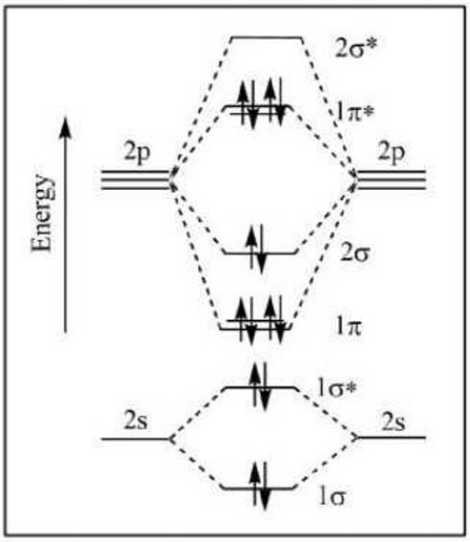
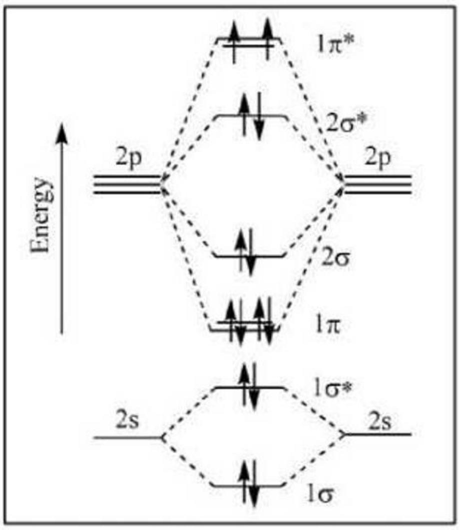
JEE Advanced 2023 paper -1

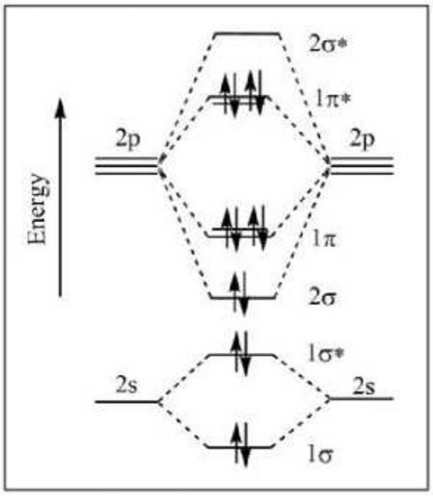
1. The correct molecular orbital diagram for F_2 molecules in the ground state

(A)

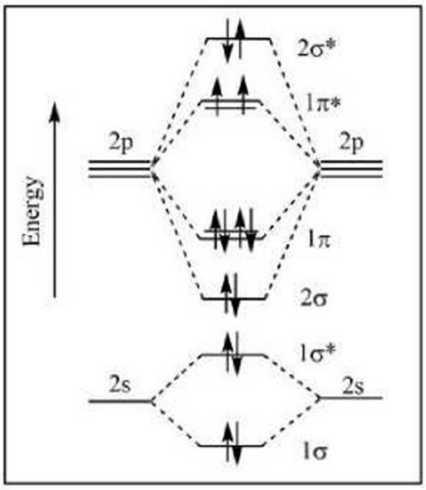




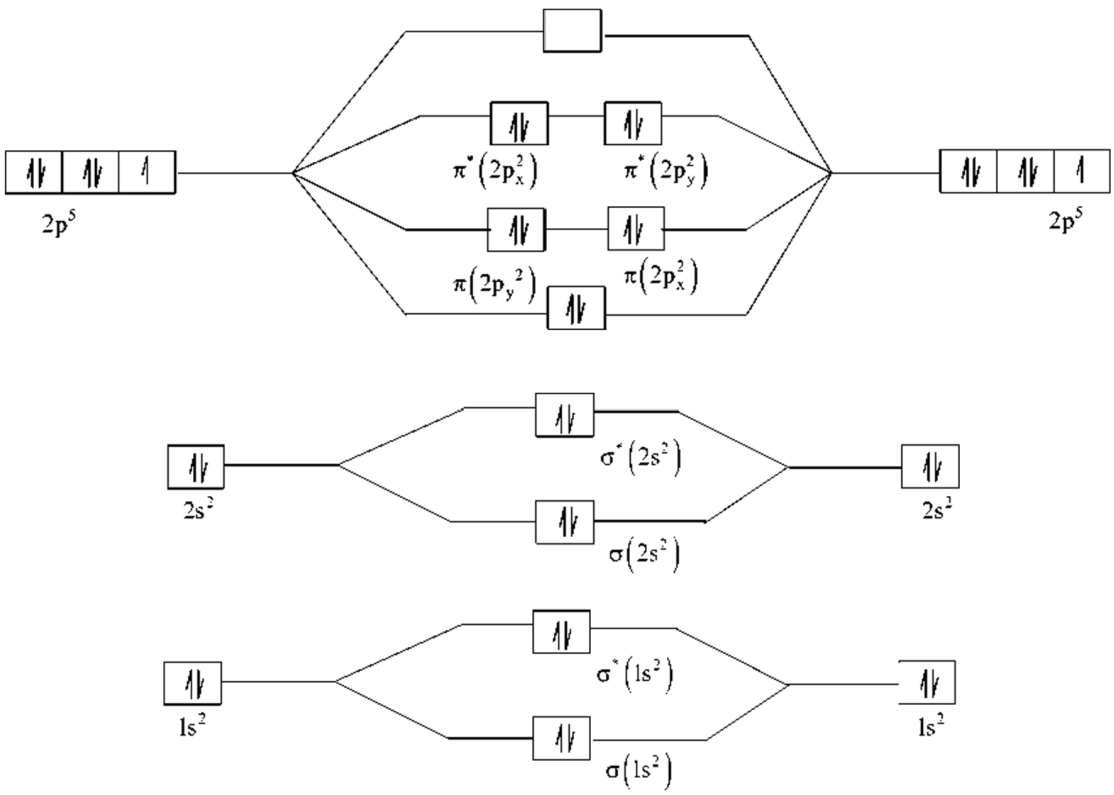
(C)



(D)



Ans: C



2. Which of the following liberates O_2 upon hydrolysis? Consider the following statements related to colloids.
   I. Lyophobic colloids are not formed by simple mixing of dispersed phase and dispersion medium.
   II. For emulsions, both the dispersed phase and the dispersion medium are liquid.
   III. Micelles are produced by dissolving a surfactant in any solvent at any temperature.
   IV. Tyndall effect can be observed from a colloidal solution with dispersed phase having the same refractive index as that of the dispersion medium.

   The option with the correct set of statements is

(A) (I) and (II) (B) (II) and (III)

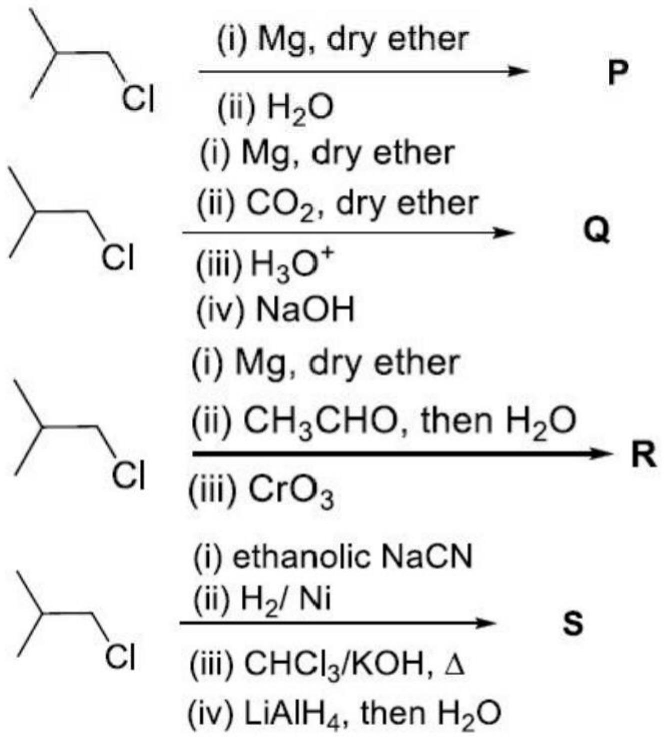
(C) (III) and (IV) (D) (II) and (IV)

Ans : A

Solution:

In Tyndall effect, refractive indices of dispersed phase and dispersion medium differ greatly in magnitude. Micelles are formed by surfactant at CMC (critical micelle Concentration) or above CMC and at Kraft temperature or above Kraft temperature

3. In the following reactions, P, Q, R, and S are the major products.

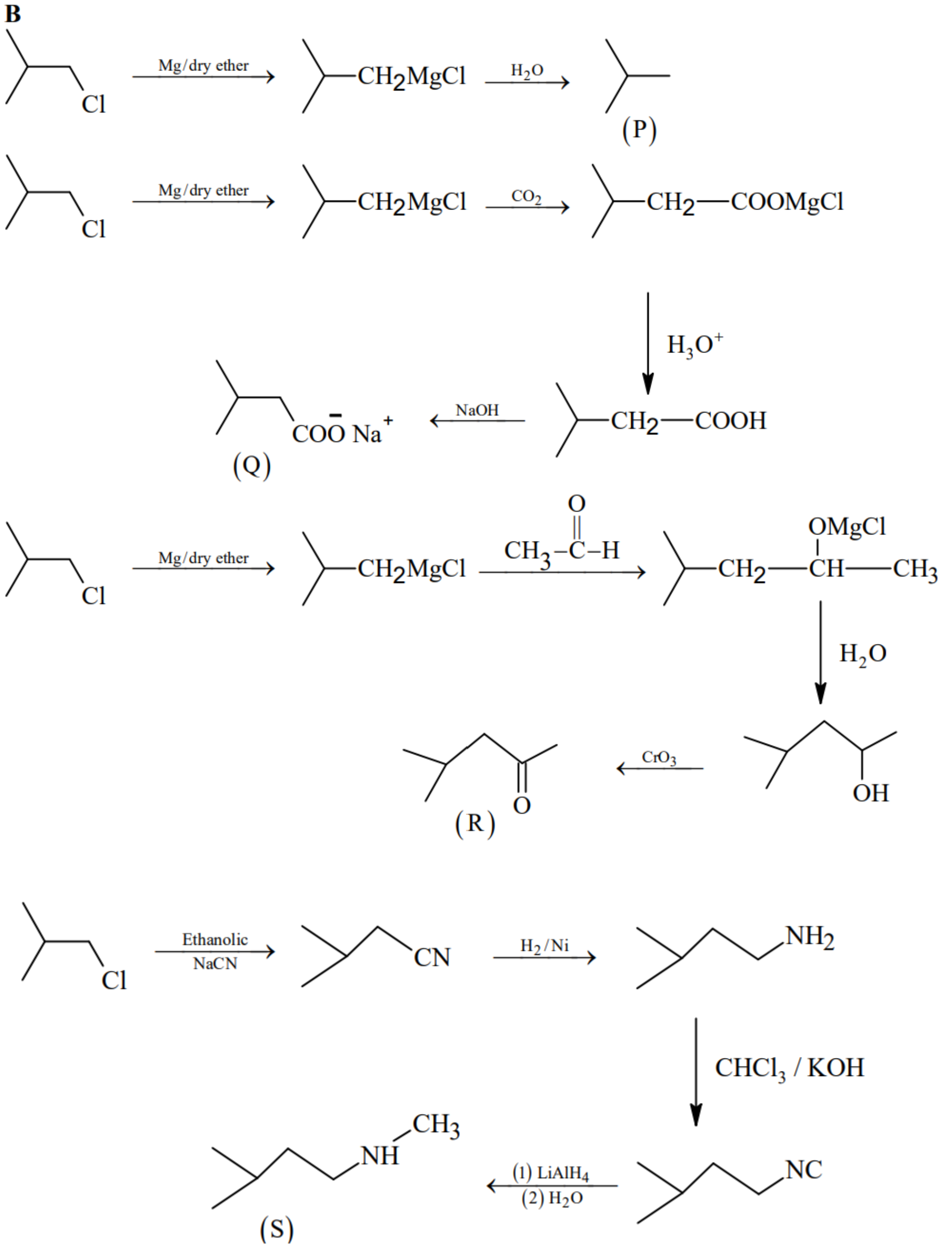


The correct statement about P, Q, R, and S is

A) P is a primary alcohol with four carbons.
B) Q undergoes Kolbe's electrolysis to give an eight-carbon product.
C) R has six carbons and it undergoes Cannizzaro reaction.
D) S is a primary amine with six carbons.

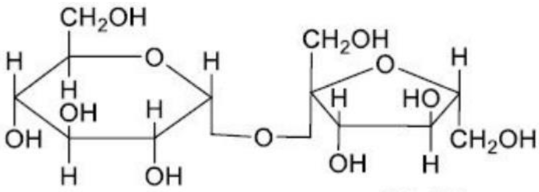
Ans : B

Sol. **B**

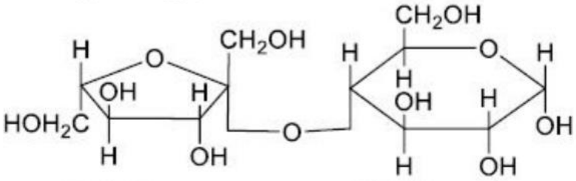


4. A disaccharide X cannot be oxidised by bromine water. The acid hydrolysis of X leads to a laevorotatory solution. The disaccharide X is

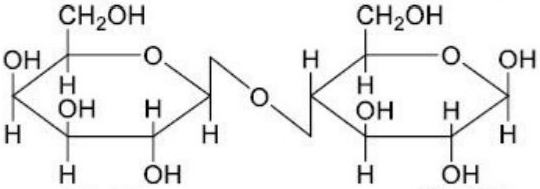
(A)



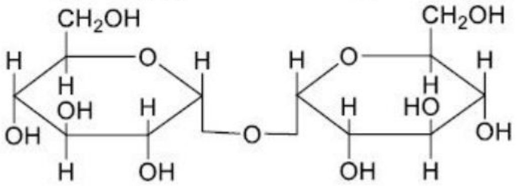
(B)



(C)

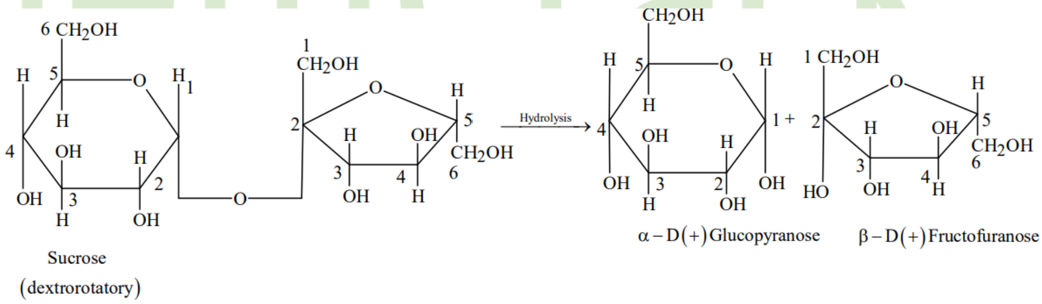


(D)



Ans : A

Solution :



Hydrolysis of sucrose brings about a change in the sign of rotation from dextro(+) to laevo(–) and the product named as invert sugar

Section -2 More than one correct

5. The complex(es), which can exhibit the type of isomerism shown by $[Pt(NH_3)_2Br_2]$, is(are) [en = $H_2NCH_2CH_2NH_2$]

   A) $[Pt(en)(SCN)_2]$
   B) $[Zn(NH_3)_2Cl_2]$

C) $[Pt(NH_3)_2Cl_4]$
D) $[Cr(en)_2(H_2O)(SO_4)]^+$

Ans : C, D

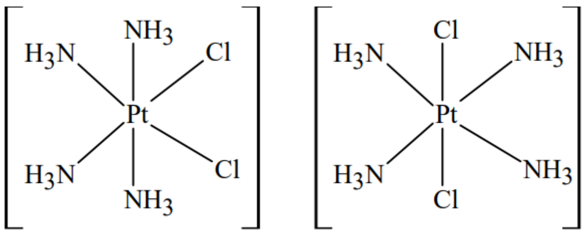
Solution:

$[Pt(NH_3)_2Br_2]$, is a square planar complex.The given compound can show geometrical isomerism (cis-trans form)

Option (A) : $[Pt(en)(SCN)_2]$ cannot show geometrical isomerism.

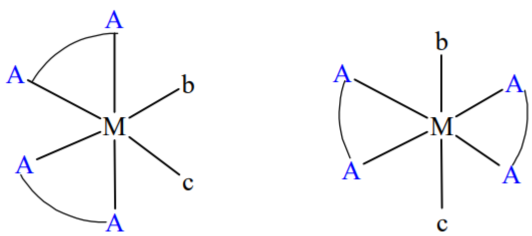
Option (B) : $[Zn(NH_3)_2Cl_2]$ is a tetrahedral complex, cannot show geometrical isomerism.

Option (C) : $[Pt(NH_3)_2Cl_4]$ is a octahedral complex, can show geometrical isomerism.



cis – form   trans – form

Option (D) : $[Cr(en)_2(H_2O)(SO_4)]^+$
is octahedral complex and is of type $[M(AA)_2bc]$
can show geometrical isomerism



6. Atoms of metals x, y, and z form face-centred cubic (fcc) unit cell of edge length Lx, body-centred cubic (bcc) unit cell of edge length Ly, and simple cubic unit cell of edge length Lz, respectively.

If $r_z = \frac{\sqrt{3}}{2} r_y$; $r_y = \frac{8}{\sqrt{3}} r_x$; $M_z = \frac{3}{2} M_y$ and $M_Z = 3M_x$,

then the correct statement(s) is(are)

[Given: Mx, My, and Mz are molar masses of metals x, y, and z, respectively. rx, ry, and rz are atomic radii of metals x, y, and z, respectively.]

(A) Packing efficiency of unit cell of x > Packing efficiency of unit cell of y > Packing efficiency of unit

(B) $L_y > L_z$

(C) $L_x > L_y$

(D) density of x > Density of y

Ans : A, B, D

Solution:

For metal 'x'

Fcc: Edge length , $a_1 = L_x$

For metal 'y'

Bcc: Edge length , $a_2 = L_y$

For metal 'z'

Bcc: Edge length , $a_3 = L_z$

$r_z = \frac{\sqrt{3}}{2} r_y ; r_y = \frac{8}{\sqrt{3}} r_x ; M_z = \frac{3}{2} M_y$ and $M_Z = 3M_x$.

For option (A)

(i) For FCC (Z = 4) metal 'x', $4r_x = \sqrt{2}L_x$

$$P.E = \frac{Z\times\frac{4}{3}\pi(r_x)^3}{a_1^3} = \frac{4\times\frac{4}{3}\pi(r_x)^3}{(L_x)^3} = \frac{4\times\frac{4}{3}\pi(r_x)^3}{\left(\frac{4}{\sqrt{2}}r_x\right)^3} = 0.24\pi$$

(ii) For BCC (Z = 2) metal 'y', $4r_y = \sqrt{3}L_y$

$$P.E = \frac{Z\times\frac{4}{3}\pi(r_y)^3}{a_2^3} = \frac{2\times\frac{4}{3}\pi(r_y)^3}{(L_y)^3} = \frac{2\times\frac{4}{3}\pi(r_y)^3}{\left(\frac{4}{\sqrt{3}}r_y\right)^3} = 0.22\pi$$

(iii) For SC (Z = 1) metal 'z', $2r_z = L_z$

$$P.E = \frac{Z\times\frac{4}{3}\pi(r_z)^3}{a_3^3} = \frac{1\times\frac{4}{3}\pi(r_z)^3}{(L_z)^3} = \frac{1\times\frac{4}{3}\pi(r_z)^3}{(2r_z)^3} = \frac{\pi}{6} = 0.17\pi$$

$$(P.E)_{FCC} > (P.E)_{BCC} > (P.E)_{SC}$$

For Option (B)

$4r_y = \sqrt{3}L_y \qquad 2r_z = L_z$

$$L_y = \frac{4r_y}{\sqrt{3}}$$

$$\frac{L_y}{L_z} = \frac{4r_y}{\sqrt{3}\times 2r_z} = \frac{2r_y}{\sqrt{3}r_z} = \frac{2r_y}{\sqrt{3}.\frac{\sqrt{3}}{2}r_y} = \frac{4}{3}$$

$$L_y > L_z$$

For Option C,

$$4r_x = \sqrt{2}L_x \,,\; 4r_y = \sqrt{3}L_y$$

$$L_x = \frac{4r_x}{\sqrt{2}},\; L_y = \frac{4r_y}{\sqrt{3}}$$

$$\frac{L_x}{L_y} = \frac{\sqrt{3}r_x}{\sqrt{2}\times 8/\sqrt{3}r_x} = \frac{3}{8\sqrt{2}}$$

, $L_x < L_y$ **incorrect**

For option d,

$$d_x = \frac{4\times M_x}{\left(\frac{4r_x}{\sqrt{2}}\right)^3 \times N_A}$$

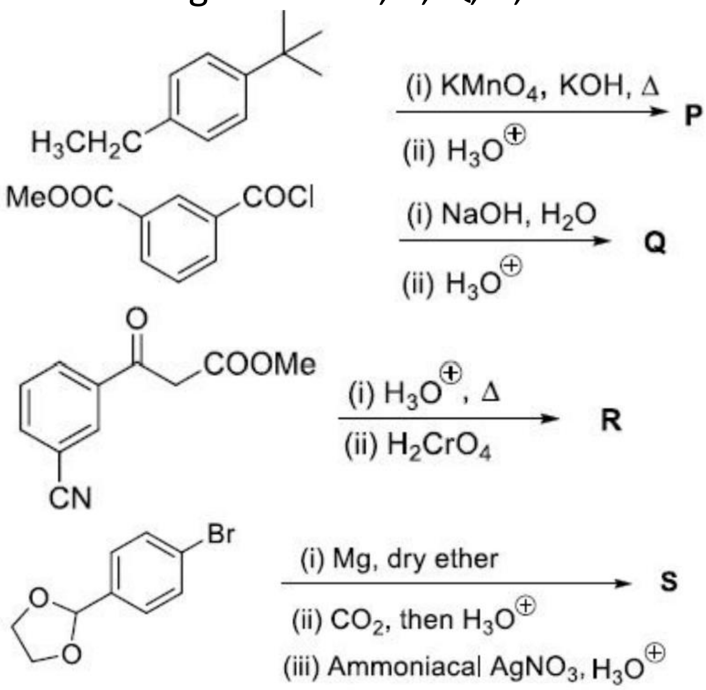
$$d_y = \frac{2\times M_y}{\left(\frac{4r_y}{\sqrt{3}}\right)^3 \times N_A}$$

$$r_y = \frac{8}{\sqrt{3}}r_x,\; \frac{M_x}{M_y} = \frac{1}{2}$$

$$\frac{d_x}{d_y} = \frac{512}{2\sqrt{2}} = \frac{256}{\sqrt{2}}$$

So $d_x > d_y$ (correct)

7. In the following reactions, P, Q, R, and S are the major products.



The correct statement(s) about P, Q, R, and S is(are)

(A) P and Q are monomers of polymers dacron and glyptal, respectively.

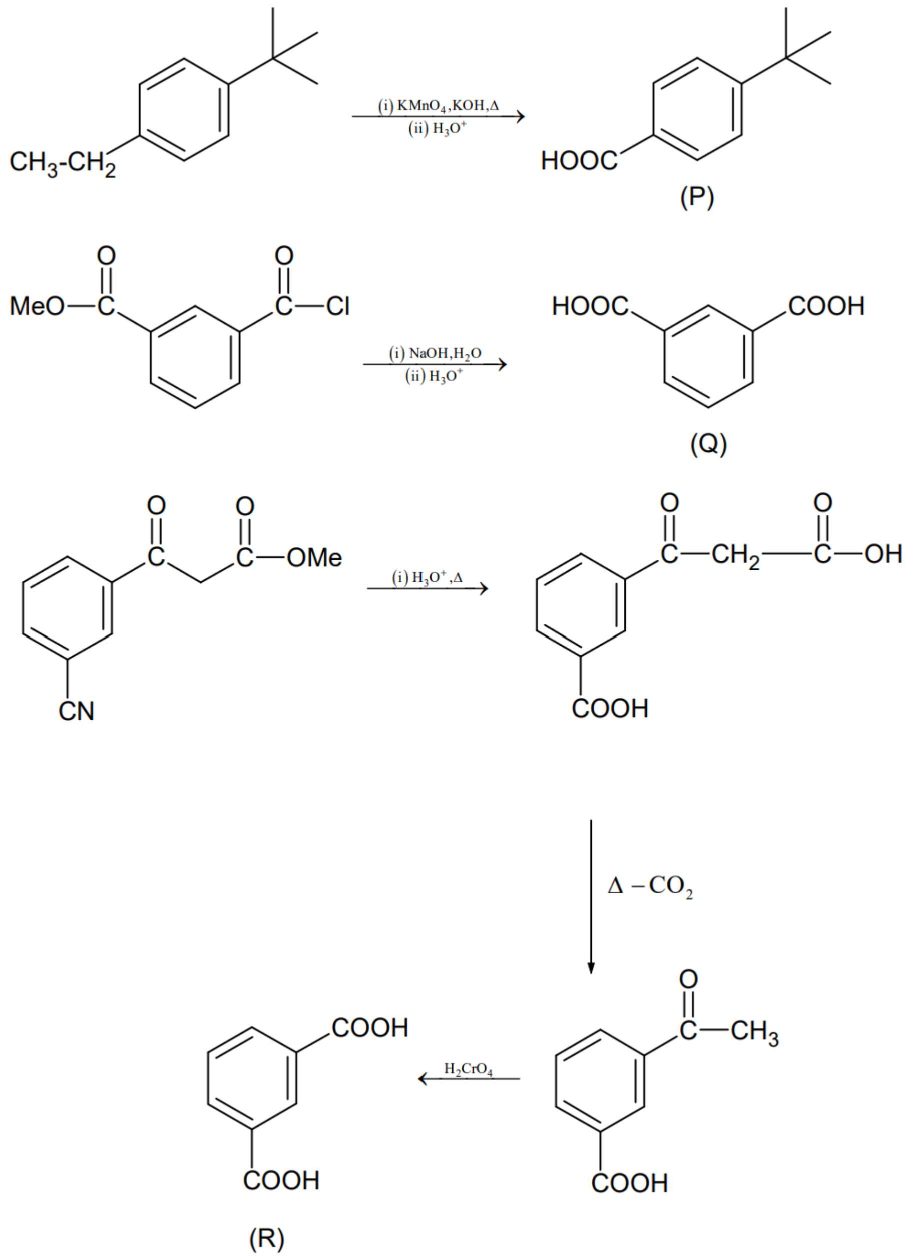
(B) P, Q, and R are dicarboxylic acids.

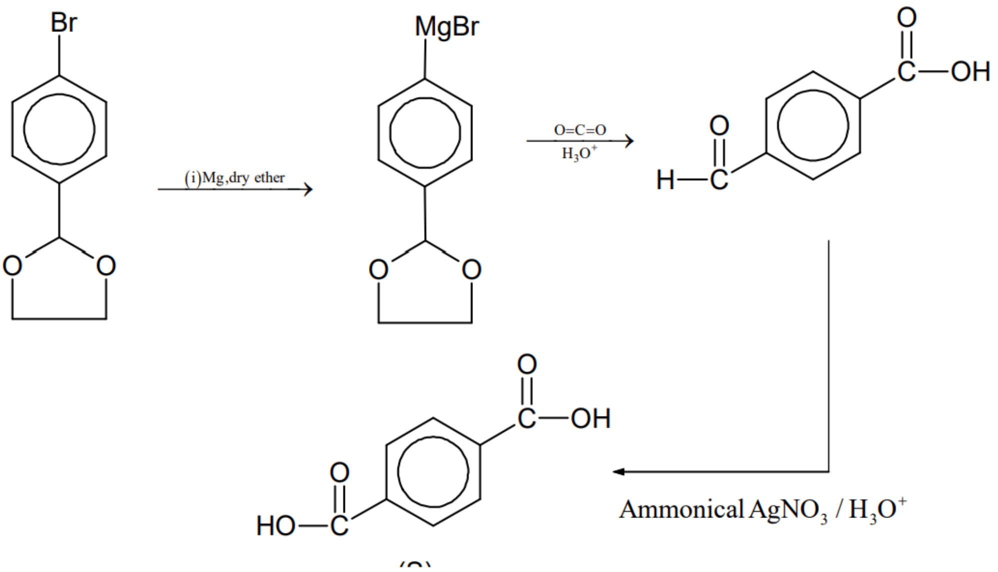
(C) Compounds Q and R are the same.

(D) R does not undergo aldol condensation and S does not undergo Cannizzaro reaction.

Answer : C,D

Solution:





Section-3 (Integer Type)

8. H_2S (5 moles) reacts completely with acidified aqueous potassium permanganate solution. In this reaction, the number of moles of water produced is x, and the number of moles of electrons involved is y. The value of (x + y) is _

   Answer : 18

$$\left(8H^+ + MnO_4^- + 5e^- \longrightarrow Mn^{2+} + 4H_2O\right)\times 2$$

$$\left(H_2S \longrightarrow S + 2H^+ + 2e^-\right)\times 5$$

$$2MnO_4^- + 16H^+ + 5H_2S \longrightarrow 2Mn^{2+} + 5S + 10H^+ + 8H_2O$$

$$2MnO_4^- + 6H^+ + 5H_2S \longrightarrow 2Mn^{2+} + 5S + 8H_2O$$

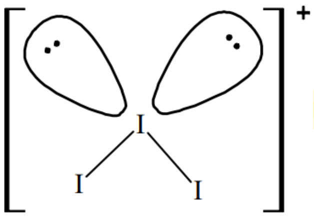
$x = 8$

$y = 10$

9. Among $[I_3]^+$, $[SiO_4]^{4-}$, SO_2Cl_2, XeF_2, SF_4, ClF_3, $Ni(CO)_4$, XeO_2F_2, $[PtCl_4]^{2-}$, XeF_4, and $SOCl_2$, the total number of species having sp^3 hybridised central atom is

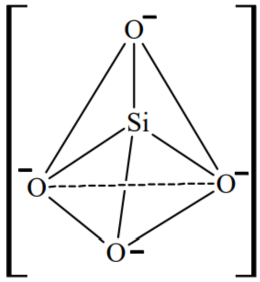
   Ans: 5

I_3^+



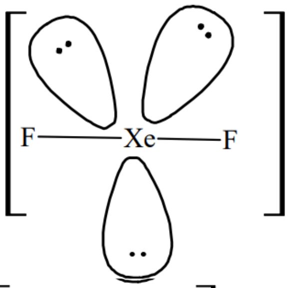
[sp^3]

$[SiO_4]^{4-}$



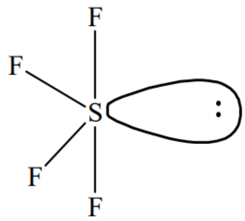
[sp^3]

$[XeF_2]$



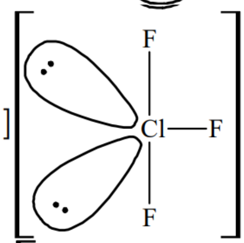
[sp^3d]

$[SF_4]$



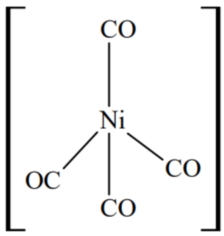
[sp^3d]

$[ClF_3]$



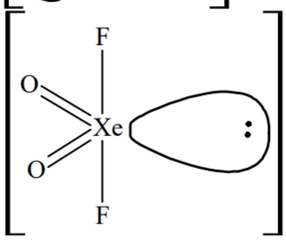
[sp^3d]

$[Ni(CO)_4]$



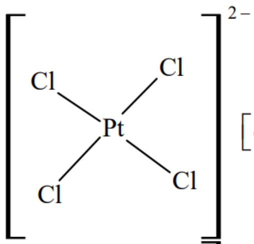
[sp^3]

$[XeO_2F_2]$



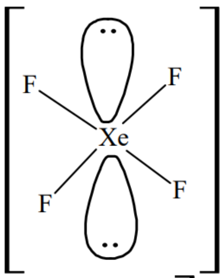
[sp^3d]

$[PtCl_4]^{2-}$



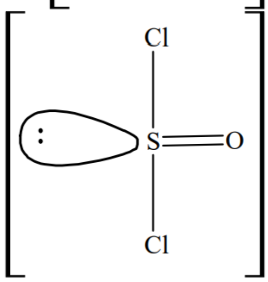
[dsp^2]

$[XeF_4]$



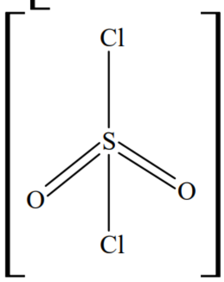
[sp^3d^2]

$[SOCl_2]$



[sp^3]

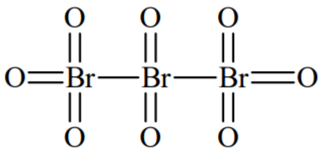
$[SO_2Cl_2]$

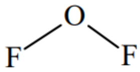


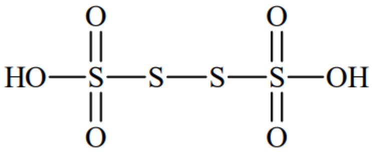
[sp^3]

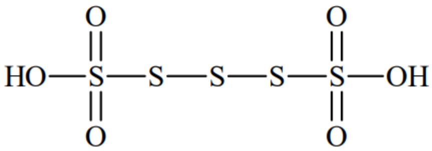
10. Consider the following molecules: Br_3O_8, F_2O, $H_2S_4O_6$, $H_2S_5O_6$, and C_3O_2. Count the number of atoms existing in their zero oxidation state in each molecule.Their sum is-------

Ans : 6

(i) 

(ii) 

(iii) 

(iv) 

(v) $O=C=C=C=O$

11. For He^+, a transition takes place from the orbit of radius 105.8 pm to the orbit of radius 26.45 pm.The wavelength (in nm) of the emitted photon during the transition is ___.

[Use: Bohr radius, a = 52.9 pm, Rydberg constant, $R_H = 2.2 \times 10^{-18}$ J, Planck's constant, $h = 6.6 \times 10^{-34}$ J s

Speed of light, $c = 3 \times 10^8$ m s^{-1}]

Ans: 30

$$r_n = \frac{52.9 \times n^2}{Z} \text{pm}$$

$$105.8 = \frac{52.9 \times n_1^2}{2} \qquad \therefore n_1^2 = 4, \; n_1 = 2$$

$$26.45 = \frac{52.9 \times n_2^2}{2} \qquad \therefore n_2 = 1$$

$$\frac{1}{\lambda} = 109677 \times 4 \times \frac{3}{4}$$

$$\lambda = \frac{4}{109677 \times 4 \times 3} \text{cm}$$

$$= \frac{10^7}{109677 \times 3} = \frac{10^7}{329031} \text{nm}$$

$$\lambda = 30.3 \text{ nm} \approx 30 \text{ nm}$$

12. 50 mL of 0.2 molal urea solution (density = 1.012 g mL $^{-1}$ at 300K) is mixed with 250 mL of a solution containing 0.06 g of urea. Both the solutions were prepared in the same solvent. The osmotic pressure (in Torr) of the resulting solution at 300 K is ____.

[Use: Molar mass of urea = 60 g mol $^{-1}$; gas constant,
R = 62 L Torr K $^{-1}$ mol $^{-1}$; Assume, $\Delta_{mix} H = 0$, $\Delta_{mix} V = 0$]

Ans: 682

0.2 molal means 0.2 moles in 1000 g of solvent

$$\text{Volume} = \frac{M}{d}$$

Mass of solution = 1012 g

$$\text{Volume} = \frac{1012\text{g}}{1.012 \text{ g ml}^{-1}}$$

V = 1000.00 ml

$$1000.00 \text{ ml} \longrightarrow 0.2 \text{ moles}$$

$$50 \text{ ml of solution } = \frac{0.2}{1000} \times 50 \text{ moles}$$

$n_{urea} = 0.01$ moles

In 2[nd] solution:

$$n_{urea} = \frac{0.06}{60} = 0.001$$

$$\text{Final molarity (M)} = \frac{n_1 + n_2}{V_1 + V_2} = \frac{0.01 + 0.001}{\frac{(50 + 250)}{1000}}$$

$$M = \frac{11}{300}$$

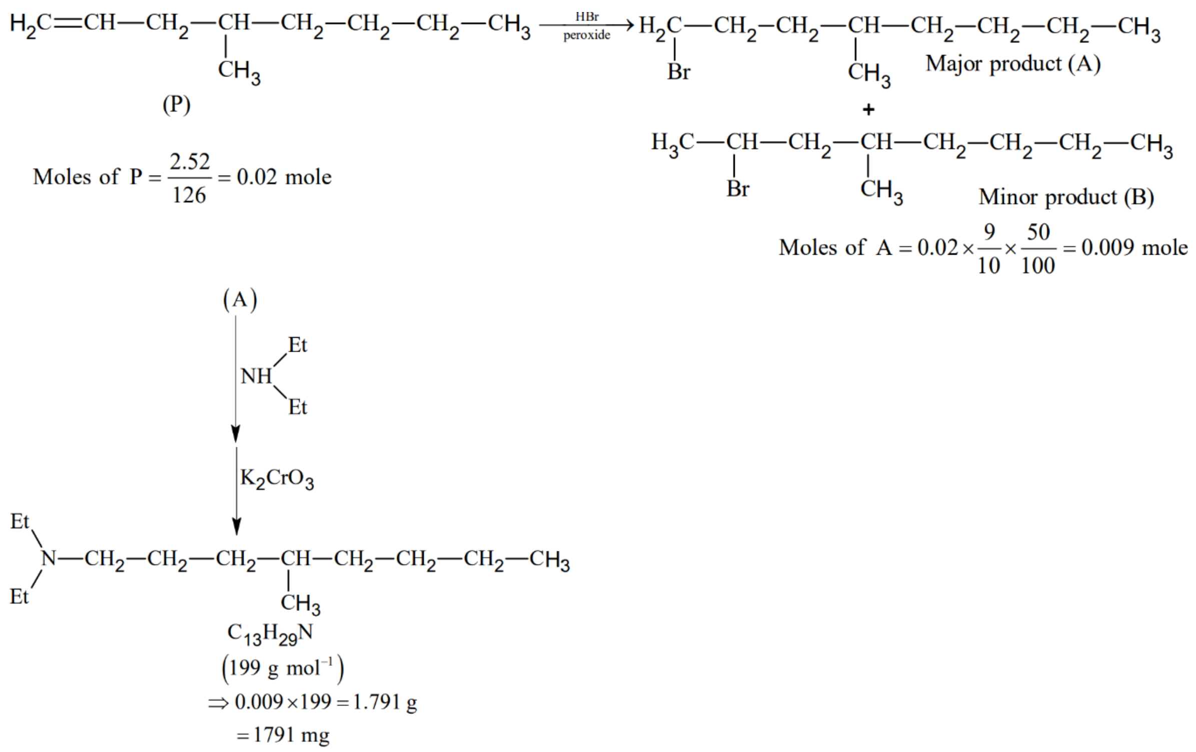
$$\pi = CRT$$

$$= \frac{11}{300} \times 62 \times 300$$

$$= 682 \text{ torr}$$

13. The reaction of 4-methyloct-1-ene (P, 2.52 g) with HBr in the presence of $(C_6H_5CO)_2O_2$ gives two isomeric bromides in a 9 : 1 ratio, with a combined yield of 50%. Of these, the entire amount of the primary alkyl bromide was reacted with an appropriate amount of diethylamine followed by treatment with aq. K_2CO_3 to give a non-ionic product S in 100% yield. The mass (in mg) of S obtained is ___. [Use molar mass (in g mol $^{-1}$): H = 1, C = 12, N = 14, Br = 80]

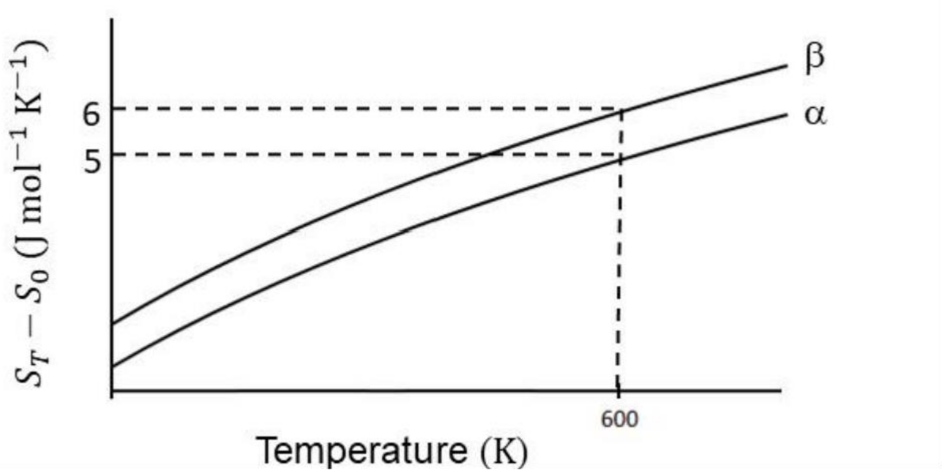
Ans : 1791



Section -4

Paragraph – 1

The entropy versus temperature plot for phases α and β at 1 bar pressure is given. S_T and S_0 are entropies of the phases at temperatures T and 0 K, respectively.



The transition temperature for α to β phase change is 600 K and $C_{p,\beta} - C_{p,\alpha} = 1$ J mol^{-1} K^{-1}. Assume ($C_{p,\beta} - C_{p,\alpha}$) is independent of temperature in the range of 200 to 700 K. $C_{p,\alpha}$ and $C_{p,\beta}$ are heat capacities of α and β phases respectively.

14. The value of entropy change, $S_\beta - S_\alpha$ (in J mol $^{-1}$ K $^{-1}$), at 300 K is ____. [Use: ln2 = 0.69 Given: $S_\beta - S_\alpha = 0$ at 0 K

Ans : 0.31

$$S = S_0 + \int C_p \frac{dT}{T}$$

$$S_\alpha = S_0 + \int (C_p)_\alpha \frac{dT}{T}$$

$$S_\beta = S_0 + \int (C_p)_\beta \frac{dT}{T}$$

$$S_\beta - S_\alpha = \left[(C_p)_\beta - (C_p)_\alpha\right] \int \frac{dT}{T}$$

Given $C_{P_\beta} - C_{P_\alpha} = 1$

$S_\beta - S_\alpha = \ln T + C$ at any temperature T.

$$(S_\beta - S_\alpha)_{T_2} - (S_\beta - S_\alpha)_{T_1} = \ln T_2 - \ln T_1$$

$T_2 = 600$ K, $T_1 = 300$ K, from the graph $S_\beta - S_\alpha$ at 600°C = 1

$(1) - (S_\beta - S_\alpha)_{300} = \ln 600 - \ln 300$

$1 - (S_\beta - S_\alpha)_{300} = \ln 2 = 0.69$

$$\Rightarrow (S_\beta - S_\alpha)_{300} = 1 - 0.69$$

$= 0.31$

15. The value of enthalpy change, Hβ − Hα (in J mol −1), at 300 K is -----------

Ans : 300

Transition : $\alpha \rightleftharpoons \beta$; $\Delta G = 0$

So, $\Delta H = T\Delta S$

$\Delta H_{600} = 600 \times 1 \quad \because \Delta S = 1$

$= 600 \text{ J mol}^{-1}$

From Krichoff's law

$$\Delta C_p = \frac{\Delta H_{600} - \Delta H_{300}}{600 - 300}$$

$$1 = \frac{600 - \Delta H_{300}}{300}$$

$\Delta H_{300} = 300 \text{ J mol}^{-1}$

Paragraph – 2

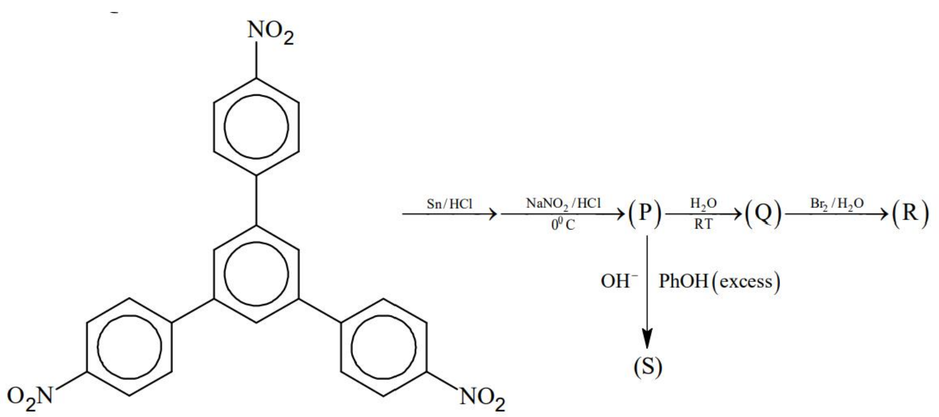
A trinitro compound, 1,3,5-tris-(4-nitrophenyl)benzene, on complete reaction with an excess of Sn/HCl gives a major product, which on treatment with an excess of $NaNO_2$/HCl at 0 °C provides P as the product. P, upon treatment with excess of H_2O at room temperature, gives the product Q. Bromination of Q in aqueous medium furnishes the product R. The compound P upon treatment with an excess of phenol under basic conditions gives the product S. The molar mass difference between compounds Q and R is 474 g mol^{-1} and between compounds P and S is 172.5 g mol^{-1} .

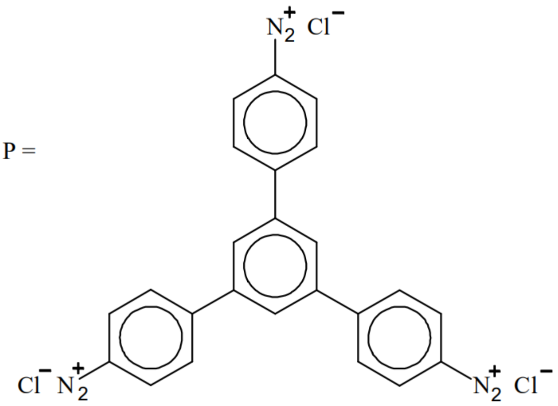
16. The number of heteroatoms present in one molecule of R is ______ . [Use: Molar mass (in g mol^{-1}): H = 1, C = 12, N = 14, O = 16, Br = 80, Cl = 35.5 Atoms other than C and H are considered as heteroatoms]

    Ans : 9

17. The total number of carbon atoms and heteroatoms present in one molecule of S is ______ . [Use: Molar mass (in g mol^{-1}): H = 1, C = 12, N = 14, O = 16, Br = 80, Cl = 35.5 Atoms other than C and H are considered as heteroatoms

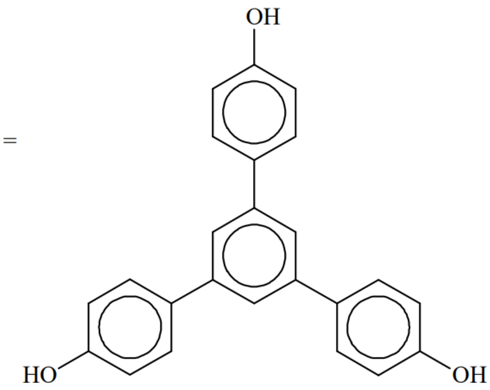
    Ans : 51



P = 

$(C_{24}H_{15}N_6Cl_3)$

493.5 g mol^{-1}

Q = 

$(C_{24}H_{18}O_3)$

354 g mol^{-1}