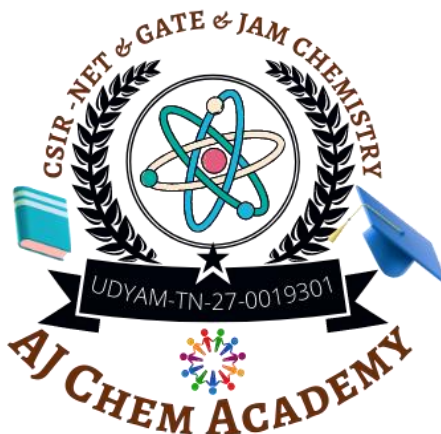


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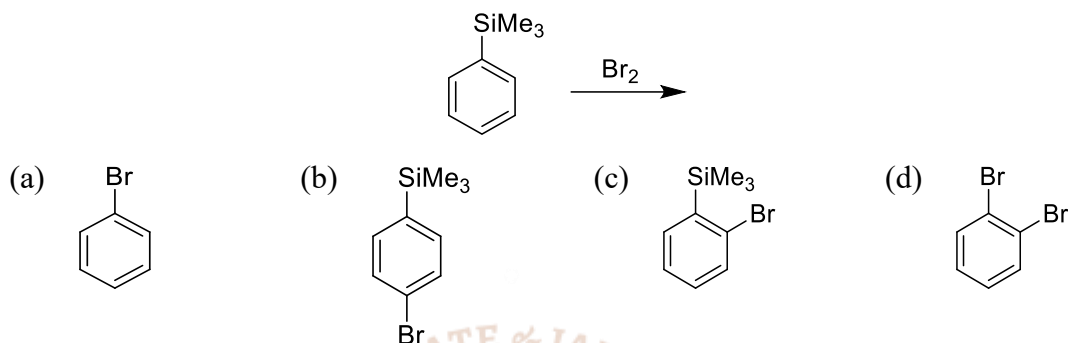
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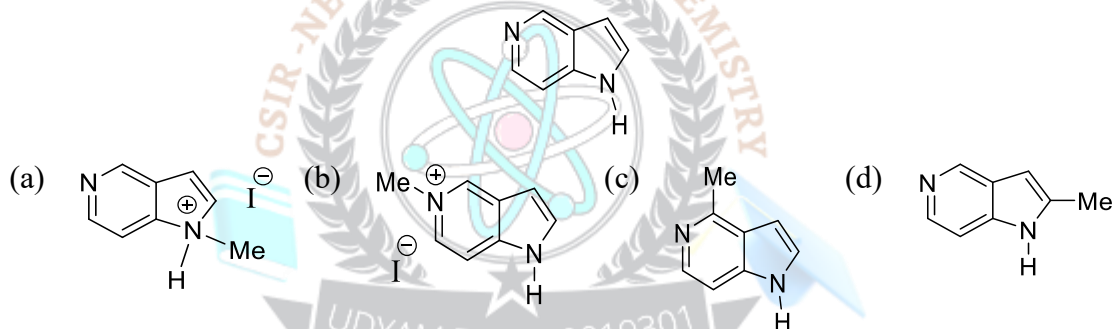


Q.21 – Q.60 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 0.5). You are required to Answer Maximum 35 Questions.

21. The major product formed in the following reaction is



22. The reaction of the given compound with MeI produces



23. For a proton, the gyromagnetic ratio is $26.752 \times 10^7 \text{ rad T}^{-1} \text{ s}^{-1}$. The Larmor frequency for a proton (in MHz) in a 21.1 T magnetic field is, approximately,

- (a) 400 (b) 500 (c) 600 (d) 900

24. $[\text{Fe}(\text{CO})_5]$ on reaction with $\text{C}_3\text{H}_5\text{I}$ gives Y with the elimination of two molecules of CO. Consider the following statements

[P] Y obeys the 18-electron rule

[Q] The reaction is an example of oxidative addition

[R] Allyl moiety shows η^1 coordination in Y

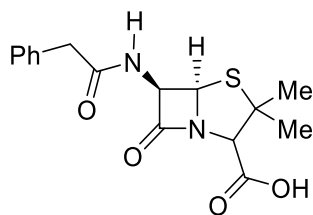
[S] Y adopts pentagonal bipyramidal geometry

The correct option is

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

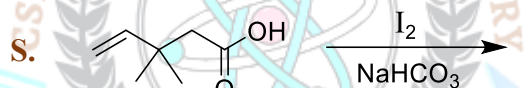
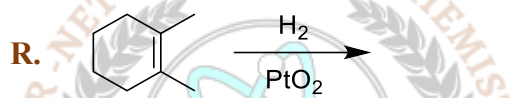
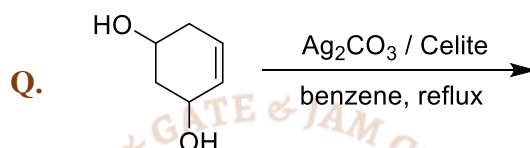
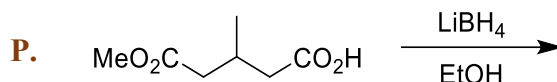
25. The most effective pharmacophore that confers antibiotic activity to penicillin G is





- (a) Phenylacetamide (b) Thiazolidine ring (c) Carboxylic acid (d) β -lactum

26. Among the following, the **examples of chemoselective reactions** are



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

27. The following **molecular orbital** corresponds to



- (a) HOMO of pentadienyl cation (b) HOMO of pentadienyl anion
(c) LUMO of pentadienyl cation (d) LUMO of pentadienyl anion

28. For **face centered cubic (FCC)** packing of a monoatomic solid, the **number of tetrahedral and octahedral holes within the unit cell**, respectively, are

- (a) 8 and 4 (b) 4 and 2 (c) 16 and 16 (d) 6 and 6

29. **2-methylbut-2-ene** is used in **Pinnick oxidation**, $[R-CHO \rightarrow R-CO_2H]$ using **$NaClO_2$, Na_2HPO_4 in $t-BuOH/H_2O$** to scavenge

- (a) HCl (b) H_3PO_4 (c) $HClO_2$ (d) HOCl

30. e^{ikx} is an eigen function of the linear momentum operator, \hat{p}_x , with the eigen value of

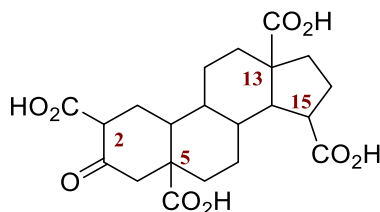
- (a) $\hbar^2 k$ (b) $\hbar k$ (c) $\hbar k^2$ (d) $\hbar^2 k^2$

31. If $H = \frac{p_x^2}{2m} + V(x)$, then $[H, p_x]$ is

- (a) $i\hbar \frac{dV}{dx}$ (b) 0 (c) $-i\hbar$ (d) $-\frac{i\hbar p_x}{m}$

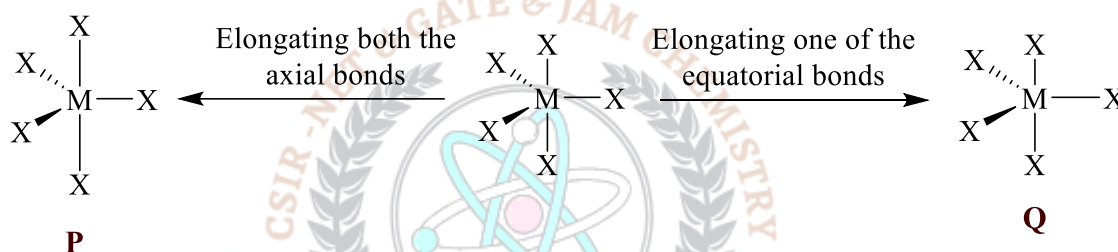


32. The given steroid molecule undergoes facile monodecarboxylation on heating. The carboxylic acid group lost is at



- (a) C15 (b) C13 (c) C5 (d) C2
33. The molecule MX_5 belongs to the point group D_{3h} . Elongation of both the axial M-X bonds yields P and elongation of one of the M-X equatorial bonds yields Q.

The point groups of P and Q, respectively are



- (a) C_{3v} and D_{3h} (b) C_{3h} and C_{3v} (c) C_{3v} and C_{2v} (d) C_{3h} and C_{2v}
34. The option showing the correct match of metal complexes in Column-I with the corresponding Δ_o (cm^{-1}) values in Column-II is

	Column-I	Column-II	P	Q	R	S
P.	$[\text{TiF}_6]^{3-}$	I. 21800	(a) II	; I	; IV	; III
Q.	$[\text{MnF}_6]^{2-}$	II. 17000	(b) III	; IV	; I	; II
R.	$[\text{Co}(\text{en})_3]^{3+}$	III. 9400	(c) II	; I	; III	; IV
S.	$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$	IV. 24000	(d) I	; IV	; III	; II

35. The number of skeletal electron pairs (SEP) and the cluster type for $[\text{B}_{10}\text{H}_{10}]^{2-}$ and $[\text{B}_6\text{H}_9]^-$ respectively are
- (a) 11, closo and 8, nido (b) 11, nido and 8, nido
 (c) 10, closo and 6, arachno (d) 10, closo and 8, nido
36. Molecule Q is twice as heavy as molecule P. The ratio of the thermal deBroglie wavelength of the molecule P to that of the molecule Q is
- (a) $\sqrt{2} : 1$ (b) $2 : 1$ (c) $1 : 2$ (d) $1 : \sqrt{2}$
37. The correct option for the oxidation state(s) of Nb in the cluster $\text{Na}_4[\text{Nb}_6\text{Cl}_{18}]$ is
- (a) two are in +3 state and four are in +2 state (b) all are in +2 state



- (c) three are in +2 state and three are in +3 state (d) all are in +3 state

38. In a flame photometric analysis of a blood serum sample for K^+ ion, a band is obtained at 766 nm. This band is due to

- (a) absorption by K^+ ion only (b) absorption by K atom only
(c) emission by K^+ ion only (d) emission by K atom only

39. The following statements are given with respect to the copper-containing nitrite reductase.

[P] It contains both Type-II and Type-III copper proteins

[Q] Type-I copper protein is involved in the electron transfer process

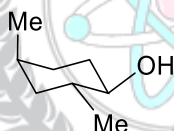
[R] Nitrite ion is reduced to NO

[S] Nitrite ion is reduced to NH_3

The option with correct statements is:

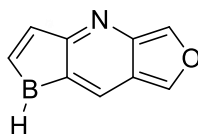
- (a) P and Q only (b) Q and R only (c) P and R only (d) P and S only

40. The structure that corresponds to the following compounds is



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

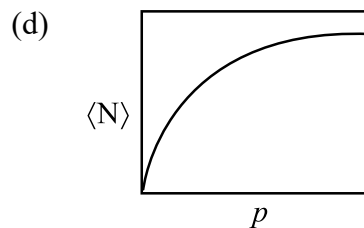
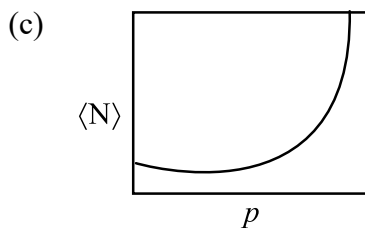
41. Based on Huckel rule, the following species is



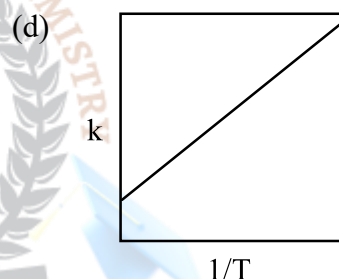
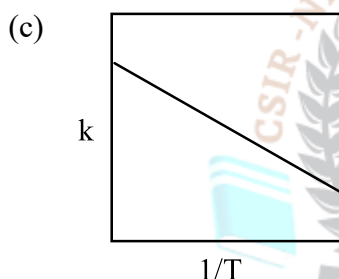
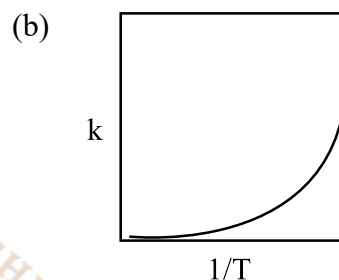
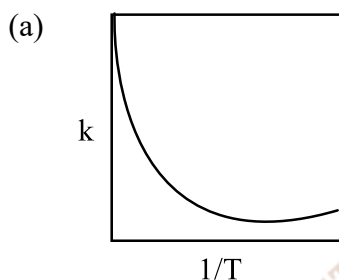
- (a) aromatic (b) antiaromatic (c) nonaromatic (d) homoaromatic

42. For step-wise polymerization, the correct plot of chain length ($\langle N \rangle$) against degree of polymerization (p) is





43. According to Arrhenius equation, the plot that correctly describes the temperature (T) dependence of the rate constant (k) is



44. The reaction of V_2O_5 with an ethanolic HCl produces a species X, which gives an EPR spectrum with an eight-line ^{51}V hyperfine coupling ($^{51}V: I = 7/2$) and a strong infra-red absorption in the region of $950 - 1035 \text{ cm}^{-1}$. X contains a _____ unit
- (a) $[V-(O)_2 - V]^{6+}$ (b) $[VO]^{2+}$ (c) $[V(O)(O_2)]^+$ (d) $[(O)V-O-V(O)]^{4+}$
45. The calculated magnetic moment of Eu^{3+} ($4f^6$) is 0 (zero) BM. The experimental value is 3.4 - 3.6 BM at 298 K. The deviation is due to the
- (a) mixing of 4f and 4d orbital (b) large spin-orbit coupling constant (λ)
 (c) large orbital angular momentum (d) populated ground and the excited states
46. The option showing the correct match for the reactants in Column-I with the second-order rate constants ($\text{l mol}^{-1}\text{s}^{-1}$) in Column-II for the outer sphere reactions in water at 25°C is

	Column-I		Column-II
P.	$[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Fe}(\text{CN})_6]^{3-}$	I.	10^5
Q.	$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$	II.	3
R.	$[\text{Co}(\text{NH}_3)_6]^{2+}$ and $[\text{Co}(\text{NH}_3)_6]^{3+}$	III.	10^{-6}



S. | $[\text{Co}(\text{en})_3]^{2+}$ and $[\text{Co}(\text{en})_3]^{3+}$ IV. | 10^{-4}

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

47. Consider the following statements,

I. Micelles form above the critical micelle concentration

II. Micelles form above the Krafft temperature

The correct option is

(a) Only I is true (b) Only II is true (c) Both I and II are true (d) Both I and II are false

48. Magnetic moment of Yb^{3+} (f^{13}) is

(a) 4.54 BM (b) 1.73 BM (c) 2.83 BM (d) 3.87 BM

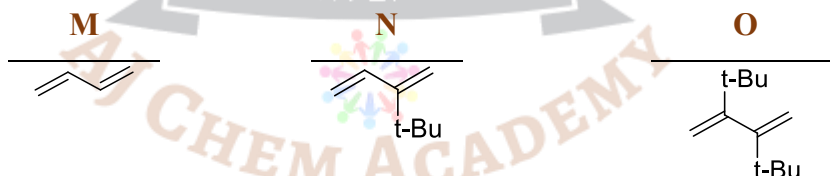
49. The number of unpaired electrons in B_2 is

(a) 0 (b) 1 (c) 2 (d) 3

50. The total number of six membered rings in the polycyclic compounds $\text{P}_4(\text{NMe})_6$ and $\text{P}_2(\text{N}_2\text{Me}_2)_3$ is

(a) 7 (b) 6 (c) 5 (d) 4

51. The correct order of reactivity for the following dienes with maleic anhydride is



(a) $M > N > O$ (b) $N > M > O$ (c) $N > O > M$ (d) $O > N > M$

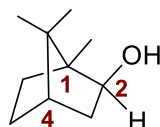
52. According to VSEPR theory, the geometries of FCIO and F_5IO respectively, are

(a) linear and octahedral (b) tetrahedral and octahedral
(c) tetrahedral and capped octahedral (d) trigonal bipyramidal and capped octahedral

53. For 0.001 M aqueous solutions of AlCl_3 , CaCl_2 and KCl at 25 °C, the correct order of Debye length is

(a) $\text{AlCl}_3 < \text{CaCl}_2 < \text{KCl}$ (b) $\text{KCl} < \text{CaCl}_2 < \text{AlCl}_3$
(c) $\text{CaCl}_2 < \text{KCl} < \text{AlCl}_3$ (d) $\text{AlCl}_3 < \text{KCl} < \text{CaCl}_2$

54. The correct absolute configuration for the structure shown below is



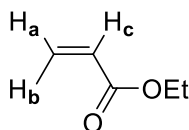
- (a) 1S, 2S, 4S (b) 1S, 2R, 4R (c) 1R, 2R, 4S (d) 1S, 2S, 4R
55. The thermodynamic variable 'X' in the equation, $\left(\frac{\partial S}{\partial P}\right)_T = \frac{1}{T} \left[X + \left(\frac{\partial H}{\partial P}\right)_T \right]$ is
 (a) V (b) S (c) -V (d) C_p
56. The difference in the second ionization energies of Li/Na, Be/Mg, B/Al and N/P are X₁, X₂, X₃ and X₄, respectively. The correct order of the difference in the second ionization energies is
 (a) X₁ > X₄ > X₃ > X₂ (b) X₁ > X₂ > X₃ > X₄
 (c) X₄ > X₃ > X₁ > X₂ (d) X₁ > X₃ > X₄ > X₂
57. The following two molecules are



- (a) Enantiomers (b) Diastereomers (c) Homomers (d) Constitutional isomers
58. The following reaction is the fastest when



- (a) X = m-NO₂ (b) X = p-OMe (c) X = p-NO₂ (d) X = m-OMe
59. Of the following atomic transitions, the allowed one is
 (a) ¹S → ⁵S (b) ³P → ¹D (c) ¹S → ¹D (d) ³D → ³P
60. The correct match for the protons of ethyl acrylate given in Column-P with chemical shifts (δ ppm) given in Column-Q is



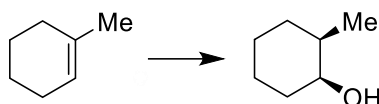
	Column-P	Column-Q	P	Q	R
P	H _a	I	6.11 (dd, J = 16, 10 Hz)	(a) I ; II ; III	
Q	H _b	II	6.4 (dd, J = 16, 4 Hz)	(b) III ; II ; I	
R	H _c	III	5.8 (dd, J = 10, 4 Hz)	(c) III ; I ; II	
				(d) II ; III ; I	



Q.61 – Q.120 Multiple Choice Question (MCQ), carry FOUR marks each (for each wrong answer: – 1). You are required to Answer Maximum 25 Questions.

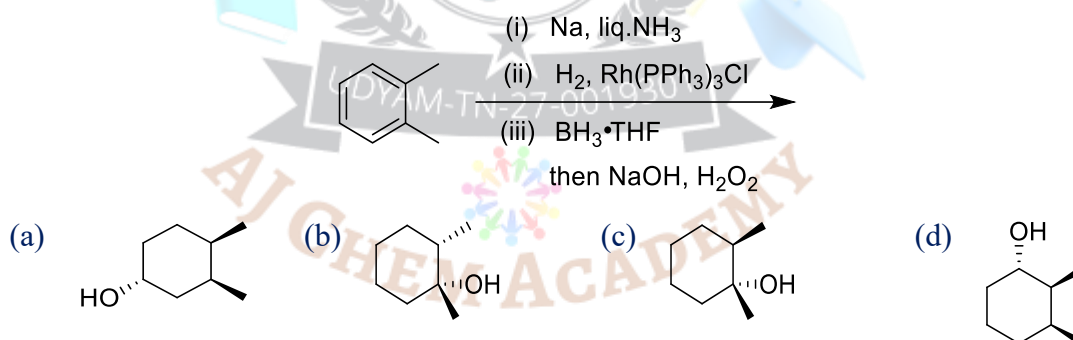
61. If E° for $\text{OCl}^-_{(\text{aq})} | \text{Cl}^-_{(\text{aq})}$ and $\text{Cl}^-_{(\text{aq})} | \frac{1}{2}\text{Cl}_{2(\text{g})}$ half-cells, respectively, are **0.94 V** and **–1.36 V**, then E° (in V) for the $\text{OCl}^-_{(\text{aq})} | \frac{1}{2}\text{Cl}_{2(\text{g})}$ half cell is
- (a) –0.42 (b) –2.20 (c) 0.52 (d) 1.04

62. The correct set of reagents that can affect the following conversion is



- (a) (i) m-CPBA; (b) (i) OsO₄, NMO;
 (ii) NaBH₃CN, BF₃·OEt₂ (ii) TsCl, pyridine;
 (iii) LiAlH₄
 (c) (i) m-CPBA; (d) (i) OsO₄, NMO;
 (ii) LiAlH₄ (ii) PhCO₂H, PPh₃, DEAD

63. The major product formed in the following reaction sequence is



64. For a diatomic molecule, which is an anharmonic oscillator, $\bar{\nu}_e$ (vibrational wave number) = **536.2 cm⁻¹**. The observed value of fundamental frequency ($\bar{\nu}_{\text{obs}}$) is **529.4 cm⁻¹**. The magnitude of $\bar{\nu}_{\text{obs}}$ (in cm⁻¹) for 3rd overtone is closest to _____
- (a) 2076.8 (b) 1588.2 (c) 1567.8 (d) 2117.2

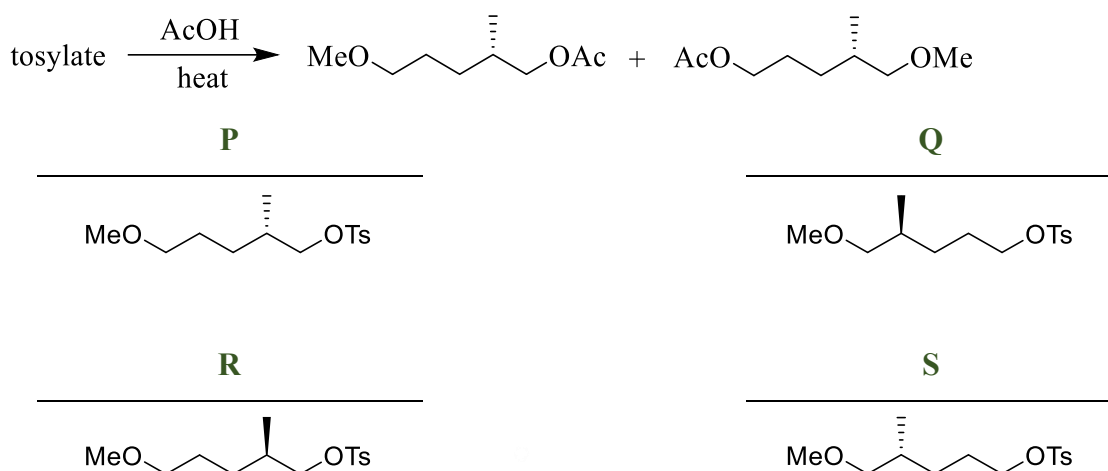
65. The option showing both the complexes obeying the **18e⁻** rule is

- (a) $[(\eta^5\text{-C}_5\text{H}_5)\text{RuCl}(\text{PPh}_3)_2]$ and $[(\eta^5\text{-C}_5\text{H}_5)_2\text{ZrCl}_2]$
 (b) $[\text{IrCl}(\text{CO})(\text{PPh}_3)_2]$ and $[\text{Co}_2(\text{CO})_8]$
 (c) $[\text{Re}(\text{CO})_5(\text{PF}_3)]^+$ and $[\text{Ni}(\text{NH}_3)_6]^{2+}$
 (d) $[(\eta^5\text{-C}_5\text{H}_5)(\eta^3\text{-C}_5\text{H}_5)\text{Fe}(\text{CO})]$ and $[(\eta^3\text{-allyl})\text{Mn}(\text{CO})_4]$

66. The tosylates that on solvolysis will give the mixture of products as shown in the



reaction are



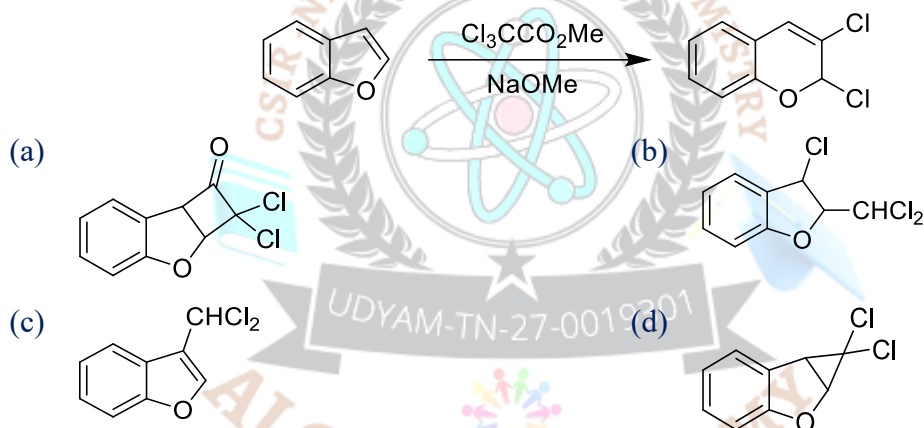
(a) P and R

(b) Q and S

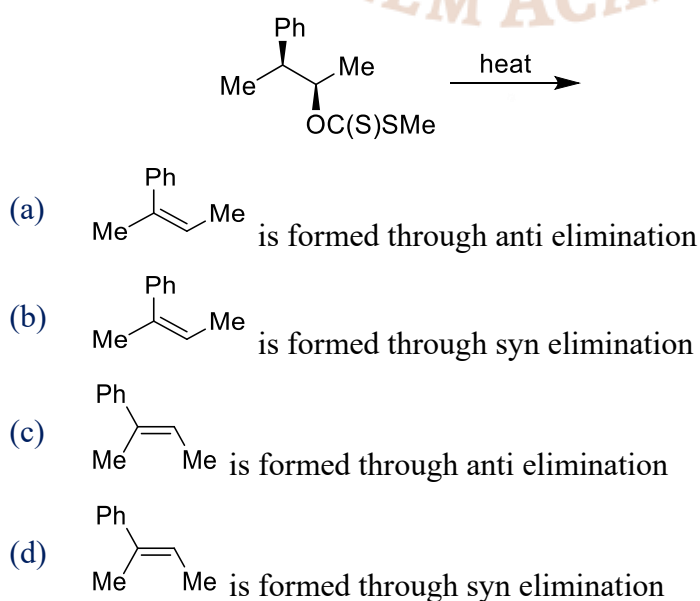
(c) P and Q

(d) R and S

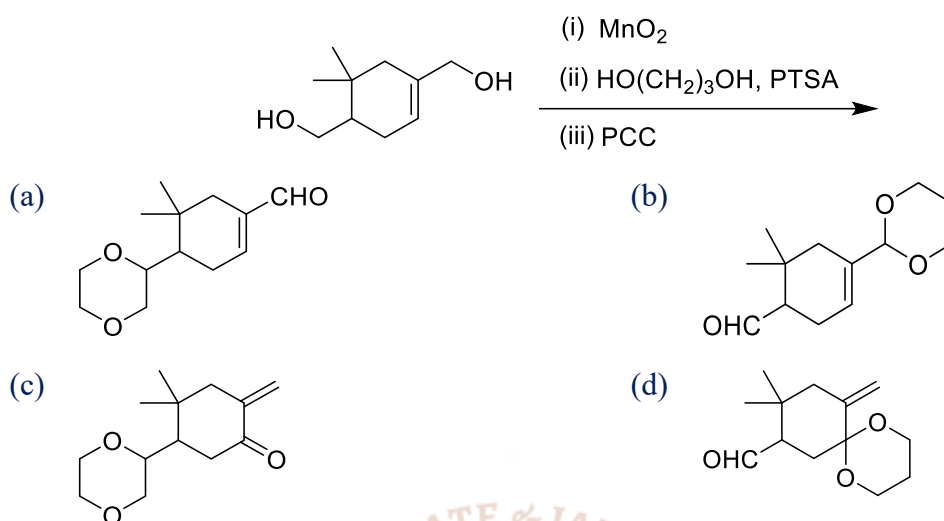
67. The intermediate formed in the following reaction is



68. The correct statement about the following reaction is



69. The major product formed in the following reaction sequence is



70. The mechanism of the following reaction involves



P. $4e^-$ conrotatory electrocyclic reaction

Q. $[2 + 2]$ cycloreversion

R. $6e^-$ disrotatory electrocyclic reaction

S. $[4 + 2]$ cycloaddition

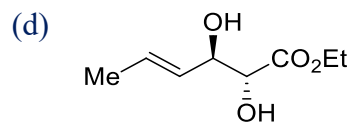
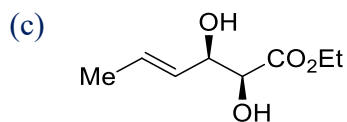
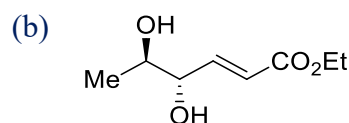
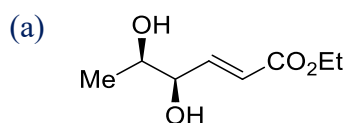
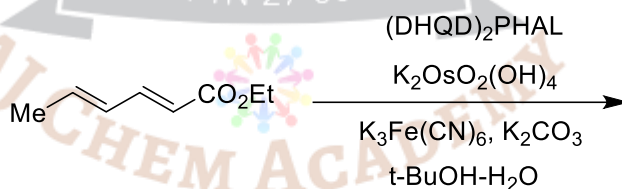
(a) P and Q

(b) P and R

(c) Q and S

(d) R and S

71. The major product formed in the following reaction is



72. Two reactions have same pre-exponential factor, but E_a (activation energy) of the first reaction is lower than that of the second reaction by $5 \text{ kcal mol}^{-1} \text{ K}^{-1}$. Given $R = 1.987 \times 10^{-3} \text{ kcal mol}^{-1} \text{ K}^{-1}$. The ratio of the rate constants of the rate constants of the first and second order reactions at 298 K is closest to

(a) 4650

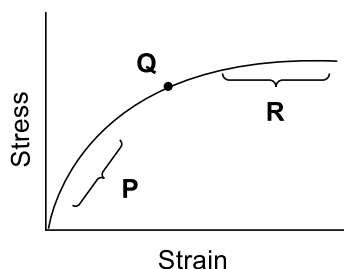
(b) 22025

(c) 5

(d) 150

73. Identify P, Q and R in the following stress-strain plot of a polymer



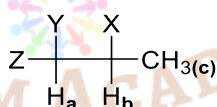


- | P | Q | R |
|--------------------|-----------------|------------------|
| _____ | _____ | _____ |
| (a) yield region | ; elastic point | ; plastic region |
| (b) plastic region | ; yield point | ; elastic region |
| (c) elastic region | ; yield point | ; plastic region |
| (d) elastic region | ; plastic point | ; yield region |

74. Reaction of an aqueous solution of **X** with **NaOH** forms a white gelatinous precipitate. Dissolution of this precipitate in excess **NaOH** gives **Y**. Bubbling **H₂S** gas into **Y** results in the formation of a white precipitate **Z**. Reaction of **Z** with **dil.H₂SO₄** gives **X**. The **X**, **Y** and **Z** respectively are

- | X | Y | Z | X | Y | Z |
|-----------------------|-----------------------|-------|-----------------------|-----------------------|-------|
| _____ | _____ | _____ | _____ | _____ | _____ |
| (a) PbSO ₄ | ; Pb(OH) ₂ | ; PbS | (b) ZnSO ₄ | ; Zn(OH) ₂ | ; ZnS |
| (c) MnSO ₄ | ; Mn(OH) ₂ | ; MnS | (d) CoSO ₄ | ; Co(OH) ₂ | ; CoS |

75. Consider the following compound where ³J_{ab} and ³J_{bc} represent three bond coupling between **H_a** & **H_b** and **H_b** & **H_c** protons, respectively.

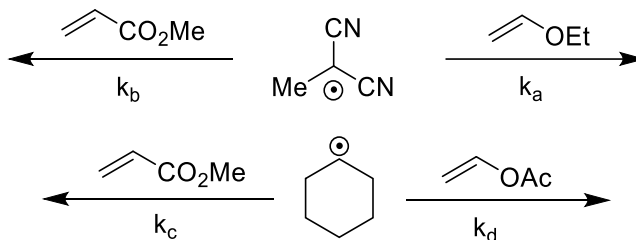


In two different scenarios, (i) ³J_{ab} < ³J_{bc} and (ii) ³J_{ab} = ³J_{bc}

The multiplicity of **H_b** proton, respectively, will be

- | (i) | (ii) | (i) | (ii) |
|-------------------------|-----------------------|-------------------------|-----------|
| _____ | _____ | _____ | _____ |
| (a) quintet | ; quartet of doublets | (b) quartet of doublets | ; quintet |
| (c) triplet of triplets | ; quartet of doublets | (d) triplet of triplets | ; quintet |

76. The correct order of relative rates of the following reactions is



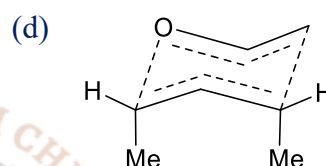
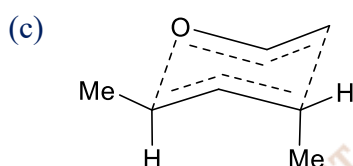
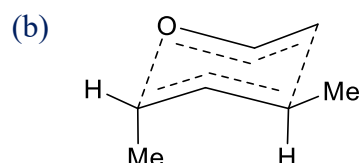
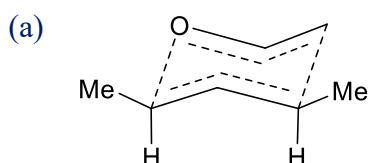
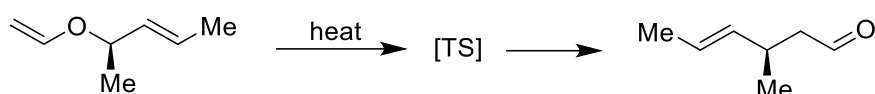
(a) $k_b \gg k_a$; $k_c \gg k_d$

(b) $k_b \gg k_a$; $k_d \gg k_c$

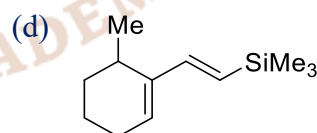
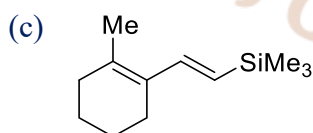
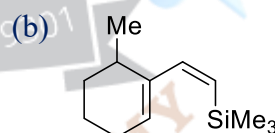
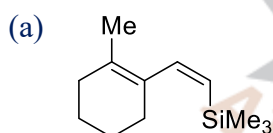
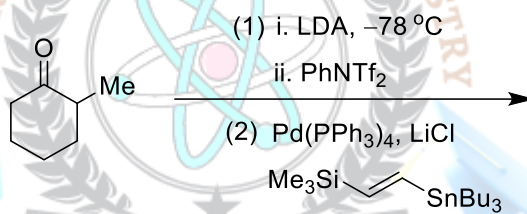


(c) $k_a \gg k_b ; k_d \gg k_c$ (d) $k_a \gg k_b ; k_c \gg k_d$

77. The transition state (TS) structure that would lead to the product in the following reaction is



78. The major product formed in the following reaction sequence is



79. Consider a matrix representation A of the water molecule in the basis $\{\bar{V}_1, \bar{V}_2\}$ where, \bar{V}_1 and \bar{V}_2 , are the bond vectors along the two O-H bonds. Consider another matrix representation B of the same molecule in a new basis set $\{\bar{U}_1, \bar{U}_2\}$, such that $\bar{U}_1 = \frac{1}{\sqrt{2}}(\bar{V}_1 + \bar{V}_2)$, $\bar{U}_2 = \frac{1}{\sqrt{2}}(\bar{V}_1 - \bar{V}_2)$. The character table for C_{2v} point group is given below:

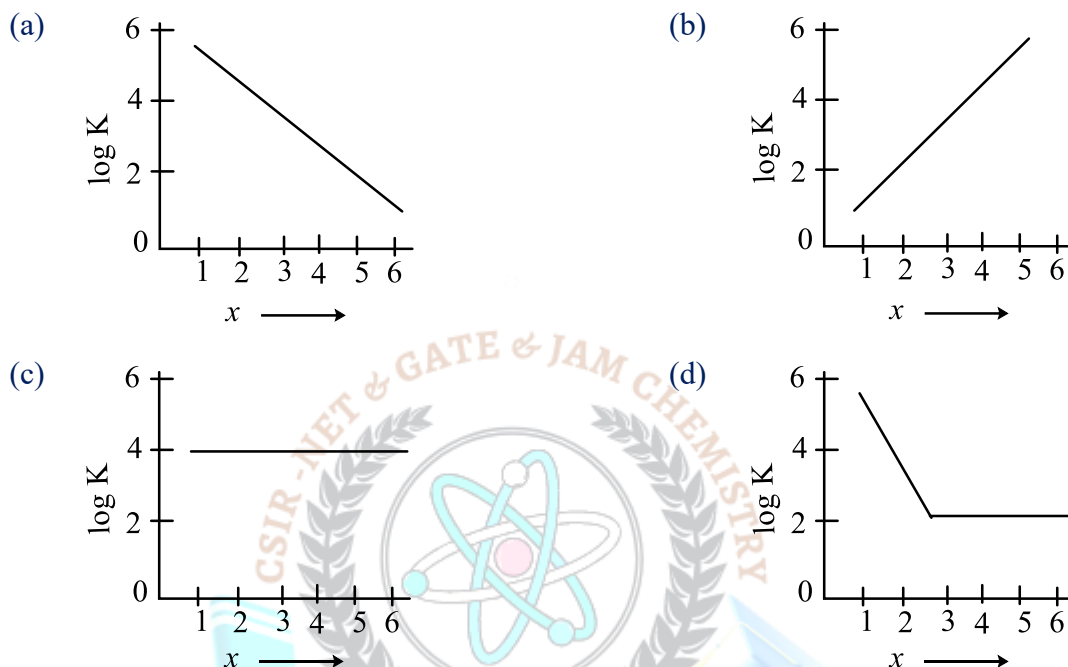
	E	C_2	$\sigma_{v(x,z)}$	$\sigma_{v(y,z)}$
A_1	1	1	1	1
A_2	1	1	-1	-1
B_1	1	-1	1	-1
B_2	1	-1	-1	1



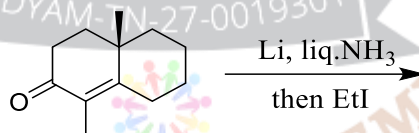
The irreducible representations that contribute to **B** are

- (a) A_1 and B_1 (b) A_1 and B_2 (c) A_2 and B_1 (d) A_1 and A_2

80. The correct plot of $\log K$ vs x ($K =$ stepwise stability constant) for the complex $[Al(OH_2)_{6-x}F_x]^{(3-x)+}$ ($x = 1 - 6$) is



81. The major product formed in the following reaction is

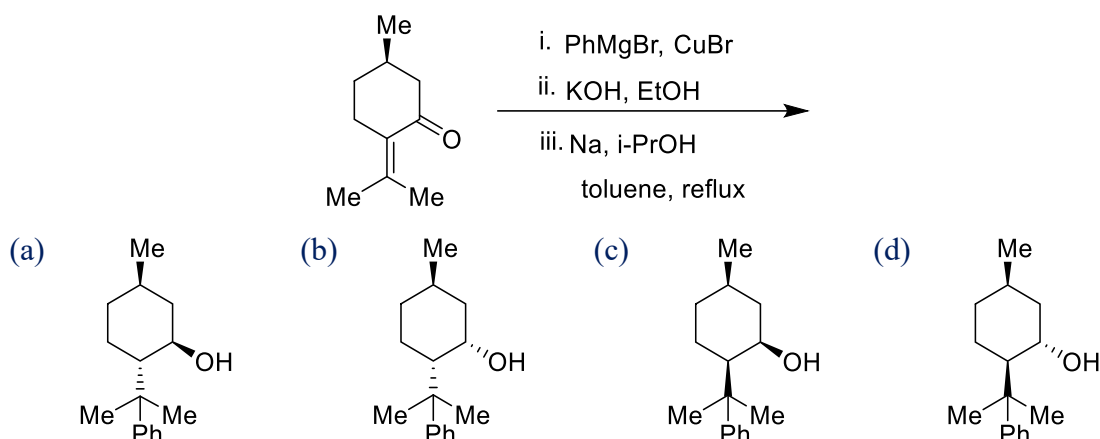


82. σ_g and σ_u are respectively the bonding and anti-bonding molecular orbitals formed by linear combination of two $1s$ atomic orbitals of H -atom. The spatial part of a purely covalent wavefunction for H_2 molecule obtained according to molecular orbital theory is

- (a) $\sigma_g(1)\sigma_g(2) + \sigma_g(1)\sigma_u(2)$ (b) $\sigma_g(1)\sigma_g(2) - \sigma_g(1)\sigma_u(2)$
 (c) $\sigma_g(1)\sigma_g(2) + \sigma_u(1)\sigma_u(2)$ (d) $\sigma_g(1)\sigma_g(2) - \sigma_u(1)\sigma_u(2)$



83. The major product formed in the following reaction sequence is



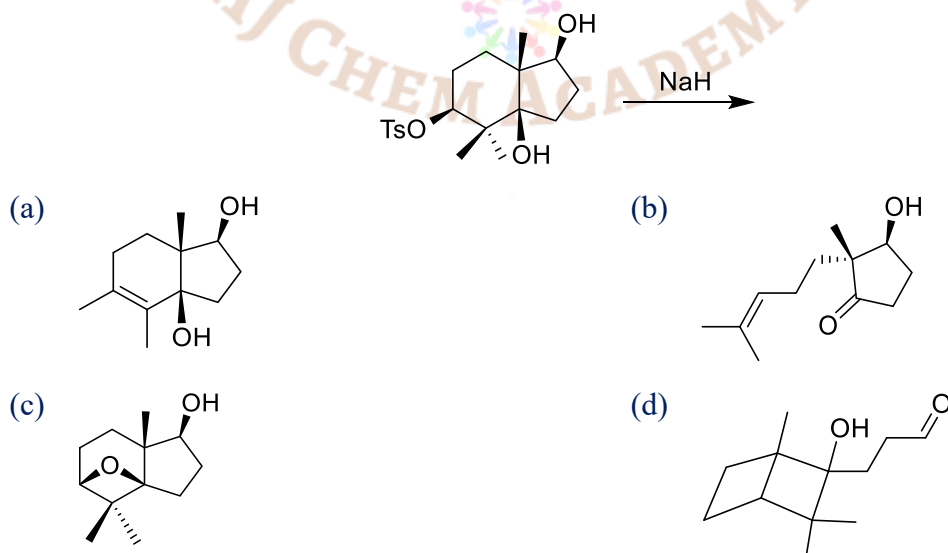
84. The $^{19}\text{F-NMR}$ spectrum of $[\text{XeF}_5]^-$ ion shows [^{129}Xe , $I = \frac{1}{2}$, 26.5% abundance]

- (a) a doublet with satellite peaks
 (b) a triplet and a quartet with satellite peaks for both
 (c) a doublet and a quintet with satellite peaks for both
 (d) a singlet with satellite peaks

85. The percentage error in the measurements of mass and linear velocity of a particle, respectively, are 3% and 4%. The maximum percentage error in the kinetic energy of the particle is

- (a) 5% (b) 7% (c) 11% (d) 24%

86. The major product formed in the following reaction is



87. The character table for a particular point group is given below. The characters in the irreducible representations Γ_4 and Γ_5 , respectively are

	E	$2\hat{R}_1$	\hat{R}_2	$2\hat{R}_3$	$2\hat{R}_4$
Γ_1	1	1	1	1	1

$$\begin{array}{c|ccccc}
 \Gamma_2 & 1 & 1 & 1 & -1 & -1 \\
 \Gamma_3 & 1 & -1 & 1 & -1 & 1 \\
 \Gamma_4 & - & - & - & - & - \\
 \Gamma_5 & - & - & - & - & -
 \end{array}$$

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

88. The rate of a surface catalysed reaction between $\text{CO}_{(g)}$ and $\text{O}_{2(g)}$ follows Langmuir-Hinshelwood mechanism. If O_2 gets dissociated during adsorption, the rate of the reaction is _____

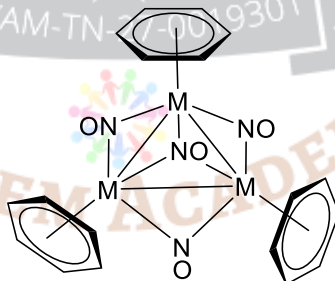
[where, p represents the partial pressure and K represents the surface binding constant on the species. k is a proportionality constant]

- (a) $\frac{k \cdot K_{\text{CO}} p_{\text{CO}} \cdot K_{\text{O}_2}^{1/2} p_{\text{O}_2}^{1/2}}{(1 + K_{\text{CO}} p_{\text{CO}} + K_{\text{O}_2}^{1/2} p_{\text{O}_2}^{1/2})^2}$ (b) $\frac{k \cdot K_{\text{CO}} p_{\text{CO}} \cdot K_{\text{O}_2} p_{\text{O}_2}}{1 + K_{\text{CO}} p_{\text{CO}} + K_{\text{O}_2} p_{\text{O}_2}}$ (c) $\frac{k \cdot p_{\text{CO}} \cdot K_{\text{O}_2} p_{\text{O}_2}}{1 + K_{\text{O}_2} p_{\text{O}_2}}$ (d) $\frac{k \cdot K_{\text{CO}} p_{\text{CO}} \cdot K_{\text{O}_2} p_{\text{O}_2}}{(1 + K_{\text{CO}} p_{\text{CO}} + K_{\text{O}_2} p_{\text{O}_2})^2}$

89. In solids, the filled molecular orbitals contribute to the

- (a) Rydberg states (b) Valence Band (c) Conduction Band (d) Frenkel Exciton

90. The compound shown below is a 48-electron metal cluster (not counting M-M bonds). The metal M is



- (a) V (b) Fe (c) Mn (d) Cr

91. A particle of mass "m" is confined in a rectangular box with $L_x = 2L_y$. The state with the energy $\frac{10h^2}{8mL_y^2}$ has a degeneracy of

- (a) 1 (b) 2 (c) 3 (d) 4

92. Consider the nuclear shape of $^{14}\text{N}_7$ and $^{17}\text{O}_8$, The option giving the correct shape, is

- (a) $\frac{^{14}\text{N}_7}{\text{Prolate}}$; $\frac{^{17}\text{O}_8}{\text{Oblate}}$ (b) $\frac{^{14}\text{N}_7}{\text{Oblate}}$; $\frac{^{17}\text{O}_8}{\text{Spherical}}$
 (c) $\frac{^{14}\text{N}_7}{\text{Oblate}}$; $\frac{^{17}\text{O}_8}{\text{Prolate}}$ (d) $\frac{^{14}\text{N}_7}{\text{Spherical}}$; $\frac{^{17}\text{O}_8}{\text{Oblate}}$

93. 1 and 2 are the labels of two electrons. If ϕ_{1s} and ϕ_{2s} are the 1s and 2s



wavefunctions of He atom and α and β are the spin wavefunctions of an electron, the Slater determinant that correctly describes one of the symmetry-adapted excited states of He atom is

- (a) $\begin{vmatrix} \phi_{1s}(1)\alpha(1) & \phi_{1s}(2)\alpha(2) \\ \phi_{1s}(1)\beta(1) & \phi_{1s}(2)\beta(2) \end{vmatrix}$ (b) $\begin{vmatrix} \phi_{1s}(1)\alpha(1) & \phi_{1s}(2)\alpha(2) \\ \phi_{2s}(1)\beta(1) & \phi_{2s}(2)\beta(2) \end{vmatrix}$
- (c) $\begin{vmatrix} \phi_{1s}(1)\alpha(1) & \phi_{1s}(2)\alpha(2) \\ \phi_{2s}(1)\alpha(1) & \phi_{2s}(2)\alpha(2) \end{vmatrix}$ (d) $\begin{vmatrix} \phi_{1s}(1)\beta(1) & \phi_{1s}(2)\beta(2) \\ \phi_{2s}(1)\alpha(1) & \phi_{2s}(2)\alpha(2) \end{vmatrix}$

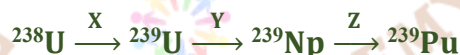
94. According to VSEPR theory, the shapes and geometries of SeF_4 and $[\text{BrF}_4]^-$, respectively, are

- (a) see-saw and trigonal bipyramidal; see-saw and trigonal bipyramidal
 (b) square planar and octahedral; square planar and pentagonal pyramidal
 (c) see-saw and trigonal bipyramidal; square planar and octahedral
 (d) square planar and square bipyramidal; square planar and octahedral

95. A linear variation is performed using two orthogonal basis functions ϕ_1 and ϕ_2 to generate two optimised energies ϵ_1 and ϵ_2 ($\epsilon_1 \leq \epsilon_2$). If the exact ground and first excited state energies are E_1 and E_2 , respectively, the correct statement is

- (a) Both ϵ_1 and ϵ_2 are lower than E_1 (b) ϵ_1 lies between E_1 and E_2
 (c) $\epsilon_1 > E_2$ (d) $\epsilon_2 < E_2$

96. In the following nuclear reaction, X, Y and Z, respectively, are



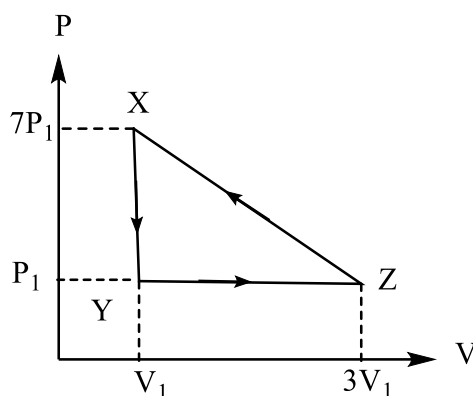
- (a) (n), $-\beta$, and $+\beta$ (b) (n, γ), $+\beta$, and $+\beta$
 (c) $(+\beta)$, (n, γ) and $-\beta$ (d) (n, γ), $-\beta$, and $-\beta$

97. The correct option with respect to the metal-metal distance(d) and the magnetic property of P. $[\text{Cr}_2\text{Cl}_9]^{3-}$ and Q. $[\text{W}_2\text{Cl}_9]^{3-}$ is

- (a) $d_{\text{Cr}\dots\text{Cr}} > d_{\text{W}\dots\text{W}}$; P is paramagnetic and Q is diamagnetic
 (b) $d_{\text{Cr}\dots\text{Cr}} > d_{\text{W}\dots\text{W}}$; P is diamagnetic and Q is paramagnetic
 (c) $d_{\text{W}\dots\text{W}} > d_{\text{Cr}\dots\text{Cr}}$; P is diamagnetic and Q is paramagnetic
 (d) $d_{\text{W}\dots\text{W}} > d_{\text{Cr}\dots\text{Cr}}$; P is paramagnetic and Q is diamagnetic

98. The total work done by the system in the cyclic process depicted below is





- (a) $6 P_1 V_1$ (b) 0 (c) $-14 P_1 V_1$ (d) $12 P_1 V_1$

99. Consider the following data with respect to J-J coupled states in Nd^{3+} ion. The option showing the correct lowest and highest states of Nd^{3+} , is

	Lowest	Highest		Lowest	Highest
(a)	$^4I_{9/2}$	$^4I_{15/2}$	(b)	$^4I_{7/2}$	$^4I_{9/2}$
(c)	$^4H_{9/2}$	$^4H_{9/2}$	(d)	$^4H_{9/2}$	$^4H_{13/2}$

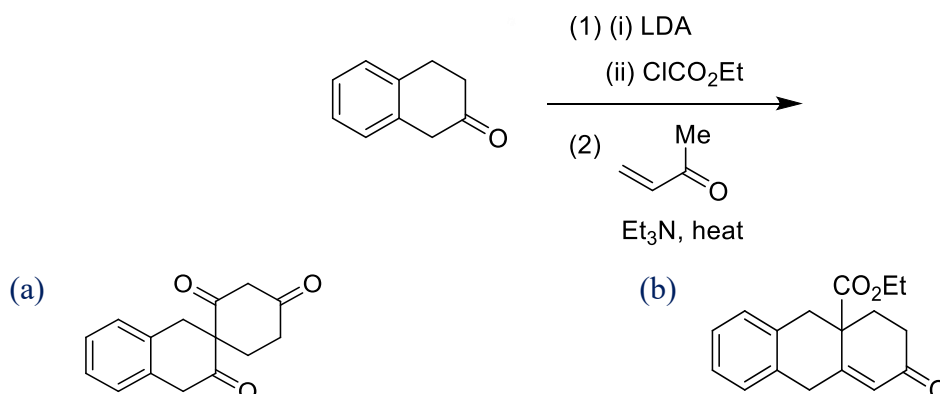
100. ^{31}P -NMR spectrum of P_4S_3 consists of (^{31}P , $I = \frac{1}{2}$, 100% abundance)

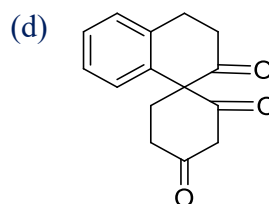
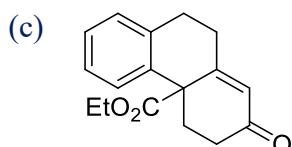
- (a) two doublets of triplets (b) triplet of triplets
(c) two triplets of equal intensity (d) a doublet and a quartet

101. Complete hydrolysis of XeF_6 gives P, whereas alkaline hydrolysis of XeF_6 gives Q and R as the major products. P, Q and R respectively are,

- (a) XeO_3 , XeO_6^{4-} and Xe (b) XeO_4 , HXeO_6^{4-} and Xe
(c) XeO_4 , Xe and XeO_6^{4-} (d) HXeO_4^- , XeO_3 and XeO_6^{4-}

102. The major product formed in the following reaction sequence is



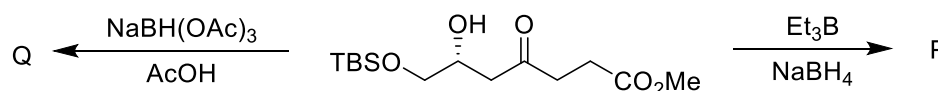


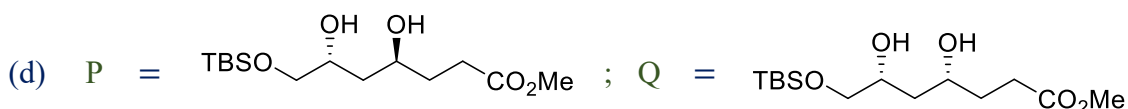
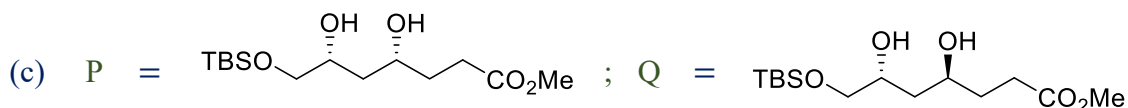
103. Complex-1 $[\text{Co}(\text{NH}_3)_5(\text{X})]\text{Cl}_2$ on reaction with aqueous NH_3 followed by the addition of $\text{NaNO}_2/\text{conc.HCl}$ yields Complex-2 $[\text{Co}(\text{NH}_3)_5(\text{Y})]\text{Cl}_2$. Reaction of Complex-1 with NaNO_2 results in Complex-3 $[\text{Co}(\text{NH}_3)_5(\text{Z})]\text{Cl}_2$. Complex-2 shows two IR spectral bands at 1310 and 1430 cm^{-1} , whereas complex-3 shows the same at 1065 and 1470 cm^{-1} . X, Y and Z respectively, are

	X	Y	Z		X	Y	Z
(a)	Cl	NO_2	ONO	(b)	H_2O	NO_2	ONO
(c)	Cl	ONO	NO_2	(d)	H_2O	ONO	NO_2

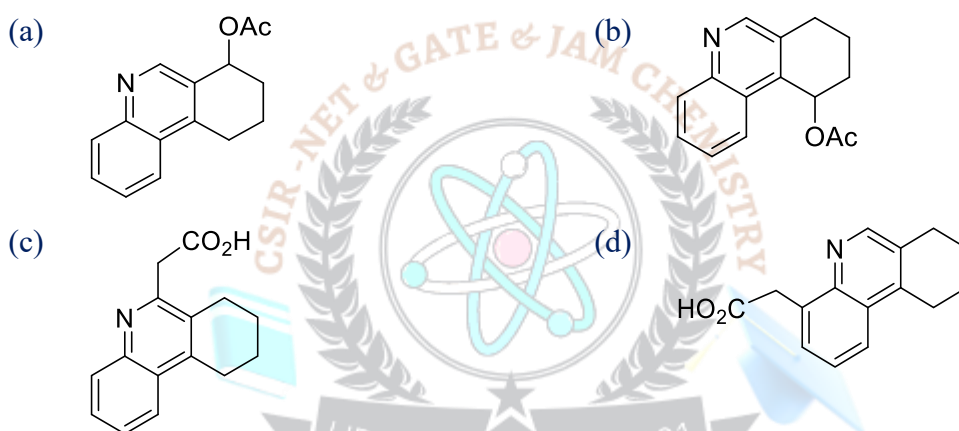
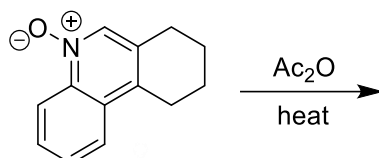
104. The temperature dependent standard electrode potential of $\text{Ag}_{(s)} | \text{AgBr}_{(s)} | \text{Br}^-_{(\text{aq})}$ fits the expression $E^\circ(\text{V}) = 0.0713 - 4.99 \times 10^{-4} \left(\frac{T}{\text{K}} - 298\right) - 3.45 \times 10^{-6} \left(\frac{T}{\text{K}} - 298\right)^2$. At 398 K , the entropy change, ΔS° , (in $\text{J K}^{-1} \text{ mol}^{-1}$) is
- (a) -48.2 (b) -114.7 (c) 48.2 (d) 114.7
105. The oxy-hemocyanin exhibits a resonance Raman signal at 744 cm^{-1} for ^{16}O - ^{16}O stretch, following its excitation at 575 nm . The value of the ^{18}O - ^{18}O stretch for an $^{18}\text{O}_2$ substituted oxy-hemocyanin, and the origin of the absorption band are,
- (a) 702 cm^{-1} and $\text{O}_2^- \rightarrow \text{Cu}(\text{II})$ charge transfer
 (b) 702 cm^{-1} and $\text{O}_2^{2-} \rightarrow \text{Cu}(\text{II})$ charge transfer
 (c) 664 cm^{-1} and $\text{O}_2^- \rightarrow \text{Cu}(\text{II})$ charge transfer
 (d) 792 cm^{-1} and $\text{O}_2^{2-} \rightarrow \text{Cu}(\text{II})$ charge transfer

106. The major products P and Q formed in the following transformations are





107. The major product formed in the following reaction is



108. Some reagents and their applications are given in the table below. The option showing the correct match of reagents and their application, is

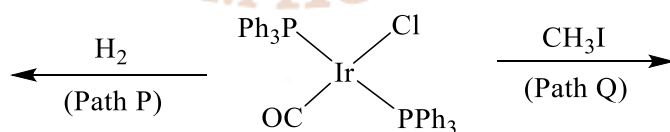
Reagents →	Fricke solution	CuSO ₄ in basic solution	MnSO ₄ in basic KI solution	Ammonium Ce(IV) sulfate solution
P	[.OH] concentration measurement	Free glucose measurement	dissolved oxygen measurement	Fe ²⁺ estimation in potable water
Q	Fe ²⁺ estimation in potable water	Free glucose measurement	[.OH] concentration measurement	dissolved oxygen measurement
R	dissolved oxygen measurement	Fe ²⁺ estimation in potable water	Free glucose measurement	[.OH] concentration measurement
S	[.OH]	dissolved	Free glucose	Fe ²⁺ estimation



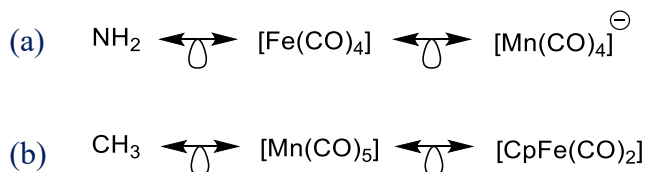
	concentration measurement	oxygen measurement	measurement	in potable water
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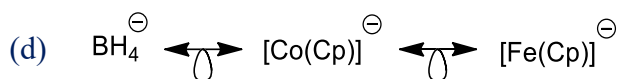
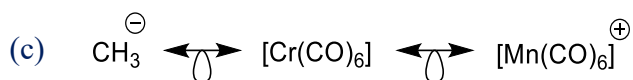
(a) P (b) Q (c) R (d) S

109. Consider a two-level system at thermal equilibrium. The ratios of the excited state population to the ground state population are 0.50 and 0.25 at 600 K and 300 K, respectively. The energy gap between the two levels (in unit of 10^{-21} J) is closest to [$k_B = 1.38 \times 10^{-23}$ JK $^{-1}$]
- (a) 1.44 (b) 2.87 (c) 5.74 (d) 11.48
110. The isomerisation of cyclopropane to propene follows Lindemann mechanism and is carried out in the high-pressure limit. The ratio of the rate constants of activation to deactivation steps is 10, and that of product formation to deactivation step is 15. Given the effective rate constant as 150 s^{-1} , the rate constant (in s^{-1}) for the deactivation step is
- (a) 1.5 (b) 1.0 (c) 10.0 (d) 7.0
111. The absorption spectrum of Ln^{3+} is normally sharp and weak in intensity. However, $\text{Sm}^{3+}(4f^5)$ in dil. acidic solution shows a broad and moderately intense transition at 495 nm. This transition is
- (a) ${}^6\text{H}_{5/2} \rightarrow {}^6\text{H}_{7/2}$ (b) ${}^6\text{H}_{5/2} \rightarrow {}^4\text{G}_{5/2}$ (c) ${}^6\text{H}_{5/2} \rightarrow {}^6\text{H}_{9/2}$ (d) ${}^4\text{G}_{5/2} \rightarrow {}^4\text{G}_{7/2}$
112. In the oxidative addition of $\text{trans}[\text{IrCl}(\text{CO})(\text{PPh}_3)_2]$ with H_2 (path P) and with CH_3I (path Q), the d-orbitals involved in the electron transfer from iridium to H_2 and CH_3I respectively, are



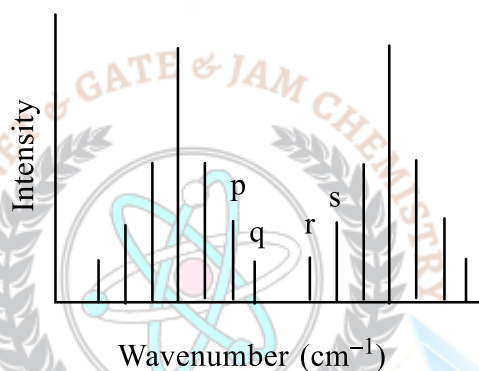
- (a) $d_{x^2-y^2}$ (in P); d_{z^2} (in Q) (b) d_{z^2} (in P); d_{xy} or d_{xz} or d_{yz} (in Q)
- (c) d_{xy} or d_{xz} or d_{yz} (in P); d_{z^2} (in Q) (d) d_{z^2} (in P); $d_{x^2-y^2}$ (in Q)
113. The correct set of isolobal species is





114. A schematic **rotational-vibrational spectrum** is depicted below and four lines of this spectrum for two diatomic molecules (M1 and M2) are tabulated.

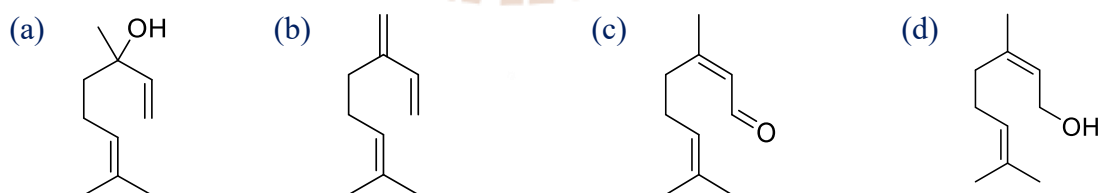
	p (cm^{-1})	q (cm^{-1})	r (cm^{-1})	s (cm^{-1})
M1	1540	1564	1636	1660
M2	1644	1676	1772	1804



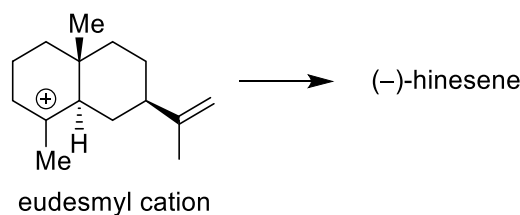
If the reduced mass of **M1** is **3-times** that of **M2**, the ratio of bond length of **M1** to that of **M2** is

- (a) $\frac{2}{3}$ (b) $\frac{3}{2}$ (c) $\frac{4}{9}$ (d) $\frac{9}{4}$

115. **Ozonolysis of a terpene gives equimolar mixture of acetone, α -hydroxyacetaldehyde and 4-oxopentanal. The correct structure of terpene is**



116. Upon **catalysis by hinesene synthase**, eudesmyl cation shown below undergoes a sequential **hydride shift**, ring contraction and loss of proton to form (-)-hinesene. The correct structure of (-)-hinesene is





117. A molecule shows two absorptions at 896 and 960 MHz in its ^{13}C -NMR spectrum in a magnetic field of 3T. The corresponding chemical shifts in ppm are _____

$$(^{13}\text{C} \text{ magnetogyric ratio } \gamma = 6.72 \times 10^7 \text{ rad T}^{-1} \text{ s}^{-1}; I = \frac{1}{2})$$

- (a) 12.8 and 13.7 (b) 14 and 15 (c) 32 and 34 (d) 28 and 30
118. The d-orbitals of a hydrogenic atom with $n = 3, l = 2$ and $m = \pm 2$ are given by:

$$\Psi_{3,2,\pm 2} = N \cdot R(r) \sin^2 \theta e^{\pm 2i\phi}$$

Where, N is the normalization constant and $R(r)$ is the radial part of the wavefunction. An appropriate linear combination of these two wavefunctions yields the real orbital

- (a) d_{z^2} (b) d_{xy} (c) d_{yz} (d) d_{zx}
119. The following statements are given with respect to the symmetry operations and symmetry elements.

P. BF_3 possesses an S_3 axis

Q. C_2H_6 in a staggered conformation possesses an S_6 axis

R. Benzene molecule possesses three σ_v -planes

S. Water molecule possesses C_2 axis and σ_h -plane

The option giving the correct statements, is

- (a) Q, R and S only (b) P, Q and R only (c) P, Q and S only (d) P, Q, R and S
120. The application of Euler's reciprocity relation (cross-derivative rule) to the volume of 1 mole of an ideal gas results in mixed second derivative of V equal to

(a) $-\frac{R}{p^2}$ (b) $-\frac{RT}{p^2}$ (c) $\frac{R}{p}$ (d) $\frac{2RT}{p^3}$



Answer KeyPART - B

Q.No	Ans
21.	a
22.	b
23.	d
24.	b
25.	d
26.	a
27.	a
28.	a
29.	d
30.	b

Q.No	Ans
31.	a
32.	d
33.	d
34.	a
35.	a
36.	a
37.	a
38.	d
39.	b
40.	c

Q.No	Ans
41.	b
42.	c
43.	a
44.	b
45.	d
46.	a
47.	c
48.	a
49.	c
50.	a

Q.No	Ans
51.	b
52.	b
53.	a
54.	a
55.	c
56.	a
57.	c
58.	c
59.	d
60.	b

PART - C

Q.No	Ans
61.	c
62.	a
63.	c
64.	a
65.	d
66.	c
67.	d
68.	d
69.	b
70.	b
71.	a

Q.No	Ans
76.	d
77.	a
78.	d
79.	a
80.	a
81.	a
82.	d
83.	a
84.	d
85.	c
86.	b

Q.No	Ans
91.	b
92.	a
93.	c
94.	c
95.	b
96.	d
97.	a
98.	a
99.	a
100.	d
101.	a

Q.No	Ans
106.	c
107.	b
108.	a
109.	c
110.	b
111.	b
112.	c
113.	b
114.	a
115.	d
116.	c



CSIR-UGC-NET - Chemical Science - Dec - 2023

72.	a
73.	c
74.	b
75.	b

87.	b
88.	a
89.	b
90.	d

102.	c
103.	a
104.	b
105.	b

117.	d
118.	b
119.	b
120.	a

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