AJ Chem Academy–Trichy

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(Q1-25) MCQ & NAT, carry ONE mark each (for each wrong answer: – 1/3). (No Negative Marks for NAT)**

1. **Among the following, the compound with the highest CO stretching frequency is**

(a) $[Mn(CO)_6]^+$ (b) $[V(CO)_6]^-$ (c) $[Cr(CO)_5]$ (d) $[Cr(dien)(CO)_3]$

2. **The ground state of $[Cr(H_2O)_6]^{2+}$ is**

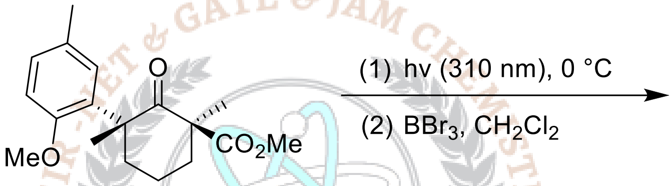
(a) ^5E_g (b) $^5T_{2g}$ (c) $^6A_{1g}$ (d) $^6A_{2g}$

3. **The reaction of XeF_2 with $HN(SO_2F)_2$ at 273 K in CF_2Cl_2 solvent yields**

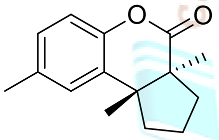
(a) $XeF_4 + SO_2 + NH_3$ (b) $Xe + SO_2 + N_2 + HF$

(c) $SOF_2 + XeO_2 + NH_3$ (d) $FXeN(SO_2F)_2 + HF$

4. **The major product in the following reaction sequence is**



(a)



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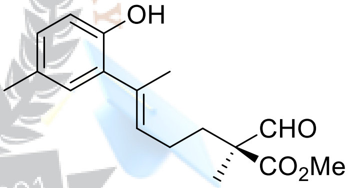

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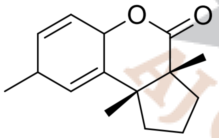

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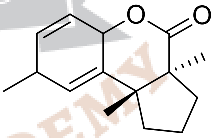
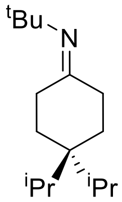


5. **Among the following, the chiral compound is**

(a)



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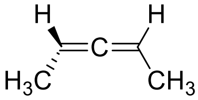

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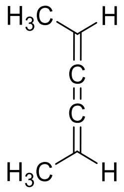

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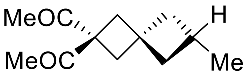
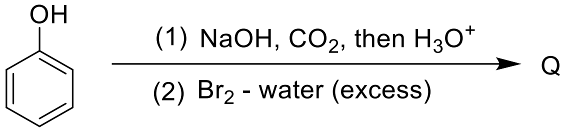


6. **The major product in the given reaction sequence is Q. The mass spectrum of Q shows** **([M] = molecular ion peak)**



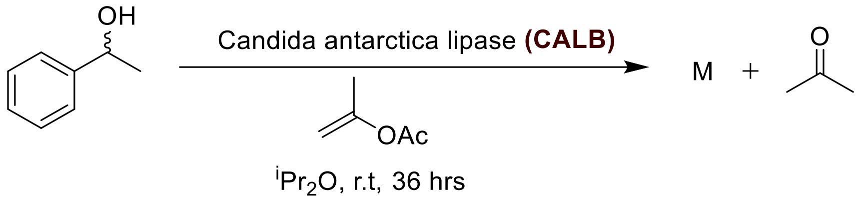
(a) [M], [M + 2], [M + 4], and [M + 6] peaks with relative intensity of 1: 1: 1: 1

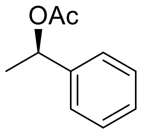
(b) [M], [M + 2], [M + 4], and [M + 6] peaks with relative intensity of 1: 3: 3: 1

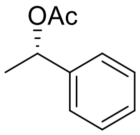
(c) [M], [M + 2], and [M + 4] peaks with relative intensity of 1: 2: 1

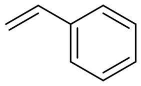
(d) M and [M + 2] peaks with relative intensity of 1: 1

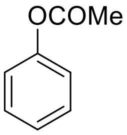
7. The product M in the following reaction is



(a) 

(b) 

(c) 

(d) 

8. Critical micellar concentration of a surfactant is 0.008 M in water at 25℃. If the aggregation number of the micelles is 80, the concentration of the micelles (in M) present in 0.088 M aqueous solution of the surfactant at 25℃ is

(a) 0.010 (b) 0.001 (c) 0.008 (d) 0.088

9. The order and the number of classes present in a group with the irreducible representations A_1, A_2, B_1, B_2, E_1 and E_2, are, respectively,

(a) 6 and 6 (b) 12 and 6 (c) 6 and 3 (d) 12 and 3

10. The molecule XY_2 is microwave active and its vibration-rotation spectrum shows only P and R transitions. In the correct structure,

(a) X is the central atom in linear XY_2

(b) X is the central atom in bent XY_2

(c) Y is the central atom in linear XY_2

(d) Y is the central atom in bent XY_2

11. The complex(es) with distorted octahedral structure is (are)

(a) $[VF_6]^{3-}$ (b) $[FeF_6]^{3-}$ (c) $[MnF_6]^{3-}$ (d) $[Fe(CN)_6]^{4-}$

12. The compound(s) which show(s) the perovskite structure in solid state is (are)

(a) $CaTiO_3$ (b) $NiFe_2O_4$ (c) Fe_3O_4 (d) $CsPbI_3$

13. Among the following metalloproteins, the pair(s) of non-heme proteins is (are)

(a) Hemoglobin and Myoglobin

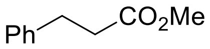
(b) Hemocyanin and Carboxypeptidase

(c) Hemerythrin and Carbonic anhydrase

(d) Cytochrome P-450 and hemocyanin

14. The reaction(s) that yield(s) X as the major product is (are)

X =



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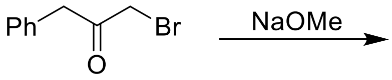

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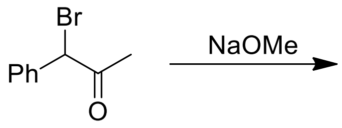
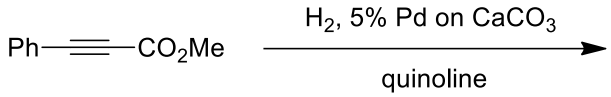


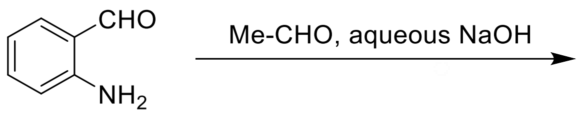
(c)

(d)



15. The reaction(s) that yield(s) 2-methylquinoline as the major product is (are)

(a)



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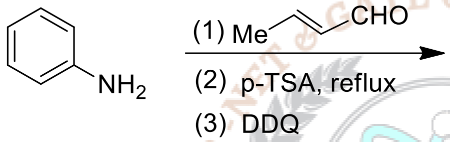
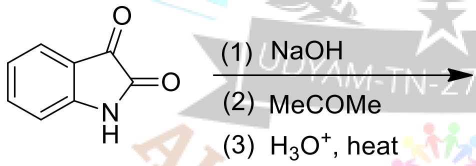


(c)

(d)



16. The correct statement(s) for decalin is (are)

(a) cis-Decalin is thermodynamically less stable than trans-decalin

(b) cis-Decalin contains plane of symmetry

(c) trans-Decalin undergoes ring inversion

(d) trans-Decalin belongs to the point group of C_2h

17. The correct statement(s) about $^4D_{5/2}$ state of an atom is (are)

(a) it corresponds to $L = 2, S = 1/2$, and $J = 5/2$

(b) it can originate from s^1p^2 electronic configuration

(c) it splits into five levels in the presence of magnetic field

(d) it can show spectral transition to $^4P_{3/2}$ state

18. The correct statement(s) related to an ensemble is (are):

(a) an ensemble is a collection of an infinite number of imaginary replications of the system of interest

(b) all members of an ensemble are macroscopically identical and also have identical microstates

(c) an ensemble average of any macroscopic property of the system is equal to the value of the property averaged over a sufficiently long time

(d) all systems in a canonical ensemble need NOT have the same composition

19. The non-dissociative adsorption of a gas on a given surface at a fixed temperature follows Langmuir isotherm. The plot(s) which give(s) a straight line is (are)

[Given: V = volume of the adsorbed gas, P = pressure of the gas]

(a) 1/V versus 1/P (b) P/V and P (c) V versus P (d) V versus 1/P

20. The crystal field stabilization energy of $[Cr(NH_3)_6]^{3+}$ with Δ_o value of $21600\ cm^{-1}$ is $y\ cm^{-1}$. The value of $|y|$ is ______. (rounded off to the nearest integer)

21. The number of metal-metal bond(s) in the complex $[(^5\eta\text{-}Cp)Mo(CO)_2]_2$ is x and in $[(^5\eta\text{-}Cp)_2Fe_2(CO)_3]$ is y. The value of $x + y$ is ______.

(Assume 18 electron rule is followed.)

22. ^{1}H-NMR spectrum of a mixture containing CH_3Br (x mol) and $(CH_3)_3CBr$ (y mol) shows two singlets at 2.7 ppm and 1.8 ppm , with the relative ratio of $3:1$ (integration value), respectively. The value of x/y is ______.

(rounded off to the nearest integer)

23. The value of $\frac{e^2}{2\pi\epsilon_0 a_0}$ in atomic unit of energy is ______.(rounded off to the nearest integer) (e: charge of electron; a_0: Bohr radius; ϵ_0: permittivity of vacuum)

24. The partial vapor pressure of 0.1 molal solution of B in liquid A is 60 kPa at 300 K. The partial vapor pressure (in kPa) of a solution containing B with mole fraction of 0.1 in liquid A at 300 K is ______. (rounded off to three decimal places)

(Assume the solute B obeys Henry's law. The molar mass of A is $80\ g\ mol^{-1}$.)

25. Consider the following two parallel irreversible first-order reactions,

$$P1 \xleftarrow{k_1} R \xrightarrow{k_2} P2 \qquad (k_1 \text{and } k_2 \text{ are the rate constants})$$

where $k_1 = 2k_2$ at 300 K. After complete conversion of R at 300 K, the concentration of P1 in the reaction mixture was $15\ mol\ L^{-1}$. The initial concentration of R (in $mol\ L^{-1}$) was ______. (rounded off to one decimal place)

(Q26-55) MCQ & NAT, carry TWO marks each (for each wrong answer: – 2/3). (No Negative Marks for NAT)**

26. **Borax on treatment with NaOH and H_2O_2 forms X. The compound X on reaction with PhCN at 60℃ in methanol-water mixture gives Y as the major product. X and Y, respectively, are**

(a) $NaB(O)(OH)_2.nH_2O$ and $PhCONH_2$

(b) $NaB(O)(OH)_2.nH_2O$ and PhCOOH

(c) $Na_2B_2(O_2)_2(OH)_4.nH_2O$ and $PhCONH_2$

(d) $Na_2B_2(O_2)_2(OH)_4.nH_2O$ and PhCOOH

27. **In the EPR spectrum of an aqueous solution of $VOSO_4$ at room temperature, the total number of hyperfine splitting signals is**

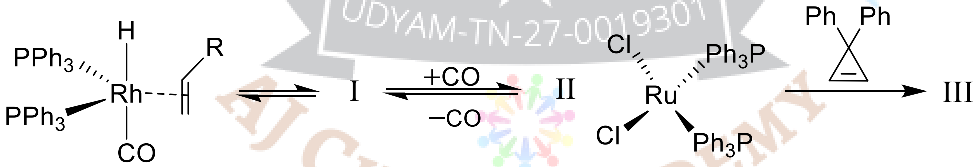
(a) 3 (b) 7 (c) 5 (d) 8

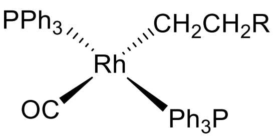
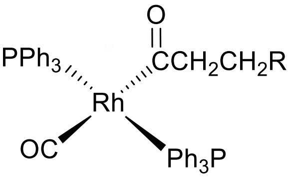
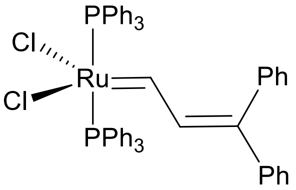
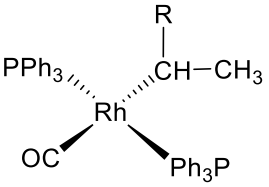
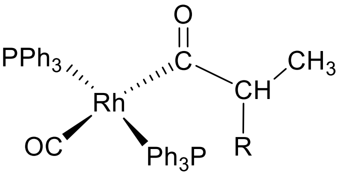
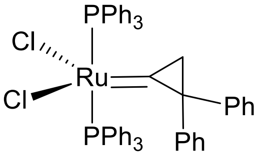
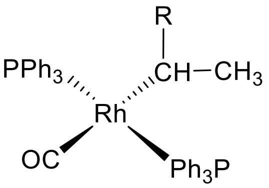
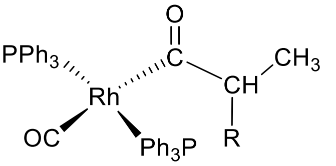
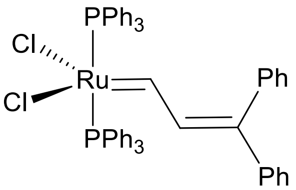
28. **The heptacity of allyl and Cp and the ligation mode of NO in the thermodynamically stable complexes $[(\eta^x\text{-allyl})Ru(CO)_2(NO)]$ and $[(\eta^y\text{-Cp})Ru(CO)_2(NO)]$, respectively, are (The heptacity of allyl and Cp are denoted by η^x and η^y, respectively)**

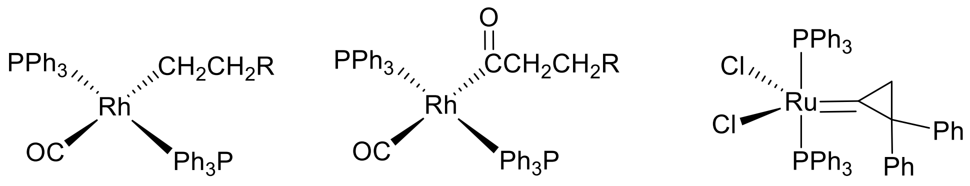
(a) (η^3, NO-bent) and (η^5, NO-linear) (b) (η^3, NO-linear) and (η^5, NO-bent)

(c) (η^1, NO-bent) and (η^3, NO-bent) (d) (η^1, NO-bent) and (η^5, NO-linear)

29. **In the following reactions, the structures of I, II and III, respectively, are**



	I	**II**	**III**
(a)			
(b)			
(c)			

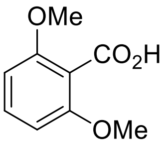
(d) 

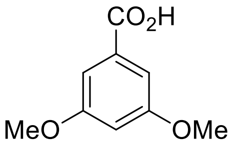
30. Consider the following data of a compound:

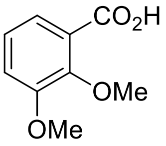
^{1}H-NMR : 400 MHz, DMSO-d^6

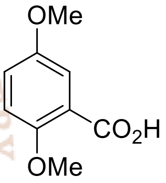
δ in ppm : 3.85(s, 6H), 6.73(t, J = 2.2 Hz, 1H), 7.1(d, J = 2.2 Hz, 2H) and 13.05(brs, 1H)

The compound is

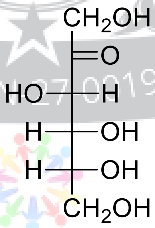
(a) 

(b) 

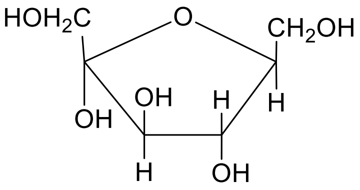
(c) 

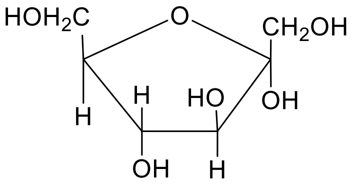
(d) 

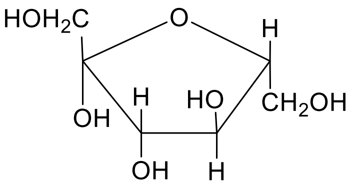
31. Fischer presentation of D-(−)-fructose is given below.

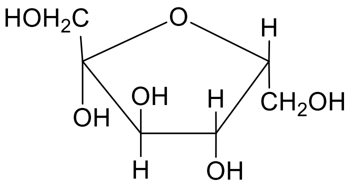


The correct structure of α-L-(+)-fructofuranose is

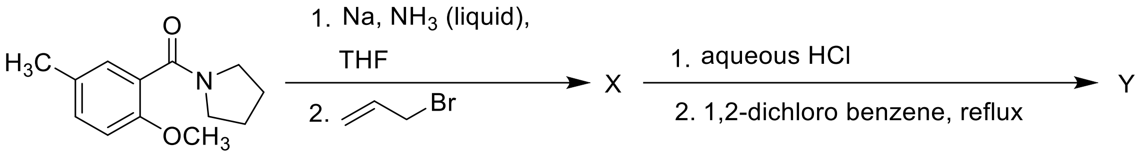
(a) 

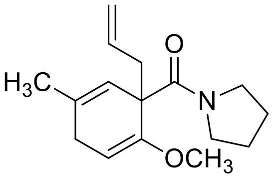
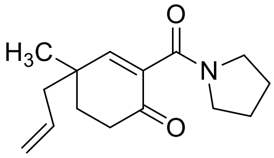
(b) 

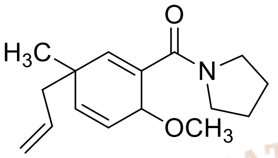
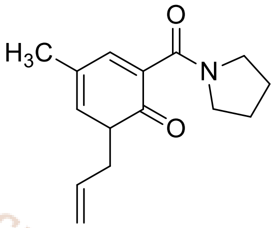
(c) 

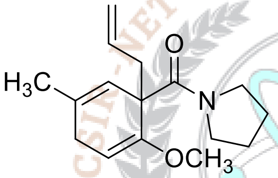
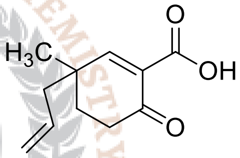
(d) 

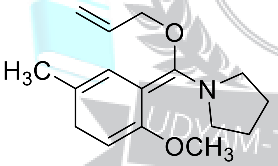
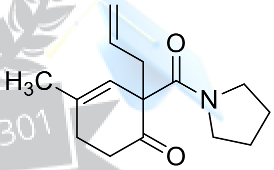
32. The major products X and Y in the following reaction sequence are



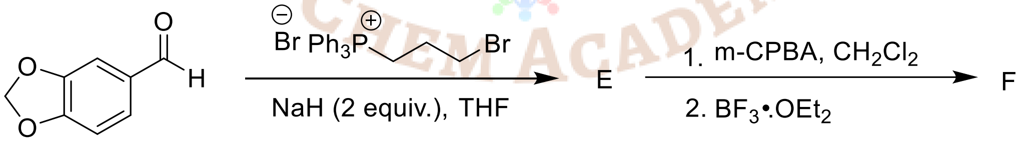
(a) X =  ; Y = 

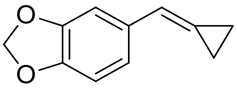
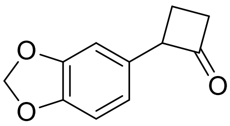
(b) X =  ; Y = 

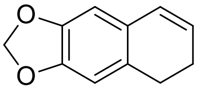
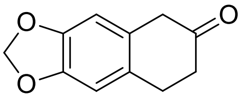
(c) X =  ; Y = 

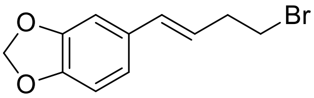
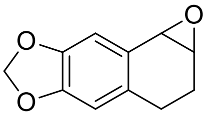
(d) X =  ; Y = 

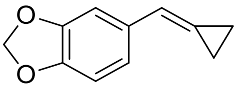
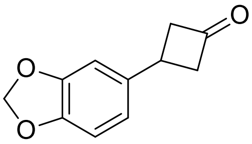
33. The major products E and F in the following reaction sequence are



(a) E =  ; F = 

(b) E =  ; F = 

(c) E =  ; F = 

(d) E =  ; F = 

34. **ψ_1, ψ_2, ψ_3, and ψ_4 are four Huckel molecular orbitals of benzene with orbital energies E_1, E_2, E_3 and E_4, respectively.**

$$\psi_1 = \frac{1}{2}(\phi_B + \phi_C - \phi_E - \phi_F)$$

$$\psi_2 = 6^{-\frac{1}{2}}(\phi_A - \phi_B + \phi_C - \phi_D + \phi_E - \phi_F)$$

$$\psi_3 = 6^{-\frac{1}{2}}(\phi_A + \phi_B + \phi_C + \phi_D + \phi_E + \phi_F)$$

$$\psi_4 = 12^{-\frac{1}{2}}(2\phi_A + \phi_B - \phi_C - 2\phi_D - \phi_E + \phi_F)$$

The correct order of the orbital energies is (The six carbon atoms of benzene are denoted by A to F and ϕ_J is the $2p_z$ orbital of J^{th} carbon of benzene.)

(a) $E_1 < E_2 = E_3 < E_4$

(b) $E_4 < E_1 = E_3 < E_2$

(c) $E_3 < E_1 = E_4 < E_2$

(d) $E_3 < E_2 < E_1 = E_4$

35. **Consider the following six vibrational modes:**

Symmetric stretching of CO_2, $O{-}H$ symmetric stretching of H_2O, stretching of HCl, stretching of H_2, $N{-}H$ symmetric stretching of NH_3, and bending of CO_2. Among these modes, if k number of modes are IR active but Raman inactive, l number of modes are IR inactive but Raman active, and m number of modes are both IR and Raman active. k, l and m, respectively, are

(a) 1, 3 and 2

(b) 3, 1 and 2

(c) 1, 2 and 3

(d) 2, 1 and 3

36. **The correct statement for a thermally initiated radical polymerization in a solution is:**

(Assume : Steady-state equal reactivity of the propagating radicals, termination reactions are only by combination, and no chain transfer reaction.

Given: Rp = rate of polymerization, DP = degree of polymerization, [I] = initiator concentration and [M] = monomer concentration)

(a) with increase in [I] , both Rp and DP increase

(b) with increase in [M] , both Rp and DP increase

(c) Rp decreases with increase in [I] but DP increases with increase in [M]

(d) DP increases with increase in [I] and DP decreases with increase in [M].

37. **If q_t and $Q_{t,m}$ are the molecular and molar translational partition functions of X_2, respectively, then $\ln(Q_{t,m}) =$ (N is the Avogadro number)**

(a) $N \ln q_t - N \ln N$

(b) $N \ln q_t - \ln N$

(c) $N \ln q_t + N \ln N + N$

(d) $N \ln q_t - N \ln N + N$

38. Among the following, the NMR active nucleus (nuclei) is (are)

(a) ^{12}C (b) ^{19}F (c) ^{2}H (d) ^{16}O

39. The complex(es) that exhibit(s) optical isomerism is (are)

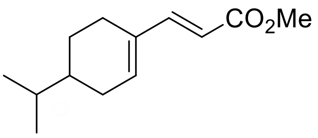
(a) $[Fe(acac)_3]$ (b) cis-$[Co(en)_2Cl_2]^+$ (c) trans-$[Co(en)_2Cl_2]^+$ (d) $[Co(en)_3]^{3+}$

40. In aqueous solution of $K_4[Fe(CN)_6]$, the allowed transition(s) is (are)

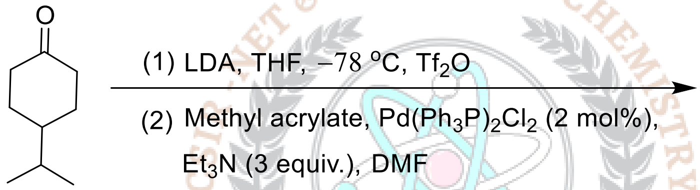
(a) $^5T_{2g}$ to ^3E_g (b) $^1A_{1g}$ to $^1T_{1g}$ (c) $^1A_{1g}$ to $^1T_{2g}$ (d) $^5T_{2g}$ to ^5E_g

41. The correct option(s) that give(s) P as the major product is (are)

P =



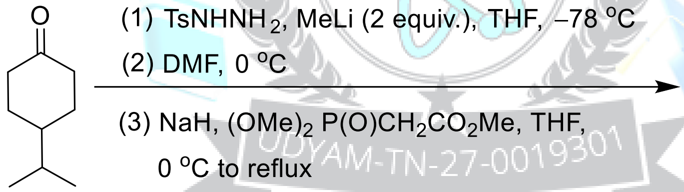
(a)



(1) LDA, THF, –78 °C, Tf_2O

(2) Methyl acrylate, $Pd(Ph_3P)_2Cl_2$ (2 mol%), Et_3N (3 equiv.), DMF

(b)

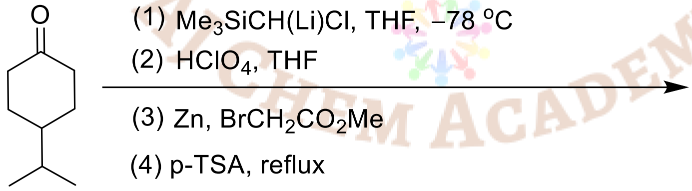


(1) $TsNHNH_2$, MeLi (2 equiv.), THF, –78 °C

(2) DMF, 0 °C

(3) NaH, $(OMe)_2P(O)CH_2CO_2Me$, THF, 0 °C to reflux

(c)



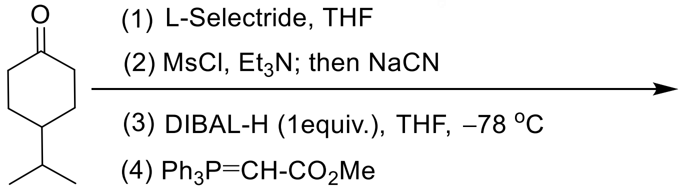
(1) $Me_3SiCH(Li)Cl$, THF, –78 °C

(2) $HClO_4$, THF

(3) Zn, $BrCH_2CO_2Me$

(4) p-TSA, reflux

(d)



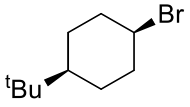
(1) L-Selectride, THF

(2) MsCl, Et_3N; then NaCN

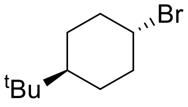
(3) DIBAL-H (1equiv.), THF, –78 °C

(4) $Ph_3P{=}CH\text{-}CO_2Me$

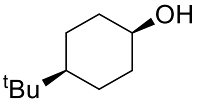
42. The correct statement(s) regarding P, Q, R and S is(are):



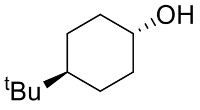
P



Q



R



S

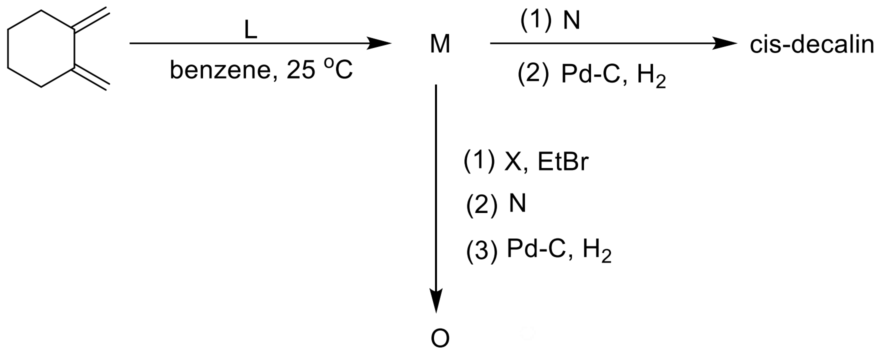
(a) P reacts faster than Q with PhSNa in DMF as a solvent

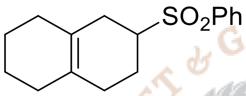
(b) Q reacts faster than P with NaN_3 in DMF as a solvent

(c) R reacts faster than S when treated with TsCl/Et_3N in DCM as a solvent

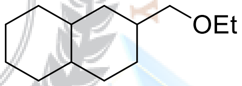
(d) R gets oxidized faster than S when treated with CrO_3 in DCM as a solvent

43. Consider the following reaction sequence. The correct option(s) is (are)



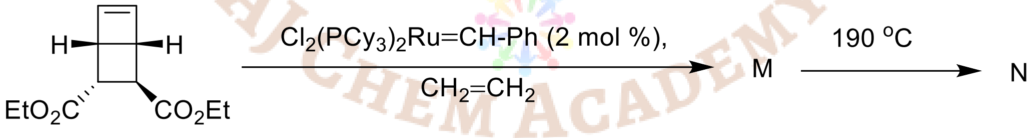
(a) M = ; N = Na-Hg/MeOH

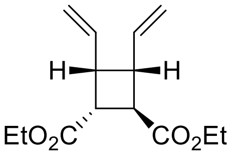
(b) X = LDA ; O = 

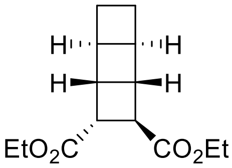
(c) L = acrolein ; O = 

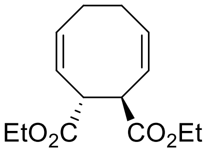
(d) X = $LiAlH_4$; L = (Vinylsulfonyl)benzene

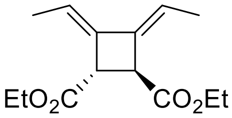
44. Consider the following reaction sequence where M and N are the major products. The correct option(s) is (are)



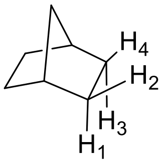
(a) M = 

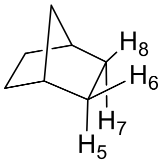
(b) M = 

(c) N = 

(d) N = 

45. The correct statement(s) about the relationship for the H-atoms in the following compounds is (are):





(a) H_1 and H_3 are enantiotopic; H_2 and H_3 are diastereotopic

(b) H_1 and H_3 are diastereotopic; H_2 and H_3 are enantiotopic

(c) H_5 and H_7 are enantiotopic; H_6 and H_7 are homotopic

(d) H_5 and H_7 are homotopic; H_6 and H_7 are enantiotopic

46. Among the following, the correct statement(s) is (are):

(a) The normalization factor of a Slater determinant for a 3-electron atom is $\sqrt{\frac{1}{3}}$

(b) The number of nodes in the radial wave function of 3s orbital of a hydrogen atom is the same as the number of nodes in the angular wave function of a 4d orbital of hydrogen atom

(c) The energy separation between any two adjacent states is same for a harmonic oscillator, while it is different for a rigid rotor

(d) The magnitude of the total spin angular momentum of an α electron is the negative of that of a β electron

47. Among the following, the correct statement(s) is (are):

(a) C_2 symmetry element is present in H_2O and H_2O_2 but NOT in PCl_5

(b) both C_2 and C_3 symmetry elements are present in CCl_4 and SF_6

(c) one σ_h and three σ_d symmetry elements are present in benzene

(d) σ_v symmetry element is present in NH_3 but NOT in BF_3

48. ΔS° (in $J\ mol^{-1}\ K^{-1}$) for the given reaction at 298 K is ______. (rounded off to two decimal places) $[Cu(H_2O)_6]^{2+} + en \rightleftharpoons [Cu(H_2O)_4(en)]^{2+} + 2H_2O$

(Given: $\log K_1 = 10.6$, Where K_1 is the equilibrium constant. $\Delta H^\circ = -54\ kJ\ mol^{-1}$ and $R = 8.314\ J\ mol^{-1}\ K^{-1}$)

49. The turnover frequency (in h^{-1}) of a reaction where 5 mol% of a catalyst is required for 90% conversion in 3h is ______. (rounded off to the nearest integer)

50. In thermogravimetric analysis, 12.45 mg of $CuSO_4.5H_2O$ was subjected to heating under N_2 atmosphere. At a particular temperature, there was a weight loss of 3.6 mg. The number of water molecule(s) lost per formula unit is ______. (rounded off to the nearest integer)

(Given: molar mass (in $g\ mol^{-1}$) of $H = 1.0$, $O = 16.0$, $S = 32.0$ and $Cu = 63.5$)

51. In the given reaction sequence, the amount of 'R' produced (in g) is ______.

$$\text{Benzene}(7.8\ g) \xrightarrow[200\ ^\circ C]{\text{Oleum (excess),}} P(80\%) \xrightarrow[\text{then } H_3O^+]{\text{NaOH,heat}} Q(75\%) \xrightarrow{HNO_3\ (excess)/H_2SO_4\ (excess)} R(50\%)$$

(Given: molar mass (in g mol^{-1}) of H = 1, C = 12, N = 14, O = 16 and S = 32)

(rounded off to two decimal places)

52. The wave function of a particle in a cubic box (of side L) is given by

$$\psi(x, y, z) = \sqrt{32/L^3}\,\sin\frac{\pi x}{L}\cos\frac{\pi x}{L}\sin\frac{2\pi y}{L}\sin\frac{\pi z}{L}$$

The ratio of the energy of the state corresponding to the above wave function to the ground state energy is _______. (rounded off to the nearest integer)

53. ϕ_1 and ϕ_2 are normalized eigenfunctions of a Hermitian operator.

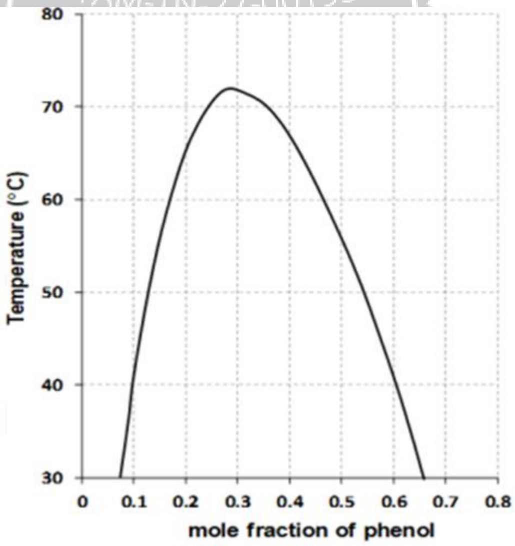
$$|\psi\rangle = 3i\,|\phi_1\rangle + 2\,|\phi_2\rangle \text{ and } |\chi\rangle = -2i\,|\phi_1\rangle + 5\,|\phi_2\rangle.$$

The value of $\langle\psi|\chi\rangle + \langle\chi|\psi\rangle$ is _______. (rounded off to the nearest integer)

54. 2 mol of a monoatomic ideal gas with initial volume of 5 L and pressure 10 bar undergoes an irreversible adiabatic expansion against a constant final pressure of 1 bar. The final volume (in L) is _______. (rounded off to one decimal place)

(Given: $R = 8.314 \times 10^{-2}$ L bar mol^{-1} K^{-1})

55. The following figure shows an experimental liquid-liquid phase diagram of phenol and water at the vapor pressure of the system. The total amount of phenol and water (in mol) present in the phenol-rich phase when 5 mol of water was shaken with 5 mol of phenol at 40℃ is _______. (rounded off to one decimal place)



Answer Key

Q.No	Ans
1.	a
2.	a
3.	d

Q.No	Ans
21.	5
22.	9
23.	2

Q.No	Ans
41.	a & b
42.	a & d
43.	a & b

4.	a
5.	b
6.	b
7.	a
8.	b
9.	b
10.	c
11.	a & c
12.	a & d
13.	b & c
14.	a & b
15.	b & d
16.	a & d
17.	d
18.	a & c
19.	a & b
20.	25920

24.	745 to 760
25.	22.5
26.	c
27.	d
28.	b
29.	a
30.	b
31.	a
32.	a
33.	a
34.	c
35.	c
36.	b
37.	d
38.	b & c
39.	a,b & d
40.	b & c

44.	a & c
45.	a & c
46.	b & c
47.	b & c
48.	21.40 to 22.00
49.	6
50.	4
51.	7.35
52.	3
53.	8 to 8
54.	31.8 to 32.2
55.	7.8 to 8.2

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

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

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