JEE–MAIN EXAMINATION – JANUARY 2025

(HELD ON THURSDAY 23rd JANUARY 2025) **TIME : 9 : 00 AM TO 12 : 00 NOON**

CHEMISTRY — TEST PAPER WITH SOLUTIONS

SECTION-A

51. The element that does not belong to the same period of the remaining elements (modern periodic table) is:

(1) Palladium

(2) Iridium

(3) Osmium

(4) Platinum

Sol. (1)

Palladium $\Rightarrow$ 5^{th} period

Iridium, Osmium, Platinum $\Rightarrow$ 6^{th} Period

52. Heat treatment of muscular pain involves radiation of wavelength of about 900 nm. Which spectral line of H atom is suitable for this ?

Given: Rydberg constant

$R_H = 10^5\ cm^{-1}$, $h = 6.6 \times 10^{-34}$ J s, $c = 3 \times 10^8$ m/s)

(1) Paschen series, $\infty \to 3$

(2) Lyman series, $\infty \to 1$

(3) Balmer series, $\infty \to 2$

(4) Paschen series, $5 \to 3$

Sol. (1)

$\lambda = 900$ nm H-atom (Z = 1)

$= 9 \times 10^{-5}$ cm

$R_H = 10^5\ cm^{-1}$

Ryderg eq. $= \dfrac{1}{\lambda} = R_H Z^2 \times \left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

$$\Rightarrow \frac{1}{\lambda \times R_H} = \frac{1}{n_1^2} - \frac{1}{n_2^2}$$

$$\Rightarrow \frac{1}{9\times10^{-5}\,cm \times 10^{5}\,cm^{-1}} = \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow \frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{1}{9}$$

It is possible when $n_1 = 3$, $n_2 = \infty$

Possible series : $\infty \to 3$

53. The **incorrect** statements among the following is

(1) PH_3 shows lower proton affinity than NH_3.

(2) PF_5 exists but NF_5 does not.

(3) NO_2 can dimerise easily.

(4) SO_2 can act as an oxidizing agent, but not as a reducing agent.

Sol. (4)

SO_2 can oxidise as well as reduce.

Hence it can act as both oxidising and reducing agent.

54. $CrCl_3.xNH_3$ can exist as a complex. 0.1 molal aqueous solution of this complex shows a depression in freezing point of 0.558ºC. Assuming 100% ionisation of this complex and coordination number of Cr is 6, the complex will be

(Given $K_f = 1.86$ K kg mol^{-1})

(1) $[Cr(NH_3)_6]\ Cl_3$

(2) $[Cr(NH_3)_4Cl_2]\ Cl$

(3) $[Cr(NH_3)_5Cl]\ Cl_2$

(4) $[Cr(NH_3)_3Cl_3]$

Sol. (3)

Given : $\Delta T_f = 0.558°C$

$$k_f = 1.86 \frac{K \times kg}{mol}$$

0.1 m aq. sol.

$\Rightarrow \Delta T_f = i \times k_f \times m$

$\Rightarrow 0.558 = i \times 1.86 \times 0.1$

$\Rightarrow i = 3$

55. $FeO_4^{2-} \xrightarrow{+2.0V} Fe^{3+} \xrightarrow{0.8V} Fe^{2+} \xrightarrow{-0.5V} Fe^0$

In the above diagram, the standard electrode potentials are given in volts (over the arrow).

The value of $E^{\ominus}_{FeO_4^{2-}/Fe^{2+}}$ is

(1) 1.7 V (2) 1.2 V
(3) 2.1 V (4) 1.4 V

Sol. **(1)**

$FeO_4^{-2} \xrightarrow[n_1=3]{E_1^o=2V} Fe^{+3} \xrightarrow[n_2=1]{E_2^o=0.8V} Fe^{+2} \xrightarrow{E_3^o=-.05V} Fe$

$FeO_4^{-2} \to Fe^{+2}$: $E_4^o = ?$, $n_4 = 4$

$$\Delta G_4^o = \Delta G_1^o + \Delta G_2^o$$

$$\Rightarrow -n_4FE_4^o = -n_1FE_1^0 - n_2FE_2^o$$

$$\Rightarrow +4E_4^o = 3\times2+(1\times0.8)$$

$$\Rightarrow E_4^o = \frac{6.8}{4}V$$

$$\Rightarrow \boxed{E_4^o = 1.7V}$$

56. Match the **LIST-I** with **LIST-II**

LIST-I **Name reaction**		**LIST-II** **Product obtainable**	
A.	Swarts reaction	I.	Ethyl benzene
B.	Sandmeyer's reaction	II.	Ethyl iodide
C.	Wurtz Fittig reaction	III.	Cyanobenzene
D.	Finkelstein reaction	IV.	Ethyl fluoride

Choose the ***correct*** answer from the options given below:

(1) A-II, B-III, C-I, D-IV
(2) A-IV, B-I, C-III, D-II
(3) A-IV, B-III, C-I, D-II
(4) A-II, B-I, C-III, D-IV

Sol. **(3)**

LIST-I **Name reaction**		**LIST-II** **Product obtainable**	
A.	Swarts reaction	I.	$Et\text{-}I \xrightarrow[DMF]{KF} Et\text{-}F$
B.	Sandmeyer's reaction	II.	$PhN_2^{\oplus}Cl^- \xrightarrow{CuCN/KCN} PhCN + N_2$
C.	Wurtz Fittig reaction	III.	$Ph\text{–}Cl + EtCl \xrightarrow[ether]{Na}$ Ph–Et + Ph–Ph + Et–Et
D.	Finkelstein reaction	IV.	$Et\text{–}Cl \xrightarrow[acetone]{NaI} Et\text{-}I + NaCl$

57. Given below are two statements:

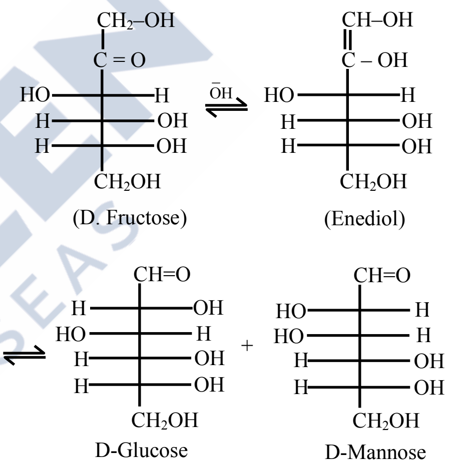
Statement I: Fructose does not contain an aldehydic group but still reduces Tollen's reagent

Statement II : In the presence of base, fructose undergoes rearrangement to give glucose.

In the light of the above statements, choose the ***correct*** answer from the options given below

(1) Statement I is false but Statement II is true
(2) Both Statement I and Statement II are true
(3) Both Statement I and Statement II are false
(4) Statement I is true but Statement II is false

Sol. **(2)**



58. 2.8×10^{-3} mol of CO_2 is left after removing 10^{21} molecules from its 'x' mg sample. The mass of CO_2 taken initially is

Given : $N_A = 6.02 \times 10^{23}\ mol^{-1}$

(1) 196.2 mg (2) 98.3 mg
(3) 150.4 mg (4) 48.2 mg

Sol. **(1)**

$$(moles)_{initial} = \frac{x\times10^{-3}}{44}$$

$$(moles)_{removal} = \frac{10^{21}}{6.02\times10^{23}}$$

$$(moles)_{left} = (moles)_{initial} - (moles)_{removed}$$

$$2.8\times10^{-3} = \frac{x\times10^{-3}}{44} - \frac{10^{21}}{6.02\times10^{23}}$$

$\Rightarrow$ x = 196.2 mg

59. Ice at –5°C is heated to become vapor with temperature of 110°C at atmospheric pressure. The entropy change associated with this process can be obtained from :

(1) $\int_{268K}^{383K} C_p\,dT + \frac{\Delta H_{melting}}{273} + \frac{\Delta H_{boiling}}{373}$

(2) $\int_{268K}^{273K} \frac{C_{p,m}}{T}dT + \frac{\Delta H_m, fusion}{T_f} + \frac{\Delta H_{m,vaporisation}}{T_b} + \int_{273K}^{373K}\frac{C_{p,m}\,dT}{T} + \int_{373K}^{383K}\frac{C_{p,m}dT}{T}$

(3) $\int_{268K}^{383K} C_p\,dT + \frac{q_{rev}}{T}$

(4) $\int_{268K}^{273K} C_{p,m}dT + \frac{\Delta H_m, fusion}{T_f} + \frac{\Delta H_{m,vaporisation}}{T_b} + \int_{273K}^{373K} C_{p,m}dT + \int_{373K}^{383K} C_{p,m}dT$

Sol. (2)

Ice → Ice ⇌ Water → Water ⇌ Water vapour → Water vapour
268 K | 273 K | 273 K | 273 K | 373 K | 383 K
(1) (2) (3) (4) (5)

$\Delta S_{overall} = \Delta S_1 + \Delta S_2 + \Delta S_3 + \Delta S_4 + \Delta S_5$

$\Delta S_2 = \frac{\Delta H_{m\ fusion}}{273}$ $T_f = 273$ 'K'

$\Delta S_3 = \int_{273}^{373}\frac{C_{p,m}dT}{T}$

$\Delta S_4 = \frac{\Delta H_{m\ vaporisation}}{373}$ $T_b = 373$ 'K'

$\Delta S_5 = \int_{373}^{383}\frac{C_{p,m}dT}{T}$

Answer = (2)

60. The d-electronic configuration of an octahedral Co(II) complex having magnetic moment of 3.95 BM is :

(1) $t_{2g}^6 e_g^1$ (2) $t_{2g}^3 e_g^0$
(3) $t_{2g}^5 e_g^2$ (4) $e^4 t_2^3$

Sol. (3)

$Co^{+2} = (Ar)_{18}\ 3d^7\ 4s^0$

↑ ↑ e_g^2
↑↓ ↑↓ ↑ t_{2g}^5

61. The complex that shows Facial – Meridional isomerism is

(1) $[Co(NH_3)_3Cl_3]$ (2) $[Co(NH_3)_4Cl_2]^+$
(3) $[Co(en)_3]^{3+}$ (4) $[Co(en)_2Cl_2]^+$

Sol. (1)

Ma_3b_3 type complexes show Facial - Meridional isomerism

(i) $[Co(NH_3)_3Cl_3]$ ⇒ Ma_3b_3
(ii) $[Co(NH_3)_4Cl_2]^+$ ⇒ Ma_4b_2
(iii) $[Co(en)_3]^{3+}$ ⇒ $M(AA)_3$
(iv) $[Co(en)_2Cl_2]^+$ ⇒ $M(AA)_2b_2$

a, b, = NH_3, Cl^-
AA = en

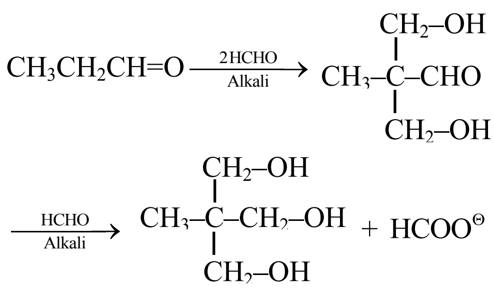
62. The major product of the following reaction is :

$CH_3CH_2CH{=}O \xrightarrow[\text{reflux}]{\text{excess HCHO, alkali}} ?$

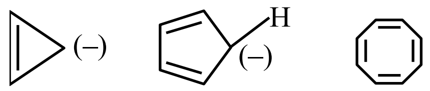
(1) $CH_3–CH_2–CH_2–OH$
(2) $CH_3–CH(CH_2–OH)–CH{=}O$
(3) $CH_3–C(CH_2–OH)_3$
(4) $CH_3–C(=CH_2)–CH{=}O$

Sol. (3)

This is an example of Tollen's reaction i.e. multiple cross aldol followed by cross Cannizaro reaction



63. The correct stability order of the following species/molecules is :



p q r

(1) q > r > p (2) r > q > p
(3) q > p > r (4) p > q > r

Sol. (1)

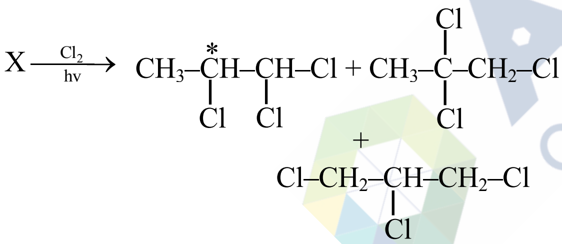
q is aromatic r is nonaromatic p is antiaromatic

64. Propane molecule on chlorination under photochemical condition gives two di-chloro products, "x" and "y". Amongst "x" and "y", "x" is an optically active molecule. How many tri-chloro products (consider only structural isomers) will be obtained from "x" when it is further treated with chlorine under the photochemical condition?

(1) 4 (2) 2
(3) 5 (4) 3

Sol. (4)

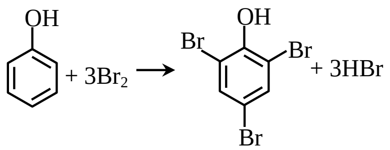
"X" is $CH_3-\overset{*}{C}H(Cl)-CH_2(Cl)$



65. What amount of bromine will be required to convert 2 g of phenol into 2, 4, 6-tribromophenol ? (Given molar mass in g mol^{-1} of C, H, O, Br are 12, 1, 16, 80 respectively)

(1) 10.22 g (2) 6.0 g
(3) 4.0 g (4) 20.44 g

Sol. (1)



Moles of phenol = $\frac{2}{94}$ = 0.021

∴ Moles of bromine = 0.021 × 3 = 0.064

∴ Mass of bromine = 0.064 × 160 = 10.22 g

66. The correct set of ions (aqueous solution) with same colour from the following is :

(1) V^{2+}, Cr^{3+}, Mn^{3+} (2) Zn^{2+}, V^{3+}, Fe^{3+}
(3) Ti^{4+}, V^{4+}, Mn^{2+} (4) Sc^{3+}, Ti^{3+}, Cr^{2+}

Sol. (1)

(1) V^{2+}(Violet), Cr^{3+}(Violet), Mn^{3+}(Violet)

(2) Zn^{2+}(Colourless), V^{3+}(Green), Fe^{3+}(Yellow)

(3) Ti^{4+}(Colourless), V^{4+}(Blue), Mn^{2+} (Pink)

(4) Sc^{3+}(Colourless), Ti^{3+}(Purple), Cr^{2+} (Blue)

67. Given below are two statements :

Statement I : In Lassaigne's test, the covalent organic molecules are transformed into ionic compounds.

Statement II : The sodium fusion extract of an organic compound having N and S gives prussian blue colour with $FeSO_4$ and $Na_4[Fe(CN)_6]$

In the light of the above statements, choose the **correct** answer from the options given below

(1) Both **Statement I** and **Statement II** are true

(2) Both **Statement I** and **Statement II** are false

(3) **Statement I** is false but **Statement II** is true

(4) **Statement I** is true but **Statement II** is false

Sol. (4)

The sodium fusion extract of organic compound having N & S gives blood red colour with $FeSO_4$ and $Na_4[Fe(CN)_6]$

68. Which of the following happens when NH_4OH is added gradually to the solution containing 1M A^{2+} and 1M B^{3+} ions ?

Given : $K_{sp}[A(OH)_2] = 9 \times 10^{-10}$ and

$K_{sp}[B(OH)_3] = 27 \times 10^{-18}$ at 298 K.

(1) $B(OH)_3$ will precipitate before $A(OH)_2$

(2) $A(OH)_2$ and $B(OH)_3$ will precipitate together

(3) $A(OH)_2$ will precipitate before $B(OH)_3$

(4) Both $A(OH)_2$ and $B(OH)_3$ do not show precipitation with NH_4OH

Sol. (1)

Condition for precipitation $Q_{ip} > K_{sp}$

For $[A(OH)_2]$

$[A^{2+}][OH^-]^2 > 9 \times 10^{-10}$

$[A^{+2}] = 1$ M

$\Rightarrow [OH^-] > 3 \times 10^{-5}$ M

For $[B(OH)_3]$

$[B^{3+}][OH^-]^3 > 27 \times 10^{-18}$

$[B^{3+}] = 1$M

$\Rightarrow [OH^-] > 3 \times 10^{-6}$ M

So, $B(OH)_3$ will precipitate before $A(OH)_2$

69. Match the **LIST-I** with **LIST-II**

LIST-I (Classification of molecules based on octet rule)		LIST-II (Example)	
A.	Molecules obeying octet rule	I.	NO, NO_2
B.	Molecules with incomplete octet	II.	BCl_3, $AlCl_3$
C.	Molecules with incomplete octet with odd electron	III.	H_2SO_4, PCl_5
D.	Molecules with expanded octet	IV.	CCl_4, CO_2

Choose the **correct** answer from the options given below :

(1) A-IV, B-II, C-I, D-III

(2) A-III, B-II, C-I, D-IV

(3) A-IV, B-I, C-III, D-II

(4) A-II, B-IV, C-III, D-I

Sol. (1)

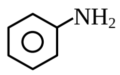
(A) A $\rightarrow$ IV

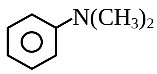
(B) B $\rightarrow$ II

(C) C $\rightarrow$ I

(D) D $\rightarrow$ III

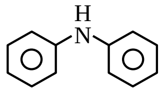
70. Which among the following react with Hinsberg's reagent?

(A) 

(2) 

(C) $CH_3–NH_2$

(4) $N(CH_3)_3$

(E) 

Choose the correct answer from the options given below :

(1) B and D only

(2) C and D only

(3) A, B and E only

(4) A, C and E only

Sol. (4)

B and D are 3° amine which does not have replaceable H on N, So does not react.

SECTION-B

71. If 1 mM solution of ethylamine produces pH = 9, then the ionization constant (K_b) of ethylamine is 10^{-x}. The value of x is ________ (nearest integer).
[The degree of ionization of ethylamine can be neglected with respect to unity.]

Sol. (7)

Sol. $C_2H_5NH_2(aq) + H_2O \rightleftharpoons C_2H_5NH_3^+ + \overset{\ominus}{O}H$

$C = 10^{-3}$ M   -   -

$C(1 - \alpha)$ $C\alpha$ $C\alpha$

$\Rightarrow C = 10^{-3}$ $=10^{-5}$ $= 10^{-5}$

$\boxed{1-\alpha \simeq 1}$

Given, $P^H = 9 \Rightarrow P^{OH} = 5 \Rightarrow \left[\overset{\ominus}{O}H\right] = 10^{-5}M$

Now, $K_b = \dfrac{[C_2H_5NH_3^+][\overset{\ominus}{O}H]}{[C_2H_5NH_2]}$

$\Rightarrow K_b = \dfrac{10^{-5} \times 10^{-5}}{10^{-3}} = 10^{-7}$

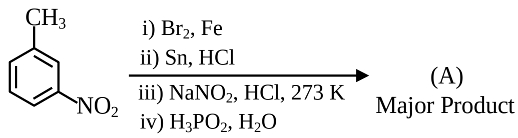
72. During "S" estimation, 160 mg of an organic compound gives 466 mg of barium sulphate. The percentage of Sulphur in the given compound is ______ %.
(Given molar mass in g mol^{-1} of Ba : 137, S : 32, O : 16)

Sol. (40)

Millimoles of $BaSO_4 = \dfrac{466}{233} = 2$m mol

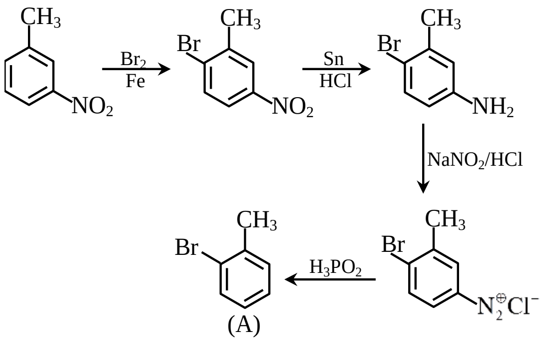
$\%S = \dfrac{\frac{466}{233} \times 32}{160} \times 100 = 40\%$

73. Consider the following sequence of reactions to produce major product (A)



Molar mass of product (A) is ______ g mol^{-1}.
(Given molar mass in g mol^{-1} of C : 12, H : 1, O : 16, Br : 80, N : 14, P : 31)

Sol. (171)



Molar mass of product (C_7H_7Br) (A) is 171 g mol^{-1}

74. For the thermal decomposition of $N_2O_5(g)$ at constant volume, the following table can be formed, for the reaction mentioned below :

$2N_2O_5(g) \rightarrow 2N_2O_4(g) + O_2(g)$

S.No.	Time/s	Total pressure / (atm)
1.	0	0.6
2.	100	'x'

x = ________ × 10^{-3} atm [nearest integer]

Given : Rate constant for the reaction is $4.606 \times 10^{-2} s^{-1}$.

Sol. (900)

NTA. (897)

$$K_{N_2O_5} = 2 \times 4.606 \times 10^{-2}\ S^{-1}$$

$$2N_2O_5(g) \longrightarrow 2N_2O_4(g) + O_2(g)$$

P_i 0.6 0 0

P_f $0.6 - P$ P $\frac{P}{2}$

$$2 \times 4.606 \times 10^{-2} = \frac{2.303}{100} \log \frac{0.6}{0.6-P}$$

$$4 \log_{10} \frac{0.6}{0.6-P}$$

$$10^4 = \frac{0.6}{0.6-P}$$

$$\Rightarrow 0.6 \times 10^4 - 10^4 P = 0.6$$

$$\Rightarrow 10^4 P = 0.6(10^4 - 1)$$

$$P = (6000 - 0.6) \times 10^{-4}$$

$$= 5999. \times 10^{-4}$$

$$= 0.59994$$

$$P_{Total} = 0.6 + \frac{P}{2}$$

$$= 0.6 + 0.29997$$

$$= 0.89997$$

$$= 899.97 \times 10^{-3}$$

Ans. 900

Given by NTA

Given : $2N_2O_5(g) \rightarrow 2N_2O_4(g) + O_2(g)$

t = 0 0.6 0 0

t = 100s 0.6 - x x x/2

$$P_{Total} = 0.6 + \frac{x}{2}$$

As given in equation

$K_r = 4.606 \times 10^{-2}\ sec^{-1}$

(Here language conflict in question)

($K_r = \frac{KA}{2}$ not considered)

$$K_r t = \ln \frac{0.6}{0.6-x}$$

$$4.606 \times 10^{-2} \times 100 = 2.303 \log \frac{0.6}{0.6-x}$$

$$P_{Total} = 0.6 + \frac{0.594}{2} = 0.897 \text{ atm}$$

$$= 897 \times 10^{-3} \text{ atm}$$

75. The standard enthalpy and standard entropy of decomposition of N_2O_4 to NO_2 are 55.0 kJ mol^{-1} and 175.0 J/K/mol respectively. The standard free energy change for this reaction at 25°C in J mol^{-1} is _______ (Nearest integer)

Sol. (2850)

$\Delta H^o_{rxn} = 55$ kJ/mol, T = 298 K

$\Delta S^o_{rxn} = 175$ J/mol

$$\Delta G^o_{rxn} = \Delta H^o_{rxn} - T\Delta S^o_{rxn}$$

$$\Rightarrow \Delta G^o_{rxn} = 55000 \text{ J/mol} - 298 \times 175 \text{ J/mol}$$

$$\Rightarrow \Delta G^o_{rxn} = 55000 - 52150$$

$$\Rightarrow \Delta G^o_{rxn} = 2850 \text{ J/mol}$$