JEE–MAIN EXAMINATION – JANUARY 2025

(HELD ON TUESDAY 28th JANUARY 2025) **TIME : 9 : 00 AM TO 12 : 00 NOON**

CHEMISTRY — TEST PAPER WITH SOLUTIONS

SECTION-A

51. The incorrect decreasing order of atomic radii is :

(1) Mg > Al > C > O

(2) Al > B > N > F

(3) Be > Mg > Al > Si

(4) Si > P > Cl > F

Ans. **(3)**

Sol. Correct order of atomic radii : Be < Mg > Al > Si

52. Given below are two statements :

Statement I : In the oxalic acid vs $KMnO_4$ (in the presence of dil H_2SO_4) titration the solution needs to be heated initially to 60°C, but no heating is required in Ferrous ammonium sulphate (FAS) vs $KMnO_4$ titration (in the presence of dil H_2SO_4)

Statement II : In oxalic acid vs $KMnO_4$ titration, the initial formation of $MnSO_4$ takes place at high temperature, which then acts as catalyst for further reaction. In the case of FAS vs $KMnO_4$, heating oxidizes Fe^{2+} into Fe^{3-} by oxygen of air and error may be introduced in the experiment.

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) Statement I is true but Statement II is false

(4) Both Statement I and Statement II are false

Ans. **(2)**

Sol. $2MnO_4^- + 5(COO)_2^{2-} + 16H^+ \rightarrow$

$$10CO_2 + 2Mn^{2+} + 8H_2O$$

This reaction is slow at room temperature, but becomes fast at 60°C. Manganese(II) ions catalyse the reaction; thus, the reaction is autocatalytic; once manganese(II) ions are formed, it becomes faster and faster.

The titration of FAS v/s $KMnO_4$ do not require heating because at higher temeprature the oxidation of Fe^{+2} to Fe^{+3} by atmospheric O_2 will be prominent.

53. Match the **List-I** with **List-II**

List-I (Redox Reaction)		**List-II (Type of Redox Reaction)**	
A	$CH_{4(g)} + 2O_{2(g)} \xrightarrow{\Delta} CO_{2(g)} + 2H_2O_{(l)}$	(I)	Disproportionation reaction
B	$2NaH_{(s)} \xrightarrow{\Delta} 2Na_{(s)} + H_{2(g)}$	(II)	Combination reaction
C	$V_2O_{5(s)} + 5Ca_{(s)} \xrightarrow{\Delta} 2V_{(s)} + 5CaO_{(s)}$	(III)	Decomposition reaction
D	$2H_2O_{2(aq)} \xrightarrow{\Delta} 2H_2O_{(l)} + O_{2(g)}$	(IV)	Displacement reaction

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

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

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

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

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

Ans. **(1)**

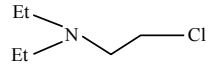
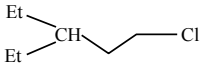
Sol. (A) Combustion of hydrocarbon

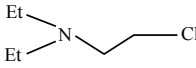
(B) Decomposition into gaseous product.

(C) Displacement of 'V' by 'Ca' atom.

(D) Disproportionation of $H_2O_2^{-1}$ into O^{-2} and O° oxidation states.

54. Given below are two statements :

Statement I :  will undergo alkaline hydrolysis at a faster rate than 

Statement II :  , intramolecular substitution takes place first by involving lone pair of electrons on nitrogen.

In the light of the above statements, choose the **most appropriate** answer from the options given below :

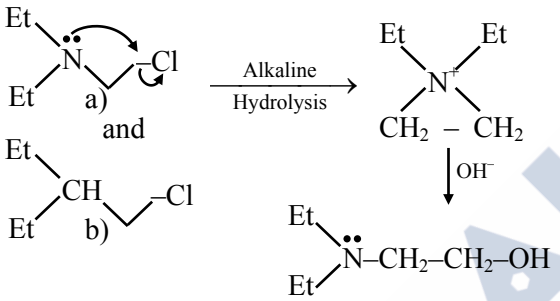
(1) Both Statement I and Statement II are incorrect

(2) Statement I is incorrect but statement II is correct

(3) Both Statement I and Statement II are correct

(4) Statement I is correct but Statement II is incorrect

Ans. **(3)**

Sol. 

Rate of (a) is faster than rate of (b) because it is a intramolecular substitution.

55. A weak acid HA has degree of dissociation x. Which option gives the correct expression of pH = pK_a) ?

(1) log (1 + 2x) (2) $\log\left(\frac{1-x}{x}\right)$

(3) 0 (4) $\log\left(\frac{x}{1-x}\right)$

Ans. **(4)**

Sol. $HA \rightleftharpoons H^{\oplus} + A^{\ominus}$

t=0 a

t = t a(1–x) ax ax

$K_a = (ax)\frac{(x)}{1-x}$; $[H^+] = ax$

$-\log(K_a) = -\log(ax) - \log\left(\frac{x}{1-x}\right)$

$pKa = pH - \log\left(\frac{x}{1-x}\right)$

$pH - pKa = \log\left(\frac{x}{1-x}\right)$

56. Consider 'n' is the number of lone pair of electrons present in the equatorial position of the most stable structure of ClF_3. The ions from the following with 'n' number of unpaired electrons are :

A. V^{3+} B. Ti^{3+}

C. Cu^{2+} D. Ni^{2+}

E. Ti^{2+}

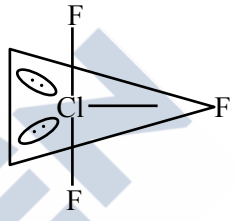
Choose the ***correct*** answer from the options given below :

(1) A and C only (2) A, D and E only

(3) B and C only (4) B and D only

Ans. **(2)**

Sol. ClF_3



n = 2 (No of lone pair present in equitorial plane)

	(Unpaired e^-)
(A) V^{+3} : $[Ar]3d^2$	2
(B) Ti^{3+} : $[Ar]3d^1$	1
(C) Cu^{+2} : $[Ar]3d^9$	1
(D) Ni^{+2} : $[Ar]3d^8$	2
(E) Ti^{+2} : $[Ar]3d^2$	2

57.

$[A]_0$ / molL^{-1}	$t_{1/2}$ / min
0.100	200
0.025	100

For a given reaction R → P, $t_{1/2}$ is related to $[A]_0$ as given in table :

Given : log 2 = 0.30

Which of the following is *true* ?

A. The order of the reaction is $\frac{1}{2}$.

B. If $[A]_0$ is 1M, then $t_{1/2}$ is $200\sqrt{10}$ min

C. The order of the reaction changes to 1 if the concentration of reactant changes from 0.100 M to 0.500 M.

D. $t_{1/2}$ is 800 min for $[A]_0$ = 1.6 M

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

(1) A and C only (2) A and B only

(3) A, B and D only (4) C and D only

Ans. **(3)**

Sol. $t_{1/2} \propto \frac{1}{A_0^{n-1}}$

$$\frac{(t_{1/2})_1}{(t_{1/2})_2} = \frac{(A_0)_2^{n-1}}{(A_0)_1^{n-1}}$$

$$\frac{200}{100} = \left(\frac{0.025}{0.100}\right)^{n-1}$$

$$2 = \left(\frac{1}{4}\right)^{n-1} \qquad n-1 = -\frac{1}{2}$$

$$n = \frac{1}{2}(\text{order})$$

$$\Rightarrow t_{1/2} \propto \sqrt{A_0}$$

$$\frac{200}{t_{1/2}} = \frac{(0.1)^{1/2}}{(1)^{1/2}} \qquad \text{when } A_0 = 1M$$

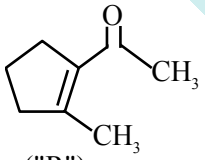
$$t_{1/2} = 200\sqrt{10} \text{ min}$$

* Ist order kinetics have $t_{1/2}$ independent of their concentration. So upon changing the concentration $t_{1/2}$ should not change for first order reaction.

$$\frac{200}{t_{1/2}} = \frac{(0.1)^{1/2}}{(1.6)^{1/2}} \qquad \text{when } A_0 = 1.6 \text{ M}$$

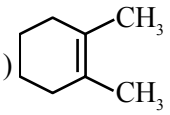
$t_{1/2} = 800$ min

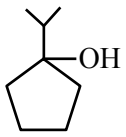
58. A molecule ("P") on treatment with acid undergoes rearrangement and gives ("Q") ("Q") on ozonolysis followed by reflux under alkaline condition gives ("R"). The structure of ("R") is given below :

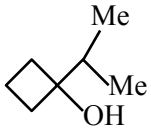


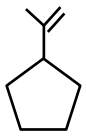
("R")

The structure of **("P")** is

(1) 

(2) 

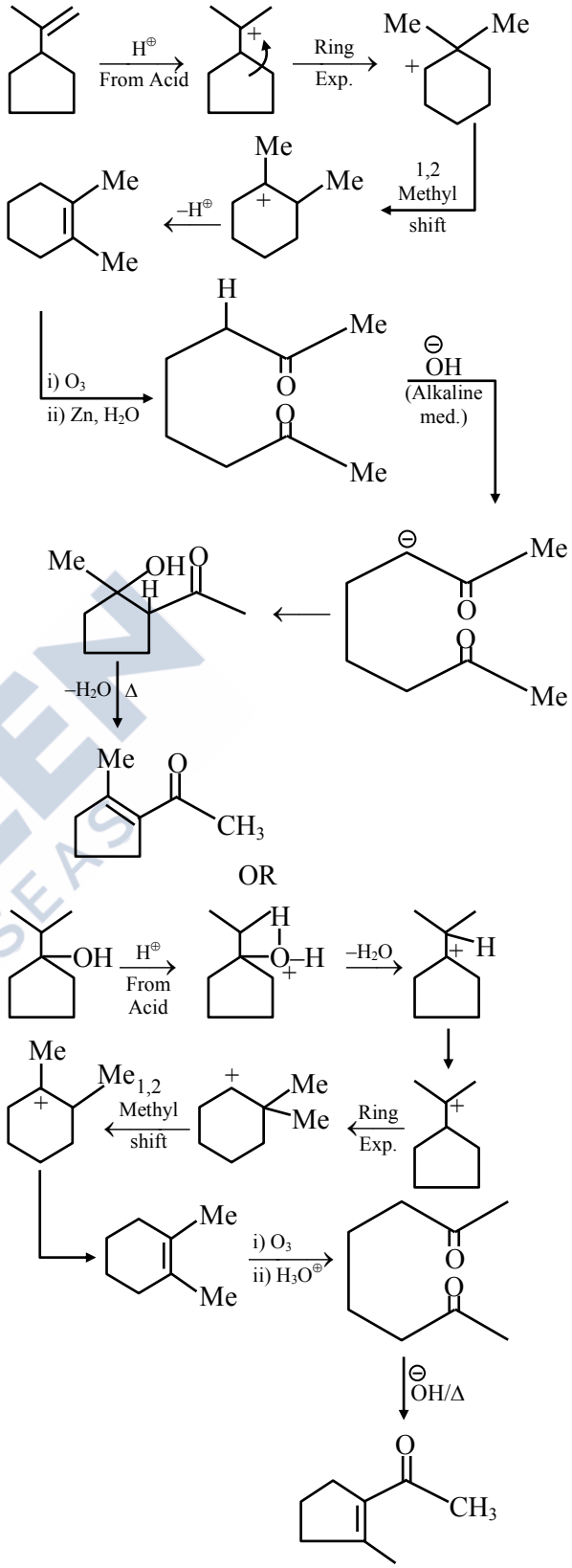
(3) 

(4) 

Allen Ans. (2 or 4)

NTA Ans. (2)

Sol.



Note : In question about molecule "P" is not clarified, weather it is alcohol or alkene and as in question language rearrangement product is asking hence according to question language ans. is either (2) or (4). As alkene also undergoes rearrangement in presence of acid but option (2) also fulfil all conditions.

59. Ice and water are placed in a closed container at a pressure of 1 atm and temperature 273.15 K. If pressure of the system is increased 2 times, keeping temperature constant, then identify correct observation from following :

(1) Volume of system increases.

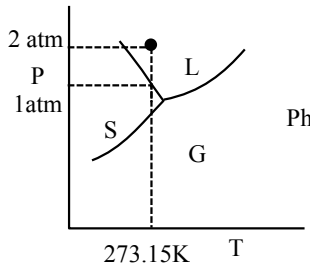
(2) Liquid phase disappears completely.

(3) The amount of ice decreases.

(4) The solid phase (ice) disappears completely.

Ans. **(4)**

Sol.



Phase diagram of H_2O

If pressure is made two time then mixture of ice and water will completely convert into water (liquid) form.

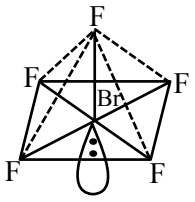
60. The molecules having square pyramidal geometry are

(1) BrF_5 & $XeOF_4$ (2) SbF_5 & $XeOF_4$

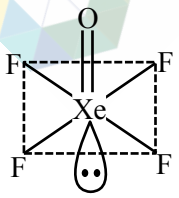
(3) SbF_5 & PCl_5 (4) BrF_5 & PCl_5

Ans. **(1)**

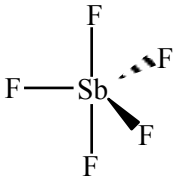
Sol.



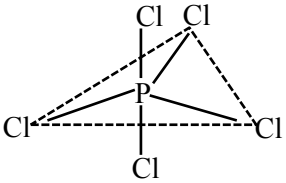
Square pyramidal



Square pyramidal



Trigonal Bipyramidal



Trigonal Bipyramidal

BrF_5 : Square pyramedal

$XeOF_4$: Square pyramedal

SbF_5 : Trigonal bipyramidal

PCl_5 : Trigonal bipyramidal

61. The metal ion whose electronic configuration is not affected by the nature of the ligand and which gives a violet colour in non-luminous flame under hot condition in borax bead test is

(1) Ti^{3+} (2) Ni^{2+}

(3) Mn^{2+} (4) Cr^{3+}

Ans. **(2)**

Sol. Ni^{+2} gives violet colured bead in non-luminous flame under hot conditions. Ni^{+2} has d^8 configuration which does not depend on nature of ligand present in octahedral complex.

$Ni^{+2} : t_{2g}^6 e_g^2$

62. Both acetaldehyde and acetone (individually) undergo which of the following reactions?

A. Iodoform Reaction

B. Cannizaro Reaction

C. Aldol condensation

D. Tollen's Test

E. Clemmensen Reduction

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

(1) A, B and D only (2) A, C and E only

(3) C and E only (4) B, C and D only

Ans. **(2)**

Sol.

S.No.	Name of Reaction	Acetaldehyde $CH_3-\underset{\underset{O}{\|}}{C}-H$	Acetone $CH_3-\underset{\underset{O}{\|}}{C}-CH_3$
1	Iodoform reaction	⊕ve	⊕ve
2	Cannizaro	⊖ve	⊖ve
3	Aldol reaction	⊕ve	⊕ve
4	Tollen's test	⊕ve	⊖ve
5	Clemmensen reduction	⊕ve	⊕ve

Ans. (2) A, C and E only

63. In a multielectron atom, which of the following orbitals described by three quantum numbers with have same energy in absence of electric and magnetic fields?

A. $n = 1, 1 = 0, m_1 = 0$

B. $n = 2, 1 = 0, m_1 = 0$

C. $n = 2, 1 = 1, m_1 = 1$

D. $n = 3, 1 = 2, m_1 = 1$

E. $n = 3, 1 = 2, m_1 = 0$

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

(1) A and B only

(2) B and C only

(3) C and D only

(4) D and E only

Ans. (4)

Sol.

	orbital
A : $n = 1, \ell = 0, m_\ell = 0$	1s
B : $n = 2, \ell = 0, m_\ell = 0$	2s
C : $n = 3, \ell = 1, m_\ell = 1$	3p
D : $n = 3, \ell = 2, m_\ell = 1$	3d
E : $n = 3, \ell = 2, m_\ell = 0$	3d

In absence of electric and magnetic fields, all orbitals of 3d are degenerate

64. The products A and B in the following reactions, respectively are

$$A \xleftarrow{Ag-NO_2} CH_3-CH_2-CH_2-Br \xrightarrow{AgCN} B$$

(1) $CH_3–CH_2–CH_2–ONO$, $CH_3–CH_2–CH_2–NC$

(2) $CH_3–CH_2–CH_2–ONO$, $CH_3–CH_2–CH_2–CN$

(3) $CH_3–CH_2–CH_2–NO_2$, $CH_3–CH_2–CH_2–CN$

(4) $CH_3–CH_2–CH_2–NO_2$, $CH_3–CH_2–CH_2–NC$

Ans. (4)

Sol. $CH_3–CH_2–CH_2–NO_2 \xleftarrow{Ag-NO_2} CH_3–CH_2–CH_2–Br$

(A)

$$\xrightarrow{AgCN} CH_3–CH_2–CH_2–NC$$

(B)

65. What is the freezing point depression constant of a solvent, 50 g of which contain 1 g non volatile solute (molar mass 256 g mol^{-1}) and the decrease in freezing point is 0.40 K?

(1) 5.12 K kg mol^{-1} (2) 4.43 K kg mol^{-1}

(3) 1.86 K kg mol^{-1} (4) 3.72 K kg mol^{-1}

Ans. (1)

Sol. $\Delta T_f = K_b.m$

$$0.4 = K_b \frac{\frac{1}{256}}{50\times10^{-3}}$$

$K_b = 5.12$ K kg / mol

66. Consider the following elements In, Tl, Al, Pb, Sn and Ge.

The most stable oxidation states of elements with highest and lowest first ionisation enthalpies, respectively, are

(1) +2 and +3 (2) +4 and +3

(3) +4 and +1 (4) +1 and +4

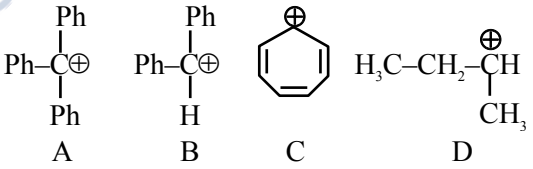
Allen Ans. (2)

NTA Ans. (3)

Sol. Among Al, In, Tl, Ge, Sn, Pb, the metal having highest IE_1 is Ge and lowest IE_1 is In.

Most stable oxidation state of Ge is +4 and In is +3.

67. The correct order of stability of following carbocations is :

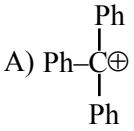
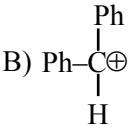


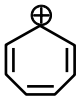
A B C D

(1) A > B > C > D (2) B > C > A > D

(3) C > B > A > D (4) C > A > B > D

Ans. (4)

Sol. A)  B) 

C)  D) $H_3C–CH_2–\overset{\oplus}{C}H–CH_3$

Solution :-

C is aromatic due to ⊕ve charge hence it is most stable

A have more resonance structure

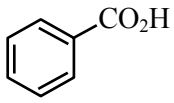
B have less resonance structure

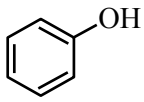
D have only hyper conjugation

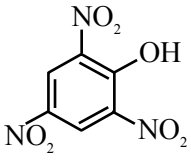
Consider First Aromaticity > Resonance > Hyper conjugation

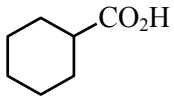
Ans. D < B < A < C

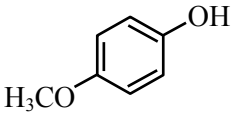
68. The compounds that produce CO_2 with aqueous $NaHCO_3$ solution are :

A. 

B. 

C. 

D. 

E. 

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

(1) A and C only (2) A, B and E only

(3) A, C and D only (4) A and B only

Ans. (3)

Sol. A, C, D produce CO_2 with aqueous $NaHCO_3$ solution.

A, C, D acids are stronger acid than H_2CO_3 (Carbonic acid)

69. Which of the following oxidation reactions are carried out by both $K_2Cr_2O_7$ and $KMnO_4$ in acidic medium ?

A. $I^- \rightarrow I_2$

B. $S^{2-} \rightarrow S$

C. $Fe^{2+} \rightarrow Fe^{3+}$

D. $I^- \rightarrow IO_3^-$

E. $S_2O_3^{2-} \rightarrow SO_4^{2-}$

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

(1) B, C and D only (2) A, D and E only

(3) A, B and C only (4) C, D and E only

Ans. (3)

Sol. $I^- \xrightarrow{H^+} I_2$ $\quad I^- \xrightarrow{OH^-} IO_3^-$

$S^{-2} \xrightarrow{H^+} S$ $\quad S_2O_3^{2-} \xrightarrow{OH^-} SO_4^{2-}$

$Fe^{+2} \longrightarrow Fe^{+3}$

$S_2O_3^{2-} \xrightarrow{H^+} S\downarrow + SO_4^{2-}$

70. Given below are two statements :

Statement I : D-glucose pentaacetate reacts with 2, 4-dinitrophenylhydrazine.

Statement II : Starch, on heating with concentrated sulfuric acid at 100°C and 2-3 atmosphere pressure produces glucose.

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

(1) Both Statement I and Statement II are false

(2) Statement I is false but Statement II is true

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

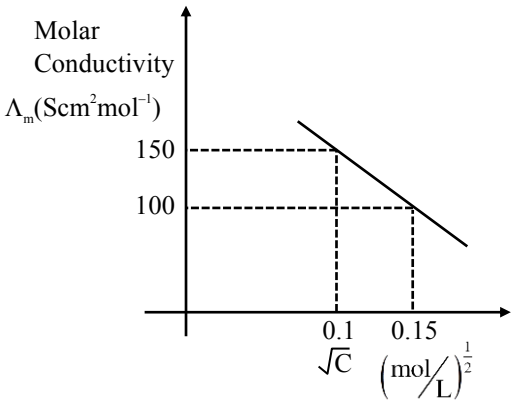
(4) Both Statement I and Statement II are true

Ans. (2)

Sol.

SECTION-B

71. Given below is the plot of the molar conductivity vs $\sqrt{\text{concentration}}$ for KCl in aqueous solution.



If, for the higher concentration of KCl solution, the resistance of the conductivity cell is 100Ω, then the resistance of the same cell with the dilute solution is 'x'Ω.

The value of x is _____ (Nearest integer)

Ans. 150

Sol. $R = \rho\frac{\ell}{A}$

$\kappa = G.G^*$ $\quad G = \frac{1}{R}; \kappa = \frac{1}{\rho}$

$G^* = \frac{\ell}{A}$

R = Resistance

ρ = Resistivity

$\frac{\ell}{A}$ = cell constant (G*)

$\frac{\kappa_c}{\kappa_d} = \frac{R_d}{R_c}$; $\lambda_m = \frac{\kappa \times 1000}{C}$

$\frac{\kappa_c}{\kappa_d} = \frac{(\lambda_m.C)}{(\lambda_m.C)_d} = \frac{R_d}{R_c}$ c = concentrated sol.
d = diluted solution

$\frac{100.(0.15)^2}{150.(0.1)^2} = \frac{R_d}{100}$

$\boxed{R_d = 150\,\Omega}$

72. Quantitative analysis of an organic compound (X) shows following % composition.

C : 14.5% Cl : 64.46%

H : 1.8%

(Empirical formula mass of the compound (X) is _____ × 10^{-1}

(Given molar mass in g mol^{-1} of C : 12, H : 1, O : 16, Cl : 35.5)

Ans. 1655

Sol.

	C	Cl	H	O
%mass	14.5	64.46	1.8	19.24
Molar ratio	$\frac{14.5}{12}$	$\frac{64.46}{35.5}$	$\frac{1.8}{1}$	$\frac{19.24}{16}$
	1.2	1.8	1.8	1.2
Minimum integral ratio	2	3	3	2

Empiricial formula = $C_2H_3Cl_3O_2$

Mass = 165.5

Mass = 1655 × 10^{-1}

73. The molarity of a 70% (mass/mass) aqueous solution of a monobasic acid (X) is _____ M(Nearest integer)

[Given : Density of aqueous solution of (X) is 1.25 g mL^{-1}

Molar mass of the acid is 70 g mol^{-1}]

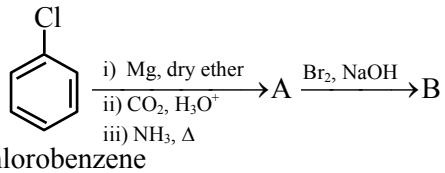
Ans. 125

Sol. Assuming 100 gm solution contain 70 gm solute.

Volume of 100 gm solution will be $\frac{100}{1.25}$ ml.

Molarity = $\frac{70/70}{100/1.25} \times 1000$ = 12.5 or 125 × 10^{-1}

74. Consider the following sequence of reactions :



Chlorobenzene

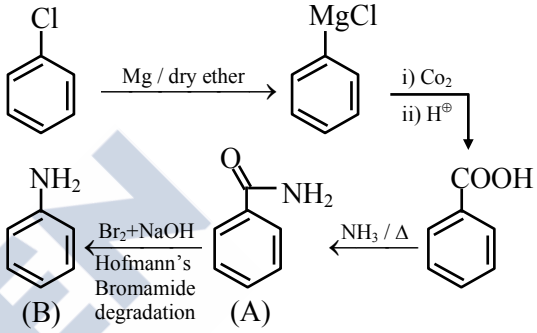
11.25 mg of chlorobenzene will produce _____ × 10^{-1} mg of product B.

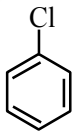
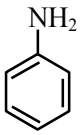
(Consider the reactions result in complete conversion.)

[Given molar mass of C, H, O, N and Cl as 12, 1, 16, 14 and 35.5 g mol^{-1} respectively]

Ans. 93

Sol.



No. of moles of  = No. of moles of 

$\frac{11.25 \times 10^{-3}}{112.5} = \frac{x \times 10^{-1} \times 10^{-3}}{93}$

x × 10^{-1} = 93 × 0.1

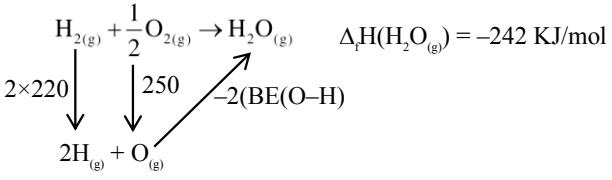
x = 93 mg

75. The formation enthalpies, $\Delta H_f^{\ominus}$ for $H_{(g)}$ and $O_{(g)}$ are 220.0 and 250.0 kJ mol^{-1}, respectively, at 298.15 K, and ΔH_f^- for $H_2O_{(g)}$ is –242.0 kJ mol^{-1} at the same temperature. The average bond enthalpy of the O–H bond in water at 298.15 K is _____ kJ mol^{-1} (nearest integer).

Ans. 466

Sol. $\frac{1}{2}H_{2(g)} \rightarrow H(g)$; $\Delta_f H(H_{(g)}) = 220$ KJ/mol

$\frac{1}{2}O_{2(g)} \rightarrow O(g)$; $\Delta_f H(O_{(g)}) = 250$ KJ/mol



$\Delta H_f(H_2O_{(l)}) = -242 = 440 + 250 - 2(B.E.(O-H))$

$\boxed{BE(O-H) = 466\ KJ/mol}$