JEE Adv. August 2022

Question Paper With Text Solution

28 August | Paper-1

CHEMISTRY

MATRIX

JEE Main & Advanced | XI-XII Foundation| VI-X Pre-Foundation

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JEE ADV. AUGUST 2022 | 28TH. AUGUST PAPER-1

SECTION 1 (Maximum Marks: 24)

- This section contains EIGHT (08) questions.
- The answer to each question is a NUMERICAL VALUE.
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +3 ONLY if the correct numerical value is entered;

  Zero Marks : 0 In all other cases.

1. 2 mol of Hg(g) is combusted in a fixed volume bomb calorimeter with excess of O_2 at 298 K and 1 atm into HgO(s). During the reaction, temperature increases from 298.0 K to 312.8 K. If heat capacity of the bomb calorimeter and enthalpy of formation of Hg(g) are 20.00 kJ K^{-1} and 61.32 kJ mol^{-1} at 298 K, respectively, the calculated standard molar enthalpy of formation of HgO(s) at 298 K is X kJ mol^{-1}. The value of |X| is _____.

   [Given: Gas constant R = 8.3 J K- 1 mol- 1]

Ans. –90.39

Sol. $Hg(g) + \frac{1}{2}O_2(g) \rightarrow HgO(s)$ ..... (1)

$q_V = C\Delta T$

$= 20\,(312.8 - 298) = 296$ kJ

$$\Delta U = -\frac{296}{2} = -148\,kJ/mole$$

$\Delta H = \Delta U + \Delta n_g RT$

$$\Delta H = -148 + \frac{\left(-\frac{3}{2}\right)\times 8.3\times 298}{1000} = -151.71kJ$$

For reaction ..... (1)

$\Delta H = \Delta H_f(HgO, s) - \Delta H_f(Hg, g)$

$-151.71 = \Delta H_f(HgO, s) - 61.32$

$\Rightarrow \Delta H_f(HgO, s) = -90.39$

2. The reduction potential (E^0, in V) of MnO_4^-(aq)/Mn(s) is _____.

[Given: $E^0_{(MnO_4^-(aq)/MnO_2(s))} = 1.68$ V; $E^0_{(MnO_2(s)/Mn^{2+}(aq))} = 1.21$ V; $E^0_{(Mn^{2+}(aq)/Mn(s))} = -1.03$ V]

Ans. 0.77

Sol. $4H^+(aq) + MnO_4^-(aq) + 3e^- \rightarrow MnO_2(s) + 2H_2O(l)$ $\quad \Delta G_1^\circ = -3F \times 1.68$

$2e^- + 4H^+(aq) + MnO_2(s) \rightarrow Mn^{2+}(aq) + 2H_2O(l)$ $\quad \Delta G_2^\circ = -2F \times 1.21$

$2e^- + Mn^{2+}(aq) \rightarrow Mn(s)$ $\quad \Delta G_3^\circ = -2F\ (-1.03)$

$7e^- + 8H^+(aq) + MnO_4^-(aq) \rightarrow Mn(s) + 4H_2O(l)$ $\quad \Delta G^\circ = -7FE^\circ$

$\Delta G^\circ = \Delta G_1^\circ + \Delta G_2^\circ + \Delta G_3^\circ$

$-7FE^\circ = -3F \times 1.68 - 2F \times 1.21 + 2F \times 1.03$

$$E^\circ = \frac{3\times1.68 + 2\times1.21 - 2\times1.03}{7} = 0.77$$

3. A solution is prepared by mixing 0.01 mol each of H_2CO_3, $NaHCO_3$, Na_2CO_3, and NaOH in 100 mL of water. pH of the resulting solution is _____.

[Given: pK_{a1} and pK_{a2} of H_2CO_3 are 6.37 and 10.32, respectively; log 2 = 0.30]

Ans. 10.02

Sol. $H_2CO_3 + NaOH \rightarrow NaHCO_3 + H_2O$

0.01 0.01

0 0 0.01

Finally solution will contain

0.02 mole $NaHCO_3$ and 0.01 mole Na_2CO_3. Hence final solution is a buffer of HCO_3^- and CO_3^{2-}

$$pH = 10.32 + \log\frac{0.01}{0.02}$$

$= 10.32 - 0.3$

$= 10.02$

4. The treatment of an aqueous solution of 3.74 g of $Cu(NO_3)_2$ with excess KI results in a brown solution along with the formation of a precipitate. Passing H_2S through this brown solution gives another precipitate X. The amount of X (in g) is _____.

[Given: Atomic mass of H = 1, N = 14, O = 16, S = 32, K = 39, Cu = 63, I = 127]

Ans. 0.32

Sol. $Cu^{2+} + I^- \rightarrow Cu^+ + I_2$

$I_2 + H_2S \rightarrow S + I^-$

equivalent of Cu^{2+} = equivalent of S

$$\frac{3.74}{187.5}\times1 = x\times2$$

$x = 9.97 \times 10^{-3}$ mole
Mass of 'S' $= 9.97 \times 10^{-3} \times 32$
$= 0.319$ gm
$= 0.32$ gm

5. Dissolving 1.24 g of white phosphorous in boiling NaOH solution in an inert atmosphere gives a gas Q. The amount of $CuSO_4$ (in g) required to completely consume the gas Q is _____.

[Given: Atomic mass of H = 1, O = 16, Na = 23, P = 31, S = 32, Cu = 63]

Ans. 2.385

Sol. $3H_2O + P_4 + 3NaOH \rightarrow 3NaH_2PO_2 + PH_3$ (Q)

$2PH_3 + 3CuSO_4 \rightarrow Cu_3P_2 + 3H_2SO_4$

moles of P_4 = moles of PH_3

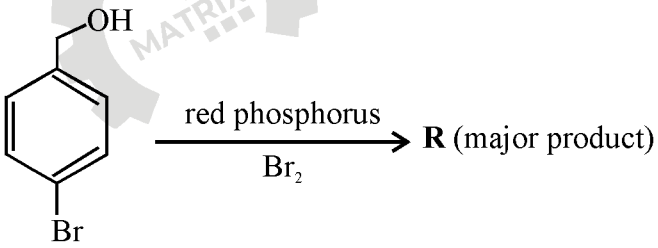
$\frac{1.24}{124}$ = moles of PH_3

moles of $CuSO_4$ = moles of $PH_3 \times \frac{3}{2}$

$= \frac{0.03}{2}$

mass of $CuSO_4 = \frac{0.03}{2} \times 159 = 2.385$ gm

6. Consider the following reaction.

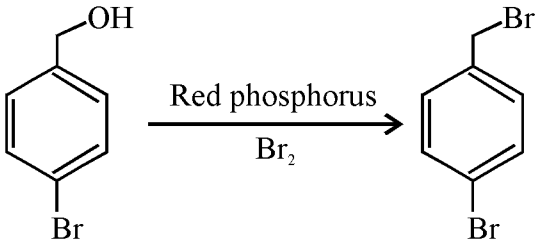


R (major product)

On estimation of bromine in 1.00 g of **R** using Carius method, the amount of AgBr formed (in g) is _____.

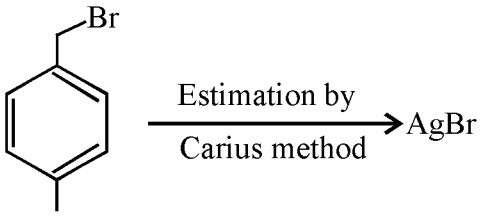
[Given: Atomic mass of H = 1, C = 12, O = 16, P = 31, Br = 80, Ag = 108]

Ans. 1.504



(R)

Sol.



(R)

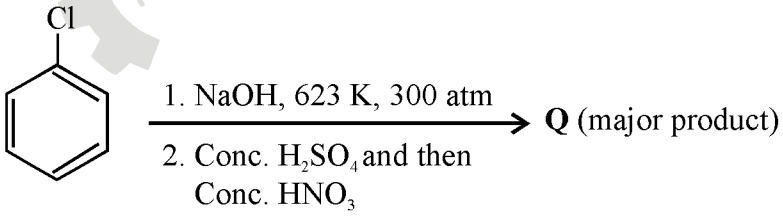
Moles of Br in R = moles of Br in AgBr

$$\frac{1}{250} \times 2 = 1 \times \text{moles of AgBr}$$

$$\text{Moles of AgBr} = \frac{1}{125}$$

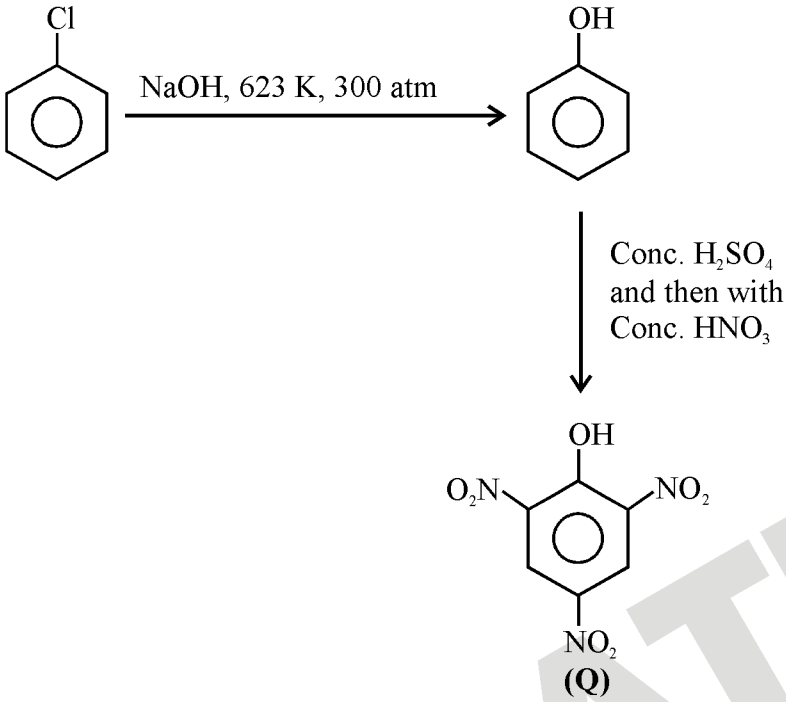
$$\text{Mass of AgBr} = \frac{1}{125} \times 188 = 1.504\,\text{gm}$$

7. The weight percentage of hydrogen in **Q**, formed in the following reaction sequence, is _____.



[Given: Atomic mass of H = 1, C = 12, N = 14, O = 16, S = 32, Cl = 35]

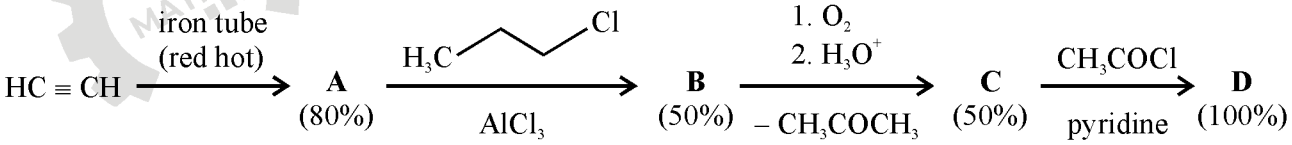
Ans. 1.31



Sol. **(Q)**

Weight percentage of 'H' in Q = $\frac{3\times1}{229}\times100 = 1.31$

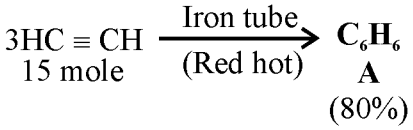
8. If the reaction sequence given below is carried out with 15 moles of acetylene, the amount of the product **D** formed (in g) is _____.

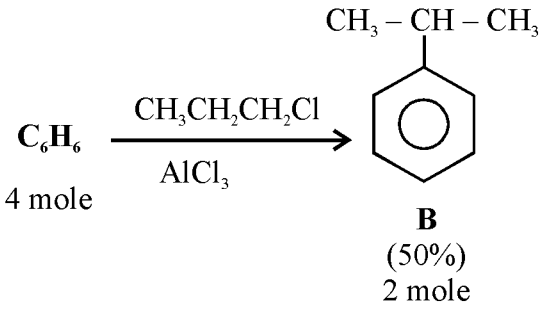


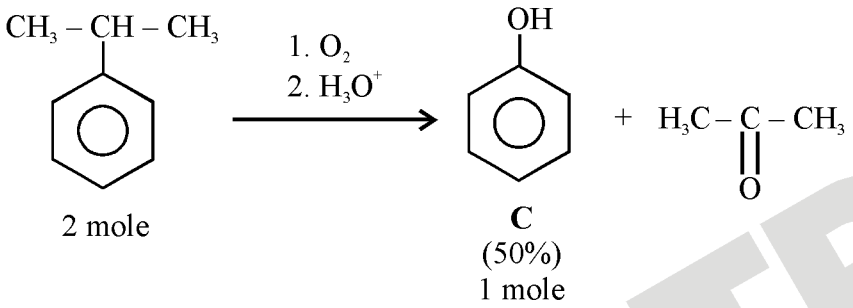
The yields of **A, B, C** and **D** are given in parentheses.

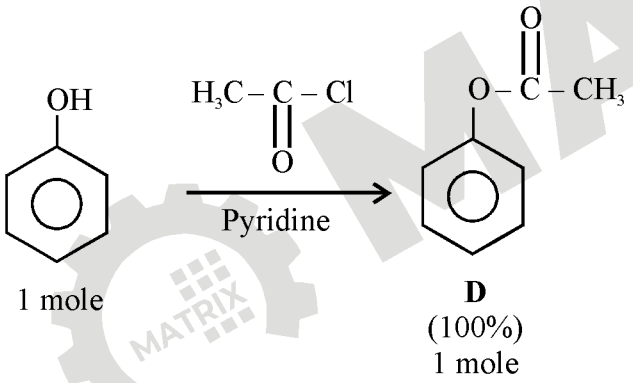
[Given: Atomic mass of H = 1, C = 12, O = 16, Cl = 35]

Ans. 136

Sol. 


CH3 – CH – CH3
C6H6
CH3CH2CH2Cl
AlCl3
4 mole
B
(50%)
2 mole


CH3 – CH – CH3
1. O2
2. H3O+
2 mole
OH
C
(50%)
1 mole
+ H3C – C – CH3
O


OH
1 mole
H3C – C – Cl
O
Pyridine
O
O – C – CH3
D
(100%)
1 mole

SECTION 2 (Maximum Marks: 24)

- This section contains SIX (06) 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.

9. For diatomic molecules, the correct statement(s) about the molecular orbitals formed by the overlap of two $2p_z$ orbitals is(are)

(A) σ orbital has a total of two nodal planes.

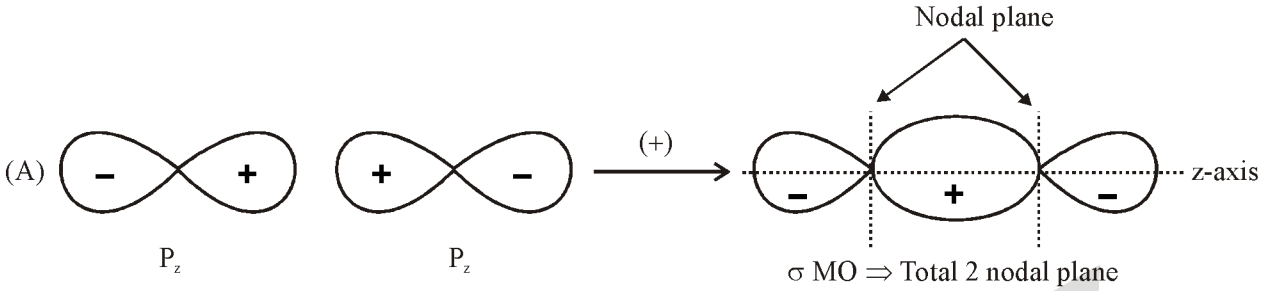
(B) σ^* orbital has one node in the xz-plane containing the molecular axis.

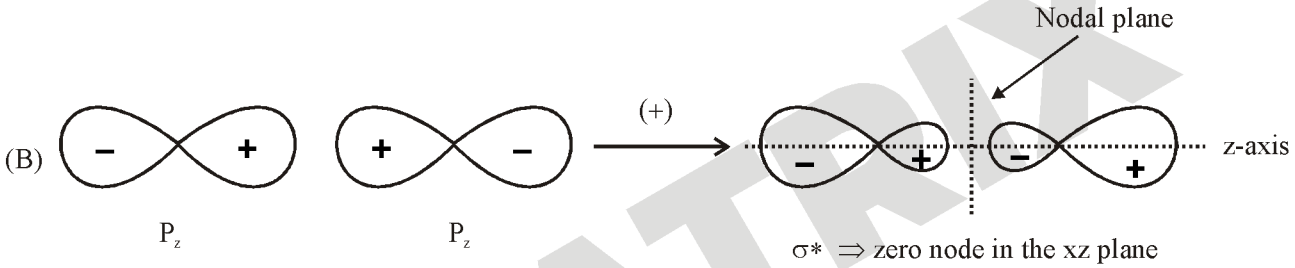
(C) π orbital has one node in the plane which is perpendicular to the molecular axis and goes through the center of the molecule.

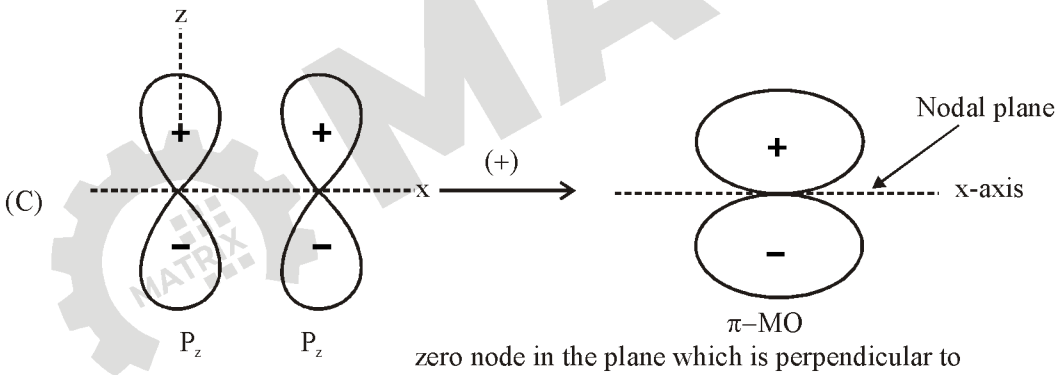
(D) π^* orbital has one node in the xy-plane containing the molecular axis.

Ans. (A) & (D)

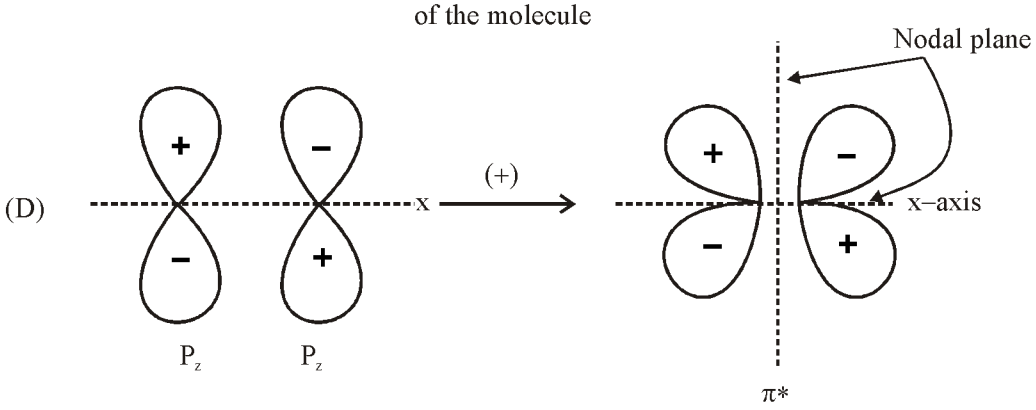
Sol.







zero node in the plane which is perpendicular to the molecular axis and goes through the center of the molecule



One node in xy plane containing the molecular axis

10. The correct option(s) related to adsorption processes is(are)

(A) Chemisorption results in a unimolecular layer.

(B) The enthalpy change during physisorption is in the range of 100 to 140 kJ mol^{-1}.

(C) Chemisorption is an endothermic process.

(D) Lowering the temperature favors physisorption processes.

Ans. (A), (D)

Sol. (A) Chemisorption always have unimolecular layer.

(B) The enthalpy change during physisorption is in the range of 20 – 40 kJ mol^{-1}.

(C) Chemisorption is an exothermic process.

(D) Physisorption increases on decreasing temperature.

11. The electrochemical extraction of aluminum from bauxite ore involves

(A) the reaction of Al_2O_3 with coke (C) at a temperature > 2500 °C.

(B) the neutralization of aluminate solution by passing CO_2 gas to precipitate hydrated alumina ($Al_2O_3.3H_2O$).

(C) the dissolution of Al_2O_3 in hot aqueous NaOH.

(D) the electrolysis of Al_2O_3 mixed with Na_3AlF_6 to give Al and CO_2.

Ans. (B), (C), (D)

Sol. (A) Al_2O_3 containing SiO_2 as impurity is mixed with Coke (C) at a temperature 1800°C.

(B) Aluminate solution is neutralized by passing CO_2 gas to precipitate hydrated alumina

(C) Al_2O_3 is leached by dissolving in NaOH.

(D) Al_2O_3 is mixed with Na_3AlF_6 and CaF_2 and electrolysed to give Al and O_2. O_2 obtained at anode reacts with rods made up of C to give CO_2.

12. The treatment of galena with HNO_3 produces a gas that is

(A) paramagnetic (B) bent in geometry

(C) an acidic oxide (D) colorless

Ans. (A), (D)

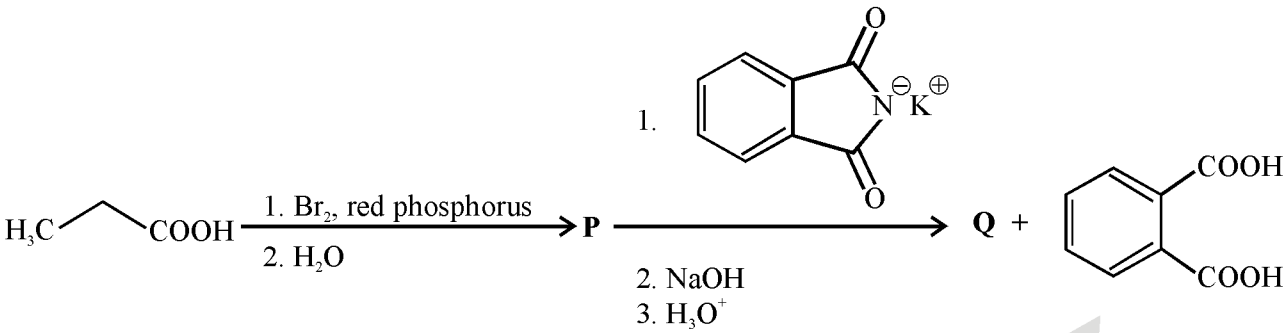
Sol. $PbS + HNO_3 \rightarrow PbSO_4 + S + H_2O + NO(g)$

$\rightarrow$ NO is paramagnetic due to presence of one unpaired e^-.

$\rightarrow$ NO is colorless and it is a neutral oxide.

$\rightarrow$ Geometry of NO is linear.

13. Considering the reaction sequence given below, the correct statement(s) is(are)



(A) **P** can be reduced to a primary alcohol using $NaBH_4$.

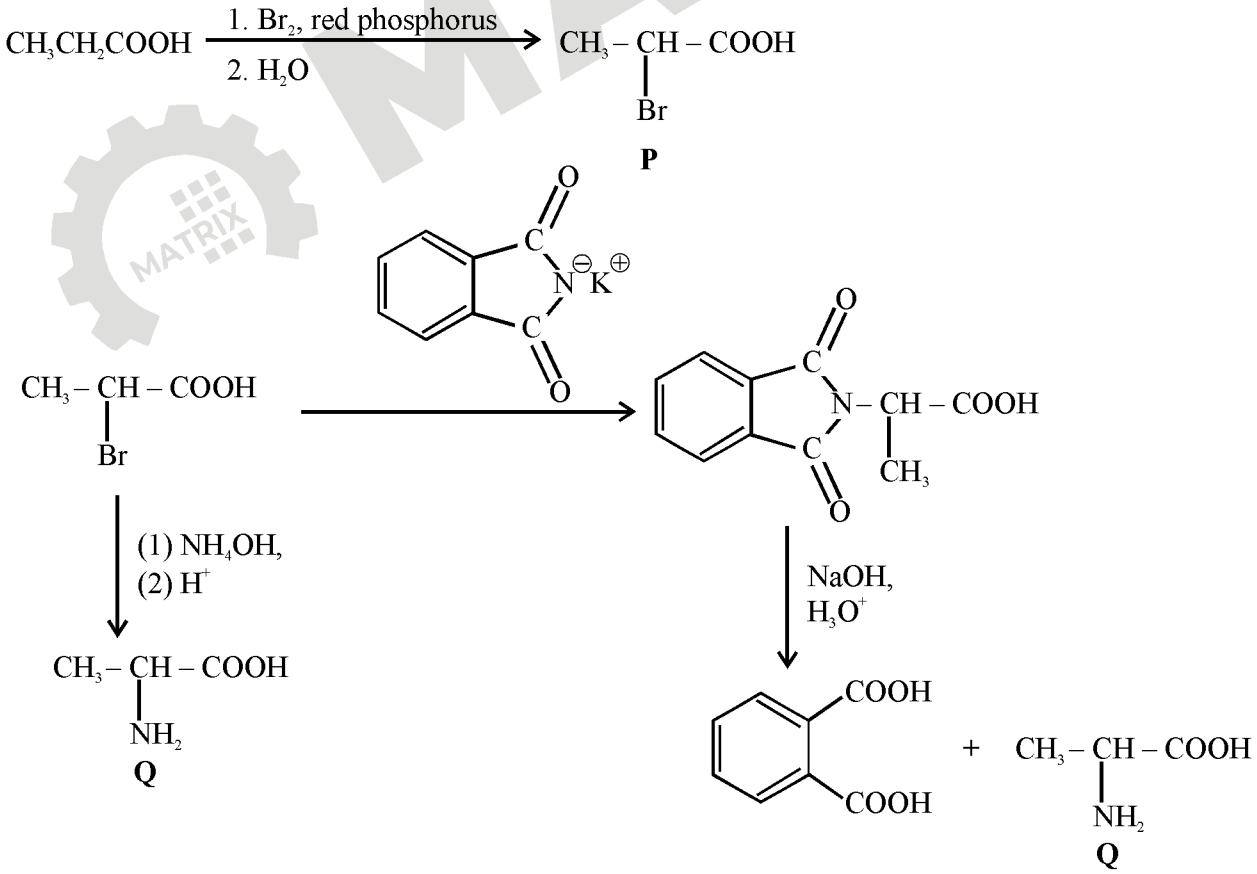
(B) Treating **P** with conc. NH_4OH solution followed by acidification gives **Q.**

(C) Treating **Q** with a solution of $NaNO_2$ in aq. HCl liberates N_2.

(D) **P** is more acidic than CH_3CH_2COOH.

Ans. (B), (C) & (D)

Sol.



(A) $NaBH_4$ can not reduce carboxylic acids.

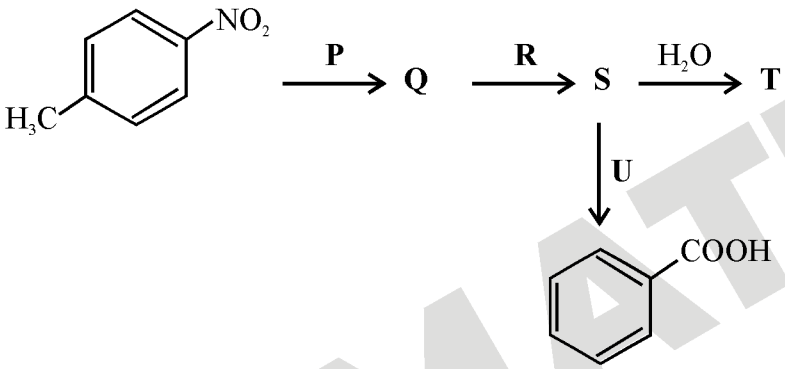
(B) $CH_3-\underset{\underset{Br}{|}}{CH}-COOH \xrightarrow[2.\ Acidification]{1.\ Conc.\ NH_4OH} CH_3-\underset{\underset{OH}{|}}{CH}-COOH$

(C) 1° amine on reaction with $NaNO_2$ + HCl will liberate N_2.

(D) $CH_3-\underset{\underset{Br}{|}}{CH}-COOH > CH_3-CH_2-COOH$

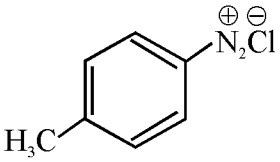
Order of acidic strength (due to –I effect of Br)

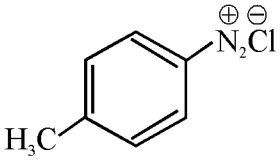
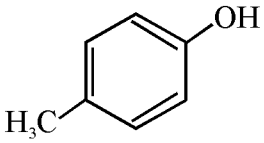
14. Considering the following reaction sequence,

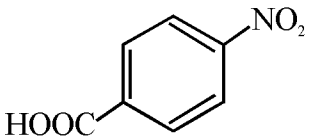
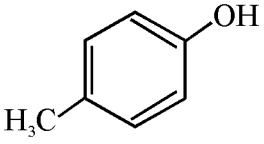


the correct option(s) is(are)

(A) **P** = H_2/Pd, ethanol; **R** = $NaNO_2$/HCl; **U** = 1. H_3PO_2, 2. $KMnO_4$ - KOH, heat

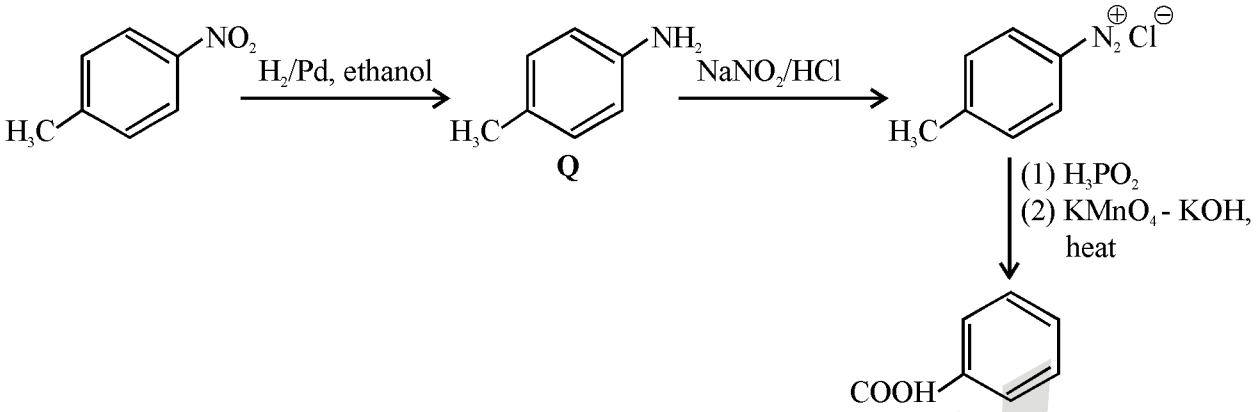
(B) **P** = Sn/HCl **R** = HNO_2 **S** = 

(C) **S** =  **T** =  **U** = 1. CH_3CH_2OH, 2. $KMnO_4$ - KOH, heat

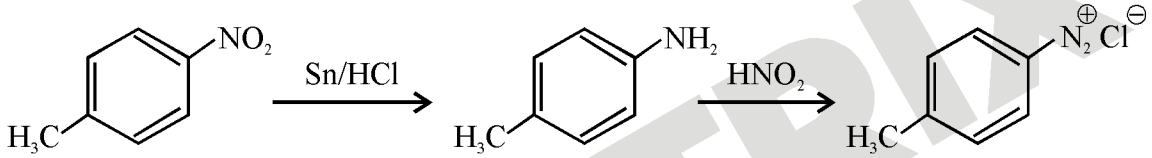
(D) **Q** =  **R** = H_2/Pd, ethanol **T** = 

Ans. (A), (B), (C)

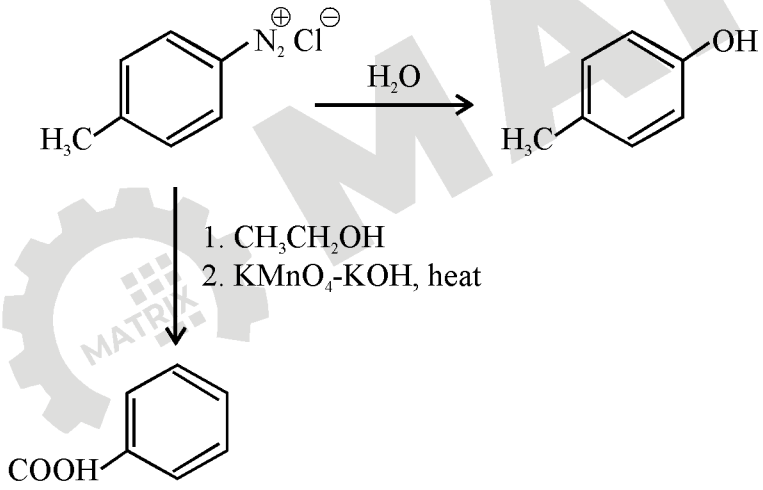
Sol. (A)


NO2
H3C
H2/Pd, ethanol
NH2
H3C
Q
NaNO2/HCl
N2 Cl
H3C
(1) H3PO2
(2) KMnO4 - KOH,
heat
COOH

(B)


NO2
H3C
Sn/HCl
NH2
H3C
HNO2
N2 Cl
H3C

(C)


N2 Cl
H3C
H2O
OH
H3C
1. CH3CH2OH
2. KMnO4-KOH, heat
COOH

SECTION 3 (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 (I), (II), (III) and (IV) and List-II has Five entries (P), (Q), (R), (S) and (T).
- 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;

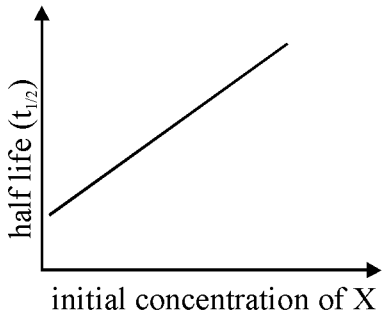
  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

  Negative Marks : -1 In all other cases.

15. Match the rate expressions in LIST-I for the decomposition of X with the corresponding profiles provided in LIST-II. X_s and k are constants having appropriate units.

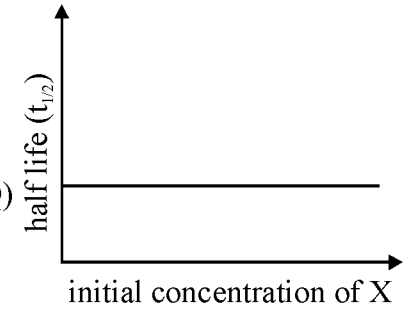
LIST-I **LIST-II**

(I) rate = $\frac{k[X]}{X_s+[X]}$

(P) 

under all possible initial concentrations of X

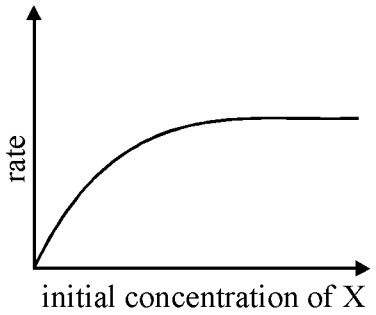
(II) rate = $\frac{k[X]}{X_s+[X]}$

(Q) 

where initial concentrations of X are much less than X_s

(III) rate = $\frac{k[X]}{X_s + [X]}$

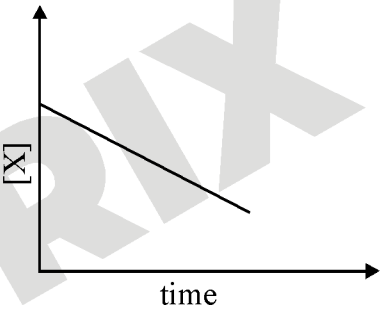
(R)



where initial concentrations of X are much higher than X_s

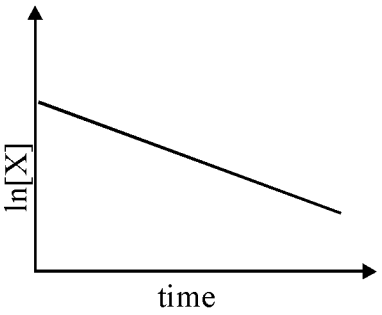
(IV) rate = $\frac{k[X]^2}{X_s + [X]}$

(S)



where initial concentration of X is much higher than X_s

(T)



(A) I→ P; II→ Q; III → S; IV → T

(B) I→ R; II→ S; III → S; IV → T

(C) I→ P; II→ Q; III → Q; IV → R

(D) I→ R; II→ S; III → Q; IV → R

Ans. (A)

Sol. $r = \frac{k[X]}{X_s + [X]}$

Case - I

If $[X] <<< X_s$ then $X_s + [X] \approx X_s$

$r = \frac{K[X]}{X_s}$

$r = K'[X]$

Hence it is a first order reaction w.r.t. 'X'.

Case - II

$[X] >>> X_s$ then $[X] + X_s \approx [X]$

$r = \frac{K[X]}{[X]}$

$r = K$

Hence it is a zero order reaction w.r.t. 'X'.

$r = \frac{k[X]^2}{X_s + [X]}$

If $[X] >>> X_s$ then $[X] + X_s \approx [X]$

$r = \frac{k[X]^2}{[X]}$

$r = k[X]$

Hence it is a first order reaction w.r.t. 'x'.

16. LIST-I contains compounds and LIST-II contains reactions

LIST-I	**LIST-II**
(I) H_2O_2	(P) $Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow$
(II) $Mg(OH)_2$	(Q) $BaO_2 + H_2SO_4 \rightarrow$
(III) $BaCl_2$	(R) $Ca(OH)_2 + MgCl_2 \rightarrow$
(IV) $CaCO_3$	(S) $BaO_2 + HCl \rightarrow$
	(T) $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow$

Match each compound in LIST-I with its formation reaction(s) in LIST-II, and choose the correct option

(A) I $\rightarrow$ Q; II $\rightarrow$ P; III $\rightarrow$ S; IV $\rightarrow$ R

(B) I $\rightarrow$ T; II $\rightarrow$ P; III $\rightarrow$ Q; IV $\rightarrow$ R

(C) I $\rightarrow$ T; II $\rightarrow$ R; III $\rightarrow$ Q; IV $\rightarrow$ P

(D) I $\rightarrow$ Q; II $\rightarrow$ R; III $\rightarrow$ S; IV $\rightarrow$ P

Ans. (D)

Sol. $Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$

$BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$

$Ca(OH)_2 + MgCl_2 \rightarrow Mg(OH)_2 + CaCl_2$

$BaO_2 + 2HCl \rightarrow BaCl_2 + H_2O_2$

$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$

17. LIST-I contains metal species and LIST-II contains their properties.

LIST-I	**LIST-II**
(I) $[Cr(CN)_6]^{4-}$	(P) t_{2g} orbitals contain 4 electrons
(II) $[RuCl_6]^{2-}$	(Q) μ(spin-only) = 4.9 BM
(III) $[Cr(H_2O)_6]^{2+}$	(R) low spin complex ion
(IV) $[Fe(H_2O)_6]^{2+}$	(S) metal ion in +4 oxidation state
	(T) d^4 species

[Given: Atomic number of Cr = 24, Ru = 44, Fe = 26]

Match each metal species in LIST-I with their properties in LIST-II, and choose the correct option

(A) I $\rightarrow$ R, T; II $\rightarrow$ P, S; III $\rightarrow$ Q, T; IV $\rightarrow$ P, Q

(B) I $\rightarrow$ R, S; II $\rightarrow$ P, T; III $\rightarrow$ P, Q; IV $\rightarrow$ Q, T

(C) I $\rightarrow$ P, R; II $\rightarrow$ R, S; III $\rightarrow$ R, T; IV $\rightarrow$ P, T

(D) I $\rightarrow$ Q, T; II $\rightarrow$ S, T; III $\rightarrow$ P, T; IV $\rightarrow$ Q, R

Ans. (A)

Sol. (I) $[Cr(CN)_6]^{4-}$

$Cr^{2+} \equiv 3d^4$

Electronic configuration $\equiv t_{2g}^{2,1,1}\ e_g^{0,0}$

Low spin complex

$\mu = \sqrt{2+(2+2)} = \sqrt{8}$ B.M.

(II) $[Ru(Cl)_6]^{2-}$

$Ru^{4+} = 4d^4$

Electronic configuration $\equiv t_{2g}^{1,1,1}\ e_g^{1,0}$

High spin complex

$\mu = \sqrt{4+(4+2)} = \sqrt{24}$ B.M.

(III) $[Cr(H_2O)]^{2+}$

$Cr^{2+} = 3d^4$

Electronic configuration $\equiv t_{2g}^{1,1,1}\ e_g^{1,0}$
High spin complex

$\mu = \sqrt{4+(4+2)} = \sqrt{24}$ B.M.

(IV) $[Fe(H_2O)_6]^{2+}$

$Fe^{2+} = 3d^6$

Electronic configuration $\equiv t_{2g}^{2,1,1}\ e_g^{1,1}$
High spin complex

$\mu = \sqrt{4+(4+2)} = \sqrt{24}$ B.M.

18. Match the compounds in LIST-I with the observations in LIST-II, and choose the correct option.

LIST-I	**LIST-II**
(I) Aniline	(P) Sodium fusion extract of the compound on boiling with $FeSO_4$, followed by acidification with conc. H_2SO_4, gives Prussian blue color.
(II) o-Cresol	(Q) Sodium fusion extract of the compound on treatment with sodium nitroprus side gives blood red color.
(III) Cysteine	(R) Addition of the compound to a saturated solution of $NaHCO_3$ results in effervescence.
(IV) Caprolactam	(S) The compound reacts with bromine water to give a white precipitate.
	(T) Treating the compound with neutral $FeCl_3$ solution produces violet color.

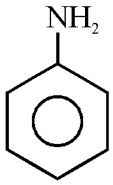
(A) I→P,Q; II→S; III→Q,R; IV→P

(B) I→P; II→R,S; III→R; IV→Q,S

(C) I→Q,S; II→P,T; III→P; IV→S

(D) I→P,S; II→T; III→Q,R; IV→P

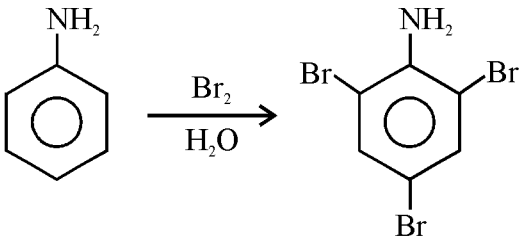
Ans. (D)

Sol. (I) 

Aniline contains both 'C' and 'N'. Hence its sodium fusion extract on boiling with H_2SO_4, Followed by acidification with Conc. H_2SO_4 gives purssian blue color.

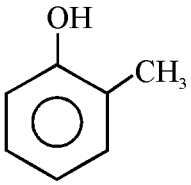
$6CN^- + Fe^{2+} \rightarrow [Fe(CN)_6]^{4-}$

$3[Fe(CN)_6]^{4-} + 4Fe^{3+} \xrightarrow{xH_2O} Fe_4[Fe(CN)_6]_3.xH_2O$ (Purssian Blue)



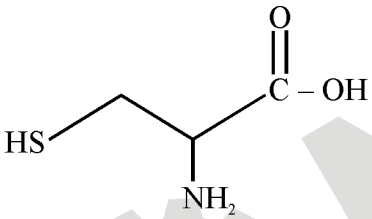
White ppt

(II) O–cresol



$\xrightarrow[FeCl_3]{\text{Neutral}}$ Voilet colored complex

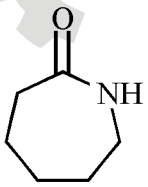
(III) Cysteine



It gives blood red color with NaSCN.

It contains COOH hence it will give effervescence of CO_2 with $NaHCO_3$.

(IV) Caprolactam



It contains both 'C' and 'N'. Hence its sodium fusion extract on boiling with H_2SO_4, Followed by acidification with Conc. H_2SO_4 gives purssian blue color.