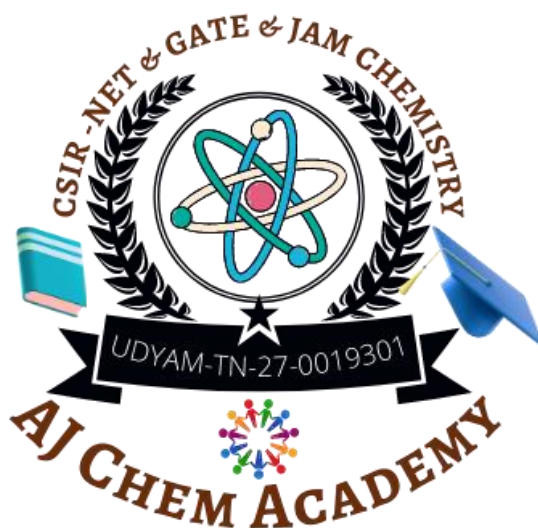


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Q.21 – Q.60 MCQ, carry TWO marks each (for each wrong answer: – 0.5).

You are required to Answer Maximum 35 Questions.

21. The lowest energy absorption bands for complex ions $[\text{CrF}_6]^{3-}$ and $[\text{Cr}(\text{en})_3]^{3+}$ are observed at $14,900 \text{ cm}^{-1}$ and $21,850 \text{ cm}^{-1}$, respectively, and are located at 18 and 34, respectively, on the horizontal axis of the corresponding Tanabe-Sugano diagram.

Analyse the following statements based on the information provided:

P. F^- is a weak-field ligand with a greater covalent character than en ligand

Q. F^- is a strong-field ligand with a lesser covalent character than en ligand

R. en is a strong-field ligand with a lesser covalent character than F^- ligand

S. en is a strong-field ligand with a greater covalent character than F^- ligand

The option with correct statement(s) is:

- (a) P and R (b) Only Q (c) Only R (d) Only S
22. The lattice parameters for the Orthorhombic and Tetragonal lattice systems, respectively, are:

(a) $a = b = c$; $\alpha = \beta = \gamma = 90^\circ$ and $a = b = c$; $\alpha = \beta = \gamma = 90^\circ$

(b) $a = b \neq c$; $\alpha = \beta = \gamma \neq 90^\circ$ and $a = b \neq c$; $\alpha = \beta = \gamma = 90^\circ$

(c) $a \neq b \neq c$; $\alpha = \beta = \gamma = 90^\circ$ and $a = b \neq c$; $\alpha = \beta = \gamma = 90^\circ$

(d) $a \neq b \neq c$; $\alpha = \beta = \gamma = 90^\circ$ and $a = b \neq c$; $\alpha = \beta = \gamma \neq 90^\circ$

23. Operators $\hat{H}$ and $\hat{L}^2$ share the same set eigenfunctions of a hydrogenic atom, having spherically symmetric potential, where $\hat{H}$ and $\hat{L}$ are the energy and angular momentum operators, respectively. Given below are two statements:

Statement I : Energy and angular momentum can be measured simultaneously.

Statement II : Operators $\hat{H}$ and $\hat{L}^2$ commute with each other.

In the light of the above statements, the correct option is,

- (a) Both statement I and statement II are true
 (b) Statement I is true but statement II is false
 (c) Statement I is true but statement II is false
 (d) Statement I is false but statement II is true
24. For an electrochemical cell, when all the reactants and products in the cell reaction are in their standard states, the increase in the reaction quotient by a factor of 10



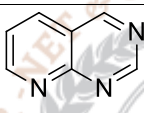
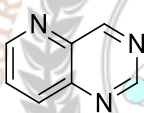
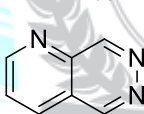
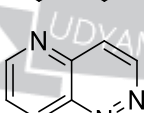
results in the

- (a) increase in EMF by $23.03 \frac{RT}{F}$ (b) increases in EMF by $2.303 \frac{RT}{F}$
 (c) decrease in EMF by $23.03 \frac{RT}{F}$ (d) decrease in EMF by $2.303 \frac{RT}{F}$

25. A mixture, consist of **2-bromopropane** and **bromoethane**, in $^1\text{H-NMR}$ shows one peak ($\delta = 3.78, 1\text{H}, \text{septet}$) with integration 75 and another peak ($\delta = 3.34, 2\text{H}, \text{quartet}$) with integration 50. What is the **mole percentage of bromoethane** in the mixture?

- (a) 25% (b) 60% (c) 40% (d) 75%

26. Match List-I with List-II

	Compound		IUPAC name
P.		I.	Pyrido[2, 3-d]pyrimidine
Q.		II.	Pyrido[3, 2-d]pyrimidine
R.		III.	Pyrido[2, 3-d]pyridazine
S.		IV.	Pyrido[3, 2-c] pyridazine

Choose the most appropriate answer from the options given below

	P	Q	R	S		P	Q	R	S
(a)	I	;	II	;	III	;	IV		
(b)	II	;	I	;	III	;	IV		
(c)	I	;	II	;	IV	;	III		
(d)	II	;	I	;	IV	;	III		

27. Using the character table given below, choose the correct **IR-active CO stretching modes** for **fac-Mo(CO)₃(CH₃CN)₃**, from the options given below:

$C_{3v}(3m)$	E	$2C_3$	$3\sigma_v$	
A_1	1	1	1	z
A_2	1	1	-1	R_z
E	2	-1	1	$(x,y) (R_x, R_y)$

- (a) One absorption band at 1790 cm^{-1}
 (b) Three absorption bands at 1790 cm^{-1} , 1920 cm^{-1} , and 1650 cm^{-1} .
 (c) Two absorption bands at 1790 cm^{-1} , and 1920 cm^{-1} .

(d) One absorption band at 1920 cm^{-1} .

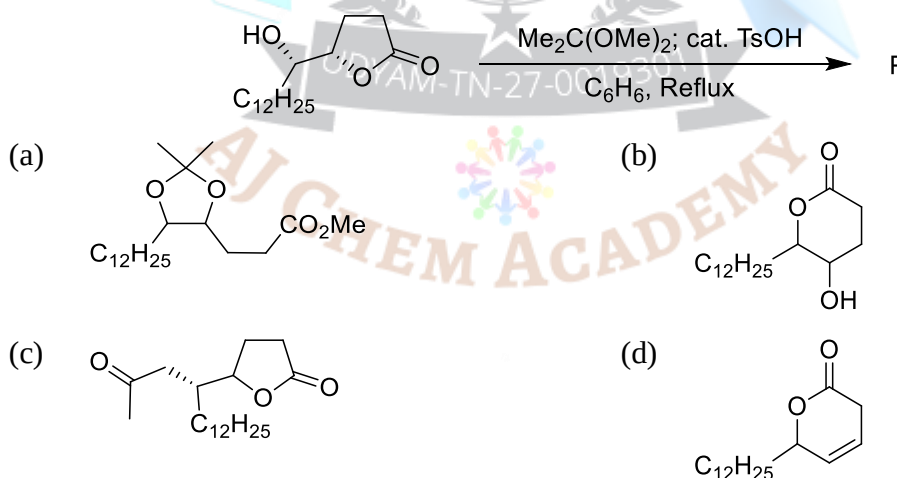
28. Match List-I with List-II

	Reaction		Reagent
P.	$\text{PhCO}_2\text{Et} \longrightarrow \text{Cyclohexyl-CO}_2\text{Et}$	I.	H_2/Pt
Q.	$\text{PhCO}_2\text{Et} \longrightarrow \text{PhCHO}$	II.	$\text{H}_2/\text{Raney Ni}/50^\circ\text{C}/100\text{ atm}$
R.	$\text{Ph}-\text{C}\equiv\text{CH}_2\text{CH}_2\text{CO}_2\text{H} \longrightarrow \text{Ph-CH}_2\text{CH}_2\text{CO}_2\text{H}$	III.	$\text{NaBH}_4/\text{EtOH}$
S.	$\text{CH}_3\text{COCH}_2\text{CO}_2\text{Et} \longrightarrow \text{CH}_3\text{CH(OH)CH}_2\text{CO}_2\text{Et}$	IV.	$\text{DIBALH}/\text{THF}/-78^\circ\text{C}$

Choose the correct answer from the options given below

	P	Q	R	S		P	Q	R	S
(a)	I	IV	I	III	(b)	I	IV	II	III
(c)	II	IV	III	I	(d)	III	IV	I	II

29. Identify the **major product-P** obtained in the following reaction.



30. The relative Lewis basicities of the compounds, $\text{N}(\text{CH}_3)_3$, $\text{O}(\text{CH}_3)_2$, $\text{O}(\text{SiH}_3)_2$ and $\text{N}(\text{SiH}_3)_3$ follow the order:

- (a) $\text{N}(\text{CH}_3)_3 < \text{N}(\text{SiH}_3)_3 < \text{O}(\text{CH}_3)_2 < \text{O}(\text{SiH}_3)_2$
 (b) $\text{O}(\text{CH}_3)_2 < \text{O}(\text{SiH}_3)_2 < \text{N}(\text{SiH}_3)_3 < \text{N}(\text{CH}_3)_3$
 (c) $\text{O}(\text{SiH}_3)_2 < \text{O}(\text{CH}_3)_2 < \text{N}(\text{CH}_3)_3 < \text{N}(\text{SiH}_3)_3$
 (d) $\text{O}(\text{SiH}_3)_2 < \text{O}(\text{CH}_3)_2 < \text{N}(\text{SiH}_3)_3 < \text{N}(\text{CH}_3)_3$

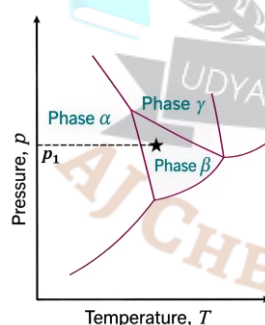
31. The bond angles decrease in series $\text{NH}_3 > \text{PH}_3 > \text{AsH}_3 > \text{SbH}_3$. This is due to:

P. The increase in size of the central atom

- Q.** Lower electronegativity as we move down the group
R. Increase in repulsion between lone pair of electrons
S. Decrease in repulsion between bonding pair of electrons
T. Increase in bond “s” character

Choose the correct answer from the options given below:

- (a) P, Q, T (b) P, R, T (c) P, Q, R, S (d) P, Q, S
32. For a hydrogenic atom in an $n = 4$ state, the maximum possible value of z-component of orbital angular momentum, is
 (a) $\sqrt{3}\hbar$ (b) $3\hbar$ (c) $12\hbar$ (d) $\sqrt{6}\hbar$
33. The origin of colours in the complexes of Ce^{4+} , Eu^{2+} and Yb^{2+} ions, respectively, are due to:
 (a) MLCT, f-f and f-d transitions (b) LMCT, f-d and f-d transitions
 (c) MLCT, f-d and f-d transitions (d) LMCT, MLCT and f-d transitions
34. The number of additional independent intensive variable(s) required to represent the point marked by asterisk at a given pressure, p_1 on the following phase diagram of a one-component system, is



- (a) 2 (b) 1
 (c) 0 (d) 3
35. Ziegler-Natta catalyst is the binary mixture of titanium chloride and aluminum alkyl ($\text{TiCl}_4/\text{Et}_3\text{Al}$). It polymerizes propylene and gives predominantly isotactic isomer. The polymerization chain growth proceeds via:
 (a) Oxidative addition (b) Reductive elimination
 (c) Oxidative coupling (d) Migratory insertion
36. The true expression for the Heisenberg Uncertainty principle for two non-commuting operators, $\hat{x}$ and $\hat{p}_x$, is
 (a) $\sigma_A \sigma_B \geq \frac{h^2}{\Lambda}$
 (b) $\sigma_A \sigma_B \geq \frac{1}{16} \left| \int \Psi^*(x) [\hat{x}, \hat{p}_x] \Psi(x) dx \right|$
 (c) $\sigma_A \sigma_B \geq \frac{1}{2} \left| \int \Psi^*(x) [\hat{x}, \hat{p}_x] \Psi(x) dx \right|$

$$(d) \sigma_A^2 \sigma_B^2 \geq \frac{1}{2} \left| \int \Psi^*(x) [\hat{x}^2, \hat{p}_x^2] \Psi(x) dx \right|$$

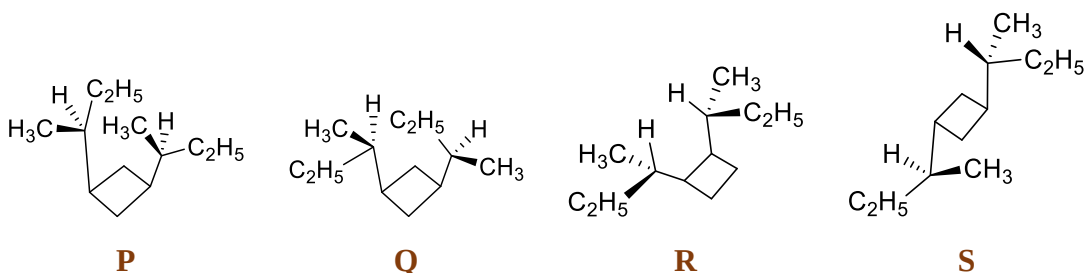
37. Given below are two statements:

Statement I : The interhalogens (XX'_n) are generally composed of two or more different halogen atoms, where X = the less electronegative and X' = more electronegative atoms.

Statement II : The larger, less electronegative atom is in the centre surrounded by one, three, five, or seven smaller, more electronegative atoms.

In light of the above statements, choose the correct answer from the options given below:

- (a) Both statement I and statement II are true
 (b) Both Statement I and Statement II are false
 (c) Statement I is true but statement II is false
 (d) Statement I is false but statement II is true
38. The point groups of the complexes, $[\text{trans-Ag}(\text{CF}_3)_2(\text{CN})_2]^-$ and $[\text{cis-Ag}(\text{CF}_3)_2(\text{CN})_2]^-$, respectively, are:
 (assuming collinear Ag-CN groups and freely rotating CF_3 groups)
 (a) C_{2v} and D_{2h} (b) C_{2h} and C_{2v} (c) D_{2h} and C_{2h} (d) D_{2h} and C_{2v}
39. According to Hückel theory, the correct statement about the butadiene, is,
 (a) Exciting an electron from the HOMO to the LUMO will not change the π bond order
 (b) The central C-C bond has a lower π -bond order than the terminal C-C bonds
 (c) It is most likely to undergo electrophilic substitution at one of the two inner carbon atoms
 (d) There are three π -energy levels and one non-bonding MO
40. The arithmetic mean and median of the given data: 20.00, 20.20, 20.40, 20.60, 20.80, 21.20, 24.20, 24.60, respectively, are
 (a) 21.50 and 20.70 (b) 21.50 and 20.60 (c) 21.50 and 21.50 (d) 20.60 and 20.80
41. Which of the following compounds are optically active



Choose the most appropriate answer given below

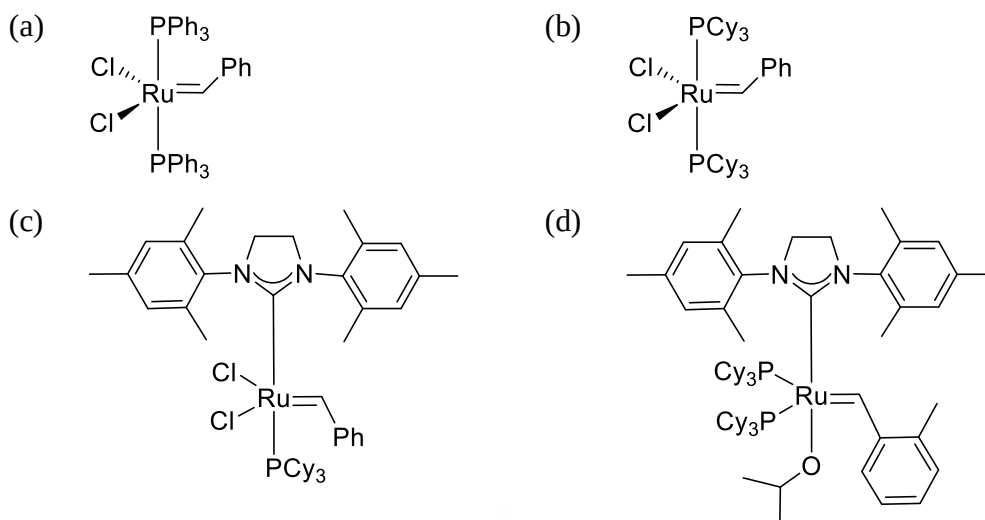
- (a) P and Q (b) P and R (c) Q and R (d) R and S
42. A proton **chemical shift** of $\delta = 3.2 \text{ ppm}$ corresponds to a frequency of **2400 Hz** on a certain **NMR instrument**. The **magnetic field strength** of this instrument, in MHz, is
- (a) 750 (b) 800 (c) 600 (d) 1000
43. For the complexes **(P)** $[\text{W}(\text{CO})_6]$ and **(Q)** $[\text{Ir}(\text{CO})\text{Cl}(\text{PPh}_3)_2]$, ^{13}C **substitution** follows ____ and the comparative rates of reactions are ____.
- (a) **P.** Dissociation
Q. Association mechanism
 Complex-Q undergoes substitution faster than complex-P
- (b) **P.** Dissociation
Q. Association mechanism
 Complex-P undergoes substitution faster than complex (Q)
- (c) **P.** Association
Q. Dissociation mechanism
 Complex (Q) undergoes substitution faster than complex (P)
- (d) **P.** Dissociation mechanism
Q. Dissociation mechanism
 Complex (Q) undergoes substitution faster than complex (P)
44. Match List-I with List-II

	List-I		List-II
P.	Catalase	I.	$2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$
Q.	P450	II.	Nonheme proteins
R.	Cytochrome c oxidase	III.	Reduction O_2 to H_2O
S.	Ferredoxins	IV.	Monooxygenase

Choose the correct answer from the options given below

	P	Q	R	S		P	Q	R	S
(a)	I	;	IV	;	III	;	II	;	I
(c)	I	;	II	;	III	;	IV	;	II
(b)	III	;	II	;	I	;	IV	;	IV
(d)	III	;	I	;	IV	;	II	;	II

45. Which one of the following is the **2nd generation Grubbs catalyst**?



46. If the volume is decreased in an **isothermal process**, the statement that correctly describes the comparison of reactive vs non-reactive system at the equilibrium ($\Delta V \neq 0$):

- (a) The compressibility of the reactive system is equal to the compressibility of the non-reactive system.
- (b) The compressibility of the reactive system is less than the compressibility of the non-reactive system.
- (c) The compressibility of the reactive system is greater than the compressibility of the non-reactive system.
- (d) The compressibility of the reactive and non-reactive systems cannot be directly compared.

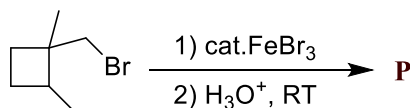
47. For a free particle moving along the x-axis, the wavefunction $\psi(x) = \frac{1}{2}e^{10x}$ is not acceptable because

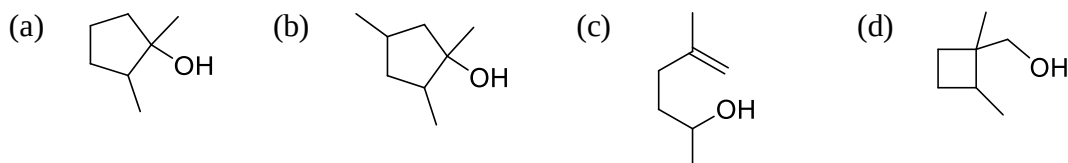
- (a) it is not an eigenfunction of the Hamiltonian operator
- (b) it is multi-valued
- (c) it is discontinuous
- (d) it approaches infinity as x approaches infinity

48. The number of doubly-bridging CO ligands in $\text{Co}_4(\text{CO})_{12}$, $\text{Rh}_4(\text{CO})_{12}$ and $\text{Ir}_4(\text{CO})_{12}$, respectively, are:

- (a) 0, 0, 0 (b) 3, 0, 0 (c) 3, 3, 0 (d) 3, 3, 3

49. The major product, **P** formed in the following reaction is

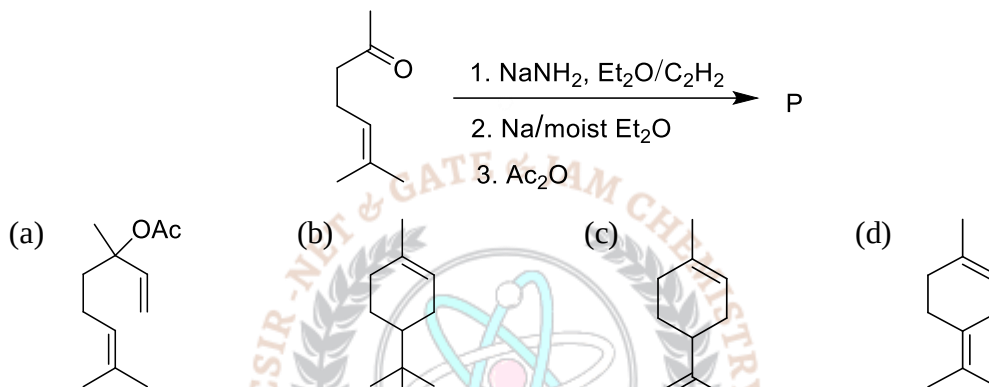




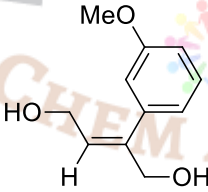
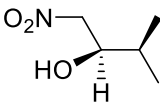
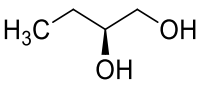
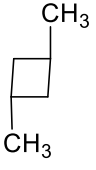
50. The ultimate source of reducing electrons generated in the **photosystem-II (PS II)**, is:

- (a) Chlorophyll-a (b) Chlorophyll-b (c) Oxygen Evolving Complex (d) H₂O

51. Which one of the following is the **major product-P** of the given reaction?



52. Match List-I with List-II

	Molecule	Number of chemically non-equivalent protons
P.		3
Q.		10
R.		7
S.		8

Choose the correct answer from the options given below

P Q R S

P Q R S

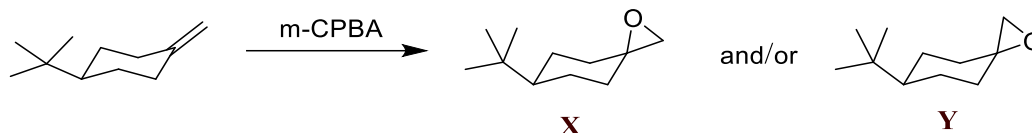
(a) III ; II ; IV ; I

(b) II ; III ; IV ; I

(c) II ; IV ; III ; I

(d) IV ; II ; III ; I

53. In the following reaction, which one of the following is **true**?



(a) X = Major; Y = Minor

(b) X = Minor; Y = Major

(c) Only product Y is formed

(d) Only product X is formed

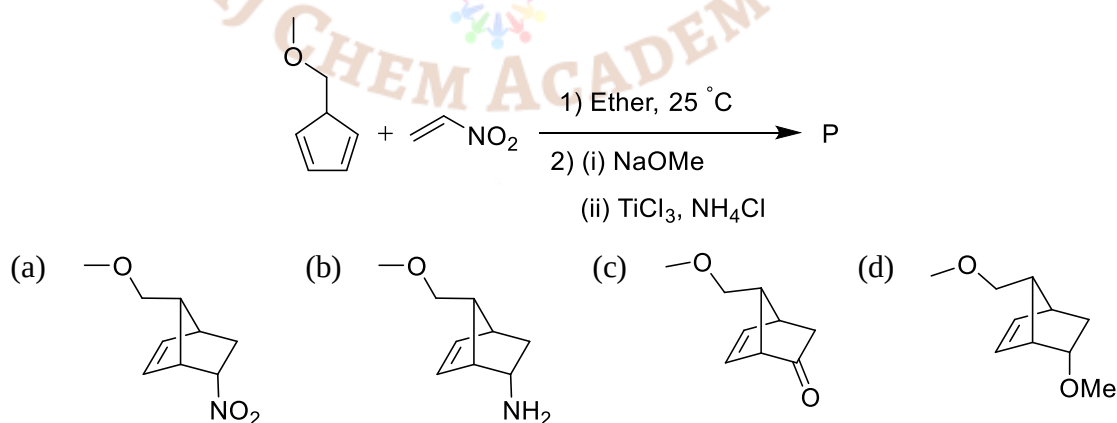
54. The **trend in stability for complexes** formed between **soft metal ions** and ligands containing the given donor atoms, is:

(a) $N < P < As < Sb$ (b) $N \ll P < As \approx Sb$ (c) $N \ll P > As > Sb$ (d) $P > N > As \approx Sb$

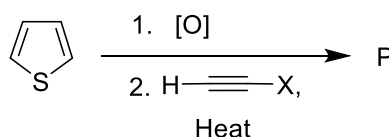
55. In which of the following compounds, the **underlined proton** possesses the **lowest pK_a value**?

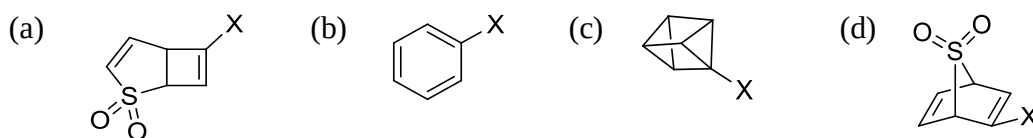


56. Identify the **major product-P**, formed in the given reaction.



57. Which one of the following is the **major product-P** of the given reaction?





58. The **Hammett plot** for a reaction series gives a straight line passing through ($\sigma = 0, \log K = -3.0$) and ($\sigma = +0.5, \log K = -1.5$). The ρ value and K_0 , respectively, are

- (a) $+3.0$ and 1.0×10^{-3} (b) $+1.5$ and 1.0×10^{-3}
(c) $+3.0$ and 3.16×10^{-2} (d) -3.0 and 1.0×10^{-3}

59. The presence of $^{40}_{19}\text{K}$ makes living tissue appreciably radioactive. It may decay either by β emission or K capture. The resulting nuclei, respectively, are:

- (a) $^{40}_{18}\text{Ar}$ and $^{40}_{20}\text{Ca}$ (b) $^{40}_{20}\text{Ca}$ and $^{40}_{18}\text{Ar}$ (c) $^{39}_{19}\text{K}$ and $^{40}_{20}\text{Ca}$ (d) $^{39}_{19}\text{K}$ and $^{40}_{18}\text{Ar}$

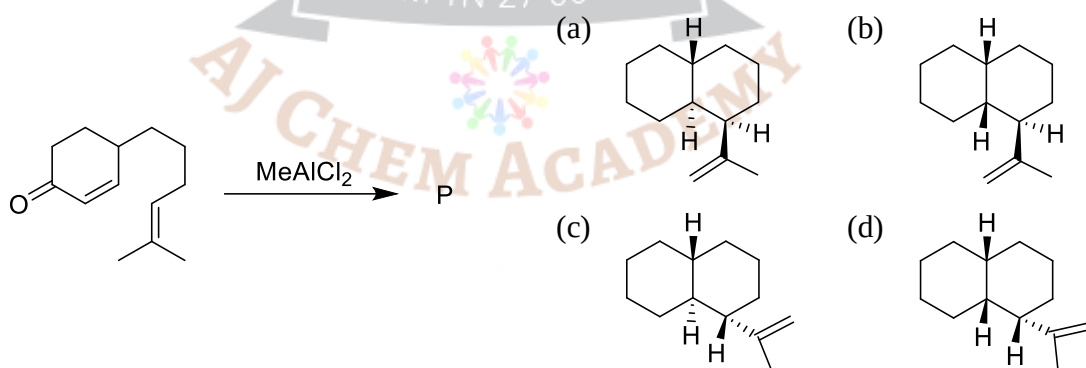
60. In **pure rotational Raman spectroscopy**, the selection rule $\Delta J = 0$ for a linear rotor contributes to which one of the following?

- (a) Rayleigh radiation (b) Vibrational excitation
(c) Stokes lines (d) Anti-stokes lines

Q.61 – Q.120 MCQ, carry FOUR marks each (for each wrong answer: – 1).

You are required to Answer Maximum 25 Questions.

61. Which one of the following is the **major product-P** of the given reaction?



62. The complete sets of symmetry representations of the **LGOs** for σ - and π -bonding, respectively, in an octahedral ML_6 complex, are:

- (a) (a_{1g}, t_{1u}) and (t_{2g}) (b) (a_{1g}, e_g, t_{1u}) and (t_{2g})
(c) (a_{1g}, t_{1u}) and $(t_{1g}, t_{2g}, t_{1u}, t_{2u})$ (d) (a_{1g}, e_g, t_{1u}) and $(t_{1g}, t_{2g}, t_{1u}, t_{2u})$

63. In the **Mössbauer spectrum** of iron compounds, the isomer shifts of Fe(II) compounds relative to metallic iron, Fe(0) , are generally in the range $+1.0$ to $+1.5 \text{ mm s}^{-1}$ whereas isomer shifts for Fe(III) compounds lie in the range $+0.2$ to $+0.5 \text{ mm s}^{-1}$. Consider the following statements as the reasons for this

observation:

P. The s-electron density at the nucleus is reduced in Fe(II) compared with Fe(0)

Q. The 3d electrons partly screen the nucleus from the inner s electrons

R. Fe(III) has increase in s-electron density at the nucleus compared to Fe(II)

S. Fe(III) has decrease in s-electron density at the nucleus compared to Fe(II)

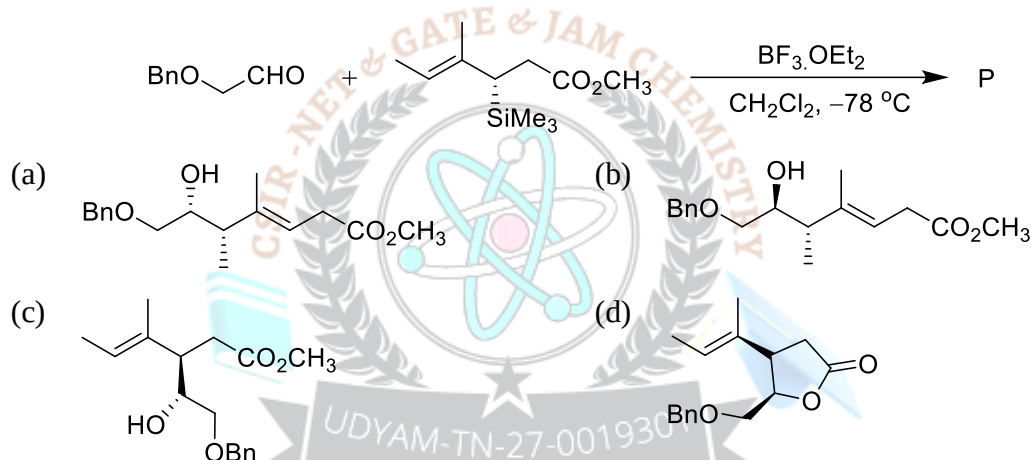
The option with correct statements, is:

- (a) P, Q and S only (b) P and R only (c) Q and R only (d) P, Q and R only

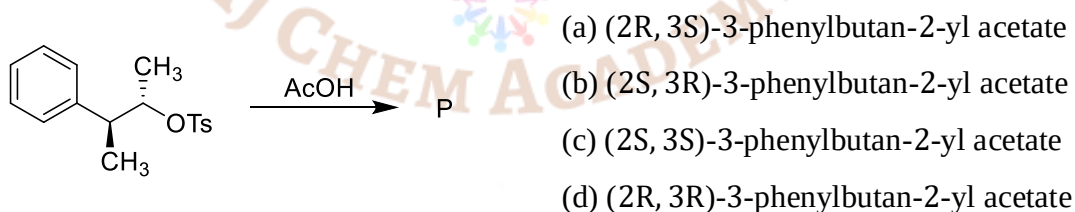
64. Labelled $^{35}_{16}\text{S}$, upon heating with an aqueous solution of sodium sulphite forms:

- (a) $^{35}_{16}\text{SSO}_3^{2-}$ (b) $^{35}_{16}\text{S}_2\text{O}_3^{2-}$ (c) $\text{S}_2\text{O}_3^{2-}$ (d) $\text{S}_4\text{O}_6^{2-}$

65. The major product, **P** formed in the following reaction, is



66. Major product-**P** formed in the given reaction is

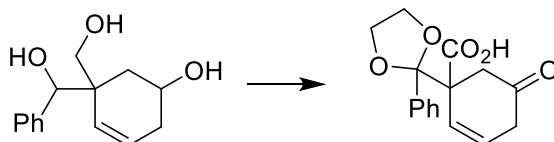


67. Identify the option containing the correct set of **isolobal fragments**:

(Cp = cyclopentadienyl ligand)

- (a) $[\text{CpCo}(\text{CO})]^+ \longleftrightarrow [\text{Co}(\text{CO})_4] \longleftrightarrow [\text{Fe}(\text{CO})_4] \longleftrightarrow \text{CH}_2$
- (b) $[\text{CpCo}(\text{CO})] \longleftrightarrow [\text{Co}(\text{CO})_4]^+ \longleftrightarrow [\text{Fe}(\text{CO})_5] \longleftrightarrow \text{CH}_2$
- (c) $[\text{CpCo}(\text{CO})] \longleftrightarrow [\text{Co}(\text{CO})_4]^+ \longleftrightarrow [\text{Fe}(\text{CO})_4] \longleftrightarrow \text{CH}_2$
- (d) $[\text{CpCo}(\text{CO})] \longleftrightarrow [\text{Co}(\text{CO})_4] \longleftrightarrow [\text{Fe}(\text{CO})_4]^+ \longleftrightarrow \text{CH}_2$

68. Which of the following is the correct sequence of the reagents that can give **product-P**?



(i)

(ii)

(iii)

- | | | | | |
|--|---|--|---|-----------------------------|
| (a) MnO_2 | ; | $\text{HOCH}_2\text{CH}_2\text{OH}/\text{H}^+$ | ; | $\text{PCC}(\text{excess})$ |
| (b) $\text{PCC}(\text{excess})$ | ; | $\text{HOCH}_2\text{CH}_2\text{OH}/\text{H}^+$ | ; | MnO_2 |
| (c) CrO_3/H^+ | ; | $\text{HOCH}_2\text{CH}_2\text{OH}/\text{H}^+$ | | |
| (d) Ag_2CO_3 on Celite/ C_6H_6 /reflux | ; | $\text{HOCH}_2\text{CH}_2\text{OH}/\text{H}^+$ | | |

69. Consider the following water substitution reactions in octahedral complexes by different anions. (where $\text{X}^- = \text{NCS}^-, \text{NO}_3^-, \text{Cl}^-, \text{Br}^-$, etc.)



Choose the option with correct mechanisms if the rate constants for different ligands are similar in case of $[\text{Cr}(\text{NH}_3)_5(\text{H}_2\text{O})]^{3+}$ while the same ligands show large variations in rate constants in case of $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$.

- (a) Both Dissociative Interchange (I_d)
 (b) P. Dissociative Interchange (I_d) and Q. Associative Interchange (I_a)
 (c) P. Associative Interchange (I_a) and Q. Dissociative Interchange (I_d)
 (d) Both Associative Interchange (I_a)
70. For a radical containing three equivalent ^{14}N ($I = 1$) nuclei, the total number of hyperfine lines and their intensities ratios, are,
 (a) 7 lines with equal intensity
 (b) 27 lines with equal intensity
 (c) 7 lines with intensity ratio of 1 : 3 : 6 : 7 : 6 : 3 : 1
 (d) 7 lines with intensity ratio of 1 : 3 : 5 : 7 : 5 : 3 : 1
71. The electronic energy (E_{elec}) of an ionic molecule H_2^+ is -1.1026 a. u. at the equilibrium bond distance (R_e) of 2.00 a. u. The value of equilibrium dissociation energy, (D_e) for this molecule in a.u., is
 (a) 2.2026 (b) 0.1026 (c) 0.6026 (d) 1.1026
72. The Gibbs free energy change (ΔG_{mic}) at -173°C when 0.1 mole fraction of the surfactant is present Critical Micelle concentration is closest to

(Given: $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$),

- (a) $19.150 \text{ J mol}^{-1}$ (b) $1.915 \times 10^2 \text{ J mol}^{-1}$
 (c) $1.915 \times 10^3 \text{ J mol}^{-1}$ (d) $1.915 \times 10^4 \text{ J mol}^{-1}$
73. Eight distinguishable particles are distributed over the states **0, ϵ , 2ϵ , 3ϵ , 4ϵ** with total energy being **4ϵ** . The number of configurations and the total number of microstates, respectively, are
 (a) 5 and 330 (b) 4 and 260 (c) 4 and 302 (d) 4 and 162
74. Tolman correlated the **carbonyl stretching frequencies of $\text{Ni(CO)}_3\text{PR}_3$ complexes** with the electronic and steric effects of the substituents. The correct order of frequencies for **$\text{R} = \text{C(CH}_3)_3$, Ph, OMe, and F**, is:
 (a) $\text{C(CH}_3)_3 > \text{Ph} > \text{OCH}_3 > \text{F}$
 (b) $\text{F} > \text{OMe} > \text{Ph} > \text{C(CH}_3)_3$
 (c) $\text{C(CH}_3)_3 > \text{OMe} > \text{Ph} > \text{F}$
 (d) $\text{F} > \text{Ph} > \text{OMe} > \text{C(CH}_3)_3$
75. Match List-I with List-II
- | | List-I | List-II | P | Q | R | S |
|----|-------------------|-------------------------------|-----------------------|---|---|---|
| P. | Melamine | I. Explosive | (a) I ; IV ; III ; II | | | |
| Q. | Rhizobium | II. Bent Structure | (b) III ; IV ; II ; I | | | |
| R. | HN_3 | III. Cyanamide | (c) I ; II ; IV ; III | | | |
| S. | Cyanuric triazide | IV. N_2 fixing genus | (d) III ; I ; II ; IV | | | |
76. Analyse the following statements regarding the changes occurring during **dioxygen binding to hemoglobin**.
P. The ionic radius of Fe increases
Q. The Fe centre becomes low-spin
R. The Fe-heme bonding interaction is strengthened
S. The complex changes from paramagnetic to diamagnetic
T. The complex changes from diamagnetic to paramagnetic
 The option with correct statements is:
 (a) P, Q and S only (b) P, R and T only (c) Q and S only (d) Q, R and S only
77. The first transition-metal complex-P with **N_2 ligand**, was synthesized by reduction of metal chloride salt with hydrazine, in water. **Complex-P** reacts with **$[(\text{NH}_3)_5\text{M(OH}_2)]^{2+}$** , **Q** to form a **$\text{N}_2$ bridged dinuclear complex R**. Identify complexes **P**, **Q** and **R** respectively

P

Q

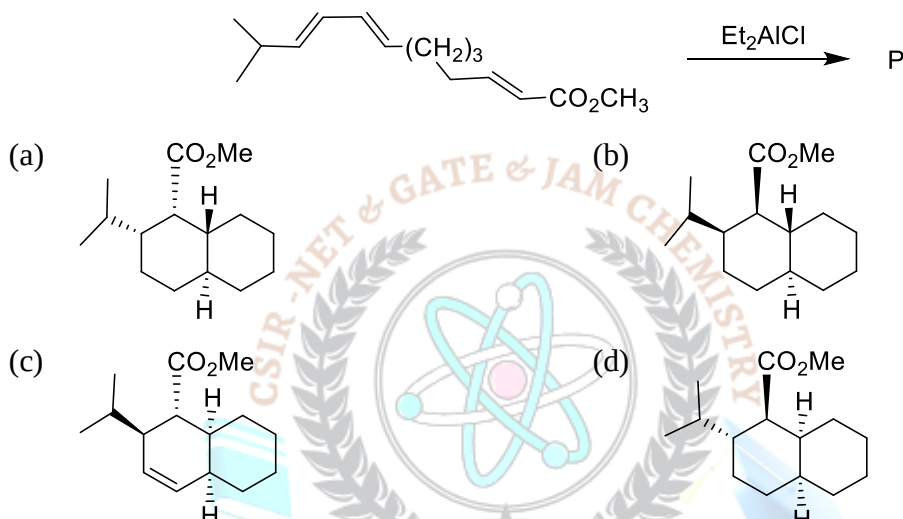
R

- (a) $[(\text{NH}_3)_5\text{Fe}(\text{N}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Fe}(\text{OH}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Fe}-\text{N}=\text{N}-\text{Fe}(\text{NH}_3)_5]^{4+}$
 (b) $[(\text{NH}_3)_5\text{Ru}(\text{N}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Ru}(\text{OH}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Ru}-\text{N}=\text{N}-\text{Ru}(\text{NH}_3)_5]^{4+}$
 (c) $[(\text{NH}_3)_5\text{Mo}(\text{N}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Ru}(\text{OH}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Mo}-\text{N}=\text{N}-\text{Ru}(\text{NH}_3)_5]^{4+}$
 (d) $[(\text{NH}_3)_5\text{Ru}(\text{N}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Fe}(\text{OH}_2)]^{2+}$ $[(\text{NH}_3)_5\text{Ru}-\text{N}=\text{N}-\text{Fe}(\text{NH}_3)_5]^{4+}$

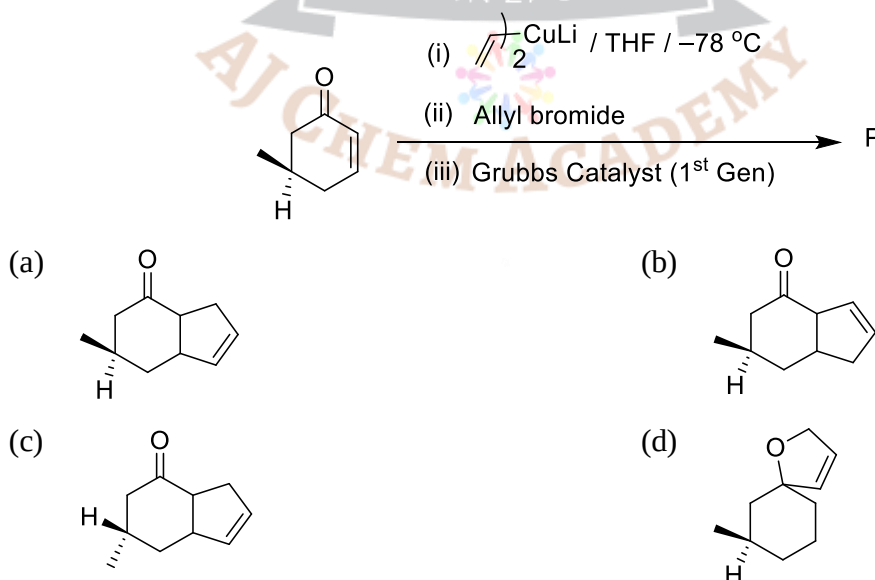
78. The point group of the molecule **bicyclo[1, 1, 1]pentane**, is

- (a) D_3 (b) D_{3d} (c) D_{3h} (d) C_{3v}

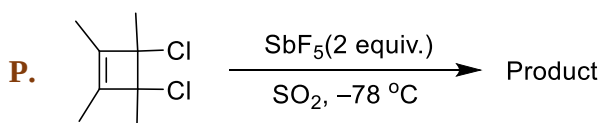
79. Identify the **major product P**, formed in the following reaction.

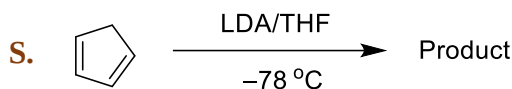
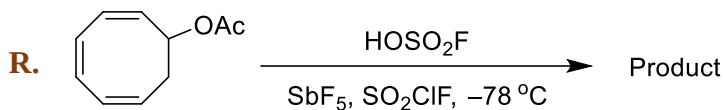
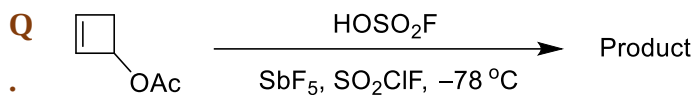


80. Identify the **major product P**, formed in the following sequence of reactions.



81. Which one of the following reactions given **homoaromatic compounds**?

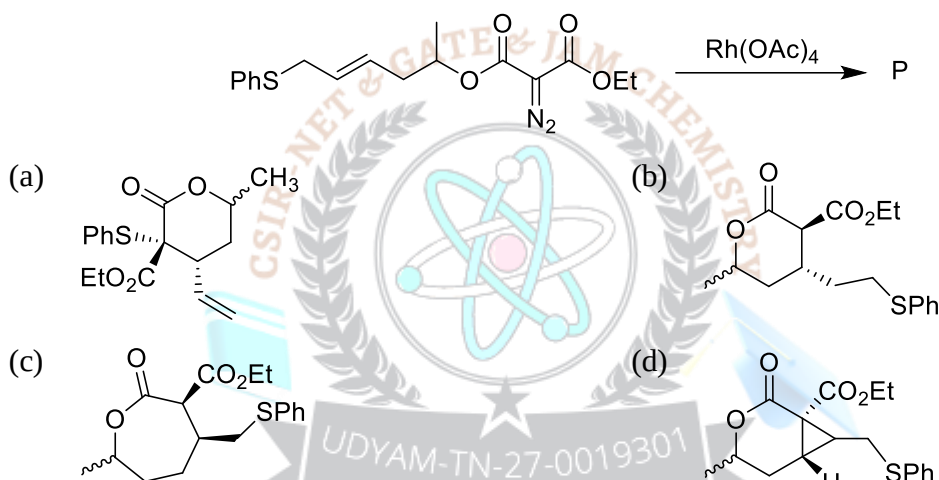




Choose the correct answer from the options given below:

- (a) P and Q only (b) Q and R only (c) P and S only (d) P, Q and R only

82. The major product, **P** formed in the following reaction, is



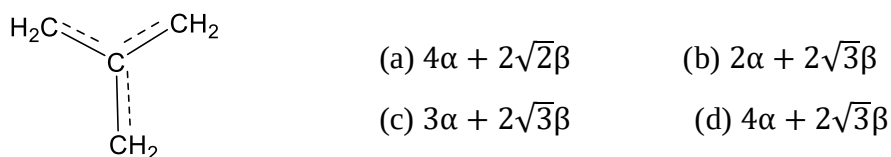
83. Amongst the given complexes, **cis-[Co(en)₂Cl₂]**, **[Cr(ox)₃]³⁻**, **[Ru(bpy)₃]²⁺**, **[Ni(phen)₃]²⁺**, **[Ru(Br)₄(phen)]⁻** and **[Ru(Cl)(py)(phen)₂]⁺**, the total number of chiral complexes is:

- (a) 3 (b) 4 (c) 5 (d) 6

84. The number of **P-O** double bonds and **P-O-P** linkages in **H₄P₂O₆**, **H₄P₂O₇**, and **H₅P₃O₁₀**, respectively, are:

- (a) (2, 1), (2, 1) and (3, 2) (b) (2, 0), (2, 1) and (3, 2)
(c) (2, 0), (2, 0) and (3, 2) (d) (2, 1), (2, 1) and (3, 0)

85. The **Huckel π -electron energy** of **trimethylenemethane**, is



86. In the **IR spectrum** of the **¹²C¹⁶O**, the **fundamental band** and **first overtone** occur at **2200 cm⁻¹** and **4260 cm⁻¹**, respectively. The values of $\tilde{\nu}_e$ and $\tilde{x}_e\tilde{\nu}_e$ for the **¹²C¹⁶O**,

respectively, are

(a) 2340 cm^{-1} and 70 cm^{-1}

(b) 2340 cm^{-1} and 140 cm^{-1}

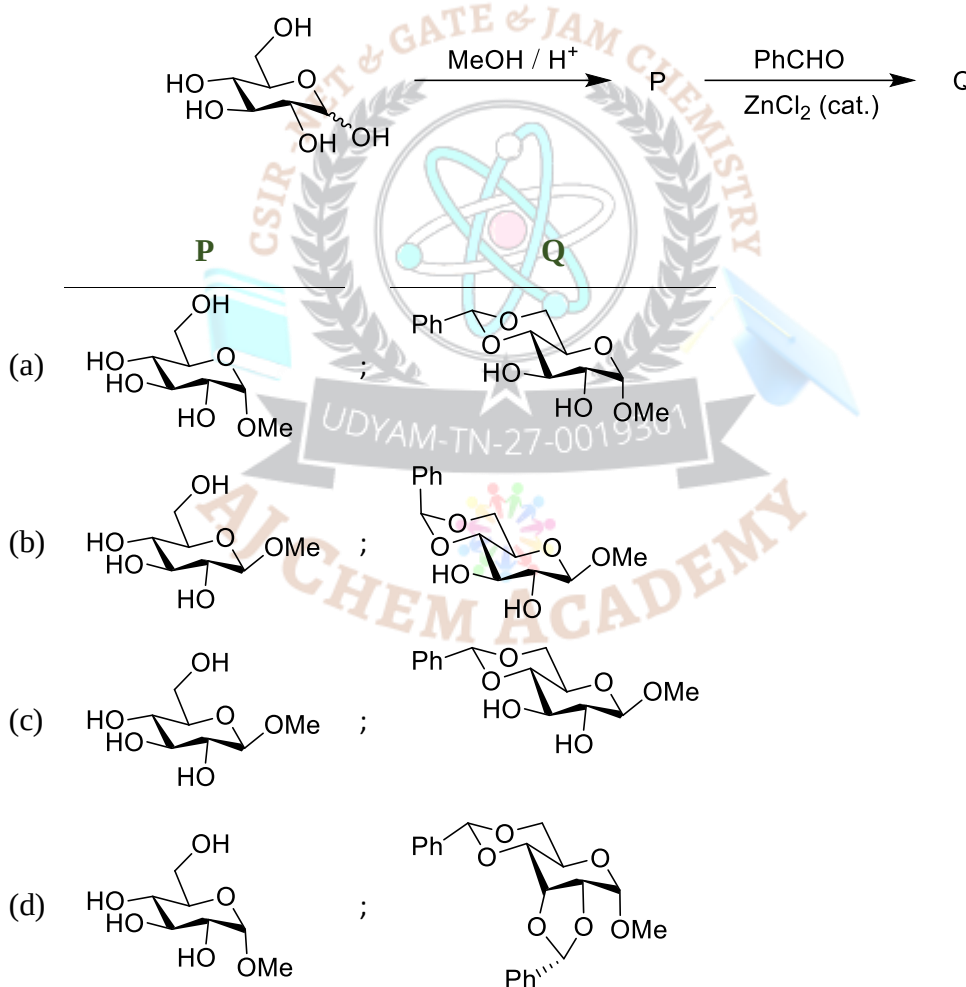
(c) 2240 cm^{-1} and 140 cm^{-1}

(d) 2230 cm^{-1} and 70 cm^{-1}

87. The structural classes of the following ions are:

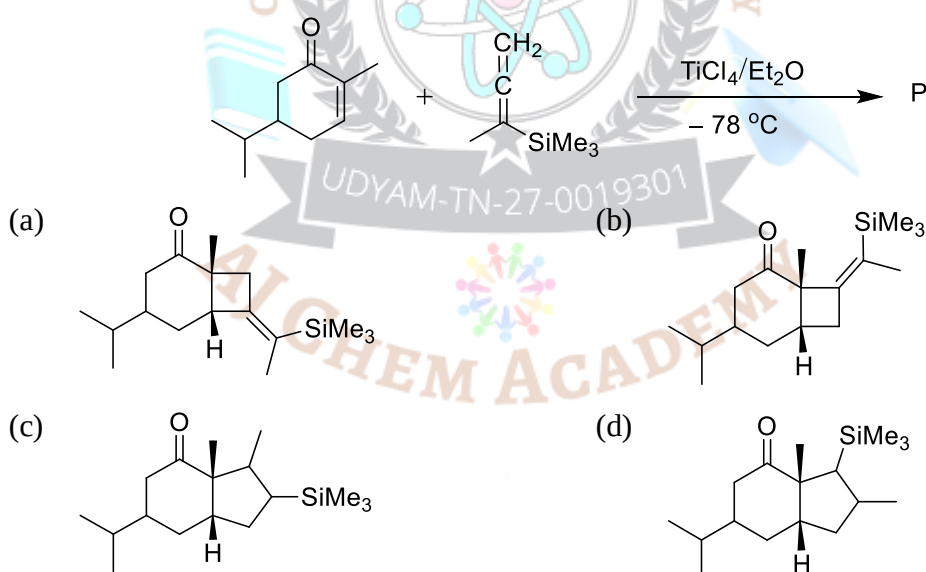
	(i)	(ii)	(iii)
(i) $[\text{Sn}_9[\text{Si}(\text{SiMe}_3)_3]_3]^-$	(a) Nido	; Nido	; Closo
(ii) Pb_5^{2-}	(b) Nido	; Closo	; Closo
(iii) Bi_5^{3+}	(c) Arachno	; Closo	; Nido
	(d) Arachno	; Nido	; Nido

88. Identify the products P and Q in the following reaction.



89. At 25°C , the conductivity of $\text{KClO}_4(\text{aq})$ system is 13.780 mS m^{-1} at concentration $c = 1.000\text{ mmol dm}^{-3}$. The Kohlrausch constant(k) is $10.000\text{ mS m}^2\text{ mol}^{-1}/(\text{mol dm}^{-3})^{1/2}$. The values of conductivity at $c = 9.000\text{ mmol dm}^{-3}$ and the limiting molar conductivity(Λ_m^0), respectively, are closest to,
[Given $(10^{-3})^{1/2} = 0.0316$]

- (a) $118.332 \text{ mS m}^{-1}$ and $14.096 \text{ mS m}^2 \text{ mol}^{-1}$
 (b) $126.864 \text{ mS m}^{-1}$ and $14.096 \text{ mS m}^2 \text{ mol}^{-1}$
 (c) $118.332 \text{ mS m}^{-1}$ and $13.148 \text{ mS m}^2 \text{ mol}^{-1}$
 (d) $126.864 \text{ mS m}^{-1}$ and $13.148 \text{ mS m}^2 \text{ mol}^{-1}$
90. For the equilibrium $A_{(s)} \rightleftharpoons A_{(g)}$, a plot of $\ln(P)$ vs $1/T$ gives a slope of **1**. The enthalpy of the sublimation (ΔH_{sub}^0), assuming ΔH_{sub}^0 to be constant for the given temperature range, is
- (a) $-R$ (b) $+R$ (c) $-RT^2$ (d) $-RT^2$
91. The system with the **highest degeneracy**, is
- (a) Particle in 3D box with $n_x^2 + n_y^2 + n_z^2 = 29$
 (b) Rigid rotor with $J = 5$
 (c) Spin free hydrogenic wave function with $n = 3$
 (d) Simple harmonic oscillator with $n = 5$
92. Identify the **major product-P** formed in the following reaction.



93. For a diatomic molecule X_2 , the data is provided in the table below. Using **variational principle**, the **energies of bonding and antibonding orbitals** of the molecule, respectively, are
- | | | |
|---------------------------|-----------------|---------------------|
| Coulomb Integral | = 25 eV | (a) 30 eV and 60 eV |
| Resonance Integral | = 5 eV | (b) 20 eV and 30 eV |
| Overlap Integral | = 0.5 eV | (c) 30 eV and 20 eV |
| | | (d) 20 eV and 40 eV |
94. The arrangements of Os atoms in the given clusters, **$\text{Os}_3(\text{CO})_{12}$** , **$\text{Os}_3(\text{CO})_{12}\text{Br}_2$** , **$\text{Os}_4$**



$(\text{CO})_{14}$, $\text{Os}_4(\text{CO})_{14}\text{I}_2$ are, respectively,

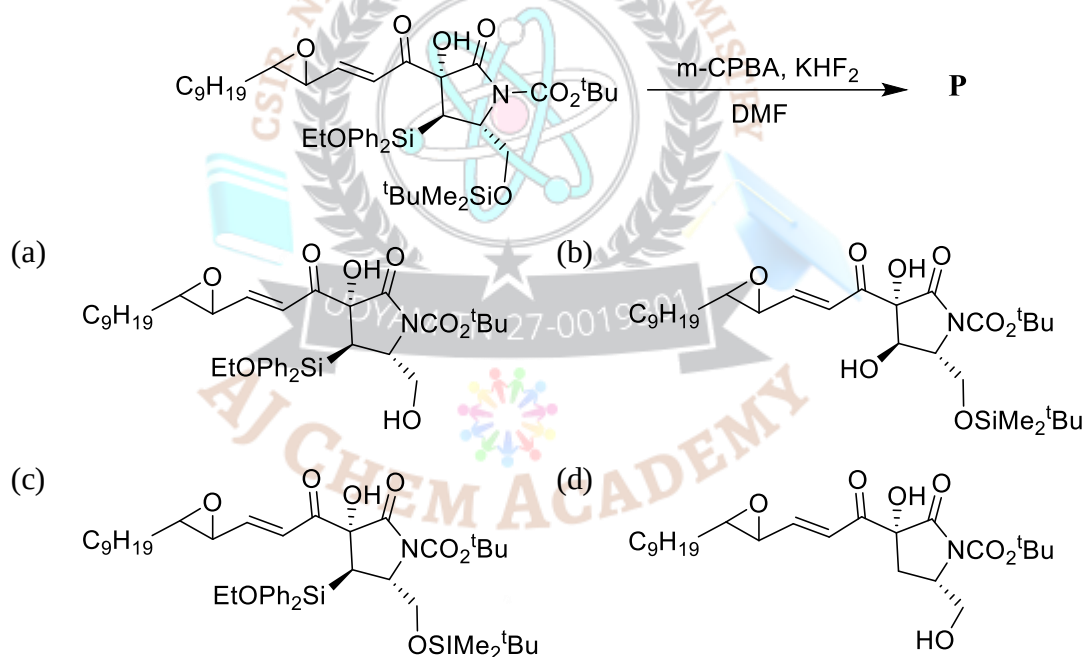
- (a) Triangular, Linear, Tetrahedral and Butterfly
 (b) Triangular, Linear, Square Planar and Tetrahedral
 (c) Linear, Triangular, Tetrahedral and Square Planar
 (d) Linear, Triangular, Square Planar and Butterfly

95. For the given complexes, the **total number of M-M bonds** in each complex, and the **number of M-M bonds per metal**, respectively, are:



- (a) (i) 6 and 3 (ii) 4 and 2
 (b) (i) 4 and 2 (ii) 3 and 2
 (c) (i) 6 and 3 (ii) 3 and 2
 (d) (i) 4 and 2 (ii) 6 and 3

96. Identify the **product, P** formed in the following reaction.



97. For the following **bimolecular gas-phase reactions**, the Arrhenius parameters, **A** and **E_a** are given below. The kinetic **isotopic ratio** (k_D/k_H) at **298 K** is closest to

[Given $e = 2.7$]

Reactions	A ($\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$)	E _a (in unit of RK)
$\text{CH}_3 + \text{OH} \rightarrow \text{CH}_3 + \text{H}_2\text{O}$	2.0×10^9	298
$\text{CD}_4 + \text{OH} \rightarrow \text{CD}_3 + \text{DOH}$	5.4×10^8	894

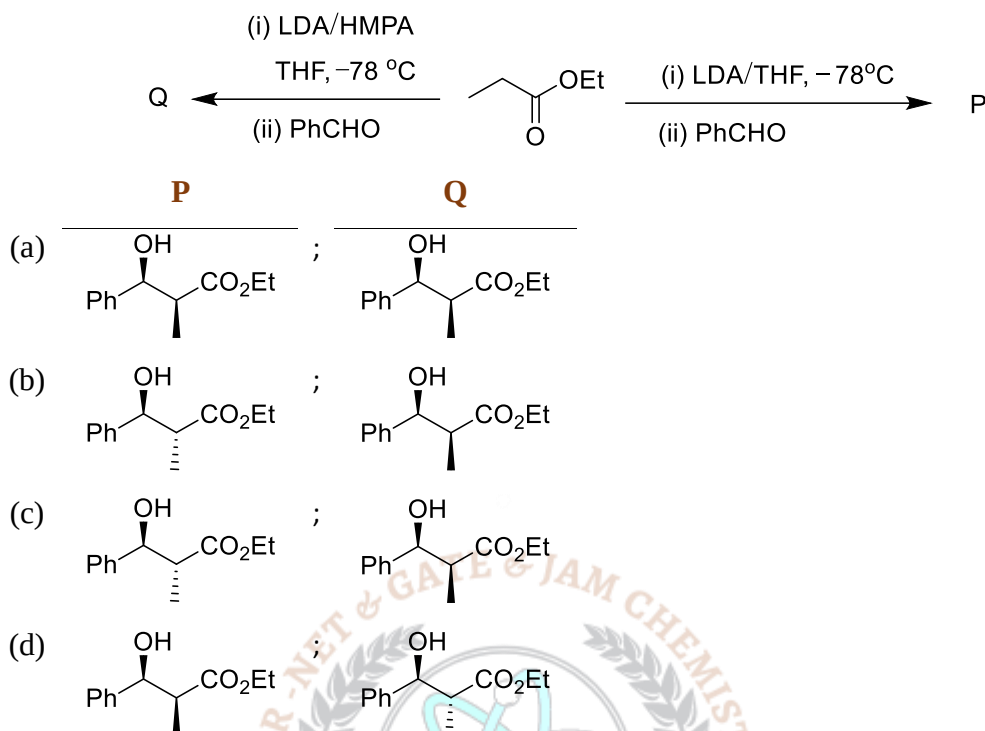
(a) 0.037

(b) 0.270

(c) 0.027

(d) 0.370

98. Identify the **products P** and **Q** in the following reaction.



99. The molecular mass of polyethylene with polydispersity index of **1.5** and the degree of polymerization of **2000**, is

- (a) 28000 (b) 42000 (c) 56000 (d) 84000

100. Consider the following statements regarding **cyclic voltammetry**:

P. It is a qualitative technique rather than quantitative

Q. $\Delta E_p = |E_a - E_c|$, is 0.059 n mV , where n is the number of electrons involved in the electrode reaction

R. The current is directly proportional to the square root of the potential scan rate

S. The redox potential is directly proportional to the concentration of the electrolyte

T. The role of the counter electrode is to complete the electrical circuit, ensuring that electrons do not need to pass across the reference-solution interface

The option having correct statements, is:

- (a) P, R and S only (b) P, R, and T only (c) P, Q, S and T only (d) R, S and T only

101. The ground state **4F** term of the **tris(oxalato)Cr(III) ion**, $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$ in the D_3 symmetry transforms into **$2A_2 + A_1 + 2E$** states with **A_2** being the ground state.

Using character table, choose the correct option for electronic transitions.

D_3	E	$2C_3$	$3C_2$	
A_1	1	1	1	$x^2 + y^2, z^2$

A₂	1	1	-1	z, R_z	
E	2	-1	0	(x, y), (R_x, R_y)	(x² - y², xy), (xz, yz)

- (a) ${}^4A_2 \rightarrow {}^4A_1$ (allowed via z-polarization) and ${}^4A_2 \rightarrow {}^4A_2$ (allowed via x,y polarization)
 (b) ${}^4A_2 \rightarrow {}^4A_1$ (allowed via z-polarization) and ${}^4A_2 \rightarrow {}^4E$ (allowed via x,y polarization)
 (c) ${}^4A_2 \rightarrow {}^4A_2$ (allowed via z-polarization) and ${}^4A_2 \rightarrow {}^4E$ (forbidden via x,y polarization)
 (d) ${}^4A_2 \rightarrow {}^4E$ (allowed via z polarization) and ${}^4A_2 \rightarrow {}^4A_2$ (allowed via x,y polarization)

102. A solution of Fe^{2+} salt upon mixing with potassium hexacyanochromate(III) results in a brick-red precipitate which turns dark green on heating at 100°C . Consider the following potential reasons for these changes:

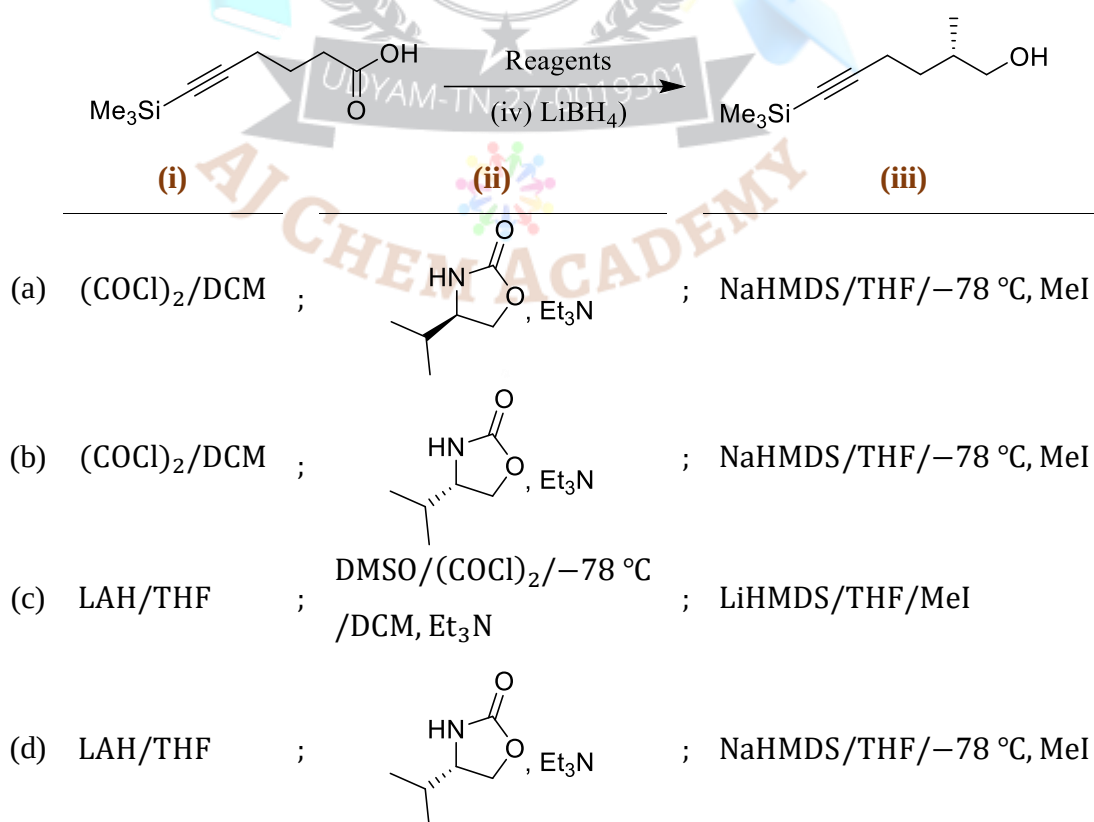
P. Linkage isomerisation

Q. The C-linkage to Fe^{2+} is favoured by LFSE

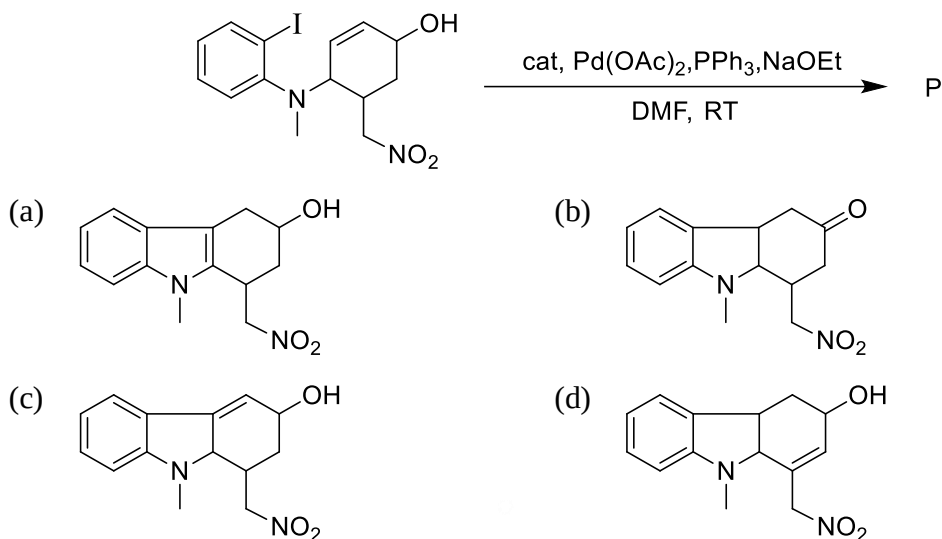
choose the correct answer:

- (a) Only P is correct
(b) Only Q is correct
(c) Both P and Q are correct
(d) Both P and Q are incorrect

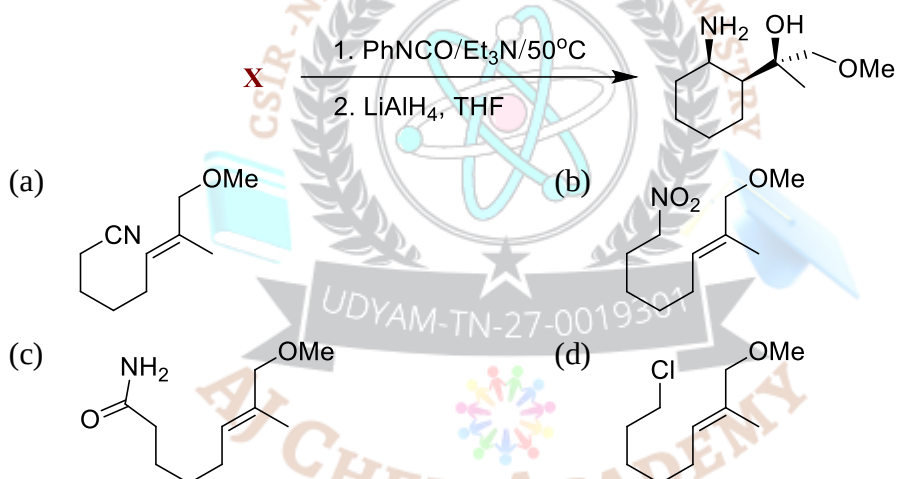
103. which of the following is the correct sequence of reagents/conditions (i-iii) in the given reaction?



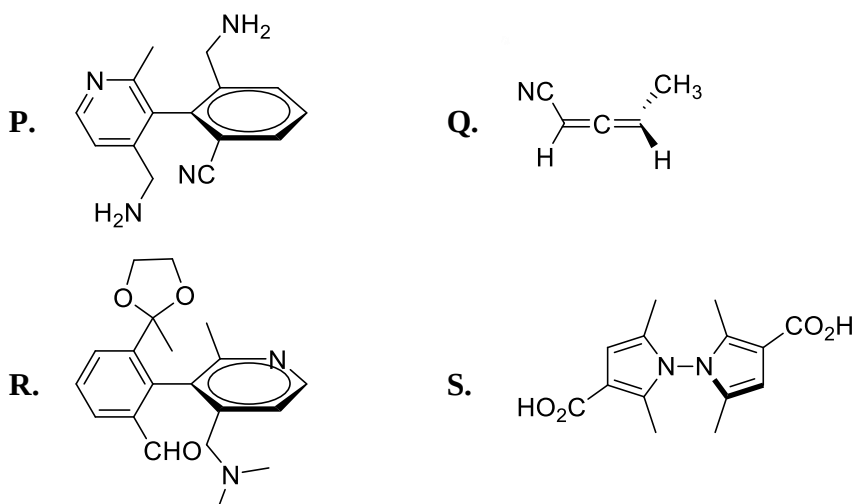
104. Identify the **product, P** formed in the following reaction.

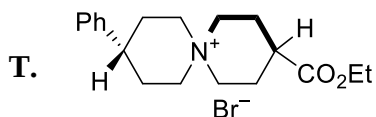


105. In the following reaction which one of the following **starting materials, X** gives the given **product**?



106. Which of the following compounds exhibit **R-configuration**?

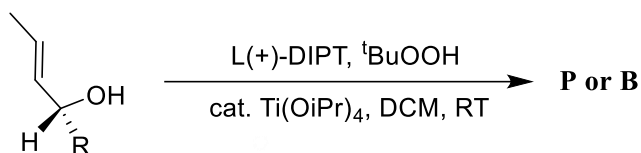




Choose the correct answer from the options given below:

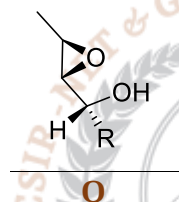
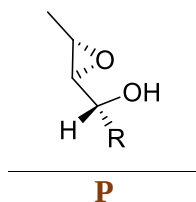
- (a) P, Q and R only (b) R, S and T only (c) Q, R and T only (d) Q and R only

107. Identify the major product formed in the following reaction and its order of reactivity in the presence of **different R groups**.



Where, I) $\text{R} = \text{C}_6\text{H}_{11}$

II) $\text{R} = \text{C}_6\text{H}_5$



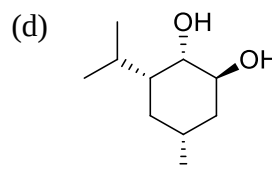
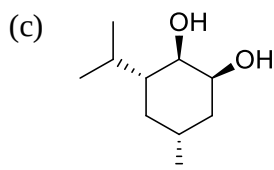
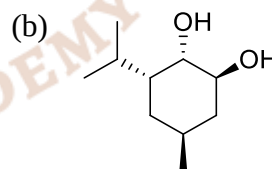
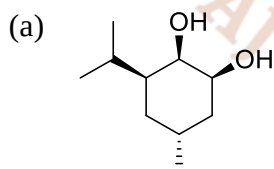
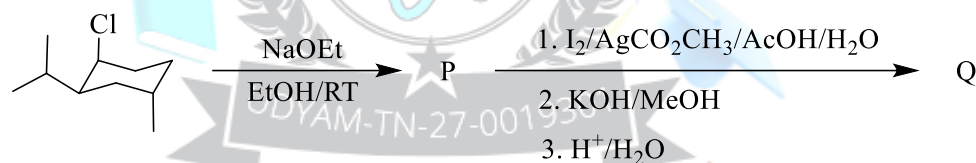
(a) P, II > I

(b) P, I > II

(c) Q, I > II

(d) Q, II > I

108. Identify the **product, Q** obtained in the following reaction.



109. $[\text{CoF}_6]^{4-}$ shows **three electronic transitions** at **7200, 15200 and 19200 cm^{-1}** . The value of the **Racah parameter, B (in cm^{-1})** for this complex, is closest to

- (a) 800 (b) 850 (c) 900 (d) 950

110. Consider the following statements about **methyl isocyanate** and **silyl isocyanate**:

P. Both are isostructural

Q. N-atom in methyl isocyanate has a lone pair

R. There is $d\pi\text{-}p\pi$ bonding in silyl isocyanate

S. Both have sp^2 hybridized N-atom

The option with correct set of statements, is:

- (a) P and S only (b) P and Q only (c) Q and R only (d) P, Q and S only

111. The variance of the momentum of a particle in a 1D-box ($0 \leq x \leq L$), is

- (a) 0 (b) $\frac{n^2\pi^2\hbar^2}{L^2}$ (c) $\frac{2n^2\pi^2\hbar^2}{L^3}$ (d) $2\frac{n^2\pi^2\hbar^2}{L^3}$

112. A normalized approximate wavefunction, ϕ for the hydrogenic atom is given as $\phi = \left(\frac{1}{\sqrt{3}}\right)\Psi_{1s} + \left(\frac{1}{\sqrt{6}}\right)\Psi_{2s} + \left(\frac{1}{\sqrt{12}}\right)\Psi_{3s} + C_{4s}\Psi_{4s}$. Assuming the $\Psi_{1s}, \Psi_{2s}, \Psi_{3s}, \Psi_{4s}$ are orthonormal, the value of C_{4s} , is

- (a) $\sqrt{\frac{7}{12}}$ (b) $\sqrt{\frac{3}{12}}$ (c) $\sqrt{\frac{5}{12}}$ (d) $\sqrt{\frac{1}{12}}$

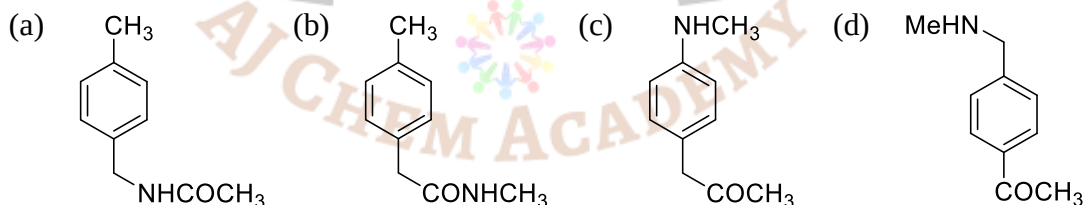
113. Predict the most probable structure of the compound having following spectral data.

Molecular formula : $C_{10}H_{13}NO$

IR stretching : 3440 (very strong) and 1710 (cm^{-1})

1H -NMR ($CDCl_3$) : 87.01 (d, 2H), 6.48 (d, 2H), 4.0 (s, 1H), 3.45 (s, 2H), 2.68 (s, 3H), and 2.1 (s, 3H).

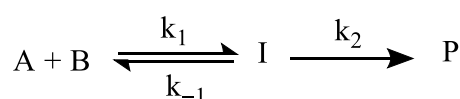
MS (m/z) : 163 (M^+), 162, 120, 43.



114. A substance undergoes phase transition from $\alpha \rightarrow \beta$ with a positive ΔS . If the phase transition temperature increases with the increase in the pressure, which of the following statements is correct?

- (a) α is denser than β (b) β is denser than α
(c) The densities of α and β are equal (d) β is denser only at higher temperature

115. For a given reaction,



Where k_1, k_{-1}, k_2 represent the rate constants; A_1, A_{-1} and A_2 pre-exponential

factors: and E_1 , E_{-1} and E_2 activation energies for the corresponding steps. As per **Lindemann mechanism**, the correct relationship between the observed pre-exponential factor (A_{obs}) and activation energy (E_{obs}) at higher concentrations, are

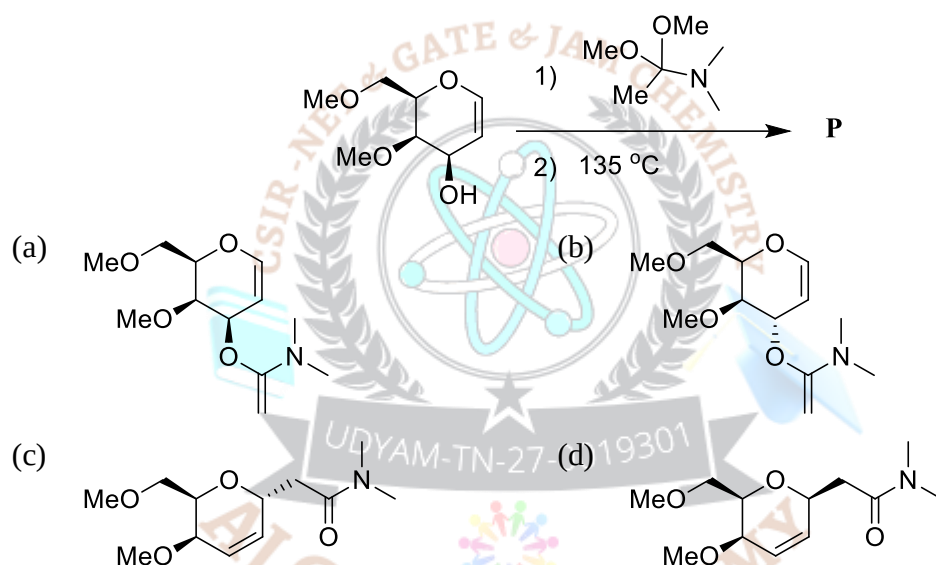
(a) $A_{\text{obs}} = \frac{A_1 A_2}{A_{-1}}$ and $E_{\text{obs}} = E_1 + E_2 - E_{-1}$

(b) $A_{\text{obs}} = \frac{A_1 A_{-1}}{A_2}$ and $E_{\text{obs}} = E_1 - E_2 - E_{-1}$

(c) $A_{\text{obs}} = \frac{A_{-1} A_2}{A_1}$ and $E_{\text{obs}} = E_1 - E_2 - E_{-1}$

(d) $A_{\text{obs}} = \frac{A_1 A_2}{A_{-1}}$ and $E_{\text{obs}} = E_1 - E_2 + E_{-1}$

116. Which of the following is the **major product, P** formed in the given reaction?



117. The correct order of **angle ONO** in the given species, is:

(a) $\text{NO}_2^+ < \text{NO}_2 < \text{NO}_3^- < \text{NO}_4^{3-}$

(b) $\text{NO}_2 < \text{NO}_2^+ < \text{NO}_3^- < \text{NO}_4^{3-}$

(c) $\text{NO}_4^{3-} < \text{NO}_3^- < \text{NO}_2 < \text{NO}_2^+$

(d) $\text{NO}_3^- < \text{NO}_4^{3-} < \text{NO}_2^+ < \text{NO}_2$

118. A brown-red crystalline Fe complex, "**X**" is used to detect the sulphides qualitatively. X reacts with sulphide to form an octahedral **Fe-complex, "Y"**. The **oxidation state of Fe and formal charge of each ligand in Y**, respectively, are:

(a) +II and +1 (b) +II and -1 (c) +III and +1 (d) +III and -1

119. The **1s orbital of A** and **2p_z orbital of B** form **AB molecule**, where B is more electronegative than A. The AB bond is **64%** covalent in nature. The wavefunction as per **valence bond theory**, is:

(a) $\Psi_{AB} = 0.8[\varphi_A(1)\varphi_B(2) + \varphi_A(2)\varphi_B(1)] + 0.6\varphi_B(1)\varphi_B(2)$

$$(b) \Psi_{AB} = 0.64[\varphi_A(1)\varphi_B(2) + \varphi_A(2)\varphi_B(1)] + 0.36\varphi_B(1)\varphi_B(2)$$

$$(c) \Psi_{AB} = 0.6[\varphi_A(1)\varphi_B(2) + \varphi_A(2)\varphi_B(1)] + 0.8\varphi_B(1)\varphi_B(2)$$

$$(d) \Psi_{AB} = 0.36[\varphi_A(1)\varphi_B(2) + \varphi_A(2)\varphi_B(1)] + 0.64\varphi_B(1)\varphi_B(2)$$

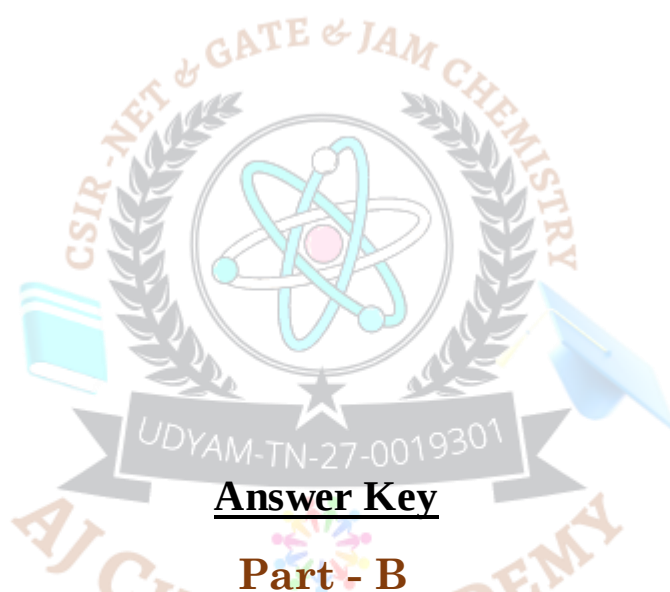
120. A first-order reflection from the {221} planes of a cubic crystal was observed when X-rays of wavelength 154 pm were used. Given the length of the side of the unit cell is 0.5 nm, the value of $\sin\theta$, is

(a) 0.462

(b) 0.195

(c) 4.62

(d) 0.3



Answer Key

Part - B

Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans
21.	d	29.	a	37.	a	45.	c	53.	a
22.	c	30.	d	38.	d	46.	c	54.	c
23.	a	31.	d	39.	b	47.	d	55.	b
24.	d	32.	b	40.	a	48.	c	56.	c
25.	a	33.	b	41.	a	49.	b	57.	b
26.	a	34.	b	42.	a	50.	d	58.	a
27.	c	35.	d	43.	a	51.	b	59.	b
28.	a	36.	c	44.	a	52.	b	60.	a



Part - C

Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans
61.	*	73.	a	85.	d	97.	a	109.	b
62.	d	74.	b	86.	a	98.	c	110.	c
63.	d	75.	b	87.	b	99.	c,d	111.	b
64.	a	76.	d	88.	a	100.	b	112.	c
65.	a	77.	b	89.	a	101.	b	113.	c
66.	c	78.	c	90.	a	102.	c	114.	a
67.	c	79.	*	91.	b	103.	b	115.	a
68.	a	80.	a	92.	*	104.	b	116.	d
69.	b	81.	b	93.	d	105.	b	117.	c
70.	c	82.	a	94.	a	106.	c	118.	b
71.	b	83.	c	95.	c	107.	a	119.	a
72.	c	84.	b	96.	b	108.	a	120.	a

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