PAPER : CSIR-UGC-NET/JRF DEC. 2024

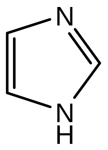
CHEMICAL SCIENCES

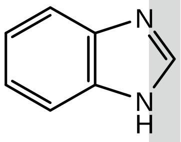
PART-B

21. Nano Particles 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

22. The correct order for the X-H bond dissociation energies (BDE) in the following compounds is
    (a) $Me_3Si-H > Me_3C-H > Me_3Sn-H$
    (b) $Me_3C-H > Me_3Si-H > Me_3Sn-H$
    (c) $Me_3C-H > Me_3Sn-H > Me_3Si-H$
    (d) $Me_3Sn-H > Me_3C-H > Me_3Si-H$

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


(I)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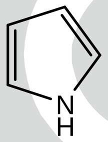
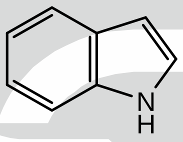

(III)


(IV)

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

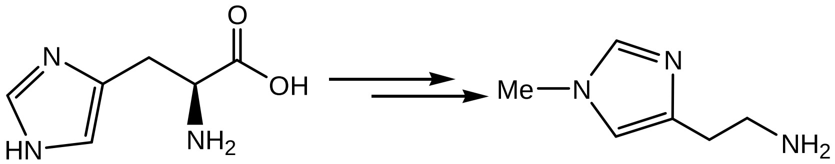
24. In the following reaction, A and B, respectively, are

$$B_2H_6 + NH_2CH_3 \xrightarrow{\quad} A$$

$$B_2H_6 + NMe_3 \xrightarrow{\quad} B$$

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

25. The co-enzymes involved in the following biosynthesis are



histidine N-methylhistamine

(A) Pyridoxal phosphate (PLP)
(B) S-Adenosylmethionine (SAM)
(C) Pyridoxamine phosphate (PMP)
(D) Adenosine triphosphate (ATP)

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

26. For the reaction of RBr with EtONa/EtOH, the correct match for the R groups in **Column P** with the relative rates in **Column Q** is
(for R = CH_3CH_2, relative rate = 1)

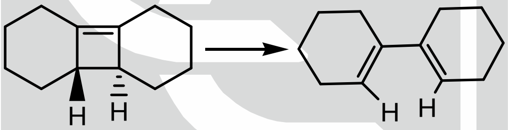
	Column - P		**Column - Q**
A.	CH_3	i.	4.2×10^{-6}
B.	$CH_3CH_2CH_2$	ii.	0.03
C.	$(CH_3)_2CHCH_2$	iii.	0.28
D.	$(CH_3)_3CCH_2$	iv.	17

(a) A-iv; B-iii; C-ii; D-i
(b) A-iv; B-i; C-iii; D-ii
(c) A-iii; B-ii; C-iv; D-i
(d) A-ii; B-iii: C-i; D-iv

27. 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

28. In a 3-dimensional isotropic harmonic oscillator, the degeneracy of the state with energy equal to (9/2) $\hbar\omega$ is [ω is the angular frequency]
(a) 3
(b) 9
(c) 6
(d) 10

29. 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

30. The order of acceptor strength towards Me_2S donor is
(a) $AlCl_3 > BCI_3 > GaCl_3$
(b) $BCI_3 > GaCl_3 > AICI_3$
(c) $GaCl_3 > AICI_3 > BCI_3$
(d) $AlCl_3 > GaCl_3 > BCI_3$

31. 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

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

$$2RMgX \rightleftharpoons MgR_2 + MgX_2$$

(R = isopropyl)
(a) hexane
(b) tetrahydrofuran
(c) dioxane
(d) diethyl ether

33. 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

34. The correct order for the relative rate of addition of $^{*}CCl_3$ to 2-methylpropene (A), styrene (B) and 2-methylbut-2-ene (C) is
(a) A > B > C (b) B > A > C (c) B > C > A (d) C > B > A

35. 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

36. Consider the statements for the complexes $[RhCl_3(H_2O)_3]$ **(X)** and $[Ir(CO)(Cl)(PPH_3)_2]$ **(Y)**
(A) **X** has two isomers
(B) **Y** has two isomers
(C) Both **X** and **Y** are prone to oxidative addition
(D) d_{z^2} orbital is most destabilized in **Y**
The correct option is
(a) A, B and C only (b) B, C and D only (c) A and B only (d) A and C only

37. 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

38. For a given metal ion, the correct order of the nephelauxetic effect of ligands is (en = ethylene diamine)
(a) $CN^- > en > NH_3 > I^-$ (b) $I^- > CN^- > NH_3 > en$
(c) $CN^- > I^- > en > NH_3$ (d) $I^- > CN^- > en > NH_3$

39. 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

40. 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

41. 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

42. 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) $1.61804\,\beta$

43. 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

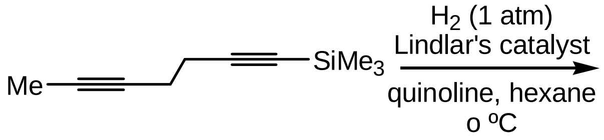
44. The half-lives for the forward and reverse reactions that are first order in both directions, are 24 ms and 39 ms, respectively. The relaxation time for return to equilibrium after a temperature jump is closest to
(a) 21 ms (b) 32 ms (c) 43 ms (d) 11 ms

45. At T = 0K, the entropy (in JK^{-1}) of 2 moles of CO is closest to
(a) 0 (b) 5.76 (c) 11.53 (d) 23.05

46. 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 vctor is
(a) 0 (b) 45 (c) 54.7 (d) 90

47. 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

48. The major product formed in the following reaction is



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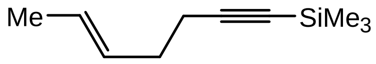

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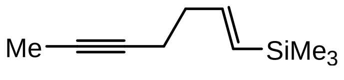

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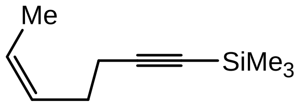

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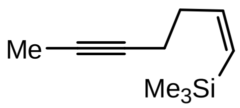


49. In the ^1H NMR, the methylene protons of $ClCH_2$-$C(Cl)(Br)CH_3$ **(X)** and CH_3CH_2-$C(Cl_2)CH_3$ **(Y)** appear as
(a) **X**=**Y**=AB quartet (b) **X**=**Y**=quartet
(c) **X**=AB quartet; **Y**=quartet (d) **X**=quartet; **Y**=AB quartet

50. Consider the statements

(A) Decomposition of H_2O_2 in aqueous solution catalyzed by bromide ion is a homogeneous catalytic reaction.

(B) Hydrogeneration of ethene to ethane accelerated by Pd or Ni particles is a heterogeneous catalytic reaction.

(C) Enzymes increase the equilibrium constants of the reactions.

(D) Turnover number is the number of catalytic cycles till the catalyst becomes inactive

The set of correct statements is

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

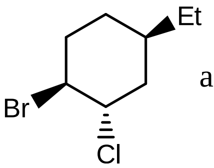
51. A two-level system consists of a double degenerate excited state which is $\in$ energy above the ground state. The y-intercept of the $\ln\left(P_e / P_g\right)$ vs 1/T plot is (P_e and P_g are the probabilities associated with the excited and ground states, respsectively.)

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

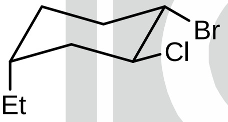
52. In the absence of nitrogen, the enzyme nitrogenase functions as

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

53. The following structures are



and



(a) identical (b) enantiomers

(c) diastereomers (d) constitutional isomers

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

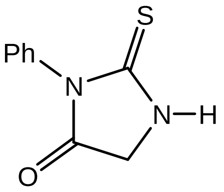
(a) T (b) $\sqrt{T}$ (c) T^2 (d) $1/\sqrt{T}$

55. The order of polarity of the B—C bond for the following compounds

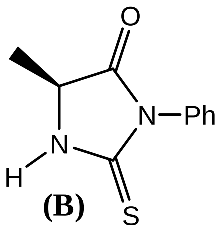
$\mathrm{B(C=CH)_3}$ (**P**); $\mathrm{B(CH=CH_2)_3}$ (**Q**); $\mathrm{B(CH_2-CH_3)_3}$ (**R**); $\mathrm{B(CH_2-C_6H_5)_3}$ (**S**)

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

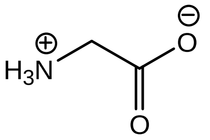
56. The reaction of dipeptide, H_2N-Gly-Ala-CO_2H, with PhNCS at pH 8 followed by



(A)



(B)



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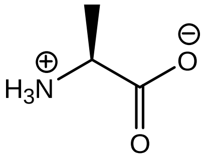
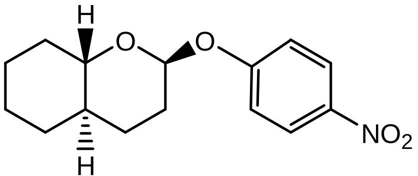


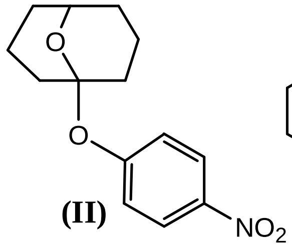
(D)

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

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



(I)



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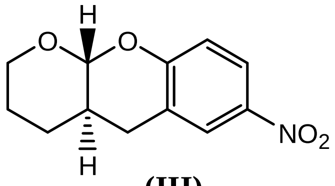


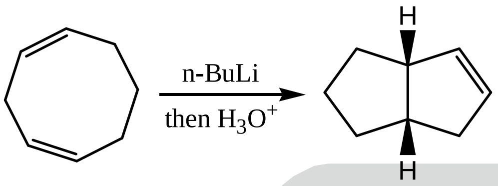
(III)

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

58. Product of two reflection operations $\sigma_v \sigma_v^{'}$ is equivalent to

(a) i (b) C_n (c) σ_h (d) σ_d

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



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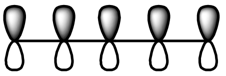

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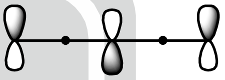

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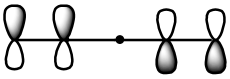

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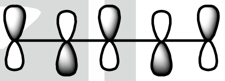


60. For the following equilibrium, the correct match for the carbonyl compounds in **Column P** with the equilibrium constant K in **Column Q** is

$$RC(O)R + H_2O \rightleftharpoons R_2C(OH)_2$$

	Column-P		**Column - Q**
A.	CH_3CHO	i.	1.2×10^6
B.	Cl_3CCHO	ii.	1.06
C.	$CF_3C(O)CF_3$	iii.	2000

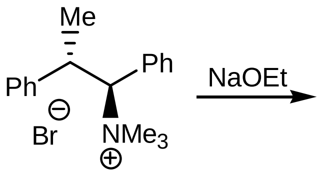
(a) A-iii; B-ii; C-i (b) A-ii; B-iii; C-i (c) A-ii; B-i; C-iii (d) A-i; B-iii; C-ii

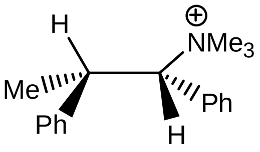
PART-C

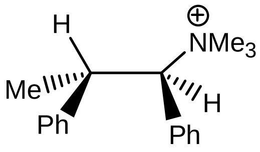
61. A correct statement, which **always** holds good, involving the zeroth-order $\left(E_0^0\right)$, first-order $\left(E_0^1\right)$ and second-order $\left(E_0^2\right)$ perturbed energies for the ground state is [E_0 is the exact ground state energy]

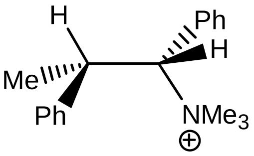
(a) $E_0^0 > E_0^1 > E_0^2 > E_0$ (b) $E_0^0 > E_0^1 > 0$ (c) $E_0^0 + E_0^1 \geq E_0$ (d) $E_0^2 > 0$

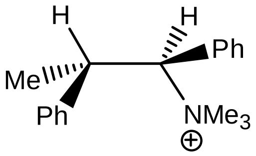
62. The conformation of the reactant that gives (E)-1, 2-diphenyl-1-propene in the following reaction is



(a) 

(b) 

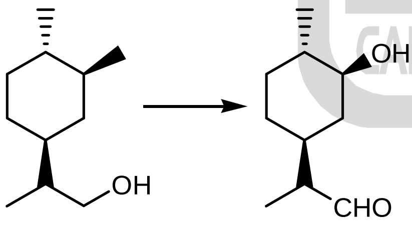
(c) 

(d) 

63. 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, θ, ϕ are spherical polar co-ordinate. $R'(r)$ is a function of r. The orbital generated from a linear combination of ψ_{322} and ψ_{32-2} orbitals, $\frac{1}{i}(\psi_{322} - \psi_{32-2})$, is

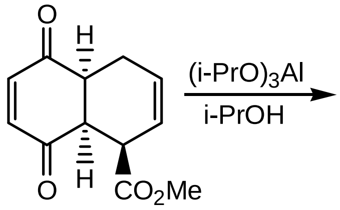
(a) d_{z^2} (b) d_{xy} (c) d_{yz} (d) d_{zx}

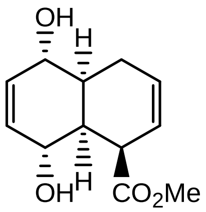
64. The correct set of reagents to effect the following transformation is

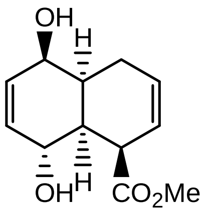


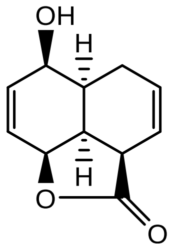
(a) TEMPO, NCS, CH_2Cl_2/H_2O (pH 8.6)
(b) MnO_2, acetone
(c) CrO_3, H_2SO_4, H_2O-acetone
(d) TEMPO (cat.), NaOCl (cat.), $NaClO_2$, toluene/phosphate buffer pH 6.8

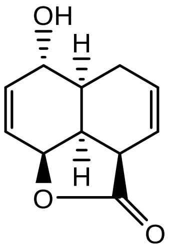
65. The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

66. The ground state term, Lande factor (g), and the calculated magnetic moment (m_{calc}) for Pr^{3+} (atomic number = 59) are

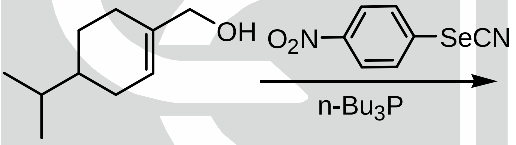
(a) ${}^3H_4$, 0.80, 2.68 (b) ${}^3H_4$, 0.80, 3.58 (c) ${}^5I_4$, 1.33, 2.68 (d) ^{6}H5/2, 1.33, 3.58

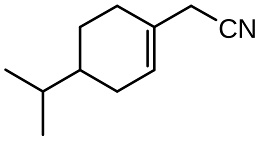
67. Match the correct set of IR bands to the given compounds (Cp = C_5H_5, Cp* = C_5Me_5)

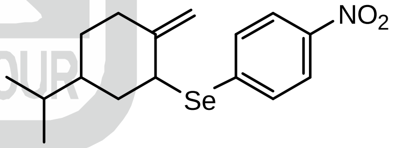
(a) $Cp_2Ti(CO)_2$	(i) 1979 and 1897 cm^{-1}
(b) $CpCp^*Ti(CO)_2$	(ii) 1956 and 1875 cm^{-1}
(c) $Cp_2^*Ti(CO)_2$	(iii) 1930 and 1850 cm^{-1}

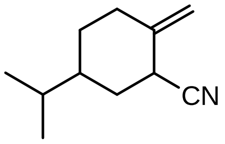
(a) a-ii, b-iii, c-i (b) a-iii, b-i, c-ii (c) a-i, b-iii, c-ii (d) a-i, b-ii, c-iii

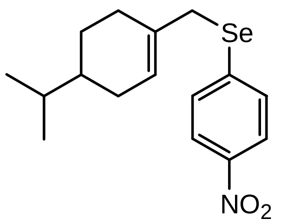
68. The major product formed in the following reaction is



(a) 

(b) 

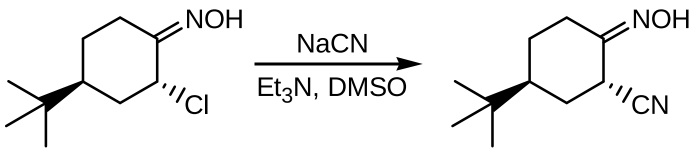
(c) 

(d) 

69. 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

70. For the following transformation, the product is formed through

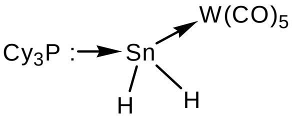


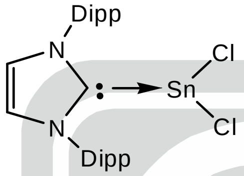
(a) an S_N2 reaction
(b) an S_N1 reaction
(c) a 1,2-elimination followed by a 1,4-addition reaction
(d) a 1,4-elimination followed by a 1,4-addition reaction

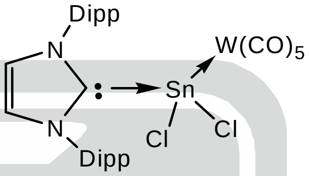
71. A chromium carbonyl compound $Cr(CO)_6$ reacts with $NaBH_4$ to give **A**. The Lewis base **A** reacts with another molecule of $Cr(CO)_6$ to form compound **B** with the release of CO. In another reaction, compound **A** reacts with BH_3 to produce **C**. Compounds **A, B** and **C**, respectively,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

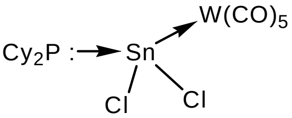
(a) $[Cr(CO)_5(BH_4)]^-$, $[(CO)_5Cr(BH_4)\text{-}Cr(CO)_5]^-$ and $[Cr(CO)_4B_2H_7]^-$
(b) $[Cr(CO)_5H]^-$, $[(CO)_5Cr\text{-}H\text{-}Cr(CO)_5]^-$ and $[Cr(CO)_4BH_4]^-$
(c) $[Cr(CO)_5(BH_4)]^-$, $[(CO)_5Cr\text{-}BH_4\text{-}Cr(CO)_5]^-$ and $[Cr(CO)_5BH_4]^-$
(d) $[Cr(CO)_5H]^-$, $[(CO)_4Cr\text{-}H\text{-}Cr(CO)_6]^-$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

72. The correct option of the isomer Shifts in ^{119}Sn Mossbauer spectra for the following compounds is





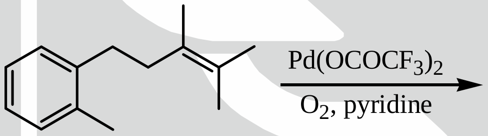


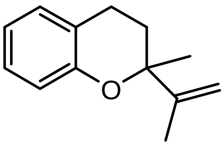


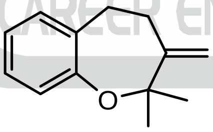
(Dipp = Diisopropylphenyl)

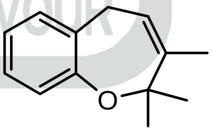
(a) Z > Y (b) W > Y (c) Y > X (d) W > X

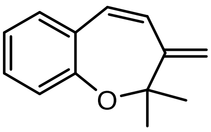
73. The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

74. Consider the following reactions,

A. $^{210}_{84}Po \rightarrow ^{206}_{82}Pb + P$ B. $\left[^{125}_{52}Te\right]^* \rightarrow ^{125}_{52}Te + Q$

C. $^{14}_{6}C \rightarrow ^{14}_{7}N + R$ D. $^{23}_{12}Mg \rightarrow ^{23}_{11}Na + S$

The correct option for **P, Q, R** and **S** is

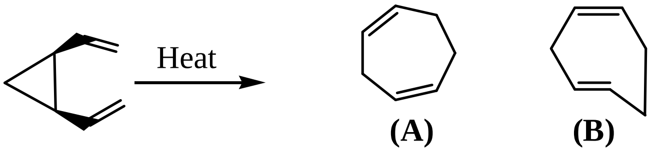
(a) $P = ^{4}_{2}He$, $Q = \gamma$, $R = ^{0}_{-1}e$, $S = ^{0}_{1}e$

(b) $P = ^{0}_{1}e$, $Q = ^{0}_{-1}e$, $R = \gamma$, $S = ^{4}_{2}He$

(c) $P = ^{0}_{-1}e$, $Q = ^{0}_{1}e$, $R = ^{4}_{2}He$, $S = \gamma$

(d) $P = ^{4}_{2}He$, $Q = \gamma$, $R = ^{0}_{1}e$, $S = ^{0}_{-1}e$

75. The correct statement about the following reaction is



(a) A is formed as major product via a chair-like transition state
(b) B is formed as major product via a chair-like transition state
(c) A is formed as major product via a boat-like transition state
(d) B is formed as major product via a boat-like transition state

76. A particle, confined in a one-dimensional box between x = 0 to x = L is perturbed by a constant potential V on the left half 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

77. The average time for which a hydrogen atom remains adsorbed 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

78. Mark-Houwink equation can be used to determine molecular weight of a polymer. The values of empirical constants are 1.6×10^{-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

79. If mean of a data set (25, 29, 25, 32, 24 and *x*} is 27, then the median is

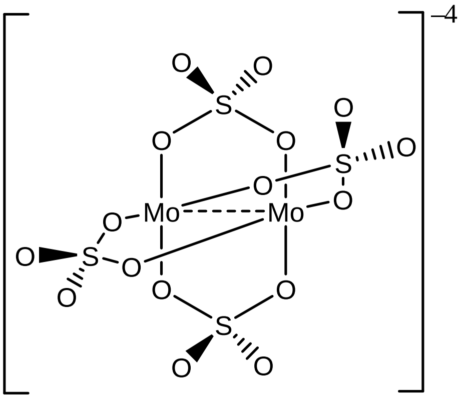
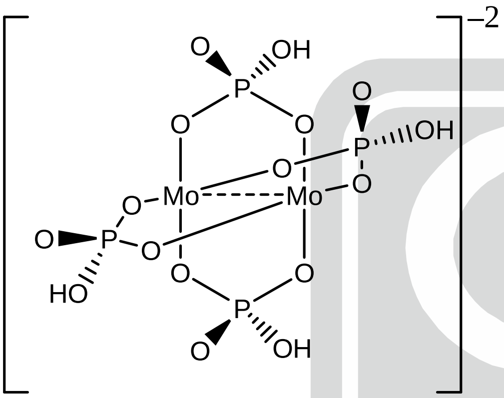
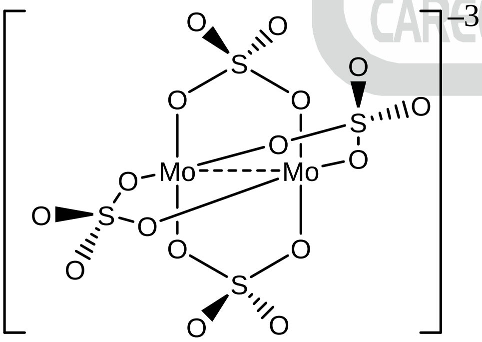
(a) 32 (b) 27 (c) 26 (d) 25

80. 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

81. 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

82.	**Complex**	**Configuration**	**M-M bond order**
a.		i. $\sigma^2\pi^4$	p. 3
b.		ii. $\sigma^2\pi^4\delta^1$	q. 4
c.		iii. $\sigma^2\pi^4\delta^2$	r. 3.5

The option showing complexes with their correct electronic configuration and bond order is

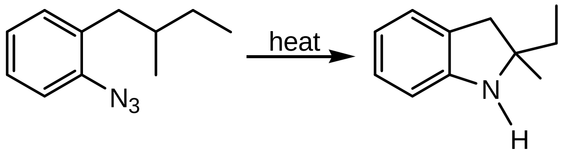
(a) a-iii-q; b-i-p; c-ii-r (b) a-i-p; b-iii-r; c-ii-q

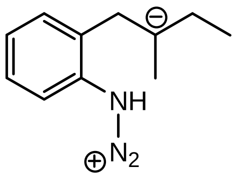
(c) a-ii-r; b-iii-q; c-i-p (d) a-ii-q; b-i-r; c-iii-p

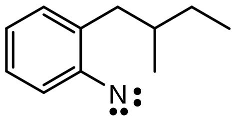
83. In the extraction of lanthanides, when an aqueous solution of Ln^{3+} is poured into a cation exchange resin column, the Ln^{3+} that moves fastest through the resin is

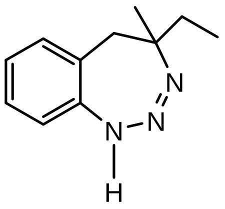
(a) Lu^{3+} (b) La^{3+} (c) Gd^{3+} (d) Sm^{3+}

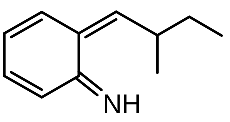
84. The intermediate involved in the following transformation is



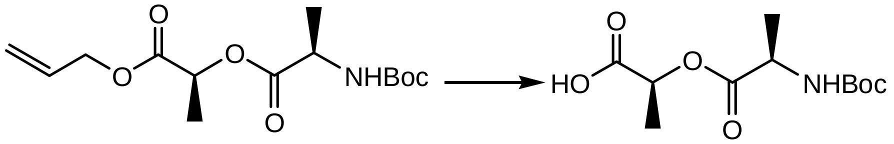
(a) 

(b) 

(c) 

(d) 

85. The correct reagent to effect the following transformation is

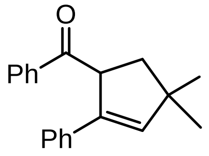


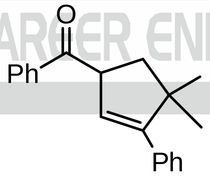
(a) 6N HCl (b) 1N NaOH (c) Morpholine, Pd(PPh$_3$)$_4$ (d) CF_3CO_2H

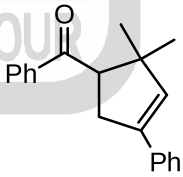
86. At 0 °C, the standard volume of transition from ice to water is -1.6 $cm^3\ mol^{-1}$ and the corresponding standard entropy of transition is 22 $JK^{-1}mol^{-1}$. An increase in pressure by 100 bar would result in lowering of freezing point (in K) of water by (1 bar=10^5 Pa)

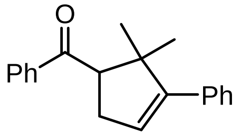
(a) 1.23 (b) 0.56 (c) 0.73 (d) 1.46

87. In the presence of single elecron transfer reagent, SmI_2, the major product formed in the following reaction is

(a) 

(b) 

(c) 

(d) 

88. 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

89. Consider the reactions in List I and related enzymes in List II

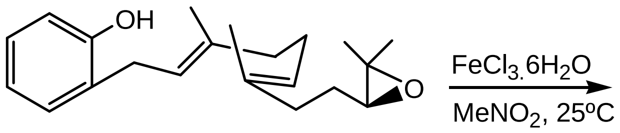
List I	**List II**
superoxide to oxygen	amine oxidase
hydrolysis of peptide	Ni-superoxide dismutase
hydroxylation of camphor	carboxypeptidase
primary amine to aldehyde	cytochrome P450

The option showing the correct match is

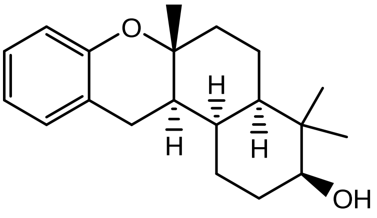
(a) a-ii, b-iii, c-iv, d-i (b) a-iv, b-i, c-ii, d-iii

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

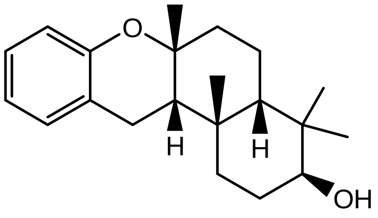
90. The major product formed in the following reaction is



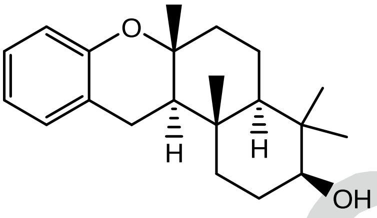
(a)



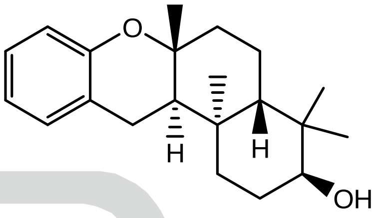
(b)



(c)



(d)



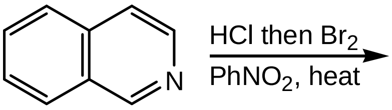
91.

C_{2v}	E	C_2	σ_v	σ'_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

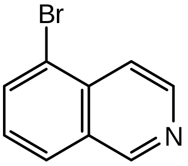
For formaldehyde (character table is shown above), the allowed electronic transition by x-polarized light is

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

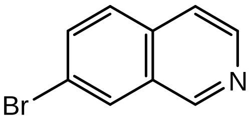
92. The major product formed in the following reaction is



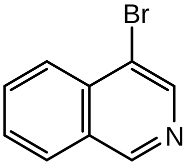
(a)



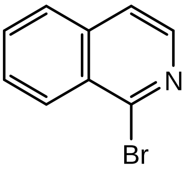
(b)



(c)



(d)



93. Colloidal solutions are stabilized by

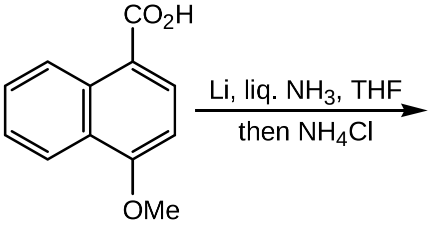
(a) van der Waal’s forces

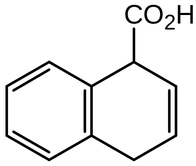
(b) small particle size

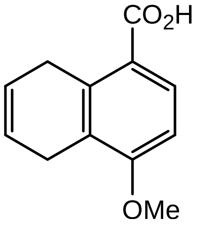
(c) shape of particles

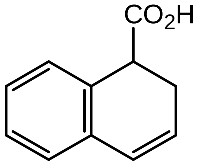
(d) electrical double layer at the surface of the particles

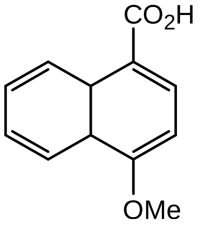
94. The major product formed in the following reaction is



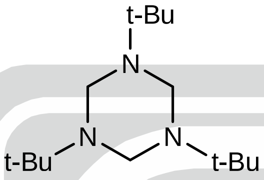
(a)


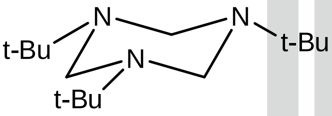
(b)


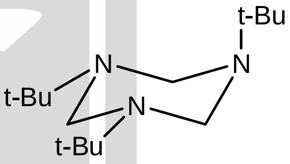
(c)


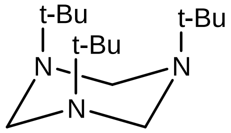
(d)


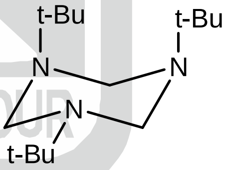
95. The most stable conformation of the following compound is



(a)


(b)


(c)


(d)


96. Consider the following statements regarding the magnetic properties of lanthanide ions.

A. Observed magnetic moments are highly dependent on the ligand field

B. Only ground J state is populated

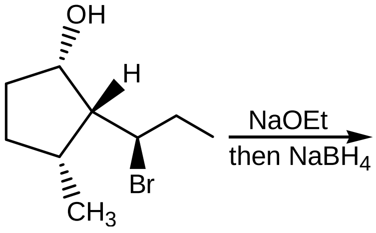
C. Spin-orbit couplings are in the order of ~1000 cm^{-1} while the ligand field effects are only about ~100 cm^{-1}

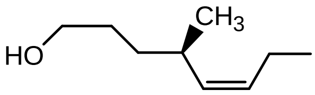
D. The spin-only formula cannot be used to calculate the magnetic moment of f^7 configuration

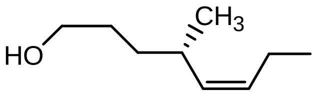
The option showing the correct statements is

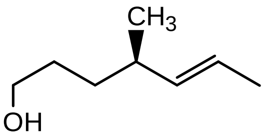
(a) A and B only (b) B and C only (c) A and D only (d) C and D only

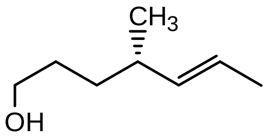
97. The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

98. 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+}) F^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+})

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

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

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

D. ΔS^0 remains nearly constant along the series

The option with the correct statements is

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

99. 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 overline A) is closest to $\left(\frac{h}{8\pi^2 c} = 2.8\times10^{-44}\ Js^2m^{-1}, 1\,amu = 1.667\times10^{-27}\ kg\right)$

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

100. 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

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

is closest to

[Assume that force constant remains same with isotopic substitution]

(a) –65
(b) –130
(c) –260
(d) –520

101. For the given cell,

$$Zn(s)\,|\,Zn^{2+}(aq, 0.5\,M)\,||\,Ag^{+}(aq., 0.1\,M)\,|\,Ag(s)$$

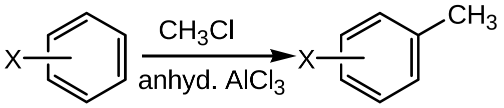
the emf (in V) of the cell at 25 ºC is closest to

[At 25ºC, $E^0_{Zn^{2+}/Zn} = -0.76\ V$ and $E^0_{Ag^{+}/Ag} = +0.80\ V$

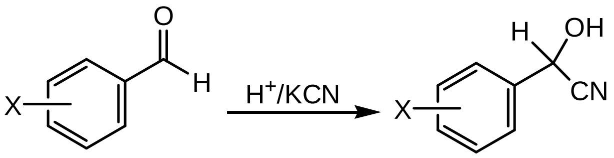
(a) 0.05
(b) 0.04
(c) 1.56
(d) 1.51

102. The slope of the Hammett plot (r) of log k_x/k_H against the substituent constant (s) for the reactions **A** and **B** will, respectively, be

Reaction A



Reaction B



(a) negative and positive (b) negative and negative
(c) positive and negative (d) positive and positive

103. The option showing the correct statements about radioactive decay is

A. All radioactive processes are 1st order

B. Radioactive decay is dependent on temperature

C. Activation energy of a radioactive process is zero

D. The rate of decay depends on the amount of radioactive materials

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

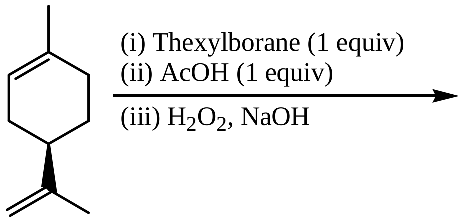
104. Consider the moieties in the enzymes that engage in hydrogen bonding with the substrates.

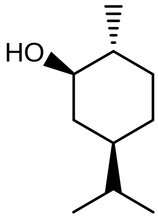
Enzymes → Moieties ↓	Haemoglobin	Nickel-superoxide dismutase	[FeFe] hydrogenase	Hemerythrin
A	tyrosine	μ-hydroxo	histidine	aza(dithiolato)
B	histidine	μ-hydroxo	aza(dithiolato)	tyrosine
C	histidine	tyrosine	aza(dithiolato)	μ-hydroxo
D	μ-hydroxo	aza(dithiolato)	histidine	tyrosine

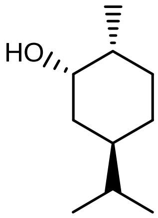
The correct option is

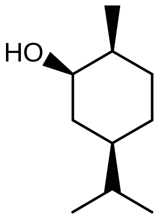
(a) A (b) B (c) C (d) D

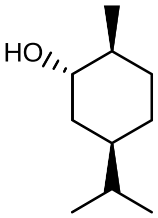
105. The major product formed in the following reaction sequence is



(a)


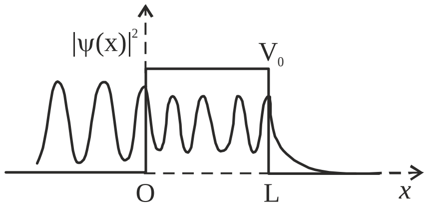
(b)


(c)


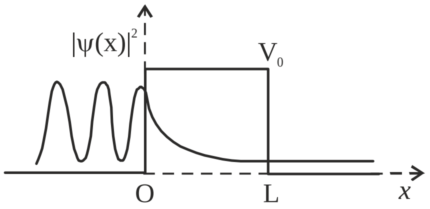
(d)


106. 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 $\left(\left|\psi(x)\right|^2\right)$ with distance (x) is

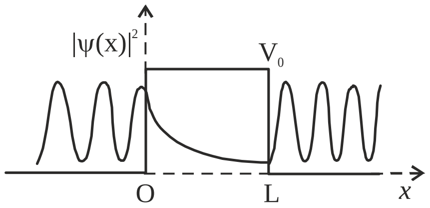
(a)



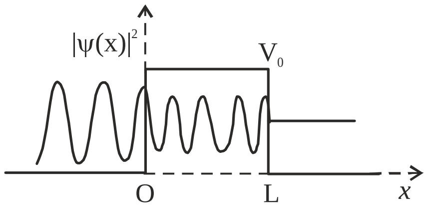
(b)



(c)



(d)



107. A mixture of CaO and $CaCO_3$ is analyzed using thermogravimetry (TG) technique. The TG curve of the sample indicates that there is a 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%

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

List-I	**List-II**
(A) $[Co(H_2O)_6]^{2+}$	(I) magnetic moment higher than spin-only value and weak JT distortion
(B) $[Cr(H_2O)_6]^{3+}$	(II) spin-only magnetic moment and absence of JT distortion
(C) $NiCl_2(PPh_3)_2$	(III) paramagnetic and tetrahedral
(D) $Pd(PPh_3)_4$	(IV) diamagnetic and tetrahedral

The correct option is

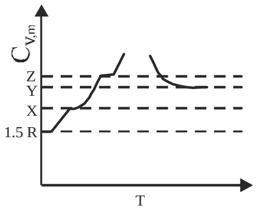
(a) A-II, B-III, C-I, D-IV (b) A-I, B-II, C-III, D-IV

(c) A-III, B-II, C-IV, D-I (d) A-I, B-IV, C-II, D-III

109. For a quantum particle in a one-dimensional simple harmonic oscillator, $\left\langle x^2\right\rangle = \hbar\left(n+1/2\right)/m\omega$ and $\left\langle p_x^2\right\rangle = m\hbar\omega\left(n+1/2\right)$ 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) $\hbar$

110. 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

111. At 25ºC, 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

112. **List I** and **List II** give the molecular formula and the geometry of the species, respectively.

List-I	**List-II**
(A) $\left[Zn\left\{N\left(CH_2CH_2NH_2\right)_3\right\}Cl\right]^+$	(I) Trigonal bipyramidal
(B) $\left[Cu\left(2,2-bpy\right)\left\{NH\left(CH_2COO\right)_2\right\}\right]$	(II) Square pyramidal
(C) $\left[ZrF_7\right]^{3-}$	(III) Monocapped trigonal prism
(D) $\left[AgTe_7\right]^{3-}$	(IV) Trigonal planar

The option showing the correct match of species in **List I** and metal geometry in **List II** is

(a) A-I, B-II, C-III, D-IV (b) A-I, B-II, C-IV, D-III

(c) A-I, B-III, C-II, D-IV (d) A-II, B-I, C-III, D-IV

113. Assuming the molecules are static, the ^{19}F NMR spectra of CIF_3 **(X)** and CIF_5**(Y)** consists of

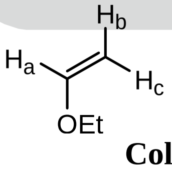
(a) **X:** doublet and triplet; **Y:** singlet

(b) **X:** singlet; **Y:** singlet

(c) **X:** doublet and triplet; **Y:** doublet and quintet

(d) **X:** singlet; **Y:** triplet and quartet

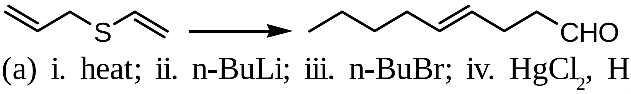
114. The correct match of the labelled protons for ethyl vinyl ether in **Column P** with their chemical shift in **Column Q** is



Column P	**Column Q**
(A) H_a	(I) 6.45 (dd, J = 13, 7 Hz)
(B) H_b	(II) 4.05 (dd, J = 7, 2 Hz)
(C) H_c	(III) 4.20 (dd, J = 13, 2 Hz)

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

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



(a) i. heat; ii. n-BuLi; iii. n-BuBr; iv. $HgCl_2$, H_2O

(b) i. n-BuLi; ii. n-BuBr; iii. heat; iv. $HgCl_2$, H_2O

(c) i. heat; ii. $HgCl_2$, H_2O; iii. n-BuLi; iv. n-BuBr

(d) i. n-BuLi; ii. n-BuBr; iii. $HgCl_2$, H_2O; iv. Heat

116. To an aqueous solution of Na**X** and Na**Y**, the addition of sulphamic acid $\left(H_2NSO_3H\right)$ 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 Na**X**. 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) $[NO_2]^-, [NO_3]^-, NO, N_2$

117. Consider the following statements regarding the electronic spectra of lanthanide complexes.

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

B. Their spectra are dependent on coordination number and geometry

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

D. Their absorption bands are sharp due to weak vibronic coupling

E. Ligand field effects are negligible

The option with correct statements is

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

118. Consider the following reactions

(A) $SbCl_5 + AlCl_3 \longrightarrow [AlCl_4]^- [SbCl_4]^+$ (B) $AsF_3 + SbF_5 \longrightarrow [AsF_2]^+ [SbF_6]^-$

(C) $NOF + SbF_5 \longrightarrow [NO]^+ [SbF_6]^-$ (D) $HF + SbF_5 \longrightarrow [SbF_4]^+ [HF_2]^-$

The correct option is

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

119. Cu crystallizes in face-centred cubic lattice. Considering each Cu atom as hard sphere and in contact with its nearest neighbors, 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

120. A molybdenum compound A is obtained by the CO displacement reaction of $Mo(CO)_6$ with P^iPr_3, reacts with H_2 to give compound B. The compounds A and B are

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

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

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

(d) $\left[Mo(CO)_4\left(P^iPr_3\right)_2\right]$ and $\left[Mo(CO)_4\left(P^iPr_3\right)_2(H)_2\right]$