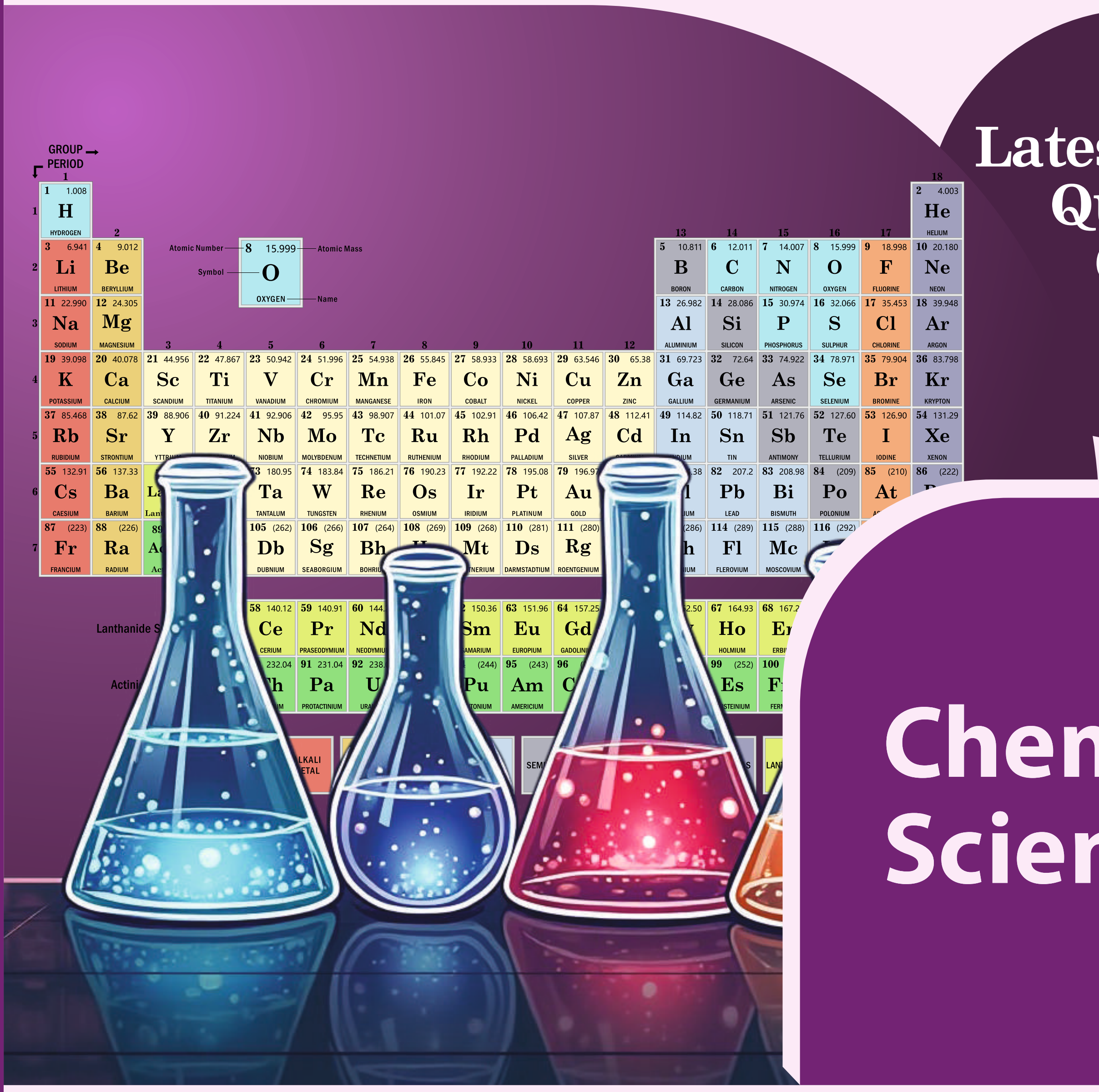
Latest Edition

# CSIR-NET RECAP

## Chapter-wise and Year-wise Previous Years Solved Papers

(2015 June 2025)



Latest Exam Questions Covered

# Chemical Sciences

Also useful for GATE, TIFR, BARC, AND IIT JAM Exams

# Analysis

| Topic | | No. of Questions Year Wise | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2016 Dec. | 2017 June | 2017 Dec. | 2018 June | 2018 Dec. | 2019 June | 2019 Dec. | 2020 Nov. | 2022 Feb. | 2022 Sept. | 2022 - Dec 2023 - June | 2023 Dec | 2024 June | 2024 Dec. | 2025 June |
| **Organic Chemistry** | **Stereochemistry** | 3 | 3 | 4 | 1 | 2 | 3 | 2 | 2 | 7 | 3 | 1 | 3 | 3 | 2 | 3 |
| | **Reagents** | 8 | 6 | 3 | 4 | 6 | 7 | 6 | 6 | 5 | 4 | 5 | 8 | 9 | 7 | 5 |
| | **Reaction Mechanism** | 3 | 1 | 3 | 3 | 5 | 2 | 6 | 1 | 2 | 1 | 3 | 4 | 6 | 4 | 6 |
| | **Reaction Intermediates** | 5 | 3 | 5 | 3 | 2 | 6 | 2 | 2 | 2 | 3 | 5 | 3 | 4 | 4 | 4 |
| | **Name Reaction** | 12 | 2 | 3 | 3 | 5 | 3 | 5 | 8 | 6 | 5 | 2 | 6 | 8 | 9 | 3 |
| | **GOC and Aromaticity** | 3 | | 1 | 1 | | | | 3 | 3 | 2 | 3 | 1 | 2 | 1 | 4 |
| | **Organic Spectroscopy** | 7 | 4 | 6 | 9 | 3 | 6 | 8 | 7 | 2 | 4 | 8 | 3 | 4 | 6 | 4 |
| | **Organic Photochemistry** | 1 | 2 | 1 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| | **Pericyclic Reaction** | 5 | 4 | 6 | 8 | 5 | 4 | 4 | 4 | 5 | 3 | 3 | 4 | 5 | 3 | 4 |
| **Inorganic Chemistry** | **Bioinorganic Chemistry** | 4 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |
| | **Chemical Bonding** | 1 | 1 | 4 | 1 | 2 | 4 | 3 | 2 | 2 | 3 | 3 | 3 | 1 | 2 | 2 |
| | **Coordination Compounds** | 10 | 8 | 7 | 7 | 7 | 10 | 9 | 7 | 9 | 5 | 3 | 7 | 9 | 7 | 6 |
| | **F Block** | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 4 | 2 | 2 | 1 | 3 |
| | **Inorganic Spectroscopy** | 6 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 | 3 |
| | **Main Group** | 3 | 2 | 1 | 3 | 5 | 7 | 3 | 3 | 4 | 4 | 2 | 4 | 5 | 2 | 5 |
| | **Organometallics** | 9 | 8 | 4 | 8 | 12 | 7 | 10 | 10 | 6 | 5 | 8 | 8 | 5 | 8 | 7 |
| | **Periodic Properties** | | 1 | 2 | 2 | 1 | 1 | 1 | 3 | | 3 | 2 | 3 | 1 | 1 | 3 |
| **Physical Chemistry** | **Group Theory** | 3 | 4 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 |
| | **Chemical Kinetics** | 5 | 5 | 3 | 4 | 3 | 2 | 5 | 1 | 3 | 3 | 2 | 4 | 4 | 3 | 4 |
| | **Thermodynamics** | 3 | 3 | 3 | 2 | 2 | 3 | 4 | 4 | 3 | 2 | 4 | 3 | 3 | 4 | 4 |
| | **Statistical Thermodynamics** | 3 | 2 | 2 | 1 | 3 | 1 | 3 | 2 | 1 | 5 | 1 | 2 | 2 | 1 | 3 |
| | **Solid State** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 4 |
| | **Quantum Mechanics** | 7 | 5 | 6 | 5 | 5 | 6 | 4 | 4 | 2 | 5 | 8 | 5 | 6 | 5 | 6 |
| | **Polymer Chemistry** | 2 | | 1 | | | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| | **Molecular Spectroscopy** | 3 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 3 | 2 | 3 |
| | **Electrochemistry** | 4 | 2 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 3 | 3 |
| | **Surface Chemistry** | 1 | 1 | | 2 | 1 | | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 3 |
| **Total** | | **115** | **78** | **81** | **87** | **86** | **90** | **89** | **89** | **82** | **78** | **83** | **93** | **91** | **88** | **100** |

# Contents

## PART-A: ORGANIC CHEMISTRY

## PART-B: INORGANIC CHEMISTRY

## PART-C: PHYSICAL CHEMISTRY

# June 2025

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

(*a*) Radius of the colloid particle

(*b*) Radius of Stern layer

(*c*) Radius of shear surface

(*d*) Outer radius of diffuse ion layer

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

(*a*) 4 (*b*) 5

(*c*) 6 (*d*) 3

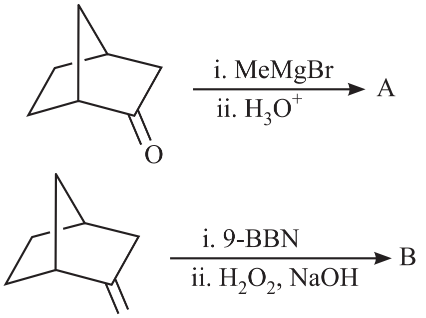
**3.** The complete combustion of 9.83 mg of an organic compound $C_xH_yO_z$ gives 23.26 mg of $CO_2$ and 9.52 mg of $H_2O$. The ESI-MS analysis of this compound gave a molecular ion peak at 130 (m/z). The value of X is

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

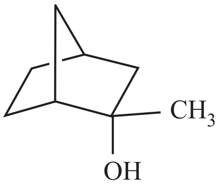
(*a*) 7 (*b*) 3

(*c*) 4 (*d*) 8

**4.** The major products A and B formed in the following reactions are



(*a*) A = B =



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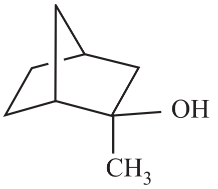

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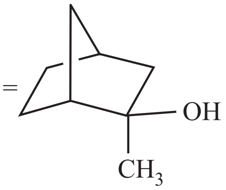
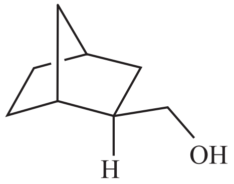
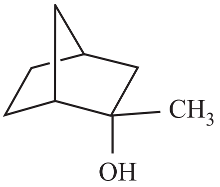


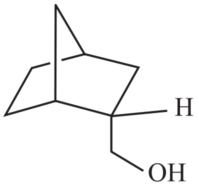
B =



(*d*) A =

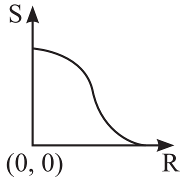


B =

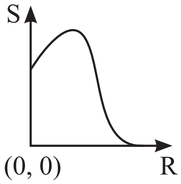


**5.** For a diatomic molecule AB, the internuclear distance is R, and the internuclear axis is along the z-direction. The plot of the overlap integral S for the $p_x$ orbital of A and $d_{zx}$ orbital of B, against R, is

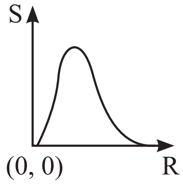
(*a*)



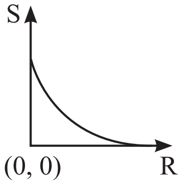
(*b*)



(*c*)

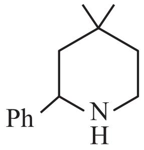


(*d*)

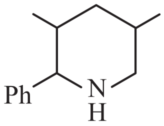


**6.** Compound A on Hofmann exhaustive N -methylation procedure (involving two cycles), followed by ozonolysis (i. $O_3$; ii. $Me_2S$ gives benzaldehyde, formaldehyde, and 2,2-dimethylpropanedial. The structure of A is

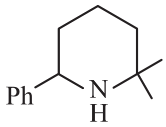
(*a*)



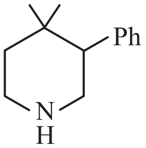
(*b*)



(*c*)



(*d*)



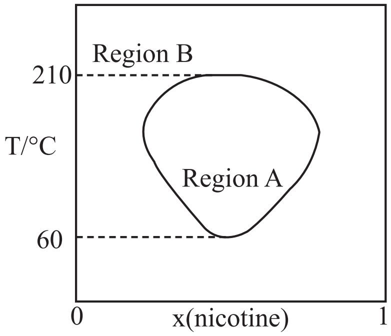
(*a*) i. deprotonation, ii. O-methylation

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

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

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

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



The correct option is

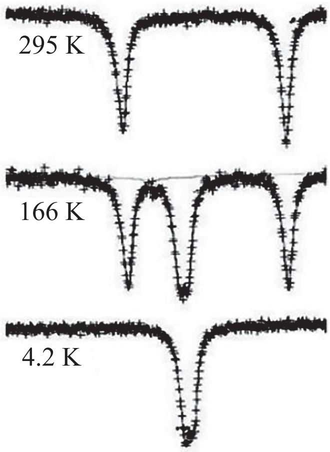
(*a*) The system has two critical solution temperatures; both nicotine and water are completely miscible at 100°C and x(nicotine) = 0.5

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

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

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

**46.** The Mössbauer spectra of $[Fe(L)_2]$ $l_2$(L = 3,5-dimethyl-tris-pyrazolylborate), shown below, exhibit temperature-dependent spin-transition behaviour.



The correct statements from the following

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

B. At 4.2 K, the Fe(II) center is low-spin.

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

D. At 4.2 K, the Fe(II) center is high-spin.

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

(*a*) A, B, and C only (*b*) B, C, and E only

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

**47.** The rate law for the reaction $N_2O_2(g) \rightarrow 2NO(g)$ is first order in the concentration of $N_2O_2$. If the initial concentration of $N_2O_2$ is 1.0 moldm$^{-3}$, the expression for the time-dependent behavior of the concentration of NO (in moldm$^{-3}$) is

(*a*) $2(1 - e^{-kt})$ (*b*) $1 - e^{-kt}$

(*c*) $0.5(1 - e^{-kt})$ (*d*) $1 + e^{-kt}$

**48.** The correct statements regarding olefin polymerization involving metallocene and alkyl aluminum species, from the following

A. Trace amounts of water cause a significant increase in the rates of ethylene polymerization by the $Cp_2TiEtCl/AIEt_2Cl$ system

B. Methylaluminoxane (MAO) is employed as an activator for the catalyst, $Cp_2ZrMe_2$.

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

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

are,

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

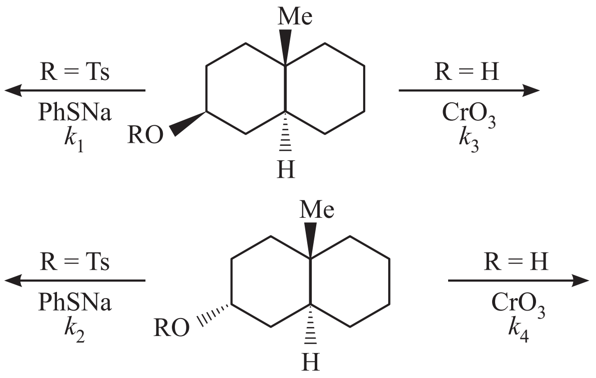
(*c*) A , B and D only (*d*) B, C and D only

**49.** If the crystal field splitting energy of d-orbitals follows the order: $d_{z^2} < d_{xy} = d_{x^2-y^2} < d_{xz} = d_{yz}$, the ligand field is

(*a*) square planar (*b*) Trigonal bipyramidal

(*c*) square antiprismatic (*d*) pentagonal bipyramidal

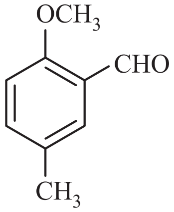
**50.** The relative order of rate constants in the following transformations are

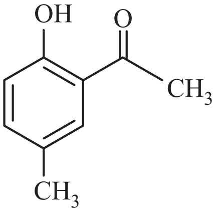


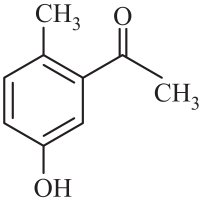
(*a*) $k_2 > k_1; k_4 > k_3$ (*b*) $k_2 > k_1; k_3 > k_4$

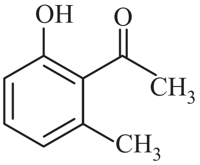
(*c*) $k_1 > k_2; k_4 > k_3$ (*d*) $k_1 > k_2; k_3 > k_4$

**51.** The compound that gives the following $^1$H NMR spectral data is $^1$H NMR ($CDCl_3$): δ11.80(s, 1H),7.69(d,J = 2.3 Hz,1H),7.35(dd, J = 8.5, 2.3 Hz,1H), 6.86(d,J = 8.5 Hz,1H), 2.63(s, 3H), 2.28(s,3H)ppm)

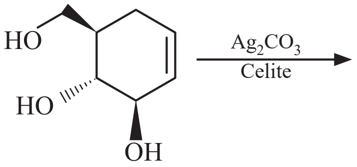
(*a*) 

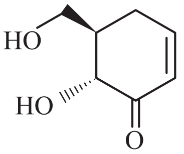
(*b*) 

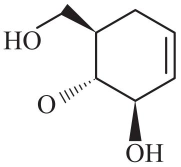
(*c*) 

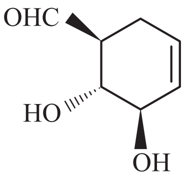
(*d*) 

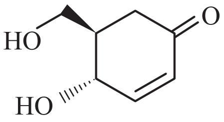
**52.** The major product formed in the following reaction is



(*a*) 

(*b*) 

(*c*) 

(*d*) 

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

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

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

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

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

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

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

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

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

(*a*) $<\phi_j|p_x|\phi_0> = \frac{i\hbar}{m}<\phi_j|x|\phi_0>(\varepsilon_j - \varepsilon_0)$

(*b*) $<\phi_j|p_x|\phi_0> = \frac{i\hbar}{m}<\phi_j|x|\phi_0>(\varepsilon_0 - \varepsilon_j)$

(*c*) $<\phi_j|p_x|\phi_0> = \frac{m}{i\hbar}<\phi_j|x|\phi_0>(\varepsilon_j - \varepsilon_0)$

(*d*) $<\phi_j|p_x|\phi_0> = \frac{m}{i\hbar}<\phi_j|x|\phi_0>(\varepsilon_0 - \varepsilon_j)$

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

(*a*) $h^2/5m$ (*b*) $h^2/3m$

(*c*) $h^2/8m$ (*d*) $h^2/10m$

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

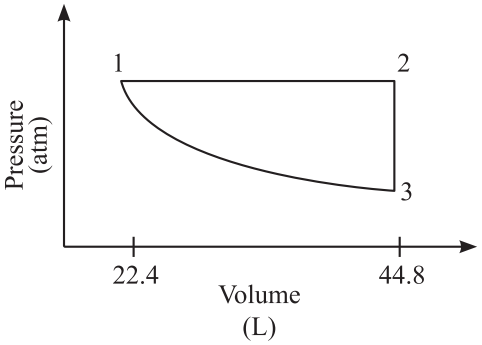
(*a*) 30018, 30010, 30002

(*b*) 30058, 30050, 30042

(*c*) 30018, 30014, 30010

(*d*) 30034, 30030, 30026

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

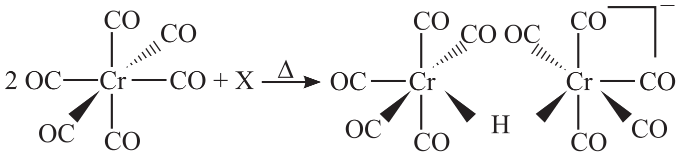


For the process 1 → 2, the reversible work done and the change in enthalpy (in kJ), respectively, are

(*a*) –2.27 and 5.67 (*b*) 3.40 and 2.27

(*c*) 3.40 and –5.67 (*d*) –2.27 and 3.40

**58.** Consider the following reaction.



X is

(*a*) $H^+$ (*b*) $H^-$

(*c*) $OH^-$ (*d*) $H_2O$

**59.** The EPR spectrum of $[InH_3^o]$ [Given: ln (I = 9/2); H(I = 1/2)] is comprised of

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

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

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

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

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

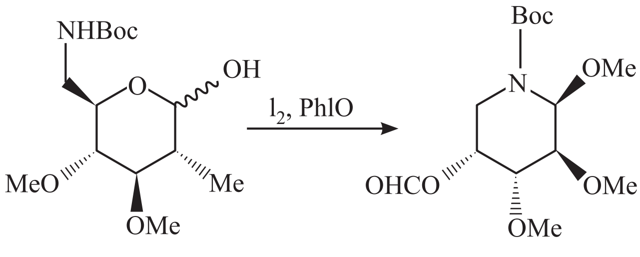
(*a*) ${}^6S_{5/2}$, 5.92BM, 5.92BM, 5.8 – 6.0BM

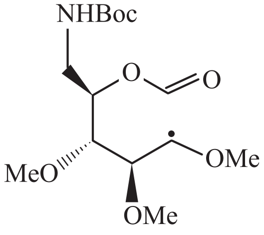
(*b*) ${}^6S_{5/2}$, 5.92BM, 6.70BM, 5.8 – 6.0BM

(*c*) ${}^6S_{5/2}$, 5.92BM, 5.92BM, 4.8 – 5.0BM

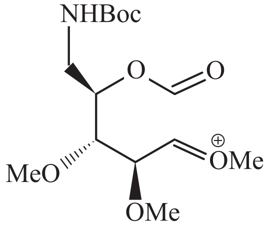
(*d*) ${}^6S_{5/2}$, 5.59BM, 6.70BM, 5.8 – 6.0BM

**61.** The intermediates involved in the following reaction are

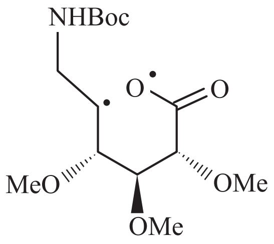




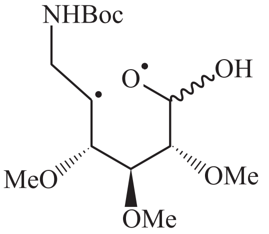
A



B



C



D

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

**62.** At 100 Pa and 500 K , the number of collisions Ar atoms make on a solid surface of area 1.0 $cm^2$ in 10 s is closest to [Molar mass of Ar is 40g $mol^{-1}$; assume Ar to behave as a perfect gas]

(*a*) $1.9 \times 10^{21}$ (*b*) $2.1 \times 10^{23}$

(*c*) $3.5 \times 10^{19}$ (*d*) $4.7 \times 10^{17}$

**63.** The correct statements about agostic interactions from the following

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

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

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

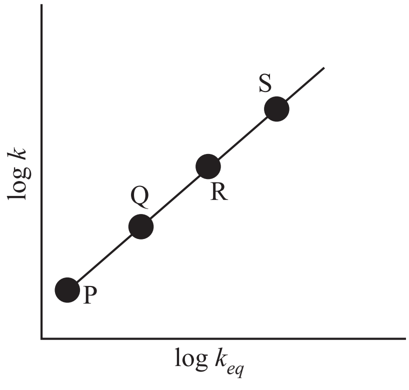
D. It lowers the $pK_a$ of the C – H bond of the ligand.

are

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

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

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



The correct option is

(*a*) $P = F^-, Q = H_2PO_4^-, R = Cl^-, S = NO_3^-$

(*b*) $P = Cl, Q = H_2PO_4^-, R = F^-, S = NO_3^-$

(*c*) $P = H_2PO_4^-, Q = Cl^-, R = F^-, S = NO_3^-$

(*d*) $P = NO_3^-, Q = Cl^-, R = H_2PO_4^-, S = F^-$

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

(*a*) $\cos^{-1}\left(\frac{1}{\sqrt{2}}\right)$ (*b*) $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$

(*c*) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (*d*) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

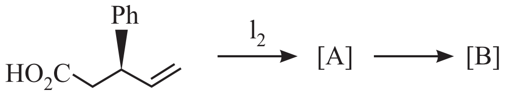
**66.** The correct match between the enzymes (Column P) and the biological functions (Column Q) from the table below

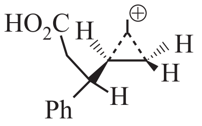
| Column P | | Column Q | |
|---|---|---|---|
| A. | Cytochrome C Oxidase | i. | DNA biosynthesis |
| B. | Tyrosinase | ii. | Hydrolysis |
| C. | Purple acid phosphatase | iii. | Oxidation of phenols |
| D. | Galactose oxidase | iv. | Oxidation of alcohols |
| E. | Ribonucleotide reductase | v. | Reduction of $O_2$ to water |

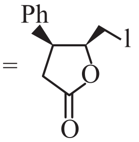
is

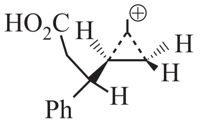
(*a*) A-iii, B-i, C-iv, D-ii, E-v
(*b*) A-i, B-ii, C-iii, D-iv, E-v
(*c*) A-v, B-iii, C-ii, D-iv, E-i
(*d*) A-ii, B-iv, C-v, D-i, E-iii

**67.** The intermediate A and major product B formed in the following reaction are



(*a*) A =


B =


(*b*) A =


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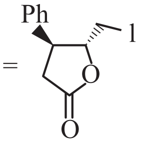
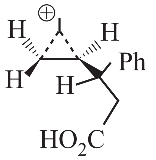
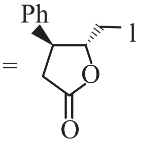
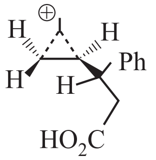
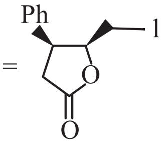


(*c*) A =


B =


(*d*) A =


B =


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

$$\psi_{\text{HOMO}} = 0.9(\phi_{2s}^{A} + 3\phi_{2p_z}^{A}) + 0.1\phi_{2p_z}^{B}$$

$$\psi_{\text{LUMO}} = 0.1\phi_{2p_x}^{A} + 0.9\phi_{2p_x}^{B}$$

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

AB is a

(*a*) σ-donor through A, π-acceptor through A
(*b*) σ-donor through B, π-acceptor through B
(*c*) σ-donor through A, π-acceptor through B
(*d*) σ-donor through B, π-acceptor through A

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

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

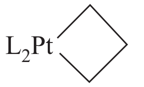
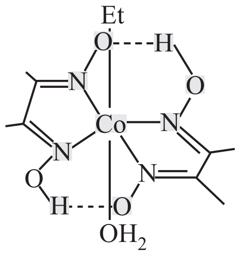
**70.** Consider the following statements regarding the corrin ring (P) and the porphyrin ring (Q)

A. P is fully conjugated, rigid, and bigger in size than Q.
B. P is fully conjugated, more flexible and ring size is same as Q.
C. P is partially reduced, more flexible, and smaller in size than Q.
D. The flexibility of P supports multiple oxidation states of cobalt.

The correct statements are:

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

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

| List I | | List II | |
|---|---|---|---|
| A. |  | P. | A planar transition state is not accessible |
| B. |  | Q. | No vacant coordination site on the metal center |

# ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (*c*) | **2.** (*a*) | **3.** (*a*) | **4.** (*d*) | **5.** (*c*) | **6.** (*a*) | **7.** (*a*) | **8.** (*a*) | **9.** (*c*) | **10.** (*a*) |
| **11.** (*b*) | **12.** (*b*) | **13.** (*d*) | **14.** (*c*) | **15.** (*d*) | **16.** (*c*) | **17.** (*a*) | **18.** (*c*) | **19.** (*a*) | **20.** (*b*) |
| **21.** (*b*) | **22.** (*a*) | **23.** (*a*) | **24.** (*a*) | **25.** (*c*) | **26.** (*a*) | **27.** (*b*) | **28.** (*c*) | **29.** (*c*) | **30.** (*a*) |
| **31.** (*a*) | **32.** (*c*) | **33.** (*a*) | **34.** (*a*) | **35.** (*a*) | **36.** (*a*) | **37.** (*d*) | **38.** (*a*) | **39.** (*c*) | **40.** (*d*) |
| **41.** (*a*) | **42.** (*d*) | **43.** (*b*) | **44.** (*d*) | **45.** (*c*) | **46.** (*d*) | **47.** (*a*) | **48.** (*a*) | **49.** (*c*) | **50.** (*a*) |
| **51.** (*b*) | **52.** (*a*) | **53.** (*d*) | **54.** (*d*) | **55.** (*a*) | **56.** (*a*) | **57.** (*a*) | **58.** (*c*) | **59.** (*a*) | **60.** (*a*) |
| **61.** (*a*) | **62.** (*a*) | **63.** (*a*) | **64.** (*a*) | **65.** (*b*) | **66.** (*d*) | **67.** (*c*) | **68.** (*c*) | **69.** (*c*) | **70.** (*b*) |
| **71.** (*a*) | **72.** (*b*) | **73.** (*d*) | **74.** (*a*) | **75.** (*b*) | **76.** (*b*) | **77.** (*b*) | **78.** (*b*) | **79.** (*c*) | **80.** (*a*) |
| **81.** (*b*) | **82.** (*c*) | **83.** (*a*) | **84.** (*b*) | **85.** (*a*) | **86.** (*c*) | **87.** (*a*) | **88.** (*b*) | **89.** (*a*) | **90.** (*a*) |
| **91.** (*b*) | **92.** (*c*) | **93.** (*b*) | **94.** (*b*) | **95.** (*c*) | **96.** (*a*) | **97.** (*b*) | **98.** (*a*) | **99.** (*a*) | **100.** (*b*) |

# SOLUTION

**1.** (*c*) In a colloidal solution, charged particles attract counter-ions, forming an electrical double layer (Stern layer + diffuse layer).

The zeta potential is not the potential at the particle surface, but at the shear plane (slipping plane), which separates the firmly bound ions from the more mobile ions in the diffuse layer.

This potential is crucial because it governs the stability of colloids — higher zeta potential (positive or negative) prevents aggregation due to repulsion.

**2.** (*a*) Total valence electrons, A = metals (4 × 8 = 32) + CO ligands (16 × 2 = 32) = 64.

If each Os is 18$e^-$, total demand (B) = 4 × 18 = 72 electrons.

Number of M – M bonds = (B – A)/2

= (72 – 64)/2 = 4

**3.** (*a*) Moles of C from $CO_2$:

$$m_{CO_2} = 23.26\text{mg} = 0.02326\text{ g}$$

$$n_C = \frac{0.02326}{44.00} = 0.00052882\text{ mol}$$

Moles of H from $H_2O$:

$$m_{H_2O} = 9.52\text{mg} = 0.00952\text{ g}$$

$$n_{H_2O} = \frac{0.00952}{18.00} = 0.00052889\text{ mol}$$

$$n_H = 2 \times n_{H_2O} = 0.00105778\text{ mol}$$

Masses in the original sample (9.83 mg):

Mass C = 0.00052882 × 12.00 = 0.0063459 g = 6.3459 mg

Mass H =1.0578 mg0.00105778 × 1.00 = 0.0010578 g = 1.0578 mg

Mass O = 9.83 − 6.3459 − 1.0578 = 2.4263 mg = 0.0024263 g

$$n_O = \frac{0.0024263}{16.00} = 0.00015164\text{ mol}$$

Mole ratios (divide by smallest, $n_O$ = 0.00015164$n_O$ = 0.00015164):

C: 0.00052882/0.00015164 = 3.488 ≈ 3.5

H: 0.00105778/0.00015164 = 6.975 ≈ 7.0

O: 1

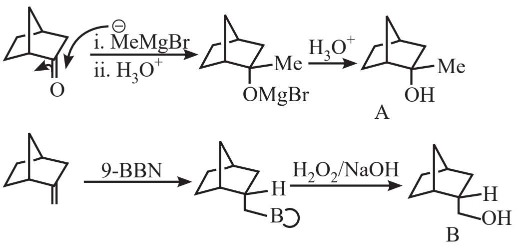
Multiply by 2 to clear the 0.5: empirical formula ≈ $C_7H_{14}O_2$.

Empirical mass = 7(12) + 14(1) + 2(16) = 84 + 14 + 32 = 130 g/mol.

This matches the molecular ion peak at m/z = 130, so the molecular formula = empirical formula.

Therefore X = 7.

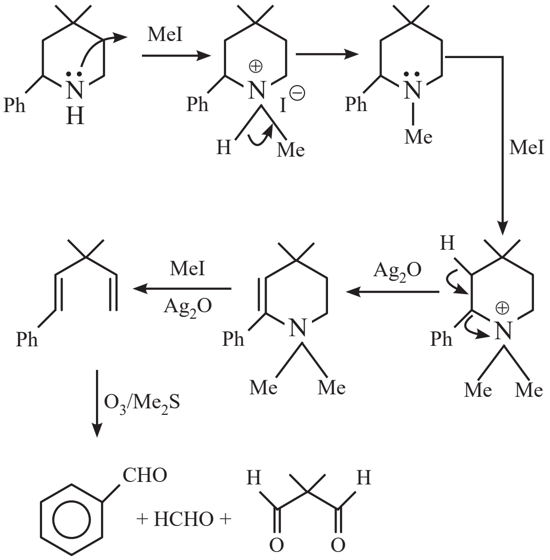
**4.** (*d*) The reaction pathway is shown below:



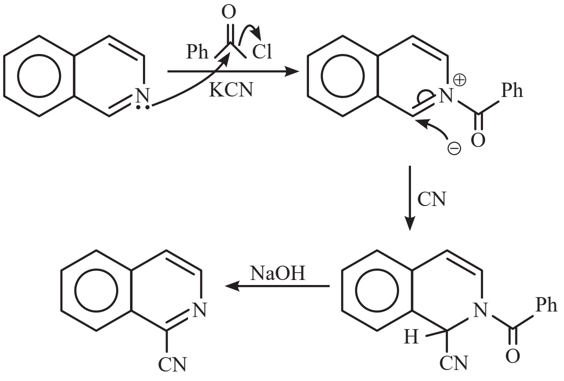
**5.** (*c*) The plot is a **monotonically decreasing positive curve**, starting at a maximum for small R and approaching zero as.

Thus, option (*c*) is the correct answer.

**6.** (*a*) The reaction pathway is shown below:



**7.** (*a*) The reaction pathway is shown below:



**8.** (*a*) Hemocyanin is dissolved in hemolymph (not inside cells like hemoglobin). Thus, It is an extracellular protein. Thus, option (*a*) is correct.

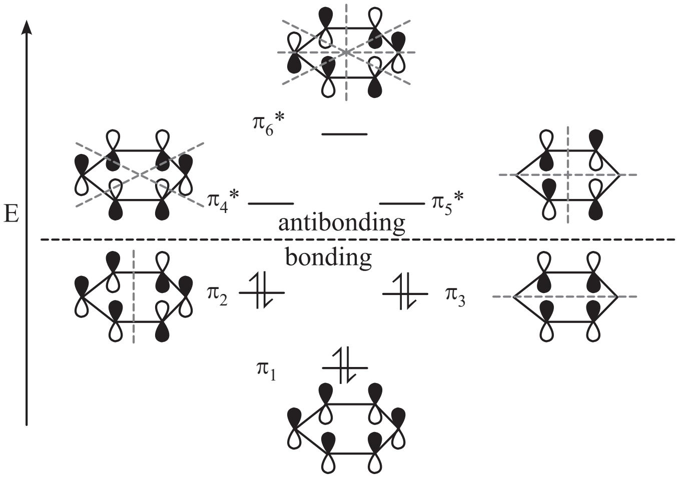
It has an oligomeric structure with each subunit containing a pair of two copper atoms as Each oxygen-binding site has a dicopper center (two $Cu^+$ ions per functional unit). Thus, option (*b*) is correct.

In deoxyhemocyanin, the two Cu(I) ions are far apart (~4.6–4.8 Å), and move closer (~3.6 Å) when $O_2$ binds. 2.8 Å is incorrect. Thus, option (*c*)is incorrect.

$O_2$ binds as a bridging peroxide ($O_2^{2-}$), and the intense blue color arises from $O^{2-} \rightarrow$ Cu(II) charge transfer. Thus, option (*d*) is incorrect.

**9.** (*c*)

The Pi Molecular Orbitals of Benzene



Thus, the correct representation for the LUMO of benzene is B and C.

**10.** (*a*) B (True): $C_{60}$ undergoes addition reactions much more readily (e.g. cycloadditions, Bingel reactions) than electrophilic substitution typical of benzene.

C (True): The curved (spherical) geometry strains the π system and pyramidalizes the carbons, making the C = C bonds more reactive toward additions.

D (True): Overall reactivity resembles that of strained alkenes (addition chemistry) rather than aromatic benzene (which favors substitution).

A (False): Although $C_{60}$ is π-conjugated, its curvature and the presence of isolated pentagons reduce delocalization and aromatic stabilization compared with benzene — it does not exhibit greater delocalization than benzene.

Thus, the correct option are (*b*), (*c*), and (*d*) only.

**11.** (*b*) Chemolithotrophs obtain energy by oxidizing inorganic substrates.

A. $NH_3 \rightarrow NO_2^-$ (ammonia → nitrite) — ammonia-oxidizing chemolithotrophs.

C. $NO_2{-}{\rightarrow}NO_3^-$(nitrite → nitrate) — nitrite-oxidizing chemolithotrophs.

D. $H_2S \rightarrow S_8$ (hydrogen sulfide → elemental sulfur) — sulfur-oxidizing chemolithotrophs.

B. ($O_2 \rightarrow H_2O_2$) and E ($CO_2 \rightarrow CO$) are reductions or uncommon transformations and are not typical chemolithotrophic energy-yielding oxidations.

**12.** (*b*) For a time-independent Hamiltonian H^, if $\psi(r)$ is a stationary state (eigenfunction of H^$\psi(r) = E\psi(r)$

Then the time-dependent Schrödinger equation gives the solution:

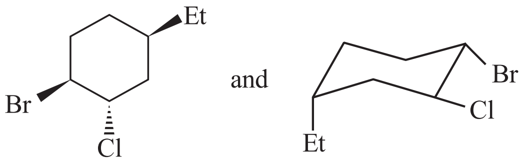
$\Psi(r,t) = \psi(r)e^{-iEt/\hbar}$

# 1

# Stereochemistry

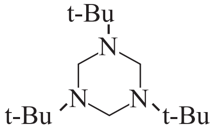
## DECEMBER 2024

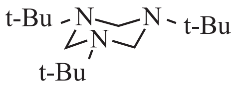
1. The following structures are

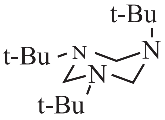


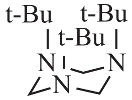
(*a*) identical (*b*) enantiomers
(*c*) diastereomers (*d*) constitutional isomers

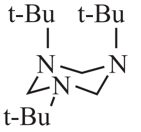
2. The most stable conformation of the following compound is



(*a*)


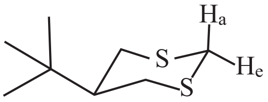
(*b*)


(*c*)


(*d*)


## JUNE 2024

3. In the following dithiane, the correct statement about acidity of $H_a$ and $H_e$ protons and the reason for the stability of the carbanion formed by deprotonation is



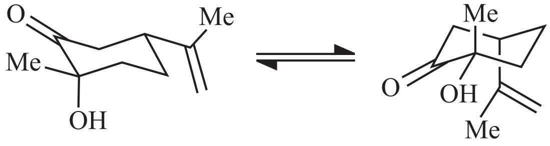
(*a*) $H_a$ is more acidic; axial carbanion is delocalised into the $\sigma^*$ orbital of C-S bond

(*b*) $H_e$ is more acidic; equatorial carbanion is delocalised into the $\sigma^*$ orbital of C-S bond

(*c*) $H_a$ is more acidic; axial carbanion is delocalised into the empty 3d orbital of sulfur

(*d*) $H_e$ is more acidic; equatorial carbanion is delocalised into the empty 3d orbital of sulfur

4. The correct statements about the following conformational equilibrium of ketone are

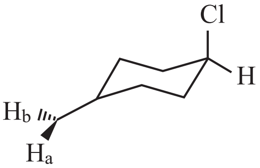


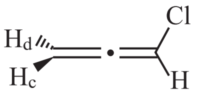
**A** **B**

I. A predominates in DMSO due to opposing dipole interaction
II. B predominates in DMSO due to intramolecular hydrogen bonding
III. A predominates in isooctane due to opposing dipole interaction
IV. B predominates in isooctane due to intramolecular hydrogen bonding

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

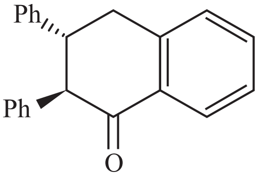
5. The correct topicity of $H_a$ and $H_c$ in the following molecules is



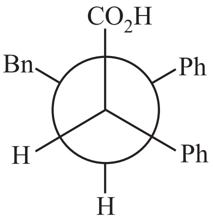


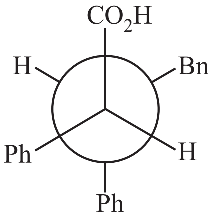
(*a*) $H_a = H_c$ = pro-R (*b*) $H_a = H_c$ = pro-S
(*c*) $H_a$ = pro-R; $H_c$ = pro-S (*d*) $H_a$ = pro-S; $H_c$ = pro-R

6. The conformer of threo-2,3,4-triphenylbutyric acid that gives the product A in the presence of anhydrous HF is

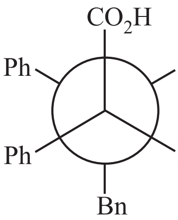


A

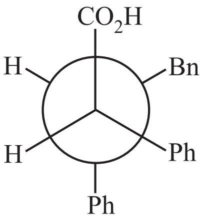
(*a*)


(*b*)


(*c*)

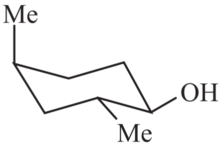


(*d*)

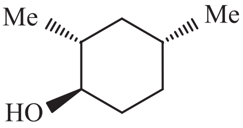


## DECEMBER 2023

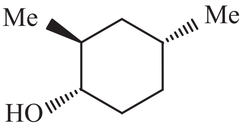
**7.** The structure that corresponds to the following compound is



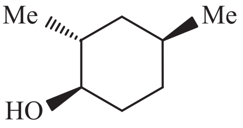
(*a*)



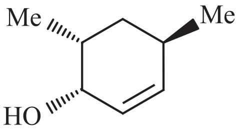
(*b*)



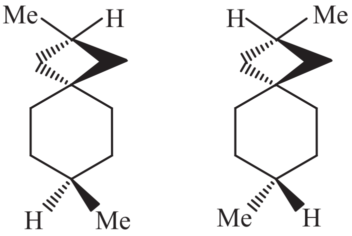
(*c*)



(*d*)



**8.** The following two molecules are



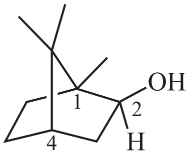
(*a*) Enantiomers

(*b*) Diastereomers

(*c*) Homomers (Identical)

(*d*) Constitutional isomers

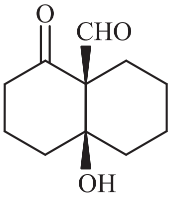
**9.** The correct absolute configuration for the structure shown below is



| | |
|---|---|
| (*a*) 1S, 2S, 4S | (*b*) 1S, 2R, 4R |
| (*c*) 1R, 2R, 4S | (*d*) 1S, 2S, 4R |

## JUNE 2023

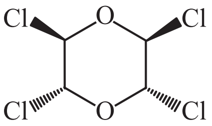
**10.** The absolute configuration of the sterogenic centres present in the following molecule.



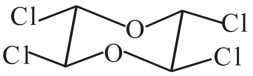
(*a*) 9R,10S (*b*) 9R, 10R (*c*) 9S, 10S (*d*) 9S,10R

## FEBRUARY 2022

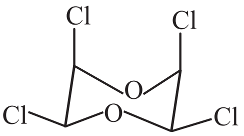
**11.** The structure that corresponds to the most stable conformation of following



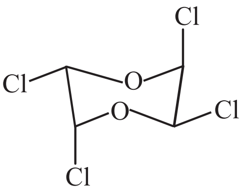
(*a*)



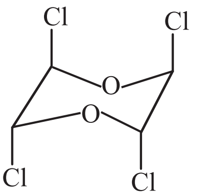
(*b*)



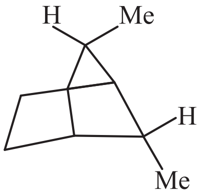
(*c*)

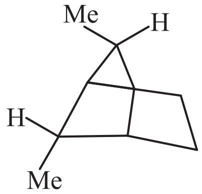


(*d*)



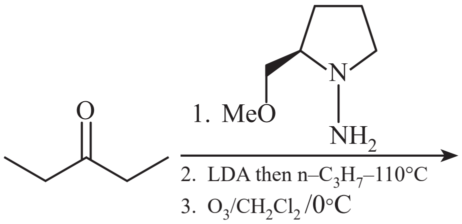
**12.** The correct relationship between the following structure is that they are

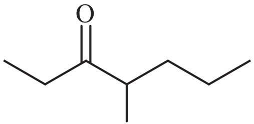




(*a*) Identical
(*b*) Enantioner
(*c*) Diasteromers
(*d*) Constitutional Isomer

**13.** Given the specific rotation $[\alpha]_D^{20}$ of (S) – 4 – methyl – 3-heptanone in hexane as 22°, the specific rotation $[\alpha]_D^{20}$, in hexane of the product A(ee = 98%) obtained from the following enantioselective alkylation reaction is

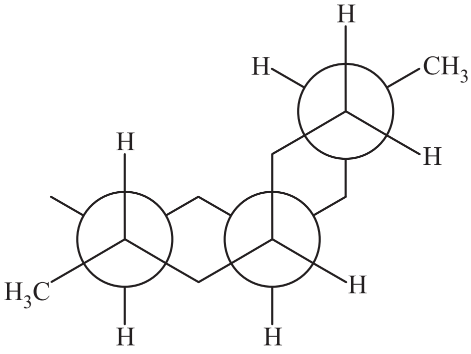




(A)

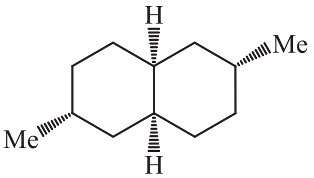
(*a*) +21.56
(*b*) +21.12
(*c*) –21.56
(*d*) –21.12

**14.** The newmann projection given below

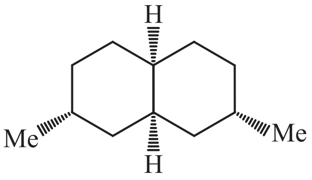


corresponds to the compound.

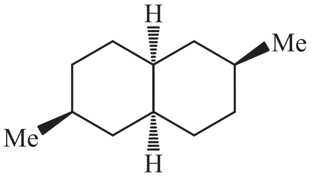
(*a*)



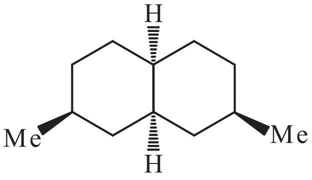
(*b*)



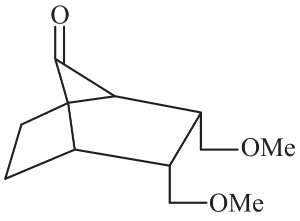
(*c*)



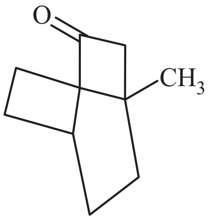
(*d*)



**15.** The correct relationship b/w the two faces at the C=O group in compounds A and B is



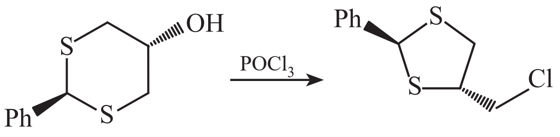
A

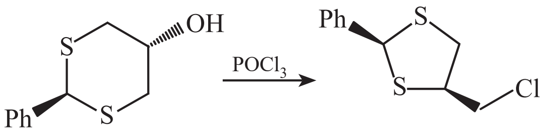


B

(*a*) diastereotopic, B = enantiotopic
(*b*) A = B = enantiotopic
(*c*) A = enantiotopic, B = diasterotopic
(*d*) A = B = diasterotopic

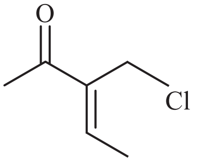
**16.** The pair of reaction depicted below are





(*a*) Enantioselective reaction
(*b*) Diastereospecific reaction
(*c*) Diastereoselective reaction
(*d*) Enantiospefic reaction

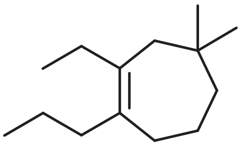
**17.** The correct IUPAC name of the following compound is



(*a*) (*E*)–3–(chloromethyl) pent-3-en-4-one
(*b*) (*Z*)–3–(chloromethyl) pent–2–en–4–one
(*c*) (*E*)–3–(chloromethyl) pent–2–en–4–one
(*d*) (*Z*)–3–(chloromethyl) pent–3–en–2–one

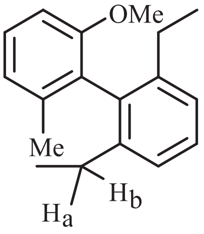
## 2020

**18.** The correct IUPAC name for the following molecule is



(*a*) 1-Propyl-2-ethyl-4, 4-dimethylcyclohept-1-ene
(*b*) 2-Ethyl-4, 4-dimethyl-1-propylcyclohept-1-ene
(*c*) 3-Ethyl-1, 1-dimethyl-4-propylcyclohept-3-ene
(*d*) 1,1-Dimethyl-3-ethyl-4-propylcyclohept-3-ene

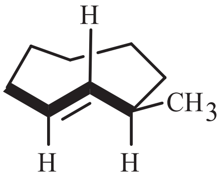
**19.** The stereochemical relationship of Ha and Hb in the following molecule is



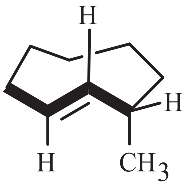
(*a*) enantiotopic
(*b*) homotopic
(*c*) diastereotopic
(*d*) constitutionally heterotopic

## JUNE 2019

**20.** The relationship between A and B is



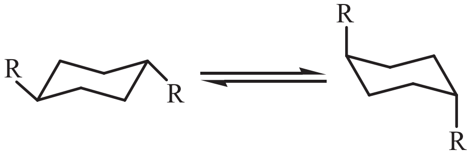
(A)



(B)

(*a*) Homomers (identical)
(*b*) Enantiomers
(*c*) Diastereomers
(*d*) Conformers

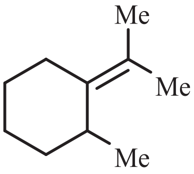
**21.** In the following equilibrium, conformer B is more stable than A when R is



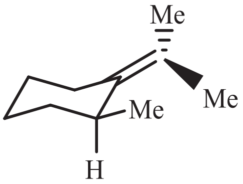
(A) (B)

(*a*) Me (*b*) F (*c*) Cl (*d*) OMe

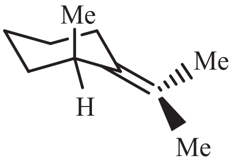
**22.** The most stable conformation of the following molecule is



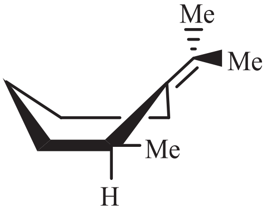
(*a*)



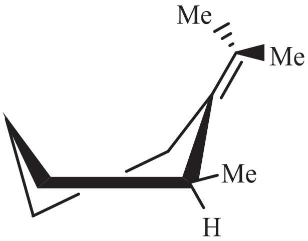
(*b*)



(*c*)



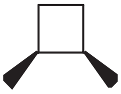
(*d*)



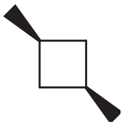
## DECEMBER 2018

**23.** Among the following, the optically active compound is

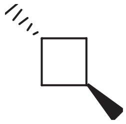
(*a*)



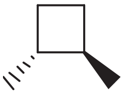
(*b*)



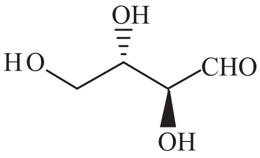
(*c*)



(*d*)



**24.** Oxidation of A with $HNO_3/H_2O$ provides the product(s) which is (are)

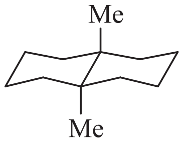


(A)

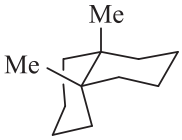
(*a*) Optically inactive as it is recemic mixture
(*b*) Optically inactive as it is meso
(*c*) Optically active as it is a single diastereomer
(*d*) Optically active as it s a single enantiomer

## JUNE 2018

**25.** The correct statement about the following compounds is



A

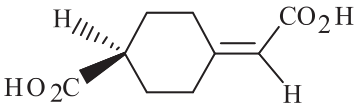


B

(*a*) A is more stable than B
(*b*) B is more stable than A
(*c*) A and B are equally stable
(*d*) A and B are both locked conformations

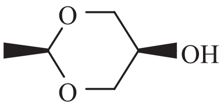
## DECEMBER 2017

**26.** The following molecule has



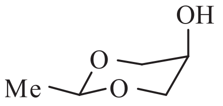
(*a*) Plane of symmetry
(*b*) R configuration
(*c*) S configuration
(*d*) centre of symmetry

**27.** Among the structure given below, the one that corresponds to the most stable conformation of compound A is

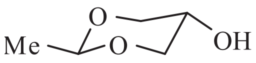


A

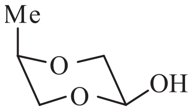
(*a*)



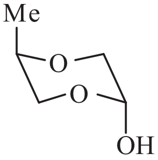
(*b*)



(*c*)



(*d*)



**28.** The number of optically active steroisomers possible for $CH_3 - CH(OH) - CH(OH) - CH(OH) - CH_3$

(*a*) two
(*b*) four
(*c*) six
(*d*) eight

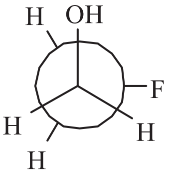
**29.** An optically pure organic compound has specific rotation of +40°. The optical purity of the sample that exhibits specific rotation of +32° is

(*a*) 8%
(*b*) 12%
(*c*) 20%
(*d*) 80%

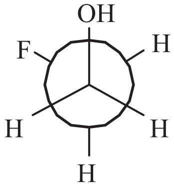
## JUNE 2017

**30.** The most stable conformation of 2-fluoroethanol

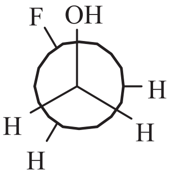
(*a*)



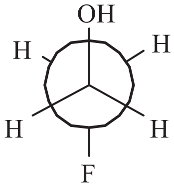
(*b*)



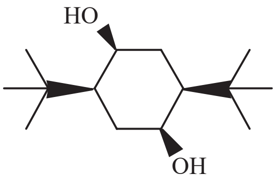
(*c*)



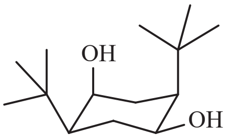
(*d*)



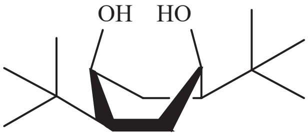
**31.** The most stable conformation for the following compound is



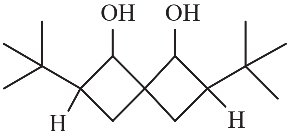
(*a*)



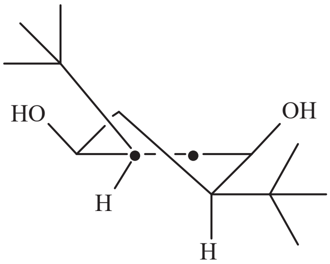
(*b*)



(*c*)



(*d*)



**32.** The specific rotation $[\alpha]_D$ for (S)-(+)-2-butanol is 10° mL/gdm. The observed optical rotation ($\alpha_{abs}$) of a sample composed of a mixture of (R)- and (S)-2-butanol is –0.45°. If the cell path length is 0.6 dm and the concentration of 2-butanol in the sample is 0.15 g/mL, the percentages of (R) and (S) enantiomers in the sample are

(*a*) (R) = 25%, (S) = 75%

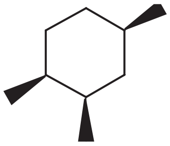
(*b*) (R) = 40%, (S) = 60%

(*c*) (R) = 60%, (S) = 40%

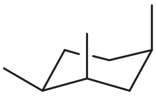
(*d*) (R) = 75%, (S) = 25%

## DECEMBER 2016

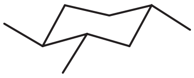
**33.** Among the structures given below, the most stable conformation for the following compound is



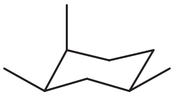
(*a*)



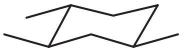
(*b*)



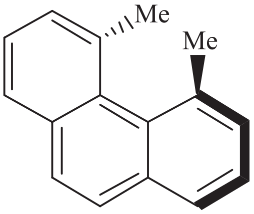
(*c*)



(*d*)



**34.** The correct statement about the following compound is



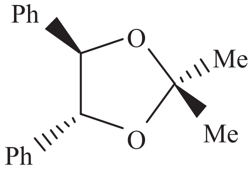
(*a*) compound is chiral and has P configuration

(*b*) compound is chiral and has M configuration

(*c*) compound is achiral as it possesses $C_2$-axis of symmetry

(*d*) compound is achiral as it possesses plane of symmetry

**35.** Methyl groups in the following compound are



(*a*) homotopic (*b*) diasterotopic

(*c*) enantiotopic (*d*) constitutionally heterotopic

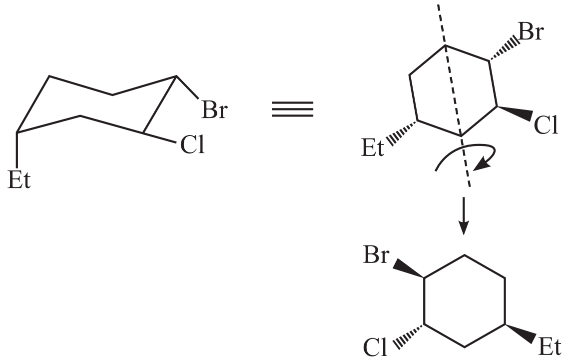
* * *

## ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (*a*) | **2.** (*b*) | **3.** (*b*) | **4.** (*b*) | **5.** (*a*) | **6.** (*b*) | **7.** (*c*) | **8.** (*c*) | **9.** (*a*) | **10.** (*a*) |
| **11.** (*d*) | **12.** (*a*) | **13.** (*c*) | **14.** (*a*) | **15.** (*a*) | **16.** (*b*) | **17.** (*d*) | **18.** (*b*) | **19.** (*c*) | **20.** (*c*) |
| **21.** (*b*) | **22.** (*b*) | **23.** (*d*) | **24.** (*b*) | **25.** (*a*) | **26.** (*b*) | **27.** (*a*) | **28.** (*a*) | **29.** (*d*) | **30.** (*b*) |
| **31.** (*c*) | **32.** (*d*) | **33.** (*c*) | **34.** (*a*) | **35.** (*a*) | | | | | |

# SOLUTION

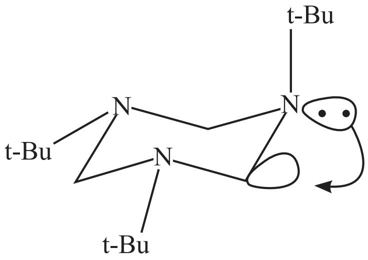
**1.** (*a*)



Hence, both structure are identical.

Thus, the correct option is (*a*).

**2.** (*b*) Due to nonbonfing to $\sigma^*$ electron donation, the most stable conformation of the following compound is B.



**3.** (*b*) The acidity of protons ($H_a$) and ($H_e$) in a dithiolane compound and understanding the stabilization of the resulting carbanion upon deprotonation.

1. Acidity Comparison: The more acidic proton is the one whose removal results in a more stabilized carbanion.
2. Stabilization of Carbanion: The carbanion is stabilized by the delocalization of its negative charge. If the carbanion is formed by removing hydrogen(a) or hydrogen(b) the delocalization of the negative charge into a $\sigma^*$ orbital (antibonding orbital) is crucial.
   - Sulfur has vacant 3d orbitals, but their role is less significant compared to the $\sigma^*$ orbitals in this context.
   - ($H_e$) is more acidic:- When ($H_e$) is removed, the resulting carbanion is in an equatorial position.
   - Stabilization via $\sigma^*$ Orbital: The negative charge on the carbanion can be delocalized into the $\sigma^*$ orbital of the adjacent C-S bond, leading to greater stabilization

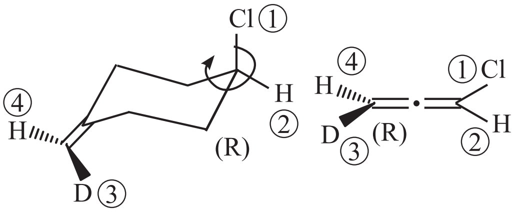
Therefore, the correct option is (*b*): ($H_e$) is more acidic, and the equatorial carbanion is delocalized into the orbital of the C-S bond.

**4.** (*b*) Statement I: A predominates in DMSO due to opposing dipole interaction. In a polar solvent like DMSO, dipole interactions are indeed stabilized. Therefore, this statement is correct. Statement II: B predominates in DMSO due to intramolecular hydrogen bonding. B allows for intramolecular hydrogen bonding, which is a stabilizing factor. In DMSO, this is a stronger effect than the dipole stabilization, so this statement is correct.

Statement III: A predominates in isooctane due to opposing dipole interaction. In a non-polar solvent like isooctane, dipole interactions are not a significant factor, but intramolecular hydrogen bonding in Conformer B would still be favored. Therefore, this statement is incorrect. Statement IV: B predominates in isooctane due to intramolecular hydrogen bonding. Even in a nonpolar solvent like isooctane, intramolecular hydrogen bonding would stabilize Conformer B, making this statement correct.

The correct answer is B (I and IV).

**5.** (*a*)



1. **Prochiral Center:** A center where replacing one of the two identical groups leads to a chiral center. To determine if a hydrogen is pro-R or pro-S, you imagine replacing the hydrogen with a higher-priority group (like deuterium) and determine the resulting configuration.
2. **Assigning Priority:** Use the Cahn-IngoldPrelog rules to assign priority to the groups around the carbon atoms where $H_a$ and $H_c$ are attached.

In this case, after applying the priority rules and checking the configuration:

Both $H_a$ and $H_c$ are determined to be **pro-R**.

The correct answer is **Option (*a*)**.

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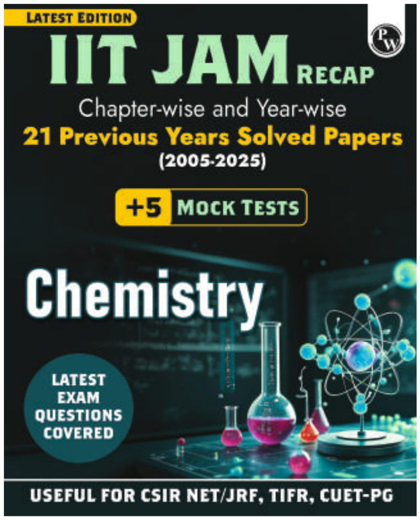

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