JEE Advanced (2023)

PAPER 1

Chemistry

General Instructions:

SECTION 1 (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 none of the options is chosen (i.e. the question is 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 +2 marks;

  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 (i.e. the question is unanswered) will get 0 marks; and

  choosing any other combination of options will get −2 marks.

Q. 1. The correct statement(s) related to processes involved in the extraction of metals is(are)

(A) Roasting of Malachite produces Cuprite.

(B) Calcination of Calamine produces Zincite.

(C) Copper pyrites is heated with silica in a reverberatory furnace to remove iron.

(D) Impure silver is treated with aqueous KCN in the presence of oxygen followed by reduction with zinc metal.

Q. 2. 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)

$$CH_3CH_2CH(CH_3)CH_2CN \xrightarrow[\text{(ii) PhMgBr, then } H_2O]{\text{(i) PhMgBr, then } H_3O^{\oplus}} \mathbf{P}$$

$$\text{Ph-H} + CH_3\overset{\overset{\displaystyle O}{\|}}{C}Cl \xrightarrow[\text{(ii) PhMgBr, then } H_2O]{\text{(i) anhyd.} AlCl_3} \mathbf{Q}$$

$$CH_3CH_2\overset{\overset{\displaystyle O}{\|}}{C}Cl \xrightarrow[\text{(ii) PhMgBr, then } H_2O]{\text{(i) } \frac{1}{2}(PhCH_2)_2Cd} \mathbf{R}$$

$$PhCH_2CHO \xrightarrow[\text{(iii) HCN, (iv) } H_2SO_4,\ \Delta]{\text{(i) PhMgBr, then } H_2O \text{, (ii) } CrO_3,\ \text{dil. } H_2SO_4} \mathbf{S}$$

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

(A) Both **P** and **Q** have asymmetric carbon(s).

(B) Both **Q** and **R** have asymmetric carbon(s).

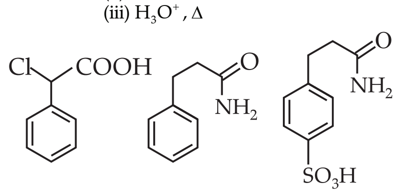
(C) Both **P** and **R** have asymmetric carbon(s).

(D) **P** has asymmetric carbon(s), **S** does **not** have any asymmetric carbon.

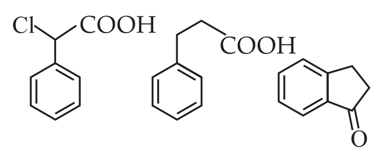
Q. 3. Consider the following reaction scheme and choose the correct option(s) for the major products Q, R and S.

$$\textbf{Styrene} \xrightarrow[\text{(ii) NaOH, } H_2O_2,\ H_2O]{\text{(i)} B_2H_6} \mathbf{P} \xrightarrow[\text{(ii) } Cl_2,\ \text{Red phosphorus, (iii) } H_2O]{\text{(i) } CrO_3,\ H_2SO_4} \mathbf{Q}$$

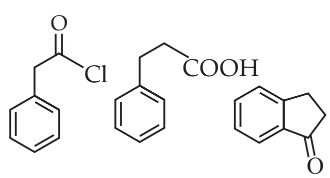
$$\mathbf{P} \xrightarrow[\text{(ii) NaCN, (iii) } H_3O^+,\ \Delta]{\text{(i) } SOCl_2} \mathbf{R} \xrightarrow{\text{conc. } H_2SO_4} \mathbf{S}$$



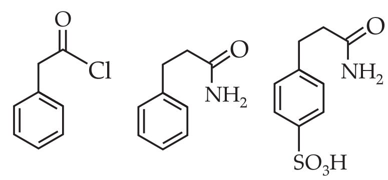
(A) Q R S



(B) Q R S



(C) Q R S



(D) Q R S

General Instructions:

SECTION 2 (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.

Q. 4. In the scheme given below, X and Y, respectively, are

$$\text{Metal } \textbf{halide} \xrightarrow{\text{aq. NaOH}} \text{White precipitate } (\mathbf{P}) + \text{Filtrate } (\mathbf{Q})$$

$$\mathbf{P} \xrightarrow[\text{heat}]{\text{aq. } H_2SO_4\text{, } PbO_2 \text{ (excess)}} \mathbf{X} \text{ (a coloured species in solution)}$$

$$\mathbf{Q} \xrightarrow[\text{warm}]{Mn(OH)_2\text{, Conc. } H_2SO_4} \mathbf{Y} \text{ (gives blue-coloration with KI-starch paper)}$$

(A) CrO_4^{2-} and Br_2 **(B)** MnO_4^{2-} and Cl_2

(C) MnO_4^- and Cl_2 (D) $MnSO_4$ and HOCl

Q. 5. Plotting $1/\Lambda_m$ against $c\Lambda_m$ for aqueous solutions of a monobasic weak acid (HX) resulted in a straight line with y-axis intercept of P and slope of S. The ratio P/S is

[Λ_m = molar conductivity

Λ_m° = limiting molar conductivity

c = molar concentration

K_a = dissociation constant of HX]

(A) $K_a \Lambda_m^\circ$ **(B)** $K_a \Lambda_m^\circ/2$

(C) $2 K_a \Lambda_m^\circ$ **(D)** $1/(K_a \Lambda_m^\circ)$

Q. 6. On decreasing the *p*H from 7 to 2, the solubility of a sparingly soluble salt (MX) of a weak acid (HX) increased from 10^{-4} mol L^{-1} to 10^{-3} mol L^{-1}. The pK_a of HX is

(A) 3 **(B)** 4

(C) 5 **(D)** 2

Q. 7. In the given reaction scheme, **P** is a phenyl alkyl ether, **Q** is an aromatic compound; **R** and **S** are the major products.

$$\mathbf{P} \xrightarrow{\text{HI}} \mathbf{Q} \xrightarrow[\text{(iii) } H_3O^+]{\text{(i) NaOH, (ii) } CO_2} \mathbf{R} \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } (CH_3CO)_2O} \mathbf{S}$$

The correct statement about S is

(A) It primarily inhibits noradrenaline degrading enzymes.

(B) It inhibits the synthesis of prostaglandin.

(C) It is a narcotic drug.

(D) It is ortho-acetylbenzoic acid.

***General Instructions*:**

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 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 : +4 If **ONLY** the correct integer is entered;

Zero Marks : 0 In all other cases.

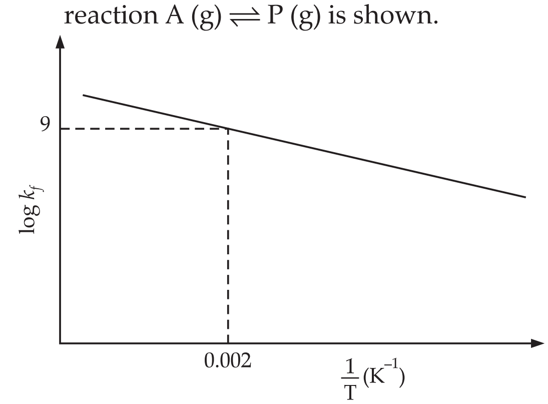
Q. 8. The stoichiometric reaction of 516 g of dimethyldichlorosilane with water results in a tetrameric cyclic product X in 75% yield. The weight (in g) of X obtained is ________.

[Use, molar mass (g mol^{-1}): H = 1, C = 12, O = 16, Si = 28, Cl = 35.5]

Q. 9. A gas has a compressibility factor of 0.5 and a molar volume of 0.4 $dm^3\ mol^{-1}$ at a temperature of 800 K and pressure *x* atm. If it shows ideal gas behaviour at the same temperature and pressure, the molar volume will be *y* $dm^3\ mol^{-1}$. The value of *x/y* is ___.

[Use: Gas constant, R = 8×10^{-2} L atm K^{-1} mol^{-1}]

Q. 10. The plot of log k_f versus 1/T for a reversible reaction A (g) $\rightleftharpoons$ P (g) is shown.



Pre-exponential factors for the forward and backward reactions are 10^{15} s^{-1} and

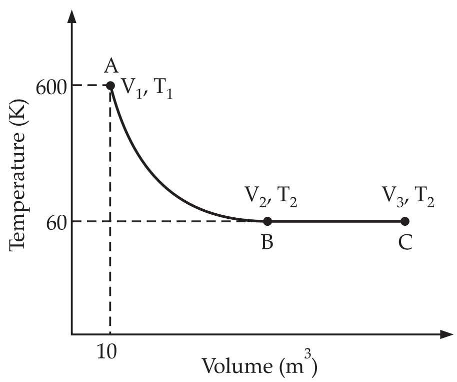
10^{11} s^{-1}, respectively. If the value of log K for the reaction at 500 K is 6, the value of $|\log k_b|$ at 250 K is ___.

[K = equilibrium constant of the reaction

k_f = rate constant of forward reaction

k_b = rate constant of backward reaction]

Q. 11. One mole of an ideal monoatomic gas undergoes two reversible processes (A → B and B → C) as shown in the given figure:

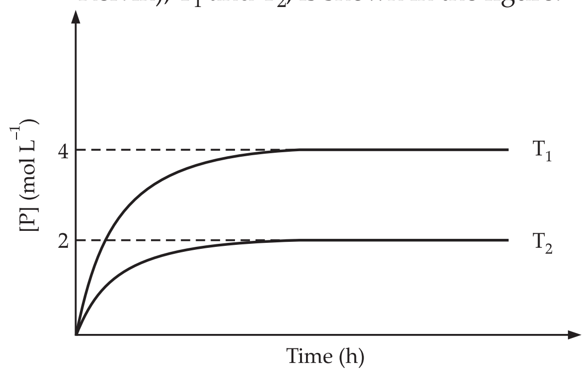


A → B is an adiabatic process. If the total heat absorbed in the entire process (A → B and B → C) is

$RT_2 \ln 10$, the value of $2 \log V_3$ is _______.

[Use, molar heat capacity of the gas at constant pressure, $C_{p,m} = \frac{5}{2}R$]

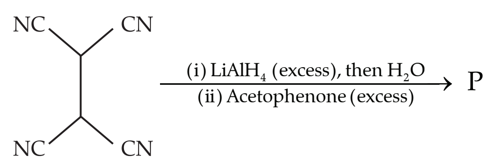
Q. 12. In a one-litre flask, 6 moles of A undergoes the reaction A (g) $\rightleftharpoons$ P (g). The progress of product formation at two temperatures (in Kelvin), T_1 and T_2, is shown in the figure:



If $T_1 = 2T_2$ and $(\Delta G_2^\ominus - \Delta G_1^\ominus) = RT_2 \ln x$, then the value of x is _______.

[$\Delta G_1^\ominus$ and $\Delta G_2^\ominus$ are standard Gibb's free energy change for the reaction at temperatures T_1 and T_2, respectively.]

Q. 13. The total number of sp^2 hybridised carbon atoms in the major product P (a non-heterocyclic compound) of the following reaction is _______.



General Instructions:

SECTION 4 (Maximum Marks: 12)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +3 **ONLY** if the option corresponding to the correct combination 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. 14. Match the reactions (in the given stoichiometry of the reactants) in List-I with one of their products given in List-II and choose the correct option.

List-I	List-II
(P) $P_2O_3 + 3H_2O \rightarrow$	(1) $P(O)(OCH_3)Cl_2$
(Q) $P_4 + 3NaOH + 3H_2O \rightarrow$	(2) H_3PO_3
(R) $PCl_5 + CH_3COOH \rightarrow$	(3) PH_3
(S) $H_3PO_2 + 2H_2O + 4AgNO_3 \rightarrow$	(4) $POCl_3$
	(5) H_3PO_4

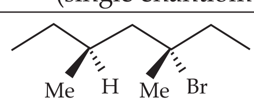
(A) $P \rightarrow 2; Q \rightarrow 3; R \rightarrow 1; S \rightarrow 5$
(B) $P \rightarrow 3; Q \rightarrow 5; R \rightarrow 4; S \rightarrow 2$
(C) $P \rightarrow 5; Q \rightarrow 2; R \rightarrow 1; S \rightarrow 3$
(D) $P \rightarrow 2; Q \rightarrow 3; R \rightarrow 4; S \rightarrow 5$

Q. 15. Match the electronic configurations in List-I with appropriate metal complex ions in List-II and choose the correct option.
[Atomic Number: Fe = 26, Mn = 25, Co = 27]

List-I	List-II
(P) $t_{2g}^6\ e_g^0$	(1) $[Fe(H_2O)_6]^{2+}$
(Q) $t_{2g}^3\ e_g^2$	(2) $[Mn(H_2O)_6]^{2+}$
(R) $e^2\ t_2^3$	(3) $[Co(NH_3)_6]^{3+}$
(S) $t_2^4\ e_g^2$	(4) $[FeCl_4]^-$
	(5) $[CoCl_4]^{2-}$

(A) $P \rightarrow 1; Q \rightarrow 4; R \rightarrow 2; S \rightarrow 3$
(B) $P \rightarrow 1; Q \rightarrow 2; R \rightarrow 4; S \rightarrow 5$
(C) $P \rightarrow 3; Q \rightarrow 2; R \rightarrow 5; S \rightarrow 1$
(D) $P \rightarrow 3; Q \rightarrow 2; R \rightarrow 4; S \rightarrow 1$

Q. 16. Match the reactions in List-I with the features of their products in List-II and choose the correct option.
[Atomic Number: Fe = 26, Mn = 25, Co = 27]

List-I	List-II
(P) (–)–1-Bromo-2-ethylpentane $\xrightarrow[S_N2\text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(1) Inversion of configuration
(Q) (–)–2-Bromopentane $\xrightarrow[S_N2\text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(2) Retention of configuration
(R) (–)–3-Bromo-3-methylhexane $\xrightarrow[S_N1\text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(3) Mixture of enantiomers
(S)  $\xrightarrow[S_N1\text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(4) Mixture of structural isomers
	(5) Mixture of diastereomers

(A) $P \rightarrow 1; Q \rightarrow 2; R \rightarrow 5; S \rightarrow 3$
(B) $P \rightarrow 2; Q \rightarrow 1; R \rightarrow 3; S \rightarrow 5$
(C) $P \rightarrow 1; Q \rightarrow 2; R \rightarrow 5; S \rightarrow 4$
(D) $P \rightarrow 2; Q \rightarrow 4; R \rightarrow 3; S \rightarrow 5$

Q. 17. The major products obtained from the reactions in List-II are the reactants for the named reactions mentioned in List-I. Match List-I with List-II and choose the correct option.

List-I	List-II
(P) Etard reaction	(1) Acetophenone $\xrightarrow{\text{Zn-Hg, HCl}}$
(Q) Gattermann reaction	(2) Toluene $\xrightarrow[\text{(ii) SOCl}_2]{\text{(i) KMnO}_4\text{, KOH, }\Delta}$
(R) Gattermann-Koch reaction	(3) Benzene $\xrightarrow[\text{anhyd. AlCl}_3]{\text{CH}_3\text{Cl}}$
(S) Rosenmund reduction	(4) Aniline $\xrightarrow[\text{273-278 K}]{\text{NaNO}_2\text{/HCl}}$
	(5) Phenol $\xrightarrow{\text{Zn, }\Delta}$

(A) P → 2; Q → 4; R → 1; S → 3
(B) P → 1; Q → 3; R → 5; S → 2
(C) P → 3; Q → 2; R → 1; S → 4
(D) P → 3; Q → 4; R → 5; S → 2

Answer Key

Q.No.	Answer key	Topic's name	Chapter's name
Section -I			
1	(B, C, D)	Extraction of Metal	General Principles and Processes of Isolation of Elements
2	(C, D)	Nucleophillic Reaction of Aldehyde And Ketone	Aldehyde Ketone and Carboxylic Acid
3	(B)	Oxidation of Alcohol	Alcohol Phenol Ether
Section -II			
4	(C)	Reaction of D Block	D Block And F Block
5	(A)	Limiting Molar Conductivity	Electrochemistry
6	(B)	pH	Ionic Equilibrium
7	(B)	Cleavage of Ether	Alcohol Phenol Ether
Section -III			
8	222	Limiting Reagent	Mole Concept
9	100	Compressibility Factor	States of Matter
10	5	Equilibrium Constant	Chemical Equilibrium
11	7	Adiabatic Process	Thermodynamics
12	8	Gibbs Free Energy	Thermodynamics
13	28	Reduction of Nitrile	Nitrogen Containing Compound
Section -IV			
14	(D)	Inorganic Reaction	P Block
15	(D)	Tetrahedral And Octahedral Complexes	Coordination Compound
16	(B)	Sn1 and Sn2	Alkyl Halide and Aryl Halide
17	(D)	Organic Name Reaction	Aldehyde Ketone and Carboxylic Acid

JEE Advanced (2023)

PAPER 1

ANSWERS WITH EXPLANATIONS

Chemistry

1. Correct options are (B, C and D).

(A) Roasting of malachite

$$CuCO_3\,Cu(OH)_2 \xrightarrow[+O_2]{\Delta} CuO + H_2O + CO_2$$

Roasting means that heating of substance in excess of oxygen. So cuprite Cu_2O is not produced. Hence, this statement is not correct.

(B) Calcination means heating in absence of air

$$\underset{\text{Calamine}}{ZnCO_3} \xrightarrow{\Delta} \underset{\text{Zincite}}{ZnO} + CO_2$$

$\therefore$ Statement is true.

(C) $CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + FeO + SO_2$

$$FeO + SiO_2 \longrightarrow FeSiO_2$$

$\therefore$ Statement is true.

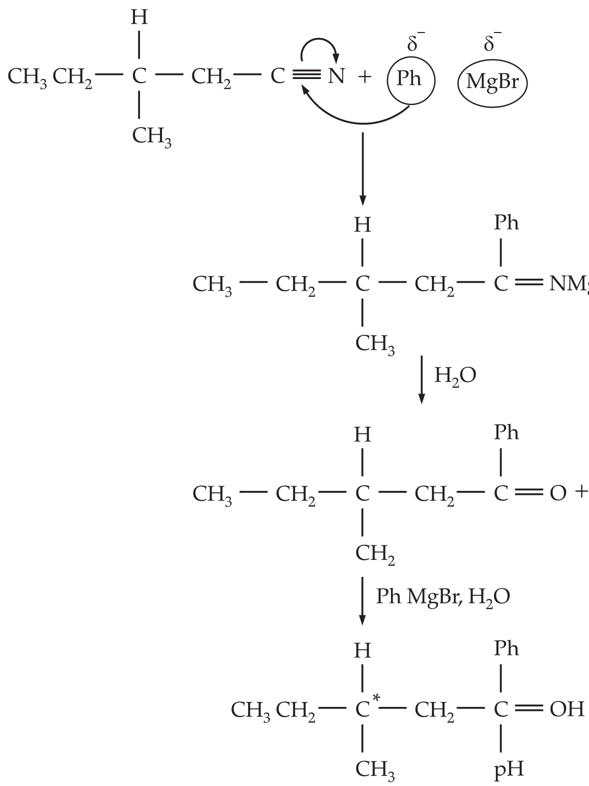
(D) $Ag + KCN + O_2 + 2H_2O \longrightarrow 4K\,[Ag(CN)_2] + 4KOH$

$$2K[Ag(CN)_2] + Zn \longrightarrow K_2\,[Zn(N)_4] + 2Ag$$

Silver is obtained by reaction with Zinc

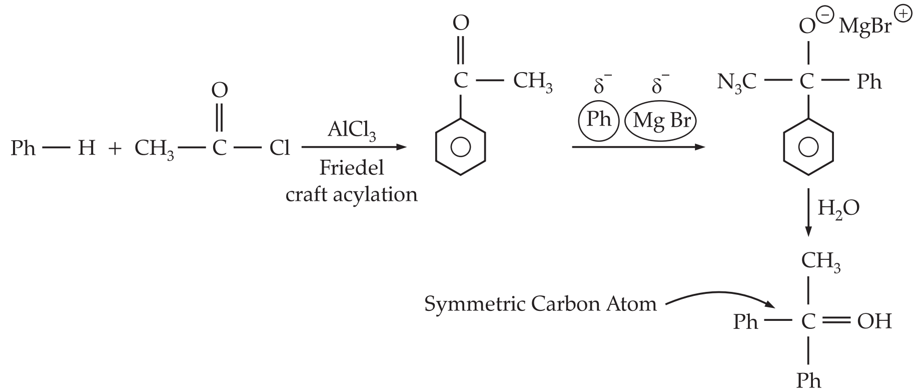
So, the above statement is true.

2. Correct options are (C and D).

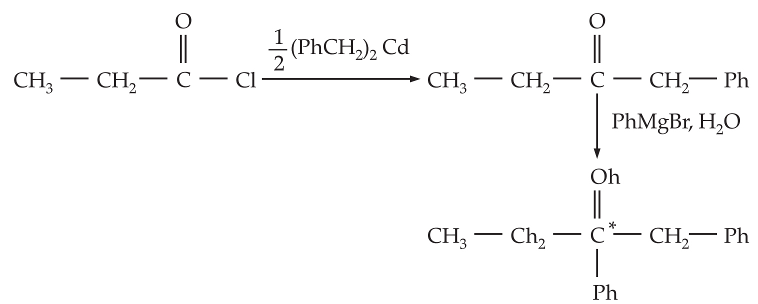


It has asymmetric carbon atom.

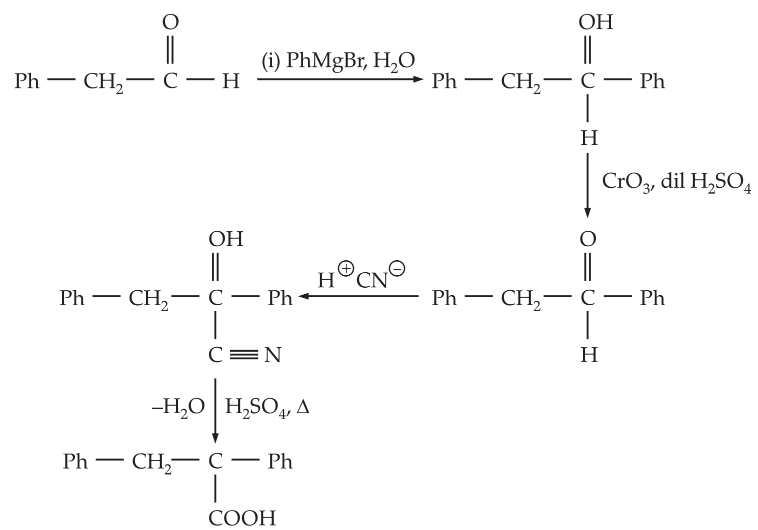
(P)



(Q)

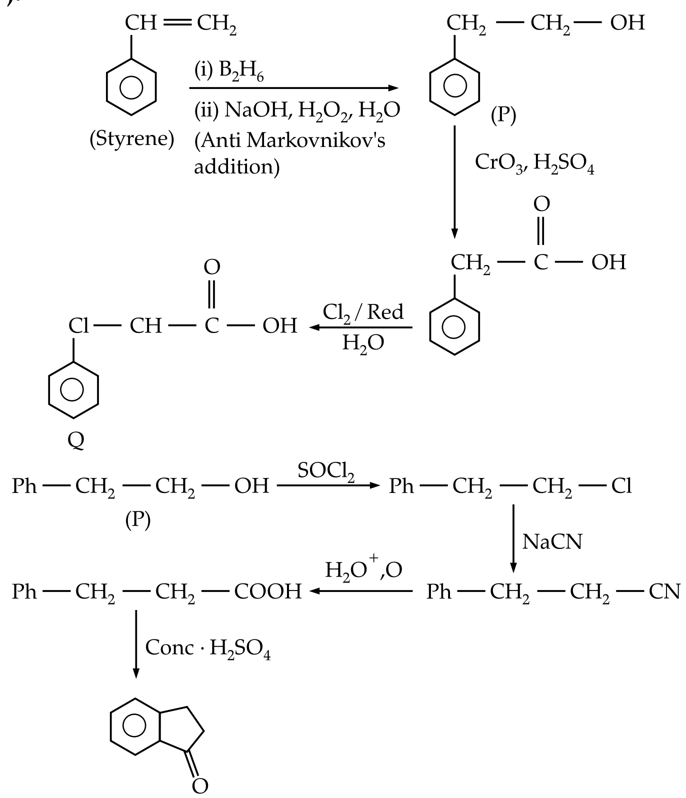


(R) have asymmetric carbon atom.



(S) does not have any asymmetric carbon atom.

3. Correct option is (B).



4. Correct option is (C).

$$MnCl_2 \xrightarrow{NaOH(aq)} \underset{(P)}{Mn(OH_2)} + \underset{(Q)}{NaCl}$$

$$Mn(OH)_2 \xrightarrow[PbO_2\,(excess)]{aq.\,H_2SO_4} \underset{(X)}{MnO_4^-} + Pb^{2+}$$

$$NaCl \xrightarrow[conc.\,H_2SO_4\ warm]{MnO(OH)_2} \underset{(Y)}{Cl_2}$$

5. Correct option is (A).

$$\alpha = \frac{\lambda_m^C}{\lambda_m^\infty} \quad ...(i)$$

$$K_a = \frac{C\alpha^2}{1-\alpha} = \frac{C\,(\lambda_m/\lambda_m^\infty)^2}{1-(\lambda_m/\lambda_m^\infty)}$$

$$1-\left(\frac{\lambda_m}{\lambda_m^\infty}\right)K_a = C\left(\frac{\lambda_m}{\lambda_m^\infty}\right)^2$$

$$\frac{1}{\lambda_m} - \frac{1}{\lambda_m^\infty} = \frac{C}{K_a}\cdot\frac{\lambda_m}{(\lambda_m^\infty)^2} \qquad \text{Here } \lambda_m^\infty = \lambda_m^0$$

$$\frac{1}{\lambda_m} = \frac{1}{\lambda_m^0} + \frac{1}{K_a(\lambda_m^0)^2}C\lambda_m$$

$$\begin{array}{ccccc} \uparrow & = & \uparrow & \uparrow & \uparrow \\ y & = & P & S & X \\ & & \text{Intercept} & \text{Slope} & \end{array}$$

$$\frac{P}{S} = \frac{1/(\lambda_m^0)}{1/[K_a(\lambda_m^0)^2]} = \frac{1}{\lambda_m^0}\times K_a(\lambda_m^0)^2 = K_a\lambda_m^0$$

6. Correct option is (B).

Relationship between solubility, H^+ and K_a is given by

$$S = \sqrt{\frac{(K_{SP}[H^+]+K_a)}{K_a}}$$

If $\quad pH = 7 \Rightarrow (H^+) = 10^{-7}$

$$S = 10^{-4} mol/L$$

$$\Rightarrow \quad 10^{-4} = \sqrt{\frac{K_{SP}(10^{-7}+K_a)}{K_a}} \quad ...(i)$$

$$10^{-3} = \sqrt{\frac{K_{SP}(10^{-2}+K_a)}{K_a}} \quad ...(ii)$$

Dividing and squaring equation (i) by equation (ii)

$$\frac{(10^{-4})^2}{(10^{-3})^2} = \frac{\cancel{K_{SP}}(10^{-7}+K_a)}{\cancel{K_a}} \times \frac{\cancel{K_a}}{\cancel{K_{SP}}(10^{-2}+K_a)}$$

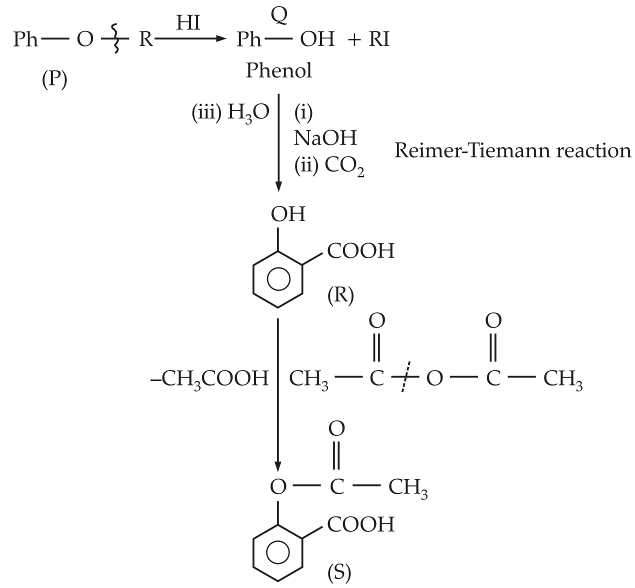
$$10^{-2} = \frac{10^{-7}+K_a}{10^{-2}+K_a}$$

$$10^{-4} + 10^{-2}.\,K_a = 10^{-7} + K_a$$

$$\therefore \quad K_a \simeq 10^{-4}$$

$$pK_a = 4$$

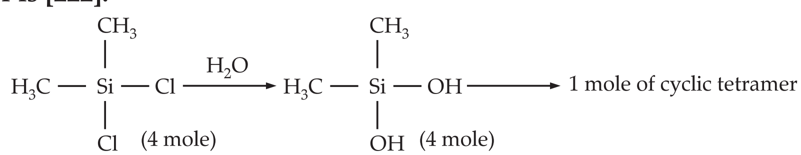
7. Correct option is (B).



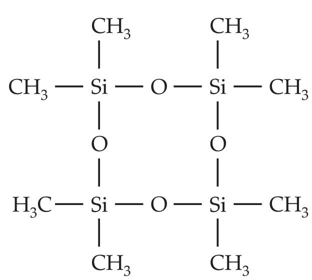
(Acetyl Salicylic Acid)

It inhibit synthesis of noradrenaline degrading enzymes.

8. Correct answer is [222].



No. of moles $= \dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{516}{129} = 4$



Cyclic tetramer
Molar Man = 296

$\therefore$ Percentage yield $= \dfrac{75}{100} = 0.75$

$\therefore$ Mole formed of cyclic tetramer = 0.75

$\therefore$ Weight = 0.75 × 296 = 222 g

9. Correct answer is [100].

If $z = 0.5$, $V_m = 0.4\ dm^3mol^{-1}$, T = 800 K,

P = x atm

$$Z = \frac{PV_m}{RT}$$

$$0.5 = \frac{x \times 0.4}{RT} \Rightarrow X = \frac{5RT}{4}$$

$\Rightarrow$ if $z = 1$

$$\Rightarrow PV_m = RT$$

$$80 \times y = RT$$

$$y = \frac{RT}{80}$$

$$\frac{x}{y} = \frac{5RT}{4} \times \frac{80}{RT}$$

$$\frac{x}{y} = 100$$

10. Correct answer is [5].

Given that log K = 6 (at 500 K)

$$K = \text{Antilog } (6)$$

$$\Rightarrow \quad K = \frac{K_f}{K_b} = 10^6$$

$$\therefore \quad K_f = 10^9, K_b = 10^3$$

$$\frac{1}{T} = 0.002, K_b = 10^3$$

$$\log K_b = \log A - \frac{E_{ab}}{2.303R}\left(\frac{1}{T}\right)$$

$$3 = 11 - \frac{E_{ab}}{2.303R}(0.002)$$

$$\frac{E_{ab}}{2.303R} = \frac{8}{0.002} = 4 \times 10^3$$

At 250 K

$$\log K_b = \log A_b - \frac{E_{ab}}{2.303R}\left(\frac{1}{T}\right)$$

$$\log K_b = 11 - 4 \times 10^{-3} (0.004)$$

$$= -5$$

$$|\log K_b| = 5$$

11. Correct answer is [7].

Since AB is Adiabatic process

$$\left(\frac{T_1}{T_2}\right) = \left(\frac{V_2}{V_1}\right)^{V-1}$$

$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$600(10)^{2/3} = 60(V_2)^{2/3}$$

$$(V_2)^{2/3} = (10)^{5/3}$$

$$V_2 = (10)^{5/2}$$

$$Q_{AB} = 0$$

$$Q_{AC} = nRT_2 \ln\left(\frac{V_3}{V_2}\right)$$

$$= RT_2 \ln\left(\frac{V_3}{V_2}\right) \quad \text{...(i)}$$

$$\text{Total heat absorbed} = RT_2 \ln\left(\frac{V_3}{V_2}\right)$$

$$= RT_2 \ln (10) \quad \text{...(ii)}$$

Equating equation (i) and equation (ii)

$$\cancel{RT_2} \ln\left(\frac{V_3}{V_2}\right) = \cancel{RT_2} \ln(10)$$

$$\ln\left(\frac{V_3}{V_2}\right) = \ln (10)$$

$$V_3 = 10 V_2$$

Substitute value of V_2

$$= 10(10)^{5/2} = (10)^{7/2}$$

$$V_3 = (10)^{7/2}$$

Taking log on both side, we get

$$\log (V_3) = \log (10)^{7/2}$$

$$\log (V_3) = \frac{7}{2} \log (10)$$

$$2 \log (V_3) = 7 \log (10)$$

$$\therefore \quad 2 \log (V_3) = 7$$

12. Correct answer is [8].

$$A (g) \rightleftharpoons P(g)$$

No. of moles $\quad 6 \quad\quad 0$

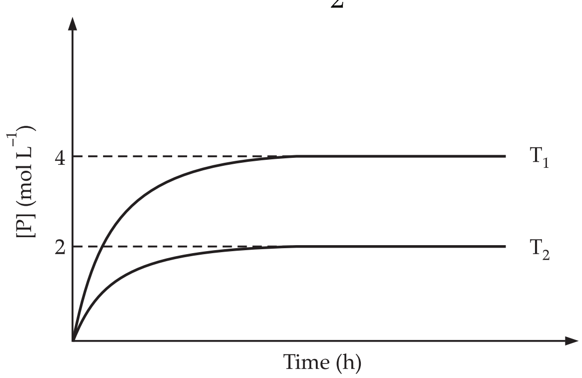
At temperature T_1

$$A (g) \rightleftharpoons P(g)$$

$$6 \quad\quad 0$$

$$6 - 4 = 2 \quad\quad 4$$

$$K \text{ (at temperature } T_1) = \frac{4}{2} = 2$$



At temperature T_2

$$A (g) \rightleftharpoons P(g)$$

$$6 \quad\quad 0$$

$$6 - 2 = 4 \quad\quad 2$$

$$K \text{ (at temperature } T_2) = \frac{2}{4} = \frac{1}{2}$$

Since $\quad \Delta G_1^0 = -RT_1 \ln KT_1 \quad \text{...(1)}$

$$\Delta G_2^0 = -RT_2 \ln KT_2 \quad \text{...(2)}$$

$$\Delta G_2^0 - \Delta G_1^0 = -RT_2 \ln KT_2 + RT_1 \ln KT_1$$

$$= -RT_2 \ln \frac{1}{2} + RT_1 \ln 2$$

$$= -RT_2 \ln \frac{1}{2} + R(2T_2) \ln 2$$

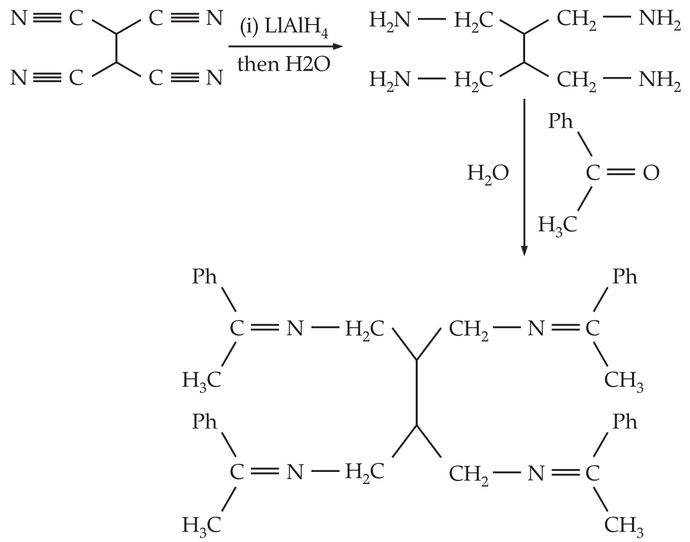
$$= RT_2 \ln 2 + 2RT_2 \ln 2$$

$$= RT_2 \ln 2 + 2RT_2 \ln 2$$

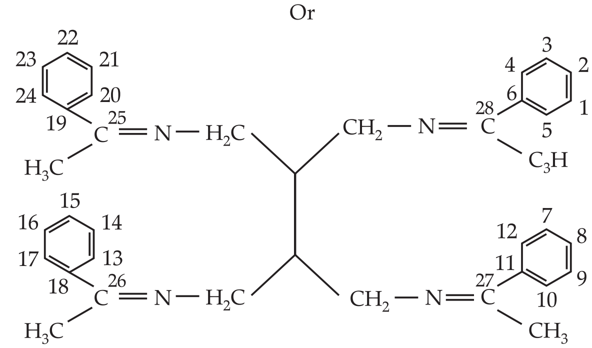
$$\Delta G_2^0 - \Delta G_1^0 = 3RT_2 \ln 2$$
$$= RT_2 (\ln 2^3)$$
$$= RT_2 \ln 8$$

$$\therefore \quad RT \ln x = RT_2 \ln 8$$
$$\therefore \quad x = 8$$

13. Correct answer is [28].



Or



14. Correct option is (D).

$P_2O_3 + 3H_2O \longrightarrow H_3PO_3 \quad P \longrightarrow 2$

$P_4 + 3NaOH + 3H_2O \longrightarrow PH_3 + NaH_2PO_2 \quad Q \to 3$

$PCl_5 + CH_3COOH \longrightarrow CH_3COCl + POCl_3 \quad R \to 4$

$H_3PO_2 + 2H_2O + ClAgNO_3 \longrightarrow H_3PO_4 + Ag + HNO_3 \quad S \to 5$

15. Correct option is (D).

1. $[Fe(H_2O)_6]^{2+}$

$Fe(26) \longrightarrow 3d^6 4s^2$

$Fe^{2+} \longrightarrow 3d^6$, H_2O is a weak field ligand.

So, the pairing does not take place.

↑	↑	e_g

↑↓	↑	↑

$t_{2g} \longrightarrow \quad t_{2g}^4 e_g^2$

$S \to 1$

2. $[Mn(H_2O)_6]^{2+}$

$Mn(25) \longrightarrow 3d^5 4s^2$

$Mn^{2+} \longrightarrow 3d^5$, H_2O is a weak field ligand.

So, there is no pairing.

↑	↑	e_g

↑	↑	↑

$t_{2g} \longrightarrow \quad t_{2g}^3 e_g^2$

$Q \to 2$

3. $[CO(NH_3)_6]^{3+}$

$CO^{3+} \longrightarrow [Ar]3d^6$

NH_3 is a strong field ligand.

So, the pairing takes place.

$t_{2g}^6 e_g^0$

$P \to 3$

$x - 1$

4. $[FeCl_4]^-$

$x + 4(-1) = -1$

$x = +3$

$Fe(26) \longrightarrow 3d^6 4s^2$

$Fe^{+3} \longrightarrow [Ar]3d^5$

$FeCl_4$ is tetrahedral complex.

↑	↑	↑

↑↓	↑

$e^3\, t_2^3$

$R \rightarrow 4$

5. $[COCl_4]^{2-}$

$CO \longrightarrow 3d^7 4s^2$

$CO^{2+} \longrightarrow 3d^7$

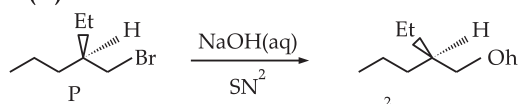
↑	↑	↑

↑↓	↑↓

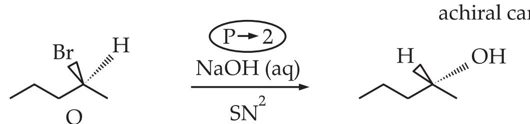
$e^4\, t_2^3$

$S \rightarrow 1$

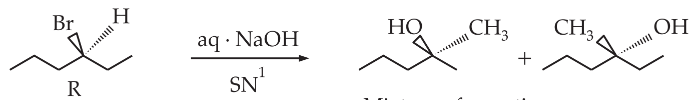
16. Correct option is (B).



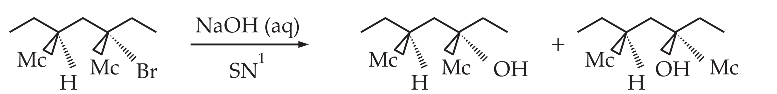
$SN^2 \longrightarrow$ Retention of configuration because Br is attached to achiral carbon



(Inversion of configuration)

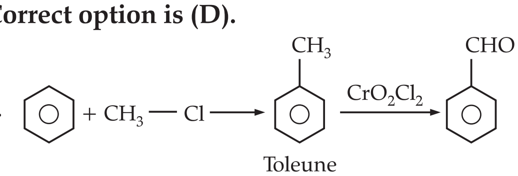


Mixture of enantiomers

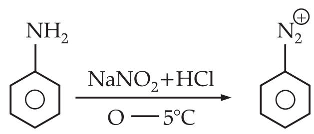


Mixture of diastereomers

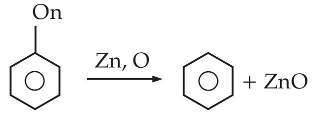
17. Correct option is (D).

1. 

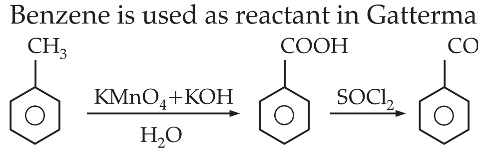
∴ Toleuence is used as reactant in Etard reaction.

2. 

Benzene diazonium salt is used as reactant in Gatterman's reaction

3. 

Benzene is used as reactant in Gatterman Koch reaction.

4. 

It is used as reactant in Rosenmund reaction.

JEE Advanced (2023)

PAPER 2

Chemistry

General Instructions:

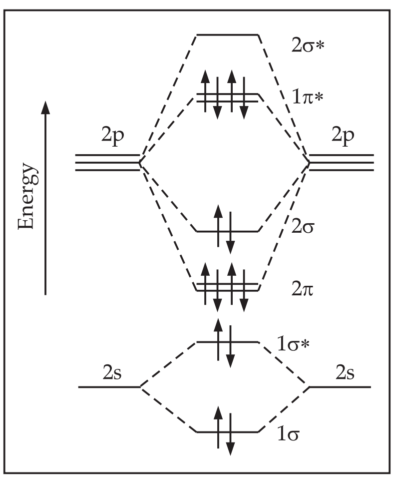
SECTION 1 (Maximum Marks: 12)

- 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:

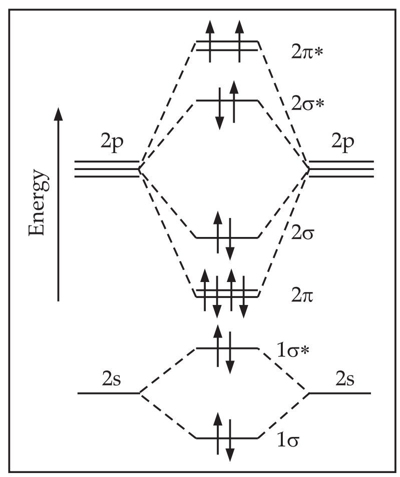
Full Marks	:	+3 If **ONLY** the correct option is chosen;
Zero Marks	:	0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	:	−1 In all other cases.

Q. 1. The correct molecular orbital diagram for F2 molecule in the ground state is

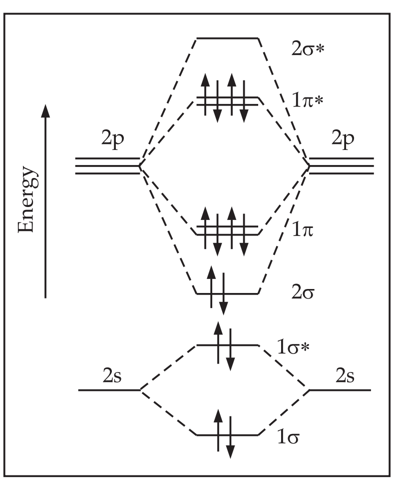
(A)



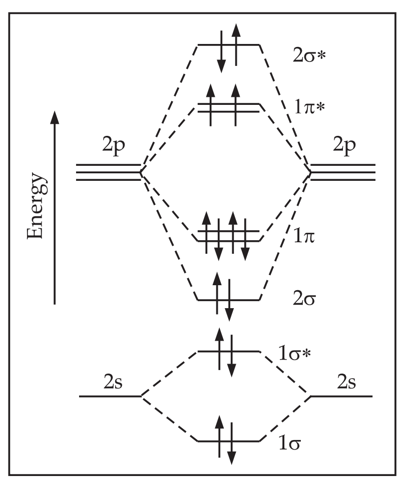
(B)



(C)



(D)



Q. 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.

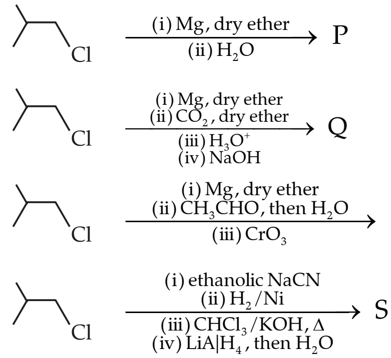
(IV) Tyndall effect can be observed from a colloidal solution with dispersed phase having the same refractive index as that of the dispersion medium.

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)

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



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

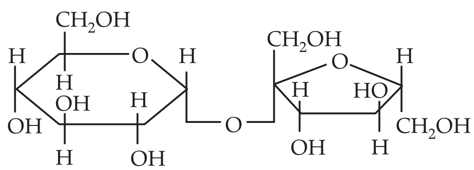
(A) P is a primary alcohol with four carbons.

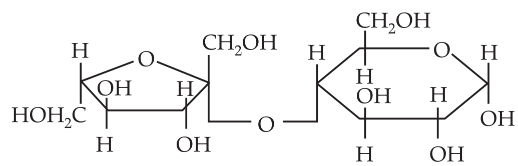
(B) Q undergoes Kolbe's electrolysis to give an eight-carbon product.

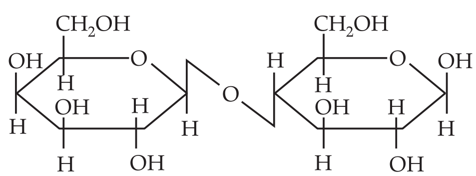
(C) R has six carbons and it undergoes Cannizzaro reaction.

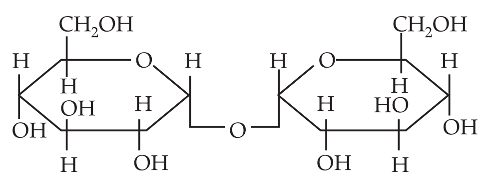
(D) S is a primary amine with six carbons.

Q. 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) 

***General Instructions*:**

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 +2 marks;
  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.

Q. 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) $[Cr(en)_2(H_2O)(SO_4)]^+$

Q. 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.]

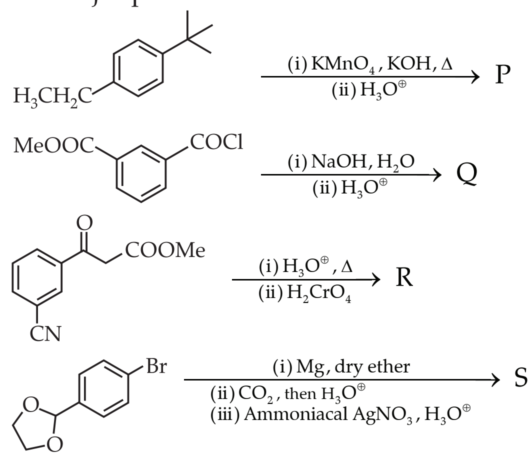
(A) Packing efficiency of unit cell of $x>$ Packing efficiency of unit cell of $y>$ Packing efficiency of unit cell of z

(B) $L_y > L_z$

(C) $L_x > L_y$

(D) Density of x > Density of y

Q. 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.

General Instructions:

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 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 : +4 If **ONLY** the correct integer is entered;

Zero Marks : 0 In all other cases.

Q. 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 ____.

Q. 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 ______.

Q. 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____.

Q. 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}]

Q. 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, $\Delta_{mix}H = 0$, $\Delta_{mix}V = 0$]

Q. 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]

General Instructions:

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:

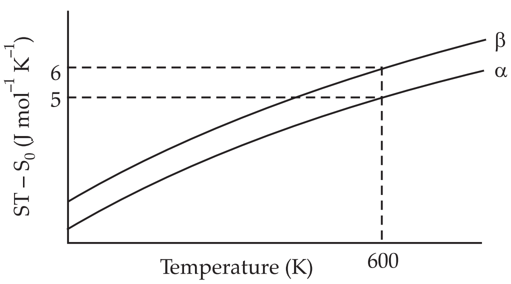
Full Marks : +3 If ONLY the correct numerical value is entered in the designated place;

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.

Q. 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]

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

"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}.

Q. 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]

Q. 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]

Answer Key

Q.No.	Answer key	Topic's name	Chapter's name
Section -I			
1.	(C)	Molecular Orbital Theory	Chemical Bonding And Molecular Structure
2.	(A)	Colloids	Surface Chemistry
3.	(B)	Grignard Reagent	Haloalkanes and Haloarenes
4.	(A)	Carbohydrates	Biomolecules
Section -II			
5.	(C, D)	Isomerism	Coordination Compounds
6.	(A, B and D)	Packing efficiency And Density	Solid State
7.	(C, D)	Preparation of Carboxylic Acids	Organic Chemistry
Section -III			
8.	18	Reaction of $KMnO_4$	D and F Block Element
9.	5	VSEPR Theory	Chemical Bonding And Molecular Structure
10.	6	Oxidation State	Redox Reactions
11.	30	Wavelength on Transition	Structure Of Atom
12.	682	Osmotic Pressure	Solutions
13.	1791	More Concepts and Chemical Properties of alkenes	Organic chemistry
Section -IV			
14.	0.31	Enthalpy Change	Thermodynamics
15.	300	Kirchhoff s law	Thermodynamics
16.	9	Chemical Reactions	Organic Compounds With Nitrogen
17.	51	Chemical Reactions	Organic Compounds With Nitrogen

JEE Advanced (2023) PAPER 2

ANSWERS WITH EXPLANATIONS

Chemistry

1. Correct option is (C).

Molecular orbital electronic configuration of F_2 molecule is

$$F_2 = KK\sigma(2S)^2, \sigma^*(2S)^2, \sigma(2p_2)^2, \pi(2p_x)^2$$

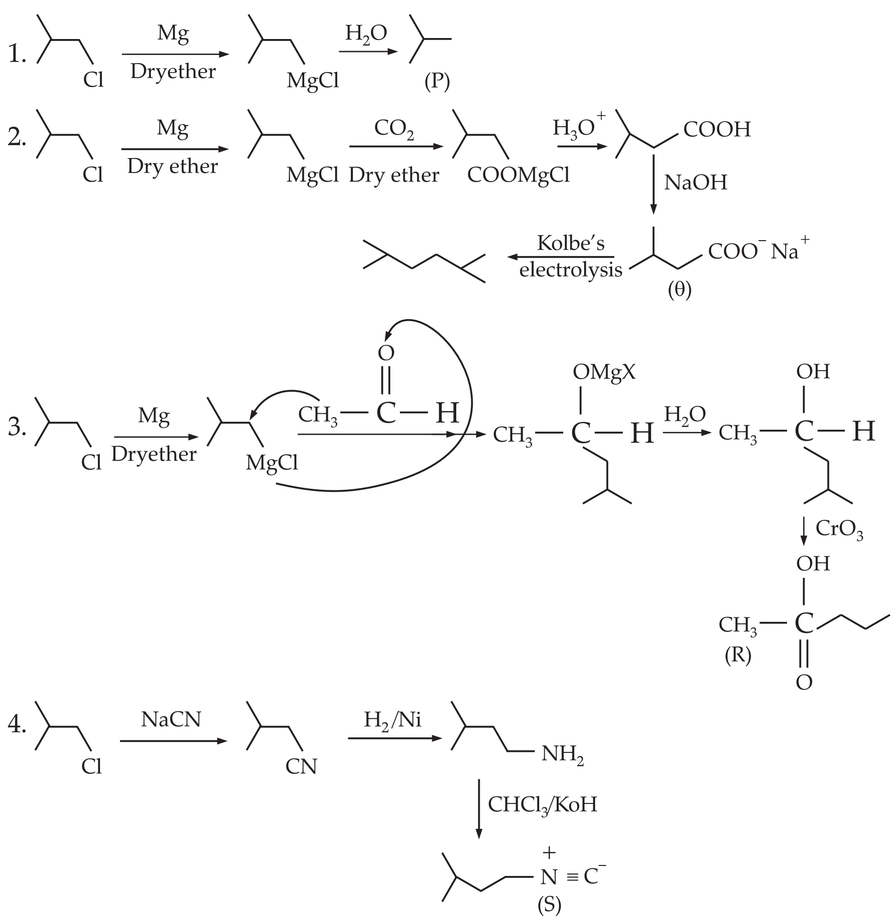
$$= (\pi 2p_y)^2, \pi^*(2p_x)^2 = \pi^*(2p_y)^2$$

2. Correct option is (A).

(I) Lyophobic colloids are not formed by simple mixing of dispersed phase and dispersion medium.

(II) For emulsion, both the dispersed phase and dispersion medium are liquid.

3. Correct option is (B).



4. Correct option is (A).

Option (A) is sucrose which is formed by condensation of glucose and fructose.

- Fructose cannot be oxidised by bromine water. Therefore, sucrose cannot be oxidised by bromine water.

$$\underset{\substack{\text{Sucrose}\\ [\alpha]_D = +66.5^\circ}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underbrace{\underset{\substack{\text{D-glucose}\\ [\alpha]_D = +53^\circ}}{C_6H_{12}O_6} + \underset{\substack{\text{D-fructose}\\ [\alpha]_D = -92^\circ}}{C_6H_{12}O_6}}_{[\alpha]_D = +53^\circ + (-92^\circ) = -39^\circ C}$$

$\therefore$ Resulting mixture is laevorstatory.

5. Correct options are (C and D).

- $[Pt(NH_3)_2Br_2]$ exhibits cis-trans (Geometric) isomers
- (D) $[M(AA)_2ab]$ and (C) $[Ma_2\ b_4]$ can exhibit geometric isomers

6. Correct options are (A, B and D).

Packing efficiency

$$\text{P.E. for FCC} = \frac{4 \times \frac{4}{3}\pi r_x^3}{(L_x)^3} = \frac{4 \times \frac{4}{3}\pi r_x^3}{(4r_x/\sqrt{2})^3}$$

$$\text{BCC, P.E.} = \frac{2 \times \frac{4}{3}\pi r_y^3}{(L_y)^3} = \frac{2 \times \frac{4}{3}\pi r_y^3}{(4r_y/\sqrt{3})^3}$$

$$\text{SC, P.E.} = \frac{1 \times \frac{4}{3}\pi r_z^3}{(L_z)^3} = \frac{1 \times \frac{4}{3}\pi r_z^3}{(2r_z)^3}$$

P.E. FCC : BCC : SC

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

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

$$8\sqrt{2} : 6\sqrt{3} : 8$$

11.3 : 10.39 : 8

$\therefore$ $(\text{P.E.})_x > (\text{P.E.})_y > (\text{P.E.})_z$

So, the option (A) is correct.

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

$$L_x < L_y$$

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

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

$$\therefore \quad \frac{L_y}{L_z} = \frac{2r_y}{r_2\sqrt{3}} = \frac{2}{\sqrt{3}} \times \frac{r_y}{r_2} = \frac{3}{\sqrt{3}} = \frac{1}{1}$$

$$\therefore \quad \frac{L_y}{L_z} = \frac{2}{\sqrt{3}} \times \frac{3}{\sqrt{3}} = \frac{4}{3}$$

$$L_y = \frac{4}{3} L_z$$

$$\therefore \quad L_y > L_z$$

$$(\text{Density})_x = d_x = \frac{4M_x}{N_A (L_x)^3}$$

$$d_y = \frac{2M_y}{N_A (L_y)^3}$$

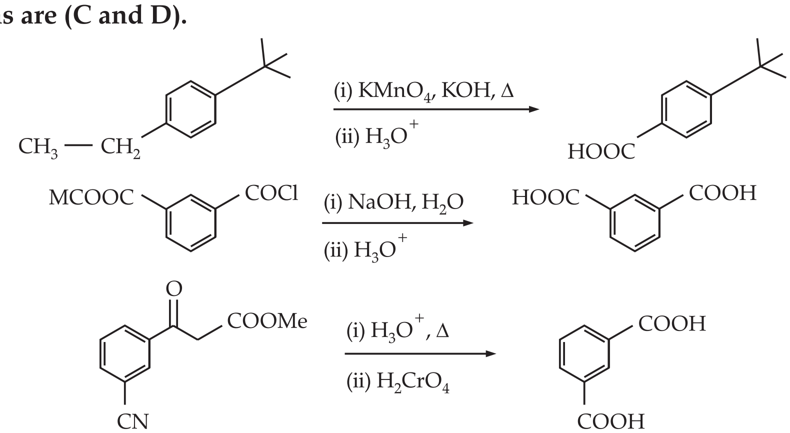
$$\frac{d_x}{d_y} = \frac{2M_x}{M_y} \cdot \left(\frac{L_y}{L_x}\right)^3$$

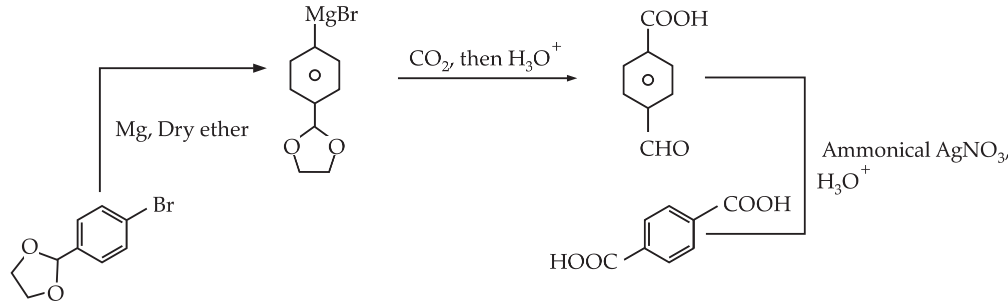
$$= 2 \times \frac{1}{2} \times \left(\frac{8\sqrt{2}}{3}\right)^3$$

So $d_x > d_y$

So, the options (B and D) are correct.

7. Correct options are (C and D).





8. Correct answer is [18].

$2KMnO_4 + 3H_2SO_4 + 5H_2S \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5\,S$

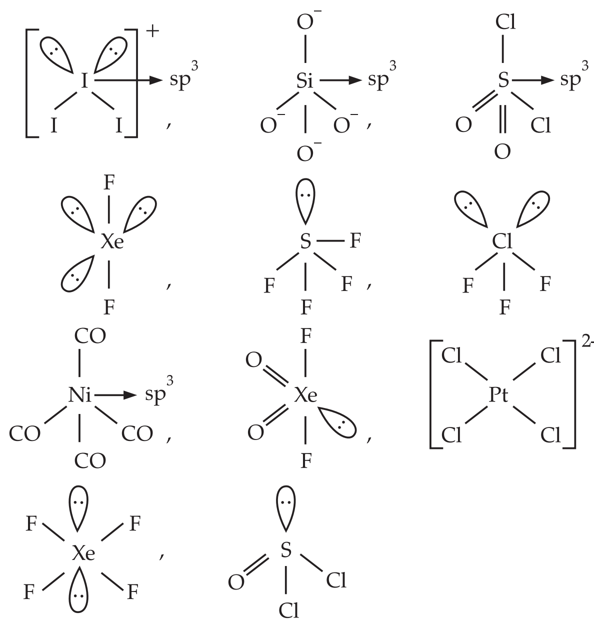
No. of moles of water produced, $x = 8$

No. of moles of electrons involved, $y = 10$

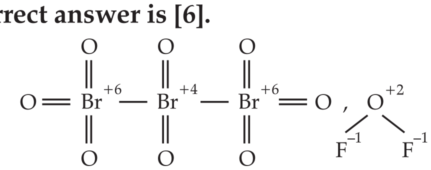
$$x + y = 8 + 10 = 18$$

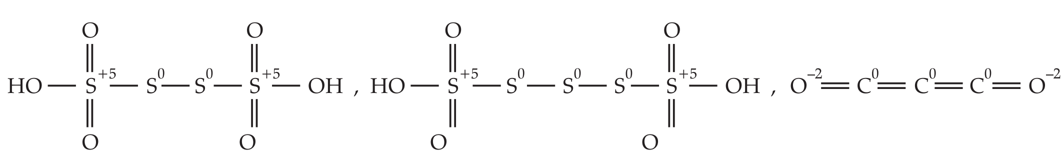
9. Correct answer is [5].

$[I_3]^+$, $[SiO_4]^{4-}$, SO_2Cl_2, $Ni(CO)_4$, $SOCl_2$



10. Correct answer is [6].





2 Sulphur 2 Sulphur 1 Carbon

11. Correct answer is [30].

$(\text{Radius})_2 = 105.8 \text{ pm} = 1.058 \text{ Å}$

$(\text{Radius})_1 = 26.45 \text{ pm} = 0.2645 \text{ Å}$

for He Z = 2

The radius of nth orbit of He^+ is given by $\frac{0.529n^2}{z}$ Å

$$\therefore \quad \frac{0.529 \times n_2^2}{2} = 1.058$$

On solving $n_2 = 2$

$$\frac{0.529 \times 4n_1^2}{2} = 0.2645$$

On solving $n_1 = 1$

Now, use the Rydberg formula

$$\bar{\upsilon} = R_H^{+2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \times Z^2$$

$$\therefore \quad \bar{\upsilon} = 2.2 \times 10^{-18} \times 4 \times \left(\frac{1}{(1)^2} - \frac{1}{(2)^2}\right)$$

Using $\bar{\upsilon} = \frac{1}{\lambda} \Rightarrow \lambda = \frac{1}{\bar{\upsilon}}$

$$\therefore \quad \lambda = \frac{1}{2.2 \times 10^{-18} \times 4 \times \left(\frac{1}{1} - \frac{1}{4}\right)}$$

On solving

$$\lambda = 304 \text{ Å} = 30.4 \text{ nm}$$
$$\simeq 30 \text{ nm}$$

12. Correct answer is [682].

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$\therefore$ mass = density × volume

= 1.012 × 50

= 50.6 g

Let x g urea is mixed in solution

$\therefore$ x g of urea + $(50.6 - x)$ g H_2O = 50.6 g

$$\text{Molality} = 0.2 = \frac{\frac{x}{60}}{\frac{50.6 - x}{1000}}$$

$\therefore$ x = 0.6 g urea

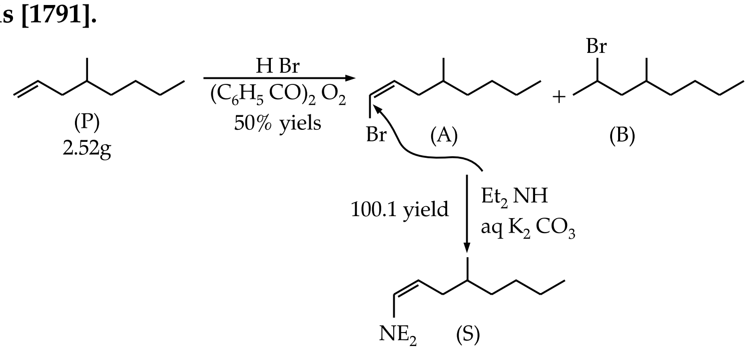
= 0.01 mol urea

Other solution has 0.06 g urea = 0.001 mil urea

$$\pi_{\text{resulting}} = \frac{(0.01 + 0.001)}{0.3} \times 62 \times 300$$

$$= \frac{0.011 \times 62 \times 300}{0.3} = 682 \text{ torr}$$

13. Correct answer is [1791].



$$\text{Moles of P} = \frac{2.52}{126} = 0.02$$

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

Moles of A = 0.009 and moles of B = 0.001

Moles of S = 0.009

Molecules mass of S = 199

So, Mass obtained of S = 199 × 0.009 = 1.791 g

1.791 × 1000 = 1791 mg

14. Correct answer is [0.31].

Enthalpy changes

$$\Delta S = \Delta S_{600K} - \Delta S_{300K}$$
$$= (S_\beta - S_\alpha)_{600K} - (S_\beta - S_\alpha)_{300K}$$
$$\Delta S = (6-5) - \Delta S_{300}$$
$$\Delta S = 1 - \Delta S_{300} \quad ...(1)$$

Now, $\Delta S = \Delta CP_m \ln \frac{T_2}{T_1}$

$$= (C_{P.B.} - C_{P,\alpha}) \ln \frac{T_2}{T_1}$$
$$= (1) \ln \frac{600}{300}$$

Given $C_{P,\beta} - C_{P,\alpha} = 1\ J\ mol^{-1}\ K^{-}$

$$\Delta S = \ln 2 = 0.69 \quad ...(2)$$

Equate equation (1) and (2), we get

$$1 - \Delta S_{300} = 0.69$$
$$\Delta S_{300} = 1 - 0.69 = 0.31\ J/mol.$$

15. Correct answer is [300].

Using Kirchhoff's law

$$\frac{\Delta H_{T_2} - \Delta H_{T_1}}{T_2 - T_1} = \Delta C_P$$

$$\frac{\Delta H_{600} - \Delta H_{300}}{600 - 300} = 1 \qquad \text{Given } \Delta C_P = 1\ J/mol/K$$

$$\Delta H_{600} - \Delta H_{300} = 300 \quad ...(1)$$

Now, at 600 K

$$\Delta G = 0$$
$$\therefore \quad \Delta H - T\Delta S = 0$$
$$\Delta H_{600} = T\Delta S_{600} \qquad \Delta S_{600} = 1$$

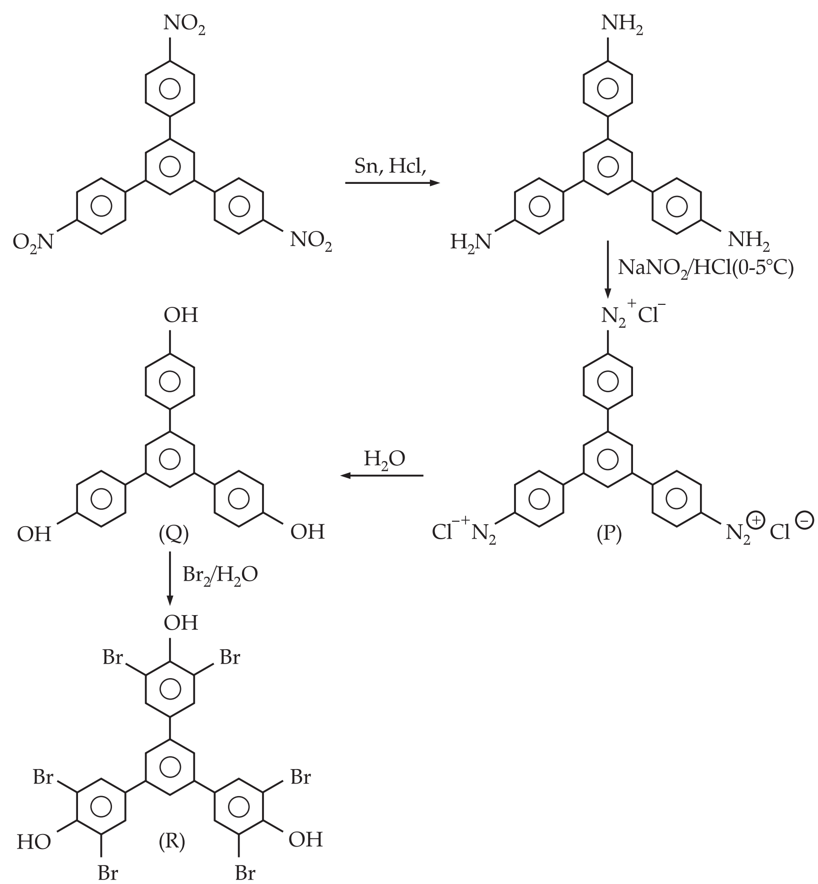
(Solved in previous question)

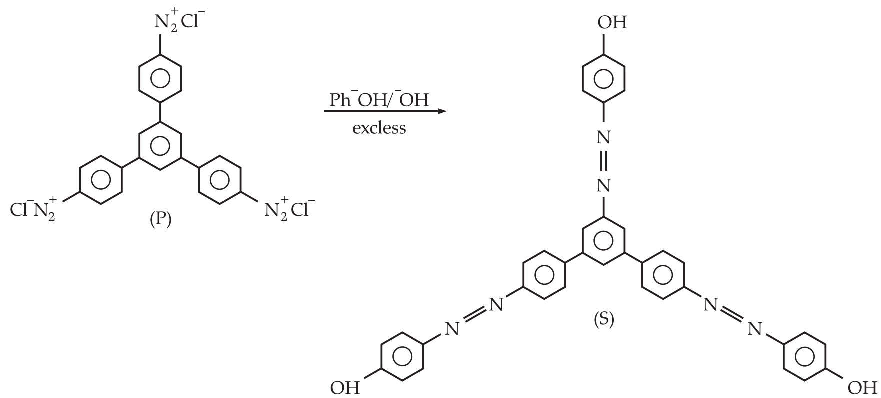
$$\therefore \quad \Delta H_{600} = 600 \times 1$$
$$\therefore \quad \Delta H_{600} = 600\ J/mol. \quad ...(2)$$

Put value of equation (2) in equation (1), we get

$$600 - \Delta H_{300} = 300$$
$$\Delta H_{300} = 300\ J/mol.$$

16. Correct answer is [9].





17. Correct answer is [51].