JEE (ADVANCED) 2024 PAPER-2

[PAPER WITH SOLUTION]

HELD ON SUNDAY 26TH 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] According to Bohr's model, the highest kinetic energy is associated with the electron in the

[:A] first orbit of H atom

[:B] first orbit of He^{+}

[:C] second orbit of He^{+}

[:D] second orbit of Li^{2+}

[:ANS] **B**

In Bohr Model

$$K.E. = 13.6\,eV \cdot \frac{z^2}{n^2}$$

a) $He^{+}, 1 = \frac{z^2}{n^2} = 4$ (Maximum)

b) $He^{+}, 2 = \frac{z^2}{n^2} = 1$

c) $Li^{2+}, 2 = \frac{z^2}{n^2} = \frac{9}{4}$

[:Q.2] In a metal deficient oxide sample, $M_XY_2O_4$ (M and Y are metals), M is present in both +2 and +3 oxidation states and Y is in +3 oxidation state. If the fraction of M^{2+} ions present in M is $\frac{1}{3}$, the value of X is _____.

[:A] 0.25 [:B] 0.33 [:C] 0.67 [:D] 0.75

[ANS] D

[:SOLN] $M_xY_2O_4$

M^{2+} & M^{3+}

$\left(\frac{x}{3}\right)$ $\left(\frac{2x}{3}\right)$

Net charge on compound = 0

$$\left(\frac{x}{3}\right)2 + \left(\frac{2x}{3}\right)\cdot 3 + 2\times 3 + 4(-2) = 0$$

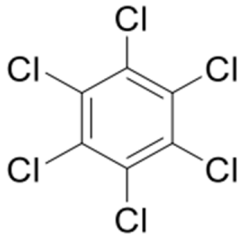
$$\frac{8x}{3} + 6 - 8 = 0$$

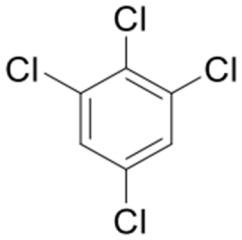
$$\frac{8x}{3} = 2$$

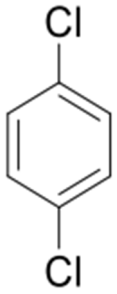
$$x = \frac{3}{4} = 0.75$$

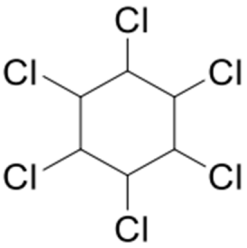
[:Q.3] In the following reaction sequence, the major product Q is

$$\text{L-Glucose} \xrightarrow[\text{ii) } Cr_2O_3,\ 775\ K,\ 10\text{-}20\ atm]{\text{i) HI, }\Delta} \mathbf{P} \xrightarrow[UV]{Cl_2\ (excess)} \mathbf{Q}$$

[:A] 

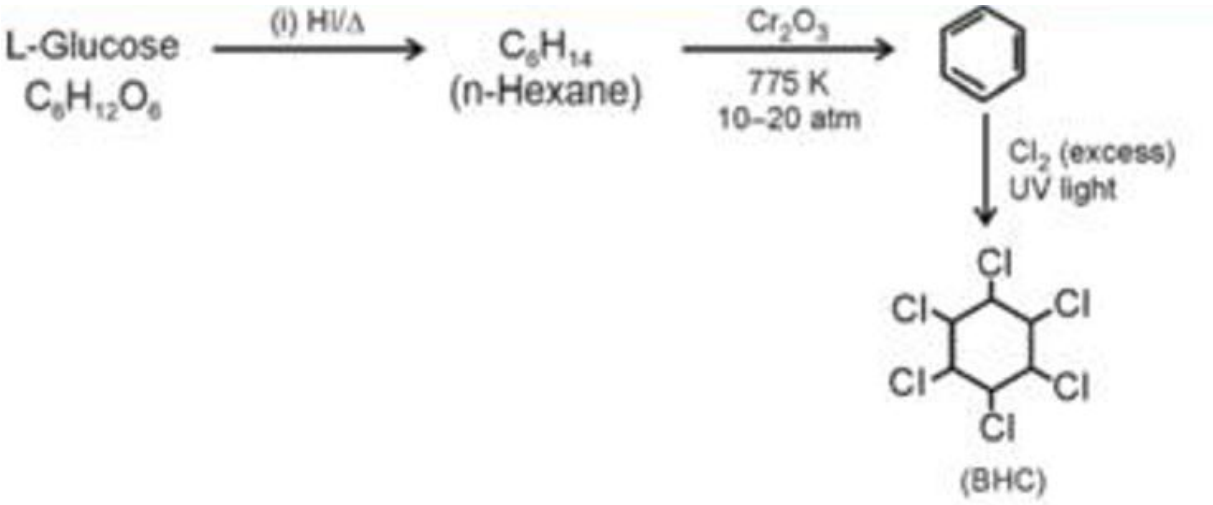
[:B] 

[:C] 

[:D] 

[:ANS] D

[:SOLN]



[:Q.4] The species formed on fluorination of phosphorus pentachloride in a polar organic solvent are

[:A] $[PF_4]^+[PF_6]^-$ and $[PCl_4]^+[PF_6]^-$

[:B] $[PCl_4]^+[PCl_4F_2]^-$ and $[PCl_4]^+[PF_6]^-$

[:C] PF_3 and PCl_3

[:D] PF_5 and PCl_3

[:ANS] B

[:SOLN]

by F atoms.[93] These compounds are obtained by addition of halogen to the appropriate phosphorus(III) chlorofluoride, but if PCl_5 is fluorinated in a polar solvent, ionic isomers are formed, e.g. $[PCl_4]^+[PCl_4F_2]^-$ (colourless crystals, subl 175°) and $[PCl_4]^+[PF_6]^-$ (white crystals, subl 135° with decomposition). The crystalline hemifluoride $[PCl_4]^+[PCl_5F]^-$ has also been identified. The analogous parallel

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 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 +2marks;
  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(s) (i.e. the question is unanswered) will get 0 marks and choosing any other option(s) will get −2 marks.

[:Q.5] An aqueous solution of hydrazine (N_2H_4) is electrochemically oxidized by O_2, thereby releasing chemical energy in the form of electrical energy. One of the products generated from the electrochemical reaction is $N_2(g)$.

Choose the correct statements(s) about the process

[:A] OH^- ions react with N_2H_4 at the anode to form $N_2(g)$ and water, releasing 4 electrons to the anode.

[:B] At the cathode, N_2H_4 breaks to $N_2(g)$ and nascent hydrogen released at the electrode reacts with oxygen to form water.

[:C] At the cathode, molecular oxygen gets converted to OH^-

[:D] Oxides of nitrogen are major by-products of the electrochemical process.

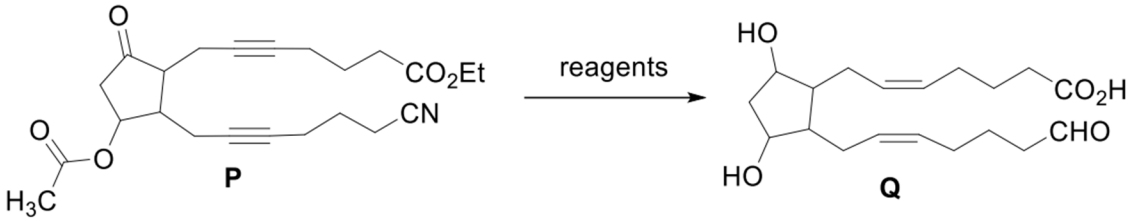
[:ANS] A,C

[:SOLN] Anode: $N_2H_4 + 4OH^- \longrightarrow N_2 + 4H_2O + 4e^-$

Cathode: $2H_2O + O_2 + 4e \longrightarrow 4OH^-$

$N_2H_4 + O_2 \longrightarrow N_2 + 2H_2O$

[:Q.6] The options(s) with correct sequence of reagents for the conversion of P to Q is(are)



[:A] (i) Lindlar's catalyst, H_2; (ii) $SnCl_2$/HCl; (iii) $NaBH_4$; (iv) H_3O^+

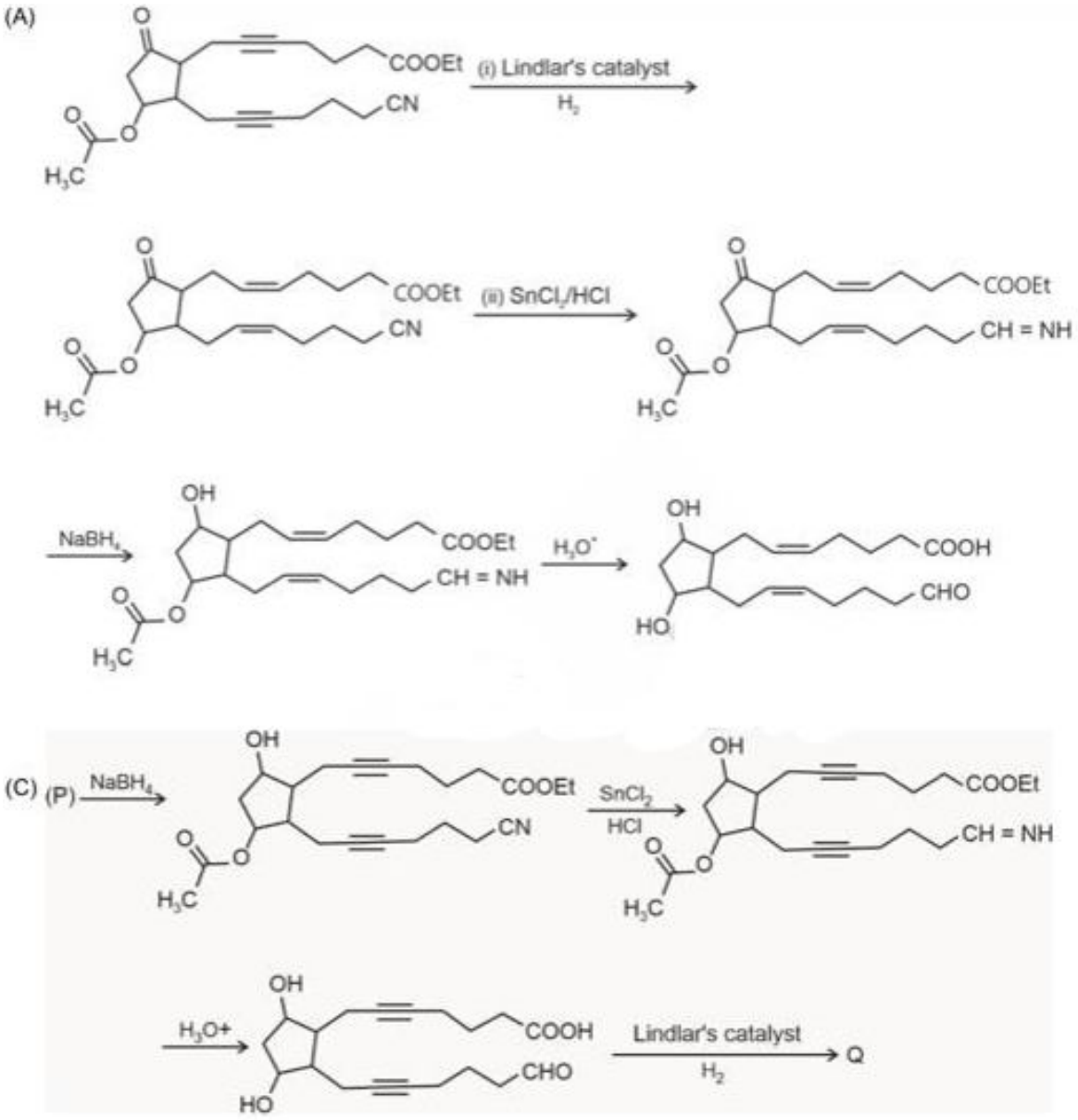
[:B] (i) Lindlar's catalyst, H_2; (ii) H_3O^+ (iii) $SnCl_2$/HCl; (iv) $NaBH_4$

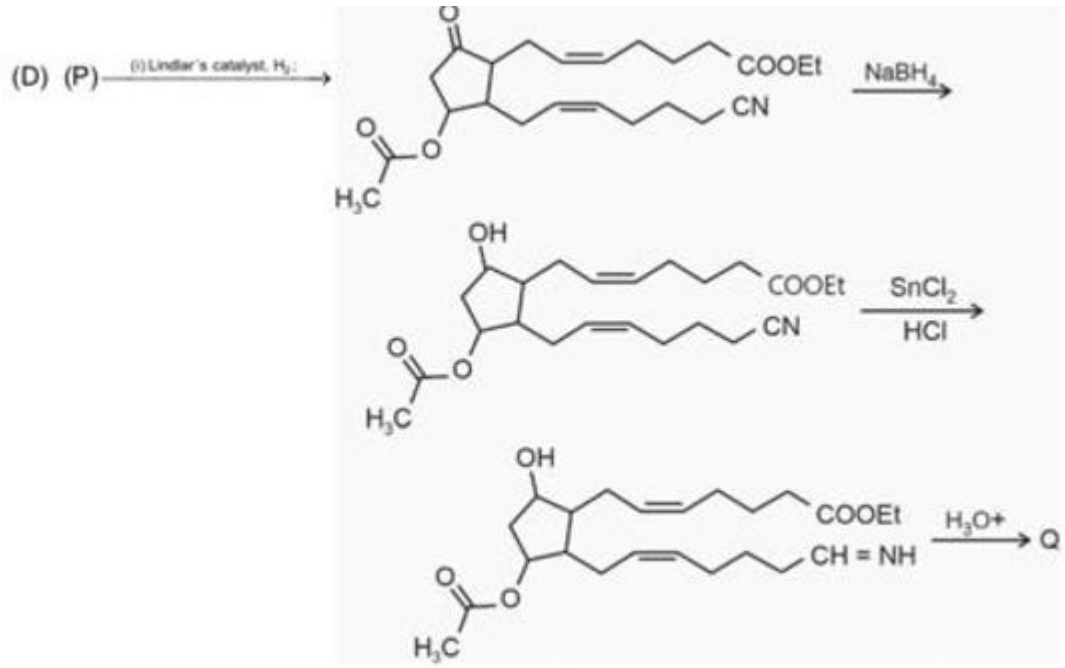
[:C] (i) $NaBH_4$ (ii) $SnCl_2$/HCl; (iii) H_3O^+ (iv) Lindlar's catalyst, H_2

[:D] (i) Lindlar's catalyst, H_2; (ii) $NaBH_4$; (iii); $SnCl_2$/HCl (iv) H_3O^+

[:ANS] ACD

[:SOLN]


(A)
COOEt
CN
(i) Lindlar's catalyst
H_2
H_3C
(ii) $SnCl_2$/HCl
CH = NH
$NaBH_4$
OH
H_3O^+
COOH
CHO
HO
(C) (P)
$SnCl_2$
HCl
H_3O+
Lindlar's catalyst
Q

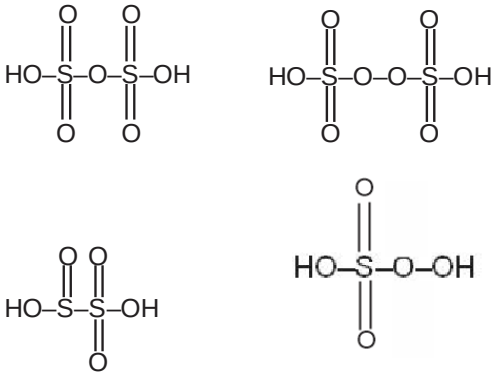


[:Q.7] The compounds(s) having peroxide linkage is(are)

[:A] $H_2S_2O_7$ [:B] $H_2S_2O_8$ [:C] $H_2S_2O_5$ [:D] H_2SO_5

[:ANS] B,D

[:SOLN]



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] To form a complete monolayer of acetic acid on 1g of charcoal, 100 mL of 0.5 M acetic acid was used. Some of the acetic acid remained unadsorbed. To neutralize the unadsorbed acetic acid, 40 mL of 1 M NaOH solution was required. If molecule of acetic acid occupies $\mathbf{P}\times10^{-23}\,m^2$ surface area on charcoal, the value of P is_____.

[Use given data: Surface area of charcoal = 1.5 × 10^2 m^2g^{-1}; Avogadro's number $(N_A)=6.0\times10^{23}\ mol^{-1}$]

[:ANS] 2500

[:SOLN] m mole of Acetic acid remained = 40×1 =40

m mole of Acetic acid given = 100 × 0.5 =50

m mole of acetic acid adsorbed = 10

No. of CH_3COOH molecule adsorbed = $\frac{10}{1000}\times6\times10^{23}$

$= 6\times10^{21}$

Surface area available $= 1.5\times10^2\,m^2$

$$\Rightarrow \frac{\text{surface area}}{\text{no. of molecule}}=\frac{1.5\times10^2}{6\times10^{21}}=0.25\times10^{-19}=2500\times10^{-23}\ m^2$$

P = 2500

[:Q.9] Vessel-1 contains w_2 g of a non-volatile X dissolved in w_1 of water. Vessel-2 contains w_2 g of another non-volatile solute **Y** dissolved in w_1 g of water. Both the vessels are at the same temperature and pressure. The molar mass of X is 80% of that of Y. The van't Hoff factor for X is 1.2 times of that of **Y** for their respective concentrations.

The elevation of boiling point for solution in Vessel-1 is_____% of the solution in Vessel-2.

[:ANS] 150

[:SOLN]

$$M_X = \frac{80}{100} M_Y$$

$$i_x = 1.2\ i_y$$

$$\frac{\Delta T_{bx}}{\Delta T_{by}} = \frac{i_x . k_b . n_x}{i_y . k_b . n_y}\left(M_{H_2O}\right) = \text{source}$$

$$= 1.2 \times \frac{M_y}{M_x}\left(m_x = m_y = w_2\right)$$

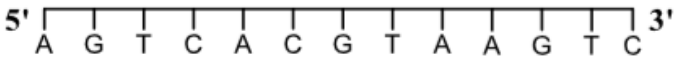
$$= 1.2 \times \frac{100}{80} = \frac{12}{8} = \frac{3}{2}$$

$$= 1.5$$

$$\Delta T_{bx} = 0.5\ \Delta T_{by}$$

$$\Delta T_{bx} = \frac{150}{100} . \Delta T\,by \Rightarrow\ \% = 150$$

[:Q.10] For a double strand DNA, one strand in given below:



The amount of energy required to split the double strand DNA into two single strand is_____kcal mol^{-1}.

[Given: Average energy per H-bond for A-T base pair = 1.0 kcal mol^{-1}, G-C base pair = 1.5 kcal mol^{-1}. Ignore electrostatic repulsion between the phosphate groups.]

[:ANS] **41**

[:SOLN]

Total energy = [BE H-bond A – T × No. of A = T pair × 2] + [BE H-bond G – C × No. of G = C pair × 3]

= [1 × 7 × 2] + [1.5 × 6 × 3]

= 14 + 27

= 41 kcal

[:Q.11] A sample initially contains only U-238 isotope of uranium. With time, some of the U-238 radioactively decay into Pb-206 while the react of it remains undisintegrated. When the age of the sample is $\mathbf{P}\times10^{8}$ years, the ratio of mass of Pb-206 to that of U-238 in the sample is found to be 7. The value of **P** is_____.

[Given : Half-life of U-238 is 4.5×10^{9} years; $\log_e 2 \;\; 0.693$]

[:ANS] **143.56**

[:SOLN]

$$\begin{array}{lccc} & U^{238} & \longrightarrow & Pb^{206} \\ t=0 & N_0 & & 0 \\ t & N_0 - x & & x \end{array}$$

$$A/q:\ \frac{m_{pb-206}}{m_u - 238} = 7$$

$$\frac{\frac{x}{N_A}.206}{\left(\frac{N_0 - x}{N_A}\right).238} = 7$$

$$\frac{x}{N_{0-x}} = \frac{7\times238}{206}$$

$$\frac{x}{N_{0-x}} = 8.08$$

$8.08\ N_0 = 9.08x$

$$x = \frac{8.08}{9.08}N_0 = \frac{N_0}{N_0 - x} = \frac{N_0}{N_0 - \frac{8.08}{9.08}N_0} = \frac{9}{1}$$

$$Kt = 2.303 \log \frac{N_0}{N_{0-x}}$$

$$\frac{0.693}{\left(4.5 \times 10^9\right)}.t = 2.303 \log 9$$

$$t = \frac{2.303 \times 2 \times 0.48 \times 4.5 \times 10^9}{0.693} = 14.356 \times 10^9 = 143.56 \times 10^8 \text{ years.}$$

$P = 143.56$

[:Q.12] Among $[Co(CN)_4]^{4-}, [Co(CO)_3(NO)], XeF_4, [PCl_4]^+, [PdCl_4]^{2-}, [ICl_4]^-, [Cu(CN)_4]^{3-}$ and P_4 the total number of species with tetrahedral geometry is_____.

[:ANS] **4**

[:SOLN] $[Co(CN)_6]^4$ – squared palanar – dsp^2

$[Co(CO)_3No]$ – Tetrahedral – sp^3

XeF_4 – octahdral – sp^3d^2

PCl_4^+ – Tetrahedral – sp3

$PdCl_4^2$ – Square planar – dsp^2

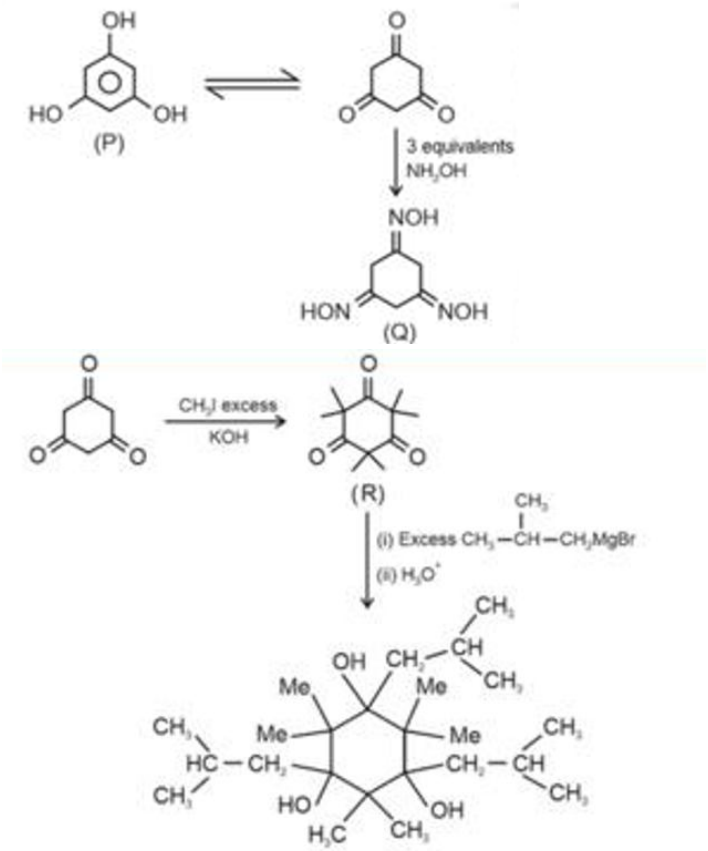
ICl_4^- – octahedral – sp^3d^2

[:Q.13] An organic compound **P** having molecular formula $C_6H_6O_3$ gives ferric chloride test and does not have intramolecular hydrogen bond. The compound **P** reacts with 3 equivalents of NaOH to produce oxime **Q**. Treatment of **P** with excess methyl iodide in the presence of KOH produces compound **R** as the major product. Reaction of **R** with excess iso-butylmagnesium bromide followed by treatment with H_3O^+ gives compound **S** as the major product.

The total number of methyl ($-CH_3$) groups(s) in compound S is_____.

[:ANS] 12

[:SOLN]



Number of CH_3 groups = 12

SECTION 4 (Maximum Marks : 12)

- This section contains TWO (02) paragraphs.
- Based on each paragraph, there are TWO (02) 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 If ONLY the correct numerical value is entered in the designated place;

Zero Marks : 0 In all other cases.

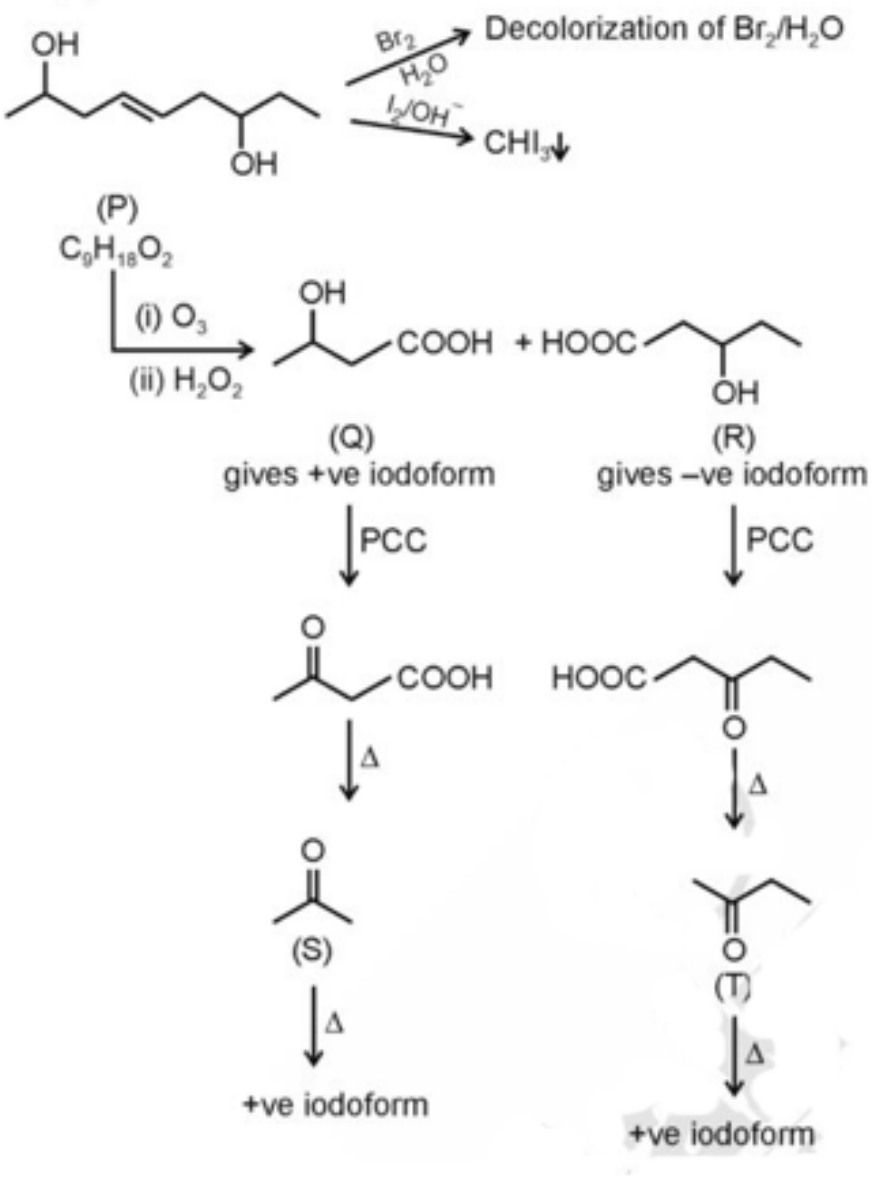
"PARAGRAPH-01"

An organic compound **P** with molecular formula $C_9H_{18}O_2$ decolorizes bromine water and also shows positive iodoform test. **P** on ozonolysis followed by treatment with H_2O_2 gives **Q** and **R**. While compound **Q** shows positive iodoform test, compound **R** does not give positive iodoform test. **Q** and **R** on oxidation with pyridinium chlorochromate (PCC) followed by heating give **S** and **T**, respectively. Both **S** and T show positive iodoform test. Complete copolymerization of 500 moles of **Q** and 500 moles of **R** gives one mole of a single acyclic copolymer **U**. [Given, atomic mass: H =1, C = 12, O =16]

[:Q.14] Sum of number of oxygen atoms in **S** and **T** is _____.

[:ANS] 2

[:SOLN]



Sum of number of O-atoms in S and T = 1 + 1 = 2

"PARAGRAPH-01"

An organic compound **P** with molecular formula $C_9H_{18}O_2$ decolorizes bromine water and also shows positive iodoform test. **P** on ozonolysis followed by treatment with H_2O_2 gives **Q** and **R**. While compound **Q** shows positive iodoform test, compound **R** does not give positive iodoform test. **Q** and **R** on oxidation with pyridinium chlorochromate (PCC) followed by heating give **S** and **T**, respectively. Both **S** and T show positive iodoform test.

Complete copolymerization of 500 moles of **Q** and 500 moles of **R** gives one mole of a single acyclic copolymer **U**.

[Given, atomic mass: H =1, C = 12, O =16]

[:Q.15] The molecular weight of **U** is_____.

[:ANS] **93018**

[:SOLN]

$$K_3[Fe(CN)_6] + KJ \longrightarrow K_4[Fe(CH)_6] + I_2$$

$$\downarrow ZnCl_2$$

$$K_2Zn_3\left[Fe(CN)_6\right]_2$$

"PARAGRAPH -02"

When potassium iodide is added to an aqueous solution of potassium ferricyanide, a reversible reaction is observed in which a complex **P** is formed. In a strong acidic medium, the equilibrium shifts completely towards **P**. Addition of zinc chloride to **P** in a slightly acidic medium results in a sparingly soluble complex **Q**.

[:Q.16] The number of moles of potassium iodide required to produce two moles of **P** is___.

[:ANS] **2**

"PARAGRAPH-02"

When potassium iodide is added to an aqueous solution of potassium ferricyanide, a reversible reaction is observed in which a complex **P** is formed. In a strong acidic medium, the equilibrium shifts completely towards **P**. Addition of zinc chloride to **P** in a slightly acidic medium results in a sparingly soluble complex **Q**.

[:Q.17] The number of zinc ions present in the molecular formula of **Q** is _____.

[:ANS] **3**

[:SOLN] $2K_4[Fe(CH)_6] + 3Z_nCl_2 \longrightarrow K_2Zn_3[Fe(CN)_6]_2 + 6KCl$