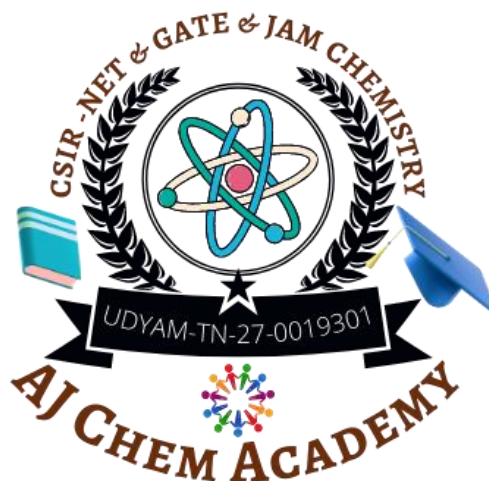


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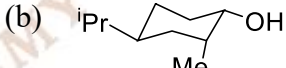

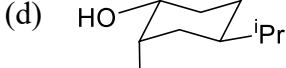
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Q.21 – Q.60 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 0.5). You are required to Answer Maximum 35 Questions.

21. The degeneracy of a state with energy $\frac{27h^2}{8mL^2}$, for a particle confined in a 3D cubic box of length L, is
 (a) 1 (b) 2 (c) 4 (d) 3
22. The peak of an absorption spectrum of a molecule is observed at $21,000 \text{ cm}^{-1}$.
 $[k_B = 8.62 \times 10^{-5} \text{ eV K}^{-1}$; energy corresponding to $\lambda(\text{nm}) = (1240/\lambda)\text{eV}]$.
 The correct statement is
 (a) It is a vibrational transition and the energy required is ~ 100 times the thermal energy at 25°C
 (b) It is an electronic transition and the energy required is ~ 100 times the thermal energy at 25°C
 (c) It is a vibrational transition and the energy required is ~ 200 times the thermal energy at 25°C
 (d) It is an electronic transition and the energy required is ~ 200 times the thermal energy at 25°C
23. The structure that corresponds to **(1S, 2R, 4S)-4-isopropyl-2-methylcyclohexanol** is
 (a)  (b) 
 (c)  (d) 
24. n moles of a perfect monatomic gas with volume V_1 undergoes an adiabatic free expansion to a final volume $V_2 = 5V_1$. The change in entropy (in $\text{J K}^{-1} \text{ mol}^{-1}$) of the gas is [Given $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$]
 (a) 0 (b) 13.38 (c) 1.61 (d) 8.31
25. Consider the following statements about H_2S generation using Kipp's apparatus
P. The reagents used are FeS and dil. H_2SO_4
Q. The reagents used are FeS and conc. HNO_3
R. H_2S can be prepared intermittently (on-demand)
S. Kipp's apparatus consists of three chambers
 The option with the correct statements is



- (a) Q, R and S only (b) P and S only (c) P, R and S only (d) Q and R only
26. $\Psi(x_1, x_2)$ represents the wavefunction for a two-particle system, where x_i is the combined space and spin coordinates of the i -th particle. The correct anti-symmetric wavefunction is
- (a) $\Psi(x_1, x_2) = (x_1^2 - x_2^2)e^{-(x_1^2+x_2^2)}$ (b) $\Psi(x_1, x_2) = (x_1^2 + x_2^2)e^{-(x_1^2-x_2^2)}$
 (c) $\Psi(x_1, x_2) = (x_1 - x_2)^2e^{-(x_1^2+x_2^2)}$ (d) $\Psi(x_1, x_2) = (x_1 + x_2)^2e^{-(x_1^2-x_2^2)}$
27. The P-O stretching frequency of phosphoryl compounds follows the order
- (a) $F_3PO > Cl_3PO > Me_3PO > Ph_3PO$
 (b) $F_3PO > Cl_3PO > Ph_3PO > Me_3PO$
 (c) $Me_3PO > Ph_3PO > Cl_3PO > F_3PO$
 (d) $Ph_3PO > Me_3PO > F_3PO > Cl_3PO$
28. For a hermitian operator \hat{A} , consider the following statements.
 P. \hat{A} has real eigen-values
 Q. $\langle \hat{A} \rangle$, with respect to any arbitrary state, is always ≥ 0
 R. $\langle \hat{A}^2 \rangle$, with respect to any arbitrary state, is always ≥ 0
 S. \hat{A} always commutes with another hermitian operator
 The correct complete set of options is
- (a) P only (b) P, Q and R (c) P, Q, R, S (d) P and R only
29. The intermediates involved in the following transformation are
-
- | carbocation | carbanion | carbene | ketene |
|-------------|-----------|---------|--------|
| P | Q | R | S |
- (a) Q and R (b) R and S (c) P and R (d) Q and S
30. The metals present in the active sites of particulate and soluble methane monooxygenases (abbreviated as pMMO and sMMO respectively) that are produced by methane-metabolizing bacteria, respectively, are
- (a) Cu and Ni (b) Fe and Ni (c) Mn and Fe (d) Cu and Fe
31. The reaction NOT falling under the category of acid-base reaction is
- (a) $HClO_4 + CH_3CN \rightarrow [CH_3CNH]^+[ClO_4]^-$ (b) $NOF + ClF_3 \rightarrow [NO]^+[ClF_4]^-$
 (c) $XeO_3 + OH^- \rightarrow [HXeO_4]^-$ (d) $Pt + XeF_4 \rightarrow PtF_4 + Xe$



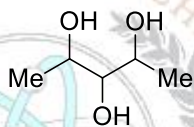
36. The approximate ground-state energy of He-isoelectronic series is given by $E(Z) = -Z^2 + \frac{5}{8}Z - 0.1576 + \frac{0.0087}{Z}$. According to Valence Bond Theory, the expression for binding energy of H_2 from H^- and H^+ ($H_2 \rightarrow H^- + H^+$) can be approximated to [Given: J, K and S represent Coulomb, exchange and overlap integrals, respectively. Energies are expressed in atomic unit]

(a) $0.5239 - \frac{J+K}{1-S^2}$ (b) $0.4761 - \frac{J-K}{1-S^2}$ (c) $0.4761 - \frac{J+K}{1+S^2}$ (d) $0.5239 + \frac{J+K}{1+S^2}$

37. For the wavefunction, $\Psi(x) = A \exp(-\frac{x^4}{a^4} + ikx)$, the ratio of probability density at $x = a$ to that at $x = 2a$ is [Given: $-\infty \leq x \leq \infty$]

(a) e^6 (b) e^2 (c) 2 (d) e^{30}

38. The number of optically active stereoisomers for the following compound is



(a) 2 (b) 4 (c) 6 (d) 8

39. The partition function of two indistinguishable non-interacting particles, where one or both can occupy any of the two available energy levels 0 and ϵ is

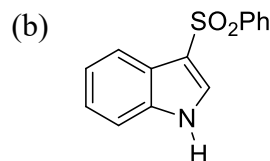
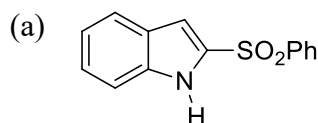
(a) $1 + e^{-\epsilon/k_B T} + e^{-2\epsilon/k_B T}$ (b) $2 + e^{-\epsilon/k_B T} + e^{-2\epsilon/k_B T}$
 (c) $1 + 2e^{-\epsilon/k_B T} + e^{-2\epsilon/k_B T}$ (d) $1 + e^{-\epsilon/k_B T} + 2e^{-2\epsilon/k_B T}$

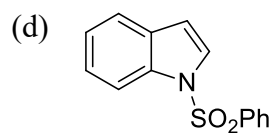
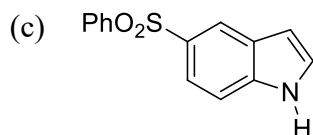
40. The expression for fractional surface coverage (θ_A) for the dissociative adsorption, $A_{2(g)} \rightarrow 2A(\text{surface})$, in the presence of an inhibitor I ($I_{(g)} \rightarrow I_{(\text{surface})}$) competing for the same site, is

[Given: K_A and K_I are equilibrium constants for adsorption of $A_{2(g)}$ and $I_{(g)}$, respectively; p_i is the partial pressure of the i^{th} gas]

(a) $\frac{K_A^{1/2} p_{A_2}^{1/2}}{(1+K_A^{1/2} p_{A_2}^{1/2})(1+K_I p_I)}$ (b) $\frac{K_A^{1/2} p_{A_2}^{1/2} K_I p_I}{(1+K_A^{1/2} p_{A_2}^{1/2})(1+K_I p_I)}$
 (c) $\frac{K_A^{1/2} p_{A_2}^{1/2}}{(1+K_A^{1/2} p_{A_2}^{1/2} + K_I p_I)}$ (d) $\frac{K_A^{1/2} p_{A_2}^{1/2} K_I p_I}{(1+K_A^{1/2} p_{A_2}^{1/2} + K_I p_I)}$

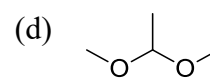
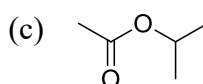
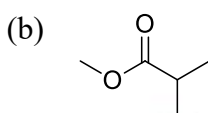
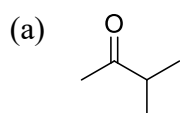
41. The major product formed in the reaction of indole with $NaNH_2$ and $PhSO_2Cl$ is





42. The point groups of $[\text{Re}_2\text{Cl}_8]^{2-}$ and $\text{trans-}[\text{Co}(\text{en})_2\text{Cl}_2]^+$, respectively, are
 (a) D_{4h} and D_2 (b) D_{4d} and D_2 (c) D_{4h} and D_{2h} (d) D_{4d} and D_{2h}
43. The compound that would give the following data is

$^1\text{H-NMR}$: δ 2.43(m, 1H), 2.10(s, 3H), 0.95(d, $J = 7\text{Hz}$, 6H)ppm



44. The correct match of class of natural products in Column-I with the compounds in Column-II is

	Column-I	Column-II		P	Q	R
P	Alkaloid	i.				
Q	Terpenoid	ii.				
R	Polyketide	iii.				
				(a)	i ; iii ; ii	
				(b)	ii ; i ; iii	
				(c)	ii ; iii ; i	
				(d)	iii ; ii ; i	

45. In the standard state at 25 °C, upon reversing the electrodes of the following electrochemical cells, $\text{Ag}_{(s)}$ will be deposited on the cathode of

Cell	Anode	Cathode
X	$\text{AgBr}/\text{Ag}, \text{Br}^-$	$\text{AgCl}/\text{Ag}, \text{Cl}^-$
Y	$\text{AgBr}/\text{Ag}, \text{Br}^-$	$\text{AgI}/\text{Ag}, \text{I}^-$
Z	$\text{AgCl}/\text{Ag}, \text{Cl}^-$	$\text{AgI}/\text{Ag}, \text{I}^-$

$[E^\circ(\text{in V}) = +0.22(\text{AgCl}/\text{Ag}, \text{Cl}^-); +0.07(\text{AgBr}/\text{Ag}, \text{Br}^-); -0.15(\text{AgI}/\text{Ag}, \text{I}^-)]$

- (a) X (b) Y and Z (c) Z, but not Y (d) X, Y and Z
46. Among the following, the **INCORRECT** statement regarding ionization energy is
 (a) It decreases as the size of the atom increases



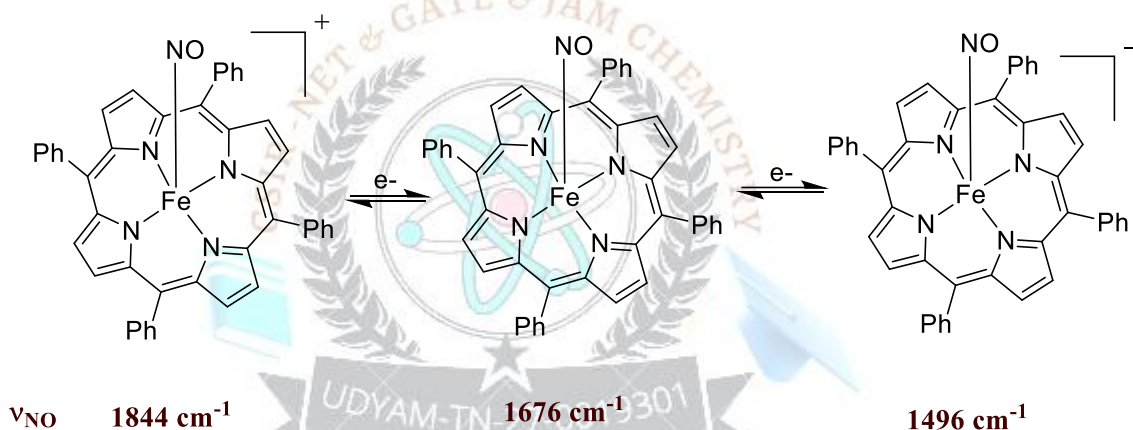
- (b) It increases with increase in nuclear charge
 (c) It increases continuously from B to F across the second period
 (d) The ionization energy is higher for electrons in orbitals with greater penetration

47. The rate(v) of the reaction $A + 2B \rightarrow P$ is given by

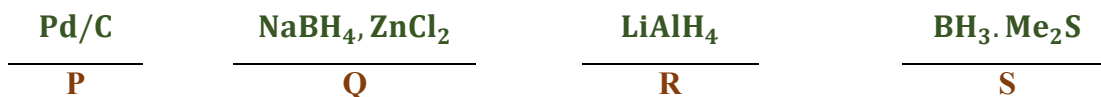
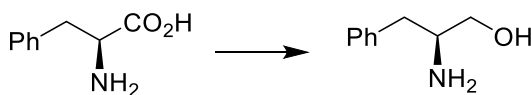
$$v = k[A][B]$$

If initial concentrations of A and B are 2 mM and 4 mM, respectively, and $k = 0.01 \text{ mol}^{-1} \text{ L s}^{-1}$, the half-life (in s) of A is

- (a) 2.5×10^4 (b) 5.0×10^4 (c) 2.5×10^5 (d) 5.0×10^5
48. For the reaction sequence given below, the correct statement for the doubly reduced species (showing N-O frequency of 1496 cm^{-1}) is



- (a) The Fe-NO bond length remains unaffected upon reduction
 (b) There is no back-bonding interaction between iron and NO
 (c) The reduction is predominantly localized on the NO ligand
 (d) The reduction is fully localized on the metal
49. The correct reagent(s) to effect the following transformation is(are)



- (a) Only P (b) Only Q and R (c) Only Q, R and S (d) Only P, Q and S
50. The correct statement about the bond angles of $\cdot\text{CF}_3$ and $\cdot\text{CH}_3$ is

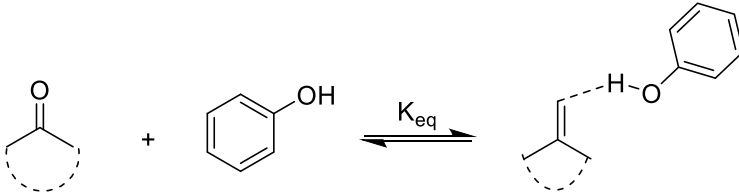
- (a) $\angle\text{CF}_3 < \angle\text{CH}_3$ due to $n \rightarrow \sigma^*$ interaction in $\cdot\text{CF}_3$
 (b) $\angle\text{CF}_3 > \angle\text{CH}_3$ due to $n \rightarrow \sigma^*$ interaction in $\cdot\text{CF}_3$

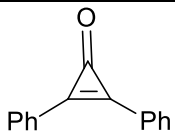
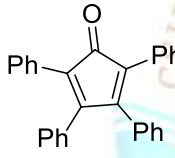
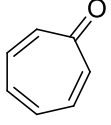


(c) ${}^{\cdot}\text{CF}_3 < {}^{\cdot}\text{CH}_3$ due to bond pair-bond pair repulsion in ${}^{\cdot}\text{CF}_3$

(d) ${}^{\cdot}\text{CF}_3 > {}^{\cdot}\text{CH}_3$ due to bond pair-bond pair repulsion in ${}^{\cdot}\text{CF}_3$

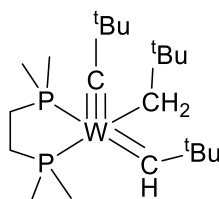
51. The correct match for the ketones in Column-I with the K_{eq} values in Column-II for their H-bonding with phenol (as shown below) is



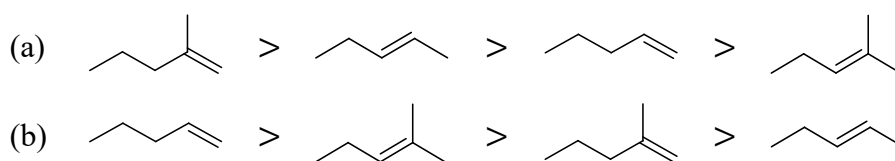
	Column-I	Column-II	
P.	 i.	6.2	
Q.	 ii.	31.2	
R.	 iii.	83.2	

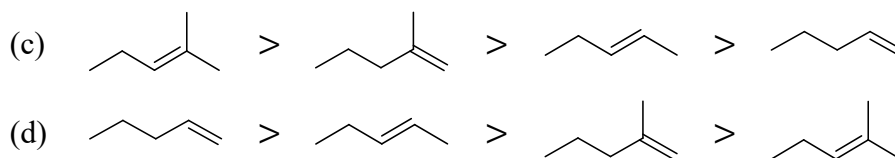
	P	Q	R
(a)	i ;	ii ;	iii
(b)	iii ;	i ;	ii
(c)	iii ;	ii ;	i
(d)	ii ;	i ;	iii

52. The correct option of bond lengths (\AA) of the metal-alkylidene and metal alkylidyne, respectively, and the corresponding ${}^{13}\text{C-NMR}$ chemical shifts (ppm) of the complex below is



- (a) 1.78, 1.94 and 296, 256 (b) 1.94, 1.78 and 256, 296
 (c) 1.94, 1.78 and 296, 256 (d) 1.78, 1.94 and 256, 296
53. The relative reactivity of alkenes for the cobalt-catalyzed hydroformylation reaction follows the order





54. C_3^2i is equivalent to

- (a) S_6 (b) S_6^5 (c) C_6^5 (d) C_6

55. The correct sequence of **increasing O–O bond length** in the following species is

- (a) $[O_2]^+$, O_2F_2 , H_2O_2 , $[O_2]^{2-}$ (b) O_2F_2 , $[O_2]^+$, H_2O_2 , $[O_2]^{2-}$
 (c) O_2F_2 , $[O_2]^+$, $[O_2]^{2-}$, H_2O_2 (d) $[O_2]^+$, H_2O_2 , O_2F_2 , $[O_2]^{2-}$

56. Among the following, the **amino acid residue in histone** that gets acetylated is

- (a) Alanine (b) Glycine (c) Phenylalanine (d) Lysine

57. An element ${}_{13}^{27}X$ is bombarded with two α -particles to give **Y** with the emission of a neutron. The element Y is

- (a) ${}_{15}^{30}Y$ (b) ${}_{17}^{35}Y$ (c) ${}_{17}^{34}Y$ (d) ${}_{16}^{32}Y$

58. Consider the following statements:

P. Schottky defects decrease the density of the crystal

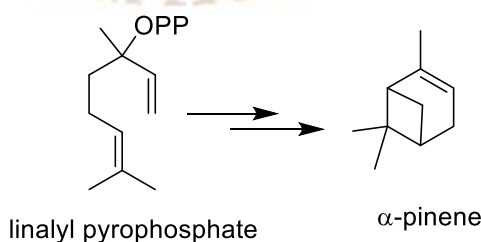
Q. Schottky defects create vacancy pair(s)

R. Alkali metal halides exhibit Frenkel defect

The option containing correct statement(s) is

- (a) Only P (b) Both P and Q (c) Both Q and R (d) Both P and R

59. The correct sequence of steps involved in the biosynthesis of **α -pinene** from linalyl pyrophosphate is



P. six-membered ring formation with loss of pyrophosphate (OPP)

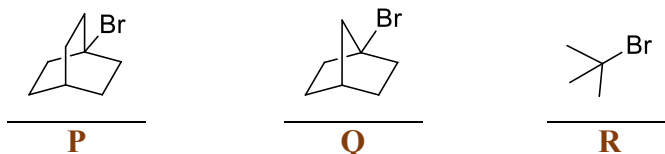
Q. four-membered ring formation

R. loss of H^+

- (a) P, Q, R (b) P, R, Q (c) Q, R, P (d) Q, P, R

60. The correct order of the relative rates of solvolysis for the following compounds in **80 % aqueous ethanol at 25 °C** is

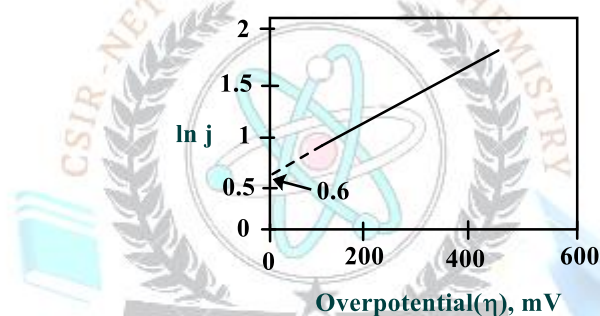




- (a) $P > Q > R$ (b) $Q > R > P$ (c) $R > P > Q$ (d) $R > Q > P$

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.

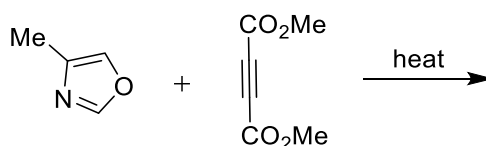
61. The following figure shows a plot of $\ln j$ versus η for the platinum electrode of area 1 cm^2 in contact with an aqueous solution of Fe^{3+} (10^{-3} M) and Fe^{2+} (10^{-3} M) at 300 K . Here j and η represent current (in mA) and overpotential (in mV), respectively.

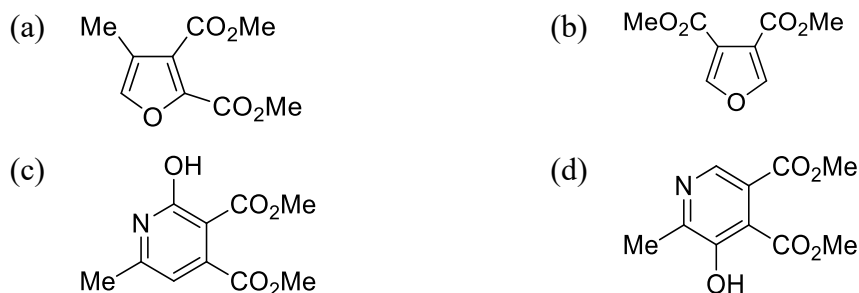


The charge transfer resistance (in Ω) for this system is closest to

- (a) 1.36 (b) 4.91 (c) 14.2 (d) 49.1
62. The correct order of $\nu_{\text{C-S}}$ (in cm^{-1}) and $\nu_{\text{C-N}}$ (in cm^{-1}) in P and Q is
- | | |
|---|---|
| $\text{trans-}[\text{Pd}(\text{AsPh}_3)_2(\underline{\text{NCS}})_2]$ | $\text{trans-}[\text{Pd}(\text{AsPh}_3)_2(\underline{\text{SCN}})_2]$ |
| P | Q |

- (a) $\nu_{\text{C-S}}$ in P < $\nu_{\text{C-S}}$ in Q ; $\nu_{\text{C-N}}$ in P < $\nu_{\text{C-N}}$ in Q
- (b) $\nu_{\text{C-S}}$ in P \approx $\nu_{\text{C-S}}$ in Q ; $\nu_{\text{C-N}}$ in P \approx $\nu_{\text{C-N}}$ in Q
- (c) $\nu_{\text{C-S}}$ in Q < $\nu_{\text{C-S}}$ in P ; $\nu_{\text{C-N}}$ in P < $\nu_{\text{C-N}}$ in Q
- (d) $\nu_{\text{C-S}}$ in Q < $\nu_{\text{C-S}}$ in P ; $\nu_{\text{C-N}}$ in Q < $\nu_{\text{C-N}}$ in P
63. The major product formed in the following reaction is



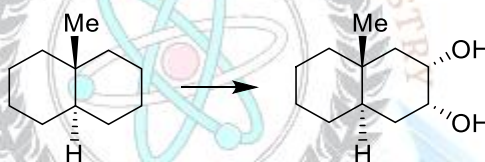


64. The symmetry labels of three normal modes of water are $\Gamma_1 = A_1$, $\Gamma_2 = A_1$ and $\Gamma_3 = B_2$. The polarization of light required for overtone $[(0, 0, 0) \text{ to } (0, 0, 3)]$ and combination $[(0, 0, 0) \text{ to } (1, 0, 1)]$ transitions, respectively, are

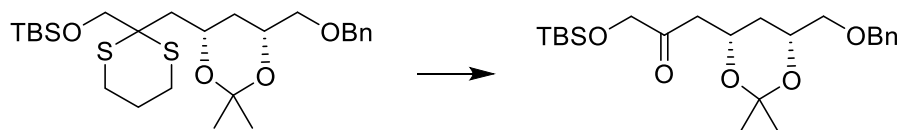
[The symmetry of the dipole moment operators μ_x , μ_y and μ_z , respectively, are $\Gamma_{\mu_x} = B_1$, $\Gamma_{\mu_y} = B_2$ and $\Gamma_{\mu_z} = A_1$]

- (a) z and z (b) y and x (c) x and y (d) y and y

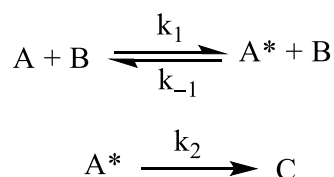
65. The correct set of reagents to effect the following transformation is



- (a) OsO_4 , NMO (b) (i) I_2 , AgOAc, H_2O ; (ii) NaOH, H_2O
 (c) (i) I_2 , AgOBz; (ii) NaOH, H_2O (d) OsO_4 , NaIO₄,
66. The ¹H-NMR of mixture of ethyl iodide and bromoform gives three signals at δ 6.80, 3.20 and 1.85 ppm with integration of 1, 3, 4.5, respectively. The molar ratio of ethyl iodide and bromoform is
- (a) 3 : 1 (b) 1.5 : 1 (c) 1 : 3 (d) 1 : 1.5
67. The correct reagent to effect the following reaction is



- (a) TBAF (b) Pd/C, H_2 (c) PTSA, MeOH (d) $\text{Hg}(\text{ClO}_4)_2$, CaCO_3
68. Consider the following gas phase reaction:



Considering $[A]_0$ and $[B]_0$ to be moderate and using steady state approximation,

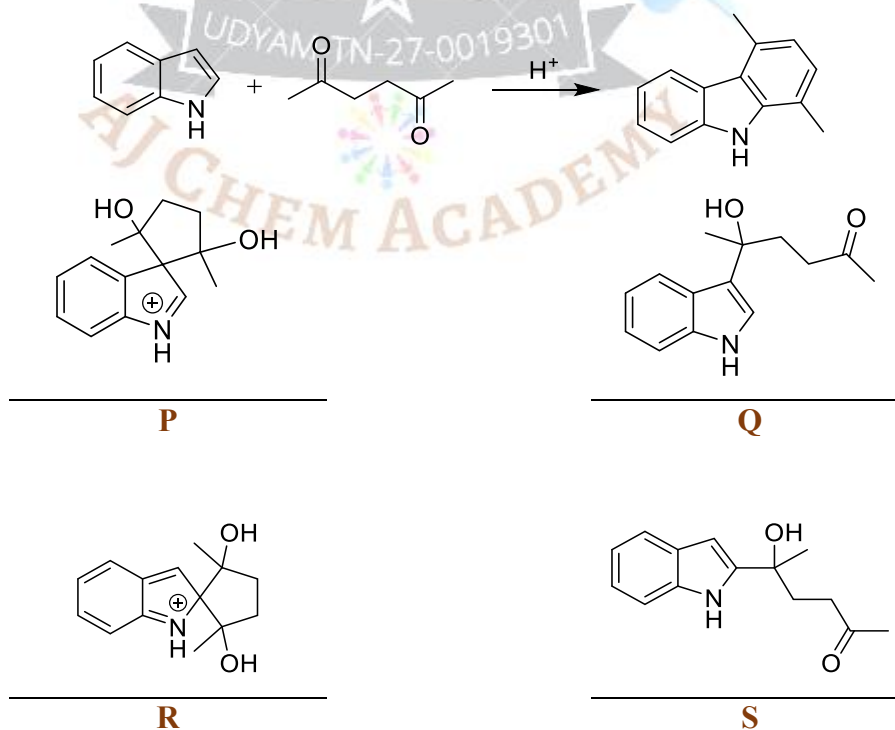


The correct option for the overall order of the reaction is

- (a) 1st order, when $k_{-1} \gg k_2$ (b) zero order, when $k_{-1} \gg k_2$
 (c) zero order, when $k_{-1} \ll k_2$ (d) 1st order, when $k_{-1} \ll k_2$
69. **0.5 M solution(A)** of a substance transmits **10%** of the incident light. Another solution(**B**) of the same substance under **identical experimental conditions** transmits **1%** of the incident light. The **concentration** (in M) of the substance in the **solution B** is
- (a) 8 (b) 10 (c) 1 (d) 5
70. Column-I contains inner transition elements and Column-II includes ores, structural property and application. The option with the correct match is

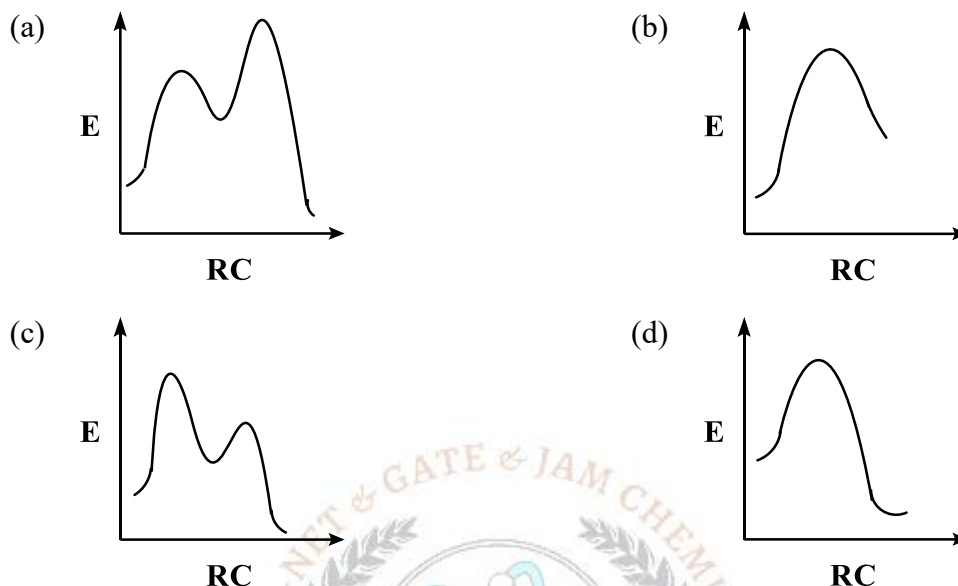
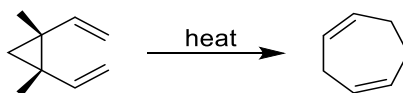
	Column-I	Column-II		P	Q	R	S
P	Th	i. Pitchblende	(a)	ii	iv	iii	i
Q	U	ii. BCC structure in its metallic form	(b)	iv	i	ii	iii
R	Eu	iii. Laser	(c)	i	iv	ii	iii
S	Nd	iv. Monazite	(d)	iv	i	iii	ii

71. The **intermediates** involved in the following transformation are

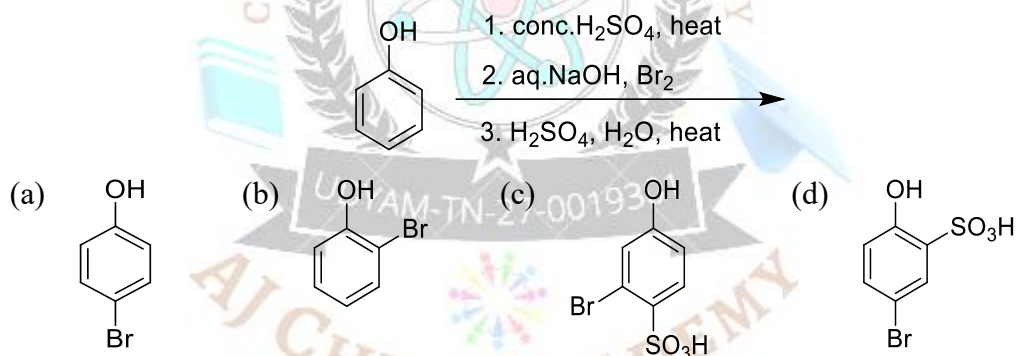


- (a) P and Q (b) R and S (c) Q and S (d) P and R
72. The **energy profile diagram** that corresponds to the following reaction is

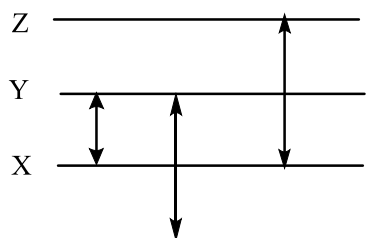




73. The **major product** formed in the following reaction sequence is



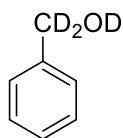
74. The **allowed electronic transitions** among **four different atomic energy levels** are indicated in the diagram below. Given that the lowest energy state is a ^3P state, a possible set of correct energy levels (X, Y and Z) is



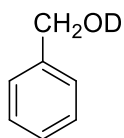
	X	Y	Z
(a)	$^3\text{D}_1$	$^3\text{P}_1$	$^3\text{D}_2$
(b)	$^3\text{P}_1$	$^3\text{D}_1$	$^3\text{D}_2$
(c)	$^3\text{P}_2$	$^3\text{D}_1$	$^3\text{P}_1$
(d)	$^3\text{P}_1$	$^3\text{P}_2$	$^3\text{D}_1$

75. The **Cannizzaro reaction** of benzaldehyde with **NaOH** was carried out independently in (i) D_2O and (ii) H_2^{18}O . The **major isotopically labelled products** obtained in these reactions are

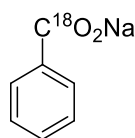




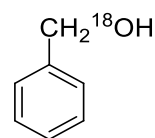
P



Q



R



S

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

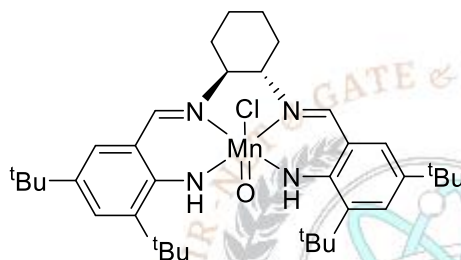
76. The correct order of rate for the given isotope exchange reaction is



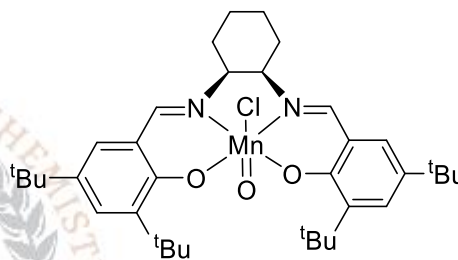
- (a) Fe > Mn > Cr (b) Mn > Fe > Cr (c) Fe > Cr > Mn (d) Cr > Mn > Fe

77. The structure of active catalyst involved in Jacobsen asymmetric epoxidation is

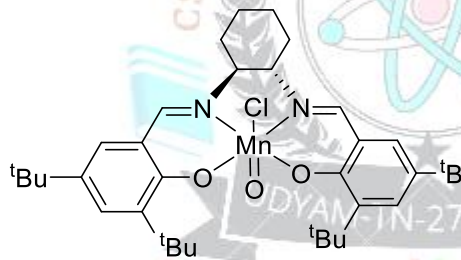
(a)



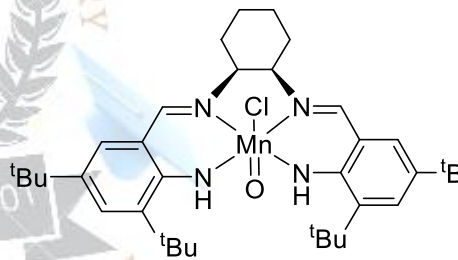
(b)



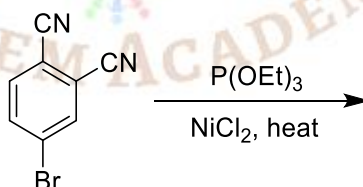
(c)



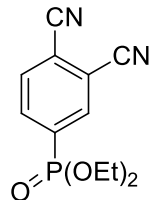
(d)



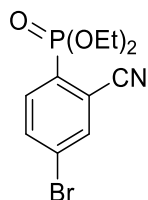
78. The major product formed in the following reaction is



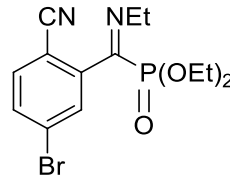
(a)



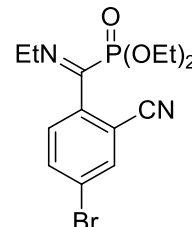
(b)



(c)

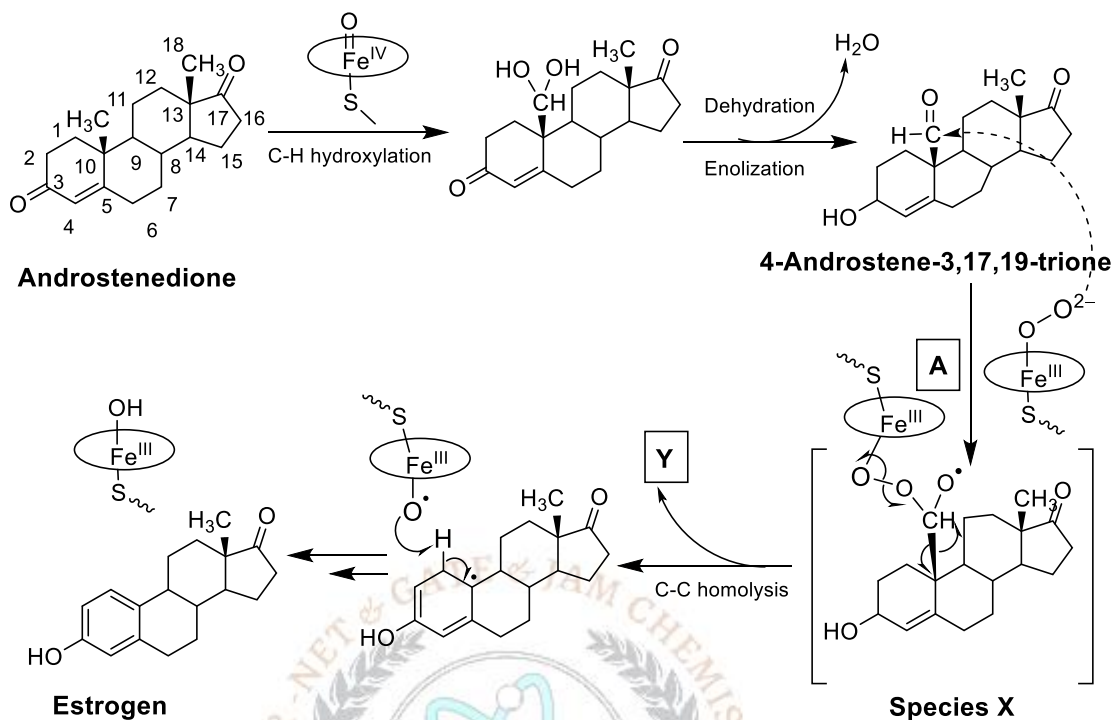


(d)



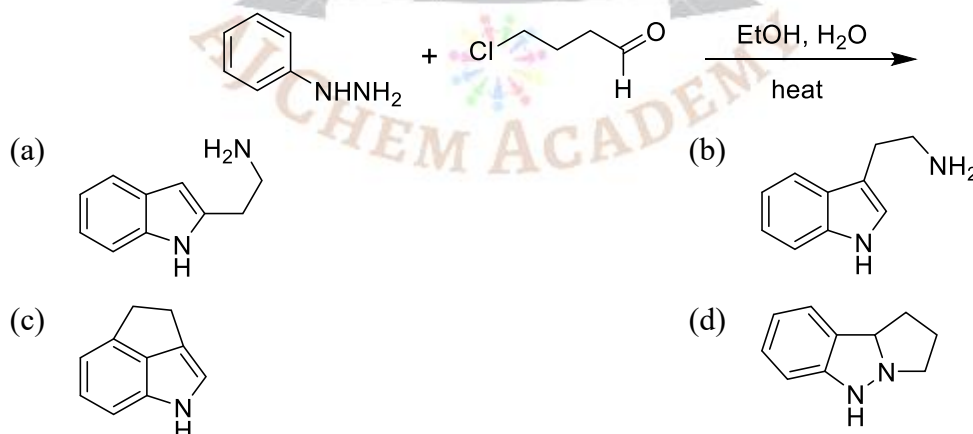
79. The synthesis of Estrogen from Androstenedione in humans is catalysed by aromatase which is a **cytochrome-P450 enzyme**. In the reaction mechanism described below, the missing reaction **step-A**, description of the intermediate species **X**, and chemical species **Y**, respectively, are





- (a) Electrophilic attack, peroxide, and CO_2
 (b) Nucleophilic attack, peroxyhemiacetal, and CO_2
 (c) Nucleophilic attack, peroxyhemiacetal, and HCOO^-
 (d) Electrophilic attack, peroxide, and HCOO^-

80. The **major product** formed in the following reaction is



81. The table below contains the following compounds with their characteristics

	Compounds		Oxidation state of phosphorus		Number of acidic hydrogens
W.	Hypophosphoric acid	P.	5	i.	2
X.	Pyrophosphorous acid	Q.	1	ii.	3
Y.	Hypophosphorous acid	R.	4	iii.	4



Z. | Orthophosphoric acid | S. | 3 | iv. | 1

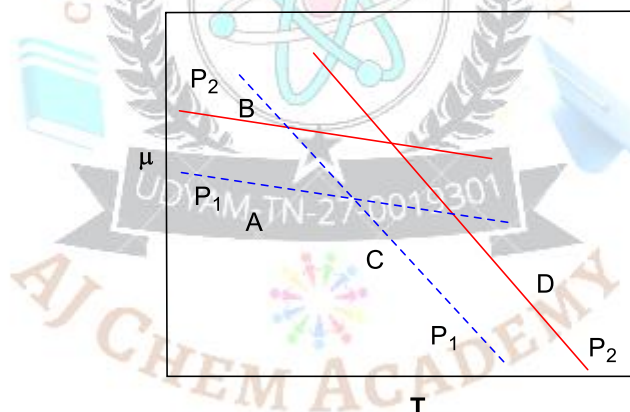
The option with the correct match is

- (a) W-R-iii ; X-S-i ; Y-Q-iv ; Z-P-ii
 (b) W-S-ii ; X-R-iii ; Y-Q-iv ; Z-P-i
 (c) W-P-ii ; X-R-iv ; Y-Q-i ; Z-S-iii
 (d) W-R-iii ; X-S-ii ; Y-Q-iv ; Z-P-i

82. The catalytic intermediate species involved in the Wacker process are

- (a) Pd-vinyl alcohol, Pd- β -hydroxyethyl, Pd-ethylene
 (b) Pd- β -hydroxyethyl, Pd-vinyl alcohol, Pd-acyl
 (c) Pd-dioxygen, Pd- β -hydroxyethyl, Pd-ethylene
 (d) Pd- β -hydroxyethyl, Pd-vinyl alcohol, Pd-dioxygen

83. The following figure shows the variation of chemical potential (μ) of a pure substance in its liquid or solid form with temperature, when the pressure is increased from p_1 to p_2 . The lines A, B, C, D shown in the figure are at constant pressure p_1 or p_2 .

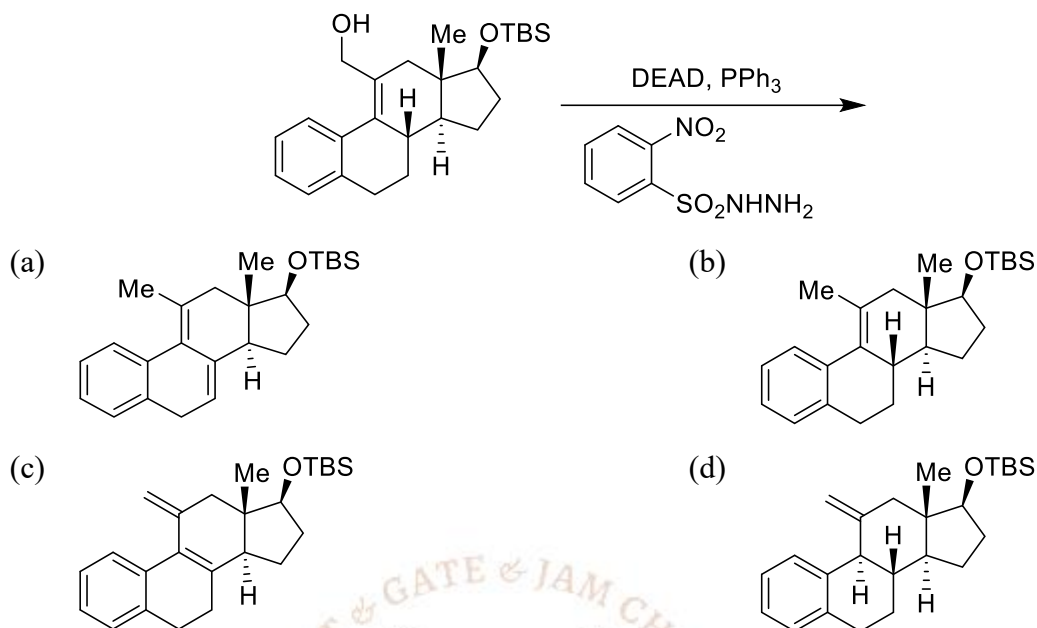


The correct option about the information shown in this figure is

- (a) A is for ice and C is for liquid water; $S_m(C) = \left(\frac{\partial \mu_C}{\partial P}\right)_T$
 (b) A and B are for an organic liquid; $V_m(B) = \left(\frac{\partial \mu_B}{\partial T}\right)_P$
 (c) A and B are for ice; $S_m(B) = -\left(\frac{\partial \mu_B}{\partial T}\right)_P$
 (d) A is for solid and C is for liquid form of an organic substance; $S_m(A) = -\left(\frac{\partial \mu_A}{\partial T}\right)_P$

84. The major product formed in the following reaction is





85. Consider the following statements related to the **glass transition temperature (T_g)** of a polymer.

P. T_g of the polymer increases with its molecular weight

Q. T_g of the polymer increases upon addition of a plasticizer

R. T_g of the polymer is always lower than its melting temperature (T_m)

The correct complete set of options is

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

86. Consider the following outer-sphere electron transfer reaction:

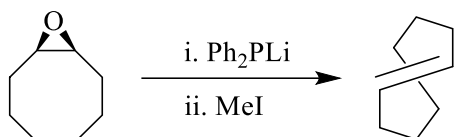


[Given: at 25 °C, E° for $\text{MnO}_4^-/\text{MnO}_4^{2-} = 0.56 \text{ V}$, $[\text{Fe}(\text{CN})_6]^{3-}/[\text{Fe}(\text{CN})_6]^{4-} = 0.36 \text{ V}$; Self exchange rate constant, k_{11} for Mn complex = $3600 \text{ M}^{-1}\text{s}^{-1}$, Self exchange rate constant, k_{22} for Fe complex = $300 \text{ M}^{-1}\text{s}^{-1}$. Assume correction factor, $f_{12} = 1$]

The cross-exchange rate constant ($k_{12}, \text{M}^{-1}\text{s}^{-1}$) for the given reaction is

- (a) 1.8×10^3 (b) 4.8×10^6 (c) 5.1×10^4 (d) 2.5×10^5

87. In the following reaction, formation of the **alkene** occurs through



- (a) a cis intermediate undergoing an anti-elimination
 (b) a trans intermediate undergoing an anti-elimination
 (c) a cis intermediate undergoing a syn-elimination



(d) a trans intermediate undergoing a syn-elimination

88. A nonlinear polyatomic molecule belongs to D_{2d} point group. The character table of the point group is given below.

D_{2d}	E	$2S_4$	C_2	$2C_2'$	$2\sigma_d$
A_1	1	1	1	1	1
A_2	1	1	1	-1	-1
B_1	1	-1	1	1	-1
B_2	1	-1	1	-1	1
E	2	0	-2	0	0

The symmetry of one of the normal modes is E. The symmetry of the second excited state of this mode in terms of the irreducible representations of the point group of the molecule is

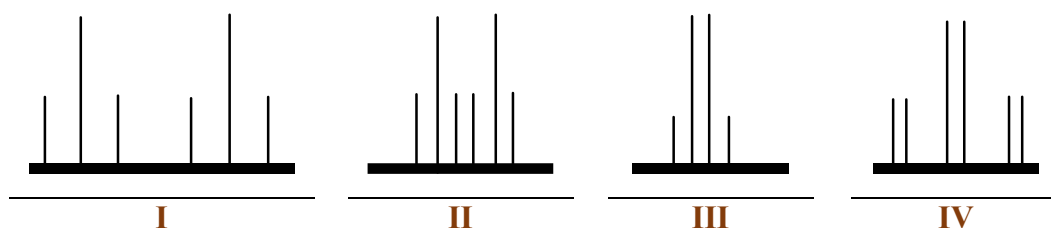
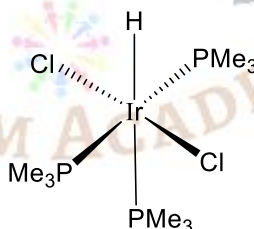
- (a) $2A_1 + 2B_2$ (b) $2A_1 + B_1 + B_2$ (c) $A_2 + 2B_1 + B_2$ (d) $A_1 + A_2 + B_1 + B_2$

89. The energy (in units of $\frac{h^2}{8mL^2}$) of the ground state of a system of six non-interacting electrons, confined in a 3-dimensional box with lengths $L, L/2$ and $L/4$, is

- (a) 74 (b) 126 (c) 156 (d) 148

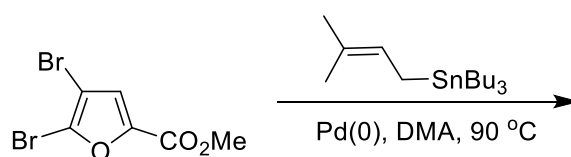
90. The $^1\text{H-NMR}$ spectral pattern in the hydride region for the given compound,

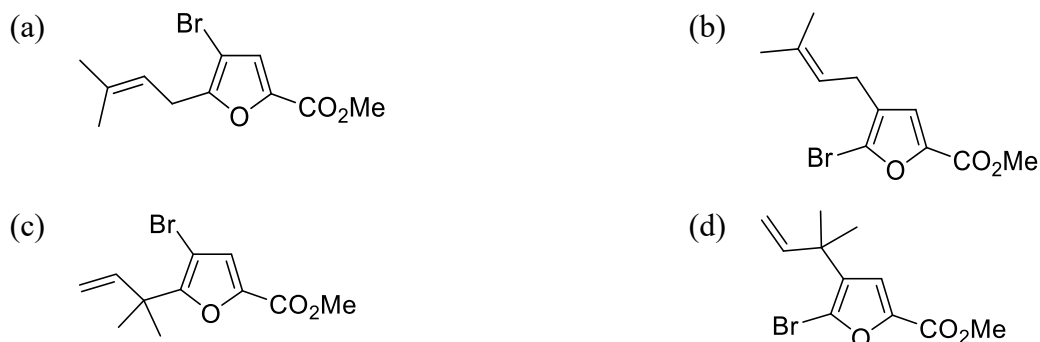
[Given, ^{31}P : I = 1/2, 100%; ^1H : I = 1/2, 99.98%]



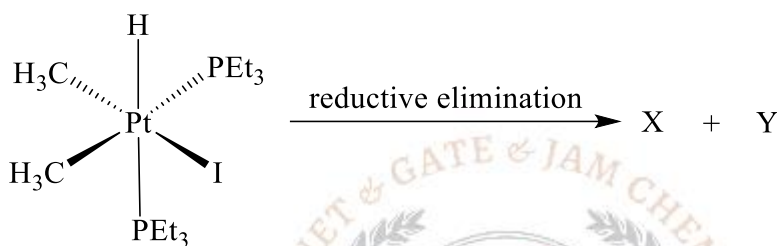
- (a) IV (b) I (c) III (d) II

91. The major product formed in the following reaction is

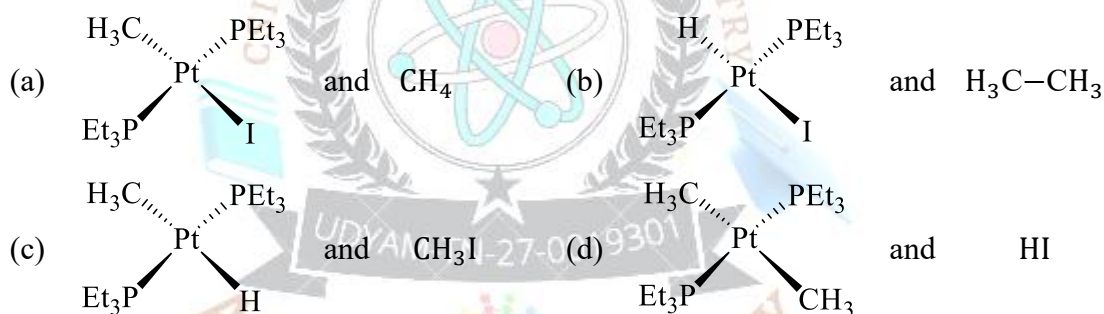




92. Consider the following reaction



The most likely products X and Y, respectively, are



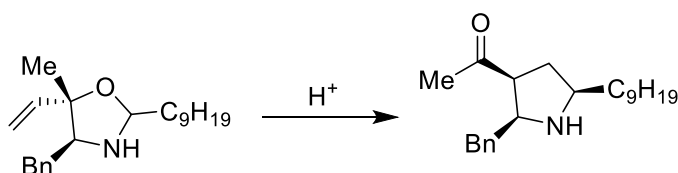
93. A metal can exist in two different crystalline forms: **face centered cubic (fcc)** lattice and **body centered cubic (bcc)** lattice with unit cell edge lengths of 2\AA and 4\AA , respectively. The ratio of the density of the fcc lattice to that of the bcc lattice is

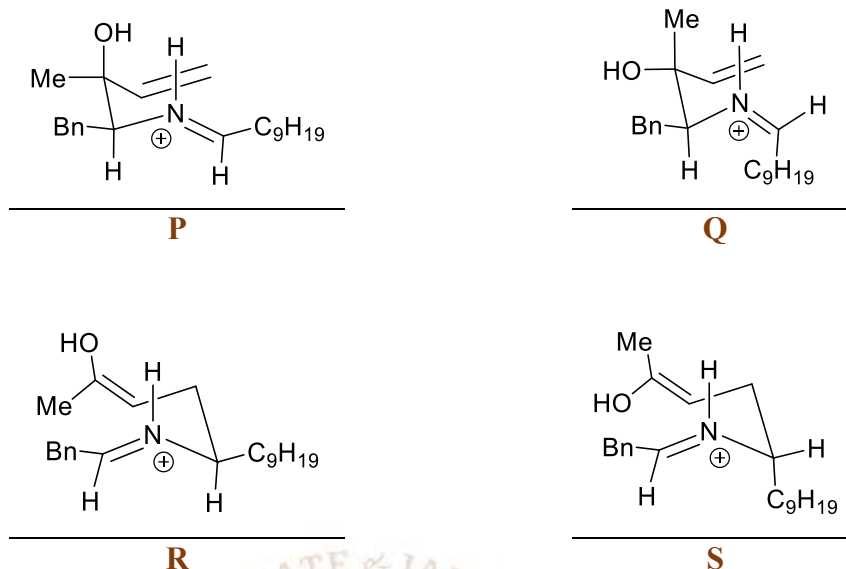
- (a) 2 (b) 8 (c) 4 (d) 16

94. Given the trial wavefunction $\phi(\mathbf{x}) = a e^{-ax^2} + b e^{-\beta|\mathbf{x}|}$ for the system having potential $V(\mathbf{x}) = \frac{1}{2} m \omega^2 x^2$, the variationally optimized ground-state energy of the system is obtained with the parameters

- (a) $a = 1, b = 0$ (b) $a = 1/\sqrt{2}, b = 1/\sqrt{2}$ (c) $a = 0, b = 1$ (d) $a = 1, b = 1$

95. In the **intermediate** involved in following reactions are



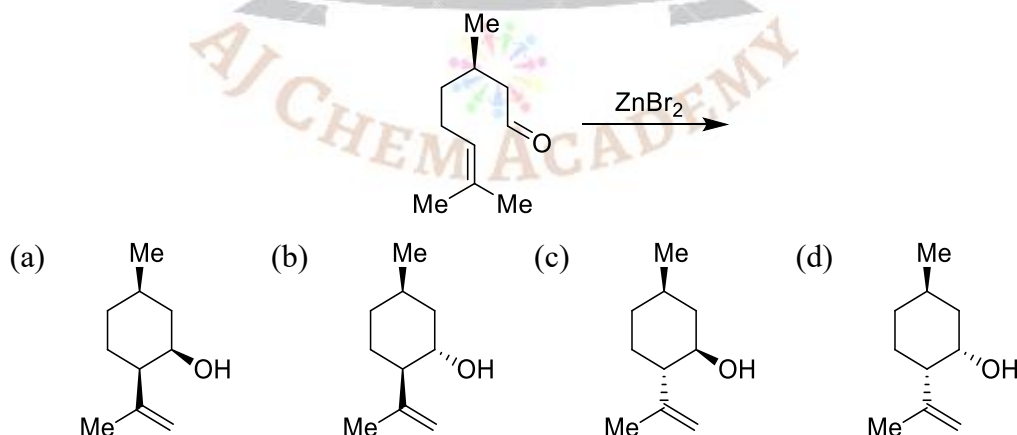


- (a) P and S (b) Q and R (c) P and R (d) Q and S

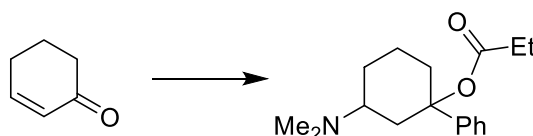
96. A graph of **surface tension** of an aqueous solution of a surfactant as a function of concentration gives a slope $\left[\frac{dy}{d \ln(c/c^\circ)} \right]$ of $-4.8 \times 10^{-3} \text{ N m}^{-1}$ at **289 K**. The area (in \AA^2) occupied by each surfactant molecule at the surface is closest to

$$[c^\circ = 1 \text{ mol L}^{-1}]$$

- (a) 41 (b) 62 (c) 83 (d) 104
97. The **major products** formed in the following reaction is



98. The correct sequence of **reagents** to effect the following transformation is

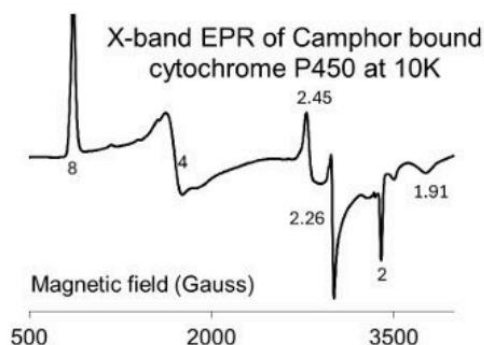


- (a) PhLi; Me₂NH/Et₂O; (EtCO)₂O/pyridine
 (b) PhLi; (EtCO)₂O/pyridine; Me₂NH/Et₂O
 (c) Me₂NH/Et₂O; PhLi; (EtCO)₂O/pyridine



(d) $\text{Me}_2\text{NH}/\text{Et}_2\text{O}$; $(\text{EtCO})_2\text{O}/\text{pyridine}$; PhLi

99. The X-band EPR spectrum of camphor-bound cytochrome-P450 at 10 K shows a mixture of high-spin and low-spin ferric species.



The correct set of g -values for the high-spin and low-spin species, respectively, are

- | High spin | Low spin | High spin | Low spin |
|-------------------|----------------------|-------------------|-------------------|
| (a) 8, 4, 2 | and 2.45, 2.26, 1.91 | (b) 8, 4, 2.26 | and 2.45, 2, 1.91 |
| (c) 8, 2.45, 2.26 | and 4, 2, 1.91 | (d) 4, 2.45, 2.26 | and 8, 2, 1.91 |
100. After 5 measurements, the length of an object is 20 ± 1 cm (mean \pm standard error). The number of measurements needed to achieve a standard error of 0.25 cm is
- (a) 10 (b) 20 (c) 40 (d) 80
101. The structures of $[\text{B}_5\text{H}_{11}]$, $[\text{C}_2\text{B}_{10}\text{H}_{12}]$ and $[\text{B}_{11}\text{H}_{14}]^-$, respectively, are
- (a) nido, arachno, closo (b) nido, closo, arachno
 (c) arachno, closo, nido (d) arachno, nido, closo
102. The observed frequencies of first and third overtones of a gaseous diatomic molecule are 1050 cm^{-1} and 2068 cm^{-1} , respectively. The magnitude of (dimensionless) anharmonicity constant is closest to
- (a) 3.5×10^{-3} (b) 5.5×10^{-3} (c) 7.5×10^{-3} (d) 9.5×10^{-3}
103. The energies, E_{\pm} (in atomic units) of bonding (+) and antibonding (-) MOs of H_2^+ , obtained by linear combination of 1s orbitals of H-atoms (utilizing variation principle), are $J = \langle 1s_A | -\frac{1}{r_B} | 1s_A \rangle + \frac{1}{R}$, $K = \langle 1s_A | -\frac{1}{r_A} | 1s_B \rangle + \frac{S}{R}$, $S = \langle 1s_A | 1s_B \rangle$
- R is the internuclear distance
- (a) $-1 - J \pm K$ (b) $-\frac{1}{2} - \frac{J \pm K}{1 \pm S}$ (c) $-1 + \frac{J \pm K}{1 \pm S}$ (d) $-\frac{1}{2} + \frac{J \pm K}{1 \pm S}$
104. The mean molar volume (V_m) of a binary solution of liquid A and liquid B is given by,
- $$V_m = a + bx + c(x - 0.5)^2$$



Where x is the mole fraction of liquid B and a , b and c are constants. The partial molar volume of A is given by

- (a) $b + 2cx - c$ (b) $a + cx^2 - \frac{c}{4}$ (c) $a - cx^2 + \frac{c}{4}$ (d) $b + cx^2 - ax$

105. Given below are the oxohalide ions (column I), and their bond lengths (column II) and bond angle (column III)

	oxohalide ions	X-O (pm)	O-X-O angle
X.	ClO_3^-	P. 165	i. 100°
Y.	BrO_3^-	Q. 149	ii. 107°
Z.	IO_3^-	R. 181	iii. 104°

The option with the correct match is

- (a) W-R-ii ; X-P-i ; Y-Q-iii
 (b) W-Q-i ; X-R-iii ; Y-P-ii
 (c) W-R-iii ; X-Q-i ; Y-P-ii
 (d) W-Q-ii ; X-P-iii ; Y-R-i

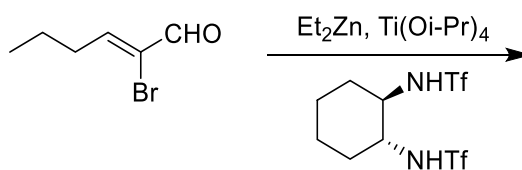
106. The following electrocyclic ring closing reaction is



P. 4 electron conrotatory ring closure Q. 4 electron disrotatory ring closure
 R. allowed under thermal condition S. allowed under photochemical condition

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

107. The major products formed in the following reaction is



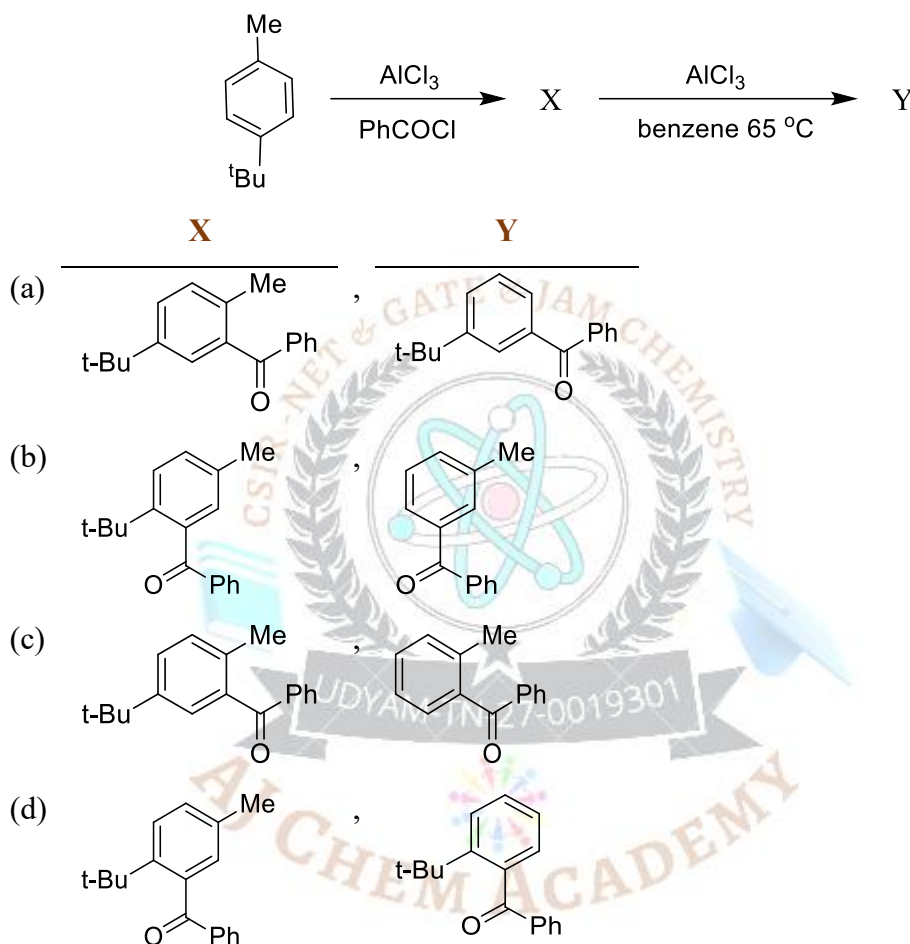
- (a) (b) (c) (d)



108. The **Raschig reaction**, involving oxidation of NH_3 with NaOCl , produces **P**, which upon treatment with KIO_3 and HCl , forms KCl , water, compounds **Q** and **R**. The compounds **P**, **Q** and **R**, respectively, are

- (a) $\text{NCl}_3, \text{Cl}_2, \text{I}_2$ (b) $\text{N}_2\text{H}_4, \text{N}_2, \text{ICl}$ (c) $\text{N}_2\text{H}_4, \text{O}_2, \text{I}_2$ (d) $\text{NCl}_3, \text{N}_2, \text{ICl}$

109. The **major products X** and **Y** formed in the following reaction sequence are



110. The correct sequence of reagent addition for the **qualitative analysis** of Pb^{2+} , Cd^{2+} , Sr^{2+} and Ni^{2+} ions in an aqueous solution of a mixture of their nitrate containing salts is

- | | i | ii | iii | iv |
|-----|--|--|--|--|
| (a) | $\text{HCl}_{(\text{aq})}$ | $\text{H}_2\text{S}_{(\text{acidic})}$ | $\text{H}_2\text{S}_{(\text{basic})}$ | $(\text{NH}_4)_2\text{CO}_3_{(\text{aq})}$ |
| (b) | $\text{H}_2\text{S}_{(\text{acidic})}$ | $\text{H}_2\text{S}_{(\text{basic})}$ | $\text{HCl}_{(\text{aq})}$ | $(\text{NH}_4)_2\text{CO}_3_{(\text{aq})}$ |
| (c) | $(\text{NH}_4)_2\text{CO}_3_{(\text{aq})}$ | $\text{H}_2\text{S}_{(\text{acidic})}$ | $\text{H}_2\text{S}_{(\text{basic})}$ | $\text{HCl}_{(\text{aq})}$ |
| (d) | $\text{HCl}_{(\text{aq})}$ | $\text{H}_2\text{S}_{(\text{basic})}$ | $\text{H}_2\text{S}_{(\text{acidic})}$ | $(\text{NH}_4)_2\text{CO}_3_{(\text{aq})}$ |



(d) W-R-i , X-Q-iii , Y-P-ii

116. An enzyme (E) catalyzes the conversion of a substrate (S) to product (P) according to



Applying steady state approximation to ES and ES', the expression for the rate of reaction is

[[E]₀ and [S]₀ are initial concentration of enzyme and substrate, respectively and [S]₀ ≫ [E]₀]

(a) $k_3[E]_0[S]_0$ (b) $\frac{k_1k_2[E]_0[S]_0}{(k_{-1}+k_2)+k_1[S]_0}$ (c) $\frac{k_1k_2[E]_0[S]_0}{(k_{-1}+k_2)+k_1\left(1+\frac{k_2}{k_3}\right)[S]_0}$ (d) $\frac{k_1k_2[E]_0[S]_0}{(k_{-1}+k_2)+k_2\left(1+\frac{k_1}{k_3}\right)[S]_0}$

117. The total number of isomers including pair(s) of enantiomers for the octahedral complex with the general formula **Ma₂b₂cd** is

- (a) 6 including 1 pair (b) 6 including 2 pairs
(c) 8 including 1 pair (d) 6 including 2 pairs

118. Consider the following statements about hemerythrin

P. Non-heme binuclear iron centers linked by two bridging carboxylate groups

Q. Heme protein coordinated by amino acid side chains

R. Coordination of O₂ occurs at only one of the Fe atoms

S. Identical active site is found in methane monooxygenase, acid phosphatases, and some ribonucleotide reductases

The option with all correct statements is

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

119. Given below are enzymes (column-I), the metal in their active sites (column-II) and the class of reactions they catalyse (column-III)

	Column-I		Column-II		Column-III
W.	Catalase	P.	Cu	i.	Hydrolysis reaction
X.	Urease	Q.	Cu and Fe	ii.	Decomposition reaction
Y.	Cytochrome c-oxidase	R.	Fe	iii.	Phenol to quinone
Z.	Laccase	S.	Ni	iv.	Oxygen to water

The option with the correct match is

- (a) W-Q-ii , X-S-i , Y-P-iv , Z-R-iii
(b) W-Q-iii , X-R-iv , Y-S-i , Z-P-ii
(c) W-R-iv , X-P-iii , Y-Q-i , Z-S-ii
(d) W-R-ii , X-S-i , Y-Q-iv , Z-P-iii



120. The Hamiltonian of a two-dimensional quantum harmonic oscillator is

$$H = \frac{p_x^2}{2m} + \frac{p_y^2}{2m} + \frac{1}{2}m\omega^2 y^2 + 2m\omega^2,$$

Where m and ω are positive constants. The degeneracy of the level with energy $E =$

$$\frac{25}{2}\hbar\omega \text{ is}$$

(a) 5

(b) 6

(c) 7

(d) 8

Answer Key

Part - B

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

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

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

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

Part - C

Q.No	Ans
61.	c
62.	c
63.	b
64.	d
65.	a
66.	b

Q.No	Ans
76.	b
77.	c
78.	a
79.	c
80.	b
81.	a

Q.No	Ans
91.	a
92.	a
93.	d
94.	a
95.	c
96.	c

Q.No	Ans
106.	d
107.	a
108.	b
109.	c
110.	a
111.	b



67.	d
68.	a
69.	c
70.	b
71.	a
72.	d
73.	b
74.	b
75.	b

82.	a
83.	d
84.	d
85.	b
86.	*
87.	d
88.	d
89.	d
90.	b

97.	c
98.	c
99.	a
100.	d
101.	c
102.	c
103.	d
104.	c
105.	d

112.	d
113.	b
114.	b
115.	a
116.	c
117.	d
118.	d
119.	d
120.	b

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