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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. **In a colloidal solution, the zeta potential is the electric potential at the**

(a) radius of the colloid particle (b) radius of stern layer

(c) radius of shear surface (d) outer radius of diffuse ion layer

22. **The activation energy and enthalpy change in the reaction $H_2 + I_2 \longrightarrow 2HI$, respectively, are $167\ kJ\ mol^{-1}$ and $-8\ kJ\ mol^{-1}$. Assuming the pre-exponential factors for production and decomposition of HI to be same at all temperatures, the correct option is**

[k_p and k_d are the rate constants for production and decomposition of HI, respectively]

(a) k_p and k_d have the same temperature dependence

(b) k_d changes more rapidly with temperature than k_p

(c) k_p changes more rapidly with temperature than k_d

(d) The activation energies of production and decomposition reaction of HI are same

23. **The correct statements about C_{60} from the following are**

P. It exhibits greater degree of delocalization than benzene

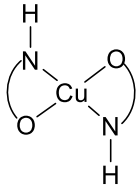
Q. It is susceptible towards addition reactions than substitution reactions

R. The spherical structure of C_{60} makes the C=C bonds more reactive

S. Its overall reactivity is more like cycloalkenes than benzene

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

24. **The total number of lines expected in the EPR spectrum of the Cu(II) complex shown below is** **[Given: Cu (I = 3/2); N(I = 1)]**



(a) 4 (b) 40 (c) 12 (d) 20

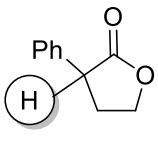
25. **The geometries of $[HgI_3]^-$ and $[SnCl_3]^-$, respectively, are**

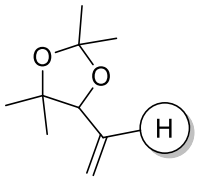
(a) trigonal planar and trigonal pyramidal (b) trigonal pyramidal and trigonal planar

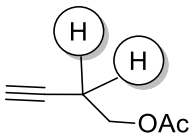
(c) trigonal planar and tetrahedral (d) tetrahedral and trigonal pyramidal

26. **In ^{1}H-NMR, the multiplicity pattern expected for the highlighted protons in the**

following compounds is







(a)	dd	;	ddd	;	td
(b)	dd	;	dt	;	dt
(c)	t	;	ddd	;	dt
(d)	t	;	dt	;	td

27. **The correct statements about $SnCl_4$ and $SnMe_4$ are**

P. $SnCl_4$ forms $[SnCl_6]^{2-}$ **Q. $SnMe_4$ does not form $[SnMe_6]^{2-}$**

R. $SnCl_4$ does not undergo hydrolysis **S. $SnMe_4$ readily hydrolyses**

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

28. **The correct option with respect to $Cs_2[XeF_8]$, is**

(a) square antiprismatic with stereochemically inactive lone pair

(b) square antiprismatic with stereochemically active lone pair

(c) capped square antiprismatic with stereochemically active lone pair

(d) capped square antiprismatic with no lone pair

29. **The numbers of metal-metal bonds in $[Os_4(CO)_{16}]$, is**

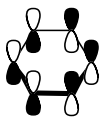
(a) 4 (b) 5 (c) 6 (d) 3

30. **For the reaction $K + Br_2 \longrightarrow KBr + Br$, the rate constant can be described as $k = A \exp\left(-\frac{E_a}{RT}\right)$. Choose the correct option regarding activation energy (E_a) and pre-exponential factor**

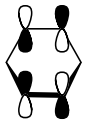
(A_E: obtained from experiment and A_T: estimated using collision theory)

(a) $E_a > 0;\ A_T > A_E$ (b) $E_a < 0;\ A_T < A_E$ (c) $E_a = 0;\ A_T < A_E$ (d) $E_a \geq 0;\ A_T > A_E$

31. **Among the following, the correct representation for the LUMO of benzene is**

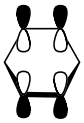


P



Q

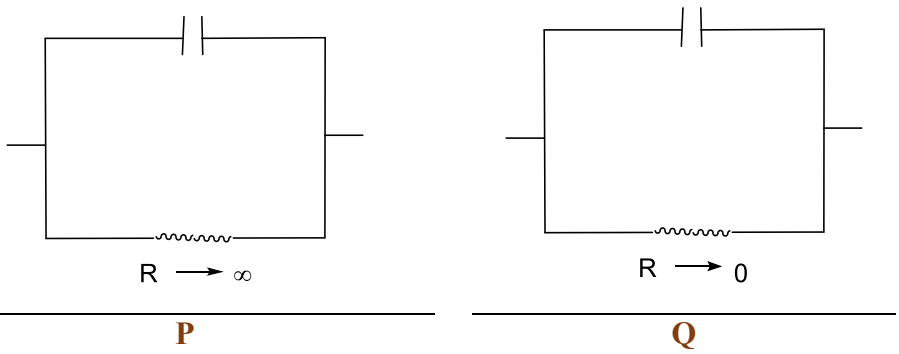
R



S

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

32. **Among the following equivalent circuits P and Q for an electrode/electrolyte interface, the correct option is**



(a) Both P and Q are ideally polarizable

(b) P is ideally non-polarizable, Q is ideally polarizable

(c) P is ideally polarizable, Q is ideally non-polarizable

(d) Both P and Q are ideally non-polarizable

33. Among the following linear combinations of determinants (written with the spatial wavefunctions 1s and 2s and electronic spin wavefunctions α and β, using 1 and 2 as labels of the two electrons), the one that denotes the un-normalised wavefunction of a triplet excited ($1s^1 2s^1$) of He, is

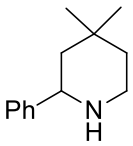
(a) $\begin{vmatrix} 1s\alpha(1) & 2s\beta(1) \\ 1s\alpha(2) & 2s\beta(2) \end{vmatrix} + \begin{vmatrix} 2s\alpha(1) & 1s\beta(1) \\ 2s\alpha(2) & 1s\beta(2) \end{vmatrix}$

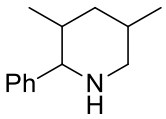
(b) $\begin{vmatrix} 1s\alpha(1) & 2s\beta(1) \\ 1s\alpha(2) & 2s\beta(2) \end{vmatrix} - \begin{vmatrix} 2s\alpha(1) & 1s\beta(1) \\ 2s\alpha(2) & 1s\beta(2) \end{vmatrix}$

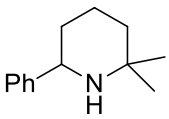
(c) $\begin{vmatrix} 1s\alpha(1) & 1s\alpha(2) \\ 2s\beta(1) & 2s\beta(2) \end{vmatrix} + \begin{vmatrix} 2s\alpha(1) & 2s\alpha(2) \\ 1s\beta(1) & 1s\beta(2) \end{vmatrix}$

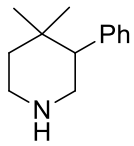
(d) $\begin{vmatrix} 1s\beta(1) & 2s\alpha(1) \\ 1s\beta(2) & 2s\alpha(2) \end{vmatrix} - \begin{vmatrix} 1s\alpha(1) & 2s\beta(1) \\ 1s\alpha(2) & 2s\beta(2) \end{vmatrix}$

34. Compound-P on Hofmann exhaustive N-methylation procedure (involving two cycles), followed by ozonolysis (i. O_3; ii. Me_2S) gives benzaldehyde, formaldehyde and 2, 2-dimethylpropanedial. The structure of P is

(a) 

(b) 

(c) 

(d) 

35. The standard Gibbs energy of a substance refers to the Gibbs free energy of its pure form at

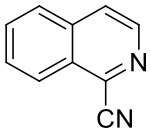
(a) temperature = 25 ℃ only and pressure = 1 atm

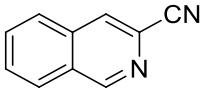
(b) temperature = 25 ℃ only and pressure = 1 bar

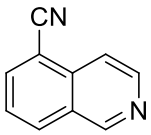
(c) any temperature and pressure = 1 bar

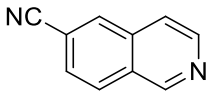
(d) any temperature and pressure = 1 atm

36. **Isoquinoline** on sequential reaction with benzoyl choride and **KCN** followed by heating with **aq. NaOH** gives

(a) 

(b) 

(c) 

(d) 

37. Two conformations, **P** and **Q**, of a single molecule have energies $5K_BT$ and $9K_BT$, respectively, at a temperature **T**. The fraction of molecules in conformation **Q** is

(a) $e^{-9}/(1+e^{-9})$ (b) $e^{-5}/(1+e^{-5})$ (c) $\frac{1}{1+e^{-4}}$ (d) $1/(1+e^{4})$

38. The complete combustion of 9.83 mg of an organic compound $(C_XH_YO_Z)$ gives 23.26 mg of CO_2 and 9.52 mg of H_2O. The ESI-MS analysis of this compound gave a molecular ion peak at 130 (m/z). The value of X is

[Given: Atomic weight: $C = 12; H = 1; O = 16$]

(a) 7 (b) 3 (c) 4 (d) 8

39. Consider the following statements about NO and NO_2.

P. The unpaired electron is in π^* orbital of NO while it is in σ_{nb} orbital of NO_2

Q. NO does not prefer dimerization, whereas NO_2 does

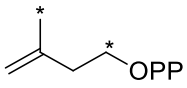
R. The reduction of NO is comparatively easier than NO_2

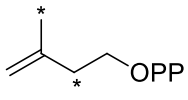
S. There is a center of inversion in NO_2

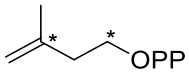
The option with the correct statements is

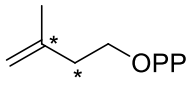
(a) P and Q only (b) P and S only (c) R and S only (d) Q and R only

40. The isopentenyl pyrophosphate formed through **mevalonate pathway** using acetyl CoA containing a ^{14}C labelled $(*)$ carbonyl carbon is

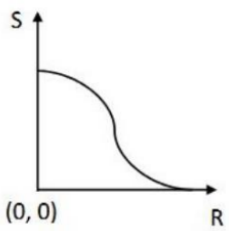
(a) 

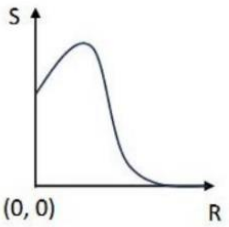
(b) 

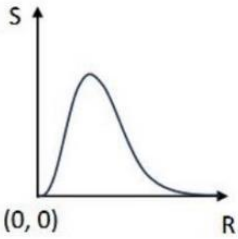
(c) 

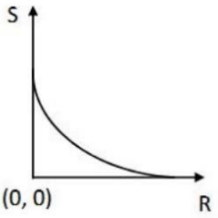
(d) 

41. For a diatomic molecule **AB**, the internuclear distance is R and the internuclear axis is along the z-direction. The plot of the overlap integral S for the p_x orbital of A and d_{zx} orbital of B, against R, is

(a) 

(b) 

(c) 

(d) 

42. **The wavefunction, $\Psi(x)$, of a one-dimensional quantum system is given by $\Psi(x) = A\, x \exp(-x^2/a^2)$, the dimension of A is [L is the dimension of length]**

(a) $L^{-1/2}$ (b) L^{-3} (c) $L^{-3/2}$ (d) L^0 (dimensionless)

43. **The pair of electronic configurations representing ground term $^3F_2$ is**

(a) p^1d^1 and s^1d^1 (b) s^1f^1 and d^1f^1 (c) d^1f^1 and p^1d^1 (d) p^1d^1 and s^1f^1

44. **The density, mass and unit cell edge length of a crystalline solid X are $2.7\ g\ cm^{-3}$, $27\ g\ mol^{-1}$ and 400 pm, respectively. The crystal lattice of X is**

(a) FCC (b) BCC (c) Simple cubic (d) Tetragonal

45. **The correct statements about the copper-containing protein, hemocyanin, from the following are**

P. It is an extracellular protein

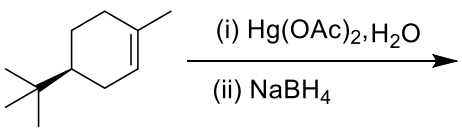
Q. It has an oligomeric structure with each sub-unit containing a pair of two copper atoms

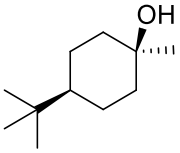
R. In deoxy form, the two Cu(I) atoms are separated by 2.8 Å

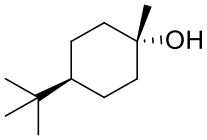
S. The blue colour of oxy form is due to charge-transfer from superoxide-to-Cu(II) ion

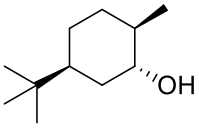
(a) P and Q only (b) P and R only (c) Q and R only (d) R and S only

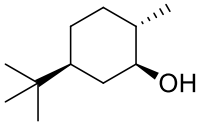
46. **The major product formed in the following reaction is**



(a) 

(b) 

(c) 

(d) 

47. **A radioactive element X emits two α and one γ particles to yield element Y of mass number 82. X also emits one α and one β particles to yield element Z with an atomic number 44.**

$$_{44}Z + \alpha + \beta \longleftarrow X \longrightarrow {}^{82}Y + 2\alpha + \gamma$$

The elements X, Y and Z, respectively, are

(a) $^{90}_{45}X$, $^{82}_{42}Y$ and $^{88}_{44}Z$ (b) $^{90}_{45}X$, $^{82}_{41}Y$ and $^{86}_{44}Z$ (c) $^{91}_{45}X$, $^{82}_{41}Y$ and $^{86}_{44}Z$ (d) $^{91}_{45}X$, $^{82}_{42}Y$ and $^{86}_{44}Z$

48. **For an eigen state Ψ of a time-independent Hamiltonian**

(a) Both Ψ and $\Psi^*\Psi$ are time-independent

(b) Ψ is time-dependent, but $\Psi^*\Psi$ is time-independent

(c) Ψ is time-independent, but $\Psi^*\Psi$ is time-dependent

(d) Both Ψ and $\Psi^*\Psi$ are time-dependent

49. **The reagent that would effect the following transformation is**

(a) H_2, Pd-C, EtOAc (b) TBAF, THF (c) $AlCl_3, CH_2Cl_2$ (d) K_2CO_3,MeOH

50. **Considering the potential energy at the equilibrium position (x_e) to be zero, the internuclear potential, V(x) as a function of distance, x between two atoms in a diatomic molecule is given by, $V(x) = D_e[1 - e^{-\alpha(x-x_e)}]^2$. Where D_e and α are two constants. The force constant of the bond between the two atoms is**

(a) $D_e\alpha^2$ (b) $2D_e\alpha^2$ (c) $\frac{1}{2}D_e\alpha^2$ (d) $D_e\alpha$

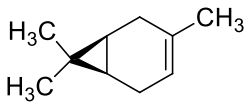
51. **Consider the following unbalanced chemical reactions:**

$NH_3 \rightarrow NO_2^-$	$O_2 \rightarrow H_2O_2$	$NO_2^- \rightarrow NO_3^-$	$H_2S \rightarrow S_8$	$CO_2 \rightarrow CO$
P	**Q**	**R**	**S**	**T**

The reactions that are brought about by the chemolithotropic bacteria, are

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

52. **The correct IUPAC name for the following compound is**



(a) (1S, 6R)-3,7,7-trimethylbicyclo[4.1.0]hept-3-ene

(b) (1R, 6S)-3,7,7-trimethylbicyclo[4.1.0]hept-3-ene

(c) (1R, 6S)-4,7,7-trimethylbicyclo[4.1.0]hept-3-ene

(d) (1S, 6R)-4,7,7-trimethylbicyclo[4.1.0]hept-3-ene

53. **According to Karplus equation, the vicinal proton-proton coupling constant is minimum when the value of dihedral angle is**

(a) 0° (b) 60° and 120° (c) 90° (d) 180°

54. **For actinides, complex formation tendency follows the order**

(a) $M^{4+} > M^{3+} > MO_2^+ > MO_2^{2+}$

(b) $MO_2^{2+} > MO_2^+ > M^{4+} > M^{3+}$

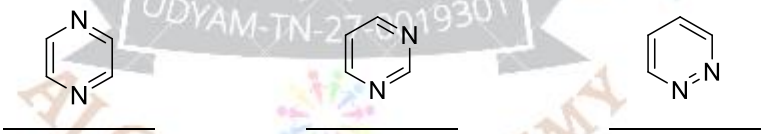
(c) $M^{4+} > M^{3+} > MO_2^{2+} > MO_2^+$

(d) $M^{4+} > MO_2^{2+} > M^{3+} > MO_2^+$

55. **Nitramide (NH_2NO_2) decomposes under basic condition to generate**

(a) N_2O (b) HNO_3 (c) NH_3 (d) NO

56. **The correct order of basicity for the following compounds is**

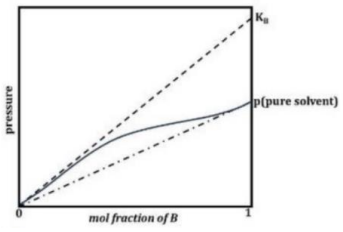


P Q R

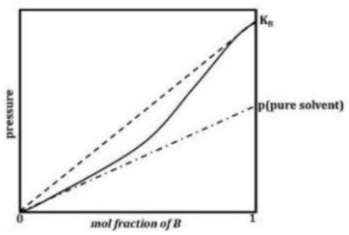
(a) P > R > Q (b) Q > P > R (c) R > P > Q (d) R > Q > P

57. **The correct option for a real solution formed by mixing liquid A with liquid B is [Here K_B is Henry's law constant and solid line represents real solution]**

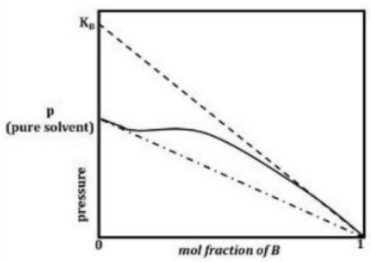
(a)



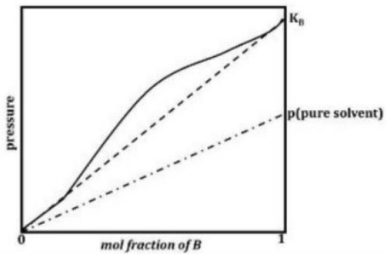
(b)



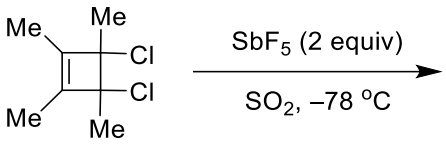
(c)



(d)

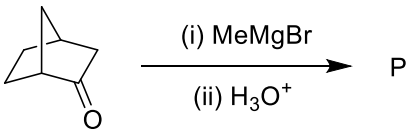


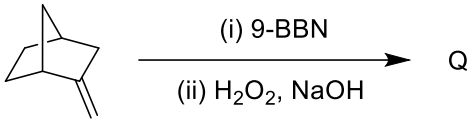
58. **The major product formed in the following reaction is**

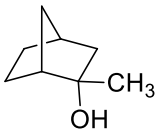
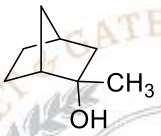
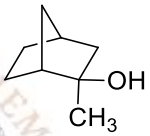
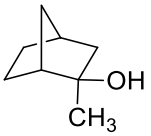
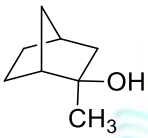
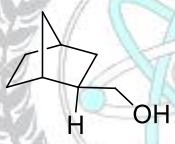
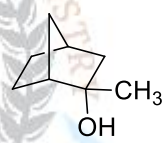
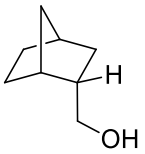


(a) aromatic (b) non-aromatic (c) antiaromatic (d) homoaromatic

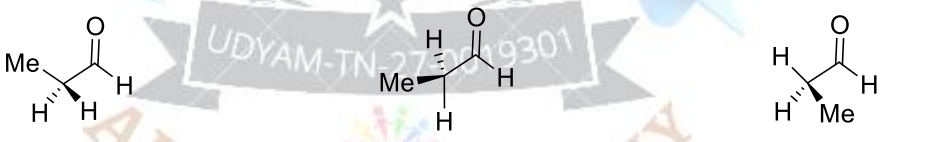
59. **The major products P and Q formed in the following reactions are**





	P	Q		P	Q
(a)			(b)		
(c)			(d)		

60. **The correct order of stability for the following conformations of propanal is**



P Q R

(a) P > R > Q (b) P > Q > R (c) Q > P > R (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. **For the C_3 point group, with C_3 axis along the z-direction, the correct statement is**

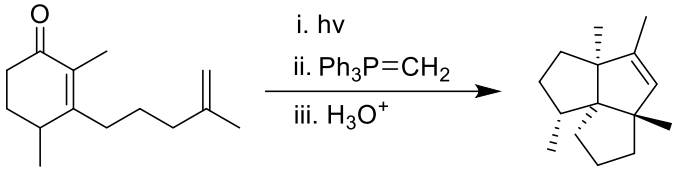
(a) All the three symmetry operations (C_3, C_3^2 and $C_3^3 = E$) belong to the same class

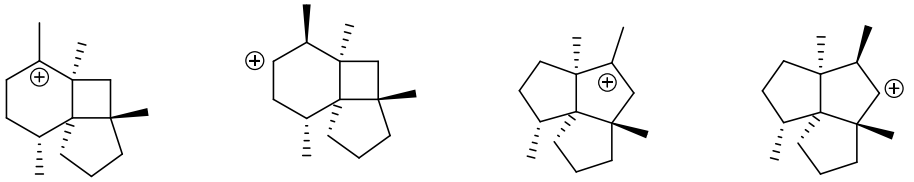
(b) The character table contains a two-dimensional irreducible representation

(c) All the characters in the character table are ± 1

(d) x and y jointly form a basis for a two-dimensional representation

62. **The intermediates involved in the following reaction sequence are**

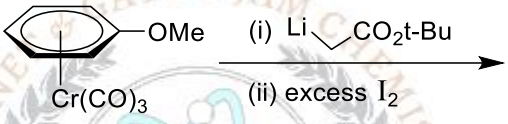


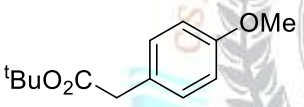


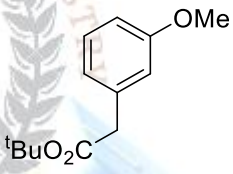
P **Q** **R** **S**

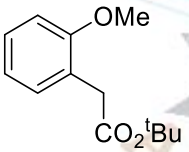
(a) P and Q (b) Q and S (c) P and R (d) R and S

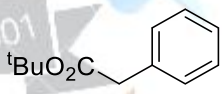
63. **The major product formed in the following reaction is**



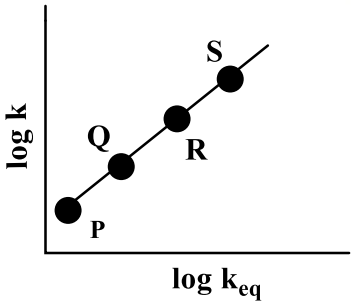
(a) 

(b) 

(c) 

(d) 

64. **The plot shown below is for the rate of acid hydrolysis reaction of $[Co(NH_3)_5X]^{2+}$ at 25 °C, where X is an anionic ligand $(F^-, Cl^-, NO_3^-, H_2PO_4^-)$. The correct option is**



	P		Q		R		S
(a)	F^-	;	$H_2PO_4^-$	;	Cl^-	;	NO_3^-
(b)	Cl^-	;	$H_2PO_4^-$	;	F^-	;	NO_3^-
(c)	$H_2PO_4^-$	;	Cl^-	;	F^-	;	NO_3^-
(d)	NO_3^-	;	Cl^-	;	$H_2PO_4^-$	;	F^-

65. **The character table of C_{3v} point group is as follows.**

C_{3v}	E	$2C_3(z)$	$3\sigma_v$		
A_1	1	1	1	z	$x^2+y^2+z^2$
A_2	1	1	−1	R_z	
E	2	−1	0	$(x,y)(R_x,R_y)$	$(x^2-y^2,xy)(xz,yz)$

The normal modes of vibration of NH_3, the correct statement, among the following, is

(a) Some of the normal modes are IR-inactive

(b) At least one normal mode is both IR and Raman-inactive

(c) Mixing of normal modes by the symmetry operations is not possible

(d) For some of the normal modes, the wavefunction of first vibrational excited state is totally symmetric

66. **The EPR spectrum of $[InH_3]^-$ (radical) [Given: $I_{In} = \frac{9}{2}$; $I_H = \frac{1}{2}$] is comprised of**

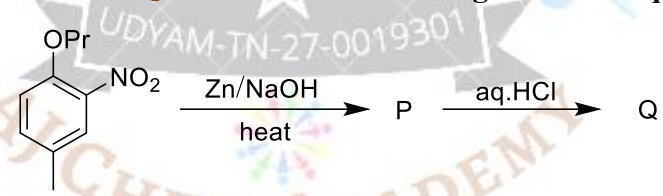
(a) 10 lines of equal intensity where each line further splits into 4 lines with intensity $1 : 3 : 3 : 1$.

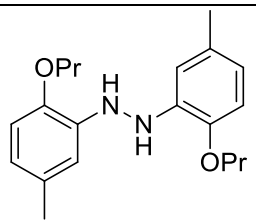
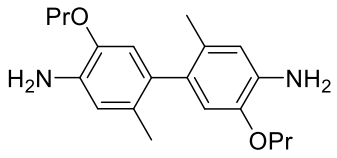
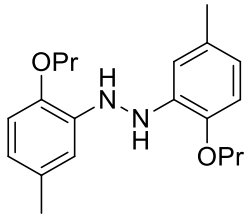
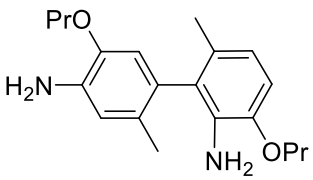
(b) 4 lines with intensity $1 : 3 : 3 : 1$ where each line further splits into 10 lines with equal intensity

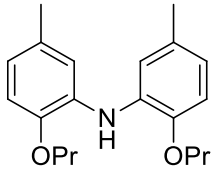
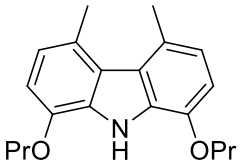
(c) 10 lines of unequal intensity where each line further splits into 4 lines with intensity $1 : 3 : 3 : 1$.

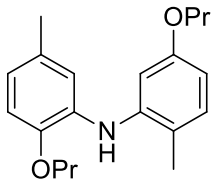
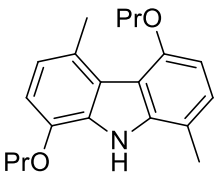
(d) 4 lines with intensity $1 : 1 : 1 : 1$ where each line further splits into 10 lines with unequal intensity

67. **The major products P and Q formed in the following reaction sequence are**



	P	Q
(a)		
(b)		

(c)  ; 

(d)  ; 

68. **The self-exchange rate and the reduction potential for the following redox couple are given below. ($R = 8.314\ J\ K^{-1}mol^{-1}$, Faraday constant $= 96485\ C\ mol^{-1}$)**

	Self-exchange rate ($M^{-1}s^{-1}$)	E° (V)
$Ce^{4+/3+}$	4.0	1.70
$[Fe(phen)]^{3+/2+}$	3×10^{7}	1.00

$$Ce^{+4} + [Fe(phen)]^{2+} \longrightarrow Ce^{+3} + [Fe(phen)]^{3+}$$

For the above reaction, the approximate rate constant (in $M^{-1}s^{-1}$) at 25 °C is

(a) 1.1×10^{10} (b) 1.1×10^{5} (c) 1.2×10^{20} (d) 3.5×10^{26}

69. **The correct statements regarding olefin polymerization involving metallocene and alkyl aluminium species, following are**

P. Trace amounts of water cause a significant increase in the rates of ethylene Polymerization by the $Cp_2TiEtCl/AlEt_2Cl$ system

Q. Methylaluminoxane is employed as an activator for the catalyst, Cp_2ZrMe_2

R. $B(C_6F_5)_3$ is an activator for Cp_2ZrMe_2

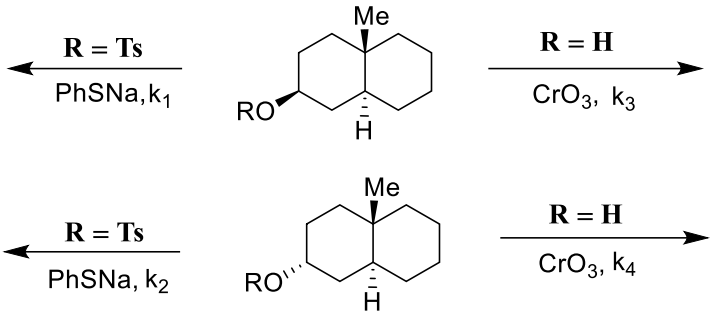
S. The termination step of the polymerization reaction is β-hydride elimination

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

70. **Double logarithmic plot of the intrinsic viscosity and the molar mass of polymers in solution is linear with slope 3/4. The ratio of molar mass of two solutions of the same polymer of different molar mass is 16. The expected ratio of their measured intrinsic viscosity in an experiment will be**

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

71. **The relative order of rate constants in the following transformations are**



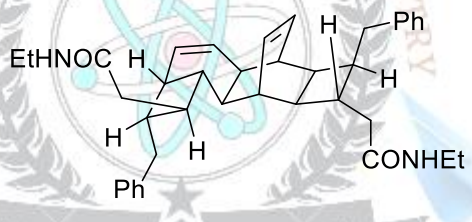
(a) $k_2 > k_1$; $k_4 > k_3$ (b) $k_2 > k_1$; $k_3 > k_4$

(c) $k_1 > k_2$; $k_4 > k_3$ (d) $k_1 > k_2$; $k_3 > k_4$

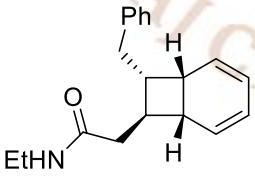
72. **In the photochemical reaction A ⟶ B, 2.5 mmol of A is converted into B on irradiation with 100 W light of wavelength 300 nm for 66 s. The quantum yield of the reaction is closest to**

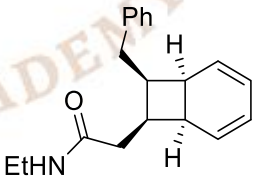
(a) 0.05 (b) 0.15 (c) 0.25 (d) 0.35

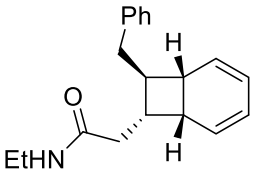
73. **The starting material that gives compound-P on heating is**

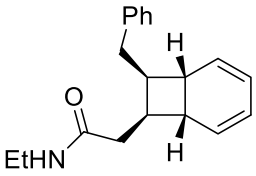


P

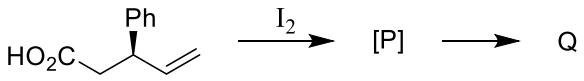
(a) 

(b) 

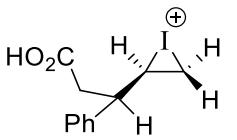
(c) 

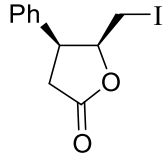
(d) 

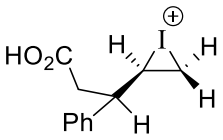
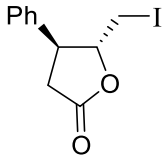
74. **The intermediate P and the major product Q formed in the following reaction are**

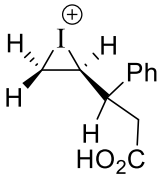
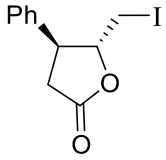


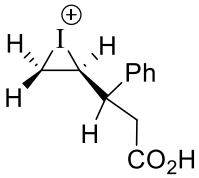
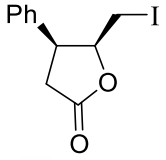
P **Q**

(a) 

; 

(b)  ; 

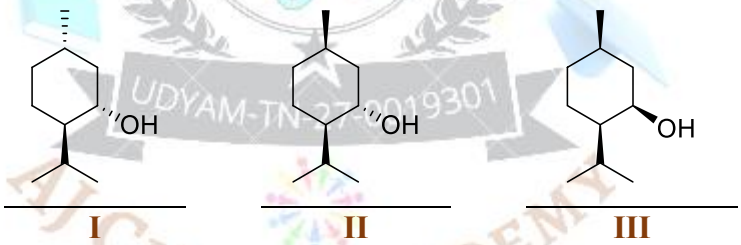
(c)  ; 

(d)  ; 

75. **The θ-dependent part of an un-normalized atomic orbital is $\Theta(\theta) = \cos\theta$. In the range $0° \leq \theta \leq 90°$, the maximum probability of finding an electron in this orbital, between θ and $\theta + d\theta$, is for $\theta =$ _____**

(a) 0° (b) 35.3° (c) 54.7° (d) 90°

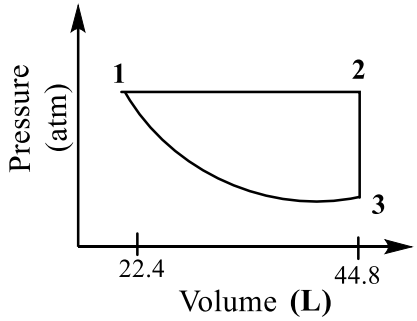
76. **The correct order for the relative rate of esterification of I, II and III with p-nitrobenzoyl chloride is**



I II III

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

77. **One mole of a monoatomic ideal gas at 1 atm pressure is taken through the p – V cycle as shown below.**



For the process 1 → 2, there reversible work done and the change in enthalpy (in kJ), respectively are

(a) −2.27 and 5.67 (b) 3.40 and 2.27 (c) 3.40 and −5.67 (d) −2.27 and 3.40

78. Let **H(x)** be the **Hamiltonian** defined by $H(x) = \frac{p_x^2}{m} + V(x)$

Given $[H, x] = \frac{\hbar}{im} p_x$ and $H\phi_j = \varepsilon_j - \phi_j \quad (j = 0, 1, 2, 3 \ldots)$; $\varepsilon_0 < \varepsilon_1 < \varepsilon_2 < \cdots$, the correct statement, for $j \neq 0$, is

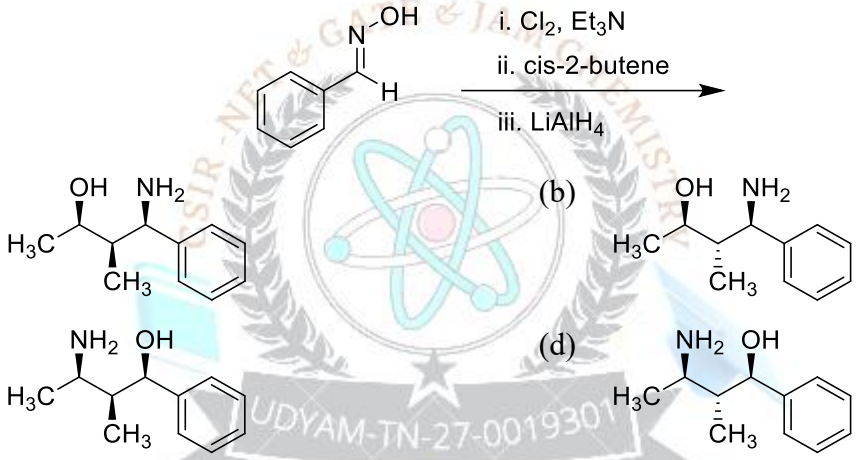
(a) $\langle \phi_j \mid p_x \mid \phi_0 \rangle = \frac{i\hbar}{m} \langle \phi_j \mid x \mid \phi_0 \rangle (\varepsilon_j - \varepsilon_0)$

(b) $\langle \phi_j \mid p_x \mid \phi_0 \rangle = \frac{i\hbar}{m} \langle \phi_j \mid x \mid \phi_0 \rangle (\varepsilon_0 - \varepsilon_j)$

(c) $\langle \phi_j \mid p_x \mid \phi_0 \rangle = \frac{m}{i\hbar} \langle \phi_j \mid x \mid \phi_0 \rangle (\varepsilon_j - \varepsilon_0)$

(d) $\langle \phi_j \mid p_x \mid \phi_0 \rangle = \frac{m}{i\hbar} \langle \phi_j \mid x \mid \phi_0 \rangle (\varepsilon_0 - \varepsilon_j)$

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



80. The **magnitude of the orbital angular momentum vector** of a quantum mechanical system is $\sqrt{6}\hbar$. The smallest possible angle between its orbital angular momentum vector and the **z-axis** is

(a) $\cos^{-1}\left(\frac{1}{\sqrt{2}}\right)$ (b) $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$ (c) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (d) $\sin^{-1}\left(\frac{1}{\sqrt{i}}\right)$

81. The correct match between the enzymes **(Column-I)** and the biological functions **(Column-II)** from the table below is

	Enzymes		Biological functions
P.	Cytochrome C-Oxidase	I	DNA biosynthesis
Q.	Tyrosinase	II	Hydrolysis
R.	Purple acid phosphatase	III	Oxidation of phenols
S.	Galactose oxidase	IV	Oxidation of alcohols
T.	Ribonucleotide reductase	V	Reduction of O_2 to water

P	Q	R	S	T

P	Q	R	S	T

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

82. **If the crystal field splitting energy of d-orbitals follows the order:**

$$d_z^2 < d_{xy} = d_x^2 - d_y^2 < d_{xz} = d_{yz},$$

The ligand field is

(a) square planar

(b) trigonal bipyramidal

(c) square antiprismatic

(d) pentagonal bipyramidal

83. **For a heteronuclear diatomic molecule AB, the un-normalized wavefunctions for HOMO and one of the two degenerate LUMOs, respectively, are**

$\Psi_{HOMO} = 0.9(\phi_{2s}^{A} + 3\phi_{2p_z}^{A}) + 0.1\phi_{2p_z}^{B}$; $\Psi_{LUMO} = 0.1\phi_{2p_x}^{A} + 0.9\phi_{2p_x}^{B}$

(Atomic orbitals of A and B are denoted by ϕ. The internuclear axis is along the z-direction)

AB is a

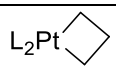
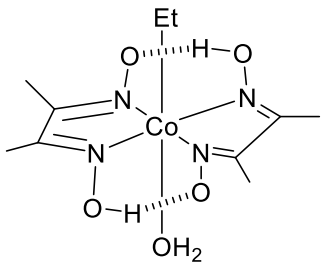
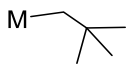
(a) σ-donor through A, π-acceptor through A

(b) σ-donor through B, π-acceptor through B

(c) σ-donor through A, π-acceptor through B

(d) σ-donor through B, π-acceptor through A

84. **List I contains metal-alkyl compounds which do not undergo β-hydride elimination step and List II gives the reasons.**

	List I		List II
P.		I.	A planar transition state is not accessible
Q.		II.	No vacant coordination site on the metal center
R.		III.	Leads to a bridgehead olefin
S.		IV.	Lacks β-hydrogen

The option containing the correct match is

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

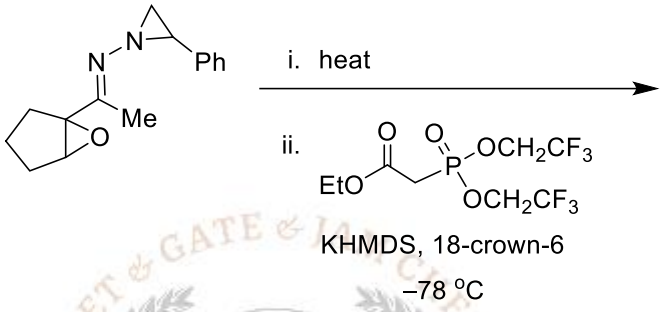
(c) III ; IV ; I ; II (d) IV ; I ; III ; II

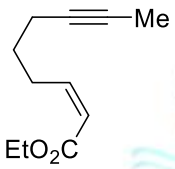
85. **At 100 Pa and 500 K, the number of collisions Ar atoms make on a solid surface of area 1.0 cm^2 in 10 s is closest to**

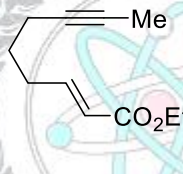
[Molar mass of Ar is 40 g mol^{-1}; assume Ar to behave as a perfect gas]

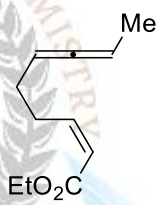
(a) 1.9×10^{21} (b) 2.1×10^{23} (c) 3.5×10^{19} (d) 4.7×10^{17}

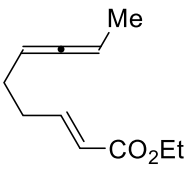
86. **The major product formed in the following reaction sequence is**



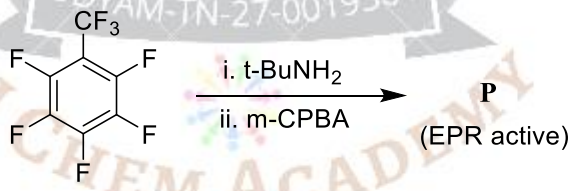
(a) 

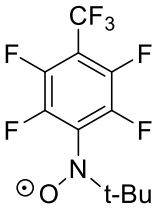
(b) 

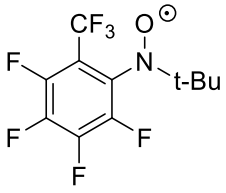
(c) 

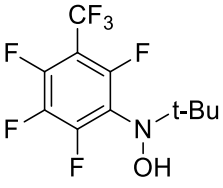
(d) 

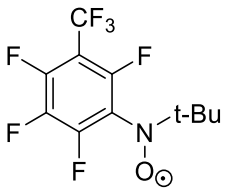
87. **The major product-P formed in the following reaction sequence is**



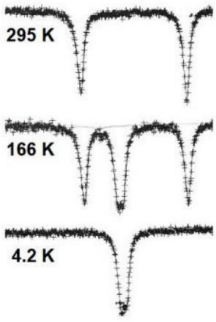
(a) 

(b) 

(c) 

(d) 

88. **The Mossbauer spectra of $[Fe(L)_2]I_2$ (L = 3,5-dimethyl-tris-pyrazolylborate), shown below, exhibit temperature-dependent spin-transition behaviour.**



The correct statements from the following are

P. At 295 K, the Fe(II) center is high-spin

Q. At 4. 2 K, the Fe(II) center is low-spin

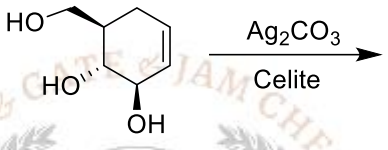
R. At 295 K, the Fe(II) center is low-spin

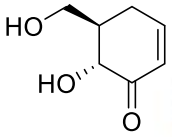
S. At 4. 2 K, the Fe(II) center is high-spin

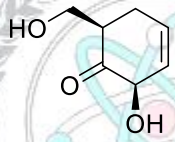
T. At 166 K, it represents a mixture of low-spin and high-spin the Fe(II) complexes

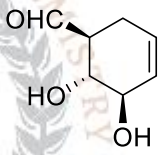
(a) P, Q and R only (b) Q, R and T only (c) R, S and T only (d) P, Q and T only

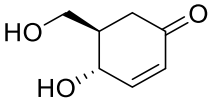
89. The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

90. The correct statements abut agostic interactions from the following are

P. It involves a three-center-two-electron interaction with a C-H bond of the ligand

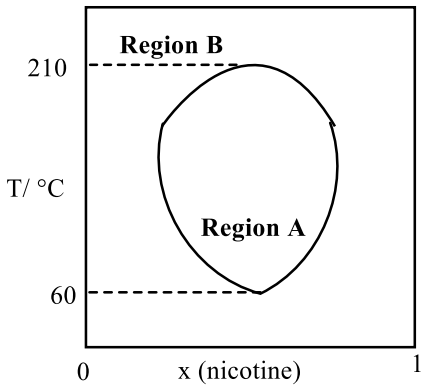
Q. The C-H bond of the ligand involved in agostic interaction is lengthened

R. Its presence is identified by an upfield chemical shift of the C-H bond of the ligand

S. It lowers the pK_a of the C-H bond of the ligand

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

91. Consider the following temperature-composition diagram for water and nicotine.



The correct option is

(a) The system has two critical solution temperatures; both nicotine and water are completely miscible at 100 ℃ and x(nicotine) = 0.5

(b) At 75°C and x(nicotine) = 0.5, nicotine and water from a strong complex which does not dissociate

(c) Nicotine and water from a weak complex at 50 °C; the number of phases (P) in the region A is 2

(d) Thermal motion homogenises the mixture in the entire region B where P = 1

92. **Consider the following statements regarding corrin ring (X) and porphyrin ring (Y)**

P. X is fully conjugated, rigid and bigger in size than Y

Q. X is fully conjugated, more flexible and ring size is same as Y

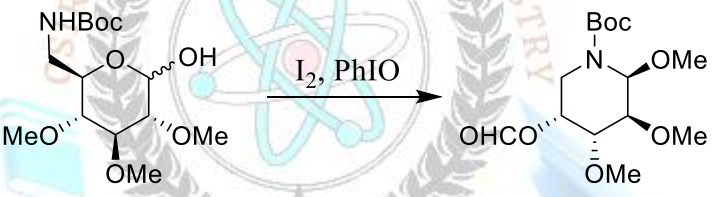
R. X is partially reduced, more flexible and smaller in size than Y

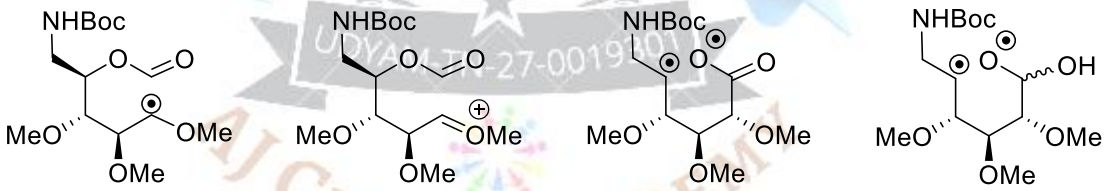
S. The flexibility of X supports multiple oxidation states of cobalt

The correct statements are:

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

93. **The intermediate involved in the following reaction are**



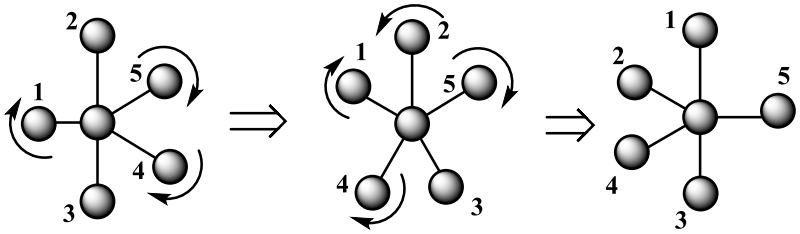


P **Q** **R** **S**

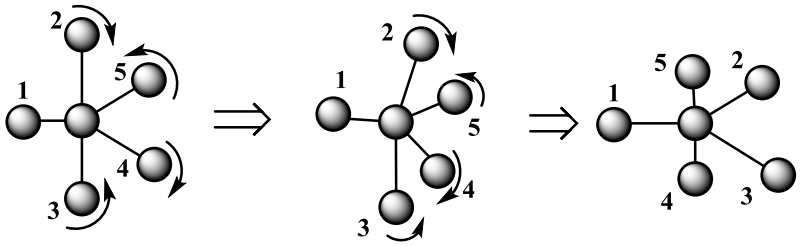
(a) P and Q (b) Q and R (c) R and S (d) P and S

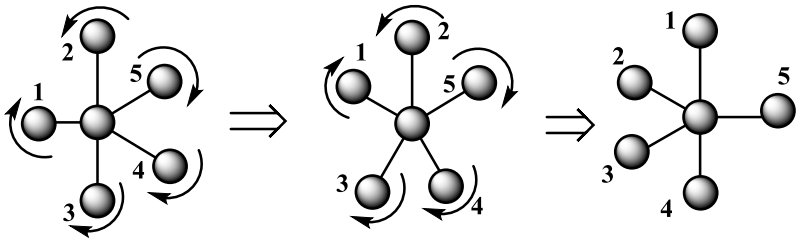
94. **The option showing the correct Berry-pseudo rotation is**

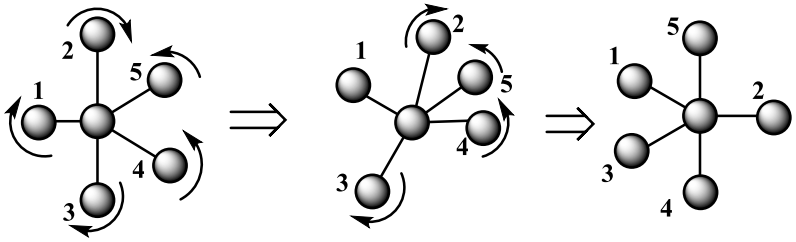
(a)



(b)



(c) 

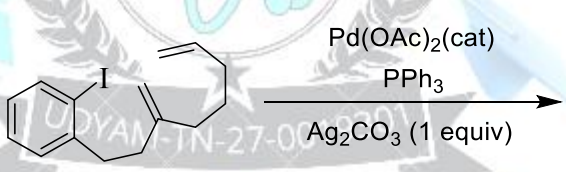
(d) 

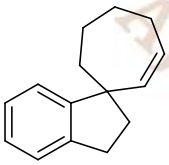
95. The free ion ground term, the calculated spin plus orbital magnetic moment value, the calculated spin-orbit magnetic moment value and the observed magnetic moment value (300 K), for a gaseous $3d^5$ ion, respectively, are

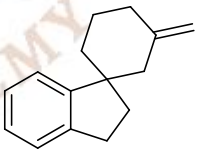
(a) $^6S_{5/2}$, 5.92 BM, 5.92 BM, 5.8-6.0 BM (b) $^6S_{5/2}$, 5.92 BM, 6.70 BM, 5.8-6.0 BM

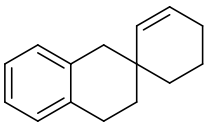
(c) $^6S_{5/2}$, 5.92 BM, 5.92 BM, 4.8-5.0 BM (d) $^6S_{5/2}$, 5.59 BM, 6.70 BM, 5.8-6.0 BM

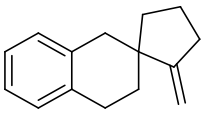
96. The major product formed in the following reaction is



(a) 

(b) 

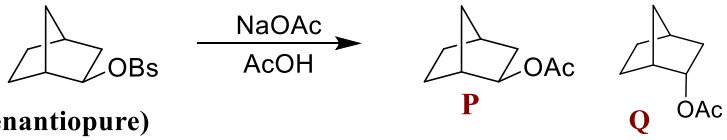
(c) 

(d) 

97. The solubility of Bi_2S_3 in aqueous at 25 °C is 1.4×10^{-20} M. Given that $E^0_{(Bi^{3+}/Bi)} = 0.226$ V, the value of $E^0_{Bi_2S_3/Bi,S^{2-}}$ (in V) at 25 °C is closest to

(a) 1.18 (b) −0.73 (c) −0.96 (d) 0.23

98. The correct statement about the major product of the following reaction is



(enantiopure) P Q

Bs = p-bromophenylsulfonyl

(a) P is formed and is optically active (b) P is formed and is racemic

(c) Q is formed and is optically active (d) Q is formed and is racemic

99. **The electronic configurations showing tetragonal compression and elongation in their octahedral complexes, respectively, are**

(a) d^1 and low-spin d^4 (b) d^1 and d^9 (c) d^9 and d^3 (d) low-spin d^4 and high-spin d^5

100. **The XRD pattern of a crystalline material, measured using Cu K_α radiation (λ= 1.54 Å), is as follows:**

2θ(degree)
38.43
44.65
65.02
78.13

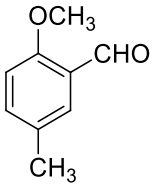
Considering the cubic edge length ~4 Å, the Miller indices and Bravais lattice of this material are

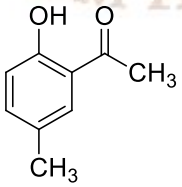
(a) (111)(200)(220)(311), BCC (b) (111)(200)(220)(311), FCC

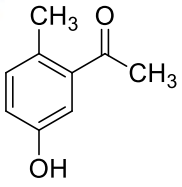
(c) (110)(200)(211)(220), BCC (d) (110)(200)(211)(220), FCC

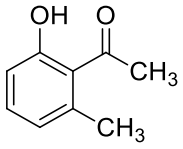
101. **The compound that gives the following ^{1}H-NMR spectral data is**

^{1}H-NMR δ in ppm : 11.80(s, 1H), 7.69(d, J = 2.3 Hz, 1H), 7.35 (dd, J = 8.5, 2.3 Hz, 1H), 6.86 (d, J = 8.5 Hz, 1H), 2.63 (s, 3H), 2.28(s, 3H)

(a) 

(b) 

(c) 

(d) 

102. **The correct number of stereoisomers and the correct number of enatiomeric pairs of $[Co(trien)Br_2]^+$ (trien = triethylenetetraamine), respectively, are**

(a) 5 and 2 (b) 4 and 2 (c) 5 and 4 (d) 6 and 4

103. **The number of microstates, the ground term, the energy separation between the ground term and the next excited state term of identical multiplicity, and the j value for the lowest energy spin-orbit state for the ground state for a d^3 configuration, respectively, are**

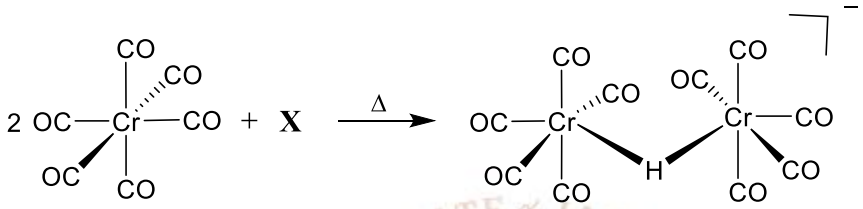
(a) 120, ^{4}F, 15B, 3/2 (b) 120, ^{4}F, 15B, 9/2

(c) 156, ^4F, 15B + C, 3/2 (d) 156, ^4F, 15B, 9/2

104. **For complex $[Ni(RNH_2)_6]^{2+}(R = alkyl), \Delta_0$ is $12,600\ cm^{-1}$. The spin-orbit coupling constant (λ) for Ni^{2+} ion is $-315\ cm^{-1}$. The μ_{eff} (in BM) for the complex is closest to**

(a) 3.11 (b) 2.97 (c) 2.83 (d) 2.55

105. **Consider the following reaction X is**



(a) H^+ (b) H^- (c) OH^- (d) H_2O

106. **A particle of mass m is confined to a one-dimensional box of unit length. The wave function of the system is $\Psi(x) = \sqrt{8/5}\ sin(\pi x)\ [1 + Cos(\pi x)]$ for $0 \leq x \leq 1$, and zero elsewhere. The average value of the energy in this state is**

(a) $h^2/5m$ (b) $h^2/3m$ (c) $h^2/8m$ (d) $h^2/10m$

107. **The correct statements regarding the inner-transition elements from the following**

P. The absorptions in the electronic spectra involve 4f → 4f and 4f → 5d transitions

Q. The experimental magnetic moment of Eu^{3+} ion is greater than the calculated spin-only magnetic moment

R. The 4f → 4f transitions are sharp while 4f → 5d transitions are broad

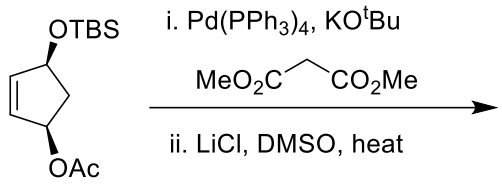
S. The peak positions for the 4f → 4f transitions are marginally affected by the ligand environment

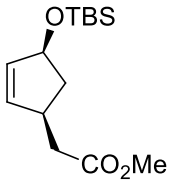
(a) P, Q and R only (b) Q, R and S only (c) P, R and S only (d) P, Q, R and S

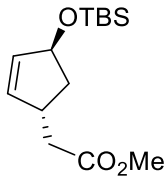
108. **The rate law for the reaction $N_2O_{2(g)} \longrightarrow 2NO_{(g)}$ is first order in the concentration of N_2O_2. If the initial concentration of N_2O_2 is $1.0\ mol\ dm^{-3}$, the expression for time-dependent behaviour of concentration of NO (in $mol\ dm^{-3}$) is**

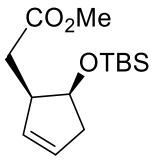
(a) $2(1 - e^{-kt})$ (b) $1 - e^{-kt}$ (c) $0.5(1 - e^{-kt})$ (d) $1 + e^{-kt}$

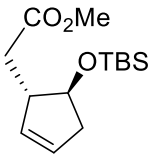
109. **The major product formed in the following reaction sequence is**



(a) 

(b) 

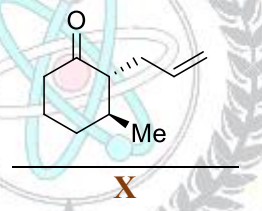
(c) 

(d) 

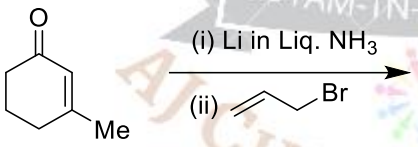
110. **The dielectric constants of electrolyte solutions, A and B, are ε and 2ε, respectively. At a given temperature(T), the ratio, $\lambda_D(A)/\lambda_D(B)$ of two Debye (ionic) screening lengths $\lambda_D(A)$ and $\lambda_D(B)$, is**

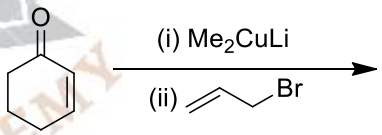
(a) 1 (b) 2 (c) $\sqrt{2}$ (d) $1/\sqrt{2}$

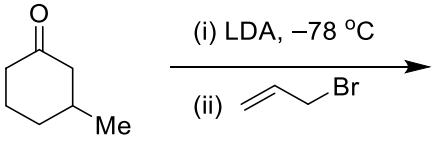
111. **The reactions that give X as the major product are**

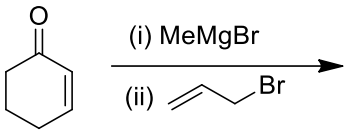


X

I. 

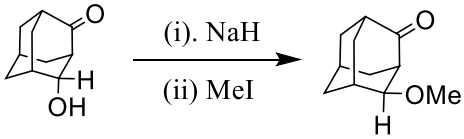
; **II.** 

III. 

; **IV.** 

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

112. **The correct sequence of processes involved in the following transformation is**



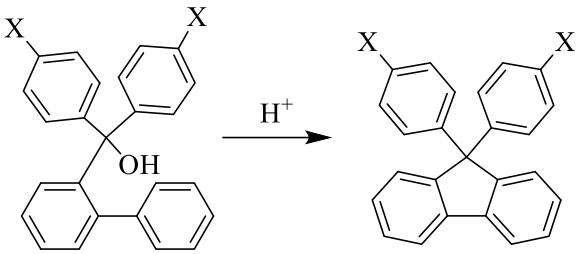
(a) (i) deprotonation, (ii) O-methylation

(b) (i) enolate formation, (ii) retro-aldol reaction, (iii) O-methylation

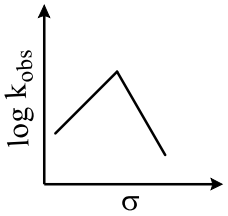
(c) (i) deprotonation, (ii) retro-aldol reaction, (iii) O-methylation, (iv) aldol reaction

(d) (i) deprotonation, (ii) retro-aldol reaction, (iii) aldol reaction, (iv) O-methylation

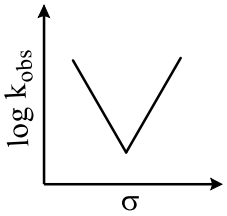
113. **The Hammett plot for the following transformation is**



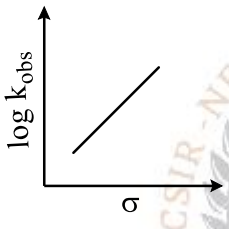
(a)



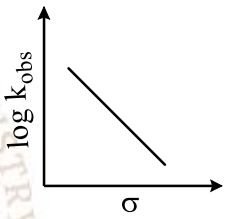
(b)



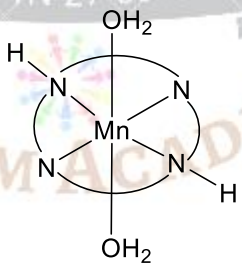
(c)



(d)



114. **The total number of lines expected in the EPR spectrum of a high-spin Mn(II) complex [Given; $I_{Mn} = \frac{5}{2}$; $I_N = 1$], for which the schematic diagram is shown below is**



(a) 6 (b) 54 (c) 270 (d) 30

115. **The mass spectra of $Pd(PPh_3)_4$ alone and a mixture of $Pd(PPh_3)_4$ and sulfonated triphenylphosphine, $[L]^-$, are recorded on two different machines. The relevant data is given below.**

Species	Machine	Mode		Relative intensity of the corresponding mass signal			
			n = 0	n = 1	n = 2	n = 3	n = 4
$[Pd(PPh_3)_n]^+$	Machine I	(+)-ion	-	1%	22%	100%	8%
$[Pd(L)(PPh_3)_n]^-$	Machine I	(−)-ion	2%	35%	100%	-	-
$[Pd(L)(PPh_3)_n]^-$	Machine II	(−)-ion	12%	100%	1%	-	-

Consider the following statements based on the above data:

P. Machine-I provides a softer ionization conditions than Machine-II

Q. In Machine-I, the stable species under the MS conditions contain three phosphine ligands

R. Mass data reveal ligand exchange reaction

S. The increased prevalence of monophosphine ion, $[Pd(L)]^-$, in Machine-II is attributed to ion fragmentation

The option containing the correct statements is

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

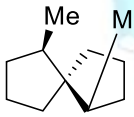
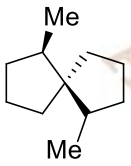
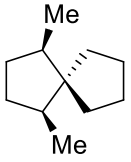
116. The unnormalized probability density of a continuous variable x is given by

$$p(x) = e^{-ax^2} \quad -\infty \leq x \leq \infty \text{ (a is a constant)}$$

The average of x^2 over the normalized distribution is

(a) a^2 (b) $2a$ (c) $a^2/2$ (d) $\frac{1}{2a}$

117. The correct match for methyl groups of molecules with their topicity is

	Molecules		topicity
P.		I.	Enantiotopic
Q.		II.	Homotopic
R.		III.	Diastereotopic

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

118. The rotational constant of a diatomic molecule is $2.0\ cm^{-1}$. The wavelength of the excitation laser is 333 nm. Assuming rigid rotor model of diatomic molecule, the first three stokes lines (in cm^{-1}) in the rotational Raman spectrum are predicted to be closest to

(a) 30018, 30010, 30002 (b) 30058, 30050, 30042

(c) 30018, 30014, 30010 (d) 30034, 30030, 30026

119. The wave function of a quantum mechanical system with the Hamiltonian H is $\Psi = c_1 f_1 + c_2 f_2$, where c_1, c_2 are constants and f_1, f_2 are orthonormal basis functions. If

$H_{11} = H_{22} = 5$ eV and $H_{12} = H_{21} = 2$ eV, where $H_{ij} = \langle f_i \mid H \mid f_j \rangle$, the ground state energy (in eV) of the system obtained by variation method is

(a) 7 (b) 5 (c) 3 (d) 2

120. The number of permitted configurations for N water molecules at absolute zero temperature is

(a) 2^{2N} (b) 2^{4N} (c) $2^{2N}\left(\frac{3}{8}\right)^{N}$ (d) $2^{2N}\left(\frac{8}{3}\right)^{N}$

Answer Key

Part - B

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

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

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

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

Part - C

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

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

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

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

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

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

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

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