JEE Adv. October 2021

Question Paper With Text Solution

03 October. | Paper-1

CHEMISTRY

MATRIX

JEE Main & Advanced | XI-XII Foundation| VI-X Pre-Foundation

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JEE ADV. OCTOBER 2021 | 03 OCTOBER PAPER-1

SECTION – A

- 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.

1. The major product formed in the following reaction is

(A) 

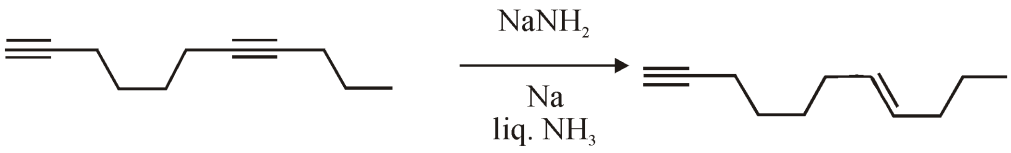
(B) 

(C) 

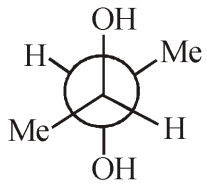
(D) 

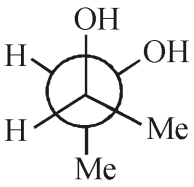
Ans. (B)

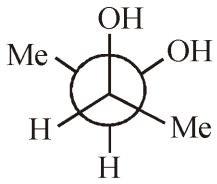
Sol. It is birch reduction and trans alkene will form. Terminal alkyne will give acid–base reaction with $NaNH_2$.

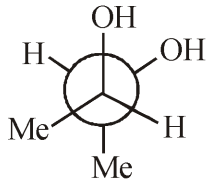


2. Among the following, the conformation that corresponds to the most stable conformation of meso-butane-2,3-diol is

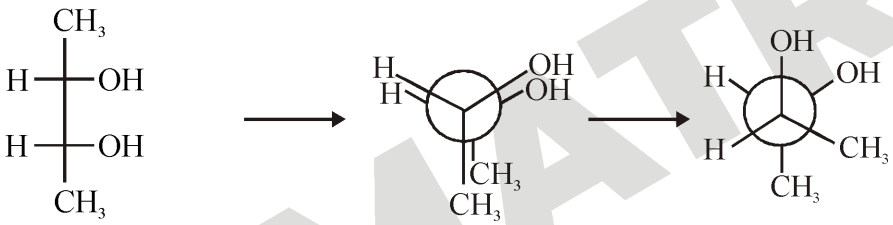
(A) 

(B) 

(C) 

(D) 

Ans. (B)

Sol. 

meso-butane-2,3-diol (Eclipsed form)

Gauche form is more stable due to intramolecular H–bonding

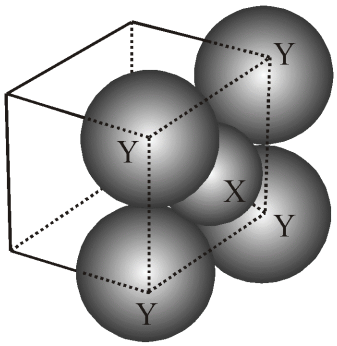
A → Anti form

B → Gauche form

C → is not meso

D → is not meso

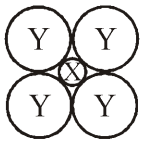
3. For the given close packed structure of a salt made of cation **X** and anion **Y** shown below (ions of only one face are shown for clarity), the packing fraction is approximately (packing fraction = $\frac{\text{packing efficiency}}{100}$)



(A) 0.74 (B) 0.63 (C) 0.52 (D) 0.48

Ans. (B)

Sol.



Let Radius of Y = R

Radius of X = r

In ΔABC

$$\cos 45° = \frac{2R}{2(r+R)}$$

$$\frac{R}{r+R} = \frac{1}{\sqrt{2}}$$

$$\frac{r}{R} = \sqrt{2} - 1$$

Number of 'Y' in one unit cell $= 8\times\frac{1}{8}=1$

Number of 'X' in one unit cell $= 6\times\frac{1}{2}=3$

Packing fraction $= \dfrac{1\times\frac{4}{3}\pi R^3+3\times\frac{4}{3}\pi r^3}{a^3}$

$$=\frac{\frac{4}{3}\pi\left[3r^3+R^3\right]}{a^3}$$

$$=\frac{\frac{4}{3}\pi\left[1+3\left(\frac{r}{R}\right)^3\right]R^3}{(2R)^3}$$

$$=\frac{\pi}{6}\left[1+3\left(\sqrt{2}-1\right)^3\right]$$

$= 0.634$

4. The calculated spin only magnetic moments of $[Cr(NH_3)_6]^{3+}$ and $[CuF_6]^{3-}$ in BM, respectively, are

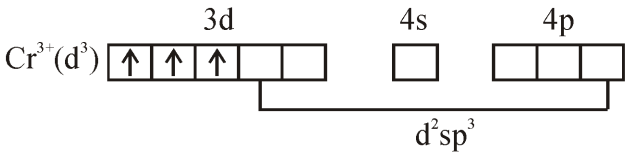
(Atomic numbers of Cr and Cu are 24 and 29, respectively)

(A) 3.87 and 2.84 (B) 4.90 and 1.73

(C) 3.87 and 1.73 (D) 4.90 and 2.84

Ans. (A)

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

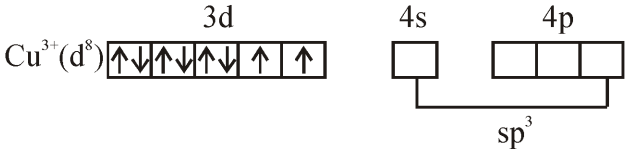


$n = 3$

$\mu = \sqrt{n(n+2)}$ B.M.

$\mu = 3.87$ B.M.

$[CuF_6]^{3-}$



$n = 2$

$\mu = 2.84$ B.M.

SECTION B

- This section contains THREE (03) question stems.
- There are TWO (02) questions corresponding to each question stem.
- The answer to each question is a NUMERICAL VALUE.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse and the on-screen virtual numeric keypad.
- 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:

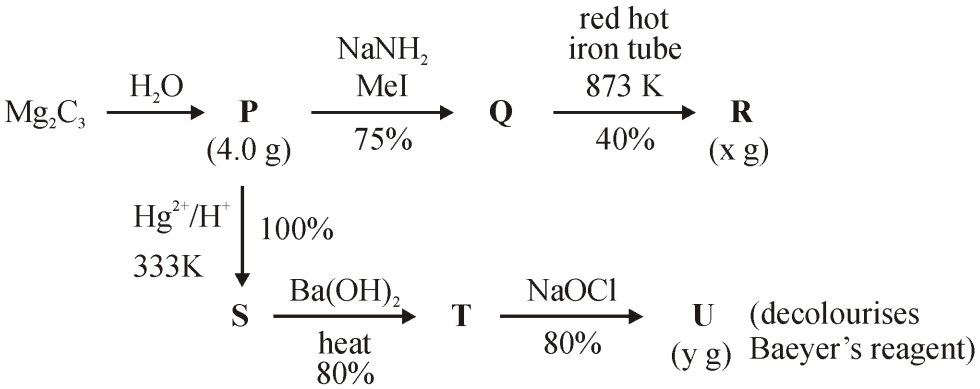
Full Marks : +2 If ONLY the correct numerical value is entered at the designated place;

Zero Marks : 0 In all other cases.

Question Stem for Question Nos. 5 and 6

Question Stem

For the following reaction scheme, percentage yields are given along the arrow:



x g and **y** g are mass of **R** and **U**, respectively.

(Use: Molar mass (in g mol^{-1}) of H, C and O as 1, 12 and 16, respectively)

5. The value of **x** is _____.

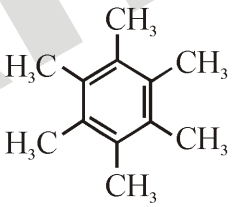
Ans. 1.62

Sol. $Mg_2C_3 + H_2O \longrightarrow Mg(OH)_2 + CH_3 - C \equiv CH$

(P)

$$\underset{\text{4 gm}}{CH_3 - C \equiv CH} \xrightarrow[\substack{CH_3-I \\ 75\%}]{NaNH_2} CH_3 - C \equiv \overset{\ominus}{C} \xrightarrow[S_{N}2]{CH_3 - I} \underset{\text{(Q)}}{CH_3 - C \equiv C - CH_3}$$

(Q) → (R): 40%, red hot iron tube, 873 K



(R)

Moles of $CH_3 - C \equiv CH = \frac{4}{40} = 0.1$

Moles of $CH_3 - C \equiv C - CH_3$ formed $= 0.1 \times 0.75 = 0.075$

Moles of R formed $= \frac{0.075 \times 0.4}{3} = 0.01$

Mass of R formed $= 0.01 \times 162 = 1.62$ gm

6. The value of **y** is _____.

Ans. 3.2

$$CH_3-C\equiv CH \xrightarrow[333\ K,\ 100\ \%]{Hg^{2+}/H^+} CH_3-\underset{\underset{O}{\|}}{C}-CH_3 \xrightarrow[Heat,\ 80\ \%]{Ba(OH)_2}$$

(P) (S)

$$CH_3-\underset{\underset{O}{\|}}{\overset{\overset{CH_3}{|}}{C}}=CH-CH_3 \xrightarrow[80\ \%]{NaOCl} CH_3-\underset{\underset{O}{\|}}{\overset{\overset{CH_3}{|}}{C}}=CH-OH + CHCl_3$$

(T) (U)

moles of P = 0.1

moles of S formed = 0.1

moles of T formed = $\frac{0.1}{2}\times 0.8 = 0.04$

moles of U formed = $0.04 \times 0.8 = 0.032$

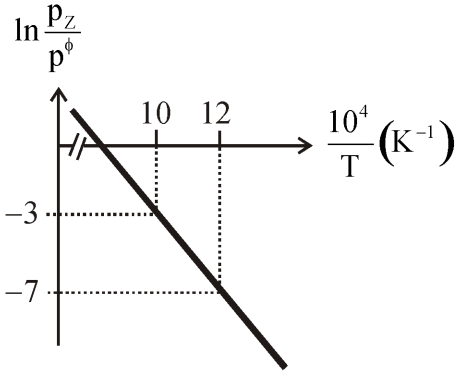
mass of U formed = $0.032 \times 100 = 3.2$ gm

Question Stem for Question Nos. 7 and 8

Question Stem

For the reaction, **X**(s) $\rightleftharpoons$ **Y**(s) + **Z**(g), the plot of $\ln \frac{p_Z}{p^\phi}$ versus $\frac{10^4}{T}$ is given below (in solid line), where p_z is the pressure (in bar) of the gas **Z** at temperature *T* and

p^ϕ = 1 bar.



(Given, $\frac{d(\ln K)}{d\left(\frac{1}{T}\right)} = -\frac{\Delta H^{\phi}}{R}$, where the equilibrium constant, $K = \frac{p_z}{p^{\phi}}$ and the gas constant, R = 8.314 J K^{-1} mol^{-1})

7. The value of standard enthalpy, ΔH^{ϕ} (in kJ mol^{-1}) for the given reaction is ___.

Ans. 166.28 kJ

Sol. $X(s) \rightleftharpoons Y(s) + Z(g)$

$$\ln k_{eq} = -\frac{\Delta H^{\circ}}{R}\frac{1}{T} + \frac{\Delta S^{\circ}}{R}$$

$$\ln k_{eq} = -\frac{\Delta H^{\circ}}{R \times 10^4} \times \frac{10^4}{T} + \frac{\Delta S^{\circ}}{R}$$

Slope of graph between $\ln k_{eq}$ vs $\frac{10^4}{T} = -\frac{\Delta H^{\circ}}{R \times 10^4}$

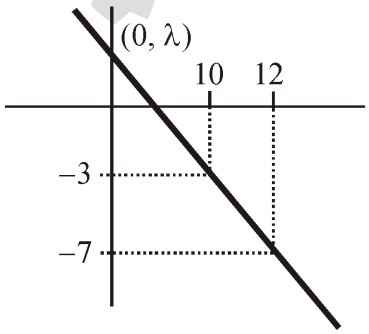
$$-\frac{\Delta H^{\circ}}{R \times 10^4} = -\frac{4}{2}$$

$\Rightarrow \Delta H^{\circ} = 2 \times R \times 10^4$ J $= 2 \times 8.314 \times 10$ kJ $= 166.28$ kJ

8. The value of ΔS^{ϕ} (in J K^{-1} mol^{-1}) for the given reaction, at 1000 K is ___.

Ans. 141.33 or 141.34 JK^{-1} $mole^{-1}$.

Sol.



$$\frac{-3-\lambda}{10-0} = \frac{-7-3}{12-10}$$

$\lambda = 17$

$\frac{\Delta S^\circ}{R} = 17$

$\Delta S^\circ = 17 \times 8.314 = 141.338\ JK^{-1}\ mole^{-1}$.

Question Stem for Question Nos. 9 and 10

Question Stem

The boiling point of water in a 0.1 molal silver nitrate solution (solution **A**) is **x** °C.

To this solution **A**, an equal volume of 0.1 molal aqueous barium chloride solution is added to make a new solution **B**. The difference in the boiling points of water in the two solutions **A** and **B** is **y** $\times 10^{-2}$ °C.

(Assume: Densities of the solutions **A** and **B** are the same as that of water and the soluble salts dissociate completely.

Use: Molal elevation constant (Ebullioscopic Constant), $K_b = 0.5$ K kg mol^{-1}; Boiling point of pure water as 100 °C.)

9. The value of **x** is ___.

Ans. 100.1 °C

Sol. For solution A

$\Delta T_b = iK_b m$

$= 2 \times 0.5 \times 0.1 = 0.1$

Hence boiling point of solution A $= 100 + 0.1 = 100.1$ °C

10. The value of |**y**| is ___.

Ans. 2.5

Sol. $BaCl_2 + 2AgNO_3 \longrightarrow 2AgCl\downarrow + Ba(NO_3)_2$

0.1 0.1

0.05 0 0.05

precipitate of AgCl will not contribute in colligative property of final solution.

For solution 'B'

$\Delta T_b = \left(\frac{3\times 0.05 + 3\times 0.05}{2}\right) \times 0.5$

$= 0.15 \times 0.5 = 0.075$

Boiling point of solution 'B' = 100 + 0.075 = 100.075 °C

Difference in boiling point = 100.1 – 100.075 = 0.025

$= 2.5 \times 10^{-2}$ °C

y = 2.5

SECTION C

- This section contains **SIX (06)** 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 If only (all) the correct option(s) is(are) chosen;

  Partial Marks : +3 If all the four options are correct but ONLY three options are chosen;

  Partial Marks : +2 If three or more options are correct but ONLY two options are chosen, both of which are correct;

  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;

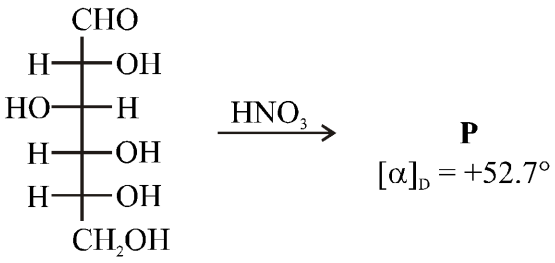
  choosing ONLY (A) will get +1 mark;

  choosing ONLY (B) will get +1 mark;

  choosing ONLY (D) will get +1 mark;

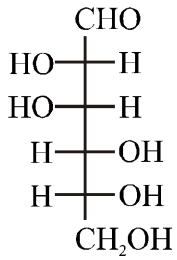
  choosing no option(s) (i.e. the question is unanswered) will get 0 marks and choosing any other option(s) will get -2 marks.

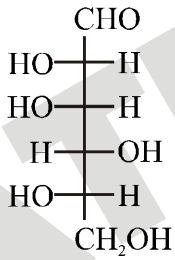
11. Given

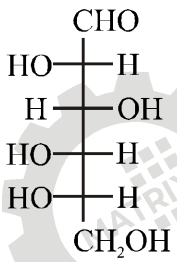


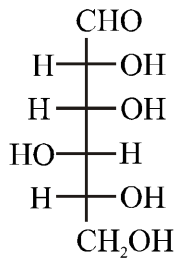
D-Glucose

The compound(s), which on reaction with HNO_3 will give the product having degree of rotation, $[\alpha]_D = -52.7°$ is(are)

(A) 

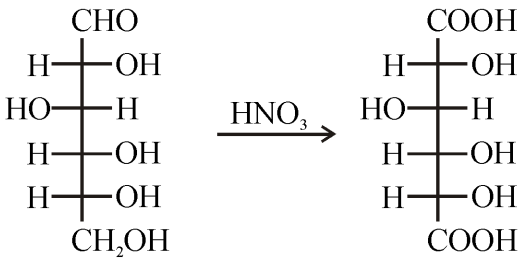
(B) 

(C) 

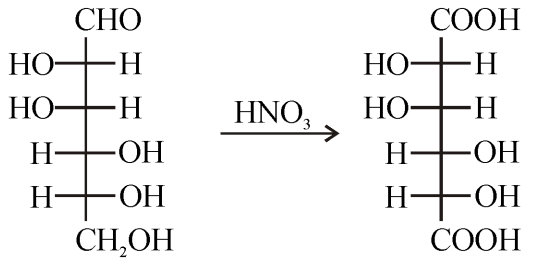
(D) 

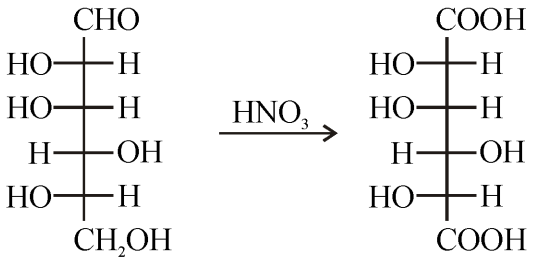
Ans. (C), (D)

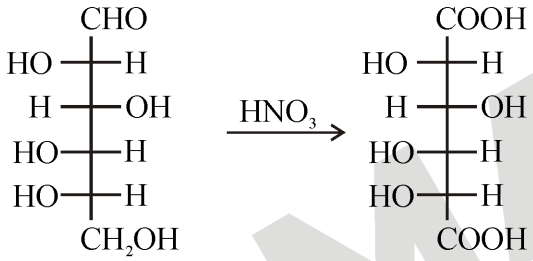
Sol. Compounds which are enantiomers of P, will have $[\alpha]_D = -52.7°$.



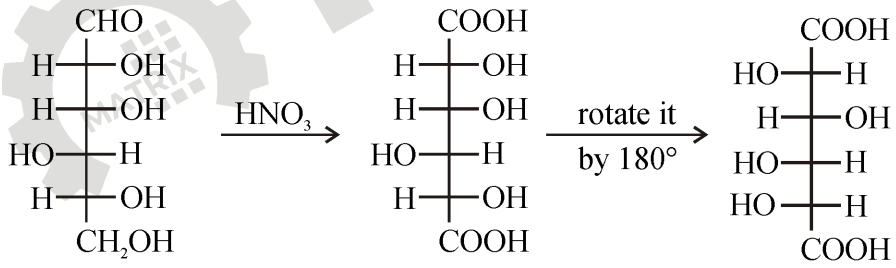
'P'

(A) 

(B) 

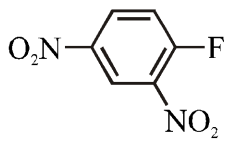
(C) 

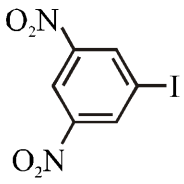
It is an enantiomer of 'P'.

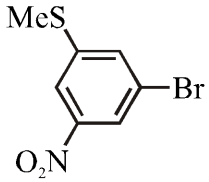
(D) 

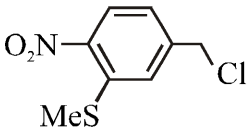
It is an enantiomer of 'P'.

12. The reaction of **Q** with PhSNa yields an organic compound (major product) that gives positive Carius test on treatment with Na_2O_2 followed by addition of $BaCl_2$. The correct option(s) for **Q** is(are)

(A) 

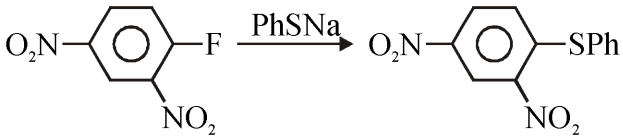
(B) 

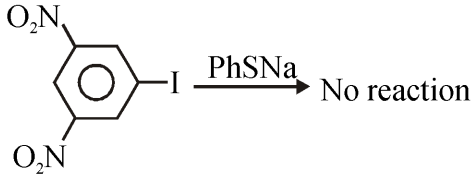
(C) 

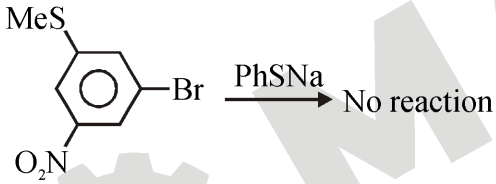
(D) 

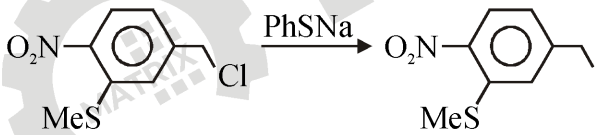
Ans. (A), (D)

Sol. Carius Test is used to estimate amount of halogens and sulphur in organic compound.

(A)  → gives positive Carius Test due to presence of sulphur

(B) 

(C) 

(D)  → gives positive Carius Test due to presence of sulphur

13. The correct statement(s) related to colloids is(are)

(A) The process of precipitating colloidal sol by an electrolyte is called peptization.

(B) Colloidal solution freezes at higher temperature than the true solution at the same concentration.

(C) Surfactants form micelle above critical micelle concentration (CMC). CMC depends on temperature.

(D) Micelles are macromolecular colloids.

Ans. (B), (C)

Sol. (A) The process of precipitating colloidal by an electrolyte is called coagulation.

(B) Value of colligative properties for colloidal solutions is relatively low in comparison to true solutions due to greater size of colloidal particles.

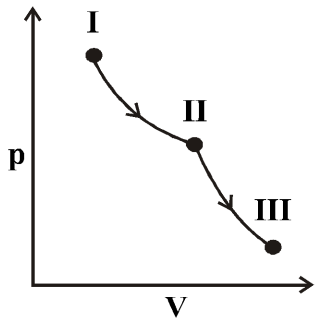
Hence $(\Delta T_f)_{colloidal} < (\Delta T_f)_{True\ solution}$

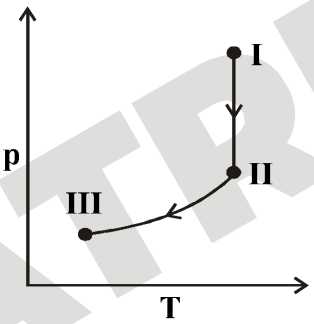
$(T_f)_{colloidal} > (T_f)_{True\ solution}$

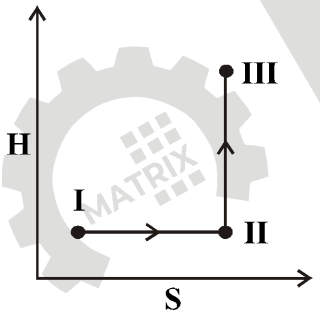
(C) Surfactants form micelle above a particular concentration and temperature known as critical micelle concentration (CMC) and kraft temperature respectively.

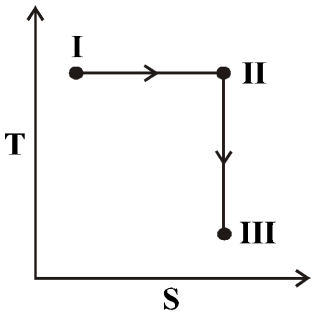
(D) Micelles are associated colloids.

14. An ideal gas undergoes a reversible isothermal expansion from state **I** to state **II** followed by a reversible adiabatic expansion from state **II** to state **III**. The correct plot(s) representing the changes from state **I** to state **III** is(are) (p: pressure, V: volume, T: temperature, H: enthalpy, S: entropy)

(A)


(B)


(C)


(D)


Ans (A), (B), (D)

Sol. I – II isothermal expanstion.

II – III adiabatic expansion.

(A) Magnitude of slope of PV curve adiabatic > isothermal

(B) I → II Temperature is constant but P will decrease due to increase in volume.

II – III → Temperature will decrease during adiabatic expansion.

$P\textcircled{V}\uparrow = nR\textcircled{T}\downarrow$

To satisfy above equation value of P should decrease.

(C) $I \rightarrow II$

$\Delta H = nC_p\Delta T = 0$

$$\Delta S = nCv \ln \frac{T_f}{T_i} + nR \ln \frac{V_f}{V_i}$$

$$= nR \ln \frac{V_f}{V_i} > 0$$

$II \rightarrow III$

$$\Delta S = nCv \ln \frac{T_f}{T_i} + nR \ln \frac{V_f}{V_i}$$

$= 0$

$\Delta H = nC_p\Delta T$

$= -Ve$

(D) $I \rightarrow II$

Entropy will increase and T will remain constant.

$II \rightarrow III$

Entropy will remain constant and T will decrease.

15. The correct statement(s) related to the metal extraction processes is(are)

(A) A mixture of PbS and PbO undergoes self-reduction to produce Pb and SO_2.

(B) In the extraction process of copper from copper pyrites, silica is added to produce copper silicate.

(C) Partial oxidation of sulphide ore of copper by roasting, followed by self-reduction produces blister copper.

(D) In cyanide process, zinc powder is utilized to precipitate gold from $Na[Au(CN)_2]$.

Ans. (A), (C), (D)

Sol. (A) $PbS + 2PbO \xrightarrow{\text{Self Reduction}} 3Pb + SO_2(g)$

(B) FeO + SiO_2 $\longrightarrow$ $FeSiO_3$

Basic Impurity — Acidic flux — iron silicate (slag)

(C) $Cu_2S \xrightarrow[\text{Oxidation}]{\text{Partial}} Cu_2S + 2Cu_2O \xrightarrow{\text{Self Reduction}} 6Cu(s) + SO_2$

Blister Copper

(D) Cyanide Process

$$Au \xrightarrow{NaCN\,Solution} Na\left[Au(CN)_2\right] \xrightarrow{Zn} Na_2\left[Zn(CN)_4\right] + Au\downarrow$$

16. A mixture of two salts is used to prepare a solution S, which gives the following results:

White precipitate(s) only $\xleftarrow[\text{Room temperature}]{\text{Dilute NaOH(aq)}}$ **S** (aq solution of the salts) $\xrightarrow[\text{Room temperature}]{\text{Dilute HCl(aq)}}$ White precipitate(s) only

The correct option(s) for the salt mixture is(are)

(A) $Pb(NO_3)_2$ and $Zn(NO_3)_2$ (B) $Pb(NO_3)_2$ and $Bi(NO_3)_3$

(C) $AgNO_3$ and $Bi(NO_3)_3$ (D) $Pb(NO_3)_2$ and $Hg(NO_3)_2$

Ans. (A), (B)

Sol. Dilute HCl(aq) gives white PPT with group–I basic radicals i.e. Ag^+, Hg^{2+}, Pb^{2+}.

$$Pb(NO_3)_2 \xrightarrow{dil.HCl} PbCl_2\downarrow$$
White PPT

$$AgNO_3 \xrightarrow{dil.HCl} AgCl\downarrow$$
White PPT

Precipitate with dil. NaOH solution

$$Pb(NO_3)_2 \xrightarrow{dil.NaOH\,solution} Pb(OH)_2\downarrow$$
White PPT

$$Zn(NO_3)_2 \xrightarrow{dil.NaOH\,solution} Zn(OH)_2\downarrow$$
White PPT

$$Bi(NO_3)_3 \xrightarrow{dil.NaOH\,solution} Bi(OH)_3\downarrow$$
White PPT

$$AgNO_3 \xrightarrow{dil.NaOH\,solution} Ag_2O\downarrow$$
Brown PPT

$$Hg(NO_3)_2 \xrightarrow{dil.NaOH\,solution} HgO\downarrow$$
Red PPT

SECTION D

- This section contains **THREE (03)** 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:

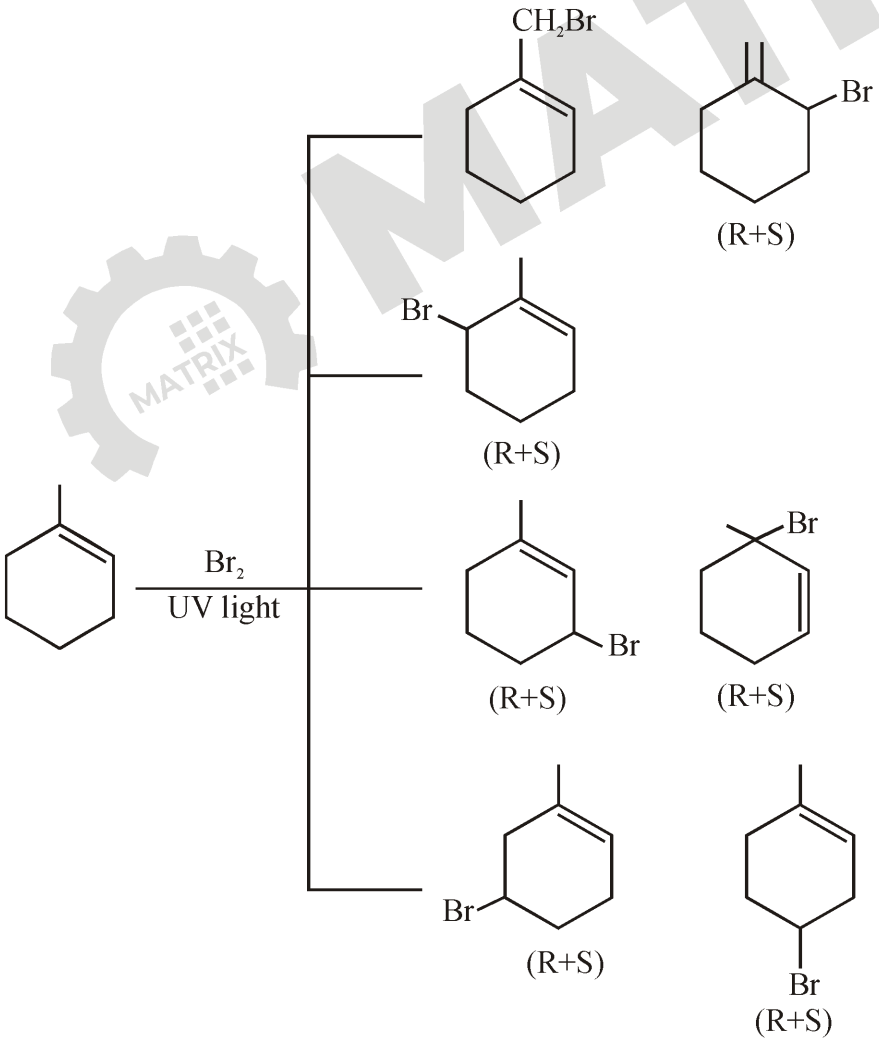
  Full Marks : +4 If ONLY the correct integer is entered;

  Zero Marks : 0 In all other cases.

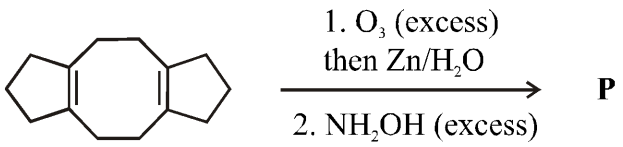
17. The maximum number of possible isomers (including stereoisomers) which may be formed on *mono*-bromination of 1-methylcyclohex-1-ene using Br_2 and UV light is ___.

Ans. 13

Sol.

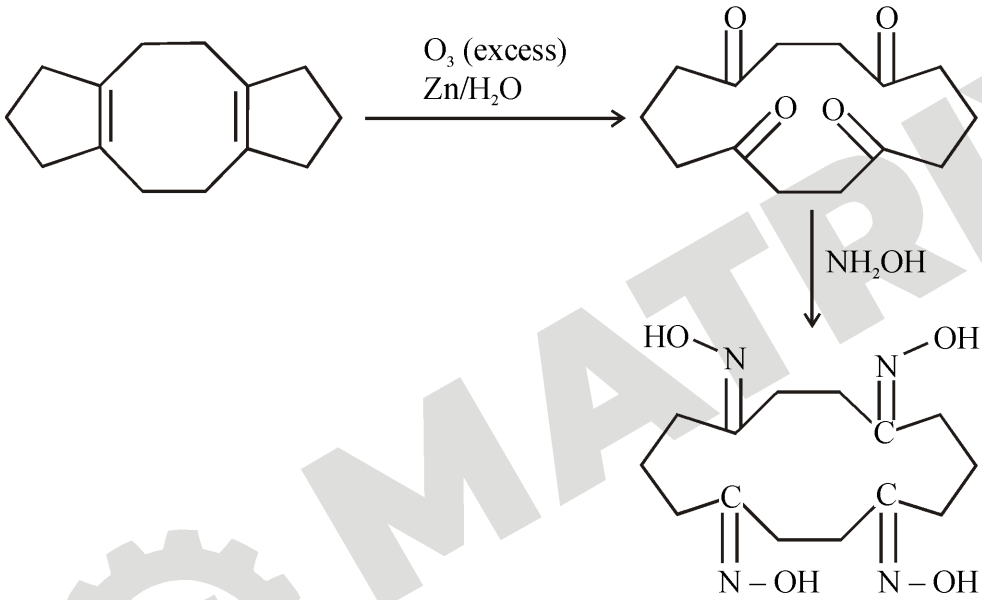


18. In the reaction given below, the total number of atoms having sp^2 hybridization in the major product **P** is ___.



Ans. 8

Sol.



19. The total number of possible isomers for $[Pt(NH_3)_4Cl_2]Br_2$ is ___.

Ans. 6.00

Sol. Total 3 ionisation isomers are possible

(1) $[Pt(NH_3)_4Cl_2]Br_2$

(2) $[Pt(NH_3)_4ClBr]BrCl$

(3) $[Pt(NH_3)_4Br_2]Cl_2$

Each ionisation isomer has 2 G.I. (1 cis + 1 trans)

Total possible isomers are $3 \times 2 \Rightarrow 6$.