JEE (ADVANCED) 2024 PAPER-1

[PAPER WITH SOLUTION]

HELD ON SUNDAY 26 TH MAY 2024

CHEMISTRY

SECTION 1 (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +3 If **ONLY** the correct option is chosen;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : −1 In all other cases.

[Q.1] A closed vessel contains 10 g of an ideal gas **X** at 300 K, which exerts 2 atm pressure. At the same temperature, 80 g of another ideal gas **Y** is added to it and the pressure becomes 6 atm. The ratio of root mean square velocities of **X** and **Y** at 300 K is

[:A] $2\sqrt{2}:\sqrt{3}$ [:B] $2\sqrt{2}:1$ [:C] 1 : 2 [:D] 2 : 1

[ANS] **D**

[SOLN] $P \propto n$

$$P \propto \frac{w}{m}$$

$$m \propto \frac{w}{p}$$

$$\frac{v_{rms_x}}{v_{rms_y}} = \sqrt{\frac{m_y}{m_x}} = \sqrt{\frac{w_y}{p_y} \times \frac{p_x}{w_x}} = \sqrt{\frac{80}{4} \times \frac{2}{10}} = 2:1$$

[Q.2] At room temperature, disproportionation of an aqueous solution of *in situ* generated nitrous acid (HNO_2) gives the species

[:A] H_3O^+, NO_3^- and NO

[:B] H_3O^+, NO_3^- and NO_2

[:C] H_3O^+, NO^- and NO_2

[:D] H_3O^+, NO_3^- and N_2O

[ANS] **A**

[SOLN] Disproportionation OF nitrous acid

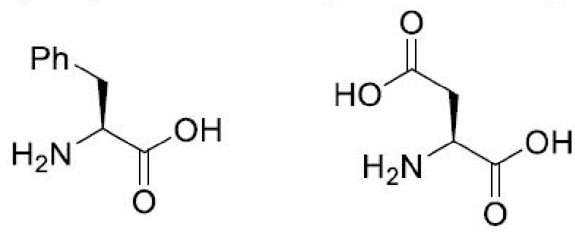
$HNO_2 \rightarrow NO + HNO_3 + H_2O$

Furnish H^+ (duet to High Charge density H^+ exist in form of H_3O+)

H_3O^+, NO_3^-, NO

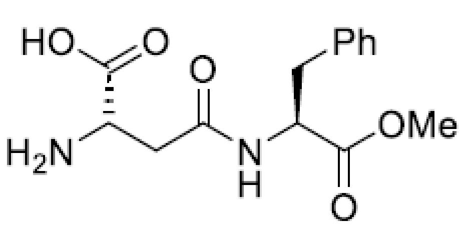
[Q.3] A spartame, an artificial sweetener, is a dipeptide aspartyl phenylalanine methyl ester. The structure of aspartame is

Structures of phenylalanine and aspartic acid are given below.

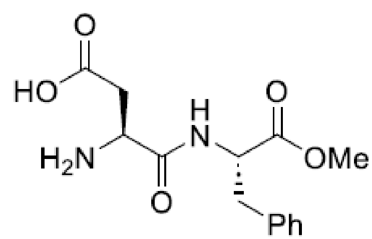


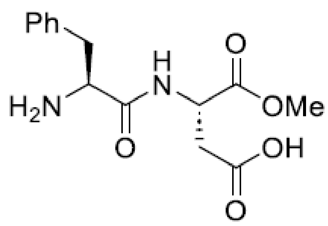
Phenylalanine   Aspartic acid

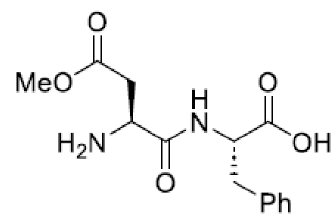
[:A]



[:B]

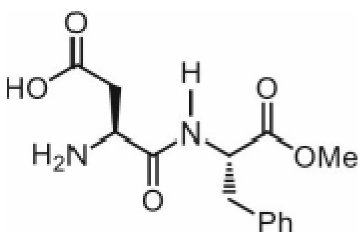


[:C] 

[:D] 

[ANS] **B**

[SOLN] Aspartame is



[Q.4] Among the following options, select the option in which each complex in **Set-I** shows geometrical isomerism and the two complexes in **Set-II** are ionization isomers of each other.

[en = $H_2NCH_2CH_2NH_2$]

[:A] Set-I: $[Ni(CO)_4]$ and $[PdCl_2(PPh_3)_2]$

Set-II: $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5(SO_4)]Cl$

[:B] Set-I: $[Co(en)(NH_3)_2Cl_2]$ and $[PdCl_2(PPh_3)_2]$

Set-II: $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$

[:C] Set-I: $[Co(NH_3)_3(NO_2)_3]$ and $[Co(en)_2Cl_2]$

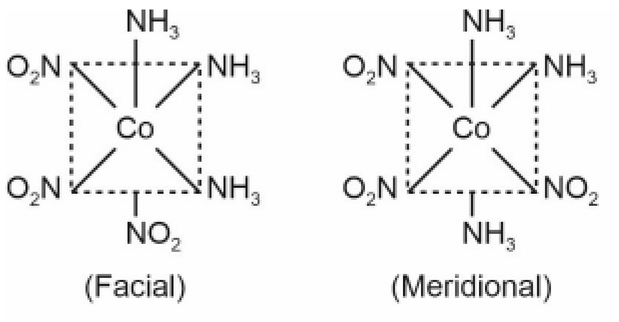
Set-II: $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5(SO_4)]Cl$

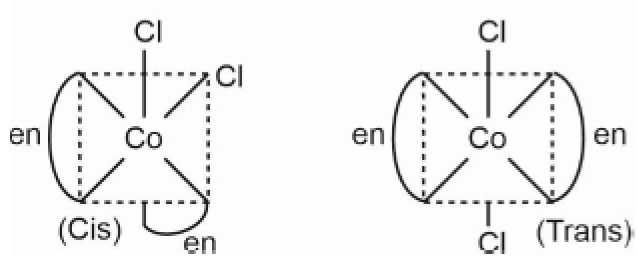
[:D] Set-I: $[Cr(NH_3)_5Cl]Cl_2$ and $[Co(en)(NH_3)_2Cl_2]$

Set-II: $[Cr(H_2O)_6]Cl_3$ and $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$

[ANS] **C**

[SOLN]





Set-II: $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$ are ionisation isomers

SECTION 2 (Maximum Marks: 12)

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks **:** +4 **ONLY** if (all) the correct option(s) is(are) chosen;

  Partial Marks **:** +3 If all the four options are correct but **ONLY** three options are chosen;

  Partial Marks **:** +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

  Partial Marks **:** +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

  Zero Marks **:** 0 If none of the options is chosen (i.e. the question is unanswered);

  Negative Marks **:** −2 In all other cases.
- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then choosing ONLY (A), (B) and (D) will get +4 marks; choosing ONLY (A) and (B) will get +2 marks; choosing

ONLY (A) and (D) will get +2 marks;

choosing ONLY (B) and (D) will get +2 marks; choosing ONLY (A) will get +1 mark; choosing ONLY (B) will get +1 mark;

choosing ONLY (D) will get +1 mark;

choosing no option (i.e. the question is unanswered) will get 0 marks; and

choosing any other combination of options will get −2 marks.

[Q.5] Among the following, the correct statement(s) for electrons in an atom is(are)

[:A] Uncertainty principle rules out the existence of definite paths for electrons.

[:B] The energy of an electron in 2*s* orbital of an atom is lower than the energy of an electron that is infinitely far away from the nucleus.

[:C] According to Bohr's model, the most negative energy value for an electron is given by n = 1, which corresponds to the most stable orbit.

[:D] According to Bohr's model, the magnitude of velocity of electrons increases with increase in values of n.

[:ANS] **ABC**

[SOLN]

$$\Delta X.\Delta P \geq \frac{h}{4\pi}$$

There must be error in position & momentum

$$E = -13.6 \text{ ev. } \frac{Z^2}{n^2}$$

n high, E : high

$$(n \to \infty, E = 0)$$

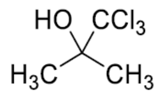
$$v = 2.178 \times 10^6 \text{ m/s} \frac{z}{n}$$

As n increases, v decreases.

[Q.6] Reaction of *iso*-propylbenzene with O_2 followed by the treatment with H_3O^+ forms phenol and a by-product **P**. Reaction of **P** with 3 equivalents of Cl_2 gives compound **Q**. Treatment of **Q** with

$Ca(OH)_2$ produces compound **R** and calcium salt **S**. The correct statement(s) regarding **P**, **Q**, **R** and **S** is(are)

[:A] Reaction of **P** with **R** in the presence of KOH followed by acidification gives



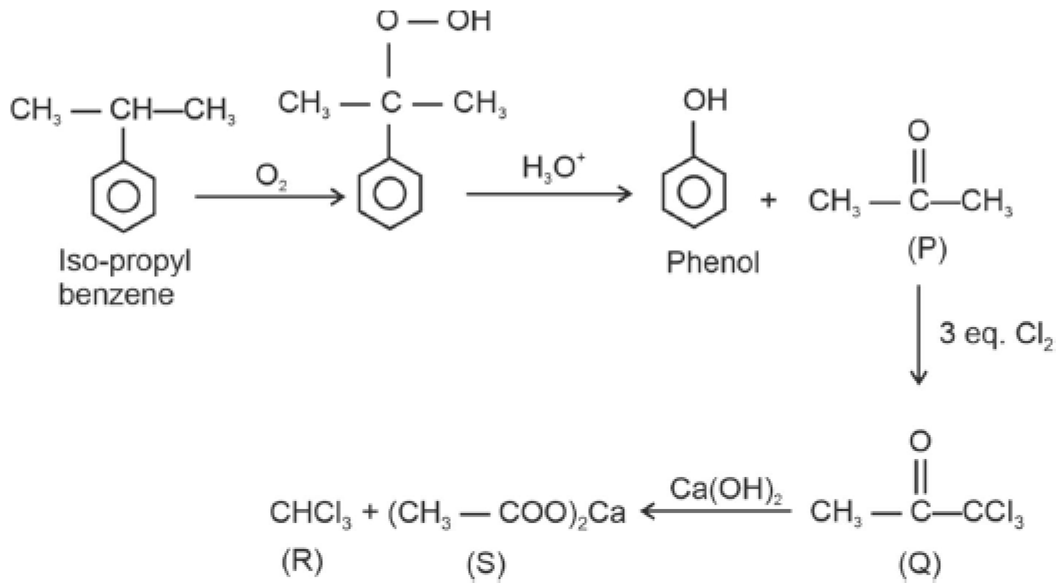
[:B] Reaction of **R** with O_2 in the presence of light gives phosgene gas

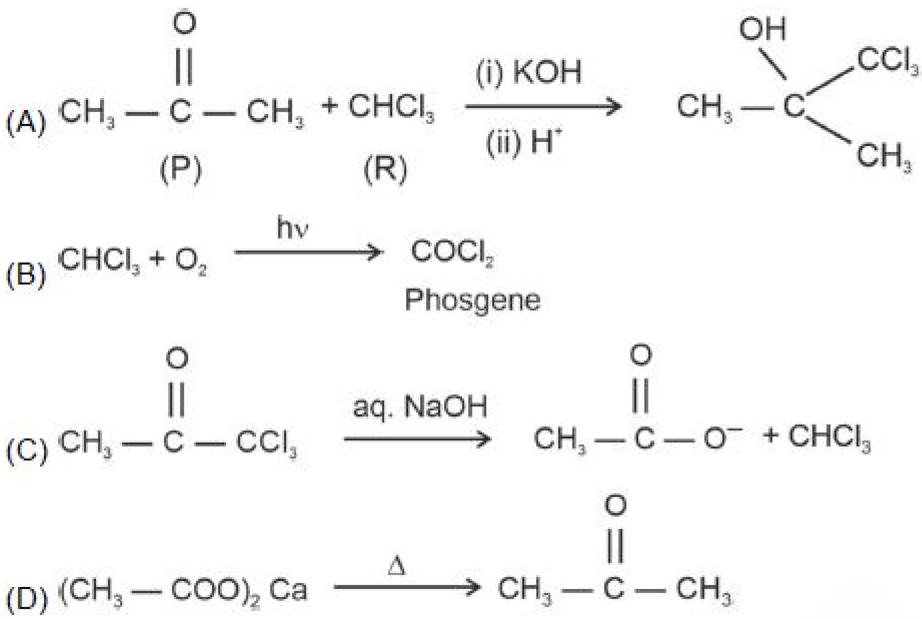
[:C] **Q** reacts with aqueous NaOH to produce Cl_3CCH_2OH and $Cl_3CCOONa$

[:D] **S** on heating gives **P**

[ANS] **ABD**

[SOLN]





[Q.7] The option(s) in which at least three molecules follow Octet Rule is(are)

[:A] CO_2, C_2H_4, NO and HCl

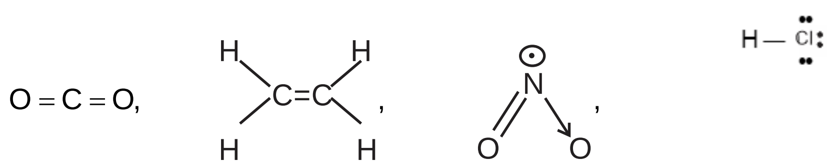
[:B] NO_2, O_3, HCl and H_2SO_4

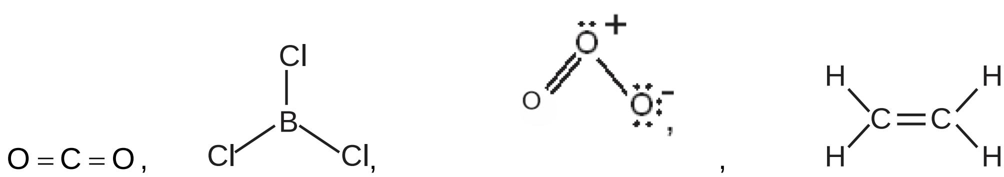
[:C] BCl_3, NO, NO_2 and H_2SO_4

[:D] CO_2, BCl_3, O_3 and C_2H_4

[ANS] **AD**

[SOLN]



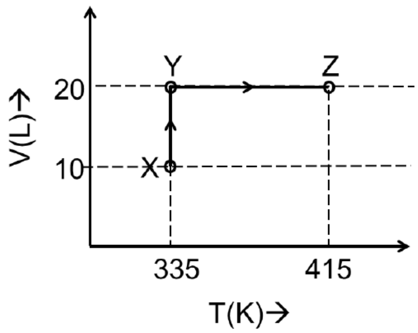
(D) 

SECTION 3 (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**.

• For each question, enter the correct integer corresponding to the answer using the mouse and the onscreen
virtual numeric keypad in the place designated to enter the answer.
• Answer to each question will be evaluated according to the following marking scheme: *Full Marks* : +4 If **ONLY** the correct integer is entered; *Zero Marks* : 0 In all other cases.

[Q.8] Consider the following volume−temperature (V−T) diagram for the expansion of 5 moles of an ideal monoatomic gas.



Considering only P-V work is involved, the total change in enthalpy (in Joule) for the transformation of state in the sequence $X \to Y \to Z$ is ______. [Use the given data: Molar heat capacity of the gas for the given temperature range, $C_{V,m} = 12\,JK^{-1}mol^{-1}$ and gas constant, $R = 8.3\,JK^{-1}mol^{-1}$]

[ANS] **8120**

[SOLN] $\Delta H = \Delta H_{xy} + \Delta H_{yz}$

$\Delta H_{xy} = 0$ (Isothermal process)

$\Delta H = \Delta H_{yz} = nc_p\Delta T = 5 \times (12 + 8.3) \times 80 = 8120J$

[Q.9] Consider the following reaction,

$$2H_2(g) + 2NO(g) \longrightarrow N_2(g) + 2H_2O(g)$$

which follows the mechanism given below:

$$2NO(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2(g) \qquad \text{(fast equilibrium)}$$

$$N_2O_2(g) + H_2(g) \xrightarrow{k_2} N_2O(g) + H_2O(g) \quad \text{(slow reaction)}$$

$$N_2O(g) + H_2(g) \xrightarrow{k_3} N_2(g) + H_2O(g) \quad \text{(fast reaction)}$$

The order of the reaction is ______.

[ANS] **3**

[SOLN] 2nd step is Rds

From 2nd step

Rate : $K_2[N_2O_2]^1[H_2]^1$ ....(1)

From 1st eq step

$$K_{eq} = \frac{[N_2O_2]}{[NO]^2}$$

$$[N_2O_2] = K_{eq}[NO]^2$$

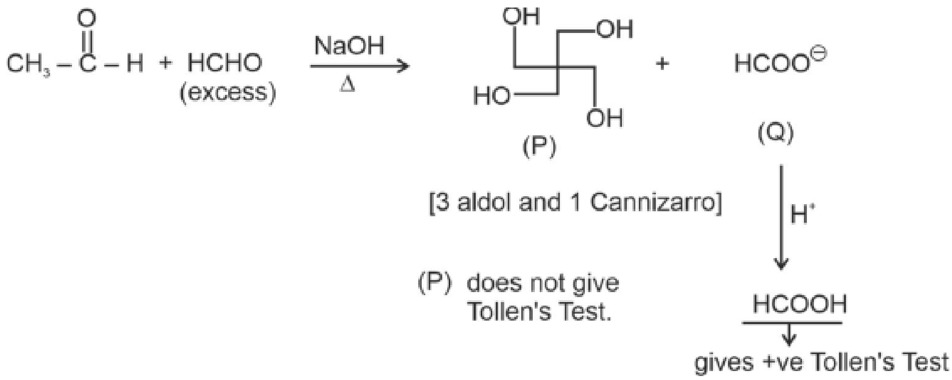
(1) $\Rightarrow$ Rate $K_2 \cdot Keq[NO]^2[H_2]^1$

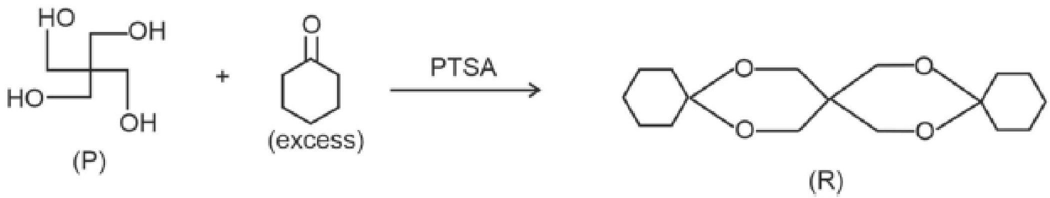
Order of reaction = 2 + 1 = 3

[Q.10] Complete reaction of acetaldehyde with excess formaldehyde, upon heating with conc. NaOH solution, gives **P** and **Q**. Compound **P** does not give Tollens' test, whereas **Q** on acidification gives positive Tollens' test. Treatment of **P** with excess cyclohexanone in the presence of catalytic amount of *p*-toluenesulfonic acid (PTSA) gives product **R**. Sum of the number of methylene groups ($-CH_2-$) and oxygen atoms in **R** is _

[ANS] **18**

[SOLN]





Number of CH_2 groups in R = 14

Number of O-atoms = 4

Required Answer = 14 + 4 = 18

[Q.11] Among $V(CO)_6$, $Cr(CO)_5$, $Cu(CO)_3$, $Mn(CO)_5$, $Fe(CO)_5$, $[Co(CO)_3]^{3-}$, $[Cr(CO)_4]^{4-}$, and $Ir(CO)_3$ the total number of species isoelectronic with $Ni(CO)_4$ is ______.

[Given, atomic number: V = 23, Cr = 24, Mn = 25, Fe = 26, Co = 27, Ni = 28, Cu = 29, Ir = 77]

[ANS] **3**

[SOLN]

$[v(CO)_6] - 35(17)$

$[Cr(CO)_5] - 34(16)$

$[Mn(CO)_5] - 37(19)$

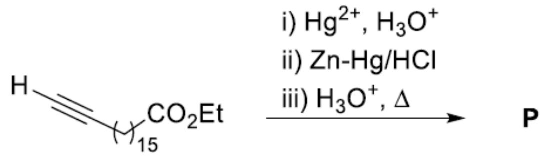
$\boxed{[Fe(CO)_5 - 36(18)}$

$\boxed{[Co(CO)_3]^{3-} - 36(18)}$

$[Ir(CO)_3] - 83(15)$

$\boxed{[Cr(CO)_4]^{4-} = 36(18)}$

[Q.12] In the following reaction sequence, the major product **P** is formed.

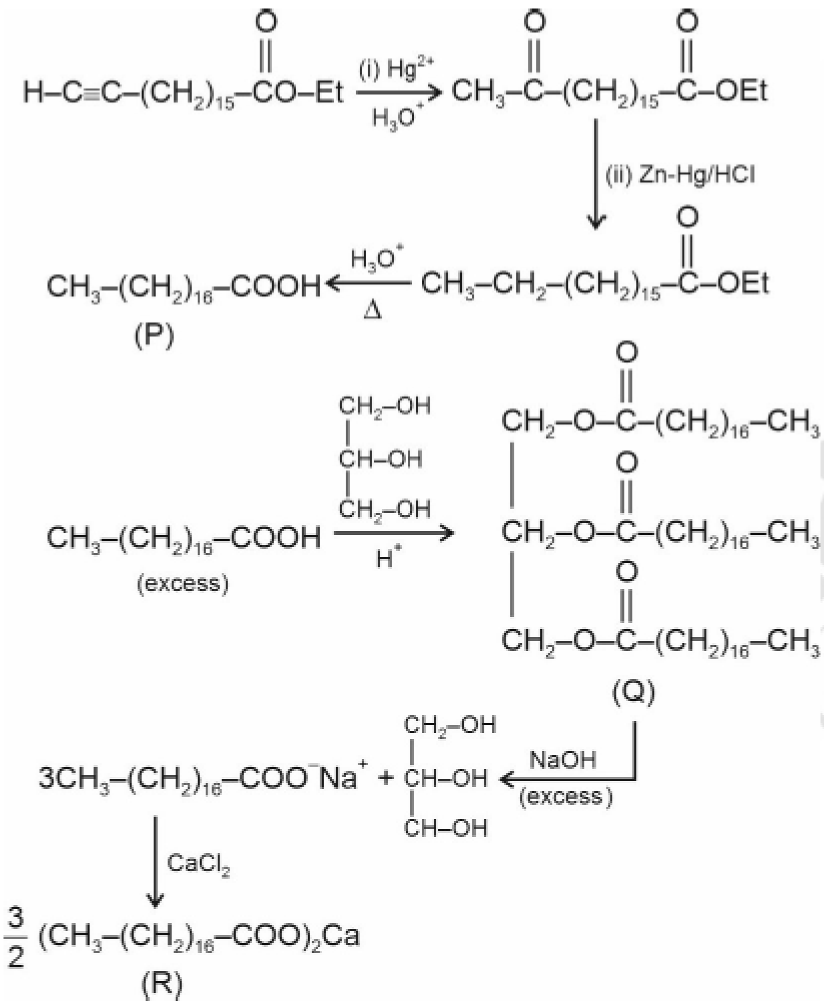


Glycerol reacts completely with excess **P** in the presence of an acid catalyst to form **Q**. Reaction of **Q** with excess NaOH followed by the treatment with $CaCl_2$ yields Ca-soap **R**, quantitatively. Starting with one mole of **Q**, the amount of **R** produced in gram is ______.

[Given, atomic weight: H = 1, C = 12, N = 14, O = 16, Na = 23, Cl = 35, Ca = 40]

[ANS] **909**

[SOLN]



1 mole of Q will give 1.5 mole of R.
So, mass of R produced = 606 g × 1.5 = 909 g

[Q.13] Among the following complexes, the total number of diamagnetic species is ______.

$\left[Mn(NH_3)_6\right]^{3+}, [MnCl_6]^{3-}, [FeF_6]^{3-}, [CoF_6]^{3-}, \left[Fe(NH_3)_6\right]^{3+}$, and $\left[Co(en)_3\right]^{3+}$

[Given, atomic number: Mn = 25, Fe = 26, Co = 27; en = $H_2NCH_2CH_2NH_2$]

[ANS] **1**

[SOLN]

$[Mn(NH_3)_6]^{3+}$ — $Mn^{3+} - 3d^4$ $\frac{n}{2}$ (Para)

$[MnCl_6]^{3-}$ — $Mn^{3+} - 3d^4$ 4 (Para)

$[FeF_6]^{3-}$ — $Fe^{3+} - 3d^5$ 5 (Para)

$[CoF_6]^3$ — $CO^{3+} - 3d^6$ 4 (Para)

$[Fe(NH_3)_6]^{3+}$ — $Fe^{3+} - 3d^5$ 1 (Para)

$[Co(enl_3)^{3+}$ — $Co^{3+} - 3d^6$ 0 (Dia)

SECTION 4 (Maximum Marks: 12)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : +3 **ONLY** if the option corresponding to the correct combination is chosen;
  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
  Negative Marks : −1 In all other cases.

[:Q.14] In a conductometric titration, small volume of titrant of higher concentration is added stepwise to a larger volume of titrate of much lower concentration, and the conductance is measured after each addition.

The limiting ionic conductivity (Λ0) values (in mS m^2 mol^{-1}) for different ions in aqueous solutions are given below:

Ions	Ag^+	K^+	Na^+	H^+	NO_3^-	Cl^-	SO_4^{2-}	OH^-	CH_3COO^-
Λ_0	6.2	7.4	5.0	35.0	7.2	7.6	16.0	19.9	4.1

For different combinations of titrates and titrants given in **List-I,** the graphs of 'conductance' versus 'volume of titrant' are given in **List-II.**

Match each entry in List-I with the appropriate entry in List-II and choose the correct option.

List- I

(P) Titrate: KCl

Titrant : $AgNO_3$

(Q) Titrate: $AgNO_3$

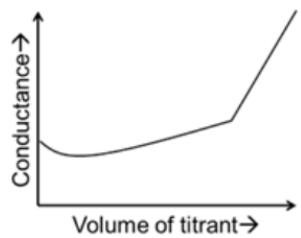
Titrant : KCl

(R) Titrate: NaOH

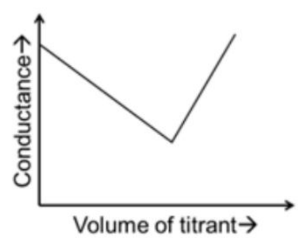
Titrant : HCl

List – II

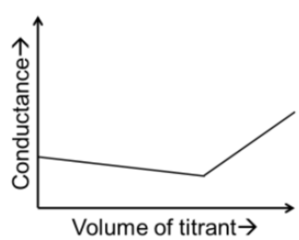
(1)



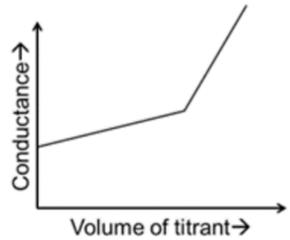
(2)



(3)

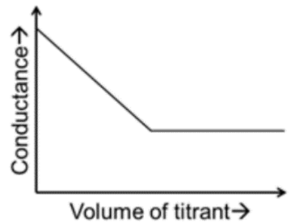


(S) Titrate: NaOH (4)



Titrant: CH_3COOH

(5)



[:A] P-4, Q-3, R-2, S-5

[:B] P-2, Q-4, R-3, S-1

[:C] P-3, Q-4, R-2, S-5

[:D] P-4, Q-3, R-2, S-1

[:ANS] **C**

[:SOLN] (P) $\underset{\text{(added)}}{KCl + AgNO_3} \rightarrow AgCl\downarrow + KNO_3$

Till eq. point, no. of ions remain same but Cl^- is being replaced by NO_3^-.

Since NO_3^- has slightly lower conductance than Cl^- so, conductance decreases slowly & then after equivalence point, conductance increases sharply.

Correct graphs is (3) : $P \rightarrow 3$

(Q) $AgNO_3 + KCl \longrightarrow AgCl\downarrow + KNO_3$

(added)

before eq. point Ag^+ is replaced by K^+

K^+ has higher conductance than Aq^+. So, conductance increases slowly & then after eq. point no. of ions increases & SO, conductance increases sharply.

Correct graph is (4) : $Q \rightarrow 4$

(R) $NaOH + HCl\ (added) \rightarrow NaCl + H_2O$

Till eq. point no. of ions remain same but Na^+ is being replaced by H^+. Since Na^+ has very low conductance compare to H^+ ions. So, conductance decreases first & after eq. point increases sharply as no no. of ions increases.

$R \rightarrow (2)$

(S) $NaOH + \underset{(added)}{CH_3COOH} \rightarrow CH_3COONa + H_2O$

Till equivalence point, no. of ions remain same but OH^- is being replaced by CH_3COOH^-. So, conductance decreases.

After equivalence point, no. of ions remain same, so, conductance remain same.

$S \rightarrow 5$

[:Q.15] Based on VSEPR model, match the xenon compounds given in List-I with the corresponding geometries and the number of lone pairs on xenon given in List-II and choose the correct option.

List- I	**List – II**
(P) XeF_2	(1) Trigonal bipyramidal and two lone pair of electrons
(Q) XeF_4	(2) Tetrahedral and one lone pair of electrons
(R) XeO_3	(3) Octahedral and two lone pair of electrons
(S) XeO_3F_2	(4) Trigonal bipyramidal and no lone pair of electrons
	(5) Trigonal bipyramidal and three lone pair of electrons

[:A] P-5, Q-2, R-3, S-1

[:B] P-5, Q-3, R-2, S-4

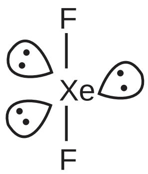
[:C] P-4, Q-3, R-2, S-1

[:D] P-4, Q-2, R-5, S-3

[:ANS] **B**

[:SOLN]

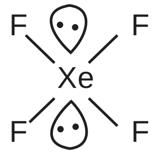
(p) $\frac{XeF_2}{F}$ (q) XeF_4 (r) XeO_3 (s) XeO_3F_2



TBP

3lp

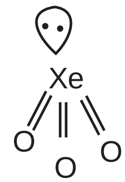
P–5



Octahedral

2lp

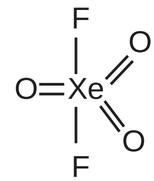
q – 3



Tetrahedral

1 lp

r – 2



TBP

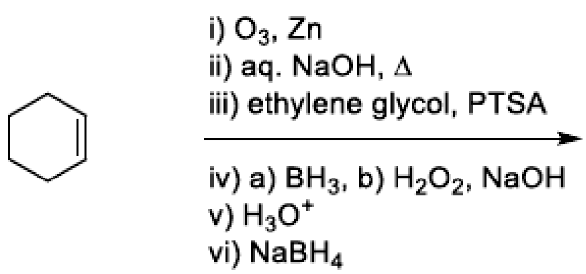
nolp

S–4

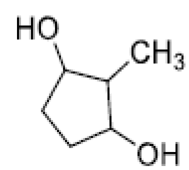
[:Q.16] **List-I** contains various reaction sequences and **List-II** contains the possible products. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

List- I **List – II**

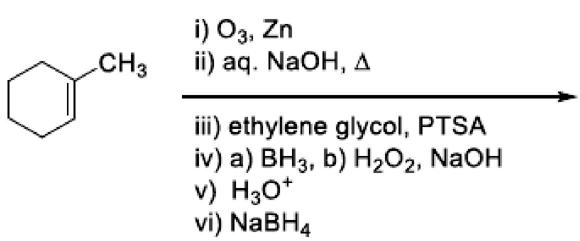
(P)



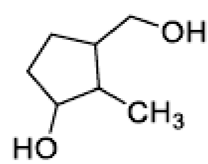
(1)



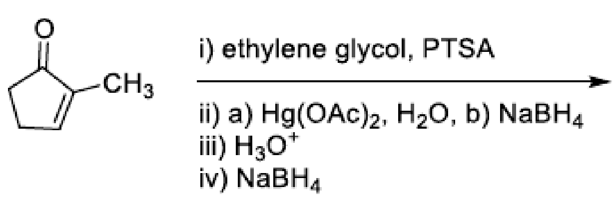
(Q)



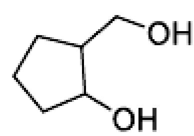
(2)

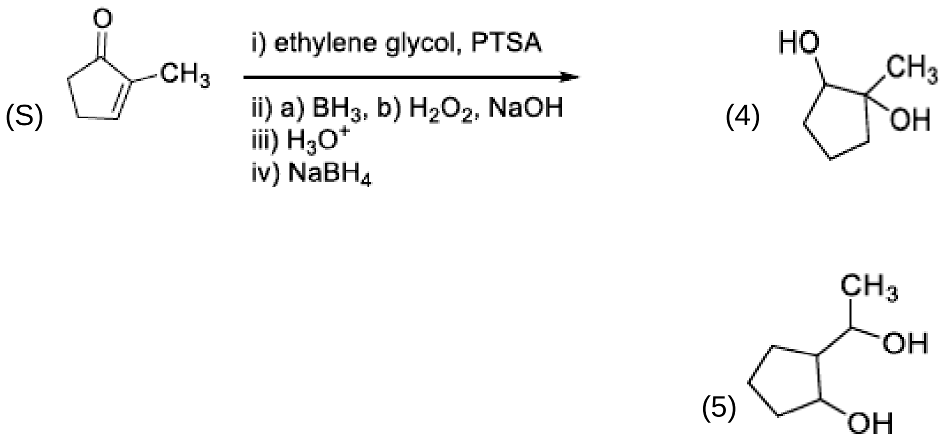


(R)



(3)





[:A] P-3, Q-5, R-4, S-1

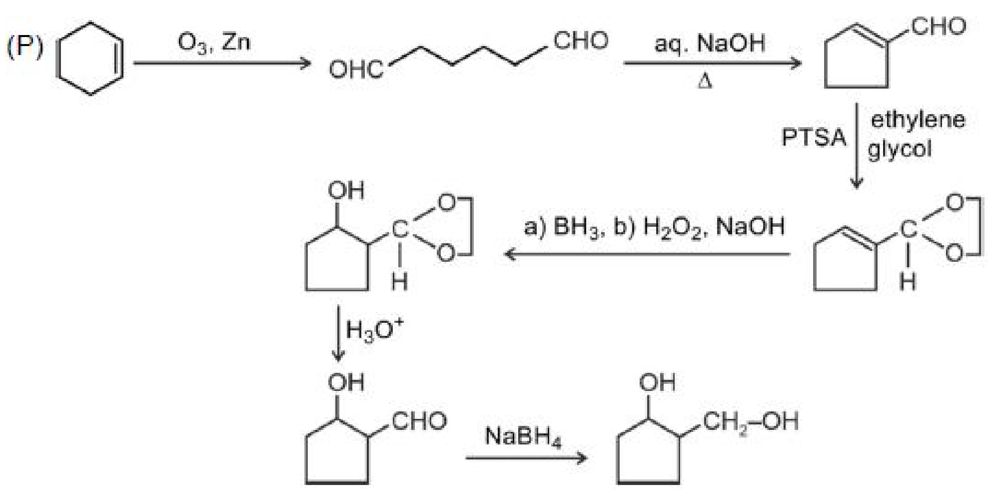
[:B] P-3, Q-2, R-4, S-1

[:C] P-3, Q-5, R-1, S-4

[:D] P-5, Q-2, R-4, S-1

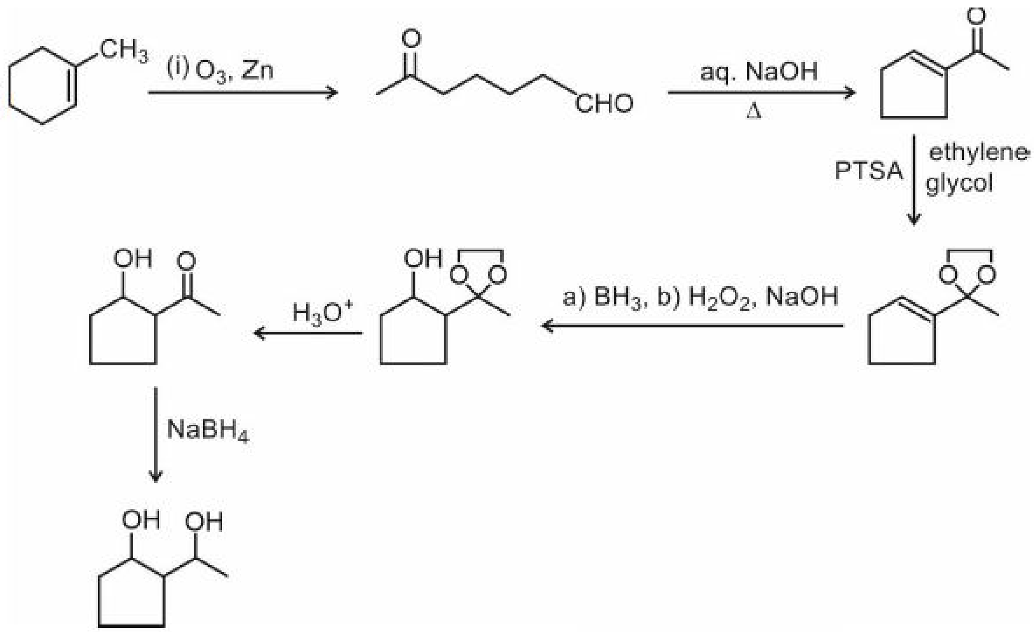
[:ANS] A

[:SOLN]

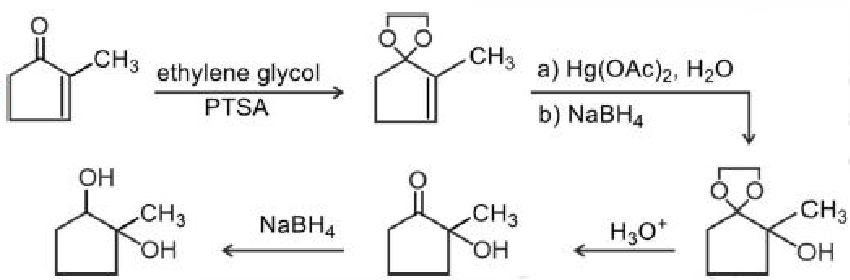


P3

(Q)

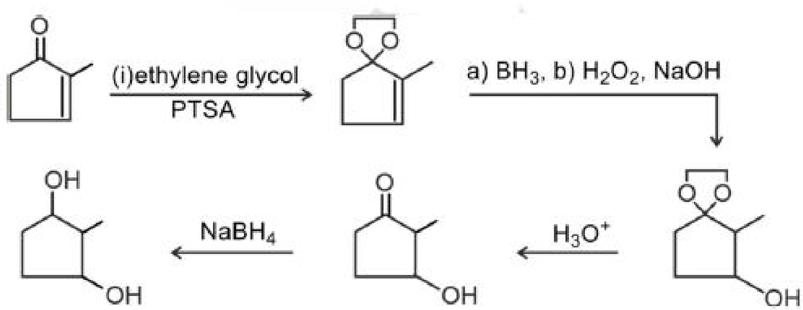

CH3
(i) O3, Zn
CHO
aq. NaOH
Δ
PTSA
ethylene
glycol
a) BH3, b) H2O2, NaOH
OH
H3O+
NaBH4
OH OH

(R)


CH3
ethylene glycol
PTSA
a) Hg(OAc)2, H2O
b) NaBH4
H3O+
OH
NaBH4

R-4

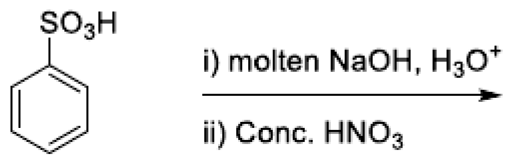
(S)


(i)ethylene glycol
PTSA
a) BH3, b) H2O2, NaOH
H3O+
NaBH4
OH

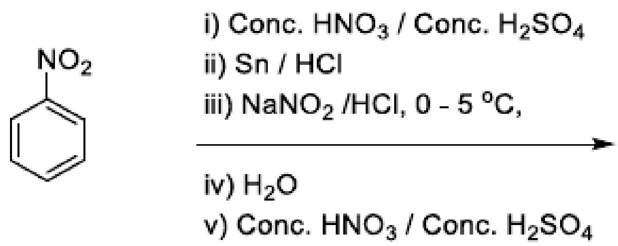
[:Q.17] **List-I** contains various reaction sequences and **List-II** contains different phenolic compounds. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

List- I

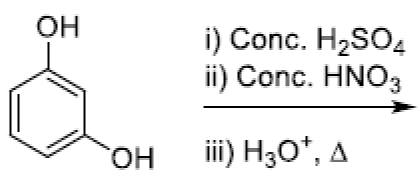
(P)



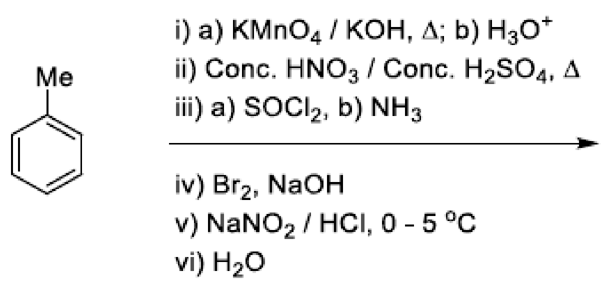
(Q)



(R)

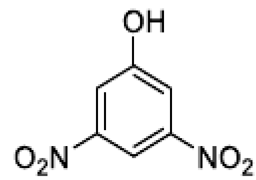


(S)

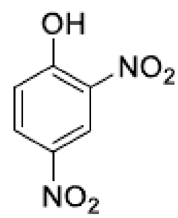


List – II

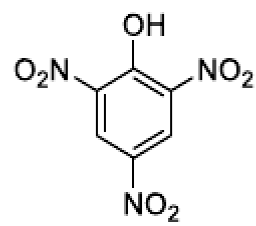
(1)



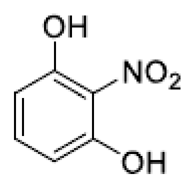
(2)



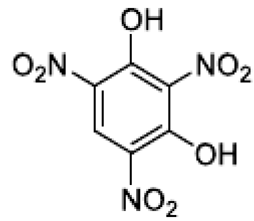
(3)



(4)



(5)



[:A] P-2, Q-3, R-4, S-5

[:B] P-2, Q-3, R-5, S-1

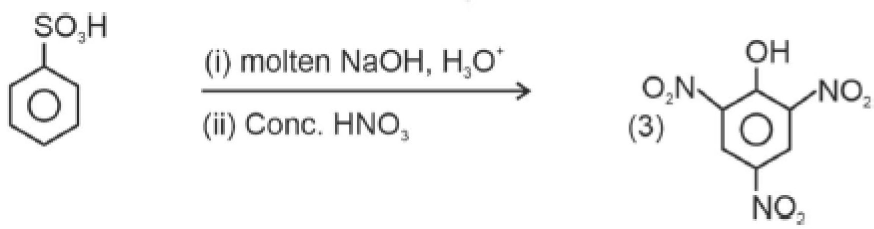
[:C] P-3, Q-5, R-4, S-1

[:D] P-3, Q-2, R-5, S-4

[:ANS] **C**

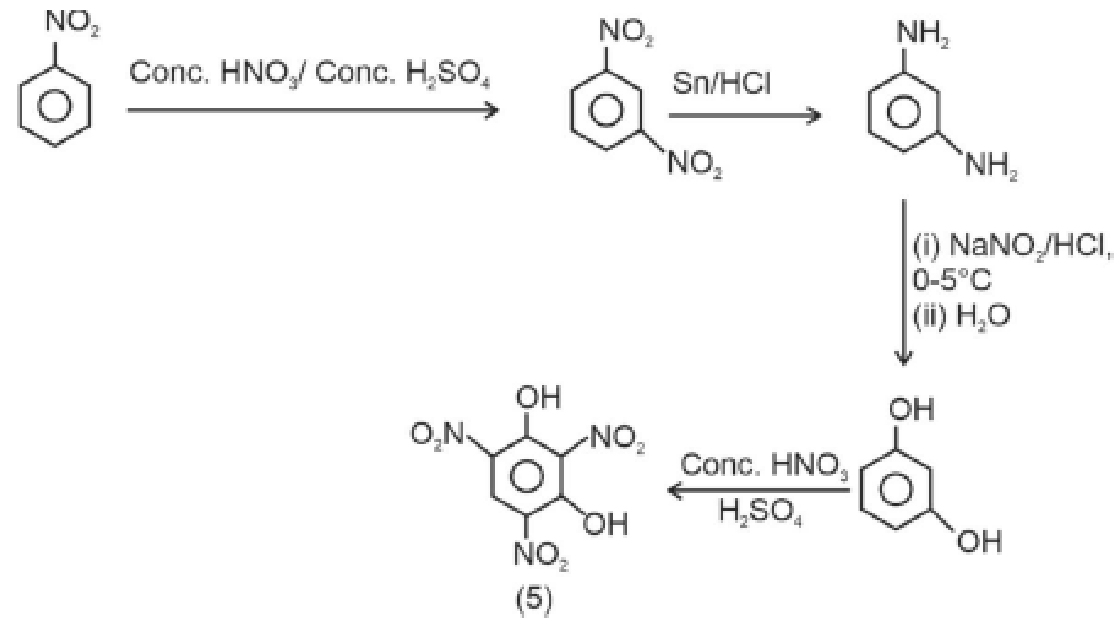
[:SOLN]

(P)

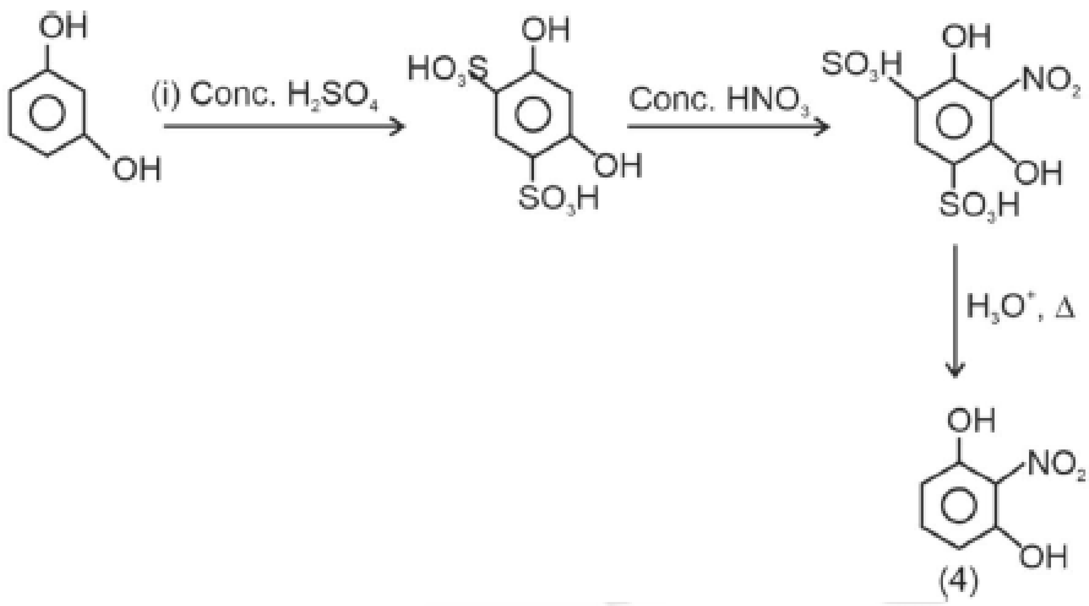


(3)

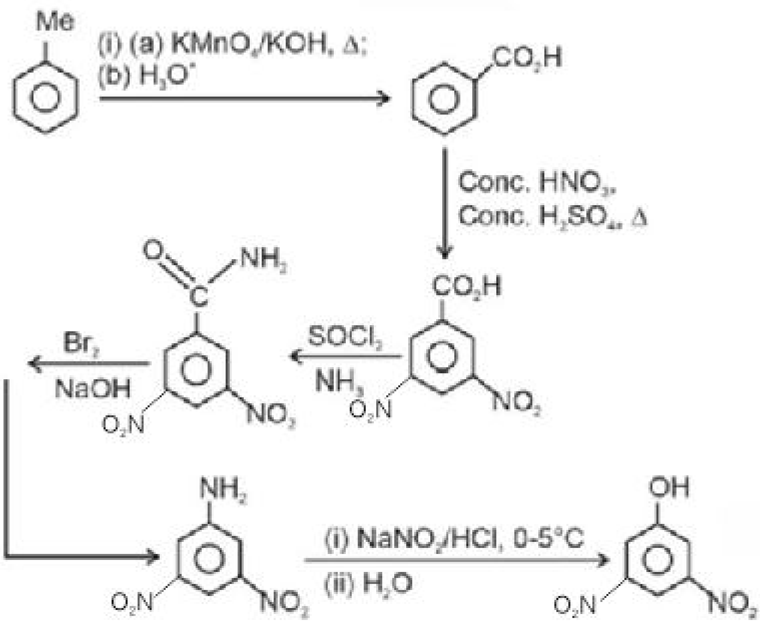
(Q)


NO2
Conc. HNO3/ Conc. H2SO4
NO2
NO2
Sn/HCl
NH2
NH2
(i) NaNO2/HCl,
0-5°C
(ii) H2O
OH
OH
Conc. HNO3
H2SO4
OH
O2N
NO2
OH
NO2
(5)

(R)


OH
OH
(i) Conc. H2SO4
HO3S
OH
OH
SO3H
Conc. HNO3
SO3H
OH
NO2
OH
SO3H
H3O+, Δ
OH
NO2
OH
(4)

(S)



Me
(i) (a) KMnO4/KOH, Δ;
(b) H3O+
CO2H
Conc. HNO3,
Conc. H2SO4, Δ
CO2H
O2N
NO2
SOCl2
NH3
O
NH2
C
O2N
NO2
Br2
NaOH
NH2
O2N
NO2
(i) NaNO2/HCl, 0-5°C
(ii) H2O
OH
O2N
NO2