# CSIR-UGC-NET (Chemical Science) DEC-2024

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# CSIR-UGC-NET - Chemical Science - Dec - 2024

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

**21.** The half-lives for the forward and reverse reactions that are first order in both directions, are 24 ms and 39 ms, respectively. The relaxation time for return to equilibrium after a temperature jump is closest to

(a) 21 ms (b) 32 ms (c) 43 ms (d) 11 ms

**22.** The correct order for the relative rate of addition of $^{\cdot}CCl_3$ radical to

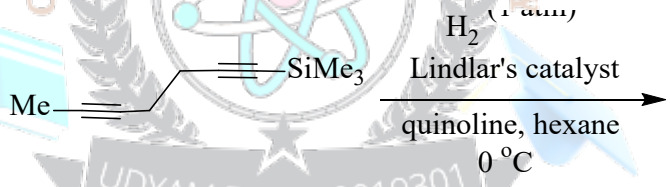
| 2-methylpropene | styrene | 2-methylbut-2-ene |
|---|---|---|
| P | Q | R |

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

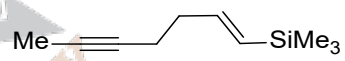
**23.** In the absence of nitrogen, the enzyme nitrogenase functions as

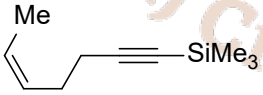
(a) nitrile hydratase (b) carboxypeptidase (c) Urease (d) hydrogenase

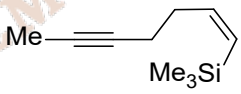
**24.** The major product formed in the following reaction is




(a) 


(b) 


(c) 


(d) 


**25.** The order of polarity of the B-C bond for the following compounds is

| $B(C\equiv CH)_3$ | $B(CH=CH_2)_3$ | $B(H_2C-CH_3)_3$ | $B(H_2C-Ph)_3$ |
|---|---|---|---|
| P | Q | R | S |

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

**26.** The ionic strength (in $mol\ kg^{-1}$) of an aqueous solution of $0.03\ mol\ kg^{-1}$ $K_3[Fe(CN)_6]$ is closest to

(a) 0.27 (b) 0.18 (c) 0.12 (d) 0.15

**27.** Consider the statements for the complexes

| $[RhCl_3(H_2O)_3]$ | $[Ir(CO)(Cl)(PPh_3)_2]$ |
|---|---|
| (X) | (Y) |

P. X has two isomers

**Q. Y has two isomers**

**R. Both X and Y are prone to oxidative addition**

**S. $d_{z^2}$ orbital is most destabilized in Y**

**The correct option is,**

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

**28. For an electron in a hydrogen atom, with azimuthal quantum number, $l = 1$ and magnetic quantum number, $m = 1$, the angle (in degrees) between the z-axis and the orbital angular momentum vector is**

(a) 0 (b) 45 (c) 54.7 (d) 90

**29. At $T = 0$ K, the entropy (in J $K^{-1}$) of 2 moles of CO is closest to**

(a) 0 (b) 5.76 (c) 11.53 (d) 23.05

**30. The correct order for the X-H bond dissociation energies (BDE) in the following compounds is**

(a) $Me_3Si\text{-}H > Me_3C\text{-}H > Me_3Sn\text{-}H$

(b) $Me_3C\text{-}H > Me_3Si\text{-}H > Me_3Sn\text{-}H$

(c) $Me_3C\text{-}H > Me_3Sn\text{-}H > Me_3Si\text{-}H$

(d) $Me_3Sn\text{-}H > Me_3C\text{-}H > Me_3Si\text{-}H$

**31. The correct statement is (en = ethylene diamine)**

(a) $K_3[CuF_6]$ is paramagnetic and sodium nitroprusside is diamagnetic

(b) Both $K[AgF_4]$ and $K_3[CuF_6]$ are diamagnetic

(c) Both $[Co(en)_3]Cl_3$ and $K_3[CuF_6]$ are paramagnetic

(d) Sodium nitroprusside is paramagnetic and $[Co(en)_3]Cl_3$ is diamagnetic

**32. In the following reaction, P and Q respectively, are**

$B_2H_6 + NH_2CH_3 \longrightarrow P$ ; $B_2H_6 + NMe_3 \longrightarrow Q$

(a) $H_3BNH_2CH_3$ and $H_3BNMe_3$

(b) $[BH_2(NH_2CH_3)_2]^+[BH_4]^-$ and $H_3BNMe_3$

(c) $H_3BNH_2CH_3$ and $[BH_2(NMe_3)_2]^+[BH_4]^-$

(d) $[BH_2(NH_2CH_3)_2]^+[BH_4]^-$ and $[BH_2(NMe_3)_2]^+[BH_4]^-$

**33. Consider the statements**

**P. Decomposition of $H_2O_2$ in aqueous solution catalyzed by bromide ion is a homogeneous catalytic reaction**

**Q. Hydrogeneration of ethene to ethane accelerated by Pd or Ni particles is a heterogeneous catalytic reaction**

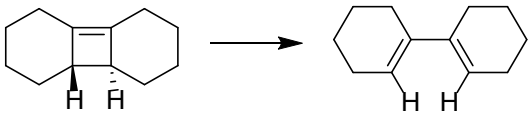
**R. Enzymes increase the equilibrium constants of the reactions**

**S. Turnover number is the number of catalytic cycles till the catalyst becomes inactive**

**The set of correct statements is**

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

**34. The following reaction occurs under**



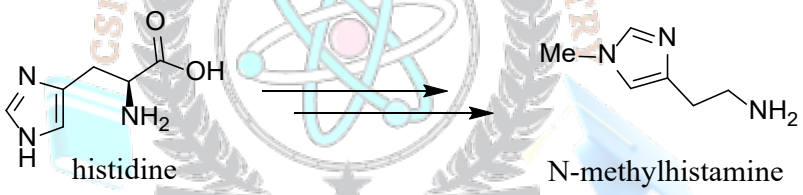
(a) Photochemical conditions via a disrotatory ring-opening

(b) Photochemical conditions via a conrotatory ring-opening

(c) thermal conditions via a disrotatory ring-opening

(d) thermal conditions via a conrotatory ring-opening

**35. The co-enzymes involved in the following biosynthesis are**




histidine N-methylhistamine

**P. Pyridoxal phosphate (PLP)** **Q. S-Adenosylmethionine (SAM)**

**R. Pyridoxamine phosphate (PMP)** **S. Adenosine triphosphate (ATP)**

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

**36. Quantum confinement leads to**

(a) increase in the band gap of the semiconductors

(b) decrease in the band gap of the metal nanoparticles

(c) decrease in the band gap of the semiconductors

(d) no change in the band gap of the quantum dots

**37. The steps involved in the reaction of acetaldehyde with formaldehyde in the presence of NaOH to produce pentaerythritol $[C(CH_2OH)_4]$ are**

(a) Claisen condensation followed by knoevenagel condensation

(b) Cannizzaro reaction followed by claisen condensation

(c) Knoevenagel condensation followed by aldol reactions

(d) aldol reactions followed by Cannizzaro reaction

**38. The solvent that shifts the Schlenk equilibrium to the right side is**

$$2RMgX \rightleftharpoons MgR_2 + MgX_2 \qquad (R = \text{isopropyl})$$

(a) hexane (b) tetrahydrofuran (c) dioxane (d) diethyl ether

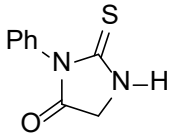
**39.** **In the $^1$H-NMR, the methylene protons of X and Y appears as,**

$ClCH_2$-C(Cl)(Br)$CH_3$ (X) **and** $CH_3CH_2$-$C(Cl_2)CH_3$ (Y)

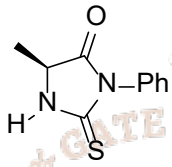
(a) X = Y = AB quartet (b) X = Y = quartet

(c) X = AB quartet; Y = quartet (d) X = quartet; Y = AB quartet

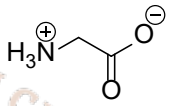
**40.** **The reaction of dipeptide, $H_2N$-Gly-Ala-$CO_2H$, with PhNCS at pH 8 followed by treatment with $CF_3CO_2H$ produces**



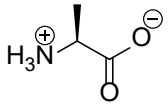

P




Q




R




S

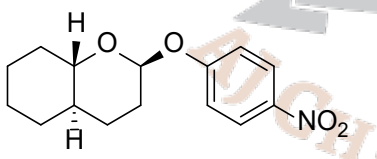
(a) P and S (b) Q and R (c) P and Q (d) R and S

**41.** **The order of acceptor strength towards $Me_2S$ donor is**

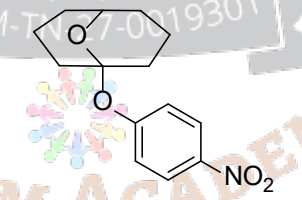
(a) $AlCl_3$ > $BCl_3$ > $GaCl_3$ (b) $BCl_3$ > $GaCl_3$ > $AlCl_3$

(c) $GaCl_3$ > $AlCl_3$ > $BCl_3$ (d) $AlCl_3$ > $GaCl_3$ > $BCl_3$

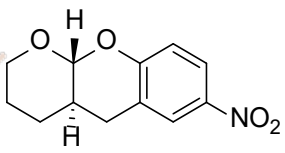
**42.** **The correct order for the rate of acidic hydrolysis of the following cyclic acetals is**




P




Q




R

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

**43.** **The standard reduction potentials of lanthanides ($Ln^{3+}/Ln$) are**

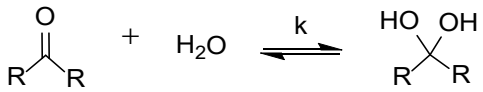
(a) similar to each other and also similar to those of late transition metals

(b) different from each other but similar to lighter p-block elements

(c) similar to each other and also similar to those of s-block elements

(d) different from each other but similar to those of s-block elements

**44.** **For the following equilibrium, the correct match for the carbonyl compounds in Column-X with the equilibrium constant K in Column-Y is**




| Column-X | Column-Y | P | Q | R |
|---|---|---|---|---|

| | | | |
|---|---|---|---|
| P. | $CH_3CHO$ | (i) | $1.2 \times 10^6$ |
| Q. | $Cl_3CCHO$ | (ii) | 1.06 |
| R. | $CF_3C(O)CF_3$ | (iii) | 2000 |

(a) (iii) ; (ii) ; (i)
(b) (ii) ; (iii) ; (i)
(c) (ii) ; (i) ; (iii)
(d) (i) ; (iii) ; (ii)

**45.** **The enzyme nitrogenase converts one mole of $N_2$ to x mole of $NH_3$ and y mole of $H_2$ using z mole of protons and w mole of electrons. The values of x, y, z and w, respectively, are**

(a) 2, 0, 6 and 6 (b) 1, 0, 6 and 6 (c) 1, 2, 8 and 8 (d) 2, 1,8 and 8

**46.** **For the reaction of RBr with EtONa/EtOH, the correct match for the R groups in Column-X with the relative rates in Column-Y is**

**(for R = $CH_3CH_2$, relative rate = 1)**

| | Column-X | | Column-Y |
|---|---|---|---|
| P. | $CH_3$ | (i) | $4.2 \times 10^{-6}$ |
| Q. | $CH_3CH_2CH_2$ | (ii) | 0.03 |
| R. | $(CH_3)_2CHCH_2$ | (iii) | 0.28 |
| S. | $(CH_3)_3CCH_2$ | (iv) | 17 |

(a) (iv) ; (iii) ; (ii) ; (i)
(b) (iv) ; (i) ; (iii) ; (ii)
(c) (iii) ; (ii) ; (iv) ; (i)
(d) (ii) ; (iii) ; (i) ; (iv)

**47.** **Nanoparticles have length scales**

(a) between 0.1 to 1000 nm in any dimension

(b) in any nanometer scale and always in one particular dimension

(c) between 1 to 500 nm and always in one particular dimension

(d) between 1 to 100 nm in any dimension

**48.** **Correct statement about polymerization is**

(a) The average molar mass of the polymer product does not depend upon the time length of stepwise polymerization

(b) The slower the initiation of the chain, the higher the average molar mass of the polymer in chain polymerization

(c) In chain polymerization, an activated monomer attacks a minimum of three other monomers to link

(d) The average chain length of a polymer in stepwise polymerization is linearly dependent on the fraction of the reacted monomers

**49.** **A two-level system consists of a double degenerate excited state which is $\in$ energy above the ground state. The y-intercept of the $\ln(P_e/P_g)$ vs. $1/T$ plot is ($P_e$ and $P_g$ are the probabilities associated with the excited and ground states, respectively.)**

(a) 0 (b) 2 (c) 2 ln 2 (d) ln 2

**50.** **For a given metal ion, the correct order of the nephelauxetic effect of ligands is**

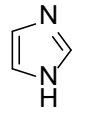
(a) $CN^- > en > NH_3 > I^-$ (b) $I^- > CN^- > NH_3 > en$

(c) $CN^- > I^- > en > NH_3$ (d) $I^- > CN^- > en > NH_3$

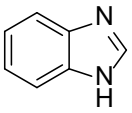
**51.** **The lowest energy π-MO of butadiene has an energy of ____[β is resonance energy]**

(a) $-1.61804\ \beta$ (b) $-0.61804\ \beta$ (c) $0.61804\ \beta$ (d) $1.61804\ \beta$

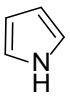
**52.** **The correct option for the pKa of following pairs of compounds is**



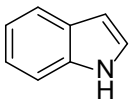
P



Q



R



S

(a) P > Q and R > S (b) P > Q and S > R

(c) Q > P and R > S (d) Q > P and S > R

**53.** **The radii of the cation and anion of an ionic compound are 74 pm and 170 pm, respectively. The coordination number of the cation and the best possible geometry of the compound are, respectively**

(a) 4, tetrahedral (b) 6, octahedral (c) 8, cubic (d) 4, square planar

**54.** **The option showing the correct structural types for $ZnFe_2O_4$ and $KMnF_3$, respectively, is**

(a) Perovskite and Fluorite (b) Perovskite and Antifluorite

(c) Spinel and Perovskite (d) Spinel and Fluorite

**55.** **The rotational quantum number associated with the most intense transition in the microwave spectrum of a diatomic molecule varies with temperature (T) as**

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

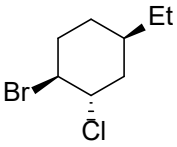
**56.** **The number of D and P terms that arise from $p^3$ electronic configuration of an atom, respectively, are**

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

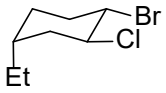
**57.** **Product of two reflection operations $\sigma_v\ \sigma_v'$ is equivalent to**

(a) i (b) $C_n$ (c) $\sigma_h$ (d) $\sigma_d$

**58.** **The following structures are**

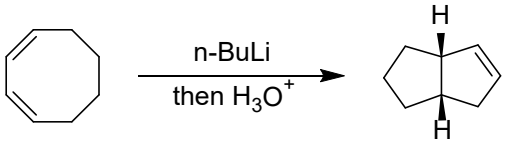


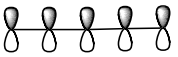

**X** **and** **Y**

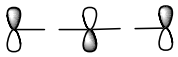


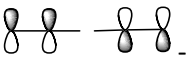

(a) identical (b) enantiomers (c) diastereomers (d) constitutional isomers

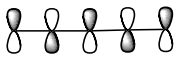
**59. The HOMO of the intermediate involved in the following reaction is**




(a) 

(b) 

(c) 

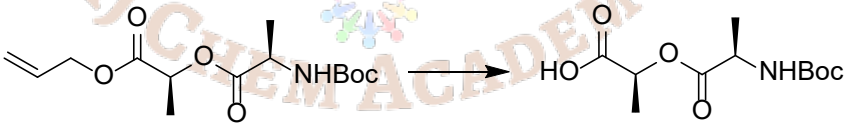
(d) 

**60. In a 3-dimensional isotropic harmonic oscillator, the degeneracy of the state with energy equal to $(9/2)\hbar\omega$ is [$\omega$ is the angular frequency]**

(a) 3 (b) 9 (c) 6 (d) 10

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

**61. The correct reagent to effect the following transformation is**




(a) 6N HCl (b) 1N NaOH (c) Morpholine, $Pd(PPh_3)_4$ (d) $CF_3CO_2H$

**62. At 25 ℃, the total volume, V (in $cm^3$) of an ethanol solution containing 1.0 kg of water fits the following expression**

$$V/cm^3 = 1000 + 60\left(\frac{m}{m^0}\right) - 0.5\left(\frac{m}{m^0}\right)^2$$

**Here 'm' is molality and $m^0 = 1\ mol\ kg^{-1}$. The partial molar volume of ethanol (in $cm^3\ mol^{-1}$) in the solution prepared by mixing 460 g of ethanol and 2 kg of water is_____. [Molar mass of ethanol = 46 g $mol^{-1}$]**

(a) 50 (b) 40 (c) 55 (d) 45

**63. The correct catalyst for conversion of acetophenone to (S)-1-phenylethanol under high pressure of hydrogen is_____ [DPEN = 1, 2-diphenyl-1, 2-ethylenediamine]**

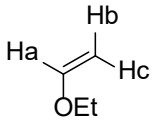
(a) [(S)-BINAP]$RuCl_2$

(b) [(R)-BINAP]$RuCl_2$

(c) [(S)-BINAP][(S,S)-DPEN]$RuCl_2$/t-BuOK

(d) [(R)-BINAP][(R,R)-DPEN]$RuCl_2$/t-BuOK

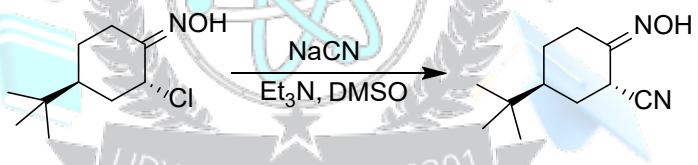
**64. The correct match of the labelled protons for ethyl vinyl ether in Column-P with their chemical shift in Column-Q is**




| | Column-X | | Column-Y |
|---|---|---|---|
| P. | $H_a$ | (i) | 6.45 (dd, J = 13, 7 Hz) |
| Q. | $H_b$ | (ii) | 4.05 (dd, J = 7, 2 Hz) |
| R. | $H_c$ | (iii) | 4.20 (dd, J = 13, 2 Hz) |

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

**65. For the following transformation, the product is formed through**




(a) an $S_N2$ reaction

(b) an $S_N1$ reaction

(c) a 1,2-elimination followed by a 1,4-addition reaction

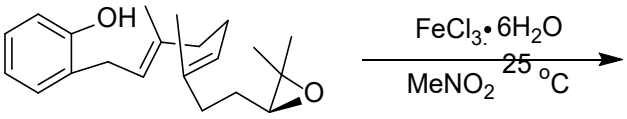
(d) a 1,4-elimination followed by a 1,4-addition reaction

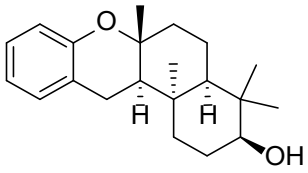
**66. List-I and List-II give the molecular formula and the geometry of the species, respectively. The option showing the correct match is**

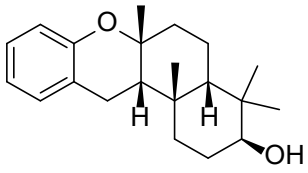
| | List-I | | List-II |
|---|---|---|---|
| P. | $[Zn\{N(CH_2CH_2NH_2)_3\}Cl]^+$ | (i) | Trigonal bipyramidal |
| Q. | $[Cu(2,2\text{-bpy})\{NH(CH_2COO)_2\}]$ | (ii) | Square pyramidal |
| R. | $[ZrF_7]^{3-}$ | (iii) | Monocapped trigonal prism |
| S. | $[AgTe_7]^{3-}$ | (iv) | Trigonal planar |

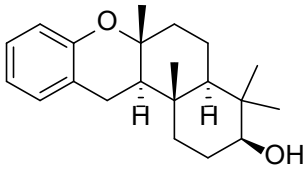
| | P | | Q | | R | | S |
|---|---|---|---|---|---|---|---|
| (a) | (i) | ; | (ii) | ; | (iii) | ; | (iv) |
| (b) | (i) | ; | (ii) | ; | (iv) | ; | (iii) |
| (c) | (i) | ; | (iii) | ; | (ii) | ; | (iv) |
| (d) | (ii) | ; | (i) | ; | (iii) | ; | (iv) |

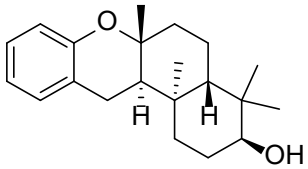
**67.** The major product formed in the following reaction is



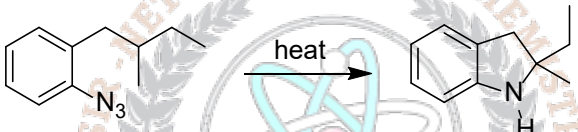

(a) 

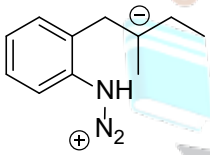
(b) 

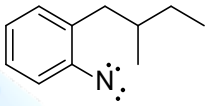
(c) 

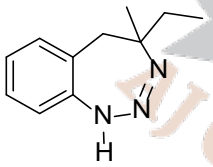
(d) 

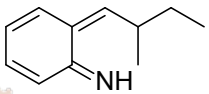
**68.** The intermediate involved in the following transformation is




(a) 

(b) 

(c) 

(d) 

**69.** A chromium carbonyl compound $Cr(CO)_6$ reacts with $NaBH_4$ to give P. The Lewis base-P reacts with another molecule of $Cr(CO)_6$ to form compound-Q with the release of CO. In another reaction, compound-P reacts with $BH_3$ to produce R. Compounds P, Q and R, respectively, are

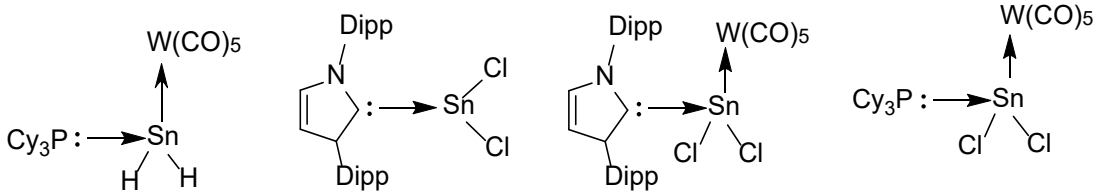
| | P | Q | R |
|---|---|---|---|
| (a) | $[Cr(CO)_5(BH_4)]^-$ | $[(CO)_5Cr(BH_4)\text{-}Cr(CO)_5]^-$ | $[Cr(CO)_4B_2H_7]^-$ |
| (b) | $[Cr(CO)_5H]^-$ | $[(CO)_5Cr\text{-}H\text{-}Cr(CO)_5]^-$ | $[Cr(CO)_4BH_4]^-$ |
| (c) | $[Cr(CO)_5(BH_4)]^-$ | $[(CO)_5Cr\text{-}BH_4\text{-}Cr(CO)_5]^-$ | $[Cr(CO)_5BH_4]^-$ |
| (d) | $[Cr(CO)_5H]^-$ | $[(CO)_4Cr\text{-}H\text{-}Cr(CO)_6]^-$ | $[Cr(CO)_5BH_4]^-$ |

**70.** At 0 ℃, the standard volume of transition from ice to water is $-1.6\ cm^3\ mol^{-1}$ and the corresponding standard entropy of transition is $22\ J\ K^{-1}\ mol^{-1}$. An increase in pressure by 100 bar would result in lowering of freezing point (in K) of

water by (1 bar = $10^5$ Pa)

(a) 1.23 (b) 0.56 (c) 0.73 (d) 1.46

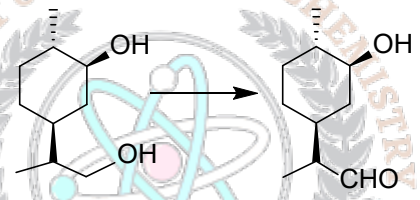
**71.** The correct option of the isomer shifts in $^{119}$Sn Mossbauer Spectra for the following compounds is (Dipp = Diisopropylphenyl)




W X Y Z

(a) Z > Y (b) W > Y (c) Y > X (d) W > X

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




(a) TEMPO, NCS, $CH_2Cl_2/H_2O$ (pH 8.6)

(b) $MnO_2$, acetone

(c) $CrO_3$, $H_2SO_4$, $H_2O$-acetone

(d) TEMPO (cat), NaOCl (cat), $NaClO_2$, toluene/phosphate buffer pH 6.8

**73.** For the given cell, $Zn_{(s)} \mid Zn^{2+}{}_{(aq.,0.5\ M)} \parallel Ag^{+}{}_{(aq.,0.1\ M)} \mid Ag_{(s)}$, the emf (in V) of the cell at 25 °C is closest to [At 25 °C, $E^0_{Zn^{2+}/Zn} = -0.76$ V and $E^0_{Ag^+/Ag} = +0.80$ V]

(a) 0.05 (b) 0.04 (c) 1.56 (d) 1.51

**74.** A molybedenum compound-P is obtained by the CO displacement of $Mo(CO)_6$ with $P^iPr_3$. P reacts with $H_2$ to give compound-Q. Compounds P and Q are

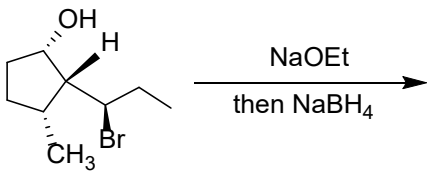
(a) $[Mo(P^iPr_3)_6]$ and $[Mo(P^iPr_3)_5(\eta^2\text{-}H_2)]$

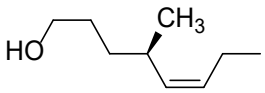
(b) $[Mo(CO)_3(P^iPr_3)_2]$ and $[Mo(CO)_3(P^iPr_3)_2(\eta^2\text{-}H_2)]$

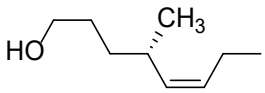
(c) $[Mo(CO)_3(P^iPr_3)_3]$ and $[Mo(CO)_3(P^iPr_3)_2(\eta^2\text{-}H_2)]$

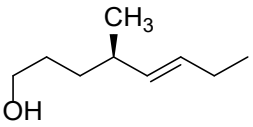
(d) $[Mo(CO)_4(P^iPr_3)_2]$ and $[Mo(CO)_4(P^iPr_3)(\eta^2\text{-}H_2)]$

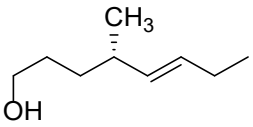
**75.** The major product formed in the following reaction is



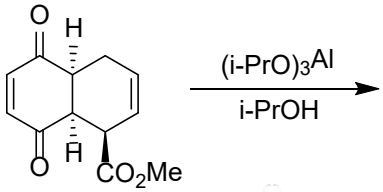
(a) 

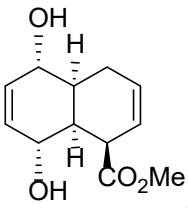

(b) 

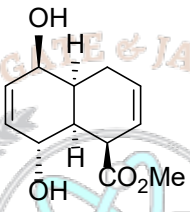

(c) 

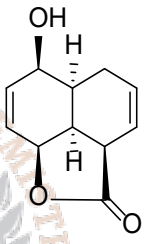

(d) 

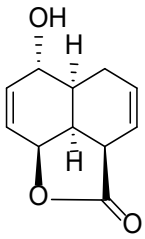

**76. The major product formed in the following reaction is**




(a) 


(b) 


(c) 


(d) 


**77. Colloidal solutions are stabilized by**

(a) van der Waals' forces (b) small particle size

(c) shape of particles (d) electrical double layer at the surface of the particles

**78. For formaldehyde (character table is shown below), the allowed electronic transition by x-polarized light is**

| $C_{2v}$ | E | $C_2$ | $\sigma_v$ | $\sigma_v'$ | | |
|---|---|---|---|---|---|---|
| $A_1$ | 1 | 1 | 1 | 1 | z | $x^2, y^2, z^2$ |
| $A_2$ | 1 | 1 | −1 | −1 | $R_z$ | xy |
| $B_1$ | 1 | −1 | 1 | −1 | $x, R_y$ | yz |
| $B_2$ | 1 | −1 | −1 | 1 | $y, R_x$ | zx |

(a) $^1A_1 \rightarrow {}^1A_1$ (b) $^1A_1 \rightarrow {}^1A_2$ (c) $^1A_1 \rightarrow {}^1B_1$ (d) $^1A_1 \rightarrow {}^1B_2$

**79. Consider the following statements regarding the electronic spectra of lanthanide complexes.**

**P. They exhibit fewer absorption bands due to a small number of microstates**

**Q. Their spectra are dependent on coordination number and geometry**

**R. Molar extinction coefficients (e) are smaller compared to transition metal complexes**

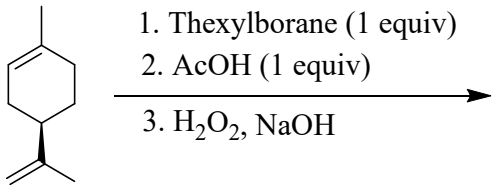
**S. Their absorption bands are sharp due to weak vibronic coupling**

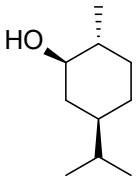
**T. Ligands field effects are negligible**

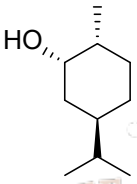
**The option with correct statements is**

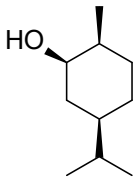
(a) P, Q, S only (b) P, R, S only (c) R, S, T only (d) Q, R, T only

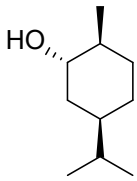
**80. The major product formed in the following reaction sequence is**




(a) 


(b) 


(c) 


(d) 


**81. Consider the reactions in List-I and related enzymes in List-II**

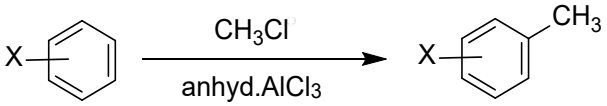
| | List-I | | List-II |
|---|---|---|---|
| P. | superoxide to oxygen | (i) | amine oxidase |
| Q. | hydrolysis of peptide | (ii) | Ni-superoxide dismutase |
| R. | hydroxylation of camphor | (iii) | carboxypeptidase |
| S. | primary amine to aldehyde | (iv) | cytochrome P450 |

**The option showing the correct match is**

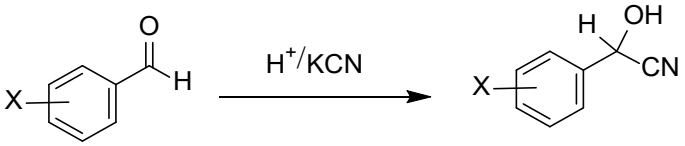
| | P | | Q | | R | | S | | P | | Q | | R | | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (a) | (ii) | ; | (iii) | ; | (iv) | ; | (i) | (b) | (iv) | ; | (i) | ; | (ii) | ; | (iii) |
| (c) | (iii) | ; | (ii) | ; | (i) | ; | (iv) | (d) | (ii) | ; | (i) | ; | (iv) | ; | (iii) |

**82. The slope of the Hammett plot (r) of $\log k_x/k_H$ against the substituent constant(s) for the reactions P and Q will, respectively, be**

**Reaction-P**




**Reaction-Q**




(a) negative and positive (b) negative and negative

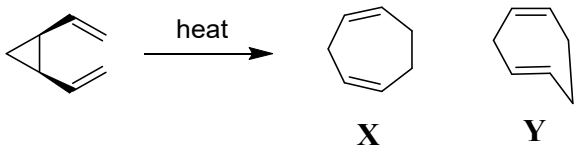
(c) positive and negative (d) positive and positive

**83. The atomic mass of X and Y are 5 amu and 40 amu, respectively. For the diatomic molecule XY, the spacing between any two successive lines is 8 $cm^{-1}$ in the microwave spectrum. The bond length of XY (in Å) is closest to_____**

$$\left(\frac{h}{8\pi^2 c} = 2.8 \times 10^{-44}\ Js^2m^{-1}, 1\ amu = 1.667 \times 10^{-27}\ kg\right)$$

(a) 0.688 (b) 0.974 (c) 1.377 (d) 1.948

**84. The correct statement about the following reaction is**




X Y

(a) X is formed as major product via a chair-like transition state

(b) Y is formed as major product via a chair-like transition state

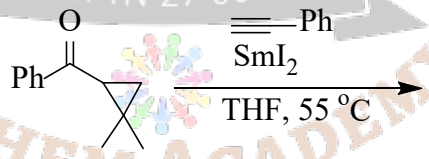
(c) X is formed as major product via a boat-like transition state

(d) Y is formed as major product via a boat-like transition state

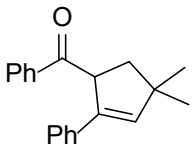
**85. Mark-Houwink equation can be used to determine molecular weight of a polymer. the values of empirical constants are $1.6 \times 10^{-4}$ dL g$^{-1}$ and 0.60. If the intrinsic viscosity of the polymer solution is 0.04 dL g$^{-1}$, the molar mass (in g mol$^{-1}$) of the polymer is closest to**

(a) 10000 (b) 1101 (c) 16000 (d) 9600

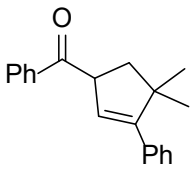
**86. In the presence of single electron transfer reagent, $SmI_2$, the major product formed in the following reaction is**



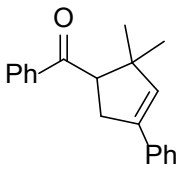

(a)



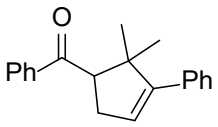

(b)




(c)




(d)




**87. A mixture of CaO and $CaCO_3$ is analyzed using thermogravimetry (TG) technique. The TG curve of the sample indicates that there is mass change from 155.2 mg to 125.3 mg. the percentage of $CaCO_3$ in the mixture is close to**

(a) 54.2 % (b) 27.1 % (c) 43.8 % (d) 29.9 %

**88. Consider the following reactions, the correct option is**

i. $^{210}_{84}Po \longrightarrow {}^{206}_{82}Pb + P$

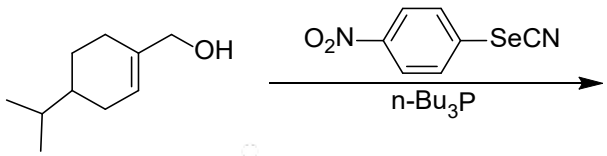
ii. $\left[{}^{125}_{52}Te\right]^{*} \longrightarrow {}^{125}_{52}Te + Q$

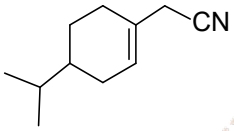
iii. $^{14}_{6}C \longrightarrow {}^{14}_{7}N + R$

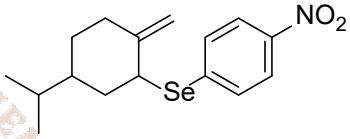
iv. $^{23}_{12}Mg \longrightarrow {}^{23}_{11}Na + S$

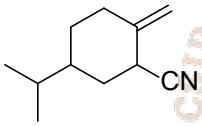
| | P | Q | R | S |
|---|---|---|---|---|
| (a) | $^{4}_{2}He$ | $\gamma$ | $^{0}_{-1}e$ | $^{0}_{1}e$ |
| (b) | $^{0}_{1}e$ | $^{0}_{-1}e$ | $\gamma$ | $^{4}_{2}He$ |
| (c) | $^{0}_{-1}e$ | $^{0}_{1}e$ | $^{4}_{2}He$ | $\gamma$ |
| (d) | $^{4}_{2}He$ | $\gamma$ | $^{0}_{1}e$ | $^{0}_{-1}e$ |

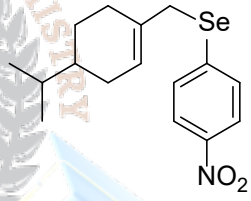
**89.** The major product formed in the following reaction is




(a) 


(b) 


(c) 


(d) 


**90.** In a diffusion-controlled reaction in benzene between two species with similar radii having $2.0\ mol\ m^{-3}$ initial concentrations, the time (in ns) required for the concentration of the species to fall to half of their initial values at 320 K is closest to

[The viscosity coefficient of benzene is $0.601$ cP and $1\ cP = 10^{-3} kg\ m^{-1} s^{-1}$]

(a) 26 (b) 76 (c) 42 (d) 62

**91.** Consider the following reactions

P. $SbCl_5 + AlCl_3 \longrightarrow [AlCl_4]^{-}[SbCl_4]^{+}$

Q. $AsF_3 + SbF_5 \longrightarrow [AsF_2]^{+}[SbF_6]^{-}$

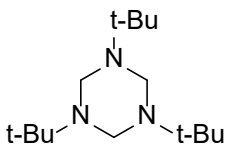
R. $NOF + SbF_5 \longrightarrow [NO]^{+}[SbF_6]^{-}$

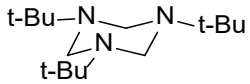
S. $HF + SbF_5 \longrightarrow [SbF_4]^{+}[HF_2]^{-}$

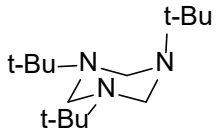
The correct option is

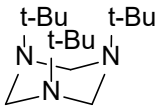
(a) P and Q only (b) Q and R only (c) R and S only (d) P and S only

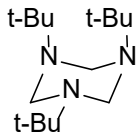
**92.** The most stable conformation of the following compound is



(a) 

(b) 

(c) 

(d) 

**93.** If mean of a data set $\{25, 29, 25, 32, 24 \text{ and } x\}$ is 27, then the median is

(a) 32 (b) 27 (c) 26 (d) 25

**94.** One mole of a monoatomic ideal gas at 1 atm pressure undergoes compression from 49.2 L to 24.6 L under adiabatic reversible conditions. The final temperature (in K) of the gas is closest to

(a) 952 (b) 848 (c) 756 (d) 1697

**95.** Consider the moieties in the enzymes that engage in hydrogen bonding with the substrates.

| Enzymes → / Moieties ↓ | Haemoglobin | Nickel-superoxide dismutase | [FeFe] hydrogenase | Hemerythrin |
|---|---|---|---|---|
| P | tyrosine | μ-hydroxo | histidine | Aza(dithiolato) |
| Q | histidine | μ-hydroxo | Aza(dithiolato) | tyrosine |
| R | histidine | tyrosine | Aza(dithiolato) | μ-hydroxo |
| S | μ-hydroxo | Aza(dithiolato) | histidine | tyrosine |

The correct option is

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

**96.** The expression for d-orbitals with $n = 3, l = 2$ and $m = \pm 2$ is

$$\Psi_{32\pm2} = NR'(r)r^2 \sin^2\theta\, e^{\pm 2i\phi}$$

Where N is a constant. $r, \theta, \phi$ are spherical polar co-ordinates. $R'(r)$ is a function of r. The orbital generated from a linear combination of $\Psi_{322}$ and $\Psi_{32-2}$ orbitals, $\frac{1}{i}(\Psi_{322} - \Psi_{32-2})$, is

(a) $d_{z^2}$ (b) $d_{xy}$ (c) $d_{yz}$ (d) $d_{zx}$

**97.** Match the correct set of IR bands to the given compounds

$(Cp = C_5H_5, Cp^* = C_5Me_5)$

| | List-I | | List-II | | P | Q | R |
|---|---|---|---|---|---|---|---|
| P. | $Cp_2Ti(CO)_2$ | (i) | 1979 and 1897 $cm^{-1}$ | (a) | (ii) | (iii) | (i) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Q. | $CpCp^*Ti(CO)_2$ | (ii) | 1956 and 1875 $cm^{-1}$ | (b) | (iii) | ; | (i) | ; | (ii) |
| R. | $Cp^*{}_2Ti(CO)_2$ | (iii) | 1930 and 1850 $cm^{-1}$ | (c) | (i) | ; | (iii) | ; | (ii) |
| | | | | (d) | (i) | ; | (ii) | ; | (iii) |

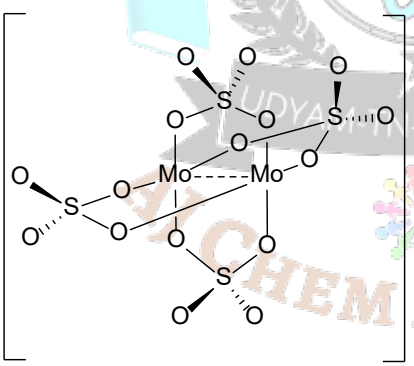
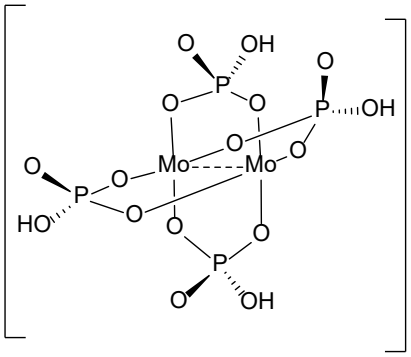
**98.** A particle, confined in a one-dimensional box between $x = 0$ to $x = L$, is perturbed by a constant potential V on the left of the box ($x = 0$ to $x = L/2$) and by $V/3$ on the right half ($x = L/2$ to $x = L$). The first-order perturbation correction to the ground state energy is

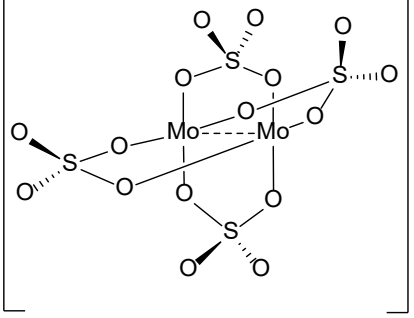
(a) $V/2$ (b) $2V/3$ (c) $3V/4$ (d) $3V/2$

**99.** For a quantum particle in a one-dimensional simple harmonic oscillator, $\langle x^2 \rangle = \hbar(n + \frac{1}{2})/m\omega$ and $\langle p_x^2 \rangle = m\hbar\omega(n + \frac{1}{2})$ for the quantum number n. The product of uncertainty of position and momentum for $n = 1$ is

(a) $3\hbar/2$ (b) $\hbar/2$ (c) $2\hbar$ (d) $\hbar$

**100.** Consider the following table

| | Complex | | Configuration | | M-M Bond order |
|---|---|---|---|---|---|
| X. |  | (i) | $\sigma^2\pi^4$ | P. | 3 |
| Y. |  | (ii) | $\sigma^2\pi^4\delta^1$ | Q. | 4 |

| | | | | |
|---|---|---|---|---|
| **Z.** |  | **(iii)** | $\sigma^2\pi^4\delta^2$ | **R.** **3.5** |

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

**101. Consider the following statements regarding the magnetic properties of lanthanide ions.**

**P. Observed magnetic moments are highly dependent on the ligand field**

**Q. Only ground J state is populated**

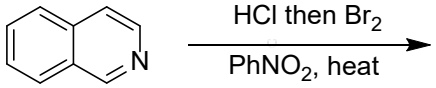
**R. Spin-orbit couplings are in the order of ~1000 $cm^{-1}$ while the ligand field effects are only about ~100 $cm^{-1}$**

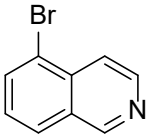
**S. The spin-only formula cannot be used to calculate the magnetic moment of $f^7$ configuration**

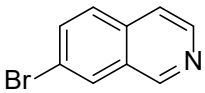
**The option showing the correct statements is**

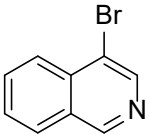
(a) P and Q only (b) Q and R only (c) P and S only (d) R and S only

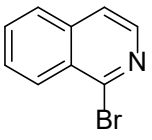
**102. The major product formed in the following reaction is**




(a) 


(b) 


(c) 


(d) 


**103. Assuming the molecules are static, the $^{19}$F-NMR spectra of $ClF_3$(X) and $ClF_5$(Y) consists of**

| | X | | Y |
|---|---|---|---|
| (a) | doublet and triplet | ; | singlet |
| (b) | singlet | ; | singlet |
| (c) | doublet and triplet | ; | doublet and quintet |

(d) singlet ; Triplet and quartet

**104.** **Given are the statements regarding the overall stability constants ($\log\beta$) for the formation of $[M(en)_3]^{2+}$ and $[M(EDTA)]^{2-}$ ($en$ = ethylene diamine, EDTA = ethylenediamine tetraacetate), where $M^{2+}$ is a divalent metal ion**

**($M^{2+} = Mn^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+}$)**

**P. The $\log\beta$ is lowest for $Mn^{2+}$ in both $[M(en)_3]^{2+}$ and $[M(EDTA)]^{2-}$ series ($Mn^{2+}$ to $Zn^{2+}$)**

**Q. The $\log\beta$ value for $[M(EDTA)]^{2-}$ is lower than $[Mn(en)_3]^{2+}$**

**R. The $\log\beta$ values increase in the series ($Mn^{2+}$ to $Zn^{2+}$) for both EDTA and "en" complexes**

**S. $\Delta S°$ remains nearly constant along the series**

**The option with the correct statement is**

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

**105.** **The option showing the correct statements about radioactive decay is**

**P. All radioactive processes are 1st order**

**Q. Radioactive decay is dependent on temperature**

**R. Activation energy of a radioactive process is zero**

**S. The rate of decay depends on the amount of radioactive materials**

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

**106.** **The ground state term, Lande factor (g) and the calculated magnetic moment ($m_{calc}$) for $Pr^{3+}$ are**

(a) $^3H_4, 0.80, 2.68$ (b) $^3H_4, 0.80, 3.58$ (c) $^5I_4, 1.33, 2.68$ (d) $^6H_{5/2}, 1.33, 3.58$

**107.** **The total number electronic transitions between triplet D and triplet F multiplets due to spin-orbit coupling is**

(a) 6 (b) 5 (c) 3 (d) 1

**108.** **Cu crystallizes in face-centered cubic lattice. Considering each Cu atom as hard sphere and in contact with its nearest neighbours, the fraction of volume of the unit cell occupied by Cu atoms is**

(a) 0.16 (b) 0.56 (c) 0.74 (d) 0.36

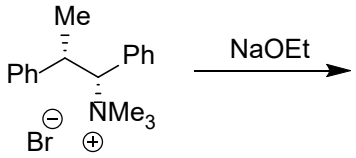
**109.** **The average time for which a hydrogen atom remains absorbed on a given surface is 35% shorter at 1000 K than at 600 K. The activation energy (in kJ $mol^{-1}$) for desorption is closest to**

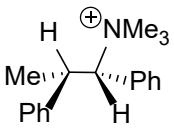
(a) 2.3 (b) 3.4 (c) 4.5 (d) 5.4

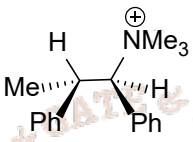
**110.** In the extraction of lanthanide, when an aqueous solution of $Ln^{3+}$ is poured into a cation exchange resin column, the $Ln^{3+}$ that moves fastest through the resin is

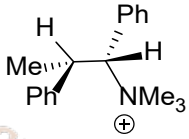
(a) $Lu^{3+}$ (b) $La^{3+}$ (c) $Gd^{3+}$ (d) $Sm^{3+}$

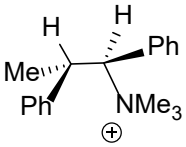
**111.** The conformation of the reactant that gives (E)-1, 2-diphenyl-1-propene in the following reaction is



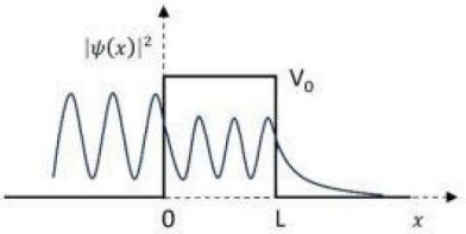

(a) 

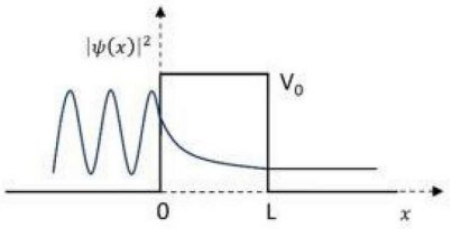

(b) 

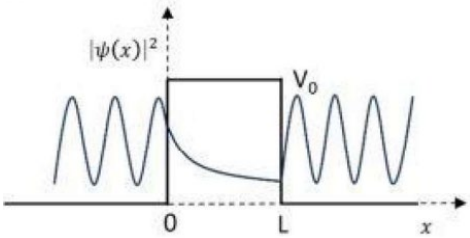

(c) 

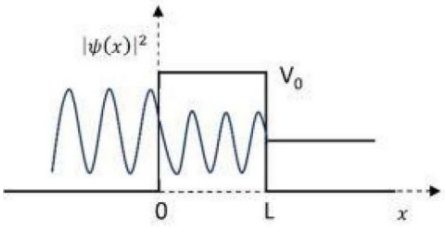

(d) 


**112.** A particle incident from the region $x < 0$ is under a potential barrier with finite height $V_0$ and finite width L, as in the diagrams. When the total energy (E) of the incident particle is less than $V_0$, the correct plot of the probability density ($|\Psi(x)|^2$) with distance (x) is

(a) 


(b) 


(c) 


(d) 


**113.** Match the given metal species in List-I with the corresponding properties in List-II

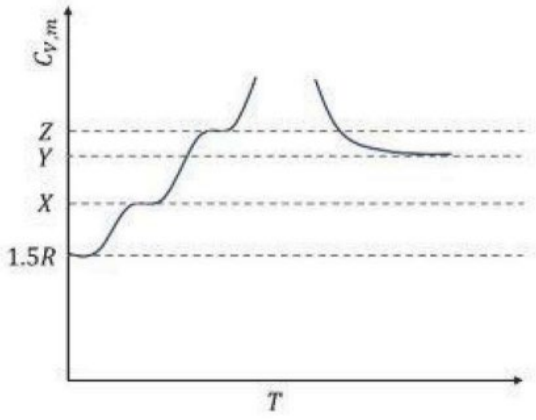
| | List-I | | List-II |
|---|---|---|---|
| P. | $[Co(H_2O)_6]^{2+}$ | (i) | Magnetic moment higher than spin-only value and weak JT distortion |
| Q. | $[Cr(H_2O)_6]^{3+}$ | (ii) | Spin-only magnetic moment and absence of JT distortion |
| R. | $NiCl_2(PPh_3)_2$ | (iii) | Paramagnetic and tetrahedral |

| S. | $Pd(PPh_3)_4$ | (iv) | diamagnetic and tetrahedral |
|---|---|---|---|

| | P | Q | R | S |
|---|---|---|---|---|
| (a) | (ii) | (iii) | (i) | (iv) |
| (c) | (iii) | (ii) | (iv) | (i) |

| | P | Q | R | S |
|---|---|---|---|---|
| (b) | (i) | (ii) | (iii) | (iv) |
| (d) | (i) | (iv) | (ii) | (iii) |

**114.** The variation of molar heat capacity at constant volume ($C_{V,m}$) with temperature (T) of a gaseous diatomic molecule is shown in the diagram below. The values of X, Y and Z, respectively, are

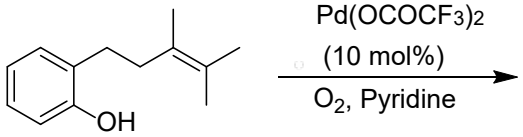


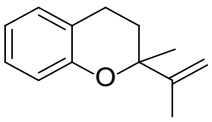

[The diagram is not to the scale and discontinuity in the diagram represents dissociation]

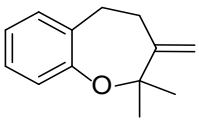
(a) 2.0 R, 2.5 R, 3.0 R (b) 2.5 R, 3.0 R, 3.5 R

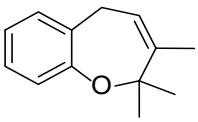
(c) 3.5 R, 4.0 R, 4.5 R (d) 3.0 R, 3.5 R, 4.0 R

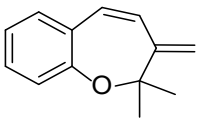
**115.** The major product formed in the following reaction is



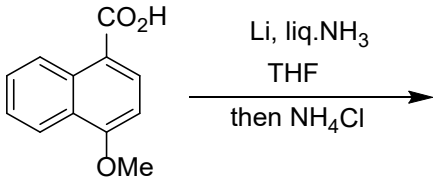

(a) 

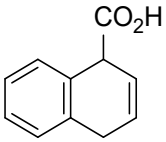

(b) 

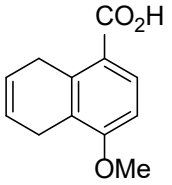

(c) 

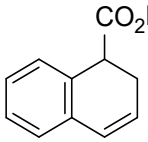

(d) 

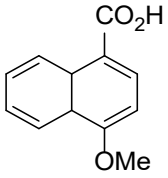

**116.** The major product formed in the following reaction is



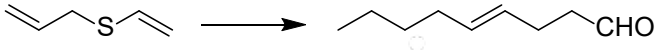

(a) 


(b) 


(c) 


(d) 


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




| | (i) | | (ii) | | (iii) | | (iv) |
|---|---|---|---|---|---|---|---|
| (a) | heat | ; | n-BuLi | ; | n-BuBr | ; | $HgCl_2, H_2O$ |
| (b) | n-BuLi | ; | n-BuBr | ; | heat | ; | $HgCl_2, H_2O$ |
| (c) | heat | ; | $HgCl_2, H_2O$ | ; | n-BuLi | ; | n-BuBr |
| (d) | n-BuLi | ; | n-BuBr | ; | $HgCl_2, H_2O$ | ; | heat |

**118.** **A correct statement, which always holds good, involving the zeroth-order ($E_0^0$), first-order ($E_0^1$) and second-order ($E_0^2$) perturbed energies for the ground state is**

**[$E_0$ is the exact ground state energy]**

(a) $E_0^0 + E_0^1 + E_0^2 > E_0$ (b) $E_0^0 + E_0^1 > 0$ (c) $E_0^0 + E_0^1 \geq E_0$ (d) $E_0^2 > 0$

**119.** **The fundamental vibrational frequencies of $H_2$ and $H^{37}Cl$ are 4395 $cm^{-1}$ and 2988 $cm^{-1}$, respectively. Considering all molecules are in their respective ground vibrational state, the energy change (in $cm^{-1}$) of the reaction below, is closest to**

$$HD + H^{37}Cl \longrightarrow H_2 + D^{37}Cl$$

**[Assume that force constant remains same with isotopic substitution]**

(a) $-65$ (b) $-130$ (c) $-260$ (d) $-520$

**120.** **To an aqueous solution of NaX and NaY, the addition of sulphamic caid ($H_2NSO_3H$) followed by acidification releases a nitrogen-containing gas P. Addition of KI and a starch solution does not yield a blue color, indicating complete removal of NaX. However, the blue color appears when a piece of granulated Zn is added. The reaction proceeds with the evolution of a nitrogen containing gas Q.**

**The correct option of X, Y, P and Q, respectively, is**

(a) $[NO_2]^-, [NO_3]^-, N_2, NO$ (b) $[NO_3]^-, [NO_2]^-, N_2, NO$

(c) $[NO_3]^-, [NO_2]^-, NO, N_2$ (d) $[NO_2]^-, [NO_3]^-, NO, N_2$

# Answer Key

## PART - B

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

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

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

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



## PART - C

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

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

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

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

| | |
|---|---|
| 72. | a |
| 73. | d |
| 74. | b |
| 75. | c |

| | |
|---|---|
| 87. | c |
| 88. | a |
| 89. | d |
| 90. | c |

| | |
|---|---|
| 102. | c |
| 103. | c |
| 104. | c |
| 105. | b |

| | |
|---|---|
| 117. | b |
| 118. | c |
| 119. | b |
| 120. | a |