I for  $^{31}\text{P} = 1/2$ , I for  $^{19}\text{F} = 1/2$ ) shows  
 (a) two triplets and two doublets (b) two triplets and one doublet  
 (c) two doublets and one triplet (d) three triplets and one doublet
- The compound  $(\text{SiH}_3)_3\text{N}$  is expected to be  
 (a) pyramidal and more basic than  $(\text{CH}_3)_3\text{N}$   
 (b) planar and less basic than  $(\text{CH}_3)_3\text{N}$   
 (c) pyramidal and less basic than  $(\text{CH}_3)_3\text{N}$   
 (d) planar and more basic than  $(\text{CH}_3)_3\text{N}$
- The Infrared and Raman spectrum of  $\text{BF}_3$  are expected to show  
 (a) the same number of peaks  
 (b) more absorption peaks in IR in comparison to Raman  
 (c) more absorption peaks in Raman in comparison with IR  
 (d) absorption peaks present in Raman are absent in IR
- The complex with maximum CFSE is  
 (a)  $[\text{CoCl}_4]^{2-}$  (b)  $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$  (c)  $[\text{CoF}_3(\text{H}_2\text{O})_3]$  (d)  $[\text{CoF}_6]^{3-}$
- The compound which has four metal-metal bonds is  
 (a)  $\text{Fe}_2(\text{CO})_9$  (b)  $\text{Co}_2(\text{CO})_8$  (c)  $[\text{Re}_2\text{Cl}_8]^{2-}$  (d)  $[\text{Ru}_3(\text{CO})_{12}]$
- The complex with spin-only magnetic moment of  $\sim 5.92$  B.M. is  
 (a)  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$  (b)  $[\text{Fe}(\text{CN})_6]^{3-}$  (c)  $[\text{Fe}(\text{CN})_6]^{4-}$  (d)  $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$
- The complex which exhibits lowest energy electronic absorption band is  
 (a)  $[\text{NiCl}_4]^{2-}$  (b)  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  (c)  $[\text{Ni}(\text{CN})_4]^{2-}$  (d)  $[\text{Ni}(\text{CO})_4]$
- The system for which energy (E) increases quadratically with the quantum number (n) is  
 (a) particle in One-dimensional box (b) hydrogen atom  
 (c) One-dimensional harmonic oscillator (d) rigid rotor
- Among the following orbitals of a diatomic molecule, the bonding one is  
 (a)  $1\sigma_u$  (b)  $2\sigma_u$  (c)  $1\pi_u$  (d)  $1\pi_g$

11. The population (N) distribution over states (n) of a diatomic molecule corresponds to



- (a) Translation (b) Vibration (c) Rotation (d) Electronic
12.  ${}^2P_{3/2}$  is the ground state of  
(a) H (b) Li (c) B (d) F
13. The vapour pressure of pure components 'A' and 'B' are 200 torr and 100 torr respectively. Assuming a solution of these components obeys **Raoult's law**, the mole fraction of component 'A' in vapour phase in equilibrium with a solution containing equimoles of 'A' and 'B' is  
(a) 0.33 (b) 0.66 (c) 0.80 (d) 0.50
14. The **half-life time** for a reaction at initial concentrations of 0.1 and 0.4 mol<sup>-1</sup> are 200s and 50s respectively. The **order of the reaction** is  
(a) 0 (b) 1 (c) 2 (d) 3
15. The **pH of a buffer solution** containing  $4 \times 10^{-3}$  and 0.4 moles of acetic acid (**pK<sub>a</sub> = 4.76**) and sodium acetate respectively will be  
(a) 6.76 (b) 4.76 (c) 2.76 (d) 0.76
16. Under the equilibrium conditions for the reaction,  $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$ , the total pressure is 12 atm. The value of K<sub>p</sub> is  
(a) 16 (b) 0.5 (c) 2 (d) 32
17. An aqueous solution containing m moles of non-volatile solute freezes at  $-0.186^\circ C$ . The elevation in the boiling point of the same aqueous solution would be (**K<sub>f</sub> = 1.86°, K<sub>b</sub> = 0.512°**)  
(a) 0.186 (b) 0.512 (c) 0.0512 (d) 0.512/1.86
18. The two H's at C-2 and C-3 in **(2R, 3S)-tartaric acid**  
(a) enantiotopic (b) diastereotopic (c) homotopic (d) constitutionally heterotopic
19. **Oxymercuration-demercuration** reaction of 1-methylcyclohexene gives  
(a) cis-2-methylcyclohexanol (b) trans-2-methylcyclohexanol

- (c) 1-methylcyclohexanol      (d) mixture of cis and trans-2-methylcyclohexanol

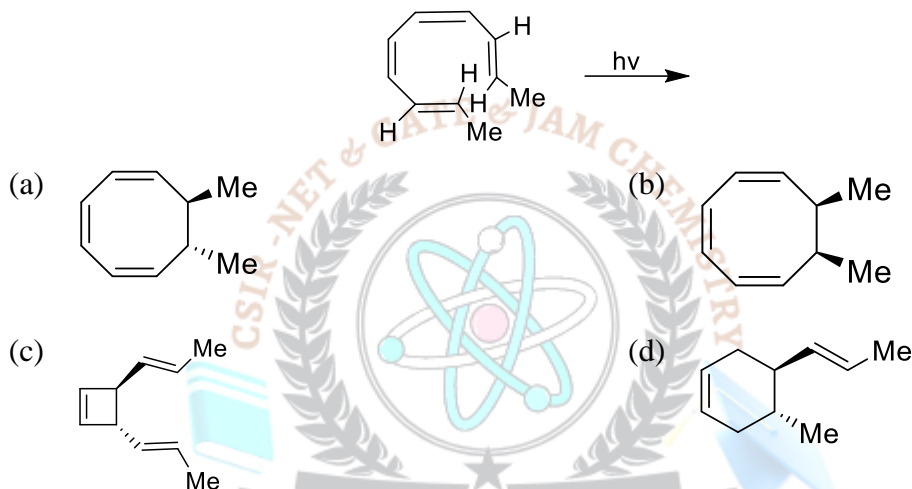
20. **Bromination of (E)-2-butenedioic acid gives**

- (a) (2R, 3S)-2,3-dibromosuccinic acid      (b) (2R, 3R)-2,3-dibromosuccinic acid  
(c) 5-iodo-tetrahydropyran-2-one      (d) 4-pentenoyl iodide

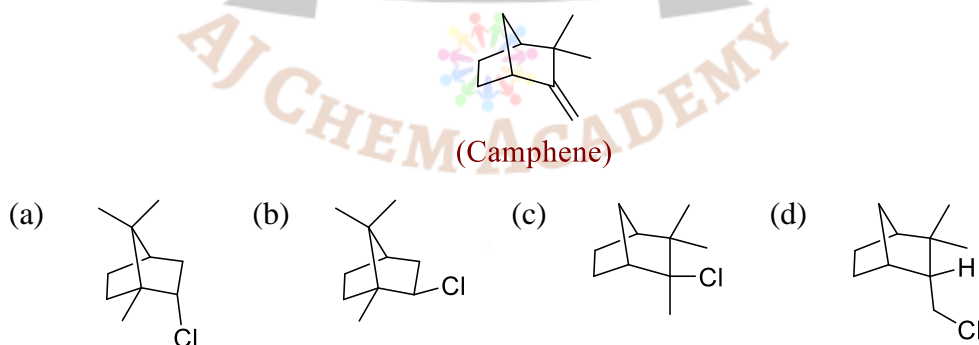
21. **4-Pentenoic acid when treated with  $I_2$  and  $NaHCO_3$  gives**

- (a) 4,5-diiodopentanoic acid      (b) 5-iodomethyl-dihydrofuran-2-one  
(c) 5-iodo-tetrahydropyran-2-one      (d) 4-pentenoyl iodide

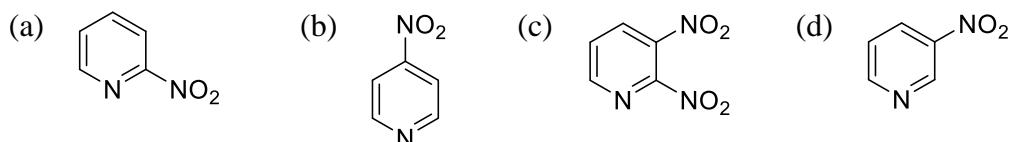
22. **The following tetraene upon photolysis gives**



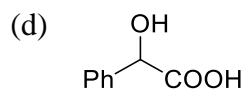
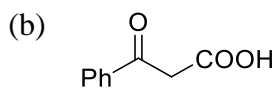
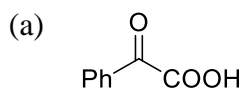
23. **The product formed upon heating camphene with HCl is**



24. **Pyridine undergoes electrophilic nitration at elevated temperature to give the following as a major product:**

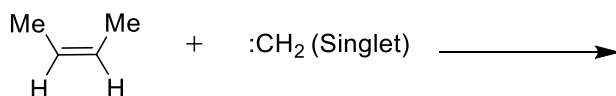


25. **Among the following, the acid which undergoes fastest decarboxylation is**



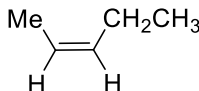


26. Which of the following statements about the molecule **NOCl** is correct?  
 (a) It has a linear structure (b) It belongs to the point group  $C_s$   
 (c) It does not have a dipole moment (d) It is a chiral molecule
27. Which of the following is an **arachno borane**?  
 (a)  $[B_6H_6]^{2-}$  (b)  $B_5H_9$  (c)  $B_2H_6$  (d)  $B_8H_{14}$
28. **C<sub>60</sub>** has  
 (a) 14 pentagons and 18 hexagons (b) 12 pentagons and 20 hexagons  
 (c) 10 pentagons and 20 hexagons (d) 12 pentagons and 18 hexagons
29. The **order of acidity** in boron trihalides is  
 (a)  $BF_3 > BCl_3 > BBr_3$  (b)  $BBr_3 > BCl_3 > BF_3$   
 (c)  $BF_3 > BBr_3 > BCl_3$  (d)  $BBr_3 > BF_3 > BCl_3$
30. The compound which obeys **18-electron rule** is:  
 (a)  $Mn(CO)_3$  (b)  $Fe(CO)_4$  (c)  $V(CO)_6$  (d)  $Cr(CO)_6$
31. The **Si–O–Si bond angle** in **Me<sub>3</sub>SiOSiMe<sub>3</sub>** is  
 (a)  $\sim 120^\circ$  (b)  $\sim 180^\circ$  (c)  $\sim 90^\circ$  (d)  $\sim 109^\circ$
32. The compound which exhibits **Jahn-Teller distortion** is:  
 (a)  $[Mn(H_2O)_6]^{2+}$  (b)  $[Mn(H_2O)_6]^{3+}$  (c)  $[Cr(H_2O)_6]^{3+}$  (d)  $[Fe(CN)_6]^{4-}$
33. The **Orange colour of Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>** is due to  
 (a) metal to ligand charge transfer transition  
 (b) ligand to metal charge transfer transition  
 (c) crystal-field transition  
 (d) charge-transfer complex formation
34. Among the following diatomic molecules, the **shortest bond length** is to be found in  
 (a)  $C_2$  (b)  $N_2$  (c)  $O_2$  (d)  $F_2$
35. Among the following diatomic molecules, the one that shows **EPR signal** is  
 (a)  $Li_2$  (b)  $B_2$  (c)  $C_2$  (d)  $N_2$
36. Among the following elements, the one that acts as the major component in a **semiconductor** is  
 (a) C (b) Si (c) Ga (d) As

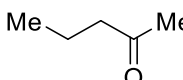
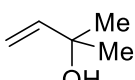
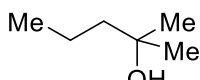
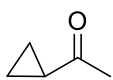
37. Among the **singlet (S)**, **doublet (D)** and **triplet (T)** electronic states, phosphorescence involves transition between  
 (a) S and S (b) D and D (c) T and T (d) S and T
38. In a system, when the chemical potential of each component is the same for all the phases, the equilibrium is said to be  
 (a) metastable equilibrium (b) thermal equilibrium  
 (c) composition equilibrium (d) mechanical equilibrium
39. The number of molecules of an ideal gas in a 8.2 L container at 380 torr and 27 °C will be  
 (a)  $1.0 \times 10^{23}$  (b)  $1.0 \times 10^{22}$  (c)  $6.02 \times 10^{23}$  (d)  $12.04 \times 10^{23}$
40. The criterion for the **spontaneity** of a process is:  
 (a)  $\Delta S_{\text{sys}} > 0$  (b)  $\Delta S_{\text{surr}} > 0$  (c)  $\Delta S_{\text{sys}} + \Delta S_{\text{surr}} > 0$  (d)  $\Delta S_{\text{sys}} - \Delta S_{\text{surr}} > 0$
41.  $\Delta H$  and  $\Delta E$  for the reaction  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{Fe}(\text{s}) + 3\text{H}_2\text{O}(\ell)$  at constant temperature are related as  
 (a)  $\Delta H = \Delta E$  (b)  $\Delta H = \Delta E + RT$  (c)  $\Delta H = \Delta E + 3RT$  (d)  $\Delta H = \Delta E - 3RT$
42. For an **ideal gas** following adiabatic reversible expansion, plot of **log P** versus **log V** is linear with a slope equal to  $(\gamma = C_p/C_v)$  :  
 (a)  $1/\gamma$  (b)  $-1/\gamma$  (c)  $\gamma$  (d)  $-\gamma$
43. **Toluene** when refluxed with  $\text{Br}_2$  in the presence of light mainly gives  
 (a) o-bromotoluene (b) p-bromotoluene  
 (c) mixture of o- and p-bromotoluene (d) benzyl bromide
44. Optically active **2-octanol** rapidly loses its optical activity when exposed to  
 (a) dilute acid (b) dilute base (c) light (d) humidity
45. **1-Hexyne** upon treatment with **disiamylborane** followed by oxidation with  $\text{H}_2\text{O}_2$  gives  
 (a) hexanoic acid (b) hexenol (c) hexanal (d) hexanol
46. **(E)-3-bromo-3-hexene** when treated with  $\text{CH}_3\text{O}^-$  in  $\text{CH}_3\text{OH}$  gives  
 (a) 3-hexyne (b) 2-hexyne (c) 2,3-hexadiene (d) 2,4-hexadiene
47. The major product formed in the following reaction is:



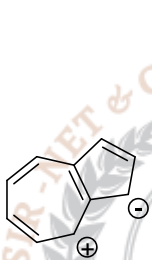


- (a)  (b)   
 (c) 50:50 mixture of above two compounds (d) 

48. **Methyl vinyl ketone** upon reaction with **LiCuMe<sub>2</sub>** gives a major product whose structure is

- (a)  (b)  (c)  (d) 

49. The following hydrocarbon has a **dipole moment of 0.8 D** because

- (a) It exist as  in which both the rings exhibit aromaticity.  
 (b) Charge separation permits conformation stability  
 (c) The two rings are of different size  
 (d) The molecule obeys  $4n + 2$  Huckel rule

50.  **$\beta$ -D-Glucose** is represented as

- (a)  (b)   
 (c)  (d) 

**Questions 51 – 83 (subjective questions) carry five marks each (Answer any twenty).**

51. Write the structures of the following compounds



**P**



**Q**



**R**

52. Account in about 10 lines the fact that the **IR stretching frequency of the P-O bond** increases in the order:  **$(\text{CH}_3)_3\text{PO} < \text{Cl}_3\text{PO} < \text{F}_3\text{PO}$**

53. Complete the following reactions supplying the missing reactant or product

- (a)  $n[\text{CH}_3)_2\text{SiO}_4] + (\text{CH}_3)_3\text{SiOSi}(\text{CH}_3)_3 \xrightarrow{\text{H}_2\text{SO}_4} (\text{A})$
- (b)  $\text{Al}_2(\text{CH}_3)_6 + 6 \text{H}_2\text{O} \longrightarrow (\text{B}) + (\text{C})$
- (c)  $3 \text{BCl}_3 + 3 \text{NH}_4\text{Cl} \longrightarrow (\text{D})$
- (d)  $\text{E} \xrightarrow[\text{haptane, 77K}]{h\nu, 270 \text{ nm}} (\text{MeS})_2\text{Si} = \text{Si}(\text{MeS})_2 \quad (\text{MeS} = 2,4,6\text{-trimethylphenyl})$
- (e)  $\text{SbF}_5 + \text{BrF}_3 \longrightarrow (\text{F}) + (\text{G})$

54. State whether the following is true or false and explain your choice in about 3 lines. “The **Ni-C** bond length in **nickelocene** is longer than the **Fe-C** bond length in **ferrocene**”.

55. Write the structure of **Co<sub>4</sub>(CO)<sub>12</sub>**. Using the **isolobal analogy** show which of the following fragments you would use to replace one of the **cobalt fragments** in the above cluster? Write the structure of the cluster so formed



56. From among the following reactions identify the type of reaction involved viz., **oxidative-addition, reductive-elimination, insertion or addition**. Justify your choice

- (i)  $[\text{RhI}_3(\text{CO})_2(\text{CH}_3)_3]^- \longrightarrow [\text{RhI}_3\text{CO}(\text{Solvent})(\text{COCH}_3)]^-$
- (ii)  $[\text{Co}_2(\text{CO})_8] + \text{H}_2 \rightleftharpoons 2[\text{CoH}(\text{CO})_4]$
- (iii)  $\text{Mn}_2(\text{CO})_{10} + \text{Br}_2 \longrightarrow 2\text{MnBr}(\text{CO})_5$

57. Write the structures of the products formed in the following reactions, keeping in view the 18-electron rule

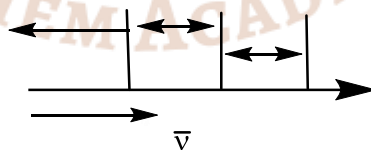
- (i)  $(\eta^4\text{-C}_4\text{H}_6)\text{Fe}(\text{CO})_3 + \text{HCl} \longrightarrow$
- (ii)  $(\eta^5\text{-Cp})_2\text{Fe} + \text{HBF}_4 \longrightarrow$

58. Lower the symmetry of a complex, closer is its magnetic moment, to the **spin-only value**. Explain in 2-3 sentences.

59. Write the **d-orbital splitting diagrams** for a **square pyramidal** and a **trigonal bipyramidal complex**



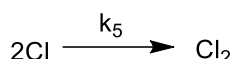
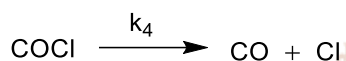
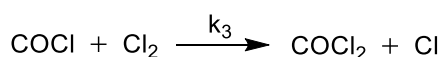
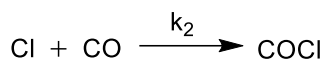
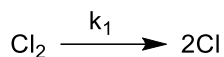
60. Draw the active site structure of rubredoxin and two common forms of ferredoxins.
61. Cytochrome-C is a redox protein but myoglobin is an oxygen storage protein. Justify in 2-3 sentences.
62. The complex  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$  displays two overlapping absorption bands at ~1000 nm. Provide an explanation in 2-3 sentences.
63. Comment in 5-6 lines on the metal-olefin bonding in  $\text{K}[\text{PtCl}_3(\text{C}_2\text{H}_4)]$
64.  $\text{O}_3$  molecule has bent geometry in its ground electronic state. Using Huckel approximation, derive the eigen values of the  $\pi$  molecular orbitals of  $\text{O}_3$  and write down the electronic configuration. Also, how schematically all the three  $\pi$  molecular orbitals and label them bonding, non-bonding and antibonding.
65. Show how would you distinguish between propanal and acetone using NMR spectroscopy. Label the axes properly and schematically show all the important features in the spectrum.
66. Using Raman spectrum and IR spectrum, show how you will determine whether a substance is trans or cis-1,2-dichloroethylene (without knowing the frequencies at which different vibrational modes occur)
67.  $\text{H}_2$  has one of the largest rotational constants ( $B_e = \frac{h}{8\pi^2 I_c} \sim 60 \text{ cm}^{-1}$ ) for a diatomic molecule. Predict the spacing between the lines in the rotational Raman spectrum indicated. Rayleigh line



68. Predict the spacing between the same set of lines in the rotational Raman spectrum of HD.
69. Two half cells of hydrogen-oxygen fuel cell under basic conditions can be depicted as  $\text{OH}^-/\text{O}_2(\text{g})/\text{Pt}$  and  $\text{OH}^-/\text{H}_2(\text{g})/\text{Pt}$  and their standard electrode potentials at 25 °C are 0.4009 and -0.8279 V respectively. Write the half cell reactions and the complete cell reaction. Depict the complete cell and calculate the emf of the cell.

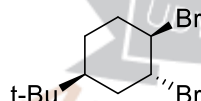


70. The solubility of  $\text{Ag}_2\text{CrO}_4$  in water is  $8 \times 10^{-5} \text{ mol Kg}^{-1}$  at  $25^\circ\text{C}$  and its solubility in  $0.04 \text{ mol Kg}^{-1} \text{ NaNO}_3$  solution is  $8.84 \times 10^{-5} \text{ mol Kg}^{-1}$ . What is the mean ionic activity coefficient of  $\text{Ag}_2\text{CrO}_4$  in  $0.04 \text{ mol Kg}^{-1} \text{ NaNO}_3$ ?
71. The formation of phosgene by the reaction  $\text{CO} + \text{Cl}_2 \rightarrow \text{COCl}_2$  appears to follow the mechanism:

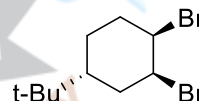


Assuming that the intermediates  $\text{COCl}$  and  $\text{Cl}$  are in a steady state, find the rate law for the formation of  $\text{COCl}_2$ .

72. Account for the fact that only one of the following compounds A and B give the expected elimination product with  $\text{KI}$  in acetone

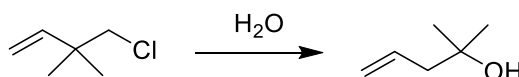


(A)

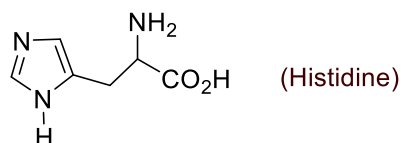


(B)

73. Account for the fact that aniline is not a suitable substrate in the **Friedel-Crafts alkylation reaction**
74. Suggest a suitable method and write all the steps for the following transformations
- (i) anisole to 2-cyclohexenone
- (ii) malonic ester to cyclobutanecarboxylic acid
75. An industrial preparation of phenol and acetone makes use of cumene and atmospheric oxygen as starting materials to produce cumene hydroperoxide which is then converted to products. Suggest what steps are involved in the process.
76. Suggest a plausible mechanism for the following hydrolysis reaction



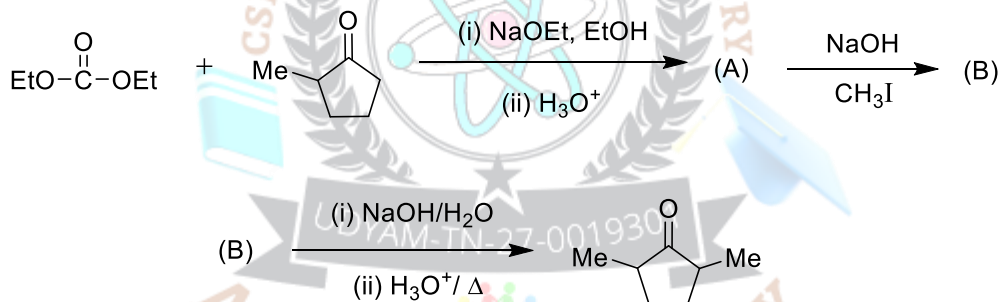
77. Explain briefly which nitrogen of the side chain ring of **histidine** is protonated in the mono-cationic form?



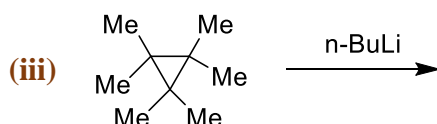
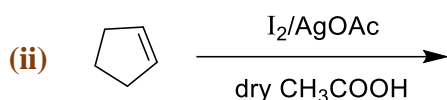
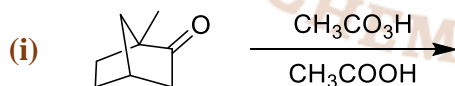
78. Optically active **ketone-A** undergoes racemization in basic solution. Suggest a mechanism for this process. Explain whether **ketone-B** would also racemize in basic solution?



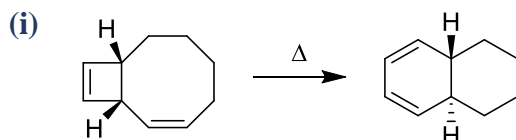
79. Write the missing products, A and B in the following reaction scheme

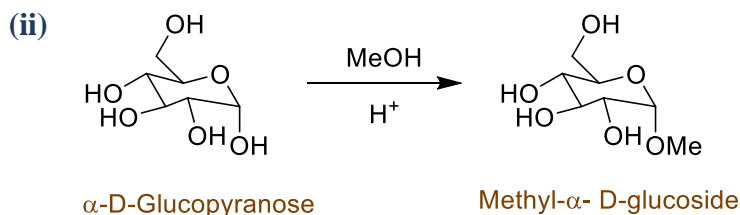


80. Write the structures of the major product in the following reactions.

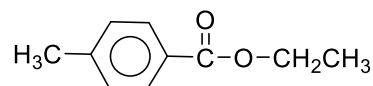


81. Suggest a suitable mechanism for each of the following reactions





82. Predict the approximate chemical shifts and multiplicities for the absorptions in the  $^1\text{H-NMR}$  spectrum of the following compound.



83. Explain how the peaks at  $m/z$  115, 101 and 73 arise in the mass spectrum of 3-methyl-3-heptanol.

### Answer Key

| Q.No | Ans |  | Q.No | Ans |  | Q.No | Ans |  | Q.No | Ans |
|------|-----|--|------|-----|--|------|-----|--|------|-----|
| 1.   | b   |  | 16.  | a   |  | 31.  | b   |  | 46.  | a   |
| 2.   | a   |  | 17.  | c   |  | 32.  | b   |  | 47.  | a   |
| 3.   | b   |  | 18.  | a   |  | 33.  | b   |  | 48.  | a   |
| 4.   | a   |  | 19.  | c   |  | 34.  | b   |  | 49.  | a   |
| 5.   | b   |  | 20.  | a   |  | 35.  | b   |  | 50.  | a   |
| 6.   | c   |  | 21.  | b   |  | 36.  | b   |  |      |     |
| 7.   | d   |  | 22.  | b   |  | 37.  | d   |  |      |     |
| 8.   | a   |  | 23.  | b   |  | 38.  | c   |  |      |     |
| 9.   | *   |  | 24.  | d   |  | 39.  | a   |  |      |     |
| 10.  | c   |  | 25.  | b   |  | 40.  | c   |  |      |     |
| 11.  | *   |  | 26.  | b   |  | 41.  | d   |  |      |     |
| 12.  | d   |  | 27.  | d   |  | 42.  | d   |  |      |     |
| 13.  | b   |  | 28.  | b   |  | 43.  | d   |  |      |     |
| 14.  | c   |  | 29.  | b   |  | 44.  | a   |  |      |     |
| 15.  | a   |  | 30.  | d   |  | 45.  | c   |  |      |     |

- © No Part of this Question Paper shall be reproduced, reprinted or Translated for any purpose whatsoever without prior permission of AJ Chem Academy.
- © In spite of best efforts taken to present this Work without mistakes, some mistakes may have inadvertently crept in. So we do not take any legal responsibility for them. If they are brought to our notice, corrections will be done in next edition.

- © இந்த வினாத்தாளின் எந்தப் பகுதியும் ஏஜே கெம் அகாடமியின் முன் அனுமதியின்றி எந்த நோக்கத்திற்காகவும் மீண்டும் உருவாக்கப்படவோ, மறுபதிப்பு செய்யவோ அல்லது மொழிபெயர்க்கவோ கூடாது.
- © இந்த படைப்பை பிழையின்றி வழங்குவதற்கு சிறந்த முயற்சிகள் எடுக்கப்பட்டாலும், சில தவறுகள் கவனக்குறைவாக ஊடுருவியிருக்கலாம். எனவே அவற்றிற்கு நாங்கள் எந்த சட்டப் பொறுப்பையும் ஏற்கவில்லை. அவற்றை எங்கள் கவனத்திற்கு கொண்டு வந்தால், அடுத்த பதிப்பில் திருத்தங்கள் செய்யப்படும்.

