JEE(ADVANCED)–2024 (EXAMINATION)

(Held On Sunday 26th MAY, 2024)

CHEMISTRY | **TEST PAPER WITH ANSWER AND SOLUTION**

PAPER-2

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.

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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)

Sol. $KE = +13.6 \times \frac{Z^2}{n^2}$

(A) $KE_{1,H} = +13.6 \times \frac{1^2}{1^2} = 13.6\,eV$

(B) $KE_{1,He^+} = +13.6 \times \frac{2^2}{1^2} = 13.6 \times 4\ eV$

(C) $KE_{2,He^+} = +13.6 \times \frac{2^2}{2^2} = 13.6\ eV$

(D) $KE_{2,Li^{2+}} = +13.6 \times \frac{3^2}{2^2} = 13.6 \times \frac{9}{4}\ eV$

2. In a metal deficient oxide sample, $\mathbf{M_xY_2O_4}$ (**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 $\mathbf{M^{2+}}$ 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)

Sol. Average oxidation state of M = $\frac{1}{3} \times 2 + \frac{2}{3} \times 3 = +\frac{8}{3}$

∴ For $M_XY_ZO_Y$

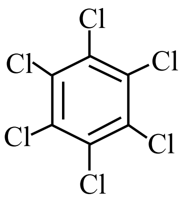
$\frac{8}{3} \times x + 3 \times 2 + 4\,(-2) = 0$

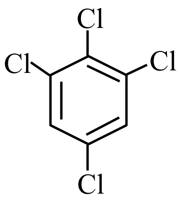
$\frac{8}{3} \times x = 2$

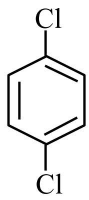
$x = \frac{3}{4} = 0.75$

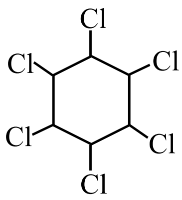
3. In the following reaction sequences, the major product **Q** is:

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

(A) 

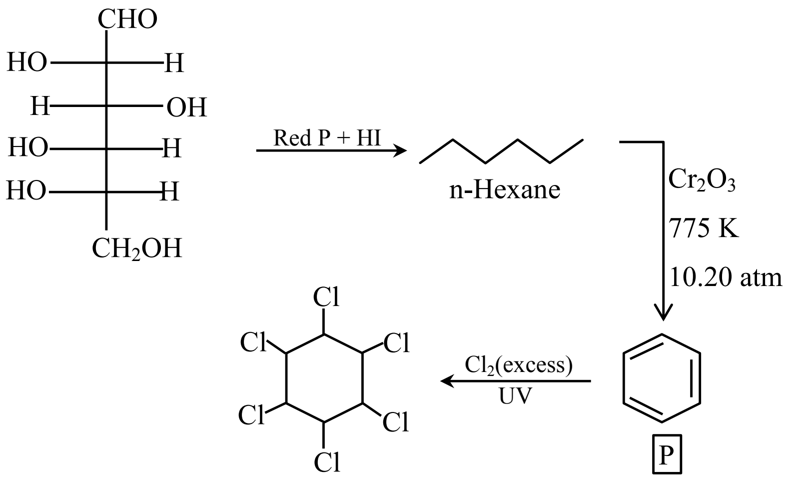
(B) 

(C) 

(D) 

Ans. (D)

Sol.



Lindane - 6, 6, 6

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)

Sol. PCl_5 when fluorinated in a polar organic solvent, ionic isomers are formed.

$[PCl_4^+][PCl_4F_2]^-$ (colorless crystals)

$[PCl_4^+][PF_6]^-$ (white crystals)

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 +2 marks;
choosing ONLY (B) and (D) will get +2 marks;
choosing ONLY (A) will get +1 marks;
choosing ONLY (B) will get +1 marks;
choosing ONLY (D) will get +1 marks;
choosing no option (i.e. the question is unanswered) will get 0 marks and
choosing any other option(s) will get –2 marks.

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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 statement(s) about the above 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^-.

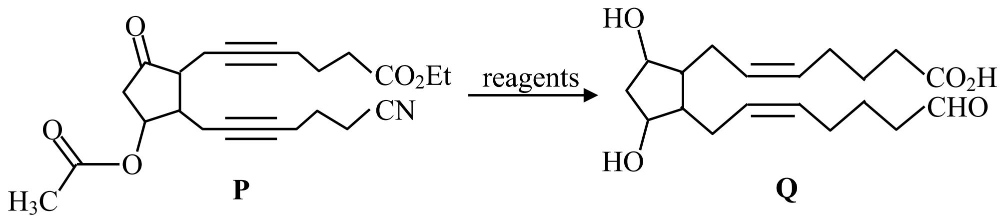
(D) Oxides of nitrogen are major by-products of the electrochemical process.

Ans. (A,C)

Sol. Anode : $N_2H_4(aq) + 4OH^-(aq) \longrightarrow N_2(g) + 4H_2O(l) + 4e^-$

Cathode : $2H_2O(l) + O_2(g) + 4e^- \longrightarrow 4OH^-(aq)$

6. The option(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^+

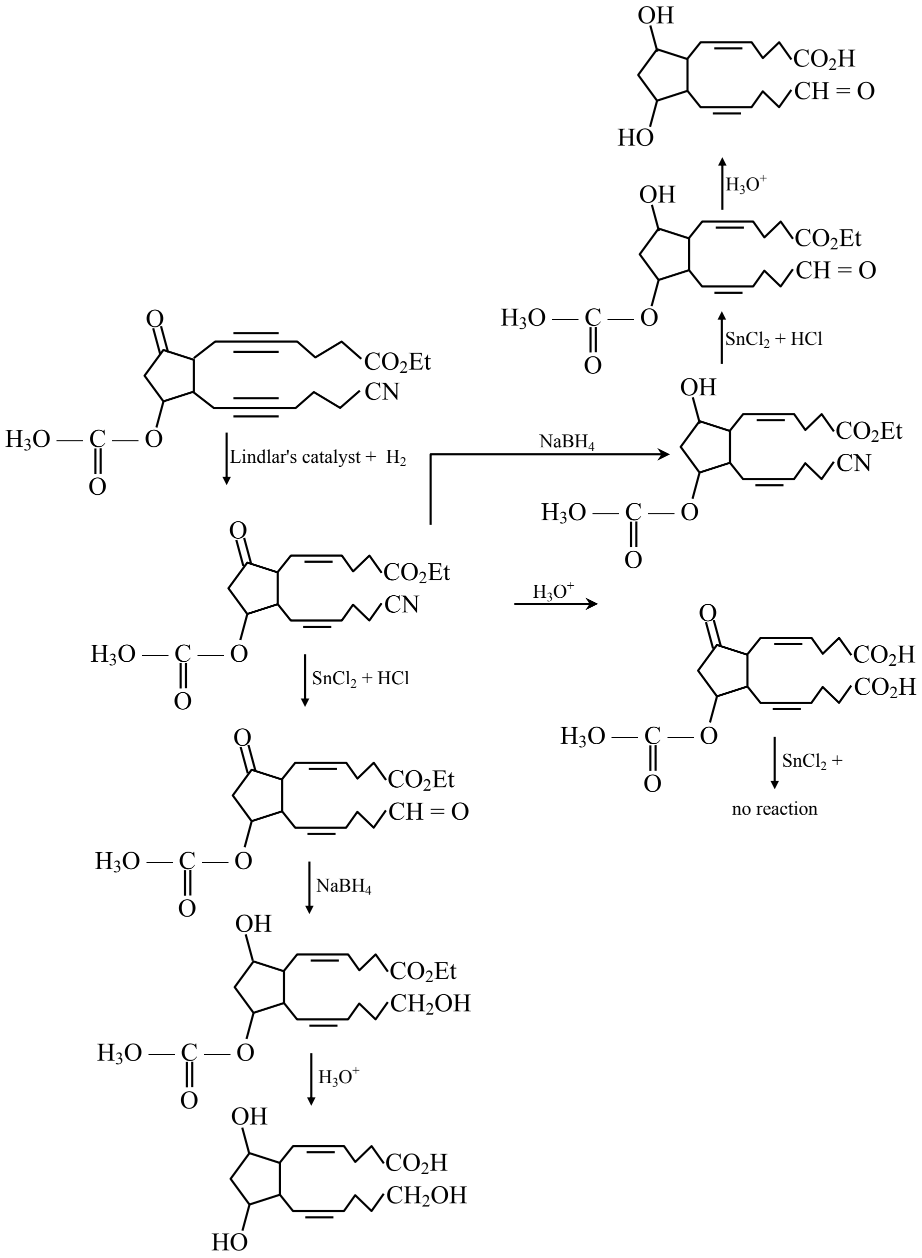
(B) i) Lindlar's catalyst, H_2 ; ii) H_3O^+ ; iii) $SnCl_2/HCl$; iv) $NaBH_4$

(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. (C,D)

Sol.



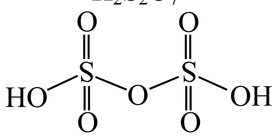
7. The compound (s) having peroxide linkage is(are) :

(A) $H_2S_2O_7$ (B) $H_2S_2O_8$ (C) $H_2S_2O_5$ (D) H_2SO_5

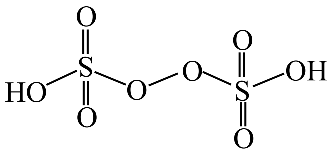
Ans. (B,D)

Sol.

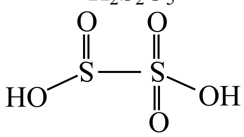
$H_2S_2O_7$



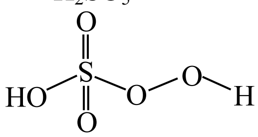
$H_2S_2O_8$



$H_2S_2O_5$



H_2SO_5



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 on-screen 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.

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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 ramained unadsorbed. To neutralize the unadsorbed acetic acid, 40 mL of 1 M NaOH solution was required. If each molecule of acetic acid occupies **P** $\times 10^{-23}$ 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) = 6.0×10^{23} mol^{-1}]

Ans. (2500)

Sol. Millimole of acid taken = $100 \times 0.5 = 50$

Millimole of NaOH used = $40 \times 1 = 40$

Millimole of acid adsorbed = $50 - 40 = 10$

Molecules of acid adsorbed = $10 \times 10^{-3} \times 6 \times 10^{23} = 6 \times 10^{21}$

Surface area occupied per molecule = $\dfrac{1.5\times10^2}{6\times10^{21}} = 0.25 \times 10^{-19} = 2500 \times 10^{-23}$

9. Vessel-1 contains $\mathbf{w_2}$ g of a non-volatile solute **X** dissolved in $\mathbf{w_1}$ g of water. Vessel-2 contains $\mathbf{w_2}$ g of another non-volatile solute **Y** dissolved in $\mathbf{w_1}$ 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)

Sol. Vessel – I :

$$(\Delta T_b)_1 = i_1 \times K_b \times \frac{w_2 / GMM_X}{w_1 / 1000}$$

Vessel – 2 :

$$(\Delta T_b)_2 = i_2 \times K_b \times \frac{w_2 / GMM_Y}{w_1 / 1000}$$

$$\frac{(\Delta T_b)_1}{(\Delta T_b)_2} = \frac{i_1}{i_2} \times \frac{GMM_Y}{GMM_X} = \frac{1.2}{0.8} = \frac{3}{2}$$

$$\left[\frac{(\Delta T_b)_1}{(\Delta T_b)_2}\right] \times 100 = \frac{3}{2} \times 100 = 150\%$$

10. For a double strand DNA, one strand is given below:

5' A G T C A C G T A A G T C **3'**

The amount of energy required to split the double strand DNA into two single strands 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}, and A-U base pair = 1.25 kcal mol^{-1}. Ignore electrostatic repulsion between the phosphate groups.]

Ans. (41)

Sol. A = T 2 H-bond

G ≡ C 3 H-bond

Number of A=T pair = 7

Number of G≡C pair = 6

Number of H-bond involve in A = T = 7 × 2 = 14

Number of H-bond involve in G ≡ C = 6 × 3 = 18

Energy required for A = T = 14 × 1 = 14

Energy required for G ≡ C = 18 × 1.5 = 27

Total energy required 14 + 27 = 41

11. A sample initially contains only U-238 isotope of uranium. With time, some of the U-238 radioactively decays into Pb-206 while the rest of it remains undisintegrated.

When the age of the sample is **P** $\times 10^8$ 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; $\log_e 2 = 0.639$]

Ans. (143)

$$_{92}U^{238} \longrightarrow {}_{82}Pb^{206} + 8\,{}_2He^4 + 6\,{}_{-1}\beta^0$$

$t = 0 \qquad N_0 = \left(\frac{1}{238} + \frac{7}{206}\right)$ moles

$t = tN_t = \frac{1}{238}$ moles $\qquad x = \frac{7}{206}$ moles

As per 1st order kinetics :

$$\lambda t = \ell n \frac{N_0}{N_t}$$

$$\frac{\ell n 2}{4.5\times10^9} = \frac{1}{t}\ell n \frac{\frac{1}{238}+\frac{7}{206}}{\frac{1}{238}}$$

$$t = \frac{4.5\times10^9}{\ell n 2}\ell n \frac{1872}{206}$$

$$t = 4.5\times10^9 \times \frac{\ell n(9.08)}{\ell n 2} = 4.5 \times 10^9 \times \frac{2.206}{0.693} = 143.3 \times 10^8$$

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. (5)

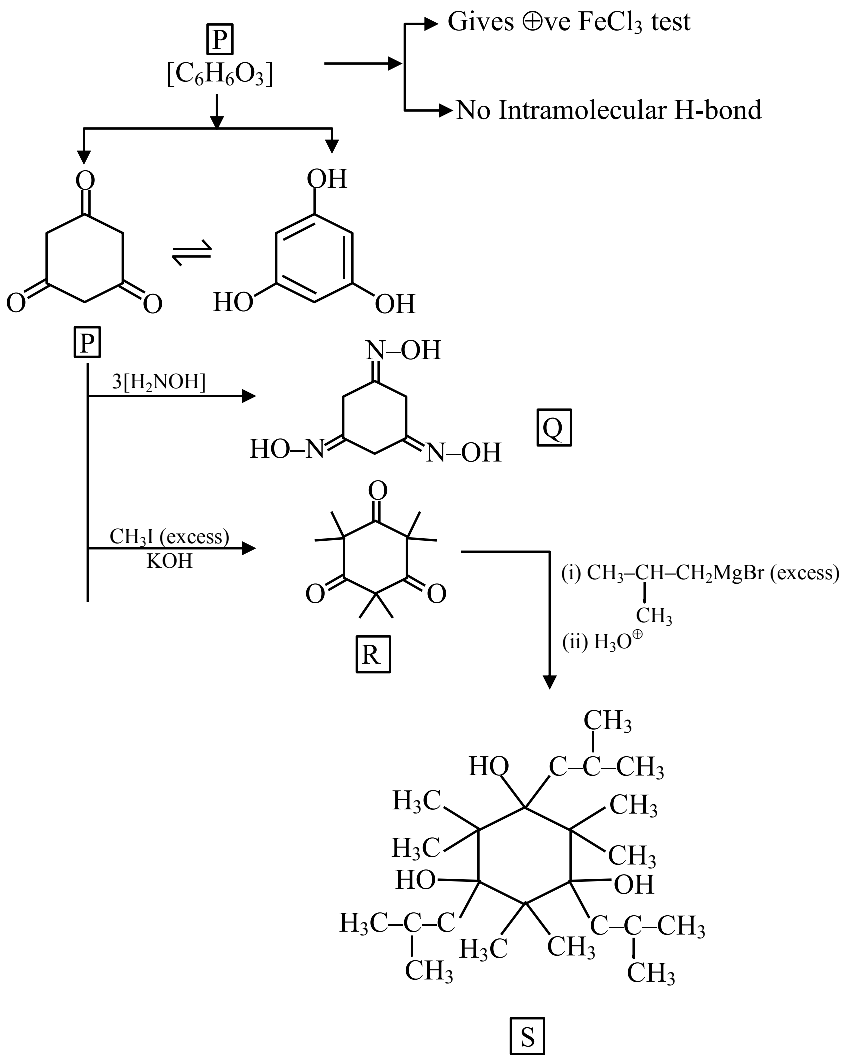
Sol. $[Co(CN)_4]^{4-}$, $[Co(CO)_3NO]$, $[PCl_4]^+$, $[Cu(CN)_4]^{3-}$ & P_4 are with tetrahedral geometry.

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 NH_2OH 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) group(s) in compound **S** is ________.

Ans. **(12)**

Sol.



No. of –CH_3 group (methyl group) in S is → 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 I"

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.

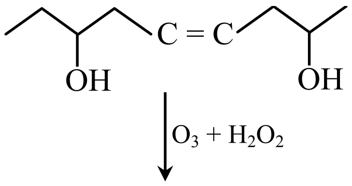
Complete copolymerization of 500 moles of **Q** and 500 moles of **R** gives one mole of a single acyclic copolymer **U**.

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

14. Sum of number of oxygen atoms in **S** and **T** is ________.

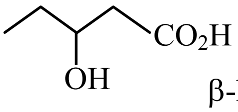
Ans. **(2)**

Sol.



(P) [$C_9H_{18}O_2$]

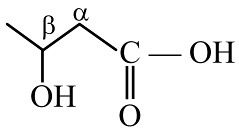
(R)



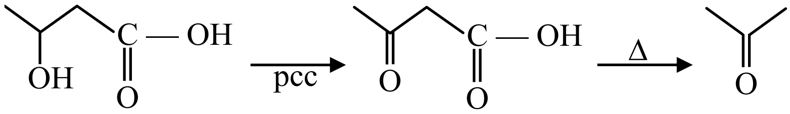
β-hydroxy valeric acid does not given +ve iodoform test

+

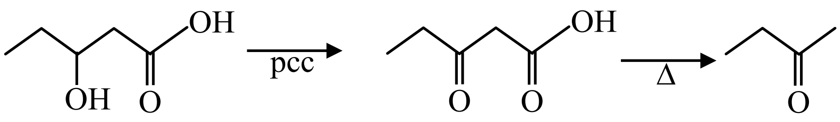
(Q)



β-hydroxy butyric acid does give +ve iodoform test



(Q) (S)



(R) (T)

S & T shows +ve idoform test.

Total oxygen atoms

present in S, T are = 1 + 1 = 2

Ans. ⇒ 2

"PARAGRAPH I"

An organic compound **P** wth 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.

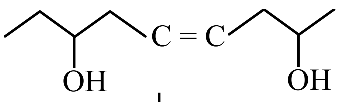
Complete copolymerization of 500 moles of **Q** and 500 moles of **R** gives one mole of a single acyclic copolymer **U**.

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

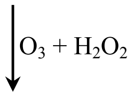
15. The molecular weight of **U** is _________.

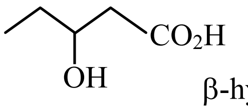
Ans. **(93018)**

Sol.



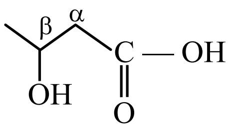
(P) [$C_9H_{18}O_2$]



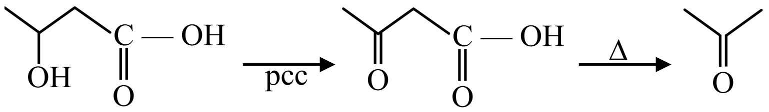
(R) 

β-hydroxy valeric acid does not given +ve iodoform test

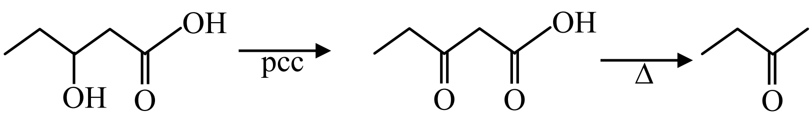
+

(Q) 

β-hydroxy butyric acid does give +ve iodoform test



(Q) (S)



(R) (T)

S & T shows +ve idoform test.

R mf $C_5H_{10}O_3$ $(M.\ wt)_R = 70 + 48 = 118$

Q mf $C_4H_8O_3$ $(M.\ wt)_Q = 56 + 48 = 104$

$$500 \text{ mole Q} + 500 \text{ mole R} \xrightarrow[\text{polymer}]{\text{Condensation}} \begin{matrix}\text{PHBV.} \\ \text{(1 mole)} \\ \text{Acyclic polymer}\end{matrix} \quad \text{V}$$

U molecular weight $= 500 \times 118 + 500 \times 104 - 999 \times 18$

$= 500 \times 222 - 17982$

$= 111000 - 17982 = 93018$

Ans. is $\Rightarrow$ 93018

"PARAGRAPH II"

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**.

16. The number of moles of potassium iodide required to produce two moles of **P** is _______.

Ans. **(2)**

Sol. $KI + K_3[Fe(CN)_6] \rightleftharpoons K_4[Fe(CN)_6] + \frac{1}{2}I_2$

Moles of KI required = 2

"PARAGRAPH II"

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**.

17. The number of zinc ions present in the molecular formula of **Q** is ________.

Ans. **(3 or 2)**

Sol. $Zn^{2+} + K_4[Fe(CN)_6] \rightarrow K_2Zn_3[Fe(CN)_6]_2$

OR

$Zn^{2+} + K_4[Fe(CN)_6] \rightarrow Zn_2[Fe(CN)_6]$