JEE Adv. August 2022

Question Paper With Text Solution

28 August | Paper-2

CHEMISTRY

MATRIX

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

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JEE ADV. AUGUST 2022 | 28TH. AUGUST PAPER-2

SECTION 1 (Maximum marks: 24)

- This section contains EIGHT (08) questions.
- The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 TO 9, BOTH INCLUSIVE.
- 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 : +3 If ONLY the correct integer is entered;
  Zero Marks : 0 If the question is unanswered;
  Negative Marks : -1 In all other cases.

1. Concentration of H_2SO_4 and Na_2SO_4 in a solution is 1 M and 1.8×10^{-2} M, respectively. Molar solubility of $PbSO_4$ in the same solution is $X \times 10^{-Y}$ M (expressed in scientific notation). The value of Y is _____.

[Given: Solubility product of $PbSO_4$ (K_{sp}) = 1.6×10^{-8}. For H_2SO_4, K_{a1} is very large and $K_{a2} = 1.2 \times 10^{-2}$]

Ans. (6)

Sol. $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$

1

0 1 1

$HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$ $\quad K_{a2} = 1.2 \times 10^{-2}$

$$\frac{[H^+][SO_4^{2-}]}{[HSO_4^-]} = 1.2 \times 10^{-2} \quad \ldots\ldots\ldots\ldots (1)$$

Conc. of SO_4^{2-} from Na_2SO_4 is 1.8×10^{-2}. If dissociation of HSO_4^- takes place then it would be more than 1.8×10^{-2} which is not possible according to equation (1)

$HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$

1 1 1.8×10^{-2}

$1 + x$ $\quad 1 - x$ $\quad 1.8 \times 10^{-2} - x$

$$\frac{(1.8\times10^{-2} - x)(1-x)}{1+x} = 1.2 \times 10^{-2}$$

Since value of x is very low

$1 + x \approx 1$

$1 - x \approx 1$

$1.8 \times 10^{-2} - x = 1.2 \times 10^{-2}$

$x = 0.6 \times 10^{-2}$

$[SO_4^{2-}] = 1.2 \times 10^{-2}$

$PbSO_4 \rightleftharpoons Pb^{2+} + SO_4^{2-}$

s s + 1.2 × 10^{-2}

$s(s + 1.2 \times 10^{-2}) = 1.6 \times 10^{-8}$

$s + 1.2 \times 10^{-2} \approx 1.2 \times 10^{-2}$

$(s)\ (1.2 \times 10^{-2}) = 1.6 \times 10^{-8}$

$s = \frac{16}{12} \times 10^{-6}$

2. An aqueous solution is prepared by dissolving 0.1 mol of an ionic salt in 1.8 kg of water at 35 °C. The salt remains 90% dissociated in the solution. The vapour pressure of the solution is 59.724 mm of Hg. Vapor pressure of water at 35 °C is 60.000 mm of Hg. The number of ions present per formula unit of the ionic salt is _____.

Ans. (5)

Sol. $\frac{P^0 - P_S}{P^0} = \frac{in}{in + N}$

$$\frac{60 - 59.724}{60} = \frac{i \times 0.1}{i \times 0.1 + \frac{1.8 \times 10^3}{18}}$$

$$\frac{0.276}{60} = \frac{i \times 0.1}{i \times 0.1 + 100}$$

$i \times 0.1 \times 0.276 + 27.6 = 6i$

$$i = \frac{27.6}{6 + 0.0276} = 4.6$$

$i = 1 + \alpha\ (n - 1)$ {Where n = no. of ions produced by one formula unit of ionic compound}

$4.6 = 1 + 0.9\ (n - 1)$

$3.6 = 0.9\ (n - 1)$

$n - 1 = 4$

$n = 5$

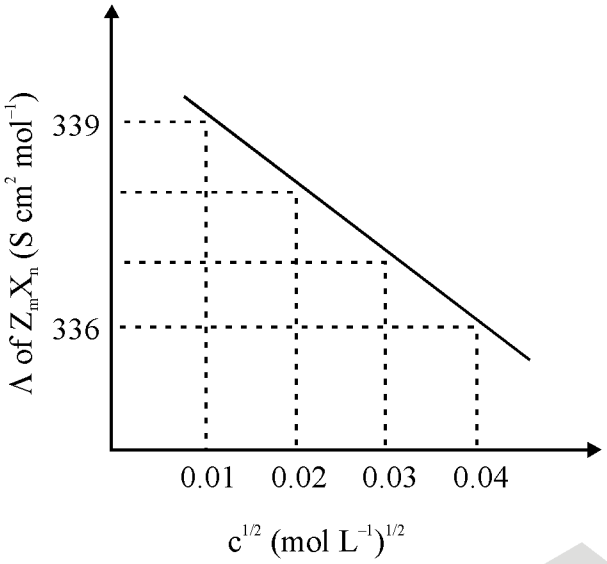
3. Consider the strong electrolytes Z_mX_n, U_mY_p and V_mX_n. Limiting molar conductivity $\left(\Lambda^0\right)$ of U_mY_p and V_mX_n are 250 and 440 S cm^2 mol^{-1}, respectively. The value of (m + n + p) is _____.

Given:

Ion	Z^{n+}	U^{p+}	V^{n+}	X^{m-}	Y^{m-}
$\lambda^0\left(Scm^2mol^{-1}\right)$	50.0	25.0	100.0	80.0	100.0

λ^0 is the limiting molar conductivity of ions

The plot of molar conductivity (Λ) of Z_mX_n vs $c^{1/2}$ is given below.



Ans. (7)

Sol. For U_mY_p

$250 = m \times 25 + p \times 100$ ..... (1)

For V_mX_n

$440 = m \times 100 + n \times 80$ ..... (2)

For electrolyte Z_mX_n

$\lambda_m = \lambda_m^0 - b\sqrt{c}$

$-b = \dfrac{336-339}{0.04-0.01} \Rightarrow b = 100$

Hence at a Conc. of 0.04

$336 = \lambda_m^0 - 100 \times 0.04$

$\lambda_m^0 = 340$

$340 = m \times 50 + n \times 80$ ..... (3)

From equation (1), (2) & (3)

$m = 2, n = 3, p = 2$

Hence $m + n + p = 7$

4. The reaction of Xe and O_2F_2 gives a Xe compound **P**. The number of moles of HF produced by the complete hydrolysis of 1 mol of **P** is _____.

Ans. (4)

Sol. $Xe + 2O_2F_2 \rightarrow \underset{\text{'P'}}{XeF_4} + 2O_2$

$6XeF_4 + 12H_2O \rightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$

Hydrolysis of one mole of XeF_4 (P) will produce 4 mole of HF.

5. Thermal decomposition of $AgNO_3$ produces two paramagnetic gases. The total number of electrons present in the antibonding molecular orbitals of the gas that has the higher number of unpaired electrons is _____.

Ans. (6)

Sol. $2AgNO_3 \rightarrow 2Ag(s) + 2NO_2(g) + O_2(g)$

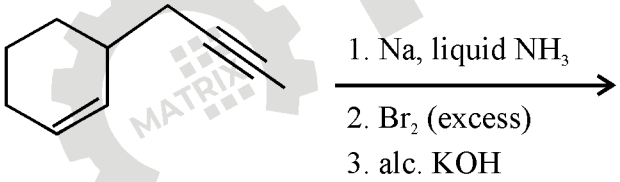
NO_2 and O_2 both are paramagnetic but O_2 contains 2 unpaired electron where as NO_2 contains one.

For O_2

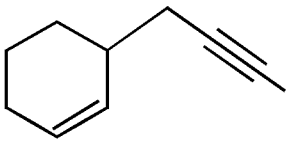
$\sigma_{1s}^2\ \sigma_{1s}^{*2}\ \sigma_{2s}^2\ \sigma_{2s}^{*2}\ \sigma_{2p_z}^2\ \pi_{2p_x}^2 = \pi_{2p_y}^2\ \pi_{2p_x}^{*1} = \pi_{2p_y}^{*1}$

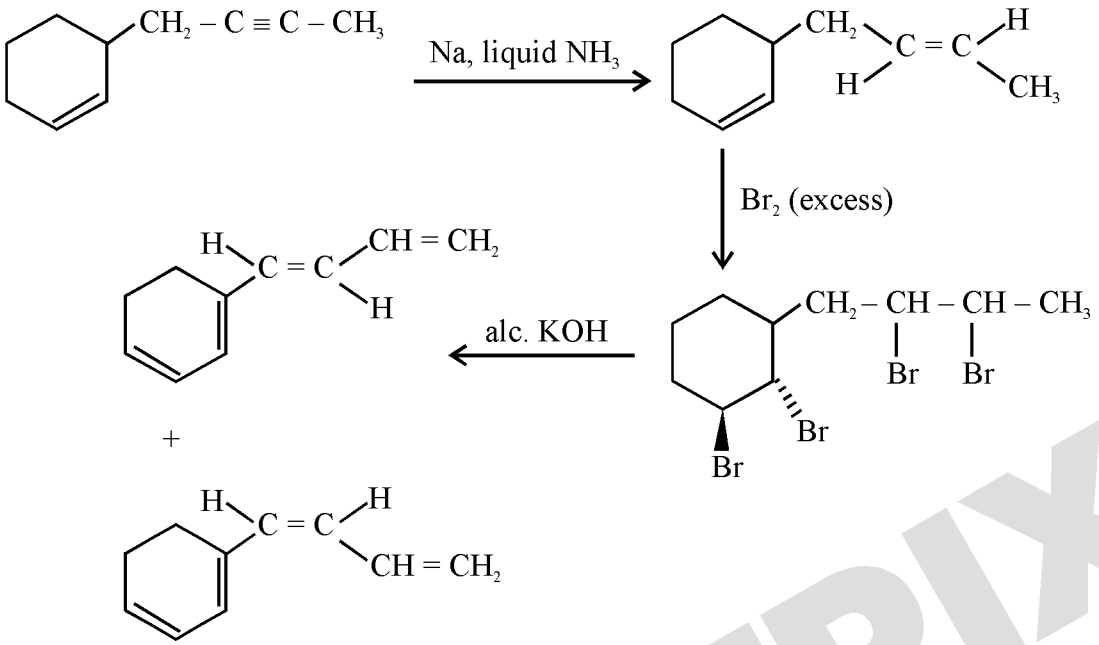
Total number of electrons in antibonding molecular orbitals = 6.

6. The number of isomeric tetraenes (**NOT** containing *sp*-hybridized carbon atoms) that can be formed from the following reaction sequence is _____.

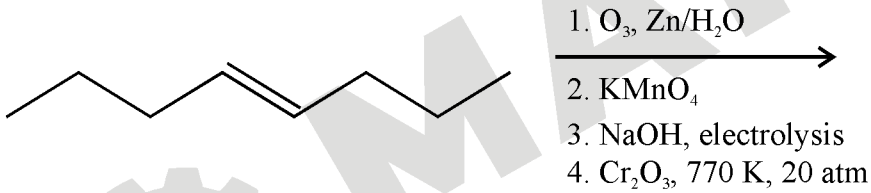


Ans. (2)

Sol. 

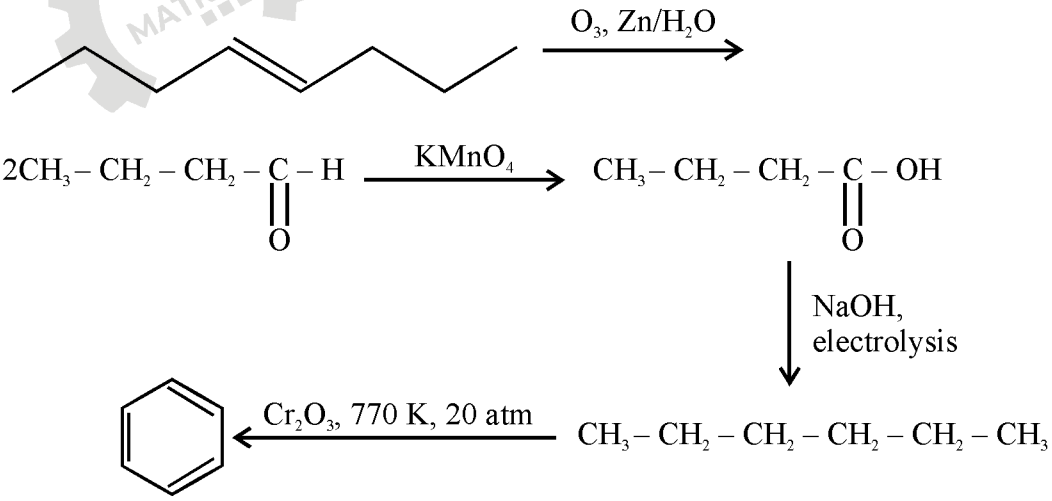


7. The number of $-CH_2-$ (methylene) groups in the product formed from the following reaction sequence is _____.

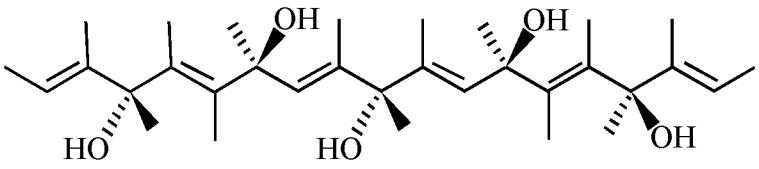


Ans. (0)

Sol.



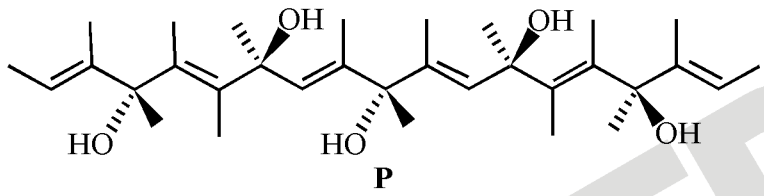
8. The total number of chiral molecules formed from one molecule of **P** on complete ozonolysis (O_3, Zn/H_2O) is _____.



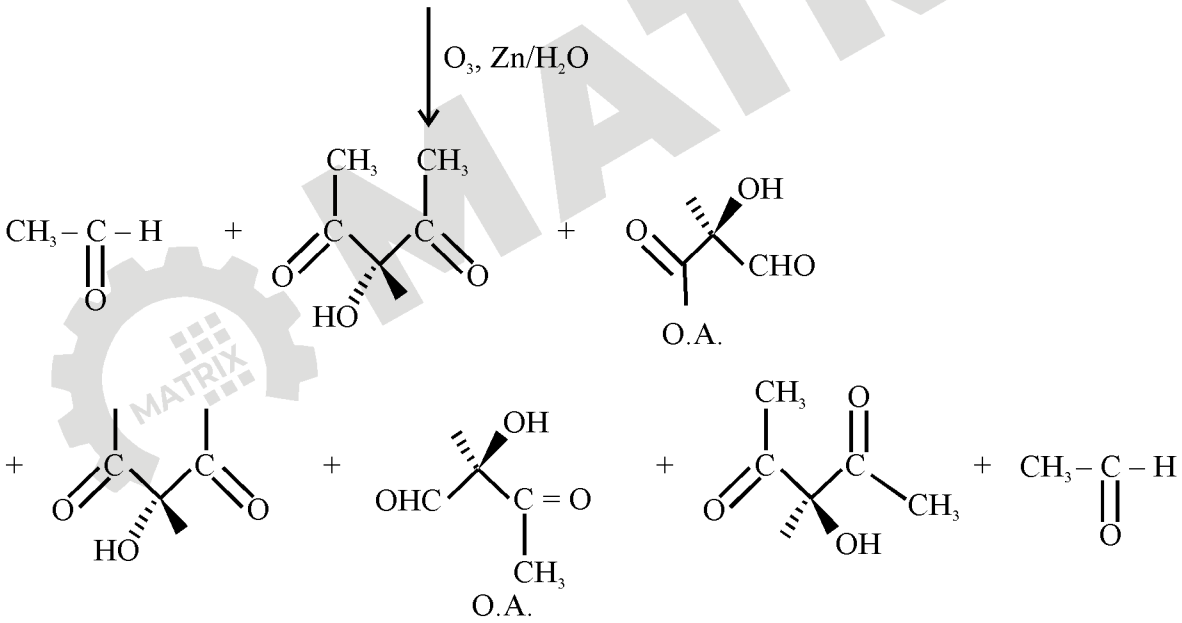
P

Ans. (2)

Sol.



P



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 unanswered;

  Negative Marks: –2 In all other cases.

9. To check the principle of multiple proportions, a series of pure binary compounds (P_mQ_n) were analyzed and their composition is tabulated below. The correct option(s) is(are)

Compound	Weight % of P	Weight % of Q
1	50	50
2	44.4	55.6
3	40	60

(A) If empirical formula of compound 3 is P_3Q_4, then the empirical formula of compound 2 is P_3Q_5.

(B) If empirical formula of compound 3 is P_3Q_2 and atomic weight of element P is 20, then the atomic weight of Q is 45.

(C) If empirical formula of compound 2 is PQ, then the empirical formula of the compound 1 is P_5Q_4.

(D) If atomic weight of P and Q are 70 and 35, respectively, then the empirical formula of compound 1 is P_2Q.

Ans. (B), (C)

Sol. (A) If empirical formula of compound 3 is P_3Q_4.

$$\frac{3M_P}{3M_P+4M_Q}\times 100 = 40$$

$15\ M_P = 6\ M_P + 8M_Q$

$9M_P = 8M_Q$

$$\frac{M_P}{M_Q} = \frac{8}{9}$$

Hence for compound 2

$$\text{Weight \% of P} = \frac{3M_P}{3M_P + 5M_Q} \times 100$$

$$= \frac{3 \times \frac{8M_Q}{9}}{3 \times \frac{8M_Q}{9} + 5M_Q} \times 100$$

$$= \frac{\frac{8}{3}}{\frac{8}{3} + 5} \times 100 = 34.78\%$$

(B) $$\frac{3M_P}{3M_P + 2M_Q} \times 100 = 40$$

$\Rightarrow 9M_P = 4M_Q$

$$M_Q = \frac{9 \times 20}{4} = 45$$

(C) If empirical formula of 2 is PQ

$$\frac{M_P}{M_P + M_Q} \times 100 = 44.4$$

$\Rightarrow 5M_P = 4M_Q$

For compound 1

$$\frac{5M_P}{5M_P + 4M_Q} \times 100 = 50$$

(D)

Element	Mass%	Mole	Relation ratio of atoms
P	50	$\frac{50}{70}$	1
Q	50	$\frac{50}{35}$	2

E.F. = PQ_2

10. The correct option(s) about entropy (S) is(are)

[R = gas constant, F = Faraday constant, T = Temperature]

(A) For the reaction, $M(s) + 2H^+(aq) \rightarrow H_2(g) + M^{2+}(aq)$, if $\frac{dE_{cell}}{dT} = \frac{R}{F}$, then the entropy change of the reaction is R (assume that entropy and internal energy changes are temperature independent).

(B) The cell reaction, $Pt(s) \mid H_2(g, Ibar)\ H^+(aq, 0.01M) \parallel H^+(aq, 0.1M)\ H_2(g, 1\ bar) \mid Pt(s)$, is an entropy driven process.

(C) For racemization of an optically active compound, $\Delta S > 0$.

(D) $\Delta S > 0$, for $[Ni(H_2O)_6]^{2+} + 3\ en \rightarrow [Ni(en)_3]^{2+} + 6H_2O$ (where en = ethylenediamine).

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

Sol. (A) $\Delta S = nF\frac{dE_{cell}}{dt}$

$\Delta S = 2F \times \frac{R}{F} = 2R$

(B) Cell reaction is

$\left[2H^+(aq.)\right]_{cathode} \rightarrow \left[2H^+(aq.)\right]_{anode}$

$E_{cell} = 0 - \frac{0.059}{2}\log\frac{(0.01)^2}{(0.1)^2} = 0.059$

Hence reaction is spontaneous and it is spontaneous due to entropy charge as ΔH is almost zero.

(C) During racemisation of optically active compound, disorder increases.

(D) In this process number of molecules increases hence entropy increases.

11. The compound(s) which react(s) with NH_3 to give boron nitride (BN) is(are)

(A) B (B) B_2H_6 (C) B_2O_3 (D) HBF_4

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

Sol. $B(Amorphous) + NH_3 \xrightarrow[Temperature]{Very\ high} BN + H_2$

$B_2H_6 + NH_3(excess) \rightarrow (BN)_x$

$B_2O_3 + 2NH_3 \rightarrow 2BN + 3H_2O$

$HBF_4 + NH_3 \rightarrow [NH_4^+]\ [BF_4^-]$

12. The correct option(s) related to the extraction of iron from its ore in the blast furnace operating in the temperature range 900 - 1500 K is (are)

(A) Limestone is used to remove silicate impurity.

(B) Pig iron obtained from blast furnace contains about 4% carbon.

(C) Coke (C) converts CO_2 to CO.

(D) Exhaust gases consist of NO_2 and CO.

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

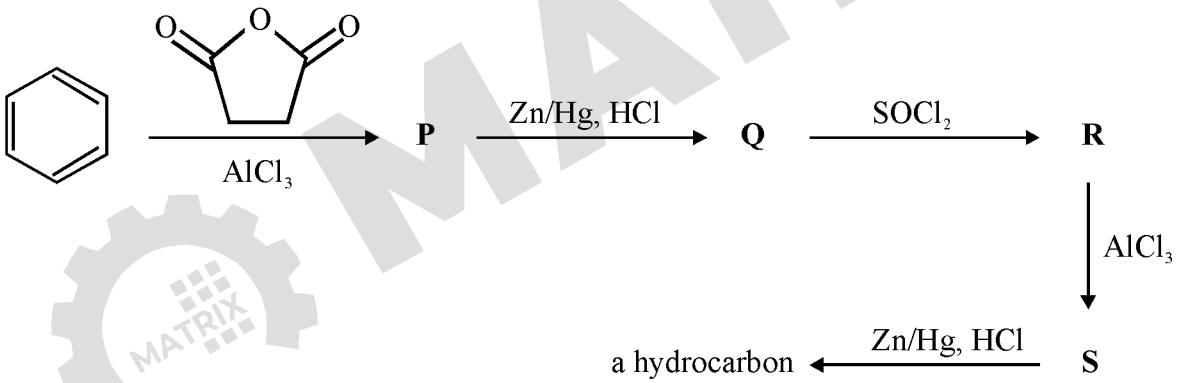
Sol. (A) $CaO + SiO_2 \rightarrow CaSiO_3$

(B) In fusion zone molten iron absorbs elemental impurities and pig iron is obtained which contains 4% carbon.

(C) $C + CO_2 \rightarrow 2CO$

(D) Exhaust gases consist of CO and CO_2.

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



(A) Compounds **P** and **Q** are carboxylic acids.

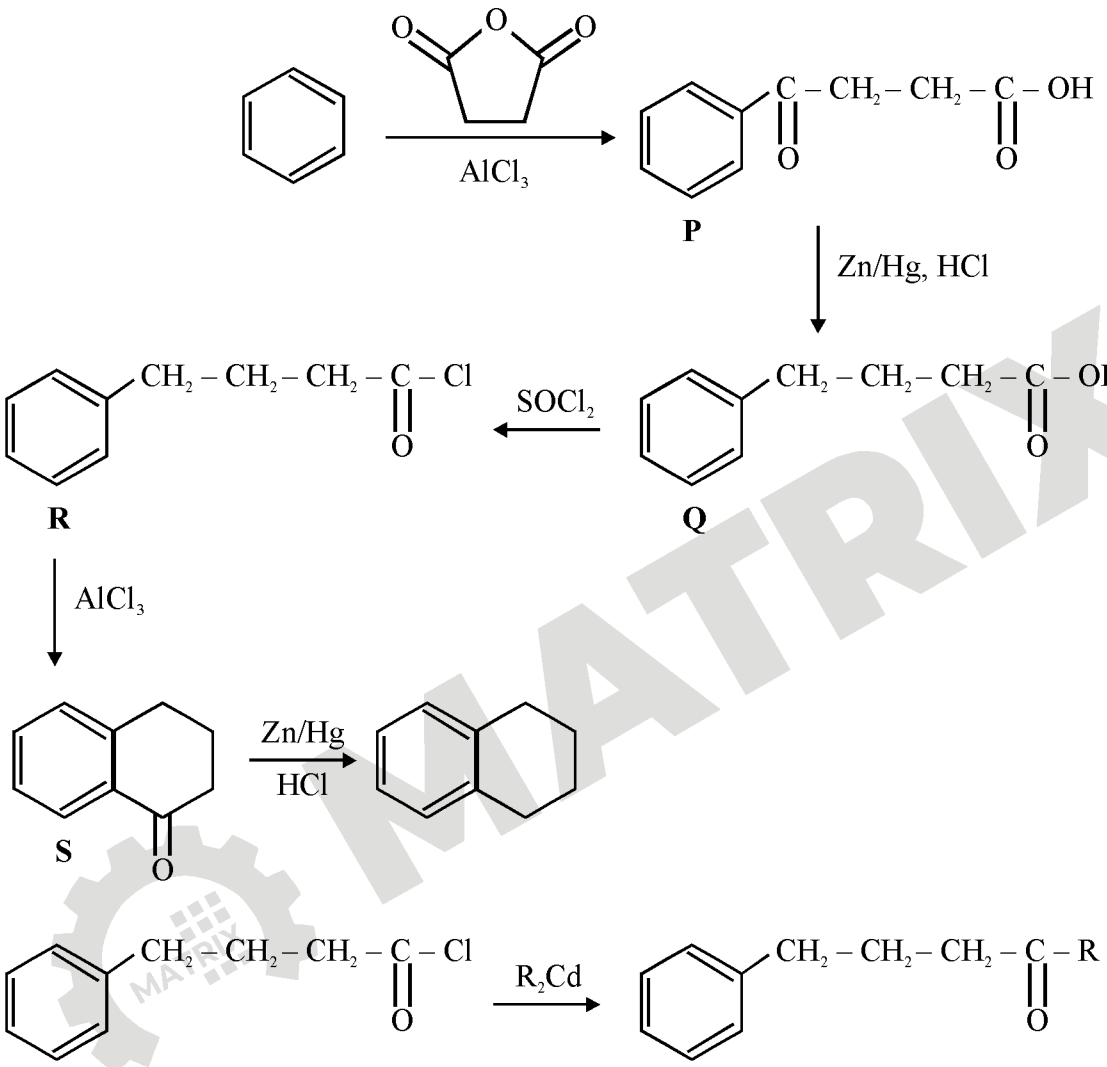
(B) Compound **S** decolorizes bromine water.

(C) Compounds **P** and **S** react with hydroxylamine to give the corresponding oximes.

(D) Compound **R** reacts with dialkylcadmium to give the corresponding tertiary alcohol.

Ans. (A), (C)

Sol.



14. Among the following, the correct statement(s) about polymers is(are)

(A) The polymerization of chloroprene gives natural rubber.

(B) Teflon is prepared from tetrafluoroethene by heating it with persulphate catalyst at high pressures.

(C) PVC are thermoplastic polymers.

(D) Ethene at 350-570 K temperature and 1000-2000 atm pressure in the presence of a peroxide initiator yields high density polythene.

Ans. (B), (C)

Sol. (A) Polymerization of choloroprene gives synthetic rubber.

(B) Teflon is prepared by heating tetraflorroethene with a free radical or persulphate catalyst at high pressure.

(C) PVC is a thermo plastic polymer

(D) Ethene at 350-570 K temperature and 1000-2000 atm pressure in the presence of a peroxide initiator yields low density polythene.

SECTION 3 (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.

15. Atom X occupies the fcc lattice sites as well as alternate tetrahedral voids of the same lattice. The packing efficiency (in %) of the resultant solid is closest to

(A) 25 (B) 35 (C) 55 (D) 75

Ans. (B)

Sol. $\frac{\sqrt{3}a}{4} = 2r$

$a = \frac{8r}{\sqrt{3}}$

Packing efficiency $= \frac{8 \times \frac{4}{3}\pi r^3}{a^3} \times 100 \approx 34\%$

16. The reaction of $HClO_3$ with HCl gives a paramagnetic gas, which upon reaction with O_3 produces

(A) Cl_2O (B) ClO_2 (C) Cl_2O_6 (D) Cl_2O_7

Ans. (C)

Sol. $HClO_3 + HCl \rightarrow \underset{\text{(Paramagnetic)}}{ClO_2} + Cl_2 + H_2O$

$ClO_2 + O_3 \rightarrow Cl_2O_6 + O_2$

17. The reaction of $Pb(NO_3)_2$ and NaCl in water produces a precipitate that dissolves upon the addition of HCl of appropriate concentration. The dissolution of the precipitate is due to the formation of

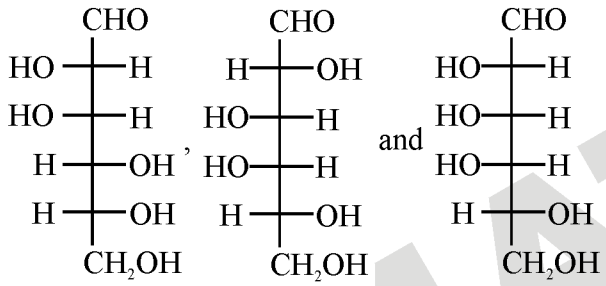
(A) $PbCl_2$ (B) $PbCl_4$ (C) $[PbCl_4]^{2-}$ (D) $[PbCl_6]^{2-}$

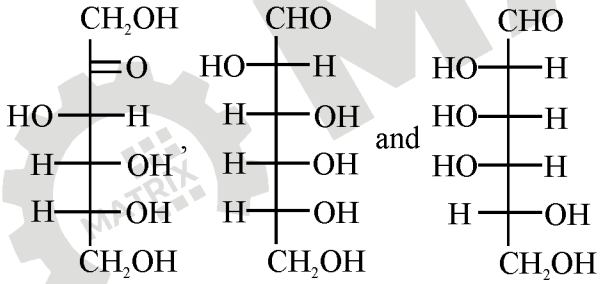
Ans. (C)

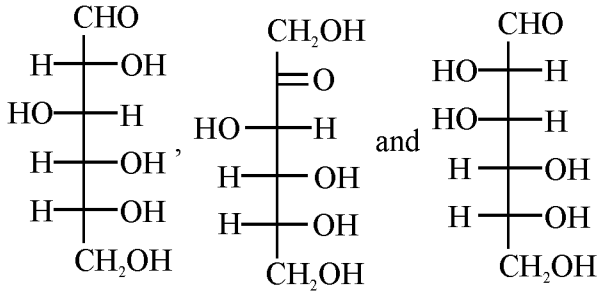
Sol. $Pb(NO_3)_2 + NaCl \longrightarrow PbCl_2 + NaNO_3$

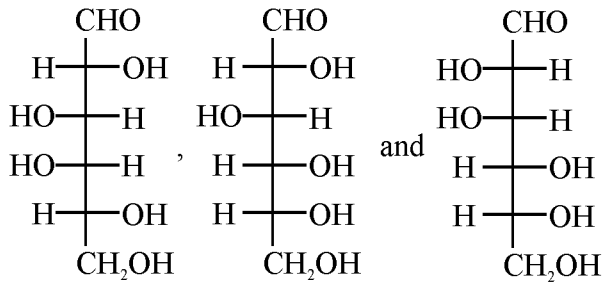
$PbCl_2 \xrightarrow{\text{excess HCl}} [PbCl_4]^{2-}$

18. Treatment of D-glucose with aqueous NaOH results in a mixture of monosaccharides, which are

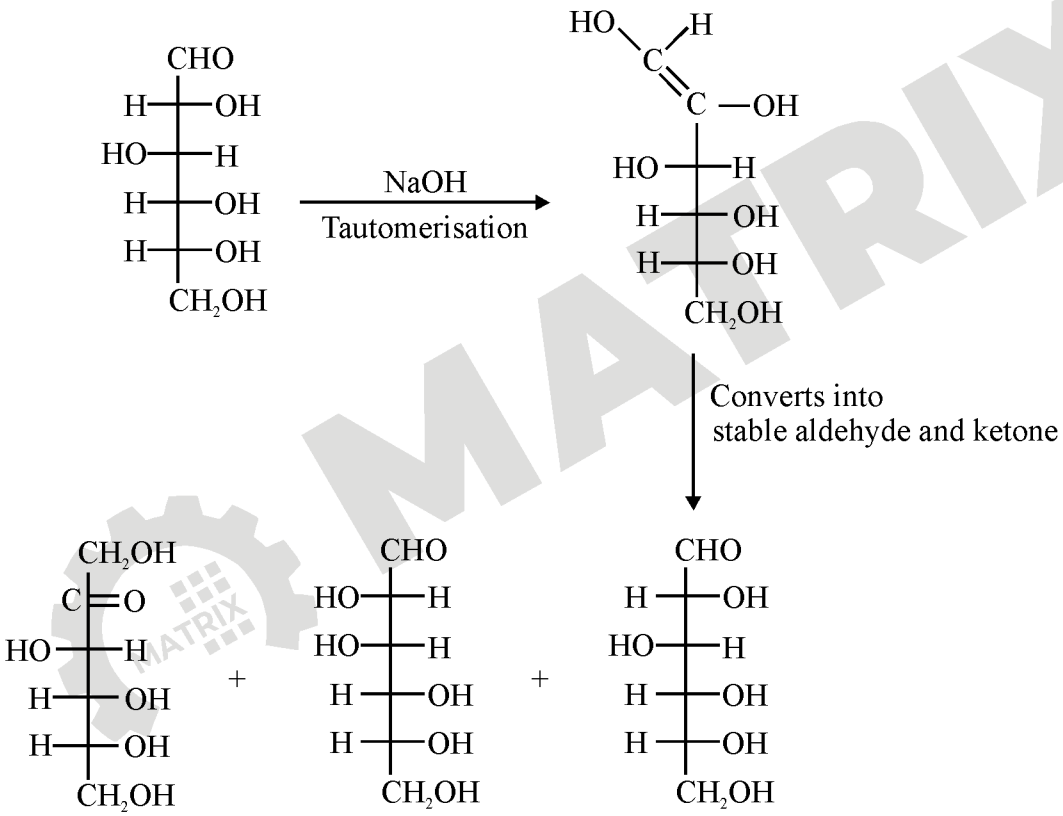
(A)  and

(B) 

(C) 

(D) 
CHO
H OH
HO H
HO H
H OH
CH2OH
,
CHO
H OH
HO H
H OH
H OH
CH2OH
and
CHO
HO H
HO H
H OH
H OH
CH2OH

Ans. (C)

Sol. 
CHO
H OH
HO H
H OH
H OH
CH2OH
NaOH
Tautomerisation
HO
H
C
C OH
HO H
H OH
H OH
CH2OH
Converts into
stable aldehyde and ketone
CH2OH
C O
HO H
H OH
H OH
CH2OH
+
CHO
HO H
HO H
H OH
H OH
CH2OH
+
CHO
H OH
HO H
H OH
H OH
CH2OH