# JEE (ADVANCED) 2022 PAPER-1

## [PAPER WITH SOLUTION]

**HELD ON SUNDAY 28$^{TH}$ AUGUST 2022**

# CHEMISTRY

## SECTION1 (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.

**[:Q.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**

[:SOLN] $\underset{2\text{mole}}{2Hg(g)} + \underset{\text{excess}}{O_2} \xrightarrow[248K]{1\text{ atm}} 2HgO(s)$

Heat capacity of bomb calorimeter = 20 kJ $K^{-1}$

Increase in temperature = 312.8 – 298 = 14.8

$\Delta U$ of reaction = $20 \times 14.8 = -296\,\text{kJ}$

$\Delta H = \Delta U + \Delta ngRT$

$= -296 - 3 \times \frac{8.3}{1000} \times 298$

$= -303.42\,\text{kJ}$

$\Delta H = 2\Delta H_f\,HgO - 2\Delta H_f Hg(g)$

$$-303.42 = 2X - 2 \times 61.32$$

$$2X = -303.42 + 122.64$$

$$X = 90.39\,\text{kJ}$$

**[:Q.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**

[:SOLN] $$MnO_4^- \xrightarrow{1.68} MnO_2 \xrightarrow{1.21} Mn^{2+} \xrightarrow{-1.03} Mn$$

$E^\circ = ?$

$$7 \times x = 3 \times (1.68) + 2 \times (1.21) + 2(-1.03)$$

$$7x = 5.04 + 2.42 - 2.06$$

$$7x = 5.40$$

$$x = 0.7714$$

**[:Q.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: $pK_{a_1}$ and $pK_{a_2}$ of $H_2CO_3$ are 6.37 and 10.32, respectively ; log 2 = 0.30]

**[:ANS] 10.02**

[:SOLN]

| | | | |
|---|---|---|---|
| $H_2CO_3$ | + NaOH | $\longrightarrow NaHCO_3$ | $+ H_2O$ |
| 0.01mol | .01mol | .01mol | |
| 0 | 0 | .02 mol | |

The solution resulting contains

$$NaHCO_3 = 0.02\,\text{mol}$$

$$Na_2CO_3 = 0.01\text{mol}$$

pH of this buffer solution

$$pH = pKa_2 + \log\frac{Na_2CO_3}{NaHCO_3}$$

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

$$= 10.32 - .30$$

= 10.02

**[:Q.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**

[:SOLN] $2Cu(NO_3)_2 + 4KI(aq) \longrightarrow 2CuI + I_2 + 4KNO_3$

$H_2S + I_2 \longrightarrow \underset{\text{ppt.}}{S}\downarrow + 2HI$

Moles of $Cu(NO_3)_2 = \dfrac{3.74}{187} = 0.02$

Moles of S (ppt) = $\dfrac{1}{2} \times 0.02 = 0.01$

Mass of S (ppt.) = $32 \times 0.01\text{mol} = 0.32\,\text{gm}$

**[:Q.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] 2.38**

[:SOLN] Balanced chemical equations are

$P_4(\text{white}) + 3\underset{(\text{excess})}{NaOH} + 3H_2O \longrightarrow PH_3 + 3NaH_2PO_2$

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

Moles of $P_4(\text{white})$ = $\dfrac{1.24}{124} = 0.01\text{mole}$ = moles of $PH_3$

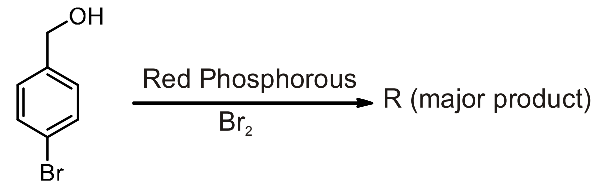
Moles of $CuSO_4$ required = $\dfrac{3}{2} \times \text{moles of } PH_3$

$= \dfrac{3}{2} \times 0.01$

Mass of $CuSO_4$ required = $\dfrac{3}{2} \times 0.01 \times 159$

= 2.38 g

**[:Q.6]** Consider the following reaction.

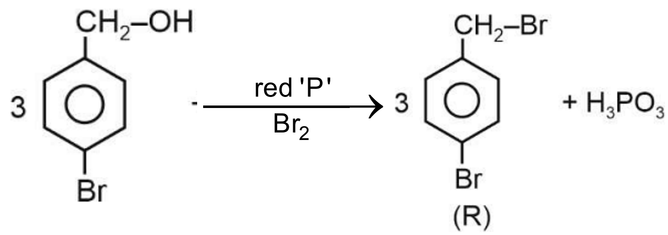



On estimation of bromine in 1.00 g of R using Carius method, the amount of AgBr formed (in g) is ________.

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

**[:ANS]** **1.50**

[:SOLN]




Molecular mass of R $C_7H_6Br_2$

$= 12 \times 7 + 1 \times 6 + 80 \times 2$

$= 84 + 6 + 160$

= 250

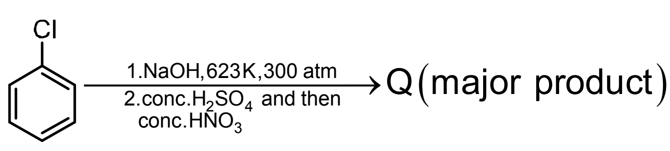
Number of mole in 1 g of R = $\frac{1}{250}$

Number of moles of AgBr formed

From R = $\frac{2}{250}$ $[AgBr = 108 + 80 = 188]$

So mass of AgBr formed = $\frac{2 \times 188}{250}$ =1.50

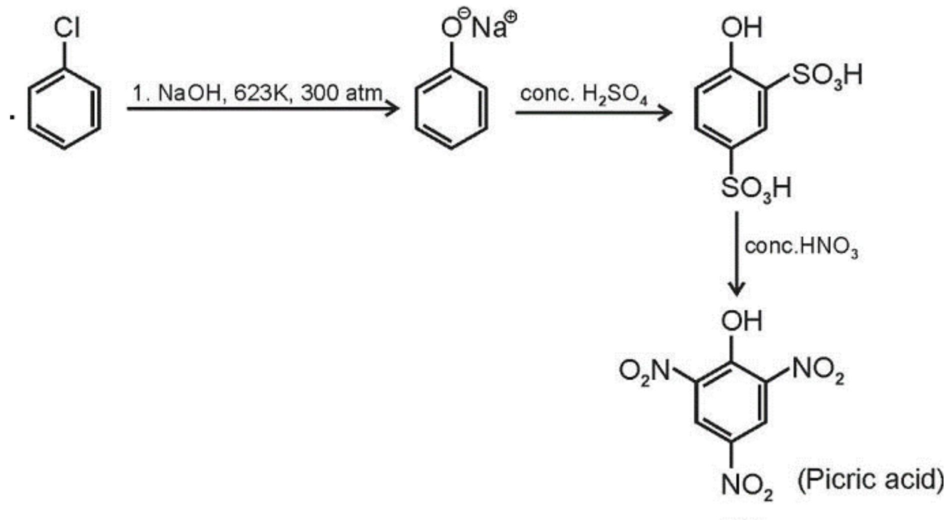
**[:Q.7]** The weight percentage of hydrogen in Q, formed in the following reaction sequence, is ________.




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

**[:ANS]** **1.31**

[:SOLN]




(Q)

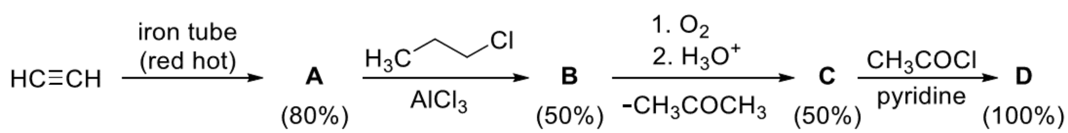
Compound 'Q' = $C_6H_3N_3O_7$

Molar mass = $\left(12\times6+3\times1+14\times3+16\times7\right)$g

= 229 g

Weight percentage 'H' = $\frac{3}{229}\times100=1.31$

**[:Q.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 ________.

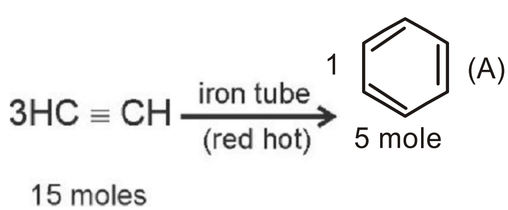



The yields of A, B, C and D are given in parentheses.

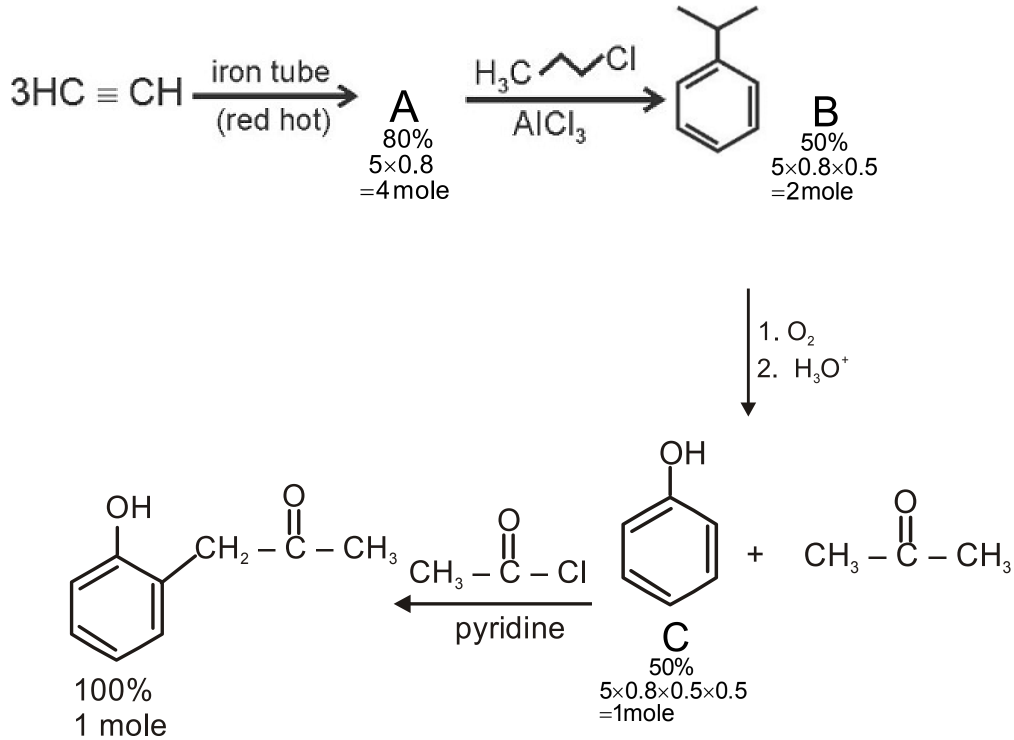
[Given: Atomic mass of H = 1, C = 12, O = 16, Cl = 35]

**[:ANS]** **136.00**

[:SOLN]




[3 moles gives1 mole of benzene so 15 mole give 5 mole of benzene]




Molecular formula of D

$C_8H_8O_2$

$12 \times 8 + 8 \times 1 + 16 \times 2 = 136\,g$

## SECTION 2 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s).
- For each question, choose the correct option(s) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : **+4** If **ONLY** (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 options.

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.

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

[:A] $\sigma$ orbital has a total of two nodal planes.

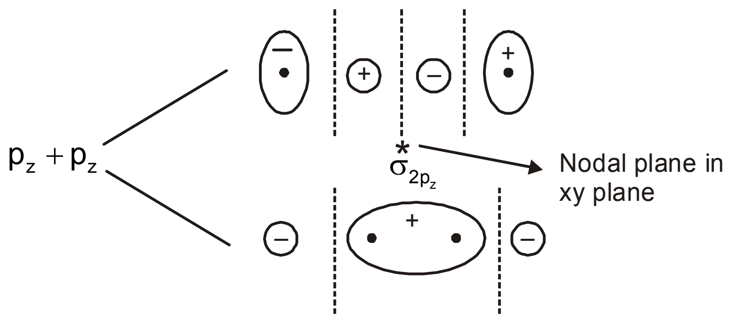
[:B] $\sigma^*$ orbital has one node in the xz plane containing the molecular axis.

[:C] $\pi$ orbital has one node in the plane which is perpendicular to the molecular axis and goes through the center of the molecule.

[:D] $\pi^*$ orbital has one node in the xy-plane containing the molecular axis.

**[:ANS]** **A, D**

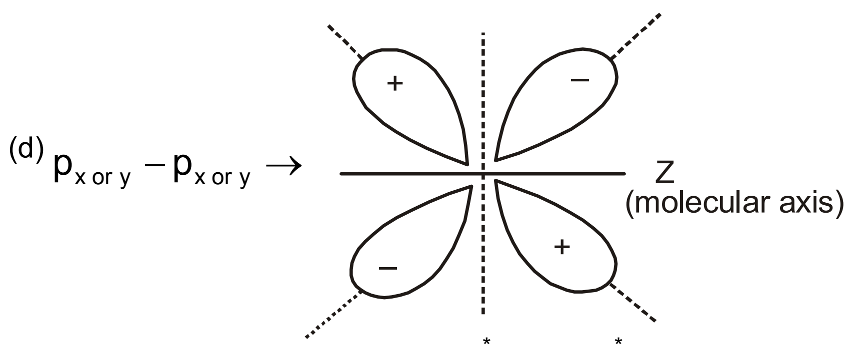
[:SOLN] M.O. formed by the two $2p_z$ orbitals are:




$\sigma_{2p_z}$ (bonding)

(2 nodal planes)

If Z is considered as molecular axis than:




$\pi^*_{2p_x}$ or $\pi^*_{2p_y}$

**[:Q.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**

[:SOLN] (A) Chemisorption unimolecular layer formation take place.

(B) In physisorption 20-40 kJ of heat evolve.

(C) Chemisorption is an exothermic process.

(D) Lowering the temperature, the physisorption increases.

**[:Q.11]** The electrochemical extraction of aluminum from bauxite ore involves

[:A] the reaction of $Al_2O_3$ with coke (C ) at a temperature > 2500 ºC.

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

[: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 $CO_2$.

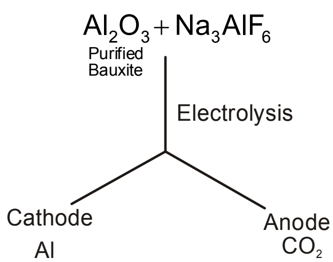
**[:ANS] B, C, D**

[:SOLN] Extraction:

(1) $\underset{\text{(Bauxite ore)}}{Al_2O_3} + 2OH^- + 3H_2O \rightarrow 2\left[Al(OH)_4\right]^-$

(2) $\left[Al(OH)_4\right]^- + CO_2 \longrightarrow Al(OH)_3 \downarrow + HCO_3^-$

(3) $2Al(OH)_3 \xrightarrow{\text{Calcination}} Al_2O_3 + 3H_2O$

(4) 


**[:Q.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**

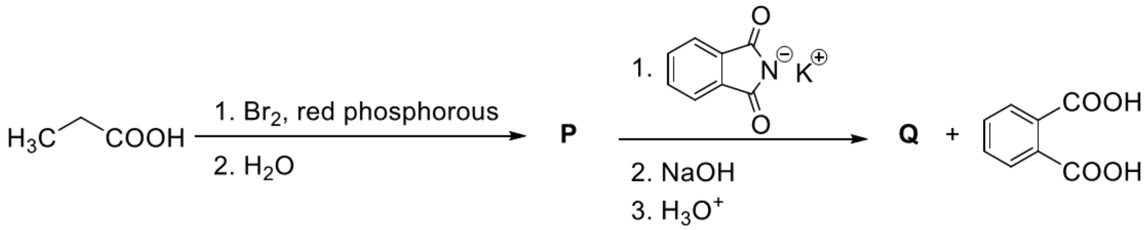
[:SOLN]
$$3PbS + 8HNO_3 \longrightarrow 3Pb^{2+} + 6NO_3^- + 2NO\uparrow(\text{gas}) + \underset{\text{(yellow)}}{3S}\downarrow + 4H_2O$$

NO: (a) Odd electron molecule, so paramagnetic.

(b) Colourless

(c) neutral oxide

**[:Q.13]** Considering the reaction sequence given below, the correct statement(s) is(are)



[:A] **P** can be reduced to a primary alcohol using $NaBH_4$.

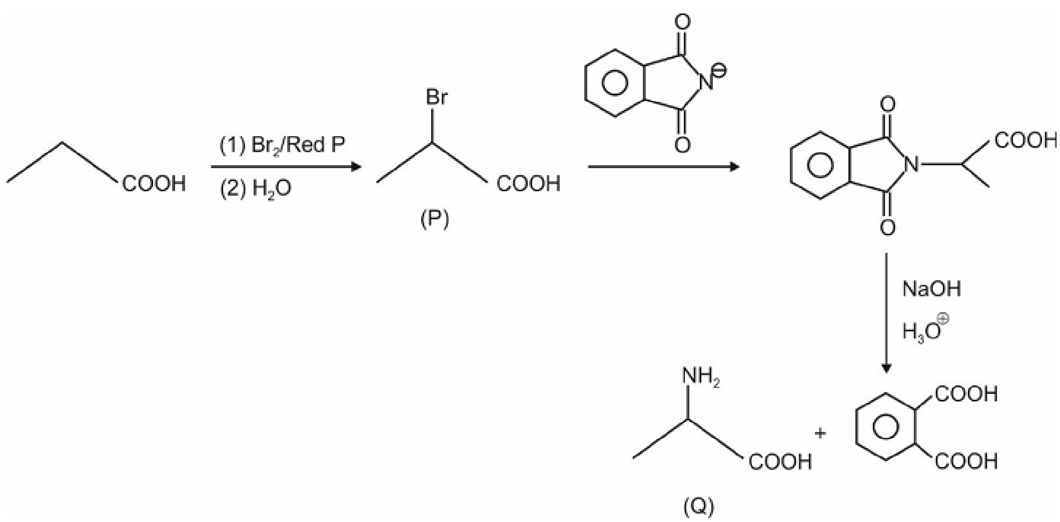
[:B] Treating **P** with conc. $NH_4OH$ solution followed by acidification gives **Q**.

[:C] Treating **Q** with a solution of $NaNO_2$ in aq. HCl liberates $N_2$.

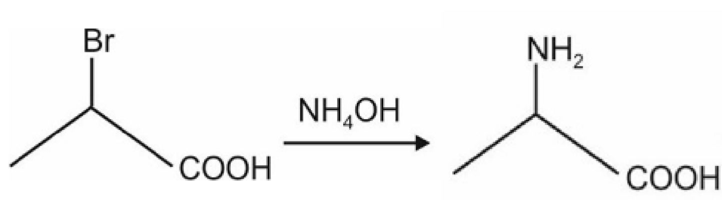
[:D] **P** is more acidic than $CH_3CH_2COOH$.

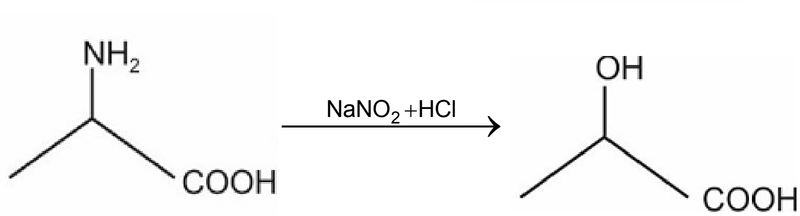
**[:ANS]** **B, C, D**

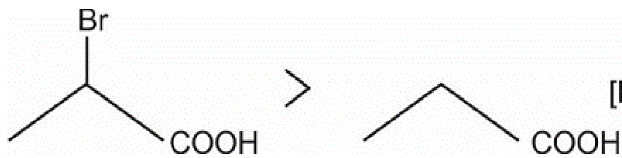
[:SOLN]



$NaBH_4$borohydride can't reduce $-\overset{\overset{\displaystyle O}{\|}}{C}-OH$

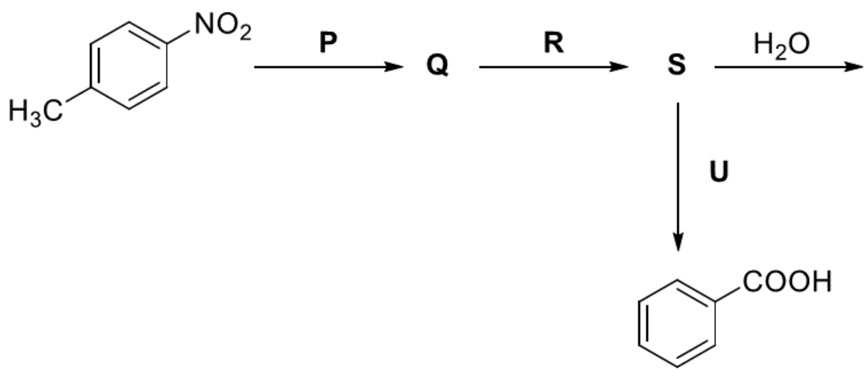
→ 

→  $+ N_2$

→ 

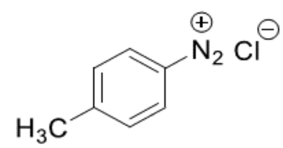
[Because of –I effect of Br]

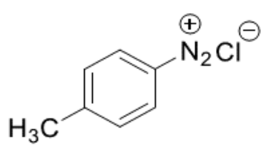
**[:Q.14]** Considering the following reaction sequence,

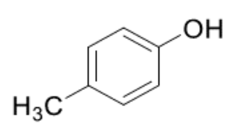



the correct option(s) is(are)

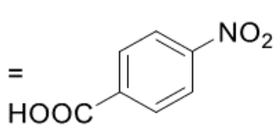
[:A] **P** = $H_2$/Pd, ethanol **R** = $NaNO_2$/HCl **U** = 1. $H_3PO_2$
2. $KMnO_4$ - KOH, heat

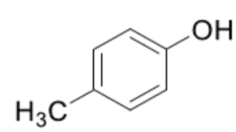
[:B] **P** = Sn/HCl **R** = $HNO_2$ **S** = 


[:C] **S** = 

**T** = 

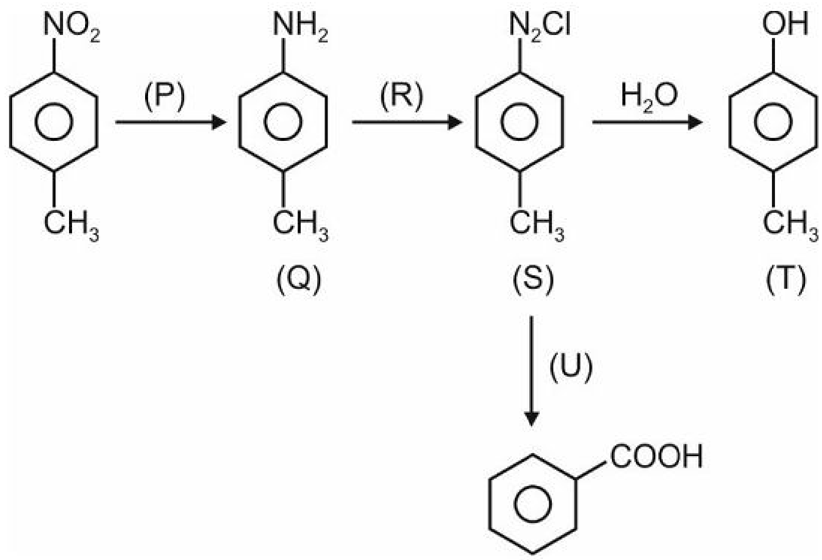
**U** = 1. $CH_3CH_2OH$
2. $KMnO_4$ - KOH, heat

[:D] **Q** = 

**R** = $H_2$/Pd, ethanol **T** = 


**[:ANS]** **A, B, C**

[:SOLN]




$\rightarrow$P may be $\rightarrow H_2$/Pd, ethanol; Sn/HCl

$\rightarrow$R may be $\rightarrow$ $NaNO_2$/HCl; $HNO_2$

$\rightarrow$ U may be $\rightarrow$ (i) $H_3PO_2$, (ii) $KMnO_4^-$ KOH,

or (i) $CH_3 - CH_2 - OH$, (ii) $KMnO_4$ – KOH, $\Delta$

## SECTION3 (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** ofthese 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.15]** Match the rate expressions in LIST-I for the decomposition of X with the corresponding profiles provided in LIST-II. Xs and k are constants having appropriate units.

**List-I**

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

under all possible initial concentrations of X

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

where initial concentrations of X are much less than $X_s$

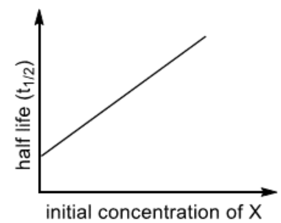
(III) $\text{rate} = \frac{k[X]}{X_s + [X]}$

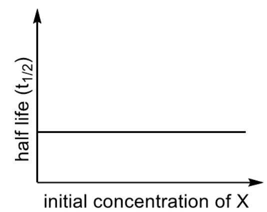
where initial concentrations of X are much higher than $X_s$

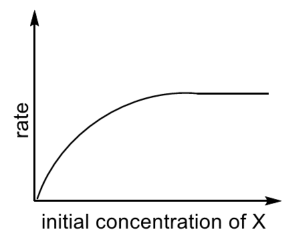
(IV) $\text{rate} = \frac{k[X]^2}{X_s + [X]}$

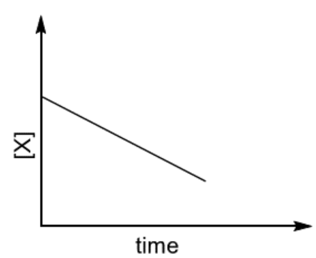
where initial concentration of X is much higher than $X_s$

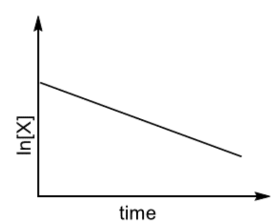
**List-II**

(P) 


(Q) 


(R) 


(S) 


(T) 

**Codes :**

[: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**

[:SOLN] (I) $\text{rate} = \dfrac{k[X]}{X_s + [X]}$

$$-\frac{dx}{dt} = k[X]$$

$$-dx\frac{[X_s + X]}{[X]} = kdt$$

$$-X_s\int_{X_0}^{X}\frac{dX}{[X]} - \int_{X_0}^{X}dx = \int_0^t kdt$$

$$X_s \ln\frac{X_0}{X} - (X - X_0) = kt$$

$$kT_{\frac{1}{2}} = X_s \ln 2 + \frac{X_0}{2}$$

$\therefore$ $I \to P$

(II) $\text{rate} = \dfrac{k[X]}{X_s + [X]}$; If $[X] << [X_s]$

Then Rate = $\dfrac{k[X]}{X_s} = \dfrac{k}{X_s}[X] = k'[X]$

It becomes 1st order kinetics

$\therefore$ $II \longrightarrow Q$

(III) Rate = $\dfrac{k[X]}{X_s + [X]}$ If $[X] >> [X_s]$

Then Rate = $\dfrac{k[X]}{[X]} = k$

It becomes zero order kinetic

$\therefore$ $III \longrightarrow S$

(IV) $\text{Rate} = \dfrac{k[X]^2}{X_s + [X]}$ if $[X] >> X_s$

Then Rate = $\dfrac{k[X]^2}{[X]} = k[X]$

It becomes I$^{st}$ order kinetics

$\therefore$ $IV \longrightarrow T$

**[:Q.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

**Codes :**

[:A] I → Q; II → P; III → S; IV → R

[:B] I → T; II → P; III → Q; IV → R

[:C] I → T; II → R; III → Q; IV → P

[:D] I → Q; II → R; III → S; IV → P

**[:ANS]** **D**

[:SOLN] Reactions:

(P) $\underset{\text{(Clark's method)}}{Mg(HCO_3)_2 + 2Ca(OH)_2} \longrightarrow Mg(OH)_2 \downarrow + 2CaCO_3 \downarrow + 2H_2O$

(Q) $\underset{\text{(Lab. method)}}{BaO_2 + H_2SO_4} \longrightarrow BaSO_4 \downarrow + H_2O_2$

(R) $Ca(OH)_2 + MgCl_2 \longrightarrow Mg(OH)_2 \downarrow + CaCl_2$

(S) $BaO_2 + 2HCl \longrightarrow BaCl_2 + H_2O_2$

(T) $\underset{\text{(Clark's method)}}{Ca(HCO_3)_2 + Ca(OH)_2} \longrightarrow 2CaCO_3 + 2H_2O$

Hence, suitable and on basis of appropriate methods

I → Q; II → R; III → S; IV → P

**[:Q.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

**Codes :**

[:A] I → R, T; II → P, S; III → Q, T; IV → P, Q

[:B] I → R, S; II → P, T; III → P, Q; IV → Q, T

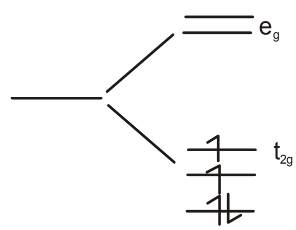
[:C] I → P, R; II → R, S; III → R, T; IV → P, T

[:D] I → Q, T; II → S, T; III → P, T; IV → Q, R

**[:ANS]** **A**

[:SOLN] (I) $[Cr(CN)_6]^{4-}$

Cr(II) = $d^4$ system

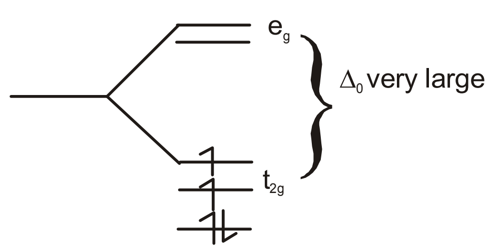



$\mu_s = 2.89\,BM$

Low spin complex

(II) $[RuCl_6]^{2-}$

$\underset{(O.S.)}{Ru^{+4}}$ : E.C. : $[Kr]4d^4$ $(5^{th}\,\text{period})$

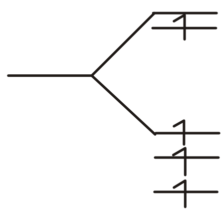



$\mu_s = 2.89\,B.M.$

$t_{2g}$ contains 4 electron.

(III) $\left[\overset{2+}{Cr}(H_2O)_6\right]^{2+}$

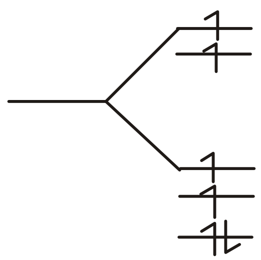
Cr(II) = $d^4$ species




$\mu_s = 4.9 B.M.$

(IV) $\left[\overset{2+}{Fe}(H_2O)_6\right]^{2+}$

Fe(II) : $d^6$ system : $(t_{2g})^4 (eg)^2$




$\mu_s = 4.9 B.M.$

**Hence:** I → R, T; II → P, S; III → Q, T; IV → P, Q

**[:Q.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 nitroprusside 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.

**Codes :**

[:A] I→P,Q; II→S; III→Q,R; IV→P

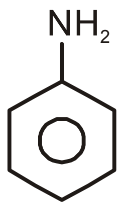
[:B] I→P; II→R,S; III→R; IV→Q,S

[:C] I→Q,S; II→P,T; III→P; IV→S

[:D] I→P,S; II→T; III→Q,R; IV→P

**[:ANS]** **D**

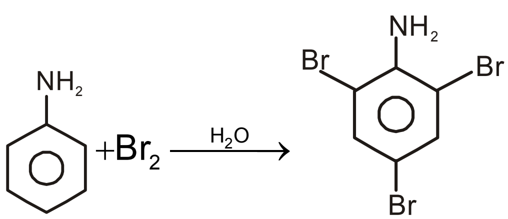
[:SOLN]



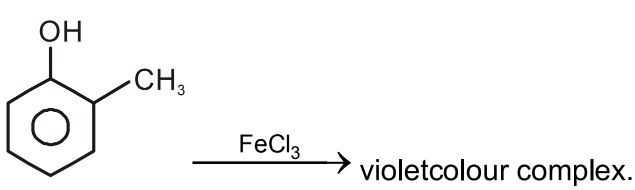
Aniline contain carbon and nitrogen, So its sodium fusion extract with boiling with $FeSO_4$, followed by acidificationwith conc. $H_2SO_4$ gives Prussian blue colour.

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

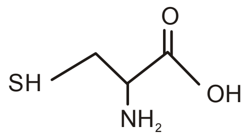
$$3\left[Fe(CN)_6\right]^{4-} + 4Fe^{3+} \longrightarrow Fe_4\left[Fe(CN)_6\right]_3 .xH_2O$$



When aniline reacted with bromine water it give 2, 4, 6-tribromoaniline of white ppt compound.



O-cresol

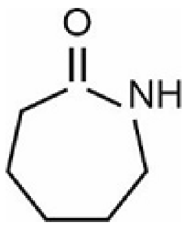


Cystein

It contain $-SH, -NH_2$ and $-\overset{\overset{\large O}{||}}{C}-OH$ group.

Due to sulphur and nitrogen its sodium fusion extract gives blood red colour with sodium nitropruside.

Since it contain $-\overset{\overset{\large O}{||}}{C}-OH$ group so it gives effervescence with $NaHCO_3$.



Fusion extract of caprolactam boiling with $FeSO_4$ followed by acidification with conc. $H_2SO_4$ gives Prussian blue colour.