JEE (ADVANCED) 2022 PAPER-2

[PAPER WITH SOLUTION]

HELD ON SUNDAY 28TH AUGUST 2022

CHEMISTRY

SECTION1 (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.

[:Q.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_{a_1} is very large and $K_{a_2} = 1.2 \times 10^{-2}$]

[:ANS] **6**

[:SOLN] $PbSo_4^{2-} \rightleftharpoons Pb^{2+} + SO_4^{2-}$

Since, SO_4^{2-} is a common ion, solublity will be determined from Pb^{2+}

$\therefore [Pb^{2+}] = S$

$\Rightarrow 5 \times [So_4^{2-}] = k_{sp} = 1.6 \times 10^{-8}$.....(1)

Here, SO_4^{2-} will be also get hydrolysed

$SO_4^{2-} + H_2O \rightleftharpoons HSO_4^- + OH^-$

$K_h = \frac{K_w}{K_{a_2}}$

Since, $[H_2SO_4] = 1$ and K_{a_1} is very large

$\therefore [HSO_4^-] = 1$ and $[H^+] = 1$

$\Rightarrow [OH^-] = 10^{-14}$

$\frac{[HSO_4^-][OH^-]}{[SO^{2-}]} = \frac{10^{-14}}{1.2 \times 10^{-2}} \Rightarrow [SO_4^{2-}] = 1.2 \times 10^{-2}$ M

From (1), $S = 1.33 \times 10^{-6}$

$\Rightarrow \boxed{y = 6}$ Ans.

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

[:ANS] 5

[:SOLN] n = 0.1 mole

Weight of water (Solvent) = 1.8 kg

$\alpha = 0.9$

P_s = 59.724 mm Hg

P^0 = 60 mm Hg

Now

$\frac{P^0 - P_s}{P_s} = i\frac{n}{N} = \left[1 + \alpha(x-1)\right]\frac{n}{N}$

or, $\frac{60 - 59.724}{59.724} = \left[1 + 0.9(x-1)\right] \times \frac{0.1 \times 18}{1800}$

or, $1 + 0.9x - 0.9 = \frac{(60 - 59.724) \times 1800}{59.724 \times 0.1 \times 18}$

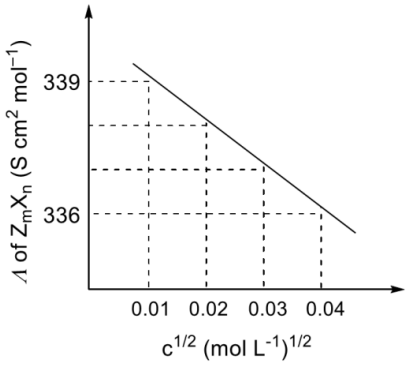
or, $0.1 + 0.9x = \frac{0.276 \times 1800}{59.724 \times 0.1 \times 18} = 4.62$

$\therefore x = \frac{4.62 - 0.1}{0.9} = 5$

[:Q.3] Consider the strong electrolytes Z_mX_n, U_mY_p and V_mX_n . Limiting molar conductivity (Λ^0) 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-}
λ^0 (S cm^2 mol^{-1})	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

[:SOLN] $V_m X_n$

$$\lambda_m^0(V_m x_n) = m\lambda_m^0(V^{n+}) + n\lambda_m^0(X^{m-})$$

$$\boxed{440 = m.100 + n\times 80} \quad \text{.....(1)}$$

$$\lambda_m^0(U_m Y_p) = m\lambda_m^0(U^{P+}) + P\lambda_m^0(Y^{m-})$$

$$\boxed{250 = m.25 + P.100} \quad \text{.....(2)}$$

$\Rightarrow$ For Z_mX_n = $m\lambda_m^0(Z^{n+}) + n\lambda_m^0(X^{m-})$

$$\boxed{\lambda_m^0(Z_mX_n) = m.50 + n.80} \quad \text{.....(3)}$$

From graph

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

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

$$= 339 + \left(-\frac{339-336}{0.01-0.04}\right)(0.01)$$

$$= 339 + \frac{1}{0.01}\times 0.01 = 340$$

From (1) & (3)

680 – 440 = 80 n

$$n = \frac{240}{80} = 3$$

$$m = \frac{440 - 240}{100} = \frac{200}{100} = 2$$

From (2) & m

$$P = \frac{250 - 2 \times 25}{100} = 2$$

= m + n + p = 3 + 2 + 2 = 7

[:Q.4] The reaction of Xe and O_2F_2gives a Xe compound **P**. The number of moles of HF produced by the complete hydrolysis of 1 mol of **P** is _____.

[:ANS] 2

[:SOLN] $Xe + O_2F_2 \xrightarrow{-118^\circ C} XeF_2 + O_2$

$$XeF_2 + H_2O \longrightarrow Xe + 2HF + \frac{1}{2}O_2$$

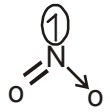
2 moles of HF

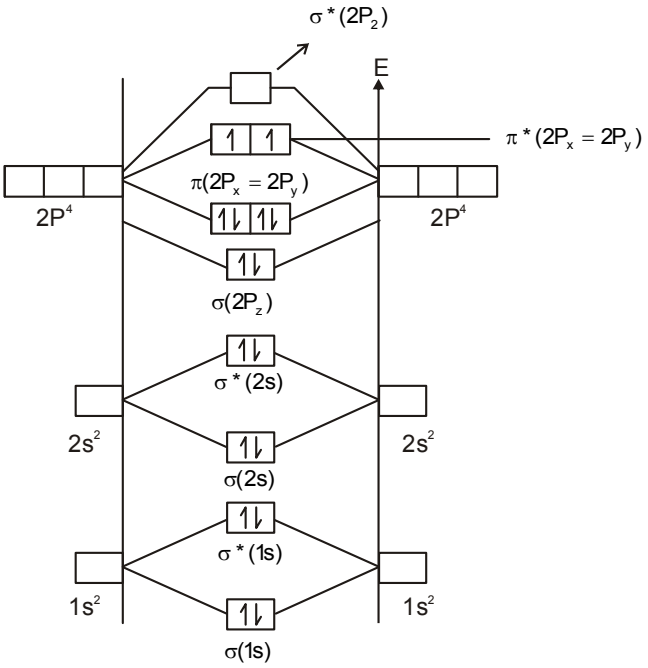
[:Q.5] Thermal decomposition of $AgNO_3$ produces two paramagnetic gases. The total number of electrons present in the antibonding molecular orbitals of the gas that has the higher number of unpaired electrons is _____.

[:ANS] 6

[:SOLN] $AgNO_3(s) \xrightarrow{\Delta} Ag(s) + NO_2(g) + \frac{1}{2}O_2(g)$

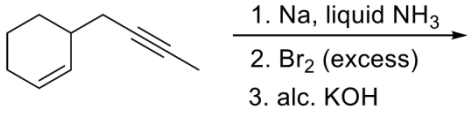
NO_2& O_2 are paramagnetic having one and two unpaired electron respectively.





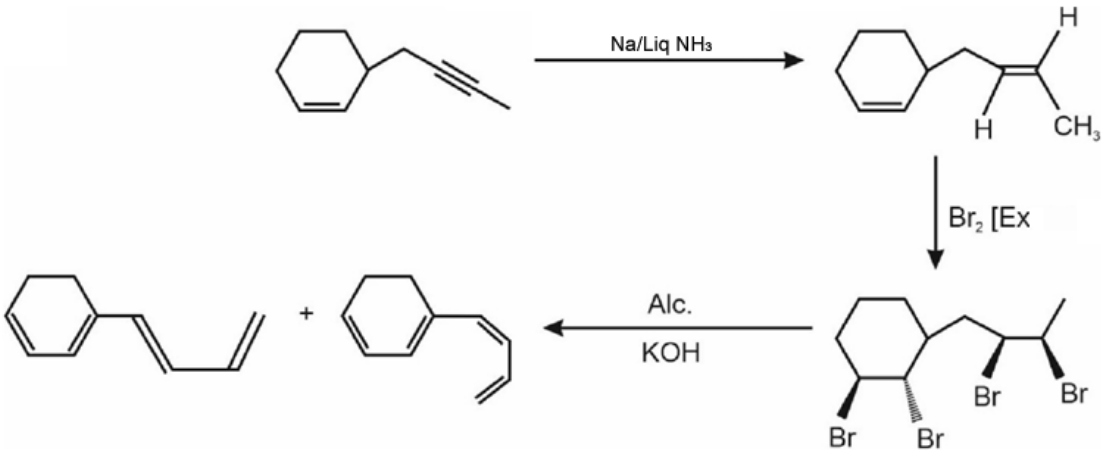
No. of electron present in A.B.M.O in $O_2(g)$ are **six**.

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

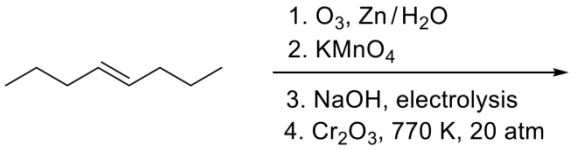


[:ANS] 2

[:SOLN]

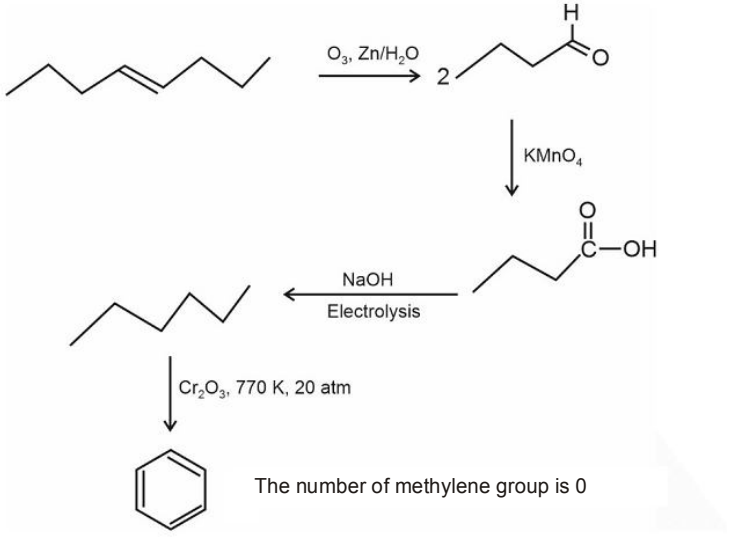


[:Q.7] The number of -CH_2 - (methylene) groups in the product formed from the following reaction sequence is _____.

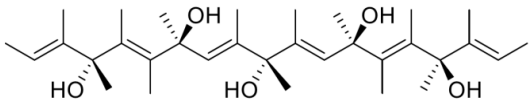


[:ANS] 0

[:SOLN]



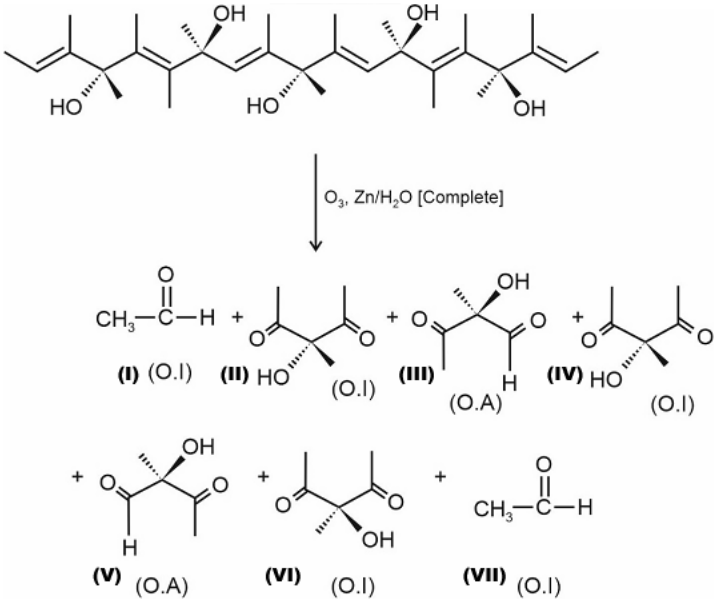
[:Q.8] The total number of chiral molecules formed from one molecule of **P** on complete ozonolysis (O_3, Zn/H_2O) is _____.



P

[:ANS] 2

[:SOLN]



Number of chiral molecules 2 (III & V), rest are achiral

SECTION2 (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] 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 the 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 are70 abd 35, respectively, then the empirical formula of compound **1** is P_2Q.

[:ANS] B,C

[:SOLN] Compound (1) $50\,gP \longrightarrow 50\,g\ Q \Rightarrow 1\,gP \longrightarrow \frac{50}{50} g\ Q = 1\ g\ Q$

Compound (2) $44.44\,g\ P \longrightarrow 55.6\ g\ Q \Rightarrow 1g\ P \longrightarrow \frac{55.6}{44.4}\ g\ Q = 1.25\,g\ Q$

Compound (3) $40\,g\ P \longrightarrow 60\,g\ Q \Rightarrow 1g\ P \longrightarrow \frac{60}{40} g\ Q = 1.5\,g\ Q$

Ratio of weights of Q reacting with same weight (1g) of P

$$= 1:1.25:1.5 = 4:5:6$$

(A) Let At.wt of P and Q be x and y of EF of compound (3) is P_3Q_4

$$3x\,g \longrightarrow 4y\,g\,Q \Rightarrow 1g\ P \longrightarrow \frac{4y}{3x} g\ Q$$

Let EF of compound (2) be P_mQ_n

$$mx\,g\ P \longrightarrow ny.g\ \ Q$$

$$1g\ P \longrightarrow \frac{ny}{nx} g\ \ Q$$

Ratio of weight of Q = $\frac{(4y/3x)\,compound(3)}{(ny/mx)\,compound(2)} = \frac{6}{5}$

$$\Rightarrow \frac{4}{3}.\frac{m}{n} = \frac{6}{5} \Rightarrow \frac{m}{n} = \frac{9}{10}$$

So, EF should be P_9Q_{10}

So, A is incorrect

(B) Compound 3

At. Wt. of P = 20
Let atomic weight of Q be x

Element	%age	% /At. Wt		
P	40	40/20 = 2	2/2 = 1	1×3 =3
Q	60	60/x	$\frac{60}{x} \div 2 = 30/x$	$\frac{30}{x} \times 3$

$\because$ EF is P_3Q_2

So, $\frac{30}{x} \times 3 = 2$

So x = 45
So B is correct

(C) EF = PQ for compound 2

$xg\ P \longrightarrow y\,g\ Q$

$1g\ P \longrightarrow \frac{y}{x} g\ Q$

Let EF for compound (1) be P_mQ_n

$mx\,g\ P \longrightarrow ny\ gQ$

$1\ g\ P \longrightarrow \frac{ny}{mx}\ gQ$

Ratio of weight of Q reacting with same weight (1 g) of P

$$= \frac{\left(\frac{y}{x}\right)\text{compound2}}{\left(\frac{ny}{mx}\right)\text{compound1}} = \frac{5}{4}$$

$$\Rightarrow \boxed{\frac{m}{n} = \frac{5}{4}}$$

So, EF = P_5Q_4
So C is correct

(D)

Element	%age	%age/at. Wt	
P	50	50/70 =5/7	$\frac{5}{7} \div \frac{5}{7} = 1$
Q	50	50/35 = 10/7	$\frac{10}{7} \div \frac{5}{7} = 2$

So, EF should be PQ_2.
So D is incorrect

[:Q.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 ofthe reaction is R (assume that entropy and internal energy changes are temperatureindependent.

[:B] The cell reaction, Pt(s) | H2(g, 1bar) | H^+(aq, 0.01M) || H^+(aq, 0.1M) | H_2(g,1bar) | 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

[:SOLN] (A) From the Definition of Gibb's free energy.

$$\boxed{dG = VdP - SdT}$$

At constant pressure

$$\boxed{dG = -SdT} \rightarrow \boxed{-S = \frac{dG}{dT}}$$

$$\Downarrow$$

$$\boxed{S = -\frac{dG}{dT}}$$

$$\Downarrow$$

$$\Delta S = nF\frac{dE_{cell}}{dT}$$

$$\Downarrow$$

$$\frac{dE_{cell}}{dT} = \frac{\Delta S}{nF}$$

$$\frac{\Delta S}{n\cancel{F}} = \frac{R}{\cancel{F}}$$

$$\boxed{\Delta S = nR = 2R}$$

option A is wrong

(B) $Pt_{(s)} \,|\, H_2(g,1bar \,|\, H^{\oplus}(aq0.1M) \,|\, H_2(g1bar) \,|$

As conc. Of cathodic compartment is greater than Anodic compartment

$E_{cell} > 0$

i.e $\boxed{\Delta G = 0}$

$\Delta G = \Delta H - T\Delta S$

$\boxed{\Delta H \approx 0}$ for this process

$\boxed{\Delta G = -T\Delta S}$ for $\Delta G < 0$

$\Delta S > 0$ = Process is entropy driven.

(Correct)

(C) Racemisation of an optically Active compound is highly feasible as $\Delta S > 0 \& \Delta H < 0$ for this process.

(D) $[Ni(H_2O)_6]^{2+} + 3en \longrightarrow [Ni(en)_3]^{2+} + 6H_2O$

As No. of Molecules [all in aqueous phase as increasing, entropy will increase.

(Correct)

[:Q.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

[:SOLN] Reaction

(A) $\underset{(amorphous)}{2B} + 2NH_3 \xrightarrow[Temperature]{High} 2BN + 3H_2$

(B) $B_2O_3 + 2NH_3 \xrightarrow[900°C]{\Delta} 2BN + 3H_2O$

(C) $B_2H_6 + \underset{(Excess)}{NH_3} \xrightarrow[Temperature]{High} (BN)_x$

(D) $HBF_4 + NH_3 \longrightarrow [NH_4]^+ [BF_4]^-$

[:Q.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

[:SOLN] (A) Limestone is used to remove silicates impurity

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$$

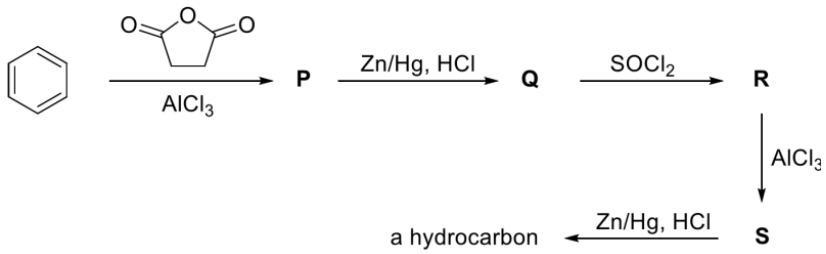
$$\underset{\text{(Basic flux)}}{CaO} + \underset{\text{(gangue)}}{SiO_2} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

(B) Pig iron contains impurities of C = 2.5%

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

(D) Exhaust gas: N_2 (58%), CO (10.5%), CO_2(6.5%).

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



[:A] Compounds **P** and **Q** are carboxylic acids.

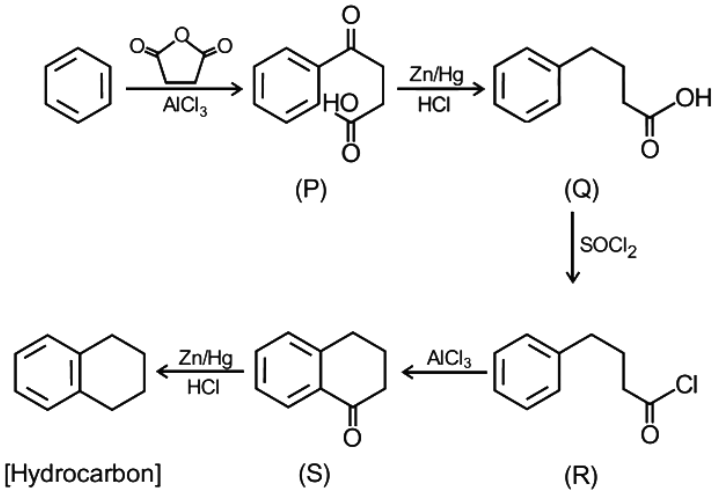
[:B] Compound **S** decolorizes bromine water.

[: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**

[:SOLN]



→ Compound (S) not decolarizes bromine water.

→ Compound R react with $(R)_2Cd$ give ketone.

[:Q.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

[:SOLN] (A) Polymerization of chloroprene gives synthetic rubber

(B) Teflon is manufactured by heating tetrafluoroethene with a free radical or persulphate catalyst at hightpressure.

(C) Polyvinyl chloride (PVC) is a thermoplastic polymer and used in making hand bags, vinyl flooring and waterpipes.

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

SECTION3 (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 correctanswer.
- 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.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

[:SOLN] r = radius of atom x

For fcc lattice (as given)

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

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

Now

No. of x atoms per unit cell = $\frac{1}{8}\times 8 + \frac{1}{2}\times 6 + 4 = 8$

$$\therefore P.F = \frac{8\times\frac{4}{3}\pi r^3}{a^3} = \frac{8\times\frac{4}{3}\pi r^3}{\left(\frac{8r}{\sqrt{3}}\right)^3}$$

$$= \frac{32\pi\times 3\sqrt{3}}{3\times 64\times 8} = 0.339 \approx 0.34$$

Hence Packing efficiency = P.F × 100 = 34%

Ans B is closest answer

[:Q.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

[:SOLN] (i) $2HClO_3 + 2HCl \longrightarrow \underbrace{2ClO_2}_{\substack{\text{odd electronmolecule}\\(3\text{unpaired electron})}} + Cl_2 + 2H_2O$

(ii) $\underset{\text{PARA}}{2ClO_2} + O_3 \longrightarrow Cl_2O_6 + O_2$

[:Q.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] $[PbCl_6]^{2-}$

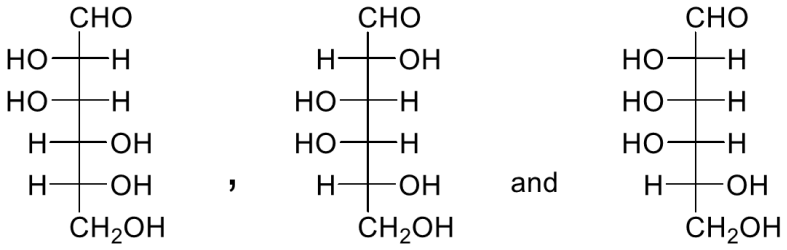
[:ANS] C

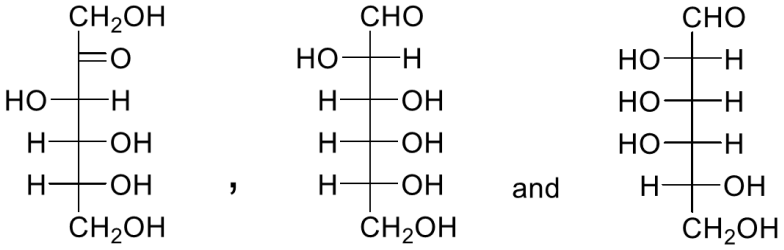
[:SOLN] $Pb(NO_3)_2 + 2NaCl \longrightarrow PbCl_2 \downarrow + 2NaNO_3$

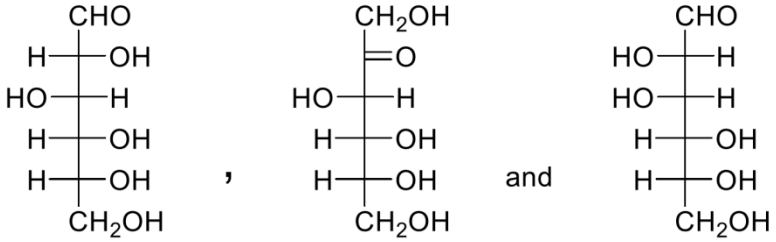
(aq.) (aq.) white ppt.

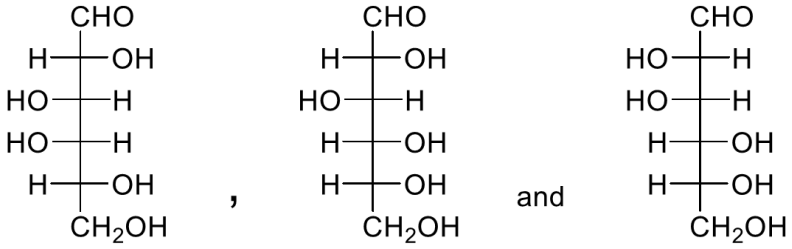
$PbCl_2 + \underbrace{2Cl^-}_{\text{conc.HCl}} \longrightarrow [PbCl_4]^{2-}$

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

[:A]  and

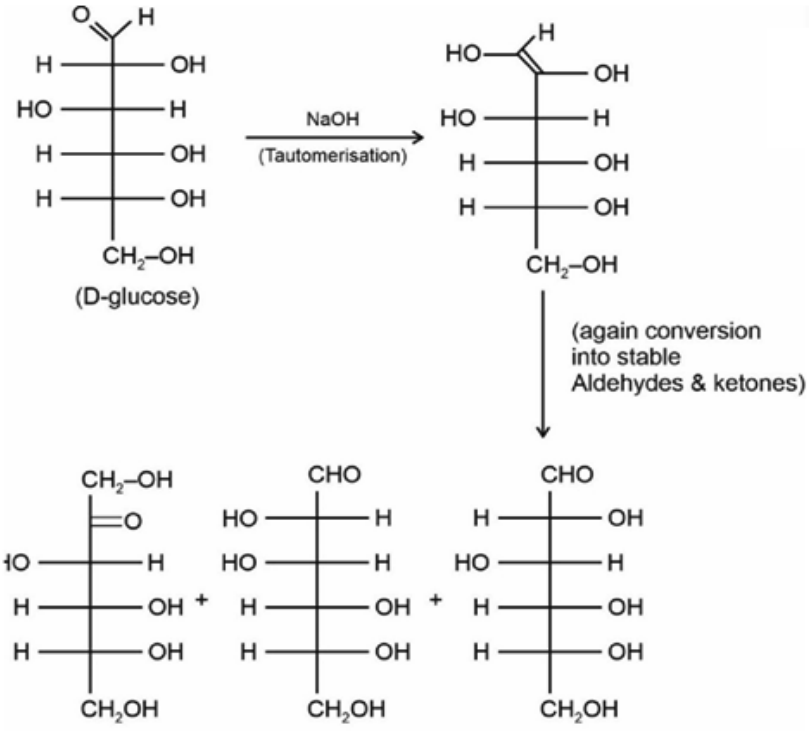
[:B] 

[:C] 

[:D] 

[:ANS] **C**

[:SOLN]



D-fructose D-Mannose D-Gulcose