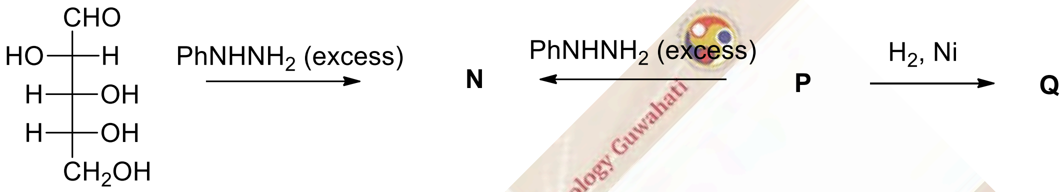
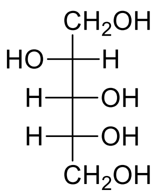
Question Paper
CY : JAM 2023

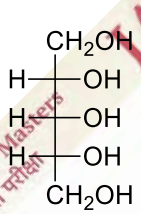
Section A: Q.1 – Q.10 Carry ONE mark each.

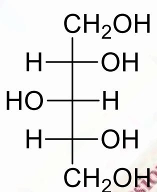
Q.1 The structure of **Q** in the following reaction scheme is

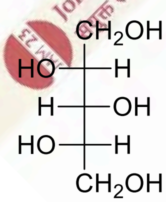


M (enantiopure)

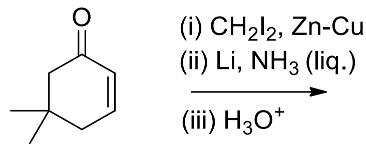
(A) 

(B) 

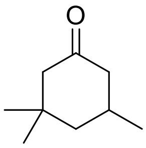
(C) 

(D) 

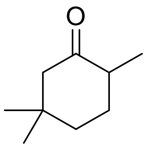
Q.2 The major product of the reaction is



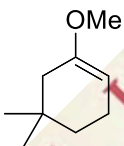
(A)



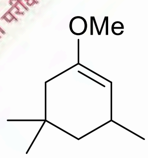
(B)



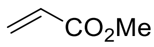
(C)



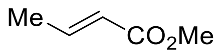
(D)



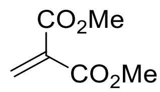
Q.3 The rate of addition of 1-hexyl radical to the given molecules follows the order



P



Q



R

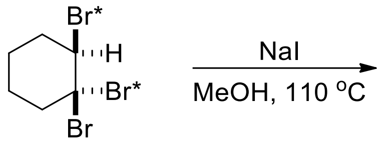
(A) **P** > **R** > **Q**

(B) **Q** > **P** > **R**

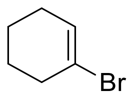
(C) **R** > **P** > **Q**

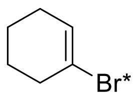
(D) **P** > **Q** > **R**

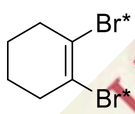
Q.4 The major product of the reaction is

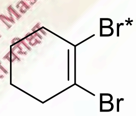


Br* = ^{82}Br

(A) 

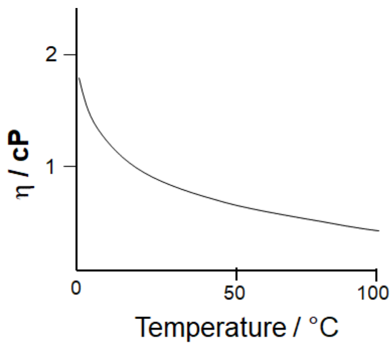
(B) 

(C) 

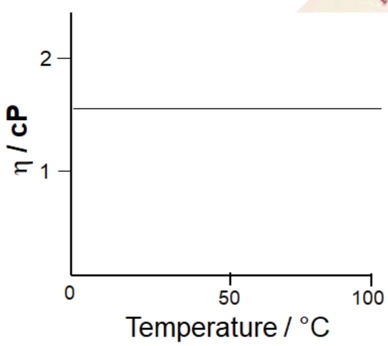
(D) 

Q.5 The diagram that best describes the variation of viscosity (η) of water with temperature at 1 atm is

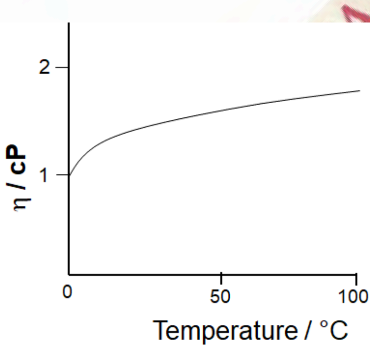
(A)



(B)



(C)



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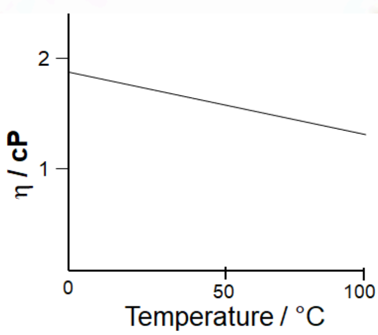

Q.6 The SI unit of the molar conductivity of an electrolyte solution is

(A) $\mathrm{S\ m^{-1}\ mol^{-1}}$

(B) $\mathrm{S\ mol^{-1}}$

(C) $\mathrm{S\ m\ mol^{-1}}$

(D) $\mathrm{S\ m^{2}\ mol^{-1}}$

Q.7 The system with the lowest zero-point energy when it is confined to a one-dimensional box of length L is

(A) an electron

(B) a hydrogen atom

(C) a helium atom

(D) a proton

Q.8 The metal ion present in human *carbonic anhydrase* is

(A) Fe^{3+}

(B) Cu^{2+}

(C) Zn^{2+}

(D) Ni^{2+}

Q.9 The oxoacid of sulfur that has $\mathrm{S-O-S}$ bond is

(A) Pyrosulfuric acid

(B) Pyrosulfurous acid

(C) Dithionous acid

(D) Dithionic acid

Q.10 An alkaline (NaOH) solution of a compound produces a yellow colored solution on addition of $NaBO_3$. The compound is

(A) $Mn(OH)_2$

(B) $Pb(OH)_2$

(C) $Cr(OH)_3$

(D) $Fe(OH)_3$

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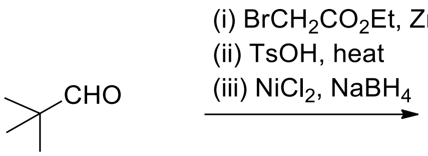
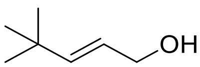
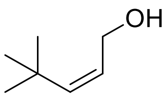
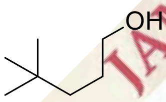
Section A: Q.11 – Q.30 Carry TWO marks each.

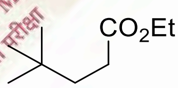
Q.11 The major product of the reaction is



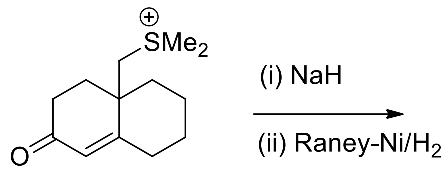
(A) 

(B) 

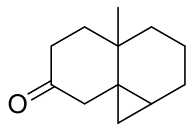
(C) 

(D) 

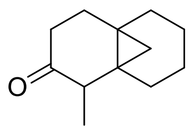
Q.12 The major product in the following reaction is



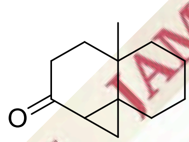
(A)



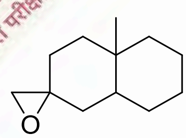
(B)



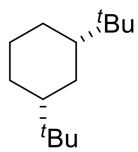
(C)

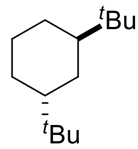


(D)

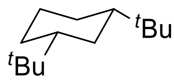


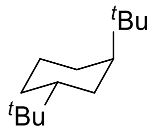
Q.13 The most stable conformation of **Y** and that of **Z** are


Y

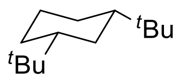

Z

(A)


Y

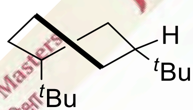

Z

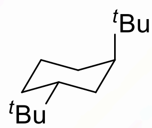
(B)


Y

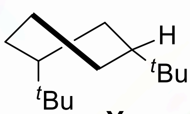

Z

(C)


Y

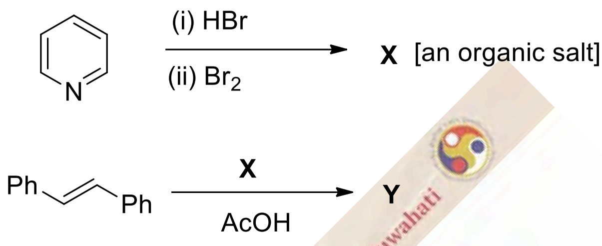

Z

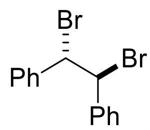
(D)

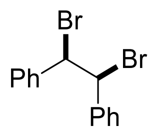

Y

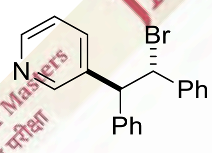

Z

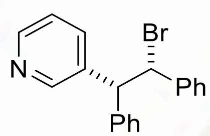
Q.14 The major product **Y** in the following reaction scheme is



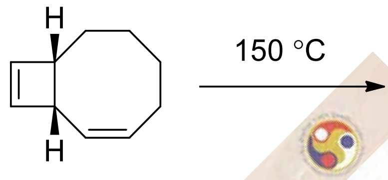
(A) 

(B) 

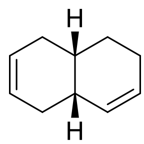
(C) 

(D) 

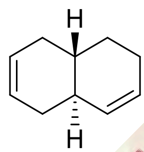
Q.15 The major product of the reaction is



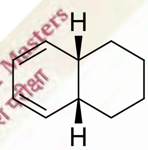
(A)



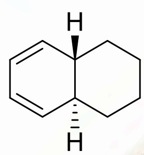
(B)



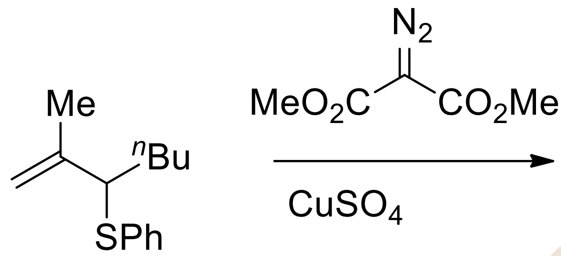
(C)



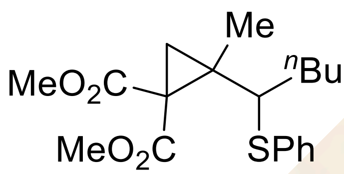
(D)



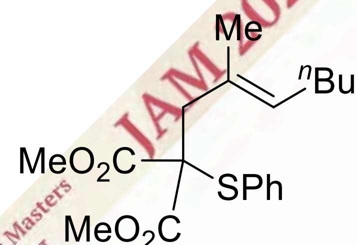
Q.16 The major product of the reaction is



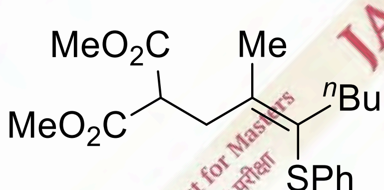
(A)



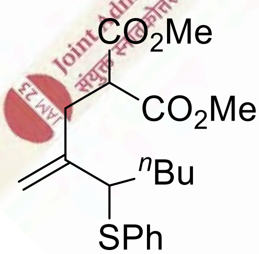
(B)



(C)



(D)



Q.17 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 25 °C is

(k_a and k_d are the rate constants for adsorption and desorption processes, respectively, at 25 °C)

(A) 1/4

(B) 1/3

(C) 1/2

(D) 2/3

Q.18 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 vapor phase behaves as an ideal gas)

(A) molality of the solution

(B) mole fraction of the solvent

(C) weight fraction of the solute

(D) mole fraction of the solute

Q.19 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 25 °C to double its degree of dissociation is

[Given: K_a of HA at 25 °C = 1.8×10^{-5}]

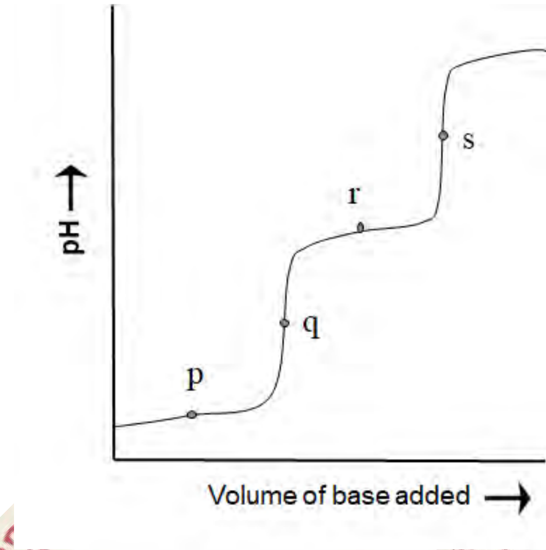
(A) 100

(B) 200

(C) 300

(D) 400

Q.20 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 $[HA^-] = [A^{-2}]$ is



(A) **p**

(B) **q**

(C) **r**

(D) **s**

Q.21 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 of **A** is

(Assume the gas molecules as hard spheres)

(A) $\sqrt{2} : 1$

(B) $2\sqrt{2} : 1$

(C) $1 : \sqrt{2}$

(D) $1 : 2\sqrt{2}$

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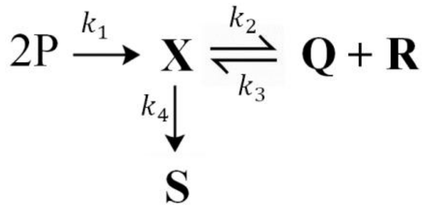
Q.22 For the given elementary reactions, the steady-state concentration of **X** is



(A) $\dfrac{k_1[\mathbf{P}]^2 + k_3[\mathbf{Q}][\mathbf{R}]}{k_2 + k_4}$

(B) $\dfrac{\frac{1}{2}k_1[\mathbf{P}]^2 + k_3[\mathbf{Q}][\mathbf{R}]}{k_2 + k_4}$

(C) $\dfrac{k_1[\mathbf{P}]^2 + k_3[\mathbf{Q}][\mathbf{R}]}{-k_1 + k_2 - k_3 + k_4}$

(D) $\dfrac{k_1[\mathbf{P}] + k_3[\mathbf{Q}][\mathbf{R}]}{k_2 + k_4}$

Q.23 The separation (in nm) of $\{134\}$ planes of an orthorhombic unit cell (with cell parameters $a = 0.5$ nm, $b = 0.6$ nm, and $c = 0.8$ nm) is

(A) 0.036

(B) 0.136

(C) 0.236

(D) 0.336

Q.24 The transition metal (**M**) complex that can have all isomers (geometric, linkage, and ionization) is

(A) $[\mathbf{M}(NH_3)_4Br_2]SCN$

(B) $[\mathbf{M}(NH_3)_4Cl_2]Br$

(C) $[\mathbf{M}(NH_3)_4(H_2O)_2]Cl_3$

(D) $[\mathbf{M}(NH_3)_4(H_2O)_2](SCN)_3$

Q.25 The geometry of $[VO(acac)_2]$ is

(A) square pyramidal

(B) trigonal bipyramidal

(C) pentagonal planar

(D) distorted trigonal bipyramidal

Q.26 The products **X** and **Y** in the following reaction sequence, respectively, are

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

(A) $B_3N_3Cl_6$ and $B_3N_3H_6$

(B) $B_3N_3H_3Cl_3$ and $B_3N_3H_6$

(C) $B_3N_3H_3Cl_3$ and $B_3N_3H_{12}$

(D) $B_3N_3H_9Cl_3$ and $B_3N_3H_{12}$

Q.27 The correct order of the energy of the d orbitals of a square planar complex is

(A) $d_{xz} = d_{yz} < d_{xy} < d_{z^2} < d_{x^2-y^2}$

(B) $d_{xz} = d_{yz} < d_{z^2} < d_{xy} < d_{x^2-y^2}$

(C) $d_{yz} < d_{xz} < d_{z^2} < d_{xy} < d_{x^2-y^2}$

(D) $d_{xy} < d_{xz} < d_{yz} < d_{x^2-y^2} < d_{z^2}$

Q.28 **X** and **Y** in the following reactions, respectively, are

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

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

(A) CH_3COOH and NO^+

(B) CH_3CHO and NO_2^+

(C) $EtOSO_3H$ and NO_2^+

(D) $EtOSO_3H$ and NO^+

Q.29 The correct order of energy levels of the molecular orbitals of N_2 is

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

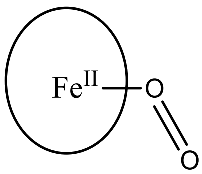
(B) $1\sigma_g < 1\sigma_u < 2\sigma_g < 2\sigma_u < 3\sigma_g < 3\sigma_u < 1\pi_u < 1\pi_g$

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

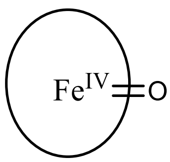
(D) $1\sigma_g < 1\sigma_u < 2\sigma_g < 2\sigma_u < 3\sigma_g < 1\pi_u < 1\pi_g < 3\sigma_u$

Q.30 Free heme in aqueous solution when exposed to dioxygen is finally converted to (circle around iron in the given choices represents the protoporphyrin IX)

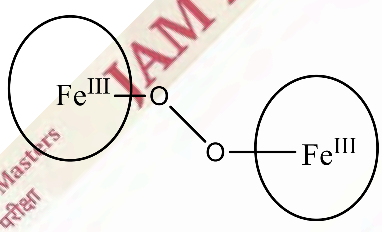
(A)



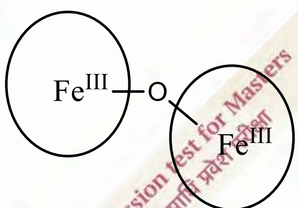
(B)



(C)

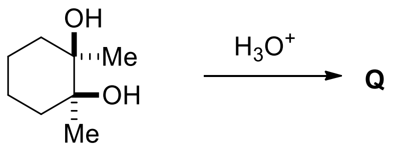


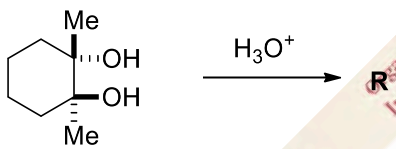
(D)



Section B: Q.31 – Q.40 Carry TWO marks each.

Q.31 Correct statement(s) about **Q** and **R** is/are





(A) Both **Q** and **R** give positive Fehling's test

(B) **Q** gives positive iodoform test and its ^{1}H NMR spectrum shows singlets at 1.0 ppm (3H) and at 1.3 ppm (3H)

(C) **R** gives positive iodoform test and its ^{1}H NMR spectrum shows singlets at 1.0 ppm (3H) and at 2.2 ppm (3H)

(D) A bright yellow precipitate is formed when **Q** and **R** treated separately with 2,4-dinitrophenyl hydrazine

Q.32 The correct statement(s) is/are

(A) The pK_{a1} of *cis*-cyclohexane 1,3-diol is greater than that of the *trans* isomer.

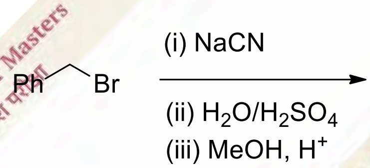
(B) The *trans*-4-(*tert*-butyl)cyclohexanamine is more basic than its *cis* isomer.

(C) 2,6-Dihydroxybenzoic acid is more acidic than salicylic acid.

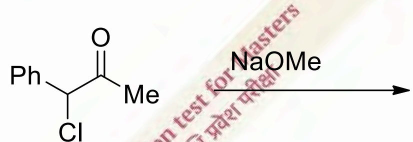
(D) 2,4,6-Trinitrophenol is more acidic than 2,4,6-trinitrobenzoic acid.

Q.33 The reaction(s) that yield(s) Ph-CH_2-CH_2-CO_2Me as the major product is/are

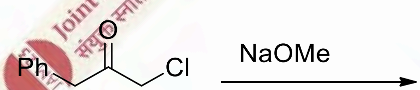
(A)



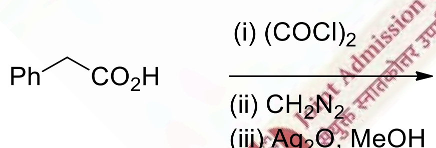
(B)



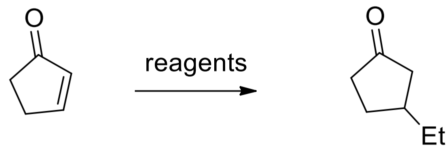
(C)



(D)



Q.34 The correct option(s) of the reagents required for the following reaction is/are



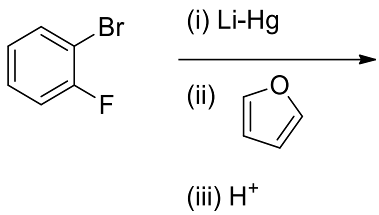
(A) (i) Et_3B, O_2 (cat), THF; (ii) H_2O

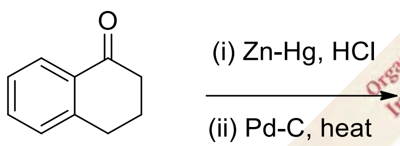
(B) (i) Et_2CuLi, Me_3SiCl; (ii) H_3O^+

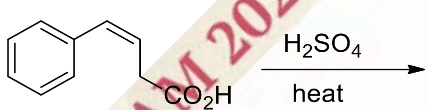
(C) (i) EtMgBr, Et_2O; (ii) H_2O

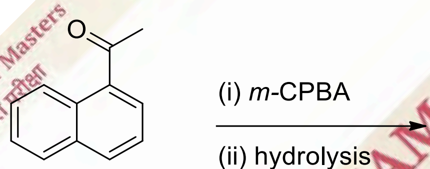
(D) (i) ^nBuLi, THF; (ii) EtI

Q.35 The reaction(s) that yield(s) 1-naphthol as the major product is/are

(A)


(B)


(C)


(D)


Q.36 The correct relation(s) for an ideal gas in a closed system is/are

(A) $\left(\frac{\partial H}{\partial V}\right)_T = 0$

(B) $\left(\frac{\partial T}{\partial P}\right)_H = 0$

(C) $\left(\frac{\partial H}{\partial P}\right)_T = 0$

(D) $\left(\frac{\partial H}{\partial T}\right)_P = 0$

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Q.37 The molecule(s) that follow(s) $I_a < I_b = I_c$ (I_a, I_b, and I_c are the principal moments of inertia) is/are

(A) HCN

(B) CH_3Cl

(C) $CH_3C{\equiv}CH$

(D) C_6H_6

Q.38 The role(s) of fluorspar in the electrolytic reduction of Al_2O_3 is/are to

(A) decrease the melting point of Al_2O_3

(B) improve the electrical conductivity of the melt

(C) prevent the corrosion of anode

(D) prevent the radiation loss of heat

Q.39 The correct statement(s) about the complexes **I** ($K_3[CoF_6]$) and **II** ($K_3[RhF_6]$) is/are

(A) Both complexes are high spin.

(B) Complex **I** is paramagnetic.

(C) Complex **II** is diamagnetic.

(D) The crystal field stabilization energy of complex **II** is more than that of complex **I**.

Q.40 The diatomic molecule(s) that has/have bond order of one is/are

(A) B_2

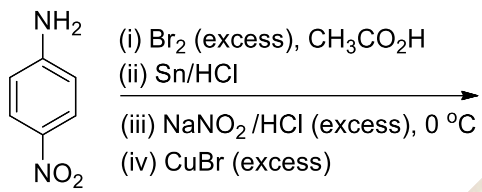
(B) N_2^{2-}

(C) Li_2

(D) O_2^{2-}

Section C: Q.41 – Q.50 Carry ONE mark each.

Q.41 The molecular weight of the major product of the reaction is ____ (*in integer*).

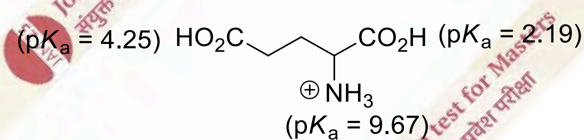


[Given: atomic weight of H = 1, C = 12, N = 14, and Br = 80]

Q.42 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*)

Q.43 The isoelectric point of glutamic acid is ______.



(*round off to two decimal places*)

Q.44 Consider the following reaction:

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

A closed system initially contains 5 moles of benzene and 25 moles of oxygen under standard conditions at 298 K. 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.45 For the elementary reaction $\mathbf{C} \xleftarrow{k_2} \mathbf{A} \xrightarrow{k_1} \mathbf{B}$, $k_1 = 2k_2$. At time $t = 0$, $[\mathbf{A}] = A_0$ and $[\mathbf{B}] = [\mathbf{C}] = 0$. At a later time t, the value of $[\mathbf{B}]/[\mathbf{C}]$ is ______.

(*round off to the nearest integer*)

Q.46 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*)

Q.47 The standard reduction potential (E^0) of $Fe^{3+} \rightarrow Fe$ is _____V.

[Given: $Fe^{3+} \rightarrow Fe^{2+}$ $E^0 = 0.77$ V and
$Fe^{2+} \rightarrow Fe$ $E^0 = -0.44$ V]

(*round off to three decimal places*)

Q.48 The number of valence electrons in $Na_2[Fe(CO)_4]$ (the Colman's reagent) is _____.

Q.49 In the Born-Haber cycle, the heat of formation of CuCl is ______ kJ/mol.

[Given: Heat of atomization of Cu = +338 kJ/mol,
Ionization energy 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]

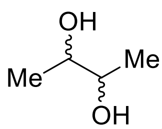
(*round off to the nearest integer*)

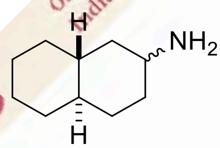
Q.50 The spin-only magnetic moment of B_2 molecule is_____ μ_B.

(*round off to two decimal places*)

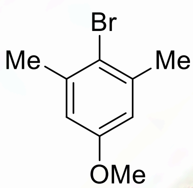
Section C: Q.51 – Q.60 Carry TWO marks each.

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





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



P

Q.53 When a glass capillary tube is dipped in water, a 1.0 cm rise in the water level is observed at 18 °C. The internal radius of the capillary is ______ cm.

[Given: Surface tension of water at 18 °C = 73.2 dyne cm^{-1}; difference in the densities of water and air at 18 °C = 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*)

Q.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*)

Q.55 The harmonic vibrational frequency of a diatomic molecule is 2000 cm^{-1}. Its zero-point energy is ____ eV.

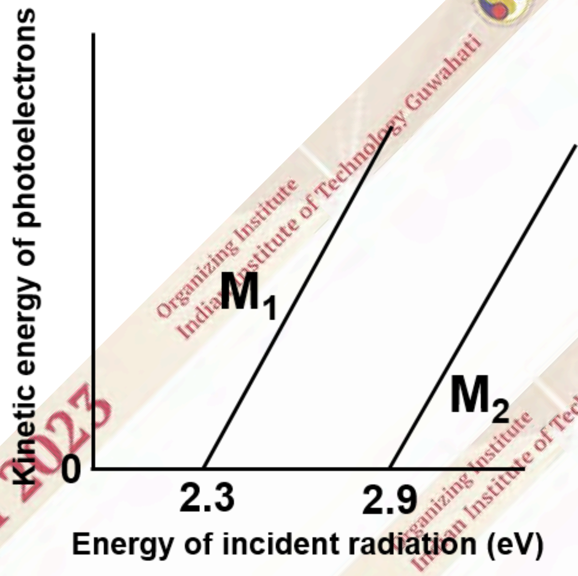
[Given: Planck's constant = 6.62×10^{-34} J s; 1 eV = 1.6×10^{-19} J]

(*round off to two decimal places*)

Q.56 An elementary reaction 2**A** → **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.

(*round off to the nearest integer*)

Q.57 The following 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} J s; 1 eV = 1.6×10^{-19} J.]

(*round off to two decimal places*)

Q.58 The spin-only magnetic moment of $[Fe(acac)_3]$ is ______ μ_B.

(*round off to two decimal places*)

Q.59 The amount of ethane produced in the following reaction is _____ kg.

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

(*round off to two decimal places*)

Q.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-hydroxyquinoline is 145.16]

(*round off to 4 decimal places*)