FINAL JEE(Advanced) EXAMINATION – 2023

(Held On Sunday 04th June, 2023)

PAPER-2 | TEST PAPER WITH SOLUTION

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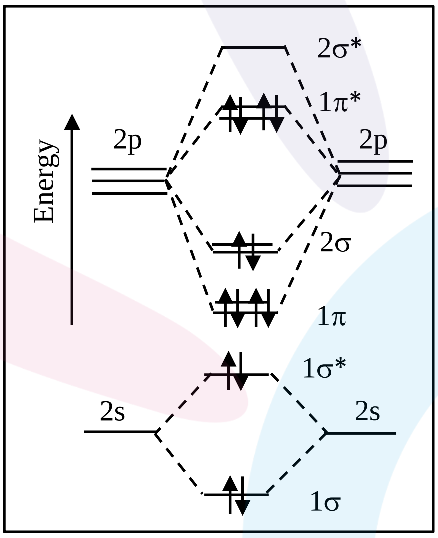
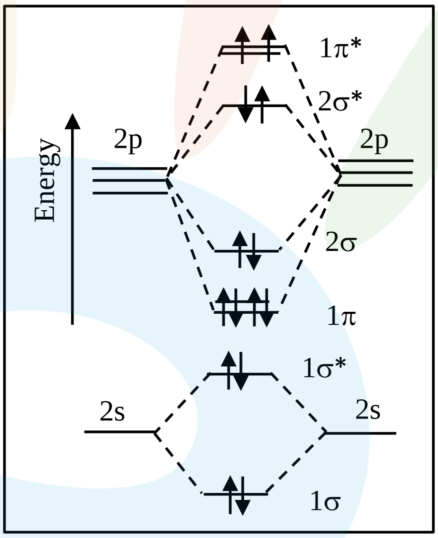
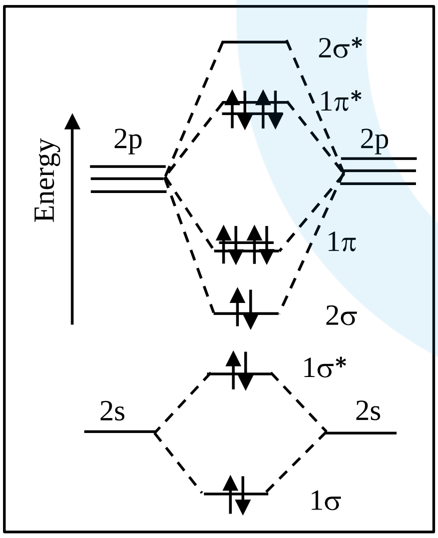
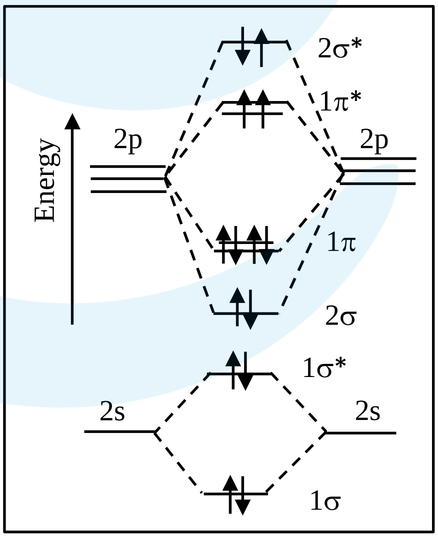
1. The correct molecular orbital diagram for F_2 molecule in the ground state is

(A)


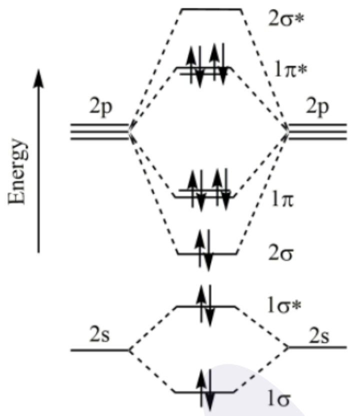
(B)


(C)


(D)


Ans. (C)

Sol. F_2 (18 e^-)



Naming of molecular orbitals are as per preference of formation of σ & π bonds respectively.

2. 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)**

Sol. (I) As in Lyophobic colloids there is no interaction between dispersed phase and dispersion medium, special methods are used for preparation, simple mixing will not form colloid.

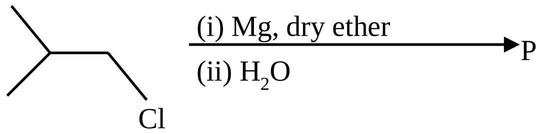
(II) Emulsions are liquid in liquid type colloids.

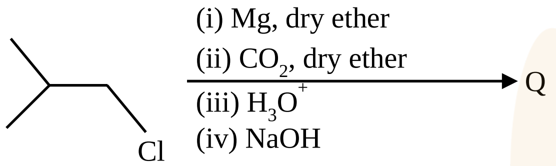
(III) Dissolving surfactant in a proper solvent will only form micelles at temperature above Kraft's temperature.

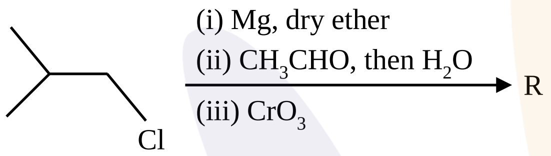
(IV) For Tyndall effect there must be a large difference in refractive index between dispersed phase and dispersion medium in order to have diffraction of light.

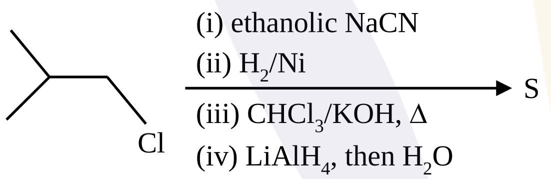
Hence ans (I) & (II) are correct.

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.

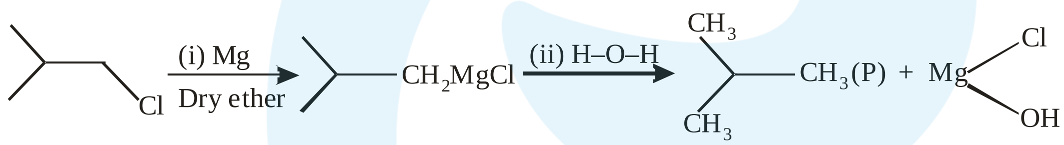
(B) **Q** undergoes Kolbe's electrolysis to give an eight-carbon product.

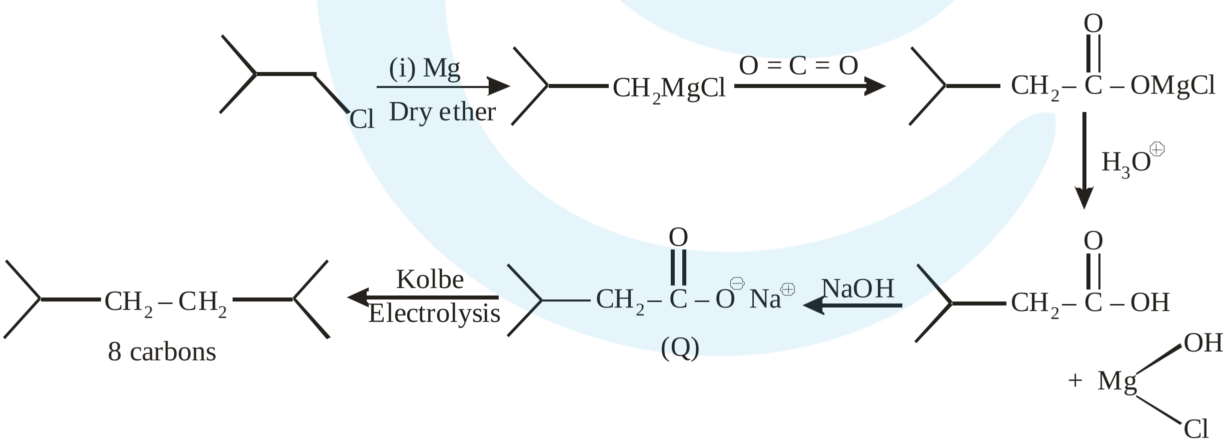
(C) **R** has six carbons and it undergoes Cannizzaro reaction.

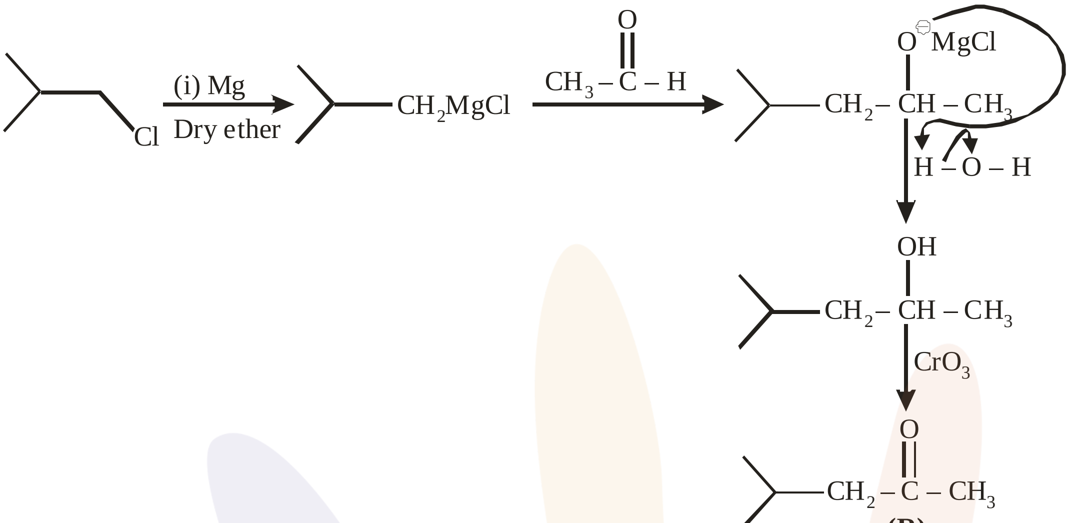
(D) **S** is a primary amine with six carbons.

Ans. **(B)**

Sol.

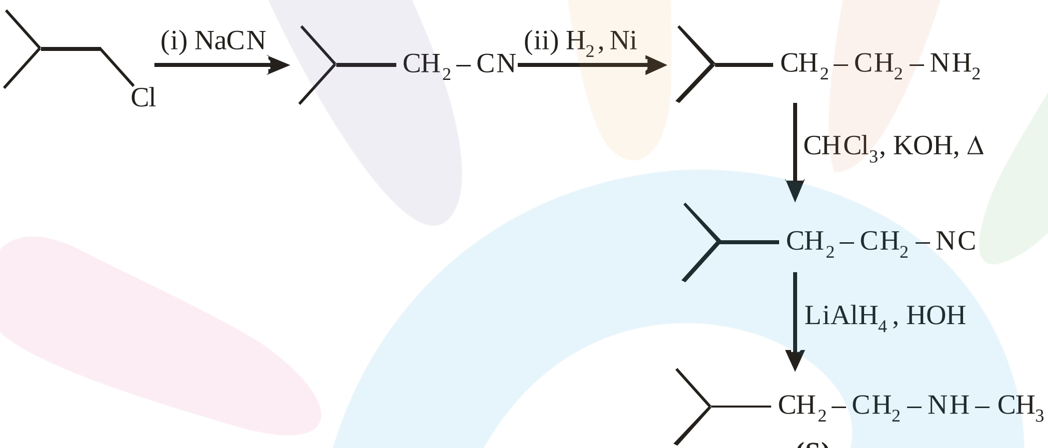






(R)

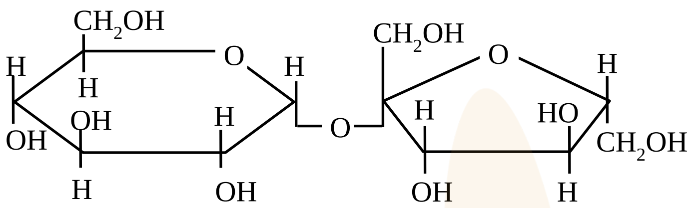
It does not give Cannizaro reaction

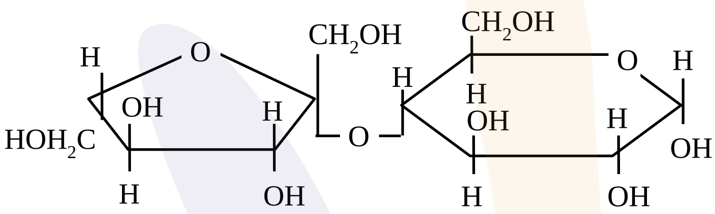


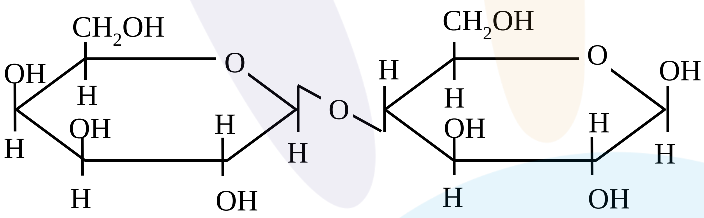
(S)

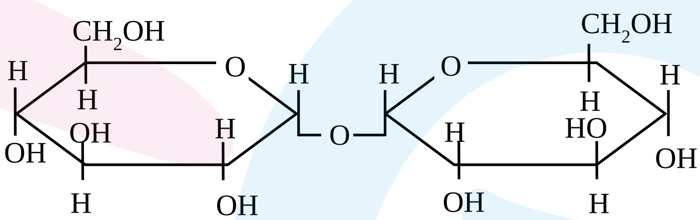
It's secondary amine

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)

Sol. Sucrose $\xrightarrow{H_3O^+}$ Glucose + Fructose

Specific rotation + 52.5°   –92° (mixture of products is laevorotatory)

Sucrose $\xrightarrow{Br_2+H_2O}$ No reaction

BCD $\Rightarrow$ reducing sugars, will get oxidized by $Br_2 + H_2O$

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 +2marks;
choosing ONLY (B) and (D) will get +2 marks;
choosing ONLY (A) will get +1 mark;
choosing ONLY (B) will get +1 mark;
choosing ONLY (D) will get +1 mark;
choosing no option(s) (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. The complex(es), which can exhibit the type of isomerism shown by $[Pt(NH_3)_2Br_2]$, is(are)
$[en = H_2NCH_2CH_2NH_2]$

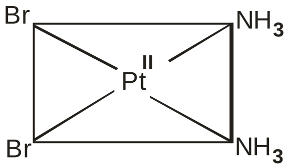
(A) $[Pt(en)(SCN)_2]$ (B) $[Zn(NH_3)_2Cl_2]$

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

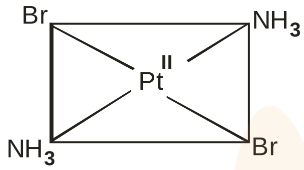
Ans. **(C,D)**

Sol. $\overset{+2}{[Pt(NH_3)_2Br_2]}$

Hybridisation : dsp^2, geometry : square planar



cis

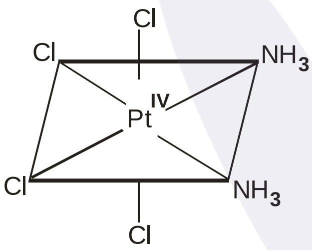


trans

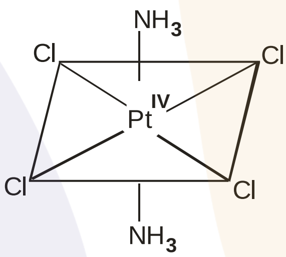
(A) $[Pt(en)(SCN)_2]$: square planar, cis–trans not possible

(B) $[Zn(NH_3)_2Cl_2]$: tetrahedral, cis–trans not possible

(C) $[Pt(NH_3)_2Cl_4]$: octahedral, cis–trans possible

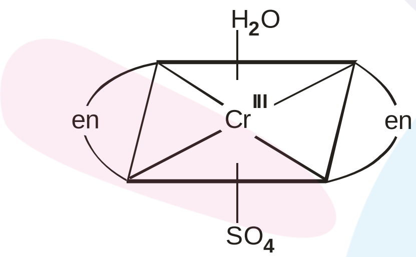


cis

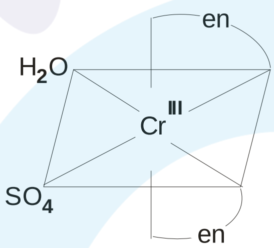


trans

(D) $[Cr(en)_2(H_2O)SO_4]^+$: Octahedral



trans



cis

6. Atoms of metals x, y, and z form face-centred cubic (fcc) unit cell of edge length L_x, body-centred cubic (bcc) unit cell of edge length L_y, and simple cubic unit cell of edge length L_z, 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 : M_x, M_y, and M_z are molar masses of metals x, y, and z, respectively.

r_x, r_y, and r_z 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 cell of z

(B) $L_y > L_z$

(C) $L_x > L_y$

(D) Density of x > Density of y

Ans. (A,B,D)

Sol.

Element	X	Y	Z
Packing	FCC	BCC	Primitive
Edge	L_x	L_y	L_z
Relation between edge length and radius	$L_x = 2\sqrt{2}r_x$	$L_y = \frac{4}{\sqrt{3}}r_y$	$L_z = 2r_z$
Packing fraction	$\frac{\pi}{3\sqrt{2}}$	$\frac{\sqrt{3}\pi}{8}$	$\frac{\pi}{6}$

Now, $r_y = \frac{8}{\sqrt{3}}r_x$ & $r_z = \frac{\sqrt{3}}{2}r_y = \frac{\sqrt{3}}{2}\times\frac{8}{\sqrt{3}}\ r_x \Rightarrow r_z = 4r_x$

So, $L_x = 2\sqrt{2}\ r_x$, $L_y = \frac{4}{\sqrt{3}}\times\frac{8}{\sqrt{3}}r_x$, $L_z = 8r_x$

$L_x = 2\sqrt{2}\ r_x$, $L_y = \frac{32}{3}r_x$, $L_z = 8r_x$

So $L_y > L_z > L_x$

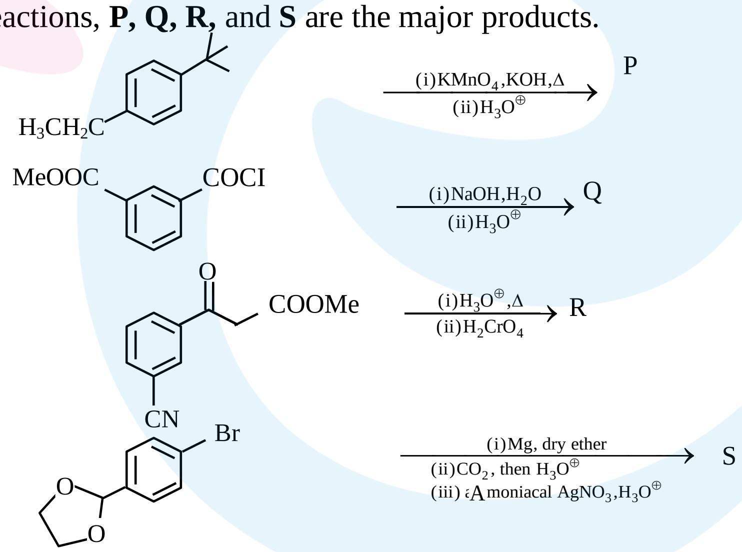
Density $\frac{4M_x}{L_x^3}, \frac{2\times M_y}{L_y^3}$

Now, $3M_x = \frac{3M_y}{2}$ or $M_x \times 2 = M_y$

$$\frac{\text{density}(x)}{\text{density}(y)} = \frac{4M_x}{2M_y}\times\frac{L_y^3}{L_x^3} = \frac{4M_x}{4M_x}\times\frac{\left(\frac{32}{3}\right)^3}{\left(2\sqrt{2}\right)^3}$$

Hence d(x) > d(y)

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.

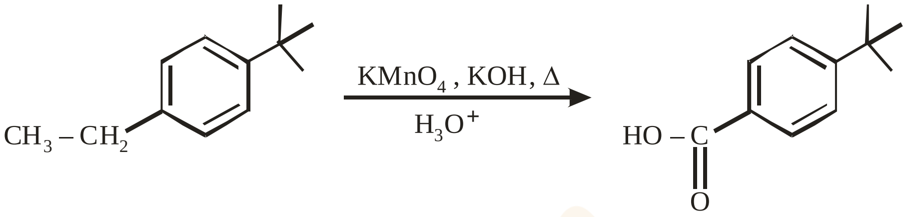
(B) **P, Q,** and **R** are dicarboxylic acids.

(C) Compounds **Q** and **R** are the same.

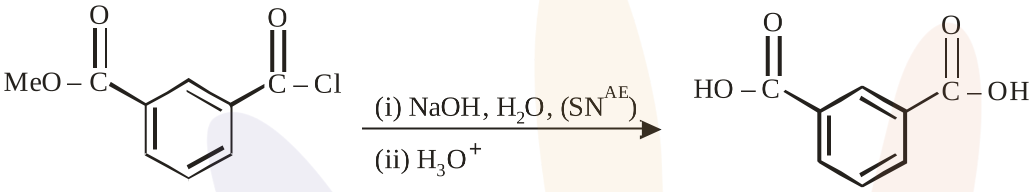
(D) **R** does **not** undergo aldol condensation and **S** does **not** undergo Cannizzaro reaction.

Ans. (C,D)

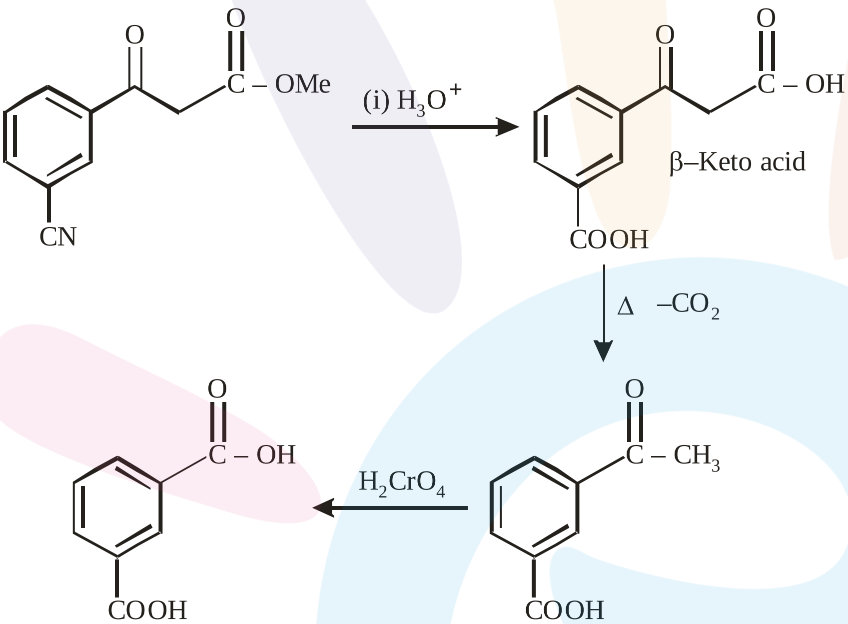
Sol.


CH_3-CH_2
$KMnO_4$, KOH, Δ
H_3O^+
HO – C
O

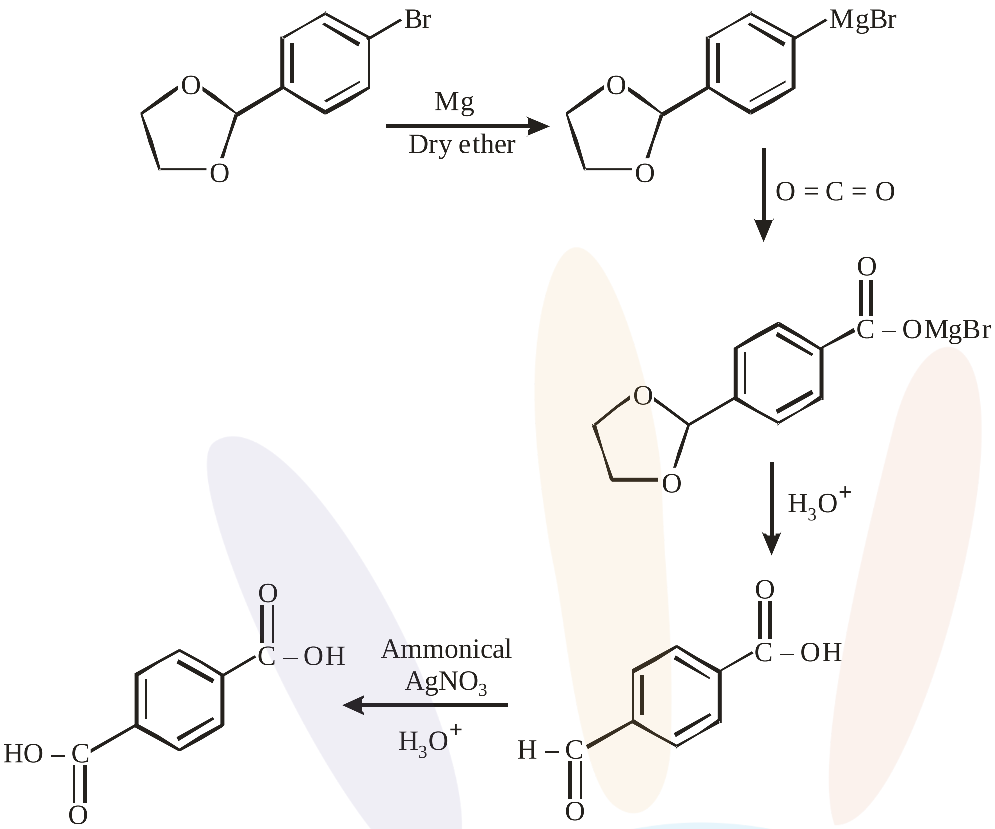
(P)


O
MeO – C
O
C – Cl
(i) NaOH, H_2O, (SN^{AE})
(ii) H_3O^+
O
HO – C
O
C – OH

(Q)


O
O
C – OMe
CN
(i) H_3O^+
O
O
C – OH
β–Keto acid
COOH
Δ $-CO_2$
O
C – CH_3
COOH
H_2CrO_4
O
C – OH
COOH

(R)



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. 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 ____.

Ans. (18)

Sol. $$2K\overset{+7}{Mn}O_4 + 5H_2S + 3H_2SO_4 \rightarrow K_2SO_4 + 2\overset{+2}{Mn}SO_4 + 5S + 8H_2O$$

x = 8 (moles of H_2O produced)

y = 14 – 4 = 10 (number of electrons involved)

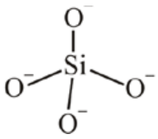
x + y = 10 + 8 = 18

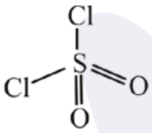
9. Among $[I_3]^+$, $[SiO_4]^{4-}$, SO_2Cl_2, XeF_2, SF_4, ClF_3, $Ni(CO)_4$, XeO_2F_2, $[PtCl_4]^{2-}$, XeF_4, and $SOCl_2$, the total number of species having sp^3 hybridised central atom is ______.

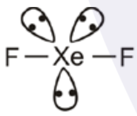
Ans. (5)

Sol.

I_3^+ :  : sp^3

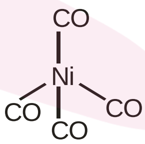
SiO_4^{4-} :  : sp^3

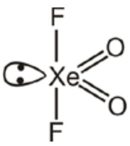
SO_2Cl_2 :  : sp^3

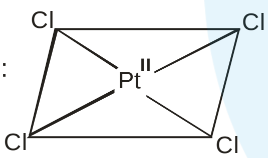
XeF_2 :  : sp^3d

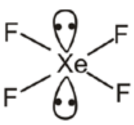
SF_4 :  : sp^3d

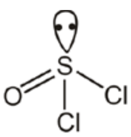
ClF_3 :  : sp^3d

$[Ni(CO)_4]$:  : sp^3

XeO_2F_2 :  : sp^3d

$[PtCl_4]^{2-}$:  : dsp^2

XeF_4 :  : sp^3d^2

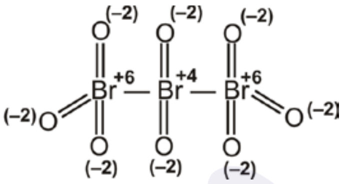
$SOCl_2$:  : sp^3

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____.

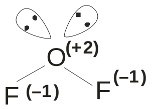
Ans. (6)

Sol. Br_3O_8



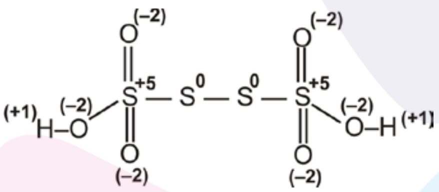
Number of atoms with zero oxidation state = 0

F_2O



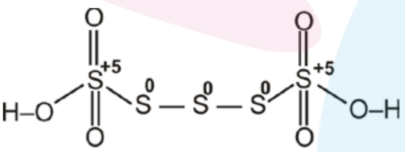
Number of atom with zero oxidation state = 0

$H_2S_4O_6$



Number of atoms with zero oxidation state = 2

$H_2S_5O_6$



Number of atoms where zero oxidation state = 3

C_3O_2

$O = C = \overset{(0)}{C} = C = O$

Number of atoms with zero oxidation state = 1

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)

Sol. For single electron system

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

Given Z = 2 for He^+

$r_2 = 105.8$ pm

So $105.8 = 52.9 \times \frac{n_2^2}{2}$

$n_2 = 2$

$r_1 = 26.45$

So $26.45 = 52.9 \times \frac{n_1^2}{2}$

$n_1 = 1$

So transition is from 2 to 1.

Now $\frac{hc}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

So $\lambda = 30 \times 10^{-9}$ m = 30 nanometer.

Here 'R_H' is given in terms of energy value.

12. 50 mL of 0.2 molal urea solution (density = 1.012 g mL^{-1} at 300 K) 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)

Sol. Weight of 50 ml 0.2 molal urea = V × d = 50 × 1.012 = 50.6 gm

Given 0.2 molal implies

1000 gm solvent has 0.2 moles urea

So weight of solution = 1000 + 0.2 × 60 = 1012 gm.

So wt. of urea in 50.6 gm solution = $\frac{12 \times 50.6}{1012}$ = 0.6 gm

Total urea = 0.6 + 0.06 = 0.66 gm

Total volume = 300 ml

Now, osmotic pressure $\pi = C \times R \times T = \frac{0.66 \times 62 \times 300}{60 \times 0.3}$ = 682 Torr.

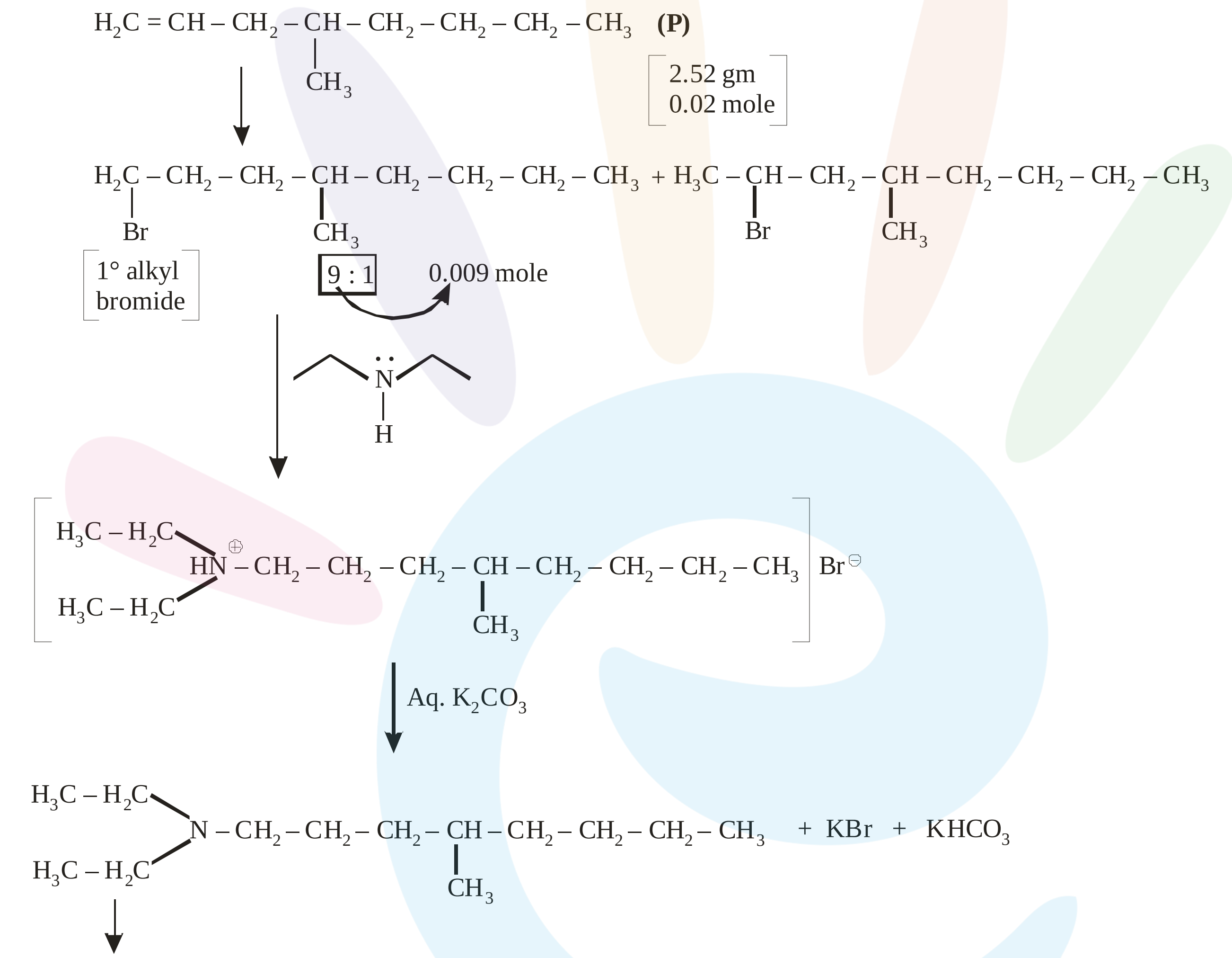
13. The reaction of 4-methyloct-ene (**P**, 2.52 g) with HBr in the presence of $(C_6H_5CO)_2O_2$ gives two isomeric bromides in a 9 : 1 ratio, with combined yield of 50%. Of these, the entire amount of the primary alkyl bromide was reacted with an appropriate amount of diethylamine followed by treatment with eq. K_2CO_3 to given 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)

Sol.



mol. mass = 199 gm

(S) 0.009 mole

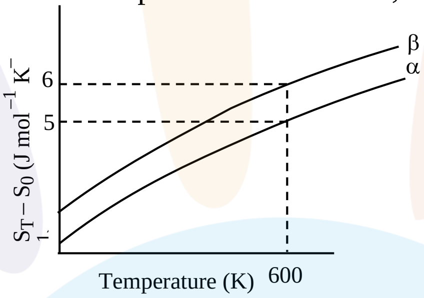
= 199 × 0.009 = 1791 mg

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 I"

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 : ln 2 = 0.69
Given : $S_\beta - S_\alpha = 0$ at 0 K]

Ans. **(0.31)**

Sol. At 1 bar

$$\alpha \longrightarrow \beta$$

$$S^o_{\alpha(600)} = S^o_{\alpha(300)} + C_{P(\alpha)} \ell n \frac{600}{300}$$

$$S^o_{\beta(600)} = S^o_{\beta(300)} + C_{P(\beta)} \ell n \frac{600}{300}$$

$$S^o_{\beta(600)} - S^o_{\alpha(600)} = S^o_{\beta(300)} - S^o_{\alpha(300)} + (C_{P(\beta)} - C_{P(\alpha)})\ \ell n 2$$

$$6 - 5 = S^o_{\beta(300)} - S^o_{\alpha(300)} + 1 \times \ell n 2$$

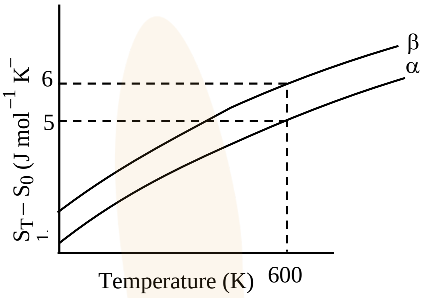
$$1 = S^o_{\beta(300)} - S^o_{\alpha(300)} + 0.69$$

$$\text{So } S^o_{\beta(300)} - S^o_{\alpha(300)} = 0.31$$

"PARAGRAPH I"

The entropy versus temperature plot for phases α and β 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.

15. The value of enthalpy change, $H_\beta - H_\alpha$ (in J mol^{-1}), at 300 K is __.

Ans. (300)

Sol. As the phase transition temperature is 600 K

So at 600 K $\Delta G^\circ_{rxn} = 0$

So $\Delta H^\circ_{reaction\ (600)} = T\ \Delta S^\circ_{reaction\ (600)}$

$\Delta H^\circ_{(600)} = 600 \times 1 = 600$ Joule/mole

So $\Delta H_{600} - \Delta H_{300} = \Delta C_P\ (T_2 - T_1)$

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

$\Delta H_{300} = \Delta H_{600} - 300 = 600 - 300 = 300$ Joule/mole.

"PARAGRAPH II"

A trinitro compound, 1, 3,5 tris-(4-nitrophenyl) benzene, on complete reaction with an excess of Sn/HCl gives 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 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)

"PARAGRAPH II"

A trinitro compound, 1, 3,5 tris-(4-nitrophenyl) benzene, on complete reaction with an excess of Sn/HCl gives 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 mol^{-1} and between compounds **P** and **S** is 172.5 g mol^{-1}.

17. The total number of carbon atoms and heteroatoms present in one molecule of **S** is **_____.**

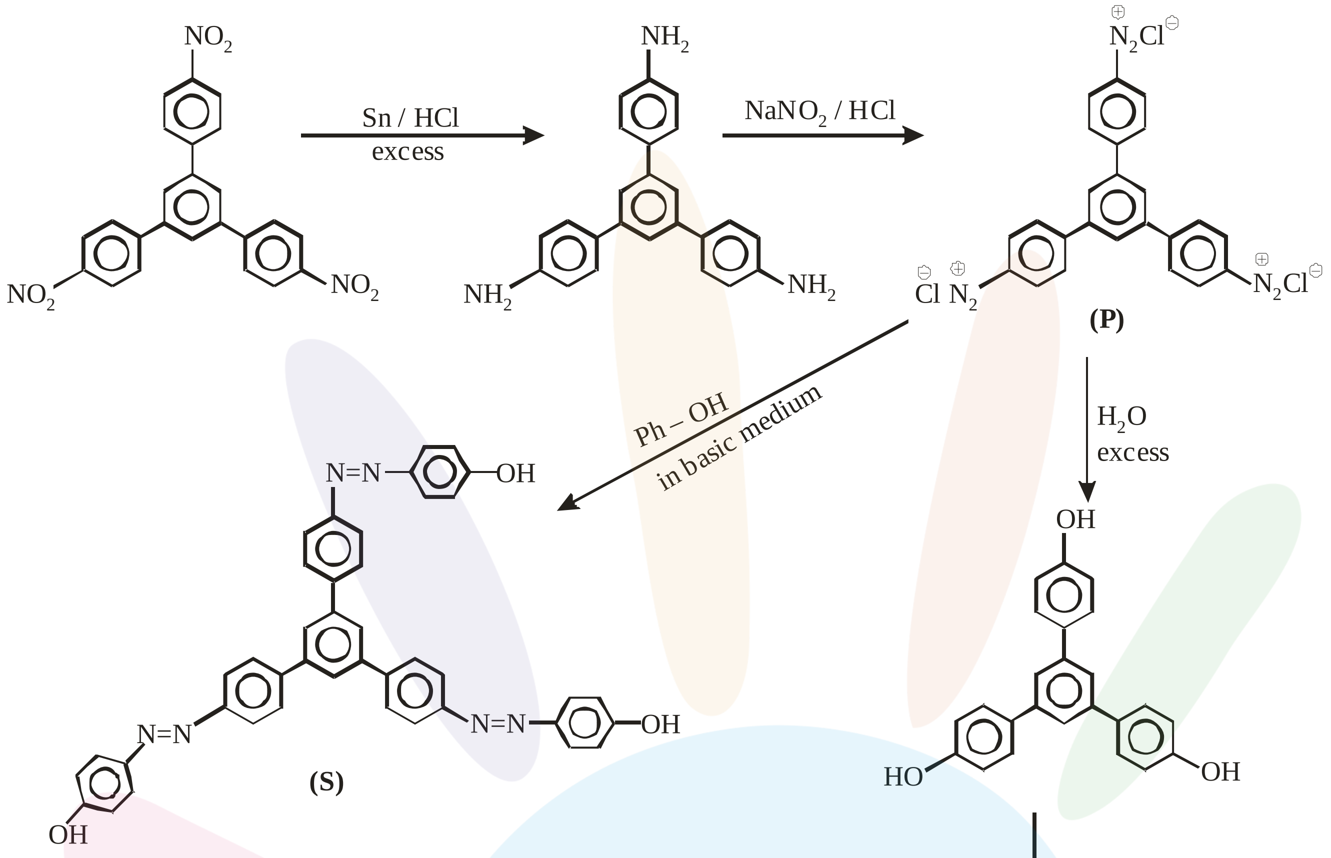
[Use: Molar mass in g mol^{-1}]: H = 1, C = 12, N = 14, O = 16, Br = 80, Cl = 35.5

Atoms other than C and H are considered as heteroatoms

Ans. (51)

Sol.

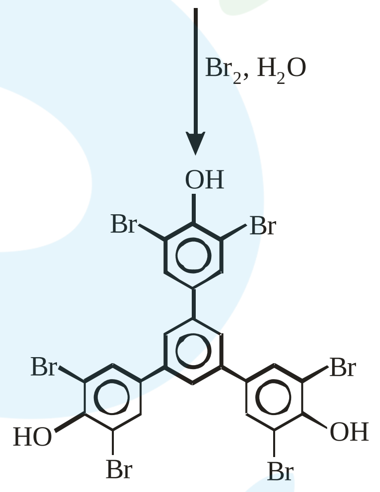
Common solution for Q.no. 16 and 17



Number of carbons = 42

Number of heteroatoms = 09

Total = 51



Number of hetero atoms in R is 9