PAPER : CSIR-UGC-NET/JRF DEC. 2025

CHEMICAL SCIENCES

PART-B

21. The rate (ν) of the reaction $A + 2B \longrightarrow P$ is given by

$$\nu = k[A][P]$$

If initial concentrations of A and B are 2 mM and 4 mM, respectively, and k = 0.1 mol^{-1} 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

22. The reaction NOT falling under the category of acid-base reaction is

(a) $HClO_4 + CH_3CN \rightarrow [CH_3CNH]^+[ClO_4]^-$ (b) $NOF + ClF_3 \longrightarrow [NO]^+[ClF_4]^-$

(c) $XeO_3 + OH^- \longrightarrow [HXeO_4]^-$ (d) $Pt + XeF_4 \longrightarrow PtF_4 + Xe$

23. 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

24. The option with the correct fragments that are isolobal with "S" atom

A. CpCo(CO) **B.** $CpFe(CO)_2$ **C.** $Cr(CO)_5$ **D.** CH_3^+

is

(a) A, B, and C only (b) A, C, and D only

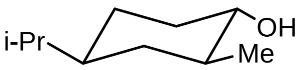
(c) B, C, and D only (d) A, B, and D only

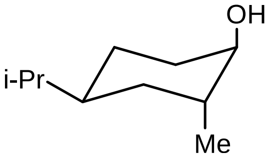
25. The partition function of two indistinguishable noninteracting particles, where one or both can occupy any of the two available energy levels 0 and ε is

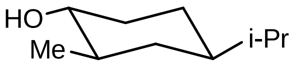
(a) $1 + e^{-\varepsilon/k_BT} + e^{-2\varepsilon/k_BT}$ (b) $2 + e^{-\varepsilon/k_BT} + e^{-2\varepsilon/k_BT}$

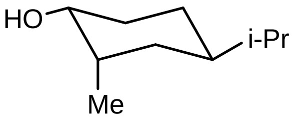
(c) $1 + 2e^{-\varepsilon/k_BT} + e^{-2\varepsilon/k_BT}$ (d) $1 + e^{-\varepsilon/k_BT} + 2e^{-2\varepsilon/k_BT}$

26. The structure that corresponds to (1S,2R,4S)-4-isopropyl-2-methylcyclohexanol is

(a)


(b)


(c)


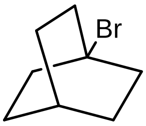
(d)


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

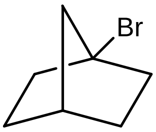
(a) $[O_2]^+, O_2F_2, H_2O_2, [O_2]^{2-}$ (b) $O_2F_2, [O_2]^+, H_2O_2, [O_2]^{2-}$

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

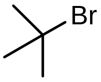
28. The correct order of the relative rates of solvolysis for the following compounds in 80% aqueous ethanol at 25 °C is



(A)



(B)



(C)

(a) A > B > C (b) B > C > A (c) C > A > B (d) C > B > A

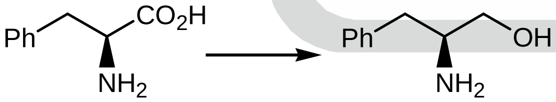
29. The expression for fraction surface coverage (θ_A) for the dissociative adsorption, $A_2(g) \longrightarrow 2A(\text{surface})$. In the presence of an inhibitor $I(Ig) \rightarrow I(\text{surface})$)competing for the same site, is

[**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 ith gas]

(a) $\dfrac{K_A^{1/2} p_{A_2}^{1/2}}{\left(1+K_A^{1/2} p_{A_2}^{1/2}\right)\left(1+K_I p_I\right)}$ (b) $\dfrac{K_A^{1/2} p_{A_2}^{1/2} K_I p_I}{\left(1+K_A^{1/2} p_{A_2}^{1/2}\right)\left(1+K_I p_I\right)}$

(c) $\dfrac{K_A^{1/2} p_{A_2}^{1/2} K_I p_I}{\left(1+K_A^{1/2} p_{A_2}^{1/2}+K_I p_I\right)}$ (d) $\dfrac{K_A^{1/2} p_{A_2}^{1/2} K_I p_I}{\left(1+K_A^{1/2} p_{A_2}^{1/2}+K_I p_I\right)}$

30. The correct reagent(s) to effect the following transformation is(are)



(A) Pd/C, H_2 (1 atm) (B) $NaBH_4$, $ZnCl_2$ (C) $LiAlH_4$ (D) $BH_3.Me_2S$

(a) Only A (b) Only B and C

(c) Only B, C and D (d) Only A, B and D

31. $C_3^2\, i$ is equivalent to

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

32. $\psi(x_1, x_2)$ 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

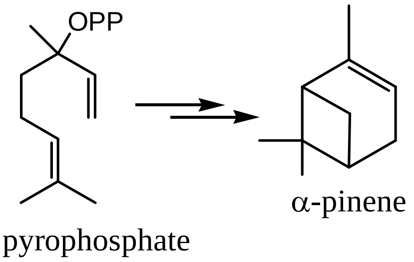
(a) $\psi(x_1,x_2)=\left(x_1^2-x_2^2\right)e^{-\left(x_1^2+x_2^2\right)}$ (b) $\psi(x_1,x_2)=\left(x_1^2+x_2^2\right)e^{-\left(x_1^2-x_2^2\right)}$

(c) $\psi(x_1,x_2)=\left(x_1-x_2\right)^2 e^{-\left(x_1^2+x_2^2\right)}$ (d) $\psi(x_1,x_2)=\left(x_1+x_2\right)^2 e^{-\left(x_1^2-x_2^2\right)}$

33. An element $^{27}_{13}A$ is bombarded with two α-particles to give B with the emission of a neutron. The element B is

(a) $^{30}_{15}B$ (b) $^{35}_{17}B$ (c) $^{24}_{17}B$ (d) $^{32}_{16}B$

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



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

B. four-membered ring formation

C. loss of H^+

(a) A, B, C (b) A, C, B (c) B, C, A (d) B, A, C

35. n moles of a perfect monoatomic gas with volume V_1 undergoes an adiabatic free expansion to a final volume $V_2 = 5V_1$. The change in entropy (in J K^{-1} mol^{-1}) of the gas is

[**Given:** R = 8.314, JK^{-1} mol^{-1}]

(a) 0 (b) 13.38 (c) 1.61 (d) 8.31

36. 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

37. Consider the following statements:

A. Schottky defects decrease the density of the crystal

B. Schottky defects create vacancy pair(s)

C. Alkali metal halides exhibit Frenkel defect

The option containing correct statement(s) is

(a) Only A (b) Both A and B (c) Both B and C (d) Both A and C

38. Consider the following statements regarding the extraction and separation of lanthanoids from Monazite

A. Monazite is primarily PO_4^{3-} salt of Ln

B. Monazite contains Th along with Ln

C. Ln^{3+} ions are separated by using ion-exchange columns

D. Ln^{3+}ions are eluted from the column by using an aqueous acidic solution of H_4EDTA

The option with all correct statements is

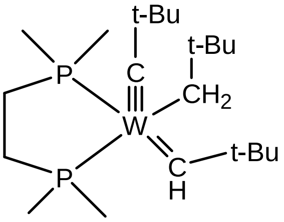
(a) A, B, and D only (b) B, C, and D only

(c) A, C, and D only (d) A, B, and C only.

39. The point groups of $\left[\mathrm{Re_2\,Cl_8}\right]^{2-}$ and *trans*-$\left[\mathrm{Co(en)_2\,Cl_2}\right]^{+}$, 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}

40. The correct option of bond lengths (Å) of the metal-alkylidene and metal-alkylidyne, respectively, and the corresponding ^{13}C NMR chemical shifts (ppm) of the complex below



(a) 1.78, 1.94 and 296, 256 (b) 1.94, 1.78 and 256, 296

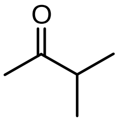
(c) 1.94, 1.78 and 296, 256 (d) 1.78, 1.94 and 256, 296

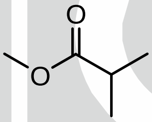
41. Among the following, the amino acid residue in histone that gets acetylated is

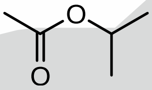
(a) Alanine (b) Glycine (c) Phenylalanine (d) Lysine

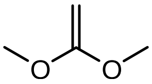
42. The compound that would give the following data is

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

(a) 

(b) 

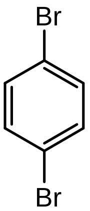
(c) 

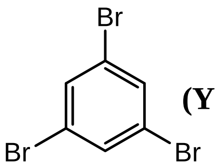
(d) 

43. 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

44. The relative intensity of molecular ion peaks in the mass spectra of compunds X and Y, respectively, is

(X) 

 **(Y)**

(a) 9:6:1 and 1:2:2:1 (b) 1:2:1 and 1:2:2:1

(c) 9:6:1 and 1:3:3:1 (d) 1:2:1 and 1:3:3:1

45. For the wavefunction, $\psi(x) = A\exp\left(\dfrac{-x^4}{a^4} + ikx\right)$, the ratio of probability density at $x = a$ to that at $x = 2a$ is [Given: $-\infty \le x \le \infty$]

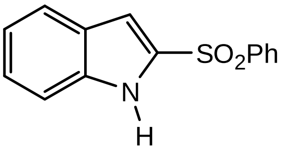
(a) e^{6} (b) e^{2} (c) 2 (d) e^{30}

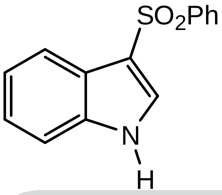
46. The approximate ground-state energy of He-isoelectronic series is given by $E(z) = -Z^2 + \frac{5}{8}Z - 0.1576 + \frac{0.0087}{z}$. According to Valence Bond Theory, the expression for binding energy of H_2 from H^- and H^+ $\left(H_2 \rightarrow H^- + H^+\right)$ can be approximated to

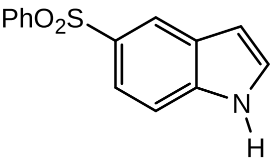
[Given : *J*, *K* and *S* represent Coulomb, exchange and overlap intergrals, respectively. Energies are expression in atomic unit]

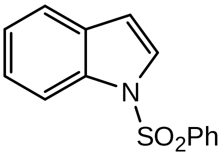
(a) $0.5239 - \frac{J+K}{1-S^2}$ (b) $0.4761 + \frac{J-K}{1-S^2}$ (c) $0.4761 - \frac{J+K}{1+S^2}$ (d) $0.5239 + \frac{J+K}{1+S^2}$

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

(a) 

(b) 

(c) 

(d) 

48. Consider the following statements about H_2S generation using Kipp's apparatus

A. The reagents used are FeS and dil. H_2SO_4

B. The reagents used are FeS and conc. HNO_3

C. H_2S can be prepared intermittently (on-demand)

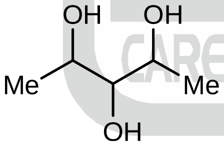
D. Kipp's apparatus consists of three chambers

The option with the correct statements is

(a) B, C and D only (b) A and D only

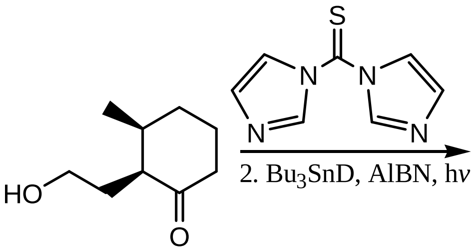
(c) A, C and D only (d) B and C only

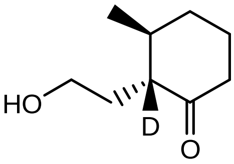
49. The number of optically active stereoisomers for the following compound is

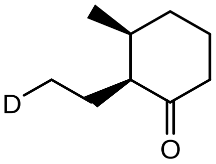


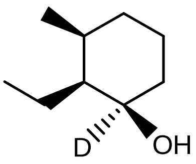
(a) 2 (b) 4 (c) 6 (d) 8

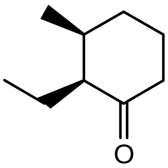
50. The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

51. For a hermitian operator, $\hat{A}$, consider the following statements

(I) $\hat{A}$ has real eigenvalues.

(II) $\langle \hat{A} \rangle$, with respect to any arbitrary state, is always ≥ 0

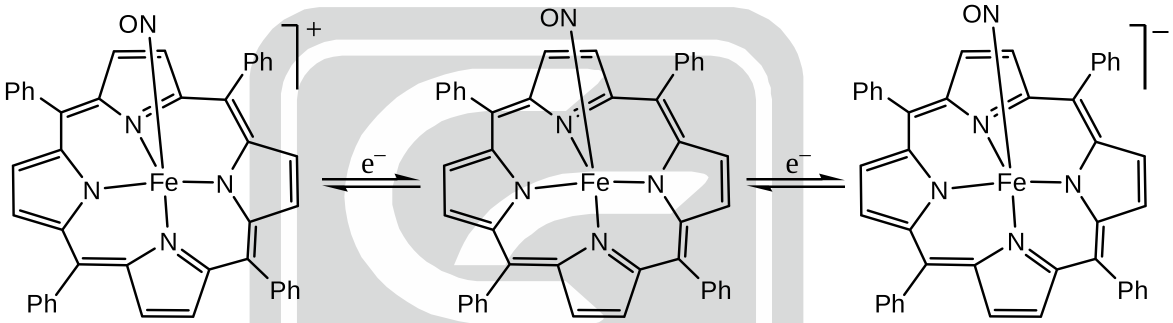
(III) $\langle \hat{A}^2 \rangle$, with respect to any arbitrary state, is always is ≥ 0

(IV) $\hat{A}$ always commutes with another hermitian operator.

The correct complete set of options is

(a) I only (b) I, II and III (c) I, II, III, IV (d) I and III only

52. For the reaction sequence given below, the correct statement for the doubly reduced species (showing N-O frequency of 1496 cm^{-1})



N–O frequency 1844 cm^{-1} 1676 cm^{-1} 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

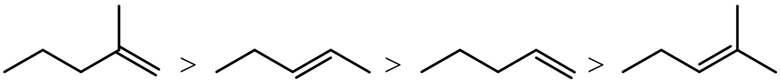
53. In the standard state at 25 ºC, upon reversing the electrodes of the following electrochemical cells, Ag(s) will be deposited on the cathode of

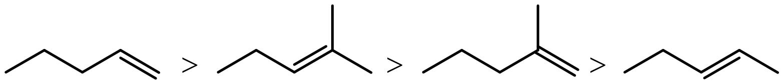
Cell	Anode	Cathode
A	$AgBr / Ag, Br^-$	$AgCl / Ag, Cl^-$
B	$AgBr / Ag, Br^-$	$AgI / Ag, I^-$
C	$AgCl / Ag, Cl^-$	$AgI / Ag, I^-$

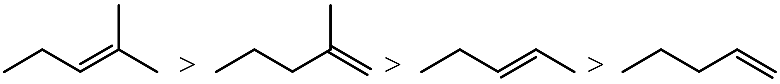
[**Given:** at 25 ºC, E^0 (in V) = +0.22 ($AgCl/Ag, Cl^-$), +0.07 ($AgBr/Ag, Br^-$); –0.15)]

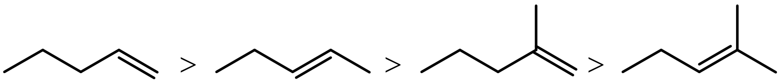
(a) A (b) B and C (c) C, but not B (d) A, B and C

54. The relative reactivity of alkenes for the cobalt-catalyzed hydroformylation reaction follows the order

(a) 

(b) 

(c) 

(d) 

55. 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) $Ph_3PO > Me_3PO > F_3PO > Cl_3PO$

56. The peak of an absorption spectrum of a molecule is observed at 21,000 cm^{-1}.

[Given: $k_B = 8.62 \times 10^{-5}\ \text{eVK}^{-1}$; 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.

57. The correct statement about the bond angles of $^{\bullet}CF_3$ and $^{\bullet}CH_3$ is

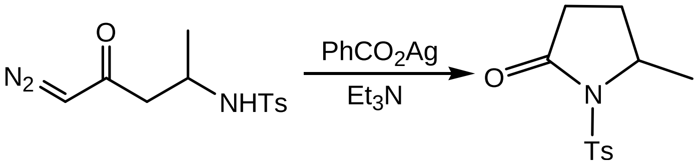
(a) $^{\bullet}CF_3 < {}^{\bullet}CH_3$ due to $n \rightarrow \sigma^*$ interaction in $^{\bullet}CF_3$.

(b) $^{\bullet}CF_3 > {}^{\bullet}CH_3$ due to $n \rightarrow \sigma^*$ interaction in $^{\bullet}CF_3$.

(c) $^{\bullet}CF_3 < {}^{\bullet}CH_3$ due to bond pair-bond pair repulsion in $^{\bullet}CF_3$.

(d) $^{\bullet}CF_3 > {}^{\bullet}CH_3$ due to bond pair-bond pair repulsion in $^{\bullet}CF_3$.

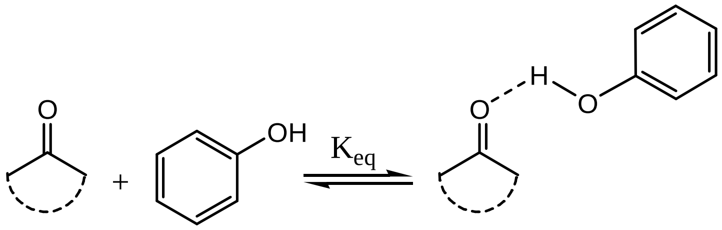
58. The intermediates involved in the following transformation are

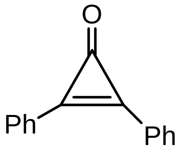
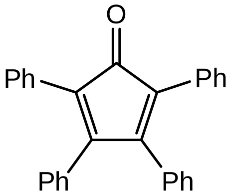
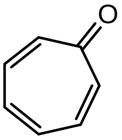


A. carbocation; B. carbanion; C. carbene; D. ketene

(a) B and C (b) C and D (c) A and C (d) B and D

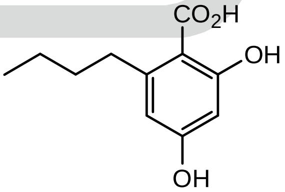
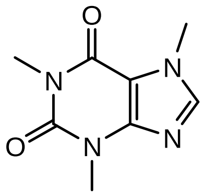
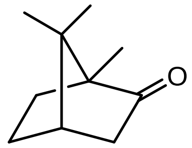
59. The correct match for the ketones in **Column-A** with the K_{eq} values in **Column-B** for their H-bonding with phenol (as shown below) is



Column-A	**Column-B**
(P) 	(I) 6.2
(Q) 	(II) 31.2
(R) 	(III) 83.2

(a) P-I, Q-II, R-III (b) P-III, Q-I, R-II (c) P-III, Q-II, R-I (d) P-II, Q-I, R-III

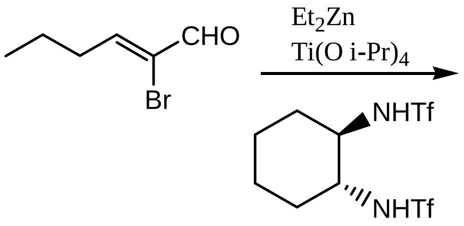
60. The correct match of class of ntural products in Column-A with the compounds in Column-B is

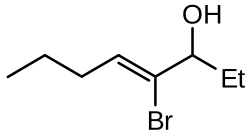
Column-A	Column-B
(P) alkaloid	(I) 
(Q) Terpenoid	(II) 
(R) Polyketide	(III) 

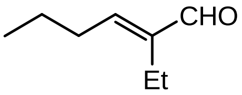
(a) P-I, Q-III, R-II (b) P-II, Q-I, R-III (c) P-II, Q-III, R-I (d) P-III, Q-II, R-I

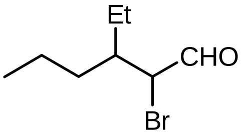
PART-C

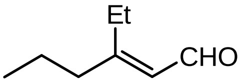
61. The major product formed in the following reaction is



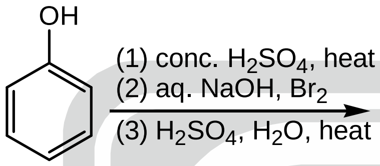
(a) 

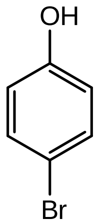
(b) 

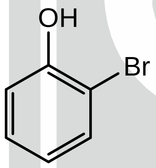
(c) 

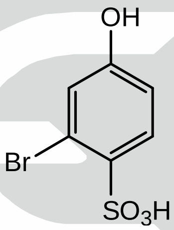
(d) 

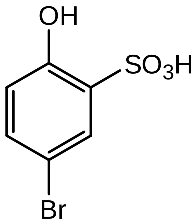
62. The major product formed in the following reaction sequence is



(a) 

(b) 

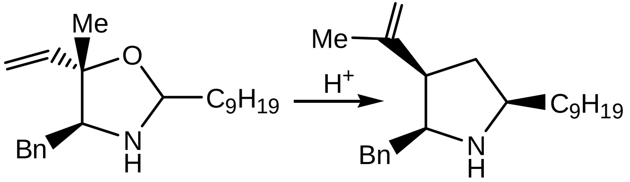
(c) 

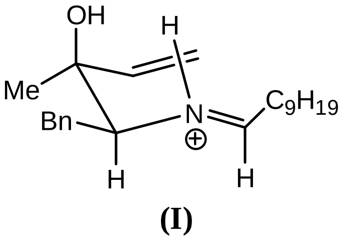
(d) 

63. 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

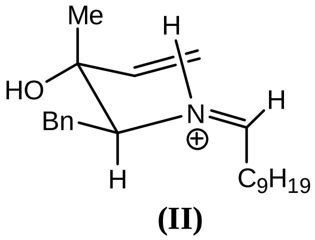
(a) 3:1 (b) 1.5:1 (c) 1:3 (d) 1:1.5

64. The intermediate involved in the following reaction are

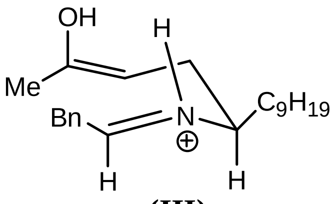




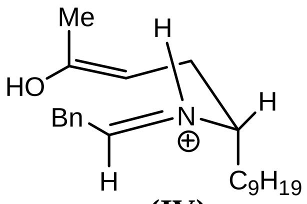
(I)



(II)



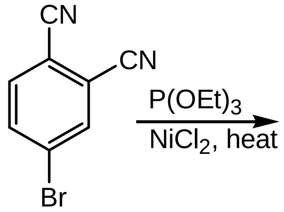
(III)



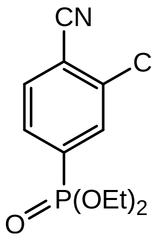
(IV)

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

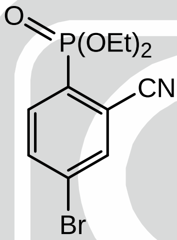
65. The major product formed in the following reaction is



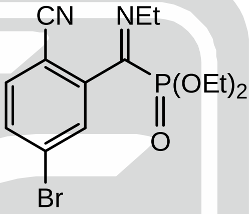
(a)



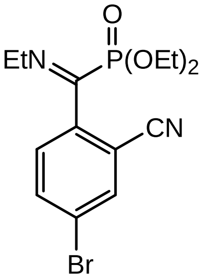
(b)



(c)



(d)



66. 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}

67. The correct order of ν_{C-S} (in cm^{-1}) and ν_{C-N} (in cm^{-1}) in trans-$[Pd(AsPh_3)_2(\underline{\mathbf{N}}CS)_2]$ (A) and trans-$[Pd(AsPPh_3)_2(\underline{\mathbf{S}}CN)_2]$ **(B)** is

(a) ν_{C-S} in **A** $<$ ν_{C-S} in **B** ; ν_{C-N} in **A** $<$ ν_{C-N} in **B**

(b) ν_{C-N} in **A** $=$ ν_{C-S} in **B** ; ν_{C-N} in **A** $=$ ν_{C-N} in **B**

(c) ν_{C-S} in **A** $<$ ν_{C-S} in **B** ; ν_{C-N} in **A** $<$ ν_{C-N} in **B**

(d) ν_{C-S} in **B** $<$ ν_{C-S} in **A** ; ν_{C-N} in **B** $<$ ν_{C-N} in **A**

68. Consider the following statements about hemerythrin

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

B. Heme protein coordinated by amino acid side chains

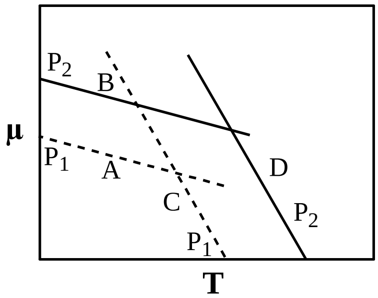
C. Coordination of O_2 occurs at only one of the Fe atoms

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

The option with all correct statements is

(a) A, C, and D only (b) B and D only (c) B, C, and D only (d) A and C only

69. The following figure shows the variation of chemical potential (μ) of a pure substance in its liqud or solid form with temperature, when the pressure is incraesed 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; $S_m(A) = -\left(\frac{\partial_{\mu A}}{\partial T}\right)_P$

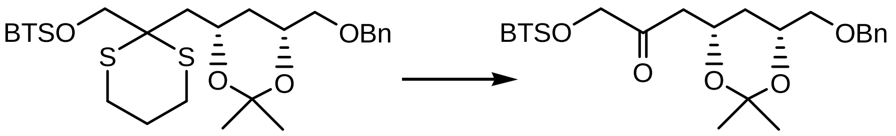
70. The Hamiltonian of a two-dimensional quantum harmonic oscillator is

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

where m and ω are positive constants. The degeneracy of the level with energy $E = \frac{25}{2}\hbar\omega$ is

(a) 5 (b) 6 (c) 7 (d) 8

71. The correct reagent to effect the following reaction is



(a) TBAF (b) Pd/C, H_2 (c) PTSA, MeOH (d) $Hg(ClO_4)_2$, $CaCO_3$

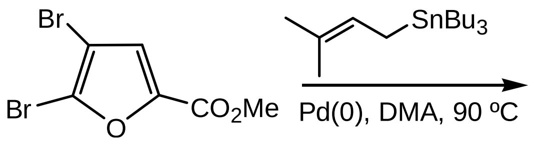
72. After 5 measurements, the length of an object is 20 ± 1 cm (mean ± standard error). The number of measurments needed to achieve a standard error of 0.25

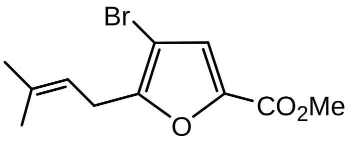
(a) 10 (b) 20 (c) 40 (d) 80

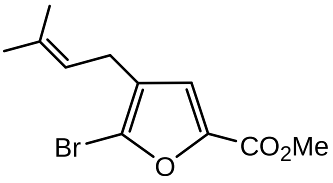
73. The energy (in units of $\frac{h^2}{8mL^2}$ of the ground state of a system of six non-interacting electrons, confined in a 3-dimensional box with lengths L, L/2 and L/4, is

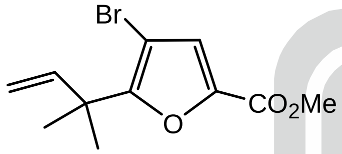
(a) 74 (b) 126 (c) 156 (d) 148

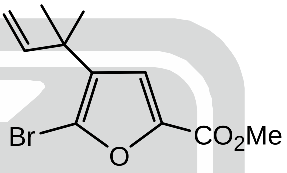
74. The major product formed in the following reaction is



(a)


(b)


(c)


(d)


75. Given the trial wavefunction $\phi(x) = ae^{-\alpha x^2} + be^{-\beta|x|}$ for the system having pontential $V(x) = \frac{1}{2}m\omega^2 x^2$, 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) $a = 1, b = 1$

76. Consider the following gas phase reaction,

$$\mathrm{A + B \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} A^* + B}$$

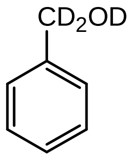
$$\mathrm{A^* \xrightarrow{k_2} C}$$

Considering $[\mathrm{A}]_0$ and $[\mathrm{B}]_0$ to be moderate and using steady state approximation, the correct option for the overall order of the reaction is

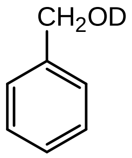
(a) 1st order, when $k_{-1} >> k_2$ (b) Zero order, when $k_{-1} >> k_2$

(c) zero order, when $k_{-1} << k_2$ (d) st order, when $k_{-1} << k_2$

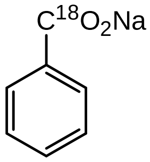
77. The Cannizzaro reaction of benzaldehyde with NaOH was carried out independently in (i) D_2O and (ii) $H_2{}^{18}O$. The major isotopically labelled products obtained in these reactions are



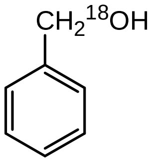
(A)



(B)



(C)



(D)

(a) A, B, D only (b) B, C, D only (c) A, D only (d) B, C only

78. 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

$$[\,J=\left\langle 1s_A\left|-\frac{1}{r_B}\right|1S_A\right\rangle+\frac{1}{R},\ K=\left\langle 1S_A\left|-\frac{1}{r_A}\right|1S_B\right\rangle+\frac{S}{R},\ S=\langle 1S_A\,|\,1S_B\rangle,\ \text{R is internuclear distance}]$$

(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) $-\frac{1}{2}+\frac{J\pm K}{1\pm S}$

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

A. T_g of the polymer increases with its molecular weight

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

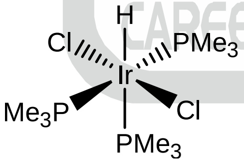
C. T_g of the polymer is always lower than its melting temperature (T_m)

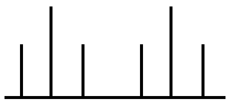
The correct complete set of options is

(a) A and B (b) A and C (c) B and C (d) A, B and C

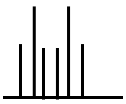
80. The ^1H NMR spectral pattern in the hydride region for the given compound

[**Given,** ^{31}P : I = ½, 100 % ; ^1H : I = ½, 99.98 %]

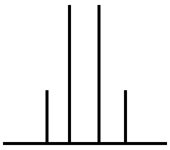




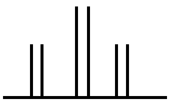
(I)



(II)



(III)



(IV)

is

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

81. The total number of isomers including pair(s) of enantiomers for the octahedral complex with the general formula Ma_2b_2cd is

(a) 6 including 1 pair (b) 6 including 2 pairs

(c) 8 including 1 pair (d) 8 including 2 pairs

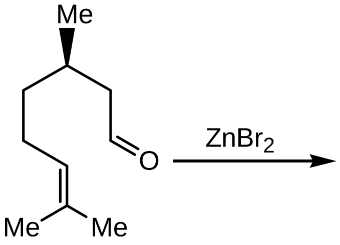
82. The correct order of rate for the following isotope exchange reaction

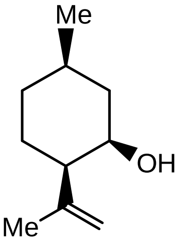
$$\left[M\left(CN\right)_6\right]^{3-} + 6\,{}^{14}CN^- \longrightarrow \left[M\left({}^{14}CN\right)_6\right]^{3-} + 6\,CN^-$$

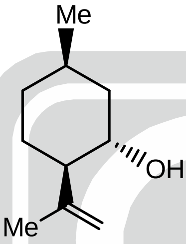
is

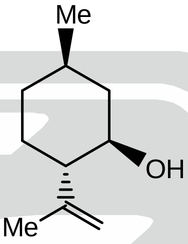
(a) Fe >Mn > Cr (b) Mn > Fe > Cr (c) Fe > Cr > Mn (d) Cr > Mn > Fe

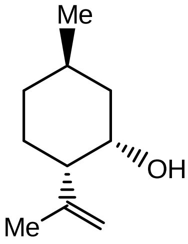
83. The major product formed in the following reaction is



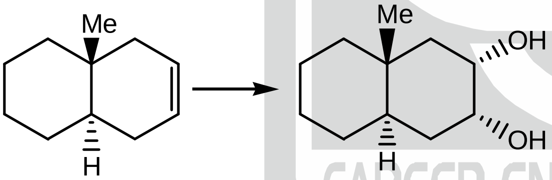
(a)


(b)


(c)


(d)


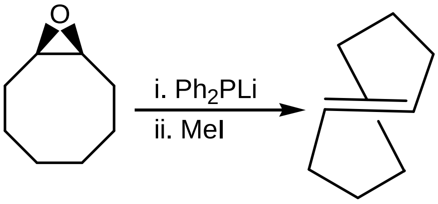
84. The correct set of reagents to effect the following transformation is



(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, $NaIO_4$

85. 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

86. Consider the following statements for ozone molecule.

A. It is Raman-active

B. It is IR-active

C. It belongs to C_{2h} point group

D. It is a diamagnetic molecule

The option with the correct statements is

(a) A, B, and C
(b) only A, B, and D
(c) only A, C, and D only
(d) B, C, and D only

87. 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 Å and 4 Å, 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

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

(a) Pd-vinyl alcohol, Pd-β-hydroxyethyl, Pd-ethylene

(b) Pd-β-hydroxethyl, Pd-vinyl alcohol, Pd-ethylene

(c) Pd-dioxygen, Pd-β-hydroxyethyl, Pd-acyl

(d) Pd-β-hydroethyl, Pd-vinyl alcohol, Pd-dioxygen

89. The structures of $[B_5H_{11}]$, $[C_2B_{10}H_{12}]$ and $[B_{11}H_{14}]^-$, respectively, are

(a) nido, arachno, closo
(b) nido, closo, arachno
(c) arachno, closo, nido
(d) arachno, nido, closo

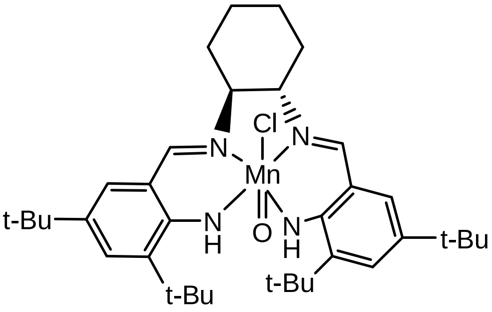
90. Given below are the oxohalide ions **(Column I)** and their bond lengths **(Column II)** and bond angles **(Column III)**

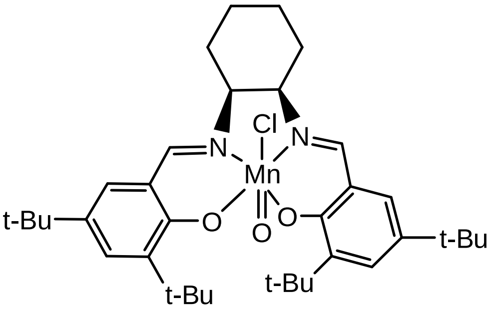
Column I	**Column II**	**Column III**
Oxchalide ion	**X-O (pm)**	**O-X-O angle $(^*)$**
(I) ClO_3^-	(P) 165	(I) 100
(II) BrO_3^-	(Q) 149	(II) 107
(III) IO_2^-	(R) 181	(III) 104

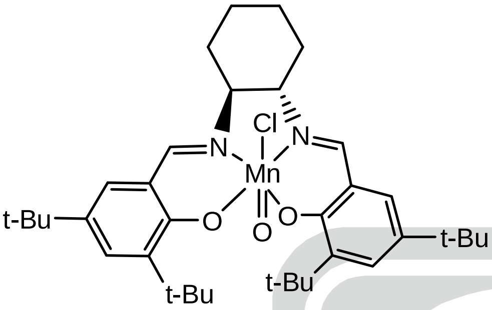
The option with the correct match is

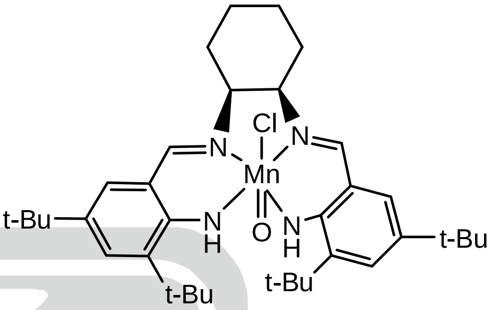
(a) (A)-(R)-(II), (B)-(P)-(I), (C)-(Q)-(III)
(b) (A)-(Q)-(I), (B)-(R)-(III), (C)-(P)-(II)
(c) (A)-(R)-(III), (B)-(Q)-(I), (C)-(P)-(II)
(d) (A)-(Q)-(II), (B)-(P)-(III), (C)-(R)-(I)

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

(a)


(b)


(c)


(d)


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

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_2} ES' \xrightarrow{k_3} E + P$$

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

[$[E]_0$ and $[S]_0$ are intial concentration of enzyme and substrate, respectively and $[S]_0 >> [E]_0$]

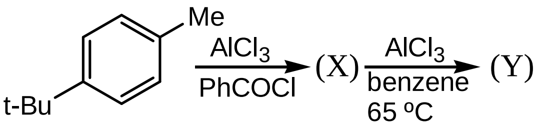
(a) $k_3[E]_0[S]_0$

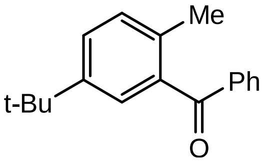
(b) $\dfrac{k_1k_2[E]_0[S]_0}{(k_{-1}+k_2)+k_3[S]_0}$

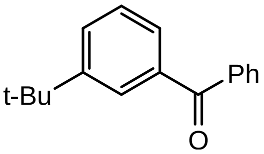
(c) $\dfrac{k_1k_2[E]_0[S]_0}{(k_{-1}+k_2)+k_3\left(1+\dfrac{k_2}{k_3}\right)[S]_0}$

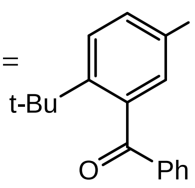
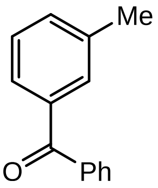
(d) $\dfrac{k_1k_2[E]_0[S]_0}{(k_{-1}+k_2)+k_2\left(1+\dfrac{k_1}{k_3}\right)[S]_0}$

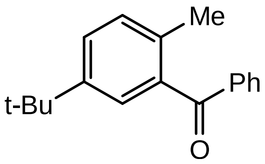
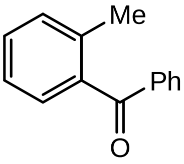
93. The major products X and Y formed in the following reaciton sequence are

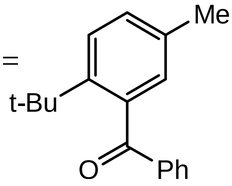
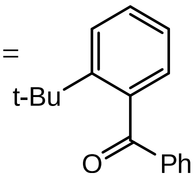


(a) X =


Y =


(b) X =  Y = 

(c) X =  Y = 

(d) X =  Y = 

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

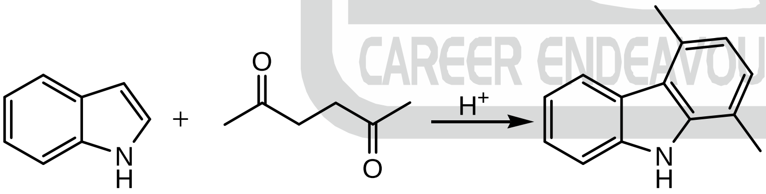
$$\mathrm{MnO_4^-} + \left[\mathrm{Fe(CN)_6}\right]^{4-} \longrightarrow \mathrm{MnO_4^{2-}} + \left[\mathrm{Fe(CN)_6}\right]^{3-}$$

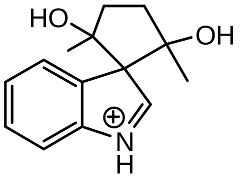
[Given at 25ºC, E^0 for $\mathrm{MnO_4^-/MnO_4^{2-}}$ = 0.56 V, $\left[\mathrm{Fe(CN)_6}\right]^{3-}/\left[\mathrm{Fe(CN)_6}\right]^{4-}$ = 0.36 V; Self-exchange rate constant, k_{11} for Mn complex = 3600 M $M^{-1}s^{-1}$, self-exchange rate constant, k_{22} for Fe complex = 300 M^{-1} s^{-1}, assume correction factor, f_{12} = 1]

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

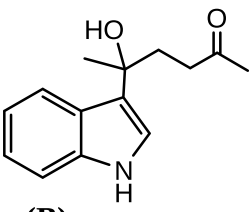
(a) 1.8×10^3 (b) 4.8×10^6 (c) 5.1×10^4 (d) 2.5×10^5

95. The intermediates involved in the following transformation are

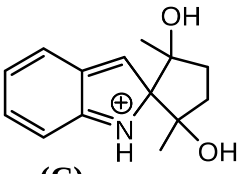




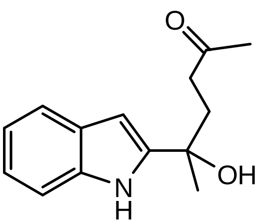
(A)



(B)



(C)



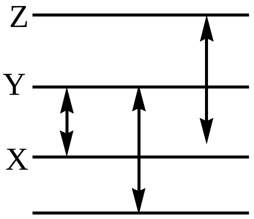
(D)

(a) A and B (b) C and D (c) B and D (d) A and C

96. A graph of surface tension of an aqueous solution of a surfactant as a function of concentration gives a slope [$d\gamma / d\ln\left(c/c^0\right)$] of –$4.8\times10^{-3}$ N m^{-1} at 289 K. The area (in $Å^2$) occupied by each surfactant molecule at the surface is closest to $\left[c^0 = 1\,\mathrm{molL^{-1}}\right]$

(a) 41 (b) 62 (c) 83 (d) 104

97. The allowed electronic transitions among four different atomic energy lvels 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

(a) $X = {}^3D_1$, $Y = {}^3P_1$ and $Z = {}^3D_2$ (b) $X = {}^3P_1$, $Y = {}^3D_1$ and $Z = {}^3D_2$

(c) $X = {}^3P_2$, $Y = {}^3D_1$ and $Z = {}^3P_1$ (d) $X = {}^3P_1$, $Y = {}^3P_2$ and $Z = {}^3D_1$

98. 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

(a) (i) HCl (aq.) (ii) H_2S (acidic) (iii) H_2S (basic) (iv) $(NH_4)_2CO_3$ (aq.)
(b) (i) H_2S (acidic) (ii) H_2S (basic) (iii) HCl (aq.) (iv) $(NH_4)_2CO_3$ (aq.)
(c) (i) $(NH_4)_2CO_3$ (aq.) (ii) H_2S (acidic) (iii) H_2S (basic) (iv) HCl (aq.)
(d) (i) HCl (aq.) (ii) H_2S (basic) (iii) H_2S (acidic) (iv) $(NH_4)_2CO_3$ (aq.)

99 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) $b + cx^2 - ax$

100. 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

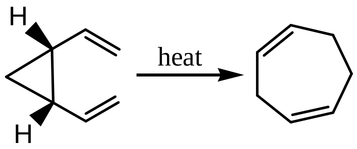
The symmetry of one of the normal modes is E. The symmetry of the second excited state of this mode in terms of the irreducible representations of the point group of the molecule is

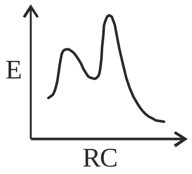
(a) $2A_1 + 2B_2$ (b) $2A_1 + B_1 + B_2$ (c) $A_1 + 2B_1 + B_2$ (d) $A_1 + A_2 + B_1 + B_2$

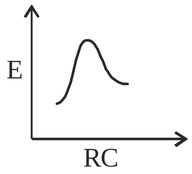
101. 0.5 M solution (A) of a substance transmits 10% of the incident light. Another solution (B) of the same substance under identical experimental conditions transmits 1% of the incident light. The concentration (in M) of the substance in the solution B is

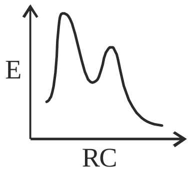
(a) 8 (b) 10 (c) 1 (d) 5

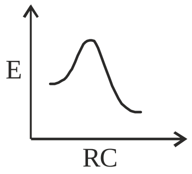
102. The energy profile diagram that corresponds to the following reaction is



(a) 

(b) 

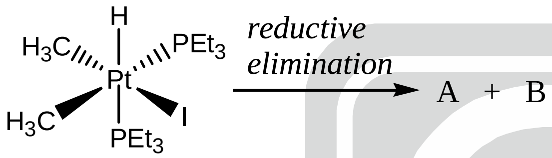
(c) 

(d) 

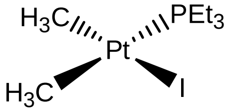
103. The average energy of an ensemble of noninteracting particles is 1000 k_BT at a temperature T. Each particle can have energy of either 0 or k_BT. The number of particles in the ensemble is closest to [k_B : Boltzmann constant]

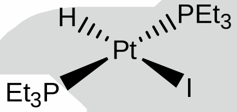
(a) 1738 (b) 3718 (c) 7183 (d) 8731

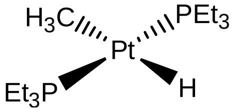
104. Consider the following reaction,

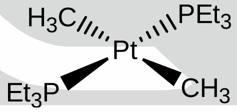


The most likely products A and B, respectively, are

(a)  and CH_4

(b)  and $CH_3—CH_3$

(c)  and CH_3I

(d)  and HI

105. Match the physical methods in **Column I** with the best suited information in **Column II** and III

Column I

A. Electron Paramagnetic Resonance spectroscopy
B. Nuclear Magnetic Resonance spectroscopy
C. Resonance Raman spectroscopy

Column II

P. Radio frequency
Q. Force constant
R. Microwave

Column III

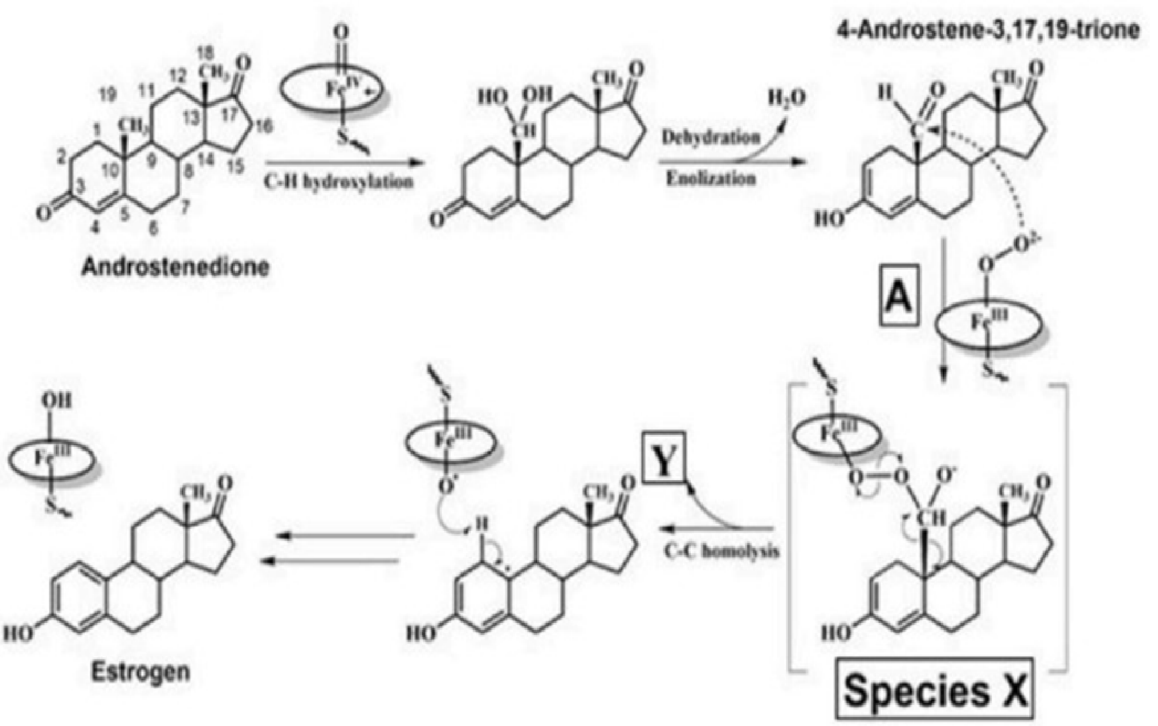
(I) Nature of O_2 bound to haemoglobin
(II) d-block metals with odd number of unpaired electrons
(III) Fluxionality in organometallic compounds

Options:

(a) (A–R–II), (B–P–III), (C–Q–I) (b) (A–P–III), (B–R–II), (C–Q–I)
(c) (A–R–II), (B–Q–III), (C–P–I) (c) (A–R–I), (B–Q–III), (C–P–II)

106. The synthesis of Estrogen from Androstenedione in humans is catalyzed 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:



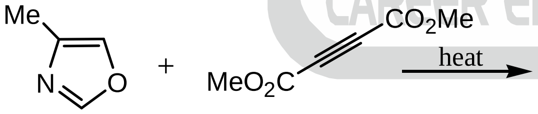
(a) Electrophilic attack, peroxide, and CO_2

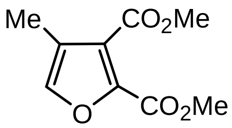
(b) Nucleophilic attack, peroxyhemiacetal, and CO_2

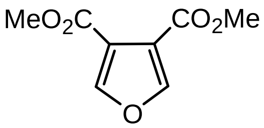
(c) Nucleophilic attack, peroxyhemiacetal, and $HCOO^-$

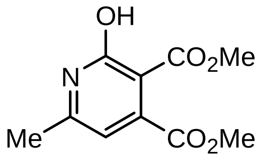
(d) Electrophilic attack, peroxide, and $HCOO^-$

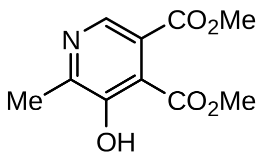
107. The major product formed in the following reaction is:



(a) 

(b) 

(c) 

(d) 

108. The maximum work available from combustion of 1.0 mol of methane gas at 298 K is 810 kJ mol^{-1}, and energy available as heat at constant pressure, at 298 K, is 890 kJ mol^{-1}

ΔS^0 (in J K^{-1} mol^{-1}) for this combustion process is closest to:
[Assume ideal gas behaviour, Gas constant R = 8.31 J K^{-1} mol^{-1}]

(a) –268 (b) –252 (c) –204 (d) –2718

109. 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) to (0, 0, 3)] and combination [(0, 0, 0) 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 $\Gamma_{\mu_z} = A_1$]

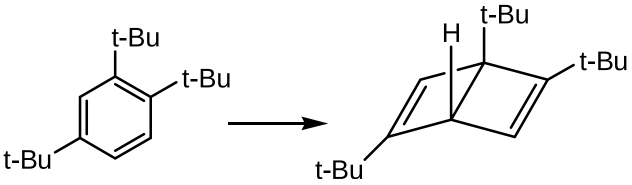
(a) z and z (b) y and x (c) x and y (d) y and y

110. The calculated magnetic moment (in B.M. unit) of a tetrahedral transition metal complex is:

[Given: free ion term = $^4F_{9/2}$, 10 Dq = 3200 cm^{-1} and $|\lambda|$ = 200 cm^{-1})

(a) 2.90 (b) 3.38 (c) 4.35 (d) 4.83

111. The following electrocyclic ring-closing reaction is:



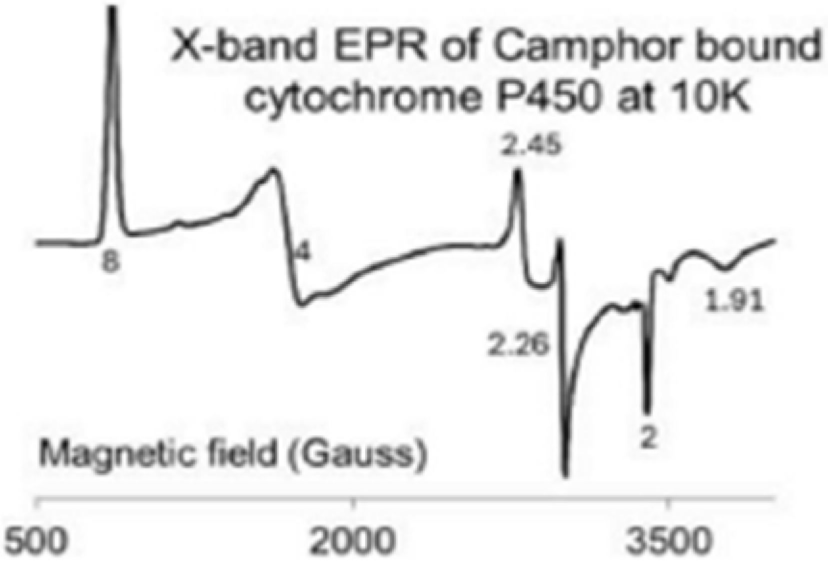
A. 4e$^-$ conrotatory ring closure
B. 4e$^-$ disrotatory ring closure
C. Allowed under thermal conditions
D. Allowed under photochemical conditions

(a) A and C (b) A and D (c) B and C (d) B and D

112. The Raschig reaction, involving partial 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) NCl_3, Cl_2, I_2 (b) N_2H_4, N_2, ICl (c) N_2H_4, O_2, I_2 (d) NCl_3, N_2, ICl

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



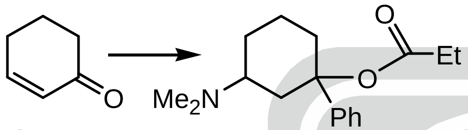
The correct set of g-values for the high-spin and low-spin species, respectively, are:
(a) High-spin: 8, 4, 2 and Low-spin: 2.45, 2.26, 1.91
(b) High-spin: 8, 4, 2.26 and Low-spin: 2.45, 2, 1.91
(c) High-spin: 8, 2.45, 2.26 and Low-spin: 4, 2, 1.91
(d) High-spin: 4, 2.45, 2.26 and Low-spin: 8, 2, 1.91

114. The table below contains the following compounds with their characteristics:

Compounds	Oxidation state of Phosphorus	Number of acidic hydrogens
a. Hypophosphoric acid	p. 5	i. 2
b. Pyrophosphorous acid	q. 1	ii. 3
c. Hypophosphorous acid	r. 4	iii. 4
d. Orthophosphoric acid	s. 3	iv. 1

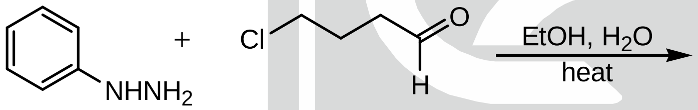
The option with the correct match is:
(a) (a-r-iii), (b-s-i), (c-q-iv), (d-p-ii) (b) (a-s-ii), (b-r-iii), (c-q-iv), (d-p-i)
(c) (a-p-ii), (b-r-iv), (c-q-i), (d-s-iii) (d) (a-r-iii), (b-s-ii), (c-q-iv), (d-p-i)

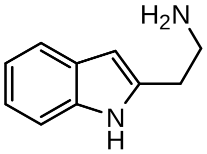
115. The correct sequence of reagents to effect the following transformation is:

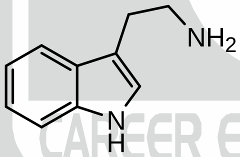


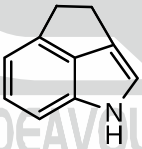
(a) PhLi; Me_2NH/Et_2O; $(EtCO)_2O$/pyridine (b) PhLi; $(EtCO)_2O$/pyridine; Me_2NH/Et_2O
(c) Me_2NH/Et_2O; PhLi; $(EtCO)_2O$/pyridine (d) Me_2NH/Et_2O; $(EtCO)_2O$/pyridine; PhLi

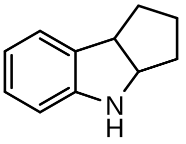
116. The major product formed in the following reaction is:



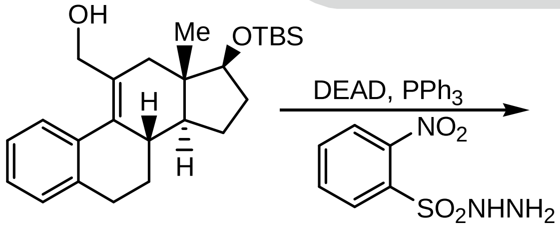
(a) 

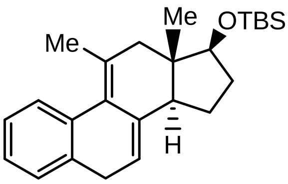
(b) 

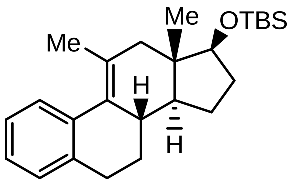
(c) 

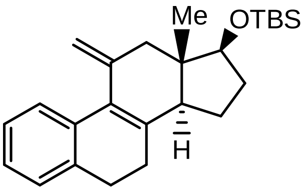
(d) 

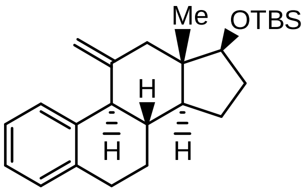
117. The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

118. Given below are enzymes **(Column I)**, the metal in their active sites **(Column II)**, and the class of reactions they catalyze **(Column III)**.

Column I	**Column II**	**Column III**
a. Catalase	p. Copper	i. Hydrolysis reaction
b. Urease	q. Copper and iron	ii. Decomposition reaction
c. Cytochrome *c* oxidase	r. Iron	iii. Phenol to quinone
d. Laccase	s. Nickel	iv. Oxygen to water

The option with the correct match is:

(a) (a–q–ii), (b–s–i), (c–p–iv), (d–r–iii) (b) (a–q–iii), (b–r–iv), (c–s–i), (d–p–ii)

(c) (a–r–iv), (b–p–iii), (c–q–i), (d–s–ii) (d) (a–r–ii), (b–s–i), (c–q–iv), (d–p–iii)

119. Column I contains inner transition elements and Column II includes ores, structural property and application.

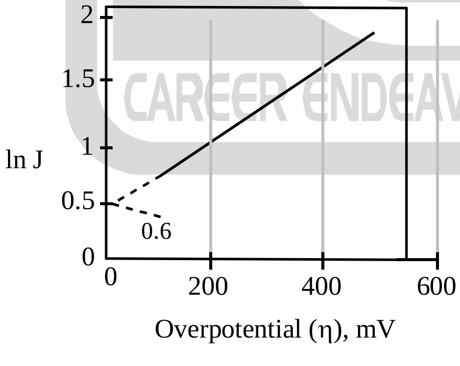
Column I	**Column II**
a. Th	i. Pitchblende
b. U	ii. BCC structure in its metallic form
c. Eu	iii. Laser
d. Nd	iv. Monazite

The option with the correct match is

(a) (a-ii), (b-iv), (c-iii), (d-i) (b) (a-iv), (b-i), (c-ii), (d-iii)

(c) (a-i), (b-iv), (c-ii), (d-iii) (d) (a-iv), (b-i), (c-iii), (d-ii)

120. The following figure shows a plot of in 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 change transfer resistance (in Ω) for this system is closest to

(a) 1.36 (b) 4.91 (c) 14.2 (d) 49.1

ANSWER KEY

PART–B

21. (a)
22. (d)
23. (c)
24. (b)
25. (a)
26. (b)
27. (a)
28. (c)
29. (c)
30. (c)
31. (a)
32. (a)
33. (c)
34. (a)
35. (b)
36. (c)
37. (b)
38. (d)
39. (c)
40. (b)
41. (d)
42. (a)
43. (d)
44. (d)
45. (d)
46. (c)
47. (d)
48. (c)
49. (a)
50. (b)
51. (d)
52. (c)
53. (b)
54. (d)
55. (b)
56. (b)
57. (a)
58. (b)
59. (b)
60. (c)

PART–C

61. (a)
62. (b)
63. (b)
64. (c)
65. (a)
66. (c)
67. (c)
68. (d)
69. (d)
70. (b)
71. (d)
72. (d)
73. (d)
74. (a)
75. (a)
76. (a)
77. (b)
78. (d)
79. (b)
80. (b)
81. (d)
82. (a)
83. (c)
84. (a)
85. (d)
86. (b)
87. (d)
88. (a)
89. (c)
90. (d)
91. (c)
92. (c)
93. (c)
94. (c)
95. (a)
96. (c)
97. (b)
98. (a)
99. (c)
100. (d)
101. (c)
102. (d)
103. (b)
104. (a)
105. (a)
106. (c)
107. (b)
108. (b)
109. (d)
110. (d)
111. (d)
112. (b)
113. (a)
114. (a)
115. (c)
116. (b)
117. (d)
118. (d)
119. (b)
120. (c)