GATE – 2023 – Chemistry

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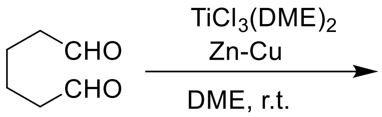
Q.1 – Q.20 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

1. The major product formed in the given reaction is, {DME: 1,2-Dimethoxyethane}



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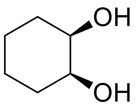

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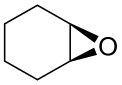

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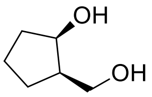

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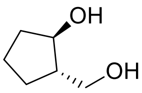
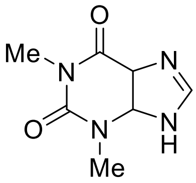


2. The compound which gives a fragment at $m/z = 124[M + H]^+$ is

(a)


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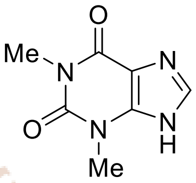

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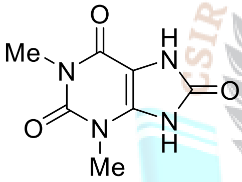

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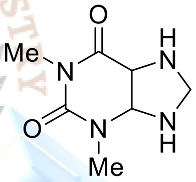
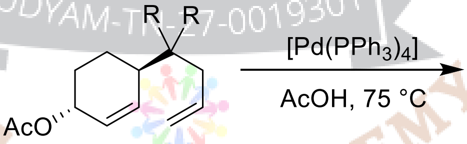


3. The major product formed in the given reaction is



R = CO_2Me

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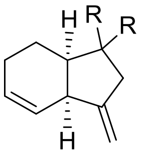

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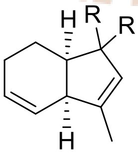

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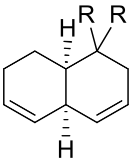

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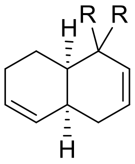
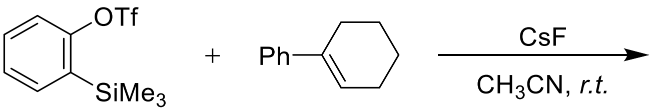


4. The major product formed in the given reaction is



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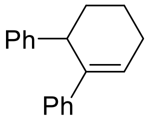

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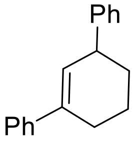

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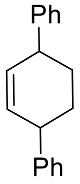

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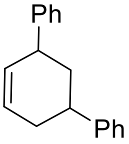
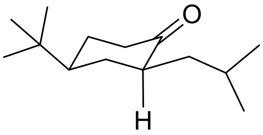
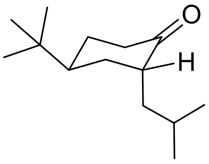


5. **On irradiation using UV light (> 300 nm), compounds X and Y, predominantly, undergo**



X



Y

(a) X: Norrish type I reaction and Y: Norrish type II reaction

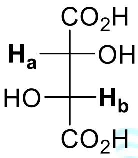
(b) X: Norrish type II reaction and Y: Norrish type I reaction

(c) Both X and Y: Norrish type I reaction

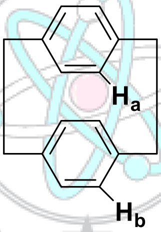
(d) Both X and Y: Norrish type II reaction

6. **The topicity relationship of H_a and H_b in X, Y and Z are, respectively,**

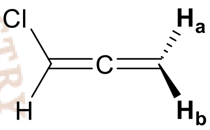
X



Y

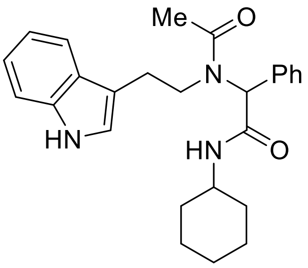


Z

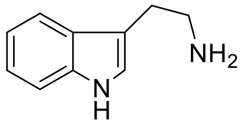
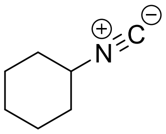


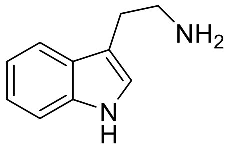
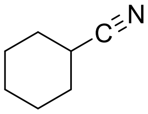
	X		Y		Z
(a)	Diastereotopic	;	Homotopic	;	Enantiotopic
(b)	Homotopic	;	Enantiotopic	;	Enantiotopic
(c)	Homotopic	;	Homotopic	;	Enantiotopic
(d)	Diastereotopic	;	Enantiotopic	;	Homotopic

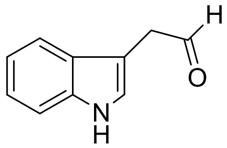
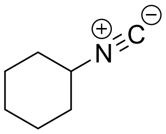
7. **Compound-P was prepared based on a four-component reaction at room temperature in methanol. The required starting materials for the synthesis are**

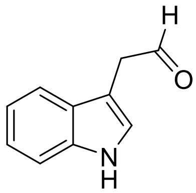
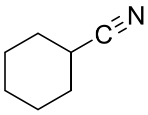


P

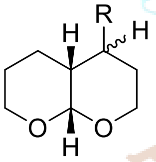
(a)  ; PhCHO ; $MeCO_2H$; 

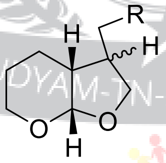
(b)  ; PhCHO ; $MeCO_2H$; 

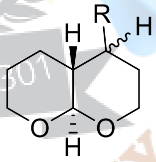
(c)  ; $PhCH_2NH_2$; $MeCO_2H$; 

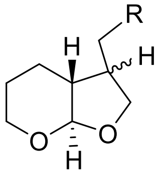
(d)  ; $PhCH_2NH_2$; $MeCO_2H$; 

8. The major product formed in the following reaction is

(a) 

(b) 

(c) 

(d) 

9. The reaction of Ph_3PCl_2 with $PhNH_2$ primarily produces

(a) $Ph_3P{=}NPh$ (b) $PhP{=}NPh$ (c) $PhCl_2P{=}NPh$ (d) $Ph_2ClP{=}NPh$

10. Formation of $[M(en)_3]^{2+}$ from $[M(H_2O)_6]^{2+}$ and three equivalents of ethylenediamine (en) is LEAST favored when M is

(a) Co (b) Ni (c) Cu (d) Fe

11. Wacker oxidation of alkenes is catalysed by a combination of

(a) Pd(II) and Cu(II) (b) Co(II) and Cu(II) (c) Pd(II) and Ni(II) (d) Pd(II) and Co(II)

12. For the conversion of $[Pt(L)Cl_3]^-$ to trans-$[Pt(L)Cl_2(H_2O)]$, the trans-effect is LEAST when the ligand L is

(a) H_2O (b) NH_3 (c) DMSO (d) C_2H_4

13. The tetracoordinated copper center in the oxidized and reduced forms of plastocyanin exhibits longest bond with

(a) cysteine-S and methionine-S, respectively

(b) methionine-S and cysteine-S, respectively

(c) cysteine-S and cysteine-S, respectively

(d) methionine-S and methionine-S, respectively

14. **The packing efficiency (in %) of spheres for a body-centered cubic (bcc) lattice is approximately**

(a) 74 (b) 68 (c) 60 (d) 52

15. **The magnitude of CFSE in $[M(H_2O)_6]^{n+}$ for Mn and Fe ions satisfy the relations**

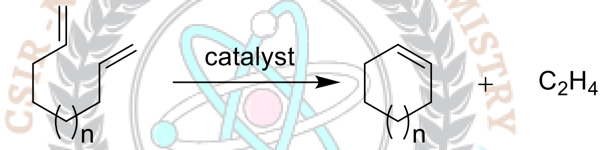
(a) $Mn^{2+} < Mn^{3+}$ and $Fe^{2+} < Fe^{3+}$

(b) $Mn^{2+} > Mn^{3+}$ and $Fe^{2+} > Fe^{3+}$

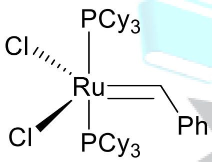
(c) $Mn^{2+} < Mn^{3+}$ and $Fe^{2+} > Fe^{3+}$

(d) $Mn^{2+} > Mn^{3+}$ and $Fe^{2+} < Fe^{3+}$

16. **The organometallic catalyst for the following transformation is**

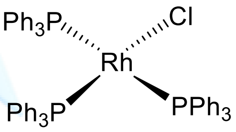


(a)



Cy: cyclohexyl

(b)



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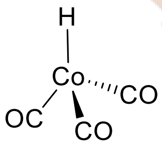

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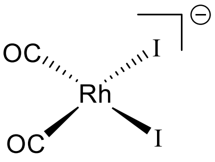


17. **Point group of naphthalene ($C_{10}H_8$) is**

(a) D_{2d} (b) D_{2h} (c) D_{3d} (d) D_{3h}

18. **The INCORRECT statement is**

(a) Zero-point energy of a quantum mechanical harmonic oscillator of frequency v is $\frac{hv}{2}$

(b) Energy level of a quantum mechanical rigid rotor is inversely proportional to its moment of inertia

(c) The time independent Schrödinger equation for Li^{2+} cannot be solved exactly

(d) Total angular momentum of an atomic system is equal to the sum of orbital angular momentum and spin angular momentum

19. **For an ideal gas, the molecular partition function in the canonical ensemble, that is**

proportional to the system volume (V), is the

(a) vibrational partition function (b) rotational partition function

(c) electronic partition function (d) translational partition function

20. Assertion (S) : The total angular momentum for light atoms (low atomic number) is obtained by Russell-Saunders coupling, whereas jj-coupling is used for heavy atoms (high atomic number).

Reasoning (R) : The spin-orbit interactions are weak in light atoms (low atomic number) and strong in heavy atoms (high atomic number).

The correct option is

(a) S and R are true; and R is the correct reason for S

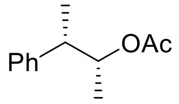
(b) S and R are true; but R is NOT the correct reason for S

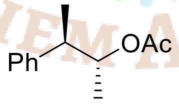
(c) S is true but R is false

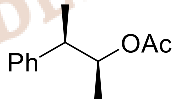
(d) S is false but R is true

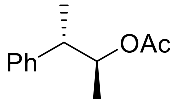
Q.21 – Q.24 Multiple Select Question (MSQ), carry ONE mark each (no negative marks).

21. The acetolysis product(s) of the given reaction is(are)

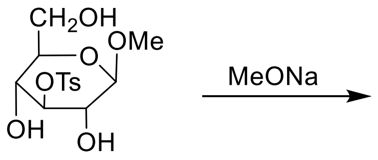
(a) 

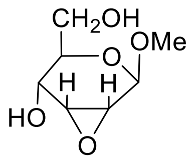
(b) 

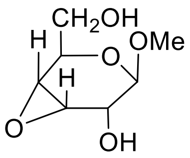
(c) 

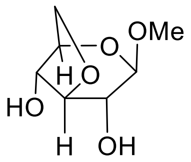
(d) 

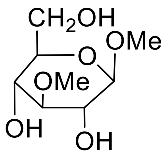
22. Product(s) formed in the given reaction is(are)



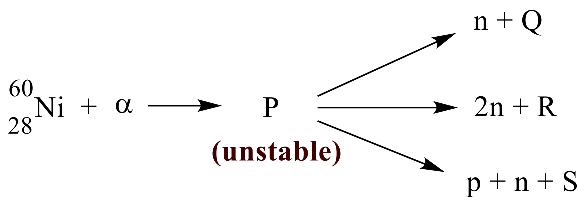
(a) 

(b) 

(c) 

(d) 

23. The choice(s) that correctly identify radioisotopes (P, Q, R, S) shown in the following nuclear reaction is(are)



(a) P = $^{64}_{30}Zn$ (b) Q = $^{63}_{30}Zn$ (c) R = $^{62}_{29}Cu$ (d) S = $^{62}_{29}Cu$

24. **For the Lindemann-Hinshelwood mechanism of gas phase unimolecular reactions, the true statement(s) is(are)**

(a) Only molecules with three or more atoms can follow the Lindemann-Hinshelwood Mechanism

(b) Lindemann-Hinshelwood Mechanism involves bimolecular elementary steps

(c) The overall reaction is of second order at low pressure

(d) The overall reaction is of second order at high pressure

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

25. **The calculated magnetic moment of $[Ce(NO_3)_5]^{2-}$ is ________ BM. (rounded off to two decimal places) (Given: atomic number of Ce is 58)**

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

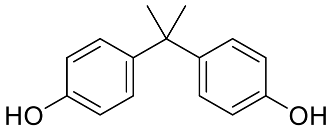
26. **A compound $C_{15}H_{16}O_2$, has the following spectral data;**

^{1}H-NMR : $9.16(s), 6.89(d, J = 8Hz), 6.64(d, J = 8Hz), 1.53(s)$

^{13}C-NMR : $154.7, 140.9, 127.1, 114.4, 40.7, 30.7$

The structure of the compound is

(a)



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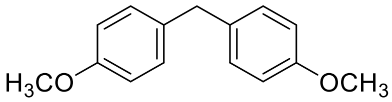

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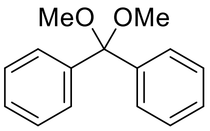
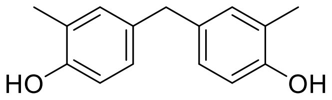
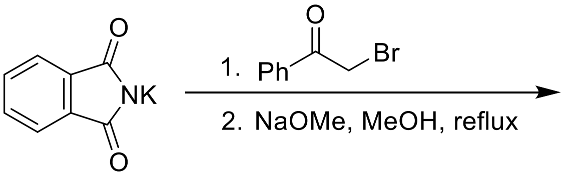


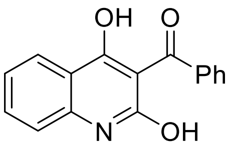
(d)



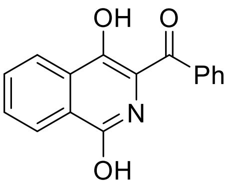
27. **The major product formed in the given reaction sequence is**



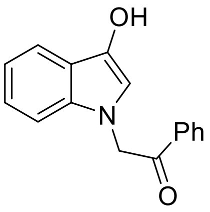
(a)



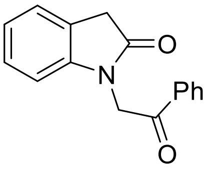
(b)



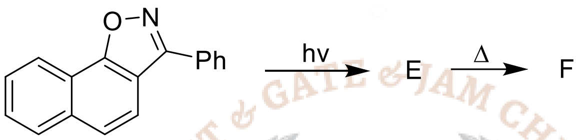
(c)

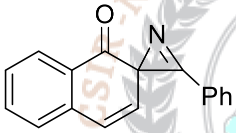
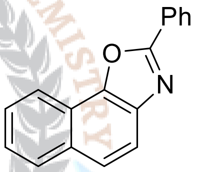


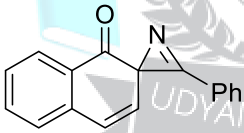
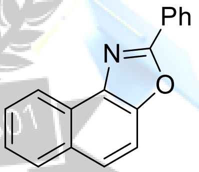
(d)

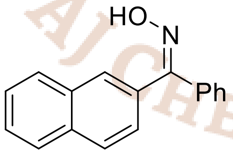
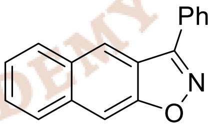


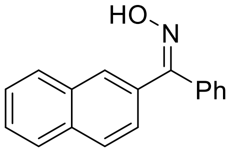
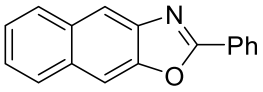
28. **E and F in the given reaction scheme are**



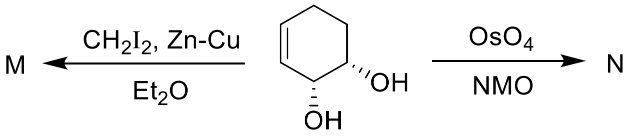
(a) E =  and F = 

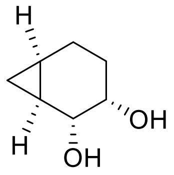
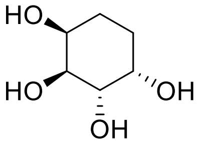
(b) E =  and F = 

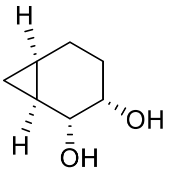
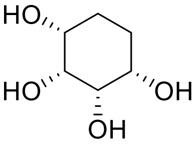
(c) E =  and F = 

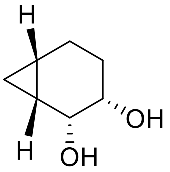
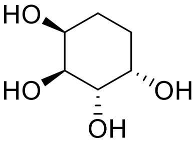
(d) E =  and F = 

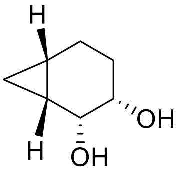
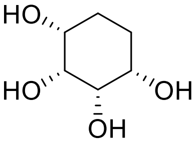
29. **M and N in the given reaction scheme are** {**NMO: N-Methylmorpholine-N-oxide**}



(a) M =  and N = 

(b) M =

and N =


(c) M =

and N =


(d) M =

and N =


30. **In the ^{1}H-NMR spectrum, multiplicity of the signal (bold and underlined H atom) in the following species is** **($Cp^* =$ Pentamethylcyclopentadienyl)**

I	II	III	IV
$[\underline{\mathbf{H}}Ni(OPEt_3)_4]^+$	$Ph_2Si(Me)\underline{\mathbf{H}}$	$P\underline{\mathbf{H}}_3$	$(Cp^*)_2Zr\underline{\mathbf{H}}_2$

	I	II	III	IV
(a)	pentet ;	quartet ;	doublet ;	singlet
(b)	pentet ;	singlet ;	singlet ;	doublet
(c)	triplet ;	triplet ;	doublet ;	doublet
(d)	singlet ;	quartet ;	singlet ;	singlet

31. **The major product obtained by the treatment of $(\eta^5\text{-}C_5H_5)_2Ni$ with Na/Hg in ethanol is**

(a) $(\eta^5\text{-}C_5H_5)(\eta^3\text{-}C_5H_5)Ni$
(b) $(\eta^3\text{-}C_5H_5)_2Ni$
(c) $(\eta^5\text{-}C_5H_5)(\eta^3\text{-}C_5H_7)Ni$
(d) $(\eta^3\text{-}C_5H_7)_2Ni$

32. **The number of shared corners of the constituent SiO_4 units in orthosilicate, pyrosilicate, cyclic silicate and sheet silicate, respectively, are**

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

33. **Concentration of Q in a consecutive reaction $P \xrightarrow{k_1} Q \xrightarrow{k_2} R$ is given by $[Q] = \frac{k_1[P]_0}{k_2 - k_1}\left[e^{-k_1t} - e^{-k_2t}\right]$, where $[P]_0$ is the initial concentration of P. If the value of $k_2 = 25\ s^{-1}$, the value of k_1 that leads to the longest waiting time for Q to reach its maximum is**

(a) $k_1 = 20\ s^{-1}$ (b) $k_1 = 25\ s^{-1}$ (c) $k_1 = 30\ s^{-1}$ (d) $k_1 = 35\ s^{-1}$

34. The wavefunction for Be^{3+} in a certain state is given by $\psi = N\,e^{-\left(\frac{4}{a_0}r\right)}$, where N is the normalization constant, r is the distance of electron from the nucleus and a_0 is the Bohr radius. The most probable distance of the electron from the nucleus in this state is

(a) $4a_0$ (b) $\frac{a_0}{4}$ (c) $8a_0$ (d) $\frac{a_0}{8}$

35. Match the following, the correct Match is,

	Column-I		Column-II
(P)	Associated Legendre polynomials	**(i)**	Harmonic oscillator
(Q)	Hermite polynomials	**(ii)**	Particle in a box model
(R)	Associated Laguerre polynomials	**(iii)**	Angular part of H atom
(S)	Trigonometric functions	**(iv)**	Radial part of H atom

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

36. In the scheme below,

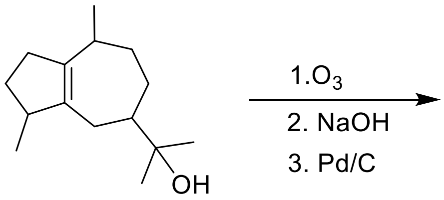
$$P_2 \underset{k_1}{\overset{I_a}{\rightleftharpoons}} 2Q \xrightarrow{k_2} R$$

I_a represents the intensity of the light absorbed. Assuming that the quantum yield of the first step is one, the steady state concentration of Q is given by

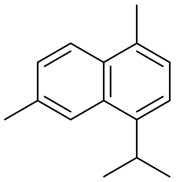
(a) $\sqrt{\frac{I_a}{k_1+k_2}}$ (b) $\sqrt{\frac{I_a[P_2]}{k_1+k_2}}$ (c) $\frac{I_a}{k_1+k_2}$ (d) $\frac{I_a[P_2]}{k_1+k_2}$

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

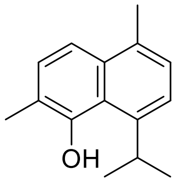
37. Product(s) formed in the given reaction sequence is(are)



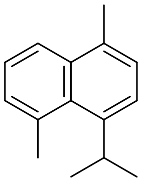
(a)



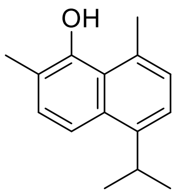
(b)



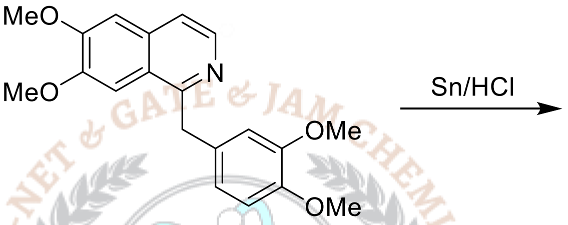
(c)



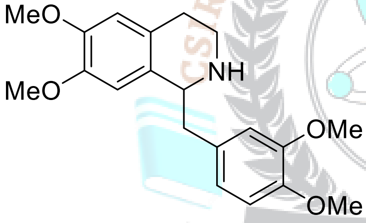
(d)



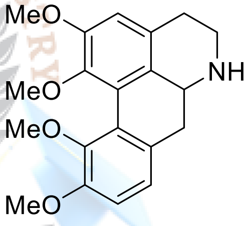
38. Product(s) formed in the reaction below is(are)



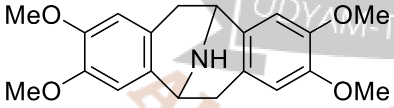
(a)



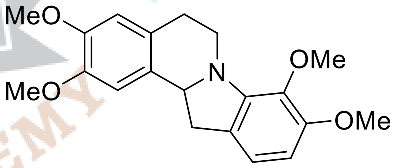
(b)



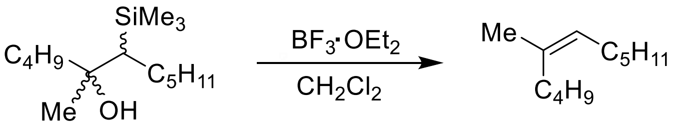
(c)



(d)

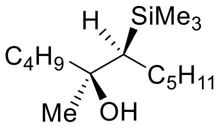


39. The stereoisomer(s) of G giving the depicted product is(are)

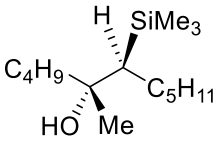


G

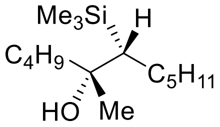
(a)



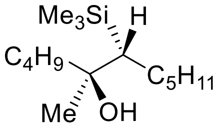
(b)



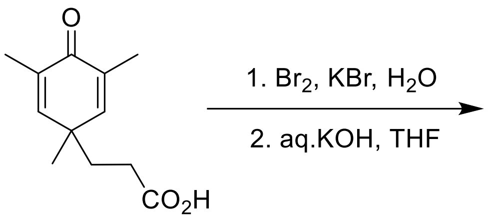
(c)



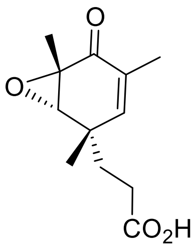
(d)



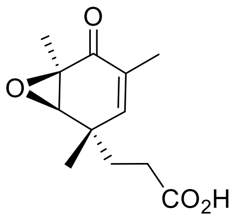
40. Product(s) formed in the given reaction sequence is(are)



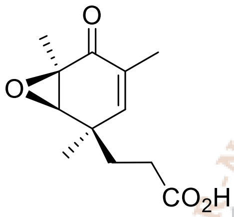
(a)



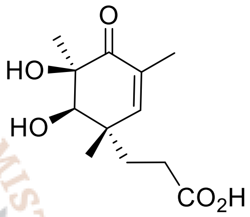
(b)



(c)

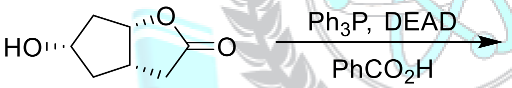


(d)



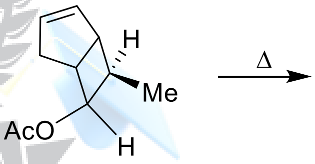
41. The reaction(s) in which inversion of configuration occur(s) is(are)

(a)

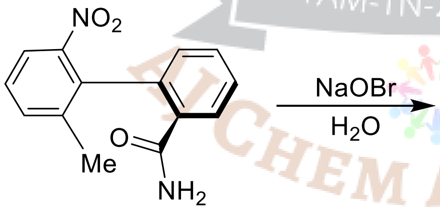


DEAD = Diethyl azodicarboxylate

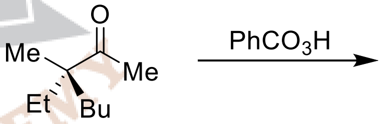
(b)



(c)



(d)



42. The correct statement(s) regarding myoglobin (Mb) and haemoglobin (Hb) is(are)

(a) At low partial pressure of O_2 (e.g.,5 kPa), the O_2 affinity of Hb lowers upon lowering the pH

(b) Binding of the first O_2 molecule to Hb results in lower affinity for the binding of second O_2 molecule

(c) Metal center in deoxy-Mb is low-spin whereas it is high-spin in the case of oxy-Mb

(d) One end of O_2 binds to the metal center in oxy-Mb and the other end of the bound O_2 is H-bonded with imidazole-NH of a distal histidine

43. The correct statement(s) regarding $Co_2(CO)_8$ is(are)

(a) It reacts with Na to give $Na[Co(CO)_4]$

(b) It contains three bridging carbonyls

(c) It can be prepared by reductive carbonylation of $Co(OAc)_2.4H_2O$

(d) Two isomers exist in hexane solution

44. **The compound(s) having $[Xe]4f^1$ configuration is(are)**

(Given the atomic numbers Ce:58, Lu:71, Pr:59 and Nd:60)

(a) $Na_3[Ce(NO_3)_6]$ (b) $Na_3[LuCl_6]$ (c) PrO_2 (d) $Nd(NR_2)_3$ $(R = SiMe_3)$

45. **The correct statement(s) for XeF_2 is(are)**

(a) Its bonding is best explained by classical 2-centered-2-electron bonds

(b) Its bonding is best explained by non-classical 3-centered-4-electron bonds

(c) It contains nine loan pairs of electrons

(d) Its point group is $D_{\infty h}$

46. **For the non-dissociative adsorption of a gas on solid,**

P. The Freundlich isotherm is given by $\theta = kp^{1/n}$ where θ is surface coverage, p is pressure, k and n are empirical constants; and

Q. The BET isotherm is given by $\frac{p}{p^*-p} = \frac{\theta}{c} + \theta(c-1)\left(\frac{p}{p^*}\right)$

Where p^* and c are empirical constants, and $p < p^*$.

The correct statement(s) is(are)

(a) At low surface coverage, the Langmuir isotherm reduces to the Freundlich isotherm With $n = 1$

(b) At high surface coverage, the Langmuir isotherm reduces to the Freundlich isotherm With $n = \infty$

(c) At very low pressure ($p << p^*$), the BET isotherm reduces to the Langmuir isotherm

(d) At very high pressure ($p \rightarrow p^*$), the BET isotherm reduces to the Langmuir isotherm

47. **Two different enzyme catalysis reactions I and II have identical Y-intercepts for the Lineweaver-Burke (equation given below) plots. The slope for reaction I is twice than that of reaction II. If the initial concentration of enzymes in I and II are same, the correct statement(s) is(are)**

$$\frac{1}{v} = \frac{1}{v_{max}} + \frac{K_M}{v_{max}}\frac{1}{[S]}$$

Where v and v_{max} are rate and maximum rate; K_M is Michaelis-Menten constant and [S] is substance concentration.

(a) Reactions I and II have same turn over number

(b) Michaelis-Menten constants for reactions I and II are identical

(c) Michaelis-Menten constant for reaction I is twice than that of reaction II

(d) The rates of the elementary steps for reactions I and II are identical

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

48. **The enthalpy change for the exothermic reaction between BeI_2 and HgF_2 is _________ $kJ\ mol^{-1}$ (rounded off to the nearest integer)**

(Given: Bond dissociation energy (in $kJ\ mol^{-1}$) for $Be-F = 632$, $Be-I = 289$, $Hg-F = 268$ and $Hg-I = 145$)

49. **Number of carbon atoms connected to the metal center in $[W(C_{60})(CO)_5]$ is _________ (rounded off to the nearest integer) (Given: atomic number of W is 74)**

50. **Two-component solid-liquid system of naphthalene-benzene forms a simple eutectic mixture. Assuming that naphthalene-benzene forms an ideal solution, the mole fraction of naphthalene in benzene at 300 K and 1bar is _________ (rounded off to two decimal places)**

(Given: Freezing point (T_{fp}) and enthalpy of fusion (ΔH_{fus}) of naphthalene are 353 K and $19.28\ kJ\ mol^{-1}$, respectively and gas constant $(R) = 8.31\ J\ K^{-1}mol^{-1}$)

51. **The intrinsic viscosity of a sample of polystyrene in toluene is $84\ cm^3g^{-1}$ at 30℃. It follows Mark-Houwink equation with empirical constant values of $K = 1.05 \times 10^{-2}cm^3g^{-1}$ and $a = 0.75$. The molecular weight of the polymer is ______ $\times 10^3\ g\ mol^{-1}$ (rounded off to the nearest integer)**

52. **According to Debye-Hückel limiting law, the mean molal activity coefficient for $0.87g\ K_2SO_4$ (molar mass $= 174\ g\ mol^{-1}$) in 1Kg of water at 25℃ is _________ (rounded off to two decimal places)**

53. **A solution is prepared by dissolving 128 g of naphthalene ($C_{10}H_8$) in 780 g of benzene (C_6H_6). The vapor pressure of pure benzene is 12.6 kPa at 25℃. Assuming that naphthalene in benzene is an ideal solution, the partial vapor pressure of benzene is _________ kPa (rounded off to two decimal places)**

54. **For the galvanic cell: $H_{2(g)}\ |\ HCl_{(aq)}\ |\ Cl_{2(g)}$ the standard electromotive force (E^0) value is given by $E^0 = 1.73 - (1.25 \times 10^{-3})T + (1.00 \times 10^{-6})T^2$**

Where E^0 is in Volts and T is in Kelvin.

For the cell reaction, the standard enthalpy change ($\Delta_r H^0$) at 300K is _________ $kJ\ mol^{-1}$ (rounded off to the nearest integer) (Given: $F = 96500\ C\ mol^{-1}$)

55. A solution of three non-interacting compounds P, Q and R is taken in a cuvette of 1 cm path length. Their concentrations are $[\mathrm{P}] = 1 \times 10^{-6}\mathrm{M}, [\mathrm{Q}] = 2 \times 10^{-6}\mathrm{M}, [\mathrm{R}] = 3 \times 10^{-6}\mathrm{M}$ and the molar extinction coefficients at 300 nm are $\varepsilon_{\mathrm{P}} = 1 \times 10^{5}\ \mathrm{M}^{-1}\ \mathrm{cm}^{-1}, \varepsilon_{\mathrm{Q}} = 2 \times 10^{5}\ \mathrm{M}^{-1}\ \mathrm{cm}^{-1}, \varepsilon_{\mathrm{R}} = 3 \times 10^{5}\ \mathrm{M}^{-1}\ \mathrm{cm}^{-1}$.

The % transmittance at 300nm is _________ (rounded off to two decimal places)

Answer Key

Q.No	Ans
1.	a
2.	b
3.	a
4.	a
5.	b
6.	b
7.	a
8.	b
9.	a
10.	d
11.	a
12.	a
13.	d
14.	b

Q.No	Ans
15.	c
16.	a
17.	b
18.	c
19.	d
20.	a
21.	a,c
22.	a,b,c
23.	a,b,d
24.	a,b,c
25.	2.51 to 2.55
26.	a
27.	b
28.	a

Q.No	Ans
29.	c
30.	a
31.	c
32.	a
33.	a
34.	b
35.	a
36.	a
37.	a,b
38.	a,c
39.	a,c
40.	a,c
41.	a,b
42.	a,d

Q.No	Ans
43.	a,c,d
44.	a,c
45.	b,c,d
46.	a,b,c
47.	a,c
48.	−440 to −440
49.	7 to 7
50.	0.30 to 0.32
51.	158 to 160
52.	0.74 to 0.76
53.	11.34 to 11.47
54.	−164 to −154
55.	3.98 to 4.00

Q. 1 – 20	1 Mark (MCQ)
Q. 26 – 36	2 Mark (MCQ)

Q. 21 – 24	1 Mark (MSQ)
Q. 37– 47	2 Mark (MSQ)

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

mistakes may have inadvertently crept in. So, we do not take any legal responsibility for them. If they are brought to our notice, corrections will be done in next edition.

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