PAPER : IIT-JAM 2023

CHEMISTRY-CY

1. **Section-A contains 30 Multiple Choice Questions (MCQ). Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which ONLY ONE is correct. From Q.1 to Q.10 carries 1 Marks and Q.11 to Q.30 carries 2 Marks each.**
2. **Section-B contains 10 Multiple Select Questions(MSQ). Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONE or MORE than ONE is/are correct. For each correct answer you will be awarded 2 marks.**
3. **Section-C contains 20 Numerical Answer Type (NAT) questions. From Q.41 to Q.50 carries 1 Mark each and Q.51 to Q.60 carries 2 Marks each. For each NAT type question, the value of answer in between 0 to 9.**
4. **In all sections, questions not attempted will result in zero mark. In Section–A (MCQ), wrong answer will result in negative marks. For all 1 mark questions, 1/3 marks will be deducted for each wrong answer. For all 2 marks questions, 2/3 marks will be deducted for each wrong answer. In Section–B (MSQ),there is no negative and no partial marking provisions. There is no negative marking in Section–C (NAT) as well.**

SECTION-A

Multiple Choice Questions (MCQ)

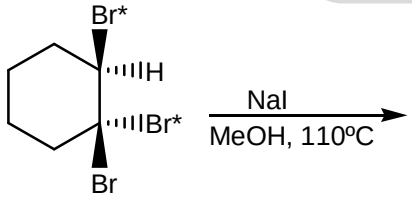
Q.1 – Q.10 carry ONE mark each.

1. The system with the lowest zero-point energy when it is confined to a one-dimensional box of length L is
   (a) a helium atom (b) a hydrogen atom (c) a proton (d) an electron.

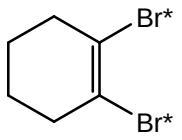
2. The SI unit of the molar conductivity of an electrolyte solution is
   (a) $Sm^2\ mol^{-1}$ (b) $S\ mol^{-1}$ (c) $S\ m\ mol^{-1}$ (d) $S\ m^{-1}\ mol^{-1}$

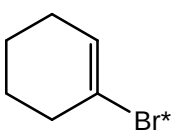
3. The metal ion present in human carbonic anhydrase is
   (a) Cu^{2+} (b) Ni^{2+} (c) Zn^{2+} (d) Fe^{3+}

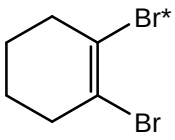
4. The major product of the reaction is

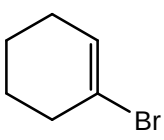


Br* = ^{82}Br

(a) 

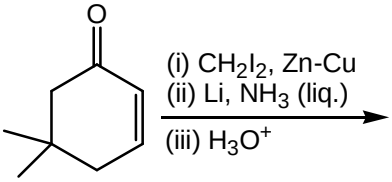
(b) 

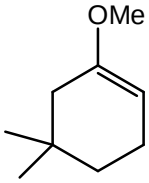
(c) 

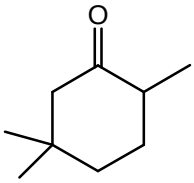
(d) 

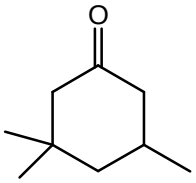
5. The oxoacid of sulfur that has S-O-S bond is
   (a) Pyrosulfuric acid (b) Dithionic acid
   (c) Pyrosulfurous acid (d) Dithionous acid

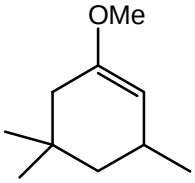
6. The major product of the reaction is



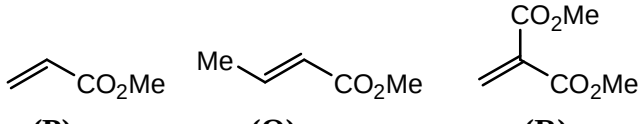
(a) 

(b) 

(c) 

(d) 

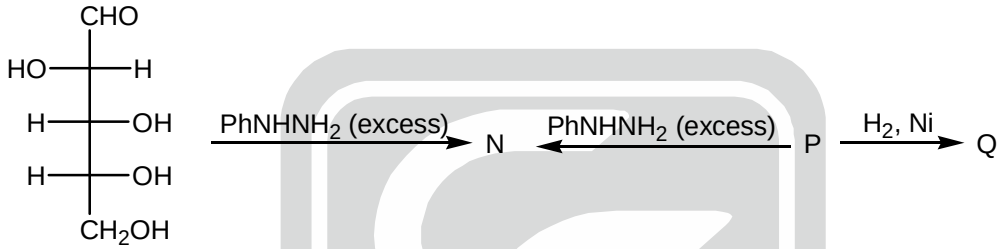
7. The rate of addition of 1-hexyl radical to the given molecules follows the order



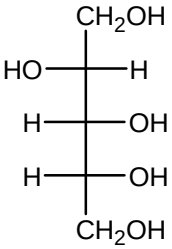
(P) **(Q)** **(R)**

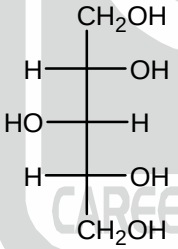
(a) P > R > Q (b) P > Q > R (c) R > P > Q (d) Q > P > R

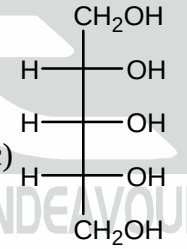
8. The structure of Q in the following reaction scheme is

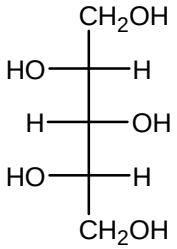


M (enantiopure)

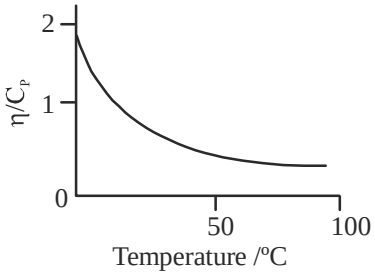
(a) 

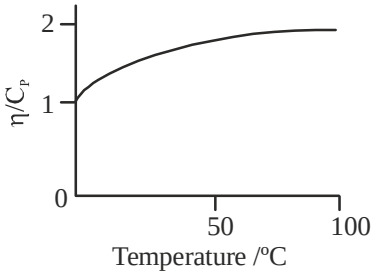
(b) 

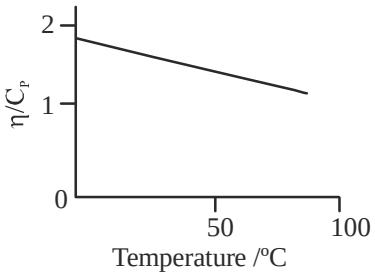
(c) 

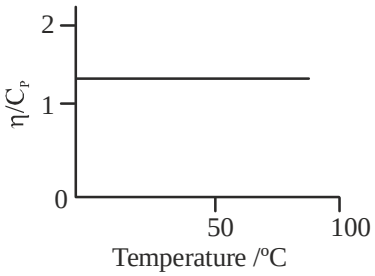
(d) 

9. The diagram that best describes the variation of viscosity (η) of water with temperature at 1 atm is

(a) 

(b) 

(c) 

(d) 

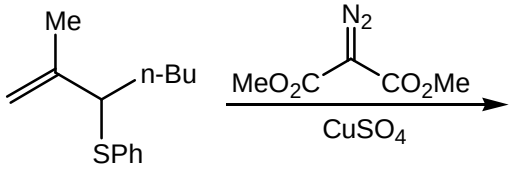
10. An alkaline (NaOH) solution of a compound produces a yellow coloured solution on addition of $NaBO_3$. The compound is
(a) $Pb(OH)_2$ (b) $Cr(OH)_3$ (c) $Mn(OH)_2$ (d) $Fe(OH)_3$

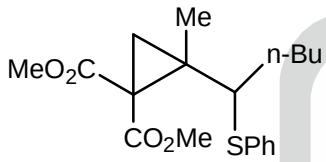
Q.11 – Q.30 carry TWO marks each.

11. The volume of water (in mL) required to be added to a 100 mL solution (aq. 0.1 M) of a weak acid (HA) at 25ºC to double its degree of dissociation is
[Given: K_a of HA at 25ºC = 1.8×10^{-5}]
(a) 200 (b) 300 (c) 100 (d) 400

12. The seperation (in nm) of {134} planes of an orthorhmbic unit cell (with cell parameters a = 0.5 nm, b = 0.6 nm, and c = 0.8 nm) is
(a) 0.236 (b) 0.336 (c) 0.036 (d) 0.136

13. The major product of the reaction is



(a)


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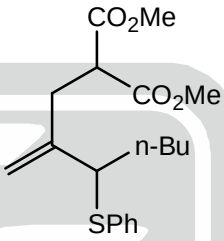

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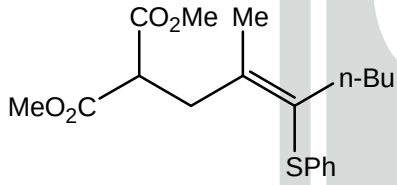

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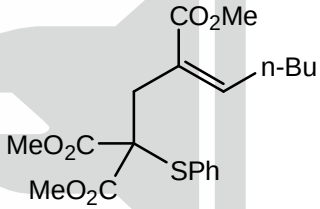
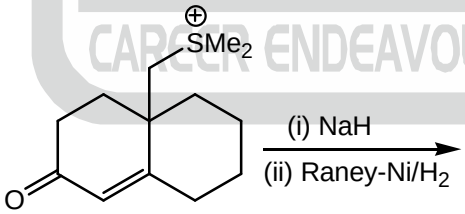
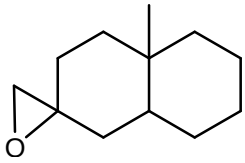


14. The major product in the following reaction is



(a)


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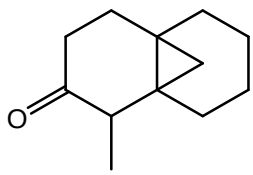

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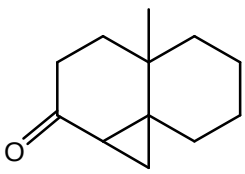

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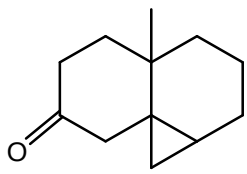
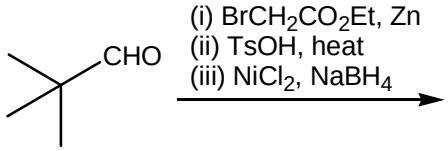
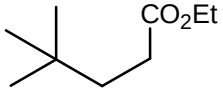
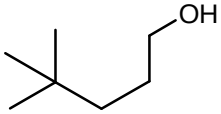


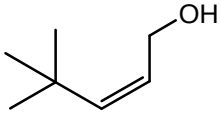
15. The correct order of the energy of the d-orbitals of a square planar complex is
(a) $d_{xz} = d_{yz} < d_{z^2} < d_{xy} < d_{x^2-y^2}$ (b) $d_{xz} = d_{yz} < d_{xy} < d_{z^2} < d_{x^2-y^2}$
(c) $d_{xy} < d_{xz} < d_{yz} < d_{x^2-y^2} < d_{z^2}$ (d) $d_{yz} < d_{xz} < d_{z^2} < d_{xy} < d_{x^2-y^2}$

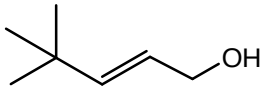
16. The major product of the reaction is



(a) 

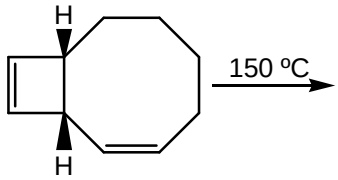
(b) 

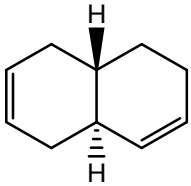
(c) 

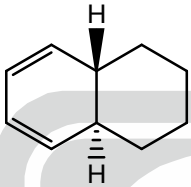
(d) 

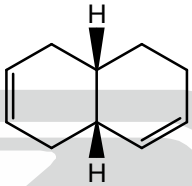
17. The geometry of $[VO(acac)_2]$ is
(a) square pyramidal
(b) pentagonal planar
(c) trigonal bipyramidal
(d) distorted trigonal bipyramidal

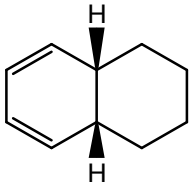
18. The major product of the reaction is



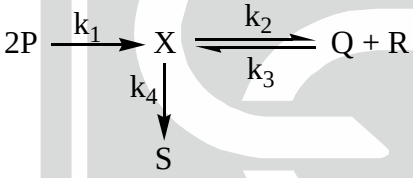
(a) 

(b) 

(c) 

(d) 

19. For the given elementary reactions, the steady-state concentration of X is



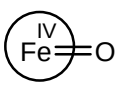
(a) $\dfrac{\frac{1}{2}k_1[P]^2 + k_3[Q][P]}{k_2 + k_4}$
(b) $\dfrac{k_1[P] + k_3[Q][R]}{k_2 + k_4}$
(c) $\dfrac{k_1[P]^2 + k_3[Q][R]}{-k_1 + k_2 - k_3 + k_4}$
(d) $\dfrac{k_1[P]^2 + k_3[Q][R]}{k_2 + k_4}$

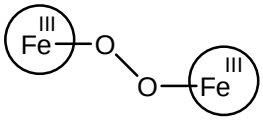
20. The vapor pressure of a dilute solution of a non-volatile solute and the vapor pressure of the pure solvent at the same temperature are P and P*, respectively.

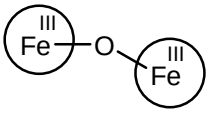
$\dfrac{P^* - P}{P^*}$ is equal to (Assume that the vapour phase behaves as an ideal gas)

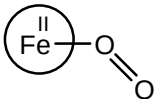
(a) mole fraction of the solvent
(b) mole fraction of the solute
(c) molality of the solution
(d) weight fraction of the solute

21. Free heme in aqueous solution when exposed to dioxygen is finally converted to (circle around iron in the given choices represents the protoporphyrin IX)

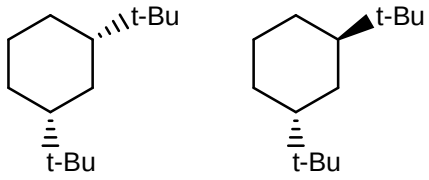
(a) 

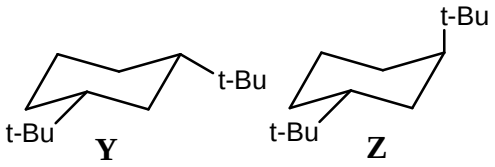
(b) 

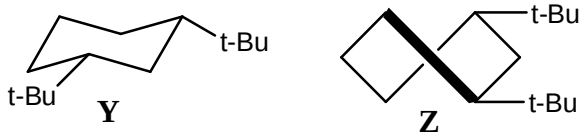
(c) 

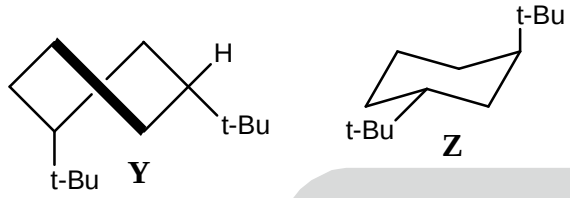
(d) 

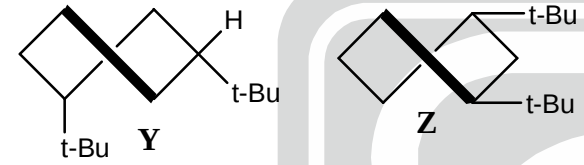
22. The most stable conformation of Y and that of Z are



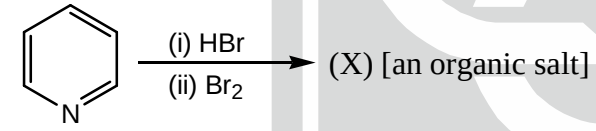
(a) 

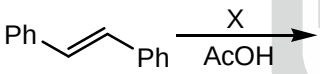
(b) 

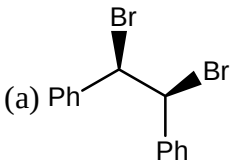
(c) 

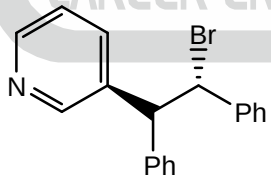
(d) 

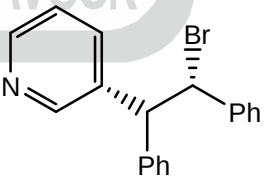
23. The major product Y in the following reaction scheme is

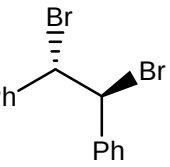




(a) 

(b) 

(c) 

(d) 

24. Adsorption of a gas on a solid surface follows the Langmuir isotherm. If $k_a / k_d = 1.0$ bar^{-1}, the fraction of adsorption sites occupied by the gas at equilibrium under 2.0 bar pressure of the gas at 25ºC is
(k_a and k_d are the rate constants for adsprotion and desorption processes, respectively at 25 ºC)
(a) 1/2 (b) 1/3 (c) 1/4 (d) 2/3

25. The correct order of energy levels of the molecular orbitals of N_2 is

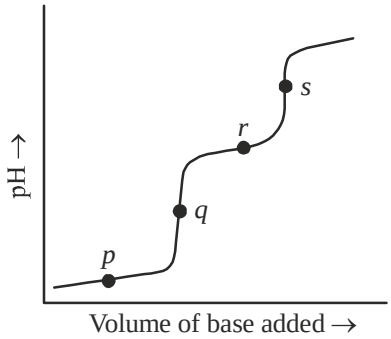
(a) $1\sigma_g < 1\sigma_u < 2\sigma_g < 2\sigma_u < 1\pi_g < 3\sigma_g < 1\pi_u < 3\sigma_u$

(b) $1\sigma_g < 1\sigma_u < 2\sigma_g < 2\sigma_u < 1\pi_u < 3\sigma_g < 1\pi_g < 3\sigma_u$

(c) $1\sigma_g < 1\sigma_u < 2\sigma_g < 2\sigma_u < 3\sigma_g < 3\sigma_u < 1\pi_u < 1\pi_g$

(d) $1\sigma_g < 1\sigma_u < 2\sigma_g < 2\sigma_u < 3\sigma_g < 1\pi_u < 1\pi_g < 3\sigma_u$

26. The following diagram is obtained in a pH-metric titration of a weak dibasic acid (H_2A) with a strong base. The point that best represents $[HA^{-1}] = [A^{-2}]$ is



(a) q (b) p (c) s (d) r

27. Equal number of gas molecules A (mass m and radius r) and B (mass 2m and radius 2r) are placed in two separate containers of equal volume. At a given temperature, the ratio of the collision frequency of B to that A is (Assume the gas molecules as hard spheres)

(a) $2\sqrt{2}:1$ (b) $1:2\sqrt{2}$ (c) $\sqrt{2}:1$ (d) $1:\sqrt{2}$

28. The transition metal (M) complex that can have all isomers (geometric, linkage, and ionization) is

(a) $\left[M(NH_3)_4(H_2O)_2\right]Cl_3$ (b) $\left[M(NH_3)_4Cl_2\right]Br$

(c) $\left[M(NH_3)_4(H_2O)_2\right](SCN)_3$ (d) $\left[M(NH_3)_4Br_2\right]SCN$

29. The product X and Y in the following reaction sequence, respectively are

$$BCl_3 \xrightarrow[150^\circ C]{NH_4Cl \text{ in } C_6H_5Cl} X \xrightarrow{NaBH_4} Y$$

(a) $B_3N_3H_9Cl_3$ and $B_3N_3H_{12}$ (b) $B_3N_3H_3Cl_3$ and $B_3N_3H_6$

(c) $B_3N_3H_3Cl_3$ and $B_3N_3H_{12}$ (d) $B_3N_3Cl_6$ and $B_3N_3H_6$

30. X and Y in the following reactions, respectively are

$$EtOH + 2H_2SO_4 \longrightarrow X + H_3O^+ + HSO_4^-$$

$$HNO_3 + 2H_2SO_4 \longrightarrow Y + H_3O^+ + 2HSO_4^-$$

(a) CH_3CHO and NO_2^+ (b) CH_3COOH and NO^+

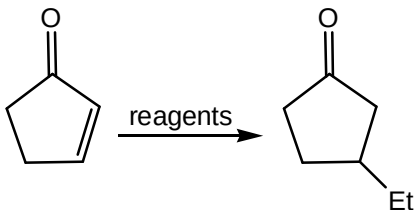
(c) $EtOSO_3H$ and NO_2^+ (d) $EtOSO_3H$ and NO^+

SECTION-B

Multiple Select Questions (MSQ)

Q.31 – Q.40 carry TWO marks each.

31. The correct option(s) of the reagents required for the following reaction is/are



(a) (i) EtMgBr, Et_2O; (ii) H_2O (b) (i) Et_3B, O_2(cat), THF; (ii) H_2O

(c) (i) Et_2CuLi, Me_3SiCl; (ii) H_3O^+ (d) (i) n-BuLi, THF; (ii) EtI

32. The correct statement(s) is/are

(a) The pK_{a_1} of cis-cyclohexane 1, 3-diol is greater than that of the trans isomer
(b) 2, 6-Dihydroxybenzoic acid is more acidic than salicyclic acid
(c) 2, 4, 6-Trinitrophenol is more acidic than 2, 4, 6-trinitrobenzoic acid
(d) The trans-4-(tert-butyl) cyclohexanamine is more basic than its cis isomer.

33. The role(s) of fluorspar in the electrolytic reduction of Al_2O_3 is/are to
(a) prevent the radiation loss of heat
(b) prevent the corrosion of anode
(c) improve the electrical conductivity of the melt
(d) decrease the melting point of Al_2O_3

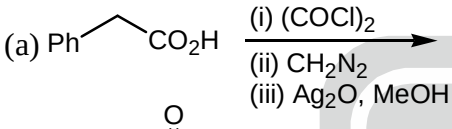
34. The diatomic molecule(s) that has/have bond order of one is/are

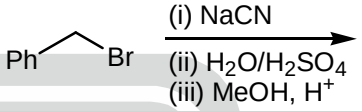
(a) N_2^{2-} (b) O_2^{2-} (c) Li_2 (d) B_2

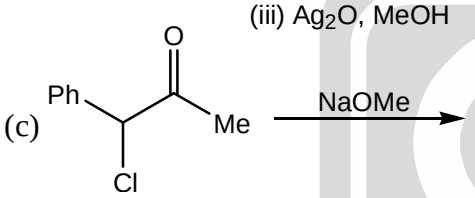
35. The molecule(s) that follows $I_a < I_b = I_c$ (I_a, I_b and I_c ar the principal moments of inertia) is / are

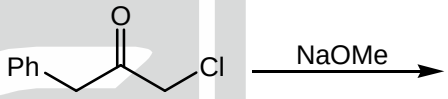
(a) $CH_3C \equiv CH$ (b) HCN (c) C_6H_6 (d) CH_3Cl

36. The reaction(s) that yield(s) Ph-CH_2-CH_2-CO_2Me as the major product is/are

(a) 

(b) 

(c) 

(d) 

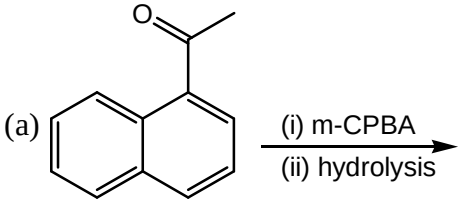
37. The correct statement(s) about the complexes I $\left(K_3[CoF_6]\right)$ and II $\left(K_3[RhF_6]\right)$ is/are

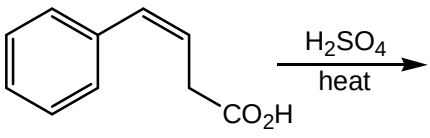
(a) The crystal field stabilization energy of complex II is more than that of complex I
(b) Complex II is diamagnetic
(c) Both complexes are high spin
(d) Complex I is paramagnetic

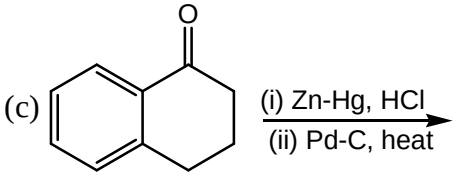
38. The correct relation(s) for an ideal gas in a closed system is/are

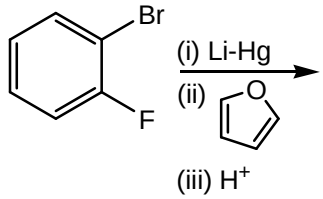
(a) $\left(\frac{\partial H}{\partial T}\right)_P = 0$ (b) $\left(\frac{\partial H}{\partial V}\right)_T = 0$ (c) $\left(\frac{\partial H}{\partial P}\right)_T = 0$ (d) $\left(\frac{\partial T}{\partial P}\right)_H = 0$

39. The reaction(s) that yield(s) 1-naphthol as the major product is/are

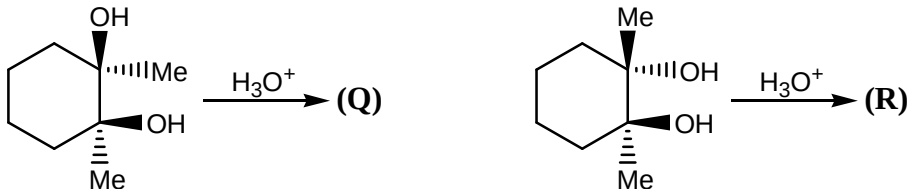
(a) 

(b) 

(c) 

(d) 

40. Correct statement(s) about Q and R is/are



(a) Both Q and R give positive Fehling's test
(b) R gives positive iodoform test and its ^1H NMR spectrum shows singlets at 1.0 ppm (3H) and at 2.2 ppm (3H)
(c) A bright yellow precipiate is formed when Q and R treated separately with 2, 4-dinitrophenyl hydrazine
(d) Q gives positive iodoform test and its ^1H NMR spectrum shows singlets at 1.0 ppm (3H) and at 1.3 ppm (3H)

SECTION-C

Numerical Answer Type (NAT)

Q.41 – Q.40 carry ONE mark each.

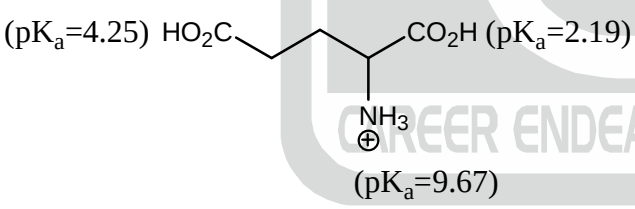
41. The number of valence electrons in $Na_2[Fe(CO)_4]$ (the Colman's reagent) is _____

42. For the elementary $(C) \xleftarrow{k_2} (A) \xrightarrow{k_1} (B)$, $k_1 = 2k_2$. At time $t = 0, [A] = A_0$ and $[B] = [C] = 0$.

At a later time *t*, the value of $[B]/[C]$ is _____

(Round off to nearest integer)

43. The isoelectric point of glutamic acid is _____

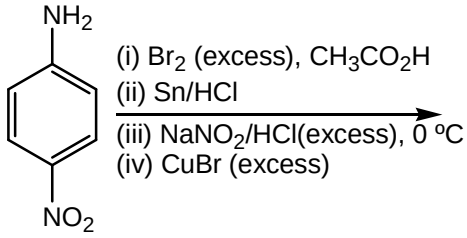


(Round off to two decimal places)

44. In the Born-Haber cycle, the heat of formation of CuCl is _____ kJ/mol.
[Given: Heat of atomization of Cu = +338 kJ/mol
Ionization enregy of Cu = +746 kJ/mol
Heat of atomization of Cl_2 = +121 kJ/mol
Electron affinity of Cl = –349 kJ/mol, and Lattice energy of CuCl = –973 kJ/mol]
(Round off to the nearest integer)

45. The highest possible energy of a photon in the emission spectrum of hydrogen atom is ____eV.
[Given: Rydberg constant = 13.61 eV]
(Round off to two decimal places)

46. The molecular weight of the major product of the reaction is _____(in integer).



[Given: atomic weight of H = 1, C = 12, N = 14 and Br = 80]

47. The standard reduction potential (E^o) of $Fe^{3+} \rightarrow Fe$ is ____V.

[Given: $Fe^{3+} \rightarrow Fe^{2+}$ $E^0 = 0.77$ V

$Fe^{2+} \rightarrow Fe$ $E^0 = -0.44$V]

(Round off to three decimal places)

48. A 0.06 g/mL solution of (S)-1-phenylethanol placed in a 5 cm long polarimeter tube shows an optical rotation of 1.2°. The specific rotation is _____°.
(Round off to the nearest integer)

49. The spin-only magnetic moment of B_2 molecule is _____μ_B.
(Round off two decimal places).

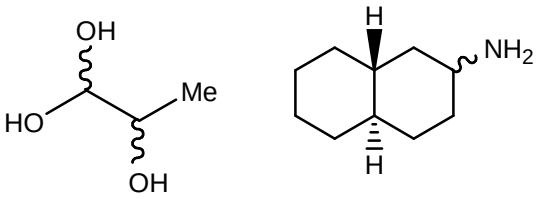
50. Consider the following reaction:

$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O \qquad \Delta_r H^0_{298} = -3120 \text{ kJmol}^{-1}$

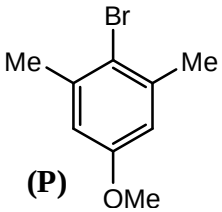
A closed system initially contains 5 moles of benzene and 25 mles of oxygen under standard conditions at 298K. The reaction was stopped when 17.5 moles of oxygen is left. The amount of heat evolved during the reaction is _____kJ.
(Round off to the nearest integer).

Q.51 – Q.60 carry TWO marks each.

51. The sum of the total number of stereoisomers (including enantiomers) present in the following molecules is _____



52. The number of singlets observed in the ^1H NMR spectrum of P is _____



(P)

53. When a glass capillary tube is dipped in water, a 1.0 cm rise in the water level is observed at 18ºC. The internal radius of the capillary is _____cm.
[Given: Surface tension of water at 18ºC = 73.2 dyne cm^{-1}, difference in the densities of water and air at 18ºC = 0.996 g cm^{-3} ; gravitational acceleration constant, g = 980 cm s^{-2}.
Assume that water completely wets the glass capillary and the interface between the water and the air phase inside the capillary is a hemisphere]
(Round off to two decimal places)

54. The volume of 2.0 mol of an ideal gas is reduced to half isothermally at 300 K in a closed system. The value of ΔG is ____ kJ. (Given: R = 8.314 J mol^{-1} K^{-1})
(Round off to two decimal places)

55. The amount of ethane produced in the following reaction is _____kg.

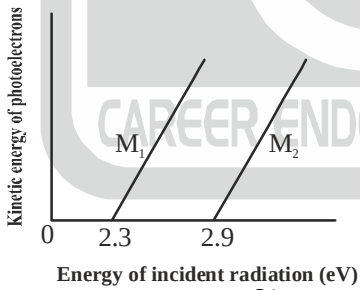
$$C_2H_4(2\text{ kg}) + H_2(2\text{ kg}) \xrightarrow{\text{Wiikinson's Catalyst}} C_2H_6 \ (90\%\text{ catalytic conversion})$$

(Round off to two decimal places)

56. An elementary reaction $2A \longrightarrow P$ follows a second order rate law with rate constant 2.5×10^{-3} dm^3 mol^{-1} s^{-1}. The time required for the concentration of A to change from 0.4 mol dm^{-3} to 0.2 mol dm^{-3} is _____s.

57. The spin-only magnetic moment of $\left[Fe(acac)_3\right]$ is _____μ_B.
(Round off to two decimal places)

58. The folowing diagram shows the kinetic energy of the ejected photoelectrons against the energy of incident radiation for two metal surfaces M_1 and M_2. If the energy of the incident radiation on M_1 is equal to the work function of M_2, the de-Broglie wavelength of the ejected photoelectron is _____nm.



[Given: Mass of electron = 9.11×10^{-31} kg. Planck's constant = 6.62×10^{-34} Js; 1 eV = 1.6×10^{-19} J]. (Round off to two decimal places).

59. The harmonic vibrational frequency of a diatomic molecule is 2000 cm^{-1}. Its zero-point energy is ____eV.
[Given: Planck's constant = 6.62×10^{-34} Js; 1eV = 1.6×10^{-19} J]
(Round off to two decimal places)

60. In a gravimetric estimation of Al, a sample of 0.1000 g $AlCl_3$ is precipitated with 8-hydroxyquinoline. The weight of the precipitate is ____g.
[Given: atomic weight of Al is 26.98; molecular weight of $AlCl_3$ is 133.34; and molecular weight of 8-hydroxyquioline is 145.16]
(Round off to 4 decimal places)