PART – A (PAPER-2)_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.

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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. K.E. of electron in n^{th} Bohr's orbit,

$$\text{K.E.} = 13.6\frac{Z^2}{n^2}\ \text{eV/atom}$$

$$n = 1(\text{H-atom}) \rightarrow \text{K.E.} \propto \frac{1^2}{1^2} = 1$$

$$n = 1\left(He^+\text{ion}\right) \rightarrow \text{K.E.} \propto \frac{2^2}{1^2} = 4$$

$$n = 2\left(He^+\text{ion}\right) \rightarrow \text{K.E.} \propto \frac{2^2}{2^2} = 1$$

$$n = 2\left(Li^{2+}\ \text{ion}\right) \rightarrow \text{K.E.} \propto \frac{3^2}{2^2} = \frac{9}{4}$$

Highest for $\rightarrow n = 1$ of He^+ ion.

2. In a metal deficient oxide sample, Mx_2Y_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)**

Sol. $M_xY_2O_4$

$$M^{+2} = \frac{X}{3}, M^{+3} = \frac{2X}{3}$$

So, total of O.N. of all atoms

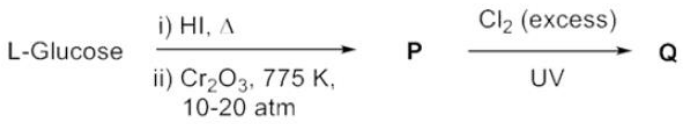
$$\frac{2X}{3} + 3\left(\frac{2X}{3}\right) + 2(+3) + 4(-2) = 0$$

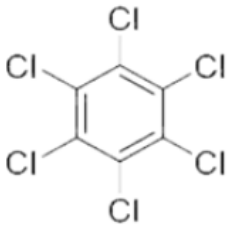
$$\frac{2X}{3} + 2X + 6 - 8 = 0$$

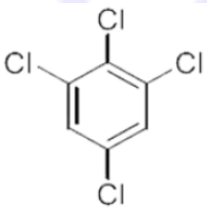
$$\frac{8X}{3} = 2$$

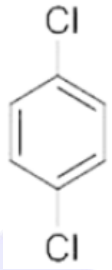
$$X = \frac{6}{8} = \frac{3}{4} = 0.75$$

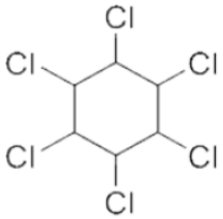
3. In the following reaction sequence, the major product Q **is**



(A) 

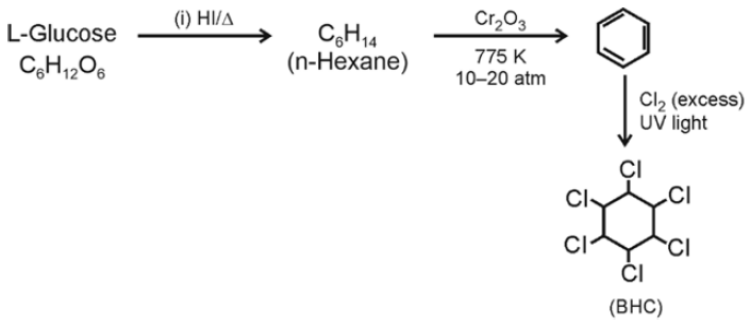
(B) 

(C) 

(D) 

Ans. **(D)**

Sol.



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. If PCl_5 is fluorinated in a polar solvent, ionic isomers are formed. e.g.:-

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

and $[PCl_4]^+[PF_6]^-$ (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.

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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)**

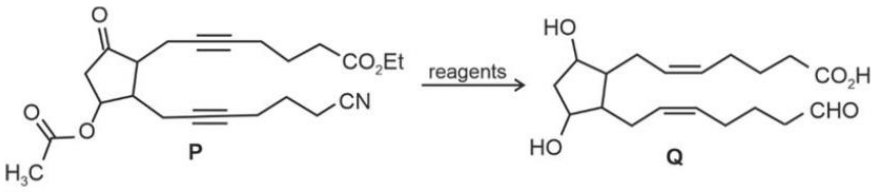
Sol. At anode: $N_2H_4 + 4OH^- \longrightarrow N_2 + 4H_2O + 4e^-$

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

Complete reaction: $N_2H_4 + O_2 \longrightarrow N_2 + 2H_2O$

Statements (A) and (C) are correct.

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^+

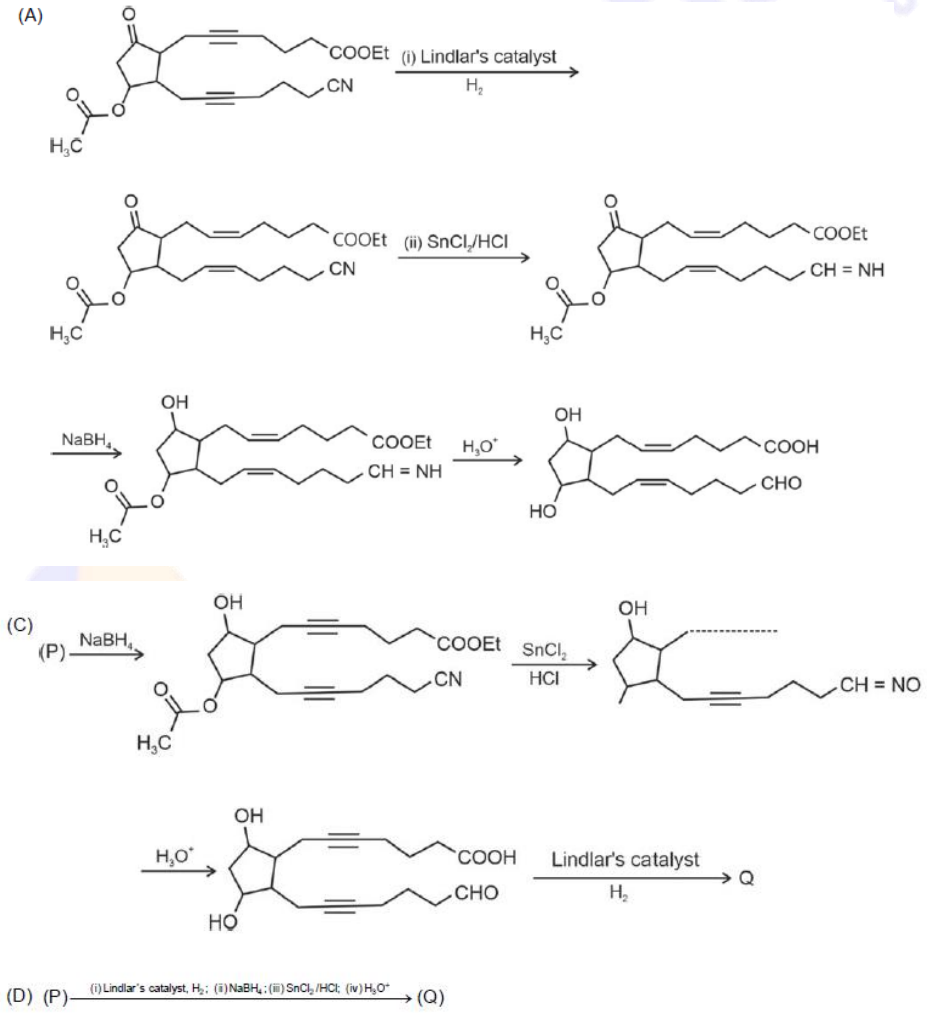
(B) i) Lindlar's catalyst, H_2 ; ii) H_3O^+ ; iii) $SnCl_2 / HCl$; iv) $NaBH_4$

(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. **(A,C,D)**

Sol.

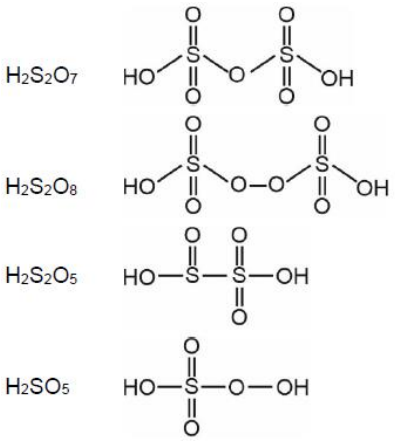


7. The compound(s) having peroxide linkage is(are)

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

Ans. **(B,D)**

Sol.



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.

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

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

Ans. **(2500)**

Sol. Number of moles of unadsorbed $CH_3COOH=\dfrac{40\times1}{1000}=4\times10^{-2}\,m$

Number of moles of adsorbed $CH_3COOH=\dfrac{100\times0.5}{1000}-4\times10^{-2}$

$=10^{-2}\,mol$

Surface area occupied by one molecule of

$$CH_3COOH=\frac{1.5\times10^{2}}{10^{-2}\times6\times10^{23}}=\frac{150\times10^{2}\times10^{-23}}{6}$$

$=2500\times10^{-23}\,m^2$

$\therefore$ As per question $P=2500$

9. Vessel- 1 contains $w_2 g$ of a non-volatile solute X dissolved in w_1 g 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)**

Sol. **Vessel-I**

$$(\Delta T_B)_1 = i_X \frac{w_2}{M_X} \cdot \frac{1}{W_1} \times 1000 \times K_b$$

$M_x = \text{Molarmass of 'X'}$

Vessel-II

$$(\Delta T_B)_{II} = i_Y \frac{W_2}{M_Y} \cdot \frac{1}{W_1} \times 1000 \times K_B$$

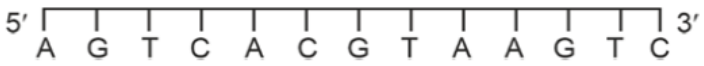
$M_Y = \text{Molarmass of 'Y'}$

$$\frac{(\Delta T_b)_l}{(\Delta T_b)_{II}} \times 100 = \frac{i_X}{i_Y} \cdot \ frac M_Y M_X \times 100$$

$$= 1.2 \times \frac{100}{80} \times 100$$

$$= 150\%$$

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



The amount of energy required to split the double strand DNA into two single strands is _____ kcalmol^{-1}.

[Given: Average energy per H-bond for A-T base pair $= 1.0 \text{kcalmol}^{-1}$, $G-C$ base pair $= 1.5 \text{kcalmol}^{-1}$, and $A-U$ base pair $= 1.25 \text{kcalmol}^{-1}$. Ignore electrostatic repulsion between the phosphate groups.]

Ans. **(41)**

Sol.

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

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** × 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; $\log_e 2 = 0.693$]

Ans. **(143)**

Sol. Life of sample $\rightarrow t$ years

$[A]_0 \propto$ Initial mole of U-238

$[A]_t \propto$ Final mole of U-238

$$\frac{[A]_0}{[A]_t} = \frac{\frac{1}{238}+\frac{7}{206}}{\frac{1}{238}}$$

$$= \frac{0.0042+0.0340}{0.0042}$$

$$= 9.1$$

$$= \frac{2.303\log 2 \times t}{4.5\times10^9} = 2.303\log 9.1$$

$$t = 14.27\times10^9 \text{ years}$$

$$= 142.7\times10^9 \text{ years}$$

$$P = 142.7$$

$$P \simeq 143$$

12. Among $\left[Co(CN)_4\right]^4, \left[Co(CO)_3(NO_2)\right], XeF_4, \left[PCl_4\right]^+, \left[PdCl_4\right]^{2-}, \left[Cl_4\right]^-, \left[Cu(CN)_4\right]^{3-}$ and P_4 the total number of species with tetrahedral geometry is _____.

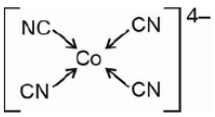
Ans. **(3)**

Sol.

$[Co(CN)_4]^{4-} \Rightarrow Co^0 \Rightarrow 3d^7 4s^2$

Due to SFL, CN^- pairing and transference of electron takes place and hybridisation is dsp^2

Geometry ⇒ Square planer

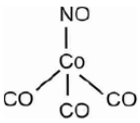


$[Co(CO)_3NO]$

$Co^{-1} \Rightarrow 3d^{10}$ due to SFL CO and NO

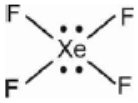
sp^3 hybridisation

Geometry = Tetrahedral



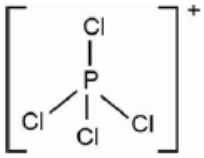
$XeF_4 \Rightarrow 4bp + 2lp \Rightarrow sp^3d^2$

Square planer



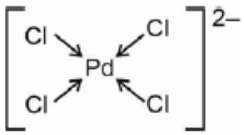
$PCl_4^+ \Rightarrow 4pb + 0lp$

$sp^3 \Rightarrow$ tetrahedral



$[PdCl_4]^{2-} \Rightarrow Pd^{2+}$, Cl^- behaves as SFL

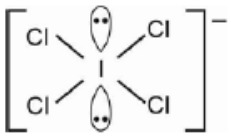
$Pd^{2+} \Rightarrow 4d^8 \Rightarrow dsp^2 \Rightarrow$ square planer



$ICl_4^- \Rightarrow 4bp + 2lp$

sp^3d^2

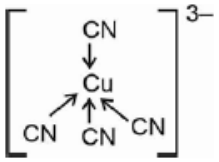
square planer



$[Cu(CN)_4]^{3-} \Rightarrow Cu^{+1} \Rightarrow 3d^{10}$

$\Rightarrow sp^3$

Tetrahedral



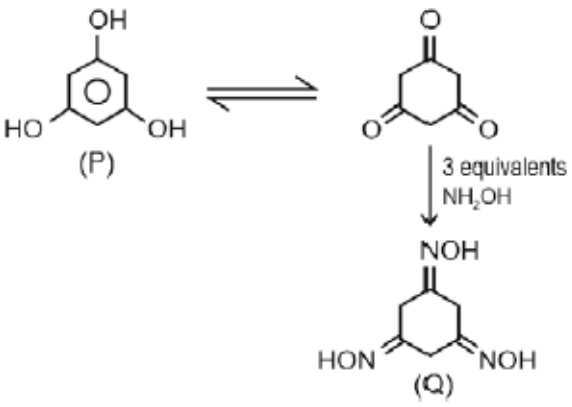
13. An organic compound **P** having molecular formula $C_6H_6O_3$ gives ferric chloride test and does not have intramolecular hydrogen bond. The compound **P** reacts with 3 equivalents of NH_2OH to produce oxime **Q**. Treatment of **P** with excess methyl iodide in the presence of KOH produces compound **R** as the major product.

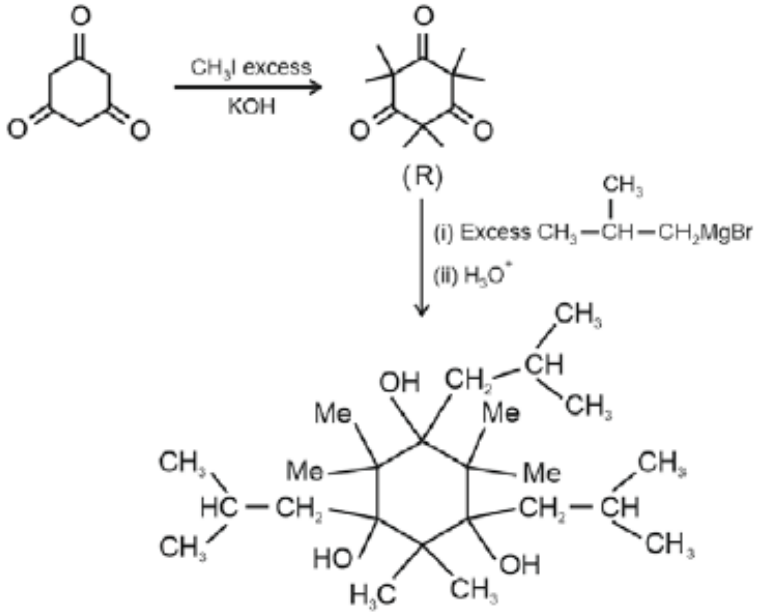
Reaction of **R** with excess *iso*-butylmagnesium bromide followed by treatment with H_3O^+ gives compound **S** as the major product.

The total number of methyl ($-CH_3$) group(s) in compound **S** is _____.

Ans. **(12)**

Sol.





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 onscreen 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 Question 14 to 15

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.

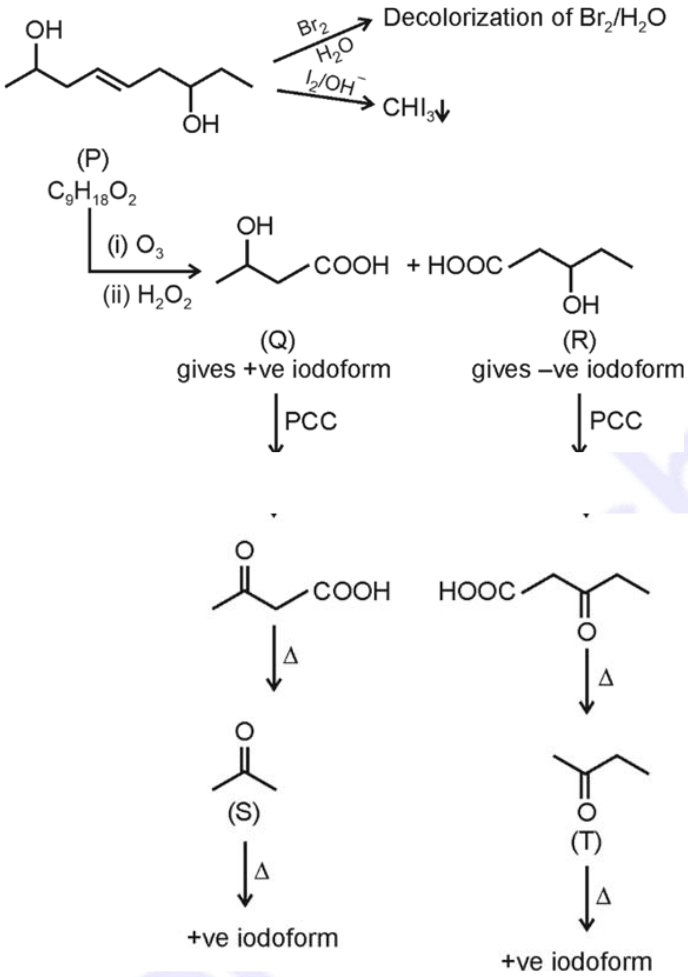
Complete copolymerization of 500 moles of **Q** and 500 moles of **R** gives one mole of a single acyclic copolymer **U**.

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

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

Ans. **(2)**

Sol.

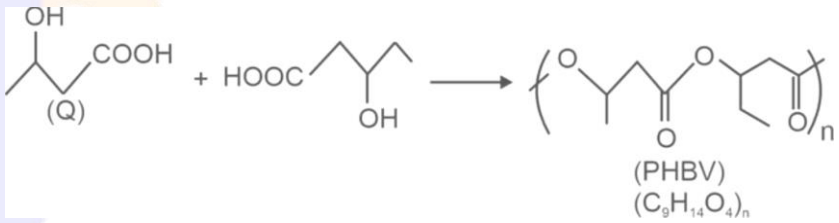


Sum of number of O-atoms in **S** and **T** = 1 + 1 = 2

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

Ans. **(102018)**

Sol.



Mol. wt. of polymer = (104 × 500) + (118 × 500) – 18 × 499

= 52000 + 59000 – 8982

= 102018 g

PARAGRAPH II Question 16 to 17

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. From this equation we need 2 mol of KI

$2KI + 2K_3[Fe(CN)_6] \rightarrow I_2 + 2K_4[Fe(CN)_6]$

$2K_4[Fe(CN)_6] + 3ZnCl_2 \rightarrow K_2Zn_3[Fe(CN)_6]_2 + 6KCl$

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

Ans. **(3)**

Sol. From this equation we need 2 mol of KI

$2KI + 2K_3[Fe(CN)_6] \rightarrow I_2 + 2K_4[Fe(CN)_6]$

$2K_4[Fe(CN)_6] + 3ZnCl_2 \rightarrow K_2Zn_3[Fe(CN)_6]_2 + 6KCl$