GATE - 2025

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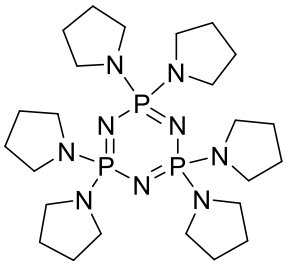
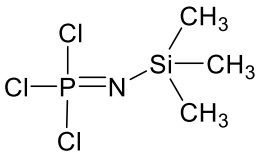
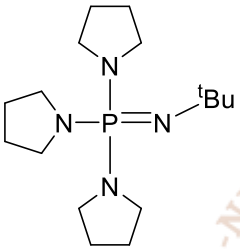
GATE-2025

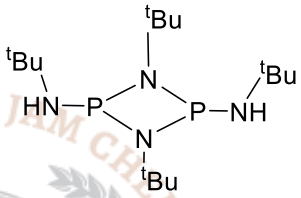
Q.1 – Q.10 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

1. The phosphazene compound that acts as a superbase is

(a) 

(b) 

(c) 

(d) 

2. The reaction for the synthesis of Me_2SiCl_2 through Rochow-Muller process is

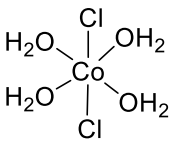
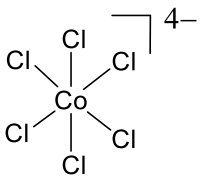
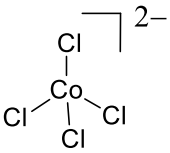
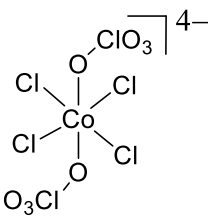
(a) $SiCl_4 + Me_2Zn \xrightarrow{0\,^\circ C}$ (b) $Si: Fe(9:1) + 2MeCl \xrightarrow{300\,^\circ C}$

(c) $Si: Cu(9:1) + 2MeCl \xrightarrow{300\,^\circ C}$ (d) $SiCl_4 + 2MeMgBr \xrightarrow{0\,^\circ C}$

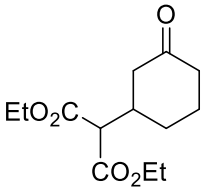
3. Upon cooling from room temperature, the magnetic susceptibility of MnO slowly increases until 118 K, and then it decreases. This phenomenon is known as

(a) ferromagnetism (b) paramagnetism (c) antiferromagnetism (d) ferrimagnetism

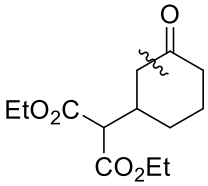
4. An aqueous solution of $Co(ClO_4)_2.6H_2O$ is light pink in colour. Addition of conc.HCl results in an intense blue coloured solution due to the formation of a new species. The new species among the following is

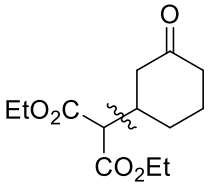
(a)  (b)  (c)  (d) 

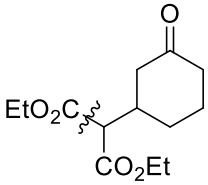
5. For an unambiguous single step synthesis of the following target molecule (TM), the best bond disconnection in its retrosynthetic analysis is

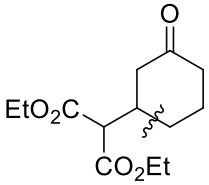


(TM)

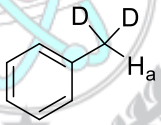
(a) 

(b) 

(c) 

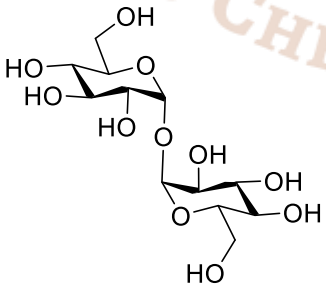
(d) 

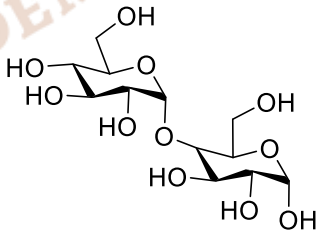
6. In the ^{1}H-NMR spectrum of the following molecule, the signal of proton H_a appears as

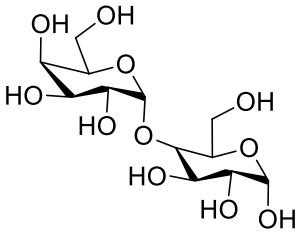


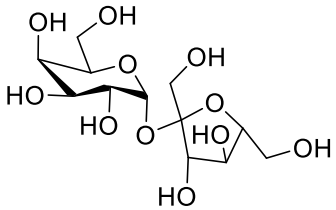
(a) singlet (b) triplet (c) quintet (d) quartet

7. A disaccharide X does NOT show mutarotation in aqueous solution. Acidic hydrolysis of X affords two different monosaccharides. The disaccharide X is

(a) 

(b) 

(c) 

(d) 

8. The symmetry element that does NOT belong to C_{4v} point group is

(a) C_4 (b) C_2 (c) i (d) σ_v

9. Rigid rotor wavefunctions are given by $Y_{l,m}(\theta,\phi)$. The wavefunctions $Y_{1,0}(\theta,\phi)$

and $Y_{2,0}(\theta,\phi)$ are given below

$$Y_{1,0}(\theta,\phi) = \sqrt{\frac{3}{4\pi}}\cos\theta \qquad Y_{2,0}(\theta,\phi) = \sqrt{\frac{5}{16\pi}}(3\cos^2\theta - 1)$$

For a non-polar diatomic molecule, the value of transition dipole moment integral for transition between $Y_{1,0}(\theta,\phi)$ and $Y_{2,0}(\theta,\phi)$ is equal to

(a) $1/\sqrt{2\pi}$ (b) 0 (c) 2 (d) $1/\sqrt{4\pi}$

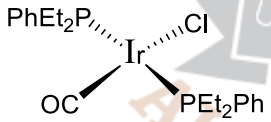
10. The translational, vibrational and rotational molecular partition functions for a system containing ideal diatomic gas molecule in the canonical ensemble (N, V, T) are written as, q_{trans}, q_{vib}, and q_{rot}, respectively. The option that correctly defines their thermodynamic variable(s) dependency is

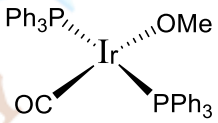
(a) $q_{trans}(T,V), q_{vib}(T,V), q_{rot}(T,V)$ (b) $q_{trans}(T,V), q_{vib}(T), q_{rot}(T)$

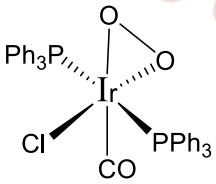
(c) $q_{trans}(T), q_{vib}(T,V), q_{rot}(T)$ (d) $q_{trans}(T,V), q_{vib}(T), q_{rot}(T,V)$

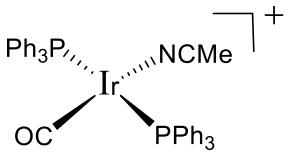
Q.11 – Q.19 Multiple Select Question (MSQ), carry ONE mark each (no negative marks).

11. The Vaska's complex trans-$IrCl(CO)(PPh_3)_2$ shows a band at 1967 cm^{-1} for the ν_{CO} stretching vibration in its infrared spectrum. The complex(es) that will show an increase in the ν_{CO} stretching vibration from 1967 cm^{-1} is/are

(a) 

(b) 

(c) 

(d) 

12. Under the conditions mentioned for each reaction, the reaction(s) that would give borazine ($B_3N_3H_6$) as the major product is/are

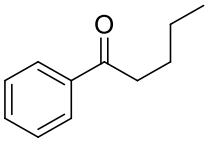
(a) $LiBH_4 + NH_4Cl \xrightarrow{230\ ^\circ C}$ (b) $B_2H_6 + 2NH_3 \xrightarrow{180\ ^\circ C}$

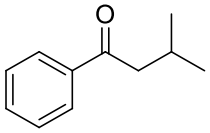
(c) $NaBH_4 + (NH_4)_2SO_4 \xrightarrow{THF,40\ ^\circ C}$ (d) $BCl_3 + NH_4Cl \xrightarrow[135\ ^\circ C]{chlorobenzene}$

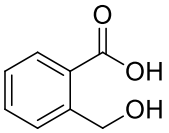
13. The essential symmetry(ies) for a monoclinic crystal system is/are the presence of

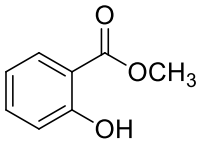
(a) one C_3 axis (b) one C_2 axis (c) one C_4 axis (d) one C_6 axis

14. Compound(s) that show(s) an intense peak at m/z 120 in the EI mass spectrum is/are

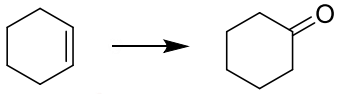
(a) 

(b) 

(c) 

(d) 

15. The correct option(s) of reagents and reaction sequence suitable for carrying out the following transformation is/are



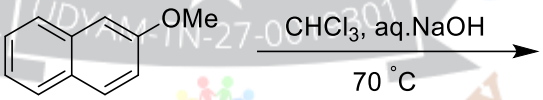
(a) (i) NBS, $(PhCOO)_2$; (ii) aq.NaOH; (iii) active MnO_2; (iv) Li/liq.NH_3, t-BuOH

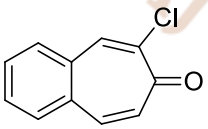
(b) (i) m-CPBA; (ii) $BF_3.Et_2O$

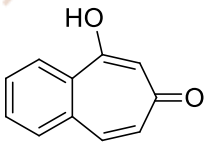
(c) (i) SeO_2; (ii) Dess-Martin periodinane; (iii) K[BH(s-Bu)$_3$] (K-selectride)

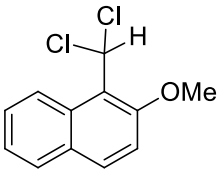
(d) (i) dil.$KMnO_4$ (ii) $NaIO_4$

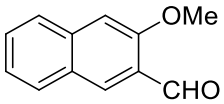
16. Among the given options, the possible product(s) that can be obtained from the following reaction is/are



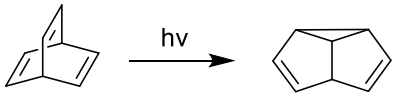
(a) 

(b) 

(c) 

(d) 

17. Choose the correct option(s) with regard to mechanism of the following transformation.



(a) It proceeds through divinyl cyclopropane rearrangement

(b) It involves a diradical intermediate

(c) It proceeds through di-π-metane rearrangement

(d) It proceed through [2 + 2 + 2] cycloaddition reaction

18. **Consider two non-interacting particles confined to a one-dimensional box with infinite potential barriers. Their wavefunctions are Ψ_1 and Ψ_2 and energies are E_1 and E_2, respectively. The INCORRECT statement(s) about this system is/are**

(a) The total energy is $E_1 + E_2$ (b) The total wavefunction is $\Psi_1 + \Psi_2$

(c) The total energy is $E_1 E_2$ (d) The total wavefunction is $\Psi_1 \Psi_2$

19. **The thermodynamic criterion/criteria for a spontaneous process is/are**

(a) $\Delta U > 0$ at constant S and V (b) $\Delta S > 0$ at constant U and V

(c) $\Delta(H - TS) > 0$ at constant T and P (d) $\Delta(U - TS) < 0$ at constant T and V

Q.20 – Q.25 Numerical Answer Type (NAT), carry ONE mark each (no negative marks).

20. **Xe and F_2 in 1 : 1 molar ratio when mixed in a closed flask and kept in the sunlight for a day, gave white crystals of a compound Q. Two equivalents of Q on reaction with one equivalent of AsF_5 gave an ionic compound X^+Y^- with the cation having two Xe atoms. The total number of lone pairs present on the cation X^+ is _____. (in integer)**

21. **The total number of hyperfine lines expected in the EPR spectrum of $\cdot CH_2OH$ (radical) is _____. (in integer) [Note: Consider all hydrogen atoms for calculation]**

22. **Partial hydrolysis of a pentapeptide yields all possible tripeptides and dipeptides. The dipeptides that are obtained upon hydrolysis are given below.**

Val-Ala, Gln-His, Phe-Val and Ala-Gln

The total number of tripeptides obtained that contain 'Ala' as one of the amino acids is _____. (in integer)

23. **The specific rotation of enantiomerically pure(S)-2-butanol is +14°. The specific rotation of enantiomeric mixture of 2-butanol obtained from an asymmetric reduction of 2-butanone is found to be +7°. The percentage of (R)-2-butanol present in the reaction mixture is _____. (in integer)**

24. **The ratio of the fundamental vibrational frequencies ($\nu_{^{13}C^{16}O}/\nu_{^{12}C^{16}O}$) of two diatomic molecules $^{13}C^{16}O$ and $^{12}C^{16}O$, considering their force constants to be the same, is _____. (rounded off to two decimal places)**

25. **The expression for the vapour pressure of solid (p_1) and vapour pressure of liquid (p_2) phases of a pure substance, respectively, are**

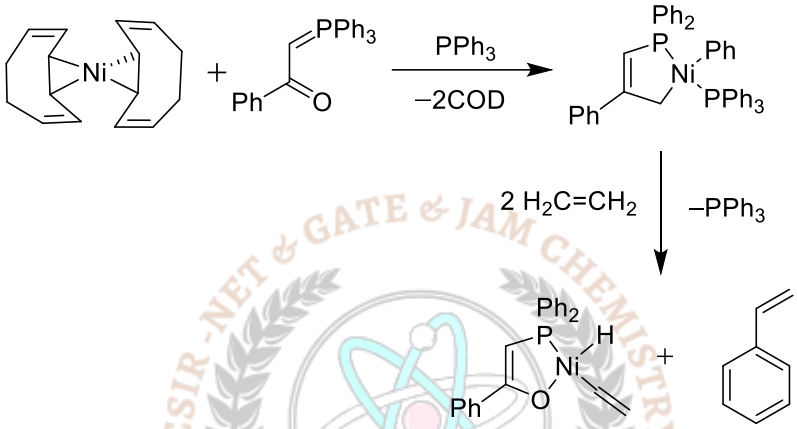
$$\ln p_1 = -\frac{2000}{T} + 5 \text{ and } \ln p_2 = -\frac{4000}{T} + 10$$

The triple point temperature of this substance is ___ K. (in integer)

Q.26 – Q.36 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

26. **The reaction that proceeds through an oxidative addition followed by a reductive elimination is** **(COD = cyclooctadiene)**

(a)



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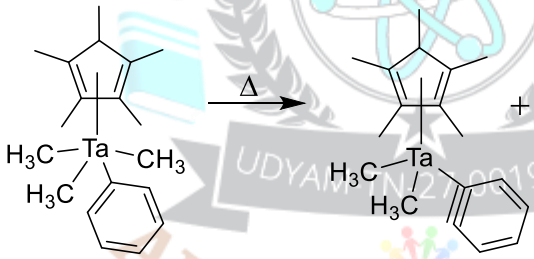

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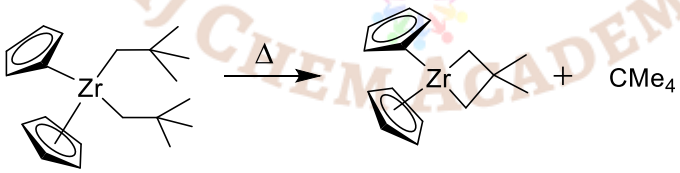

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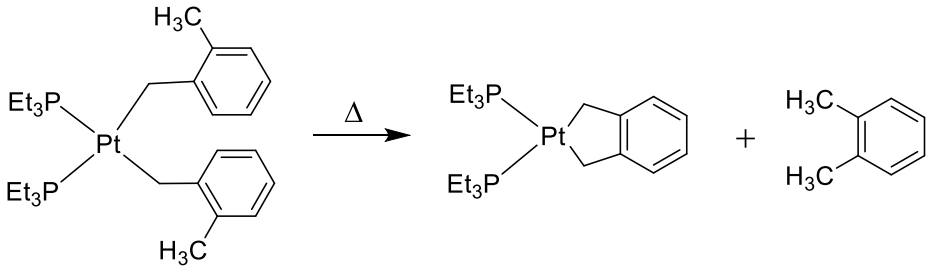


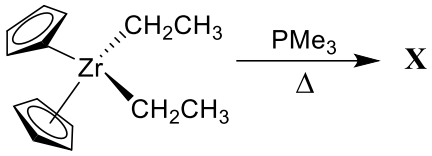
27. **The homogeneous catalyst whose metal ion does NOT undergo either oxidation or reduction in any of the steps during the hydrogenation of terminal olefins is**

(a) $RhCl(PPh_3)_3$ (b) $HRuCl(PPh_3)_3$ **(COD = cyclooctadiene)**

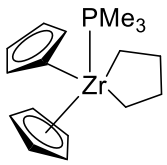
(c) $[Ir(COD)(PCy_3)(Py)]^+PF_6^-$ (d) $[Rh(COD)(PPh_3)_2]^+PF_6^-$

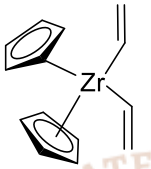
28. **The given zirconocene compound, $(\eta^5\text{-Cp})_2ZrEt_2$, when heated in the presence of**

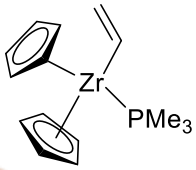
an equimolar amount of PMe_3 results in the formation of a compound-X which obeys the 18 electron rule. The reaction also resulted in the release of a saturated hydrocarbon.

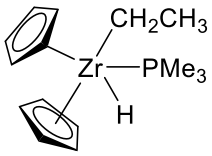


The structure of compound X is

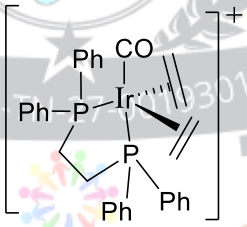
(a) 

(b) 

(c) 

(d) 

29. **The ^{1}H-NMR spectrum of the given iridium complex at room temperature gave a single signal at 2.6 ppm, and its ^{31}P-NMR spectrum gave a single signal at 23.0 ppm. When the spectra were recorded at lower temperatures, both these signals split into a complex pattern. The intra-molecular dynamic processes shown by this molecule are**



(a) Berry pseudo-rotation and rotation of the ethylene units along the C=C axis

(b) Berry pseudo-rotation and propeller type rotation of the ethylene units along the Ir-alkene axis

(c) Ray-Dutt twist and rotation of the ethylene units along the C=C axis

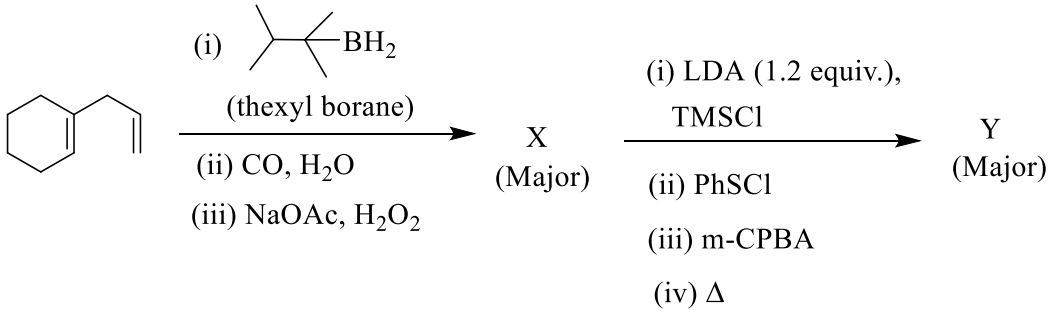
(d) Ray-Dutt twist and propeller type rotation of the ethylene units along the Ir-alkene axis

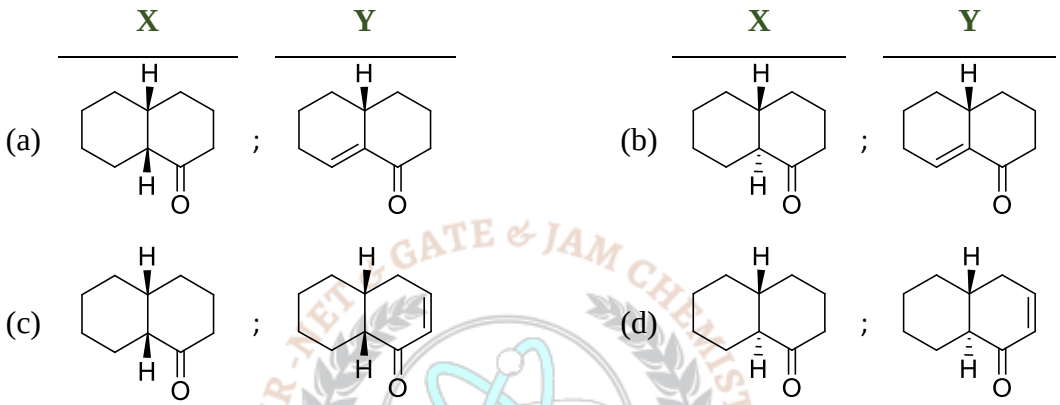
30. **The effective magnetic moment, μ_{eff} value for $[Cr(H_2O)_6]^{3+}$ taking into account for spin-orbit coupling is closest to**

[Given: Atomic number of Cr = 24, spin-orbit coupling constant $\lambda = 92\ cm^{-1}$ and $\Delta_o = 17400\ cm^{-1}$]

(a) 3.79 μ_B (b) 3.87 μ_B (c) 4.05 μ_B (d) 3.60 μ_B

31. **The major products X and Y formed in the following reaction sequences are**



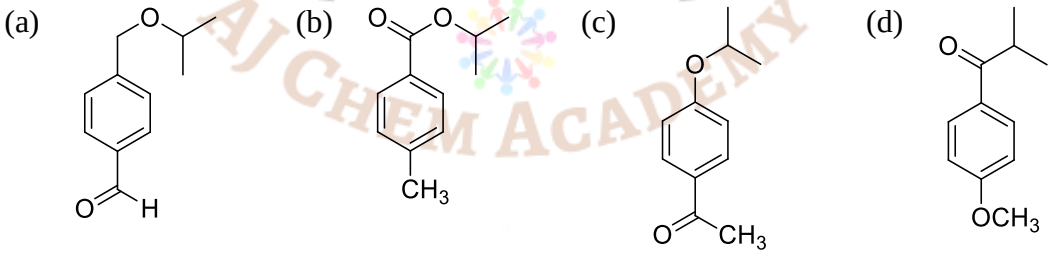


32. **Compound K displayed the spectral data as follows:**

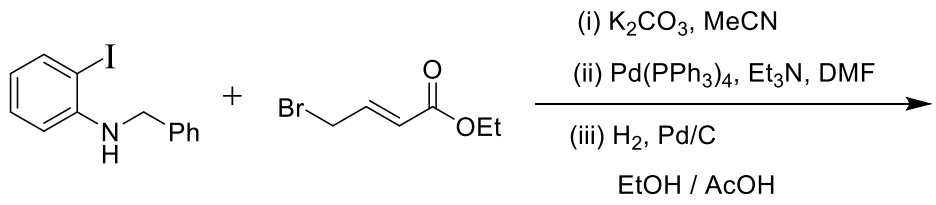
IR : $1680\ cm^{-1}$

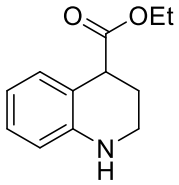
^{1}H-NMR : $7.30\ (d, J = 7.2\ Hz, 2H), 6.8 (d, J = 7.2\ Hz, 2H),$
$3.8\ (septet, J = 7.0\ Hz, 1H), 2.2 (s, 3H), 1.9 (d, J = 7.0\ Hz, 6H)$

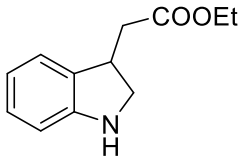
The correct structure of compound K is



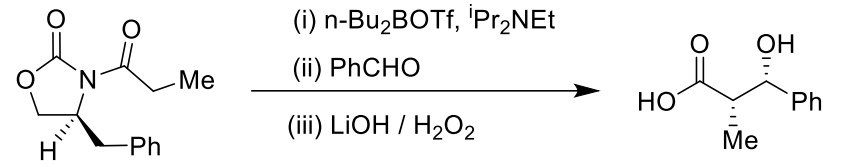
33. **The major product formed in the following reaction sequences is**



(c) 

(d) 

34. In the following asymmetric transformation, the key aldol reaction involves the attack of



(Pure enantiomer) (Pure enantiomer)

(a) Si face of enolate on to the Re face of aldehyde

(b) Si face of enolate on to the Si face of aldehyde

(c) Re face of enolate on to the Re face of aldehyde

(d) Re face of enolate on to the Si face of aldehyde

35. The correct option with regard to the following statement is

P. Time-independent Schrodinger equation can be exactly solved for Be^{2+}

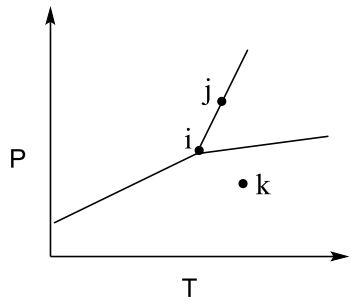
Q. For a particle confined in a one-dimensional box of length l with infinite Potential barriers, the trial variation function $\phi = \left[\left(\frac{3}{l^3}\right)^{1/2} x\right]$ is not an acceptable trial variation wavefunction for $0 \leq x \leq l$

R. Wavefunctions for system of Fermions must be anti-symmetric with respect to exchange of any two Fermions in the system

S. Born-Oppenheimer approximation can be used to separate the vibrational and Rotational motion of a molecule

	P		Q		R		S
(a)	True	;	False	;	False	;	True
(b)	True	;	True	;	False	;	False
(c)	False	;	True	;	True	;	False
(d)	False	;	True	;	True	;	True

36. The phase diagram of a single component system is given below.



The option with the correct number of degrees of freedom corresponding to the labelled points i, j and k, respectively, is

(a) 0,1,2 (b) 3,2,1 (c) 2,0,1 (d) 0,2,1

Q.37 – Q.47 Multiple Select Question (MSQ), carry TWO marks each (no negative marks).

37. An approximate partition function $Q(N, V, T)$ of a gas is given below.

$$Q(N, V, T) = \frac{1}{N!}\left(\frac{2\pi mk_BT}{h^2}\right)^{3N/2}(V - Nb)^N$$

The equation of state(s) for this gas is/are

[Note: b is a parameter independent of volume.]

(a) $P(V - Nb) = Nk_BT$ (b) $PV^{(N-b)} = k_BT$ (c) $PV = Nk_BT$ (d) $P(V - Nb) = Nk_B$

38. The compound(s) having structure similar to that of B_2H_6 is/are

(a) I_2Cl_6 (b) Si_2Cl_6 (c) Al_2Cl_6 (d) Cl_2O_6

39. The UV-visible spectrum of $[Ni(en)_3]^{2+}(en = ethylenediamine)$ shows absorbance maxima at $11200\ cm^{-1}$, $18350\ cm^{-1}$ and $29000\ cm^{-1}$.

	Absorbance maximum		Electronic transition
(P)	$11200\ cm^{-1}$	(i)	$^3A_{2g} \rightarrow {}^3T_{1g}(F)$
(Q)	$18350\ cm^{-1}$	(ii)	$^3A_{2g} \rightarrow {}^3T_{2g}$
(R)	$29000\ cm^{-1}$	(iii)	$^3A_{2g} \rightarrow {}^3T_{1g}(P)$

The correct match(es) between absorbance maximum and electronic transition is/are

(a) (P) → (ii) (b) (Q) → (i) (c) (P) → (iii) (d) (R) → (iii)

40. Cytochrome-P450 (CYP) enzymes catalyze stereoselective C-H hydroxylation of hydrocarbons in the presence of O_2. The correct statement(s) about the structure and activity of CYP is/are

(a) A thiolate group is coordinated to the Fe center at one of the axial positions around Fe

(b) While one of the oxygen atoms of O_2 is inserted into a C-H bond of a hydrocarbon, the other oxygen atom gets reduced to water

(c) An imidazole group is coordinated to the Fe center at one of the axial positions around Fe

(d) An iron-oxo species acts as a key oxidant in the catalytic cycle of CYP

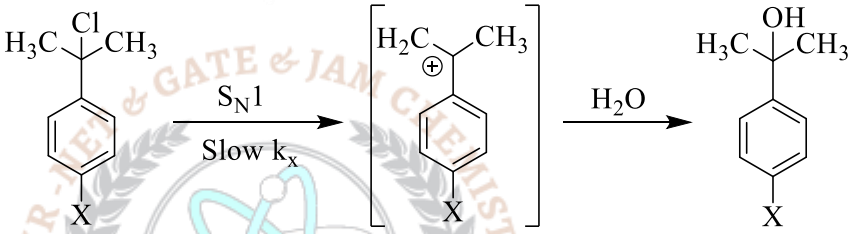
41. The complex(es) having metal-metal bond order ≥ 3.5 is/are

(a) $[Mo_2(\mu\text{-}SO_4)_4(H_2O)_2]^{3-}$ (b) $[Mn_2(CO)_{10}]$

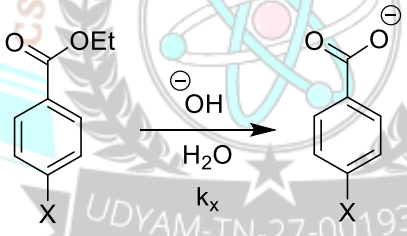
(c) $[Cr_2(\mu\text{-}O_2CCH_3)_4]$ (d) $[Mo_2(\mu\text{-}HPO_4)_4(H_2O)_2]^{2-}$

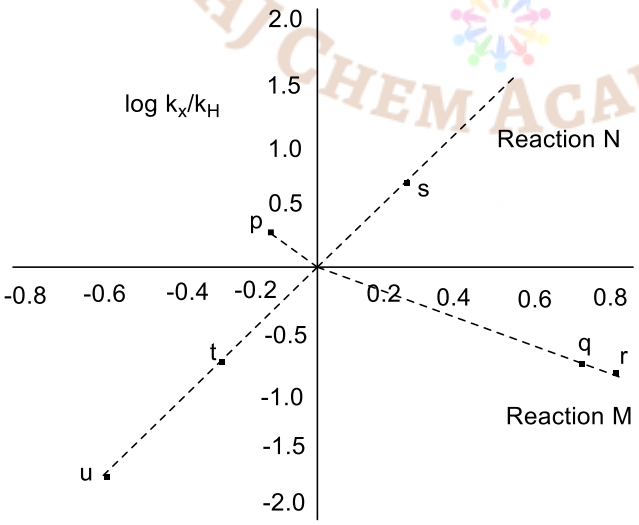
42. Consider the following two reactions and their corresponding Hammett plots

Reaction M :



Reaction N :





Column-I (point on the graph)	Column-II (substituent X)
P	NH_2
Q	NO_2
R	OMe
S	Cl
T	Me
u	CN

Choose the option(s) that correctly match(es) the points on the graph given in Column-I with substituents X given in Column-II in accordance with their substituents constant σ

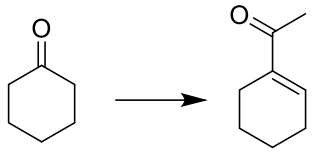
(a) $s \rightarrow \sigma_{(X=Cl)}; t \rightarrow \sigma_{(X=OMe)}; u \rightarrow \sigma_{(X=NH_2)}; r \rightarrow \sigma_{(X=NO_2)}$

(b) s → $\sigma_{(X=Me)}$; u → $\sigma_{(X=NH_2)}$; t → $\sigma_{(X=OMe)}$; r → $\sigma_{(X=Br)}$

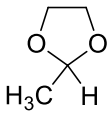
(c) p → $\sigma_{(X=Me)}$; q → $\sigma_{(X=CN)}$; r → $\sigma_{(X=NO_2)}$; t → $\sigma_{(X=OMe)}$

(d) p → $\sigma_{(X=Cl)}$; q → $\sigma_{(X=NO_2)}$; r → $\sigma_{(X=CN)}$; t → $\sigma_{(X=Me)}$

43. The correct option(s) of reagents and reaction sequences suitable for carrying out the following transformation is/are



(a) (i) Li-C ≡C-H, THF, −70°C; (ii) cat.$HgSO_4$, H_2SO_4, H_2O; (iii) aqueous acid, Δ

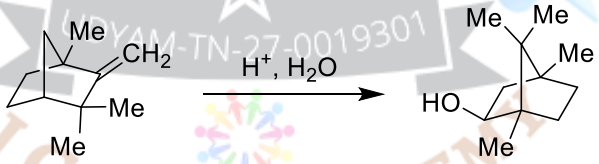
(b) (i)  , NaH ; (ii) aqueous acid, Δ

(c) (i) LDA, $TfNPh_2$; (ii) cat.[(dppe)Pd(0)],  ; (iii) aqueous acid, Δ

(dppe = diphenylphosphinoethane)

(d) (i) H_3C-NO_2, $NaOCH_3$; (ii) sat.NaCl (iii) $TiCl_3$, H_2O; (iv) aqueous acid, Δ

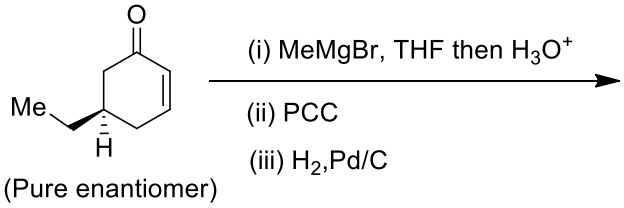
44. The process(es) and/or intermediate(s) through which the following transformation proceeds is/are



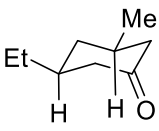
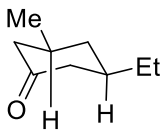
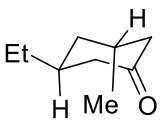
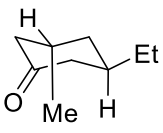
(a) 1,2-methide shift (b) 1,3-methide shift

(c) non-classical carbocation (d) tertiary carbocation

45. For the following reaction, the possible product(s) is/are



(Pure enantiomer)

(a)  (b)  (c)  (d) 

46. Wavefunctions and energies for a particle confined in a cubic box are Ψ_{n_x,n_y,n_z} and E_{n_x,n_y,n_z}, respectively. The ϕ_1, ϕ_2, ϕ_3 and ϕ_4 are written as linear combinations of

Ψ_{n_x,n_y,n_z}. Among these functions, the eigen function(s) of the Hamiltonian operator for this particle is/are

$$\phi_1 = \frac{1}{\sqrt{2}}\Psi_{1,4,1} - \frac{1}{\sqrt{2}}\Psi_{2,2,3}$$

$$\phi_2 = \frac{1}{\sqrt{2}}\Psi_{1,5,1} + \frac{1}{\sqrt{2}}\Psi_{3,3,3}$$

$$\phi_3 = \frac{1}{\sqrt{2}}\Psi_{1,3,8} + \frac{1}{\sqrt{2}}\Psi_{3,8,1}$$

$$\phi_3 = \frac{1}{\sqrt{2}}\Psi_{3,3,1} + \frac{1}{\sqrt{2}}\Psi_{2,4,1}$$

(a) ϕ_2 (b) ϕ_4 (c) ϕ_3 (d) ϕ_1

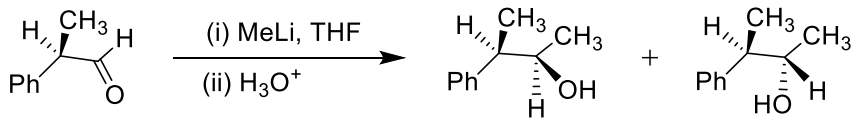
47. If a particle's state function is an eigenfunction of the operator $\hat{L}^2$ with eigenvalue $30\hbar^2$, then the possible eigen value(s) of the operator $\hat{L}_Z^2$ for the same state function is/are

(a) $10\hbar^2$ (b) $16\hbar^2$ (c) $25\hbar^2$ (d) 0

Q.48 – Q.55 Numerical Answer Type (NAT), carry TWO marks each (no negative marks).

48. An achaeological specimen containing ^{14}C gives 45 counts per gram of carbon in 5 minutes. A specimen of freshly cut wood gives 20 counts per gram of carbon per minute. The counter used recorded a background count of 5 counts per minute in the absence of any ^{14}C containing sample. The age of the specimen is_____ years. (in integer). [Note: $t_{1/2}$ of $^{14}C = 5730$ years]

49. In the following reaction, 13.4 grams of aldehyde-P gave a diastereomeric mixture of alcohols Q and R in a ratio of 2 : 1. If the yield of the reaction is 80 %, then the amount of Q (in grams) obtained is _____ (in integer).



(P) (Q) (R)

50. The kinetic energies of an electron (e) and a proton (p) are E and 3E, respectively. Given that mass of a proton is 1836 times that of an electron, the ratio of their de Broglie wavelengths (λ_e/λ_p) is _____ (rounded off to two decimal places).

51. If a molecule emitting a radiation of frequency 3.100×10^{9} Hz approaches an observer with a relative speed of 5.000×10^{6} m s^{-1}, then the observer detects a frequency of _____ $\times 10^{9}$ Hz. (rounded off to three decimal places).

[Given: Speed of light $c = 3.000 \times 10^{8}$ m s^{-1}]

52. The mean energy of a molecule having two available energy states at $\varepsilon = 0$ J and $\varepsilon = 4.14 \times 10^{-21}$ J at 300 K is _____ $\times 10^{-21}$ J. (rounded off to two decimal places). [Given: Boltzmann constant $(k_B) = 1.38 \times 10^{-23}$ J K^{-1}]

53. For the cell reaction,

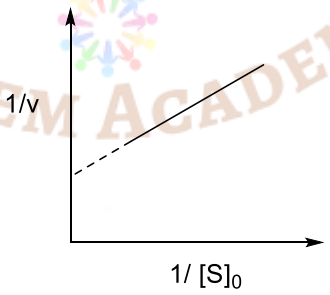
$$Hg_2Cl_{2(s)} + H_2(1\ atm) \rightarrow 2Hg_{(l)} + 2H^{+}(a = 1) + 2Cl^{-}(a = 1)$$

The standard cell potential is $\varepsilon^0 = 0.2676$ V, and $\left(\frac{\partial \varepsilon^0}{\partial T}\right)_P = -3.19 \times 10^{-4}$ V K^{-1}. The standard enthalpy change of the reaction $(\Delta_r H^0)$ at 298 K is $-x$ kJ mol^{-1}. The value of x is _____ (rounded off to two decimal places).

[Given: Faraday constant F = 96500 C mol^{-1}]

54. Consider a Carnot engine with a hot source kept at 500 K. From the hot source, 100 J of energy (heat) is withdrawn at 500 K. The cold sink is kept at 300 K. The efficiency of the carnot engine is _____ (rounded off to one decimal place).

55. The Lineweaver-Burk plot for an enzyme obeying the Michaelis-Menten mechanism is given below.



The slope of the line is 0.36×10^{-2}s, and the y-intercept is 1.20 $mole^{-1}$ Ls. The value of the Michaelis constant (K_M) is _____ $\times 10^{-3}$ mol L^{-1} (in integer).

[Note: v is the initial rate, and $[S]_0$ is the substrate concentration]

Answer Key

Q.No	Ans
1.	c
2.	c

Q.No	Ans
15.	a, c
16.	a

Q.No	Ans
29.	b
30.	a

Q.No	Ans
43.	a, c
44.	a, c, d

3.	c
4.	c
5.	b
6.	c
7.	d
8.	c
9.	b
10.	b
11.	c, d
12.	a, b
13.	b
14.	a, b, d

17.	b, c
18.	b, c
19.	b, d
20.	14
21.	6
22.	3
23.	25
24.	0.97 to 0.99
25.	400
26.	d
27.	b
28.	c

31.	d
32.	c
33.	b
34.	d
35.	c
36.	a
37.	a
38.	c
39.	a, b, d
40.	a, b, d
41.	a, c
42.	a, c

45.	a, c
46.	a, c
47.	b, c, d
48.	10926 to 10934
49.	8
50.	74.10 to 74.30
51.	3.110 to 3.200
52.	1.00 to 1.20
53.	69.00 to 71.00
54.	0.4
55.	3

Q. 1 – 10	1 Mark (MCQ)
Q. 26 – 37	2 Marks (MCQ)

Q. 11 – 19	1 Mark (MSQ)
Q. 38– 47	2 Marks (MSQ)

Q. 20-25	1 Mark (NAT)
Q. 48 – 55	2 Marks (NAT)