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, $\infty \rightarrow 3$

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

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

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

Sol. **(1)**

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

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

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

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

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

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

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

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

Possible series : $\infty \rightarrow 3$

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

(1) PH_3 shows lower proton affinity than NH_3.

(2) PF_3 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)**

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

$E_4^o = ?$

$n_4 = 4$

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

$\Rightarrow -n_4 FE_4^o = -n_1 FE_1^0 - n_2 FE_2^o$

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

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

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

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

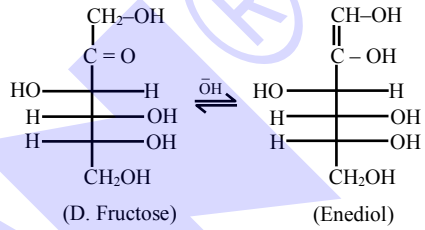
(1) Statement I is false but Statement II is true

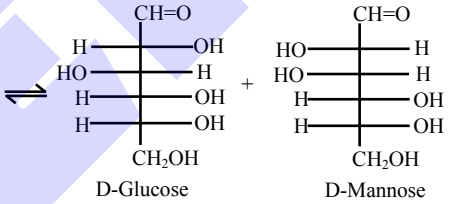
(2) Both Statement I and Statement II are true

(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)**

$$\text{Ice} \rightarrow \text{Ice} \rightleftharpoons \text{Water} \rightarrow \text{Water} \rightleftharpoons \underset{\text{vapour}}{\text{Water}} \rightarrow \underset{\text{vapour}}{\text{Water}}$$

268 K (1) 273 K (2) 273 K (3) 273 K (4) 373 K (5) 383 K

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

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

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

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

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

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)**

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

$\uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow t_{2g}^5 \quad \uparrow e_g^2$

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) $[Co(NH_3)_3Cl_3] \Rightarrow Ma_3b_3$

(ii) $[Co(NH_3)_4Cl_2]^+ \Rightarrow Ma_4b_2$

(iii) $[Co(en)_3]^{3+} \Rightarrow M(AA)_3$

(iv) $[Co(en)_2Cl_2]^+ \Rightarrow M(AA)_2b_2$

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) $CH_3{-}\underset{\displaystyle CH_2{-}OH}{\underset{|}{CH}}{-}CH{=}O$

(3) $CH_3{-}\underset{\displaystyle CH_2{-}OH}{\overset{\displaystyle CH_2{-}OH}{\overset{|}{\underset{|}{C}}}}{-}CH_2{-}OH$

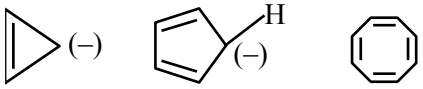
(4) $CH_3{-}\underset{\displaystyle CH_2}{\underset{\|}{C}}{-}CH{=}O$

Sol. **(3)**

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

$$CH_3CH_2CH{=}O \xrightarrow[\text{Alkali}]{2HCHO} CH_3{-}\underset{\displaystyle CH_2{-}OH}{\overset{\displaystyle CH_2{-}OH}{\overset{|}{\underset{|}{C}}}}{-}CHO \xrightarrow[\text{Alkali}]{HCHO} CH_3{-}\underset{\displaystyle CH_2{-}OH}{\overset{\displaystyle CH_2{-}OH}{\overset{|}{\underset{|}{C}}}}{-}CH_2{-}OH + HCOO^{\ominus}$$

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)**

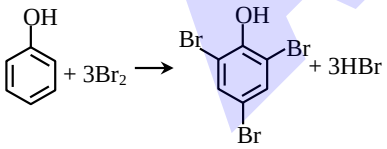
"X" is $CH_3-\overset{*}{C}H(Cl)-CH_2Cl$

$$X \xrightarrow[h\nu]{Cl_2} CH_3-\overset{*}{C}H(Cl)-CH(Cl)-Cl + CH_3-C(Cl)_2-CH_2Cl + Cl-CH_2-CH(Cl)-CH_2-Cl$$

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)**



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

$\therefore$ Moles of bromine = $0.021 \times 3 = 0.064$

$\therefore$ Mass of bromine = $0.064 \times 160 = 10.22$ 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)**

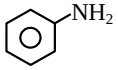
(A) A $\rightarrow$ IV

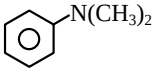
(B) B $\rightarrow$ II

(C) C $\rightarrow$ I

(D) D $\rightarrow$ III

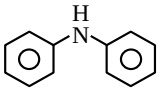
70. Which among the following react with Hinsberg's reagent?

(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. $C_2H_5NH_2(aq) + H_2O \rightleftharpoons C_2H_2NH_3^+ + \overset{\ominus}{O}H$

$C = 10^{-3}$ 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 _____ %.

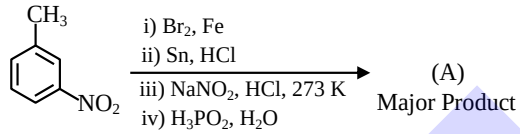
(Given molar mass in g mol^{-1} of Ba : 137, S : 32, O : 16)

Sol. **(40)**

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

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

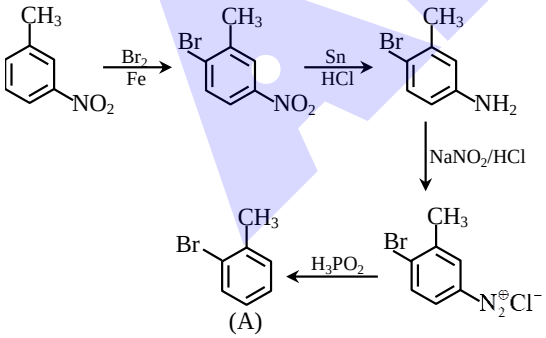
73. Consider the following sequence of reactions to produce major product (A)



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 = _____ $\times 10^{-3}$ 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)

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

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

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

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

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

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)**

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

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

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

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

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

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

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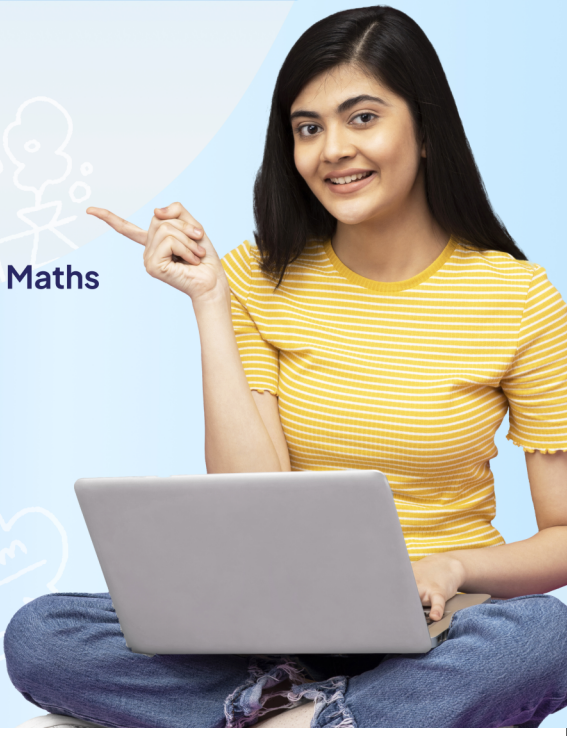

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