Reliable INSTITUTE
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JEE ADVANCED 2023

PAPER - 2

QUESTIONS & SOLUTIONS

4 JUNE, 2023

02:30 PM to 05:30 PM

Duration : 3 Hours

SUBJECT - CHEMISTRY

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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 <u>according to the following marking scheme:</u>

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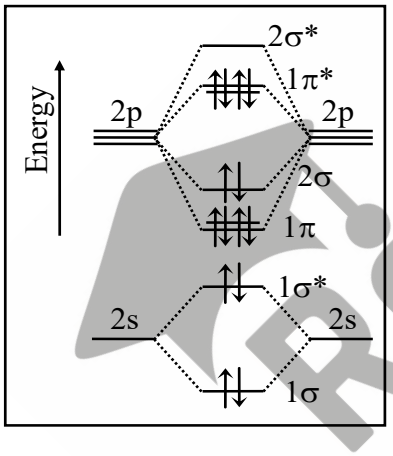
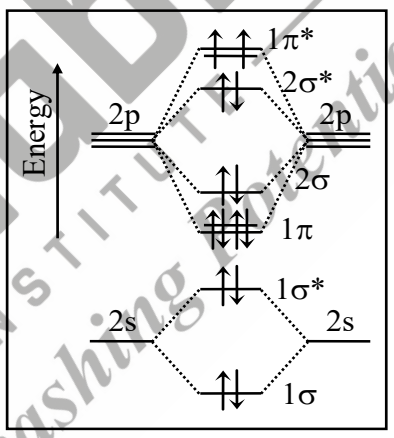
1. The correct molecular orbital diagram for F_2 molecule in the ground state is

(A)



(B)



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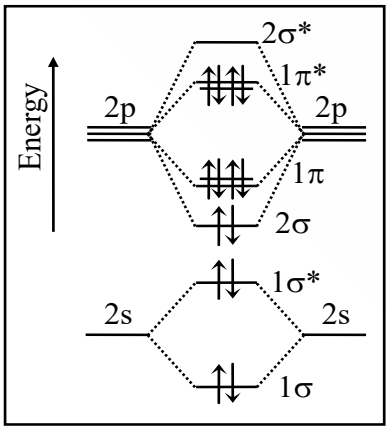
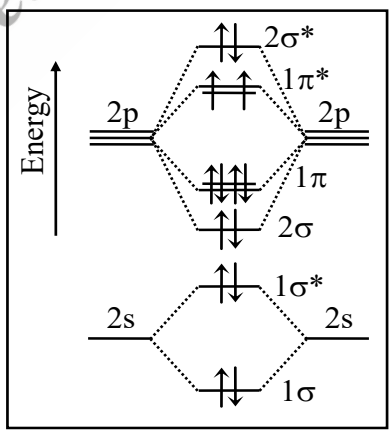


(D)



Ans. **(C)** **(Chemical Bonding) (E)**

Sol. For F_2 KK $(\sigma 2s)^2(\sigma^* 2s)^2(\sigma 2p)^2(\pi 2p^2 = \pi 2p^2)(\pi^* 2p^2 = \pi^* 2p^2)$

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) **(Surface Chemistry) (M)**

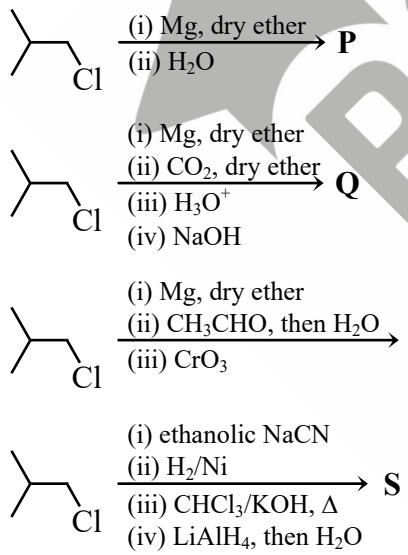
Sol. (I) Lyophobic colloids are formed by using special methods.

(II) Emulsions are colloidal solution of two immiscible liquids.

(III) Micelles are formed above Kraft temperature and above CMC.

(IV) For Tyndall effect, large difference between refractive index of dispersed phase and dispersion medium should present.

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.

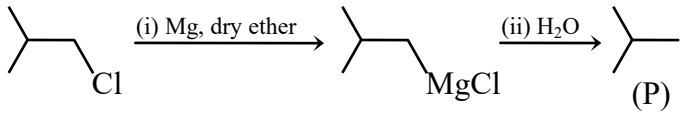
(C) R has six carbons and it undergoes Cannizzaro reaction.

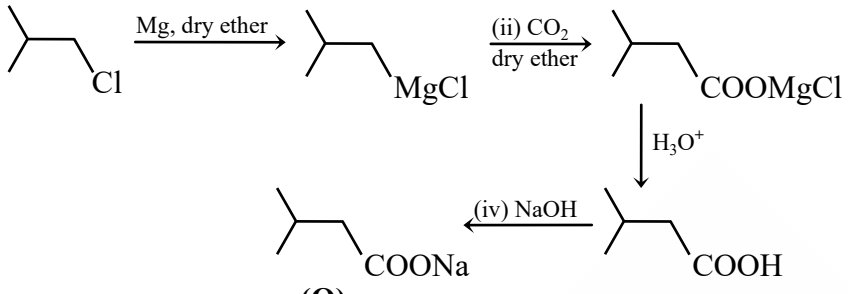
(D) S is a primary amine with six carbons.

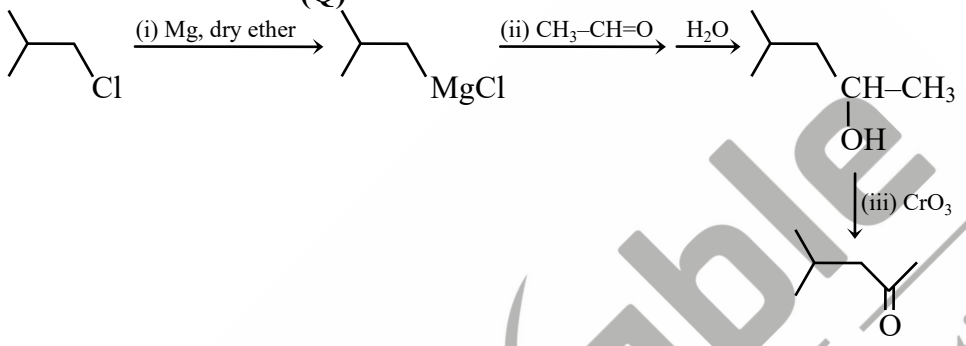
[Carbonyl Compounds] (T)

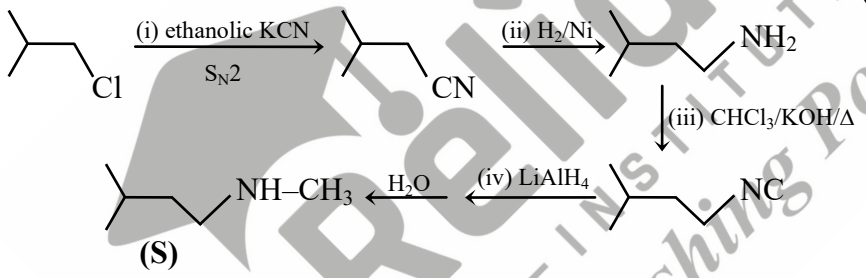
Ans. (B)

Sol.

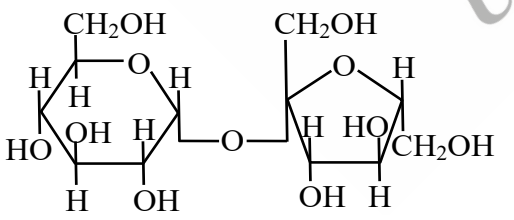


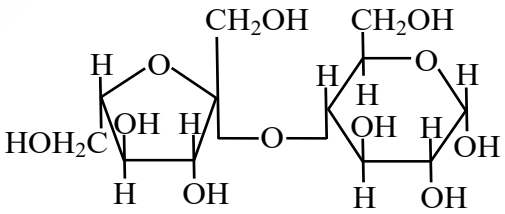


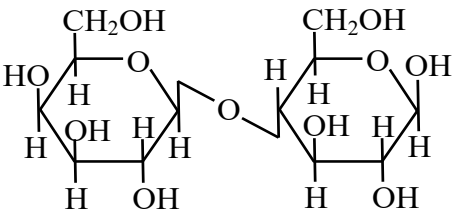


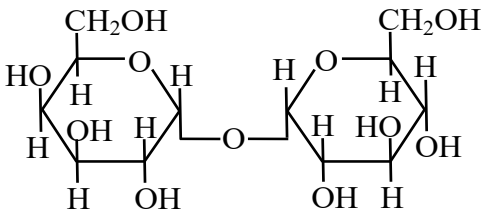


4. A disaccharide X cannot be oxidised by bromine water. The acid hydrolysis of X leads to a laevorotatory solution. The disaccharide X is

(A) 

(B) 

(C) 

(D) 

[Biomolecules] (E)

Ans. (A)

Sol. It is sucrose because it can not oxidise bromine water and its acid hydrolysis gives D-(+)-glucose and D-(–)-fructose leads to laevorotatory solution.

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) $[Zn(NH_3)_2Cl_2]$

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

Ans. (CD) **(Coordination compound) (M)**

Sol. $[Pt(NH_3)_2Cl_2]$: dsp^2 square planar

It can show geometrical isomerism.

$[Pt(en)_2(SCN)_2] \Rightarrow$ Can't show geometrical isomerism.

$[Zn(NH_3)_2Cl_2] \Rightarrow$ Can't show geometrical isomerism because it is tetrahedral.

$[Pt(NH_3)_2Cl_4] \Rightarrow$ Can show geometrical isomerism.

$[Cr(en)_2(H_2O)(SO_4)]^+ \Rightarrow$ Can show geometrical isomerism.

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. **(ABD)**

Sol. **(A)** $r_x : r_y : r_z = 1 : \frac{8}{\sqrt{3}} : 4$

Packing efficiency $\eta_x : \eta_y : \eta_z$

$$\frac{4\times\frac{4}{3}\pi r_x^3}{L_x^3} : \frac{2\times\frac{2}{3}\pi r_y^3}{L_y^3} : \frac{1\times\frac{4}{3}\pi r_z^3}{L_z^3}$$

$$\frac{4\times\frac{4}{3}\pi r_x^3}{(2\sqrt{2}\,r_x)^3} : \frac{2\times\frac{2}{3}\pi r_y^3}{\left(\frac{4}{\sqrt{3}} r_y\right)^3} : \frac{1\times\frac{4}{3}\pi r_z^3}{(2r_z)^3}$$

$$\frac{4}{(2\sqrt{2})^3} : \frac{2}{\left(\frac{4}{\sqrt{3}}\right)^3} : \frac{1}{(2)^3}$$

$$\frac{4}{16\sqrt{2}} : \frac{2\times 3\sqrt{3}}{64} : \frac{1}{8}$$

$$\frac{1}{4\sqrt{2}} \quad : \quad \frac{3\sqrt{3}}{32} \quad : \quad \frac{1}{8}$$

$$0.707 \quad : \quad 0.65 \quad : \quad 0.5$$

Order: $\therefore\ \eta_x > \eta_y > \eta_z$

(B, C, D)

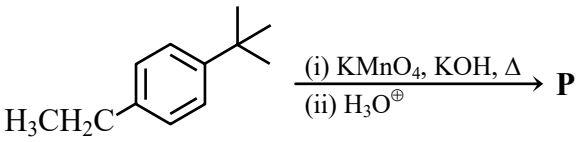
X	Y	Z
$L_x = 2\sqrt{2}\, r_x$	$L_y = \frac{4r_y}{\sqrt{3}}$	$L_z = 2r_z$
	$= \frac{4\times\frac{8}{\sqrt{3}} r_x}{\sqrt{3}}$	$= 2\times\frac{\sqrt{3}}{2}\times\frac{8}{\sqrt{3}} r_x$
	$= \frac{32}{3} r_x$	$= 8r_x$

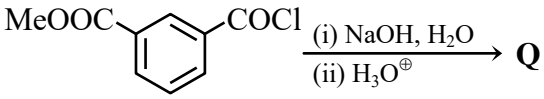
$L_y > L_z > L_x$

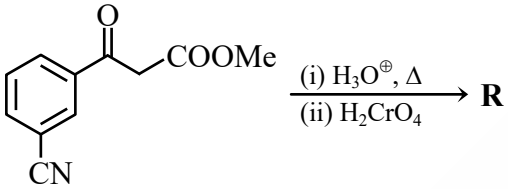
$\rho_x = \frac{4\times\frac{M_x}{N_A}}{L_x^3}$	$\rho_y = \frac{2\times\frac{M_y}{N_A}}{L_y^3}$	$\rho_z = \frac{1\times\frac{M_z}{N_A}}{L_z^3}$
$= \frac{4\times\frac{M_z}{3}}{N_A\times\left(2\sqrt{2}r_x\right)^3}$	$= \frac{2\times\frac{2}{3}M_z}{N_A\times\left(\frac{32}{3}r_x\right)^2}$	$= \frac{1\times M_z}{N_A(8r_x)^3}$
$= \frac{4}{3\times8\times2\sqrt{2}}\times\frac{M_z}{N_A\times r_x^3}$	$= \frac{4}{3}\times\frac{3\times3\times3}{32\times32\times32}\frac{M_z}{N_A r_x^3}$	$= \frac{1\times M_z}{N_A\times512 r_x^3}$
$= \frac{1}{12\sqrt{2}}\frac{M_z}{N_A r_x^3}$	$= \frac{9}{8192}\frac{M_z}{N_A r_x^3}$	$= \frac{1\times M_z}{512 N_A r_x^3}$
$= 0.0589\frac{M_z}{N_A r_x^3}$	$= 0.0010\frac{M_z}{N_A r_x^3}$	$= 0.0019\frac{M_z}{N_A r_x^3}$

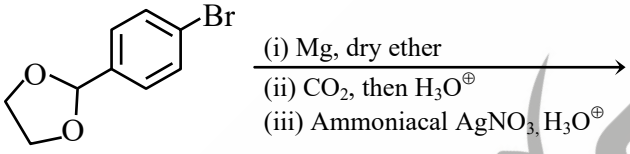
Order of density $\rho_y < \rho_z < \rho_x$

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.

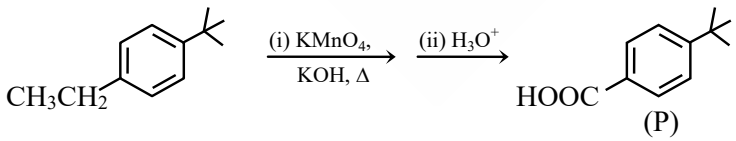
(C) Compounds **Q** and **R** are the same.

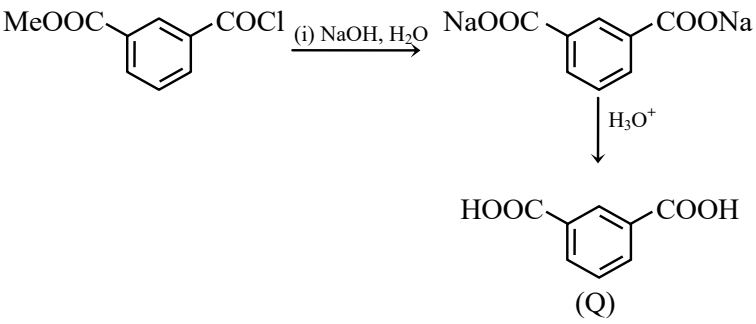
(D) **R** does **not** undergo aldol condensation and S does **not** undergo Cannizzaro reaction.

[Reduction, Oxidation, Hydrolysis & Decarboxylation] (M)

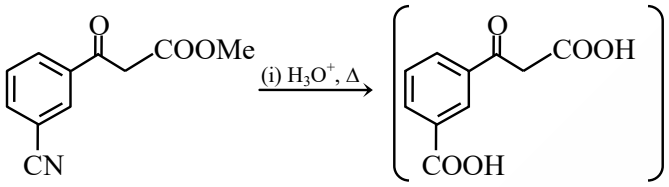
Ans. (CD)

Sol.

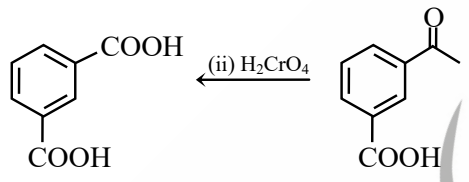




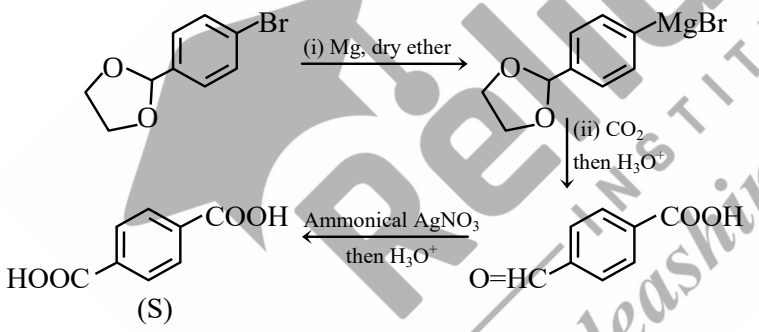
(Q)



β-keto acid



(R)



(S)

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. $S^{2-} \longrightarrow S + 2e^-] \times 5$

$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O] \times 2$

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

$x = 8,\ y = 10$

$x + y = 8 + 10 = 18$

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**

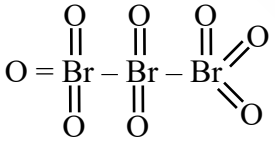
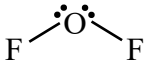
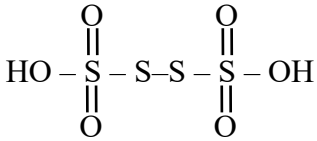
Sol.

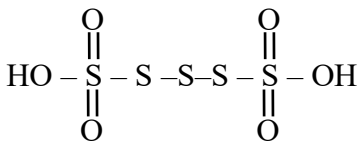
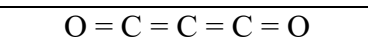
I_3^+	—	sp^3
SiO_4^{4-}	—	sp^3
SO_2Cl_2	—	sp^3
XeF_2	—	sp^3d
SF_4	—	sp^3d
ClF_3	—	sp^3d
$Ni(CO)_4$	—	sp^3
XeO_2F_2	—	sp^3d
$[PtCl_4]^{2-}$	—	dsp^2
XeF_4	—	sp^3d^2
$SOCl_2$	—	sp^3

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.

Structure	No. of atoms having zero oxidation state
	0
	0
	2

	3
	1
Total	**6**

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 **(Atomic Structure) (M)**

Sol. $Z = 2$

$$r = \frac{an^2}{z}$$

$$\Rightarrow \quad 52.9\frac{n^2}{2} = 105.8$$

$$n = 2$$

$$\Rightarrow \quad 52.9\frac{n^2}{2} = 26.45$$

$$n = 1$$

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

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

$$\frac{hc}{\lambda} = 3R$$

$$= 3 \times 2.2 \times 10^{-18} \text{ J}$$

$$\lambda = \frac{6.6\times10^{-34}\times3\times10^8}{3\times2.2\times10^{-18}} \text{ m}$$

$$= 3 \times 10^{-8} \text{ m}$$

$$= 30 \text{ nm}$$

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 **(Solutions & Colligative properties)**

Sol. For 1st solution: $0.2 = \dfrac{W_{urea}/60}{\left(\dfrac{50\times1.012 - W_{urea}}{1000}\right)}$

$\therefore \quad W_{urea} = 0.6$ g

For 2nd solution, Wu = 0.06 g & $V_{sol} = 250$ mL

For resulting solution,

$\pi = CRT$

$= \left(\dfrac{0.66/60}{0.3}\right) \times 62 \times 300$

$= 682$ 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.

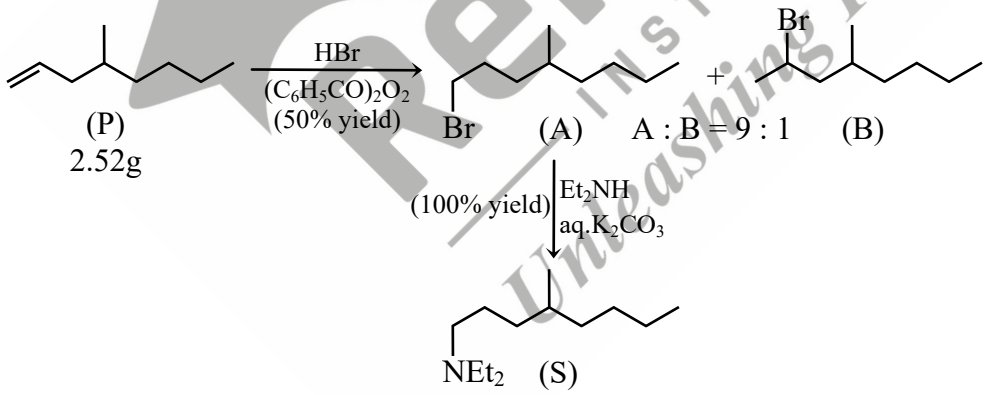
The mass (in mg) of **S** obtained is ___.

[Use molar mass (in g mol^{-1}): H = 1, C = 12, N = 14, Br = 80]

[Aromatic Compounds] (T)

Ans. **1791 mg**

Sol.



Mole of P = $\dfrac{2.52}{126} = 0.02$

50% yield of A and B combined formed in 9 : 1 ratio

Mole of A = 0.009 and mole of B = 0.001

Mole of S = 0.009

Molecular mass of S = 199

So mass obtained of S = 199 × 0.009 = 1.791 g

1.791 × 1000 = 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:

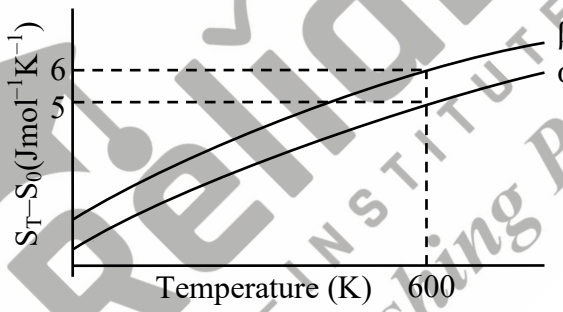
  Full Marks : +3 If ONLY the correct numerical value is entered in the designated place;

  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 $C_{p,\beta} - C_{p,\alpha} = 1$ $Jmol^{-1}K^{-1}$. 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.

$$\begin{array}{ccc} S_\alpha & \longrightarrow & S_\beta \\ (300\ K) & & (300\ K) \\ \Delta S_1 \downarrow & & \uparrow \Delta S_3 \\ S_\alpha & \xrightarrow{\Delta S_2} & S_\beta \\ (600\ K) & & (600\ K) \end{array}$$

$$\Delta S_1 = C_{p,\alpha} \ln \frac{600}{300}$$

$$\Delta S_3 = C_{p,\beta} \ln\left(\frac{300}{600}\right)$$

$$\Delta S_2 = (S_\beta - S_\alpha)_{600\,K} = (S_\beta - S_\alpha)_{600\,K} + \underbrace{\left(S_\beta - S_\alpha\right)_{0K}}_{\Downarrow \text{ gives as zero}}$$

$$= \left(S_{\beta_{600K}} - S_{\beta_{0K}}\right) - \left(S_{\alpha_{600K}} - S_{\alpha_{0K}}\right) = 1$$

$$\Delta S_{total} = C_{p,\alpha} \ln 2 + C_{p,\beta} \ln\left(\frac{1}{2}\right) + 1$$

$$= \ln 2(C_{p,\alpha} - C_{p,\beta}) + 1$$
$$= \ln 2(-1) + 1$$
$$= -0.69 + 1 = 0.31 \text{ J/mole-K}$$

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

Ans. **300**

Sol.

$$\begin{array}{ccc} H_\alpha & \longrightarrow & H_\beta \\ (300\text{ K}) & & (300\text{ K}) \\ \Delta H_1 \downarrow & & \uparrow \Delta H_3 \\ H_\alpha & \xrightarrow{\Delta H_2} & H_\beta \\ (600\text{ K}) & & (600\text{ K}) \end{array}$$

$$\Delta H_1 = C_{p,\alpha}(300)$$

$$\Delta H_3 = -C_{p,\beta}(300)$$

$\Delta G_2 = \Delta H_2 - T\Delta S_2 = 0$ ($\because$ transition temperature is 600 K)

$$0 = \Delta H_2 - 600\,(1)$$

$$\Delta H_2 = (600)(1)\frac{J}{mol}$$

$$\Delta H_{total} = 300(C_{p,\alpha} - C_{p,\beta}) + 600$$
$$= 300(-1) + 600$$
$$= 300 \text{ J/mol}$$

"PARAGRAPH II"

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]

[Aromatic Compounds] (M)

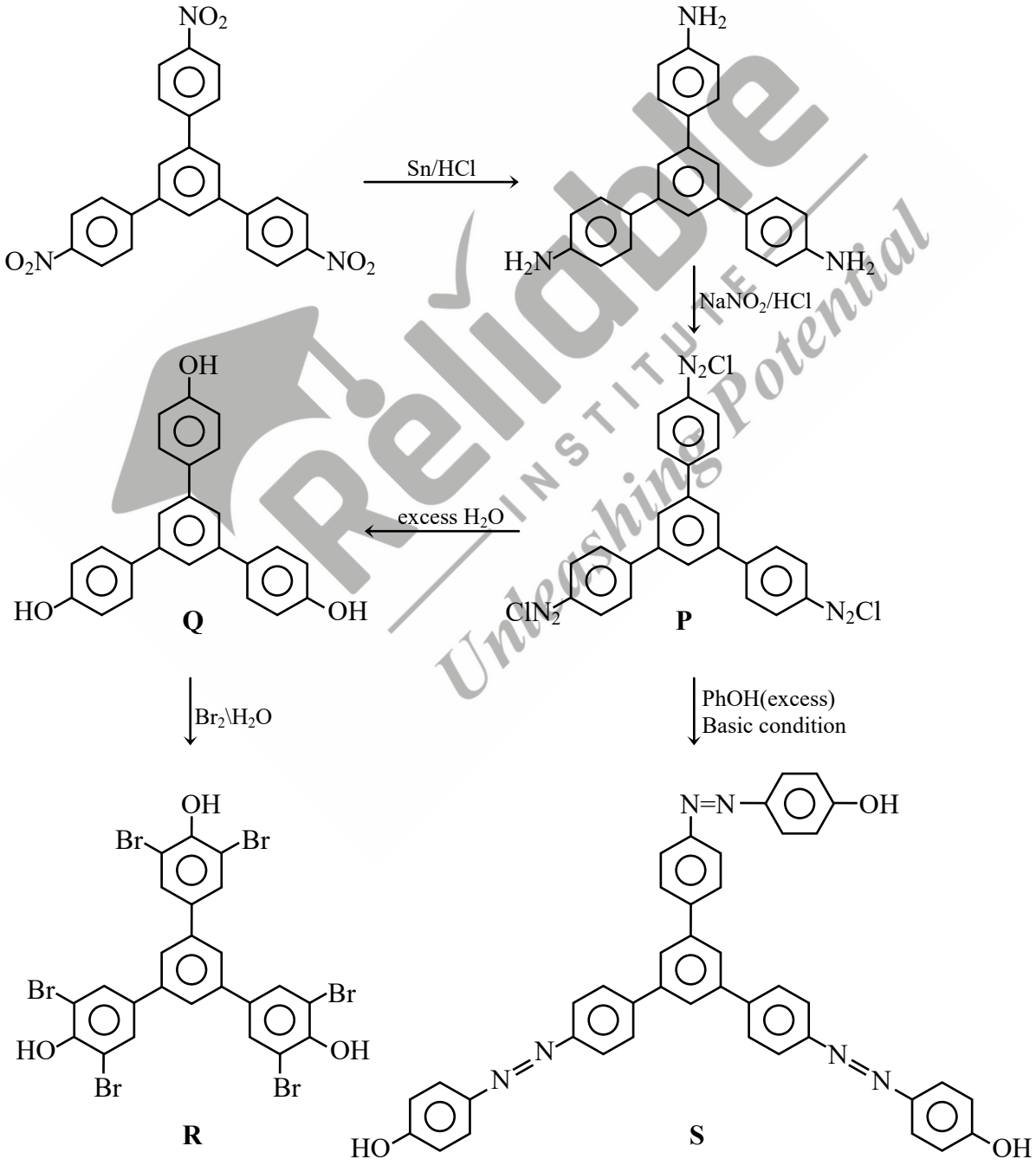
Ans. 9

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]

[Aromatic Compounds] (M)

Ans. 51

Sol. 16 & 17



Heteroatoms = 9 in **R**

Total number of C atoms and Heteroatoms present in **S** = 51

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