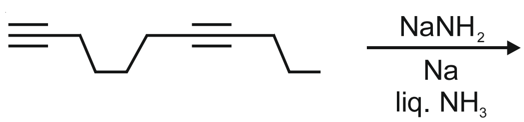
# PART-II : CHEMISTRY

## SECTION - 1

- 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:

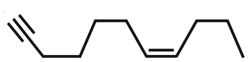
| | | | |
|---|---|---|---|
| *Full Marks* | : | +3 | If ONLY the correct option is chosen; |
| *Zero Marks* | : | 0 | If none of the options is chosen (i.e. the question is unanswered); |
| *Negative Marks* | : | –1 | In all other cases. |

1. The major product formed in the following reaction is




(A) 

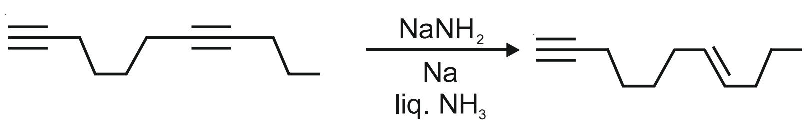
(B) 

(C) 

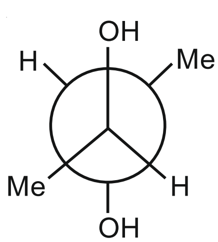
(D) 

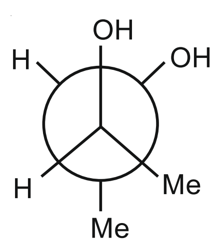
Answer (B)

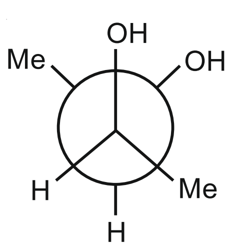
**Sol.** It is a case of Birch reduction. Alkynes on reaction with alkali metal in liq. $NH_3$ gives trans-alkene. But terminal alkynes do not get reduced.

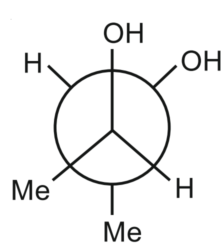



2. Among the following, the conformation that corresponds to the most stable conformation of *meso*-butane-2,3-diol is

(A) 

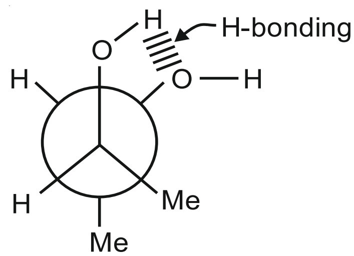

(B) 


(C) 

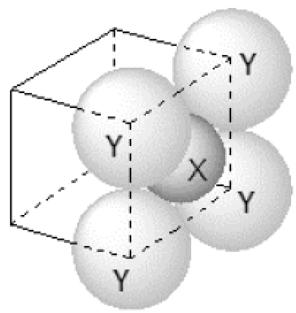

(D) 


Answer (B)

**Sol.** Meso compounds have plane of symmetry. In case of butan-2, 3-diol, gauche form is the most stable due to intra-molecular H-bonding.




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

Answer (B)

**Sol.** a = edge length of unit cell

$2r_y = a$

$2(r_x + r_y) = \sqrt{2}a$

$2r_x + a = \sqrt{2}a$

$2r_x = a(\sqrt{2} - 1)$

$r_x = 0.207\ a$

Packing fraction = $\frac{3 \times \text{vol. of } x + \text{vol. of } y}{\text{vol. of unit cell}}$

$$= \frac{3 \times \frac{4}{3} \times \pi r_x^3 + \frac{4}{3} \times \pi \times r_y^3}{a^3}$$

$$= \frac{4 \times \pi \times (0.207a)^3 + \frac{4}{3} \times \pi \times (0.5a)^3}{a^3}$$

$\approx 0.63$

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

Answer (A)

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

$Cr^{3+} = 3d^3\ 4s^0$

It has 3 unpaired electrons

$\mu = \sqrt{n(n+2)}$ BM

$= \sqrt{3(3+2)}$ BM

= 3.87 BM

$[CuF_6]^{3-} = Cu^{+3}$

$Cu^{+3} = 3d^8\ 4s^0$

It has 2 unpaired electrons

$\mu = \sqrt{2(2+2)}$ BM

= 2.84 BM

## SECTION - 2

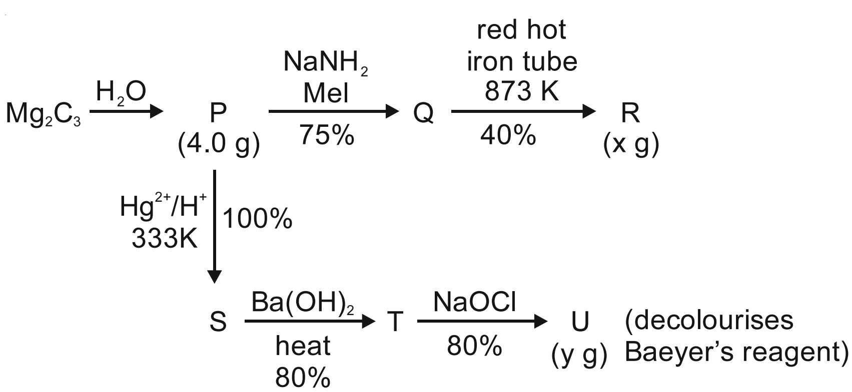
- This section contains **THREE (03)** question stems.
- There are **TWO (02)** questions corresponding to each question stem.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value corresponding to the answer in the designated place using the mouse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

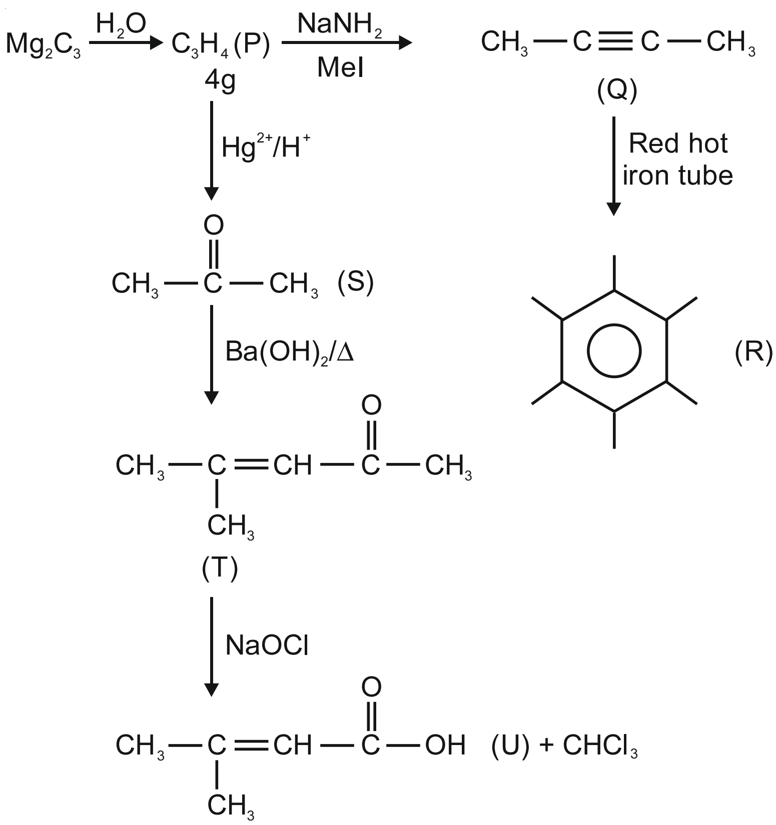
5. The value of x is ______.

Answer (1.62)

6. The value of y is ______.

Answer (3.20)

**Sol. of Q. No. 5 and 6**



4 g of $C_3H_4$ = 0.1 mol

From 0.1 mol of P, 0.01 mol of R will be produced

$\Rightarrow$ 1.62 g of R is produced

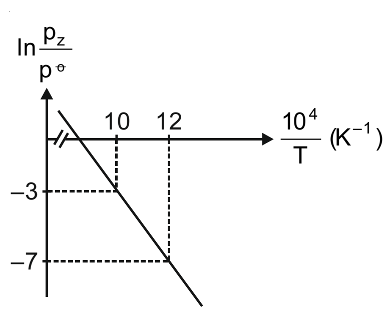
From 0.1 mol of P, 0.032 mol of U is produced

= 3.2 g of U is produced

**Question stem for Question Nos. 7 and 8**

**Question Stem**

For the reaction, $X(s) \rightleftharpoons Y(s) + Z(g)$, the plot of $\ln\frac{p_z}{p^{\ominus}}$ 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 $p^{\ominus} = 1$ bar.




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

7. The value of standard enthalpy, $\Delta H^{\ominus}$ (in kJ mol–1) for the given reaction is ______.

Answer (166.28)

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

Given $K = \frac{p_z}{p^{\ominus}}$

$\ln K = \ln A - \frac{\Delta H^o}{RT}$

$\Rightarrow \ln \frac{p_z}{p^{\ominus}} = \ln A - \frac{\Delta H}{RT}$

Slope of $\ln \frac{p_z}{p^{\ominus}}$ vs $\frac{1}{T}$ is $\frac{d\left[\ln\left(\frac{p_z}{p^{\ominus}}\right)\right]}{d\left(\frac{1}{T}\right)} = \frac{-\Delta H^o}{R}$

From the graph, we have $\frac{-\Delta H^o}{R} = -2 \times 10^4$

$\Rightarrow \Delta H^o = 2 \times 10^4 \times 8.314$ J

$\Delta H^o$ = 166.28 kJ mol$^{-1}$

8. The value of $\Delta S^{\ominus}$ (in J K$^{-1}$ mol$^{-1}$) for the given reaction, at 1000 K is ____.

Answer (141.34)

**Sol.** –RTln K = $\Delta G^o = \Delta H^o - T\Delta S^o$

$\ln k = -\frac{\Delta H^o}{RT} + \frac{\Delta S^o}{R}$

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

$\Delta S^o$ = 17R

= 141.338 J K$^{-1}$

**Question stem for Question Nos. 9 and 10**

**Question Stem**

The boiling point of water in a 0.1 molal silver intrate solution (soltuion 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 × 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 ______.

Answer (100.1)

10. The value of |y| is _____.

Answer (2.5)

**Sol. of Q. No. 9 and 10**

Given molality of $AgNO_3$ solution is 0.1 molal (solution-A)

$\Delta T_b = ik_bm$

$AgNO_3 \rightarrow Ag^+ + NO_3^-$

van't Hoff factor (i) for $AgNO_3 = 2$

$\Delta T_b = 2 \times 0.5 \times 0.1$

$(T_s - T^o) = 0.1$

$(T_s)_A = 100.1^oC$, so x = 100.1

Now solution-A of equal volume is mixed with 0.1 molal $BaCl_2$ solution to get solution-B. $AgNO_3$ reacts with $BaCl_2$ to form AgCl(s).

0.1 mole of $AgNO_3$ present in 1000 gram solvent or 1017 gram or 1017 mL solution,

milli moles of $AgNO_3$ in V ml 0.1 molal solution is nearly 0.1 V. Similarly in $BaCl_2$.

$2AgNO_3(aq) + BaCl_2(aq) \rightarrow 2AgCl(s) + Ba(NO_3)_2\ (aq)$

| | | | |
|---|---|---|---|
| 0.1 V | 0.1 V | 0 | 0 |
| 0 | 0.05 V | 0.1 V | 0.05 V |

$$\Delta T_b = \left[\frac{0.05V \times 3}{2V} + \frac{0.05V \times 3}{2V}\right] \times 0.5 = 0.075$$

$$(T_s)_B = 100.075^o C$$

$(T_s)_A - (T_s)_B = 100.1 - 100.075 = 0.025^oC$

$= 2.5 \times 10^{-2}\ ^oC$

So x = 100.1 and |y| = 2.5

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## SECTION - 3

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options (A), (B), (C) & (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 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(s) (i.e., the question is unanswered) will get 0 marks and

choosing any other options will get –2 marks.

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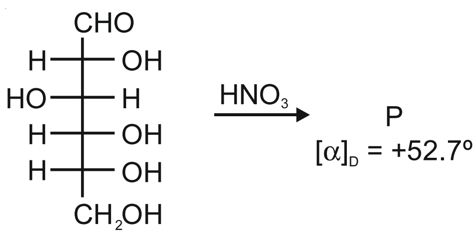
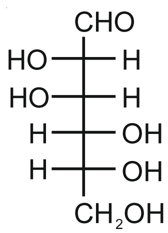
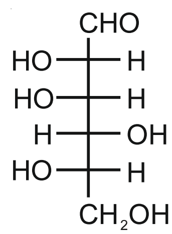
11. Given:

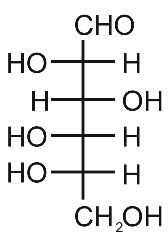


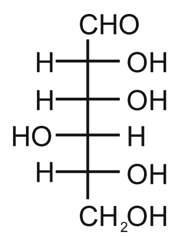

D-Glucose

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

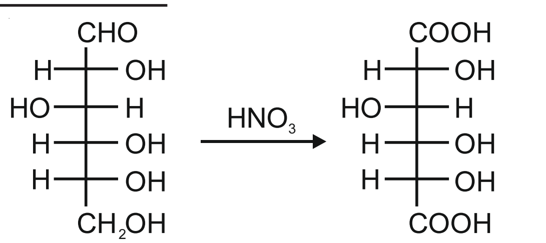
(A) 

(B) 

(C) 

(D) 

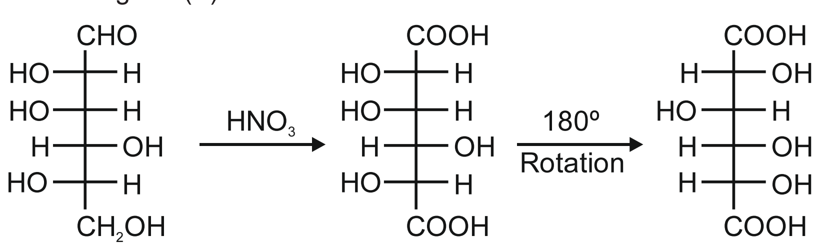
Answer (C, D)

**Sol.** 

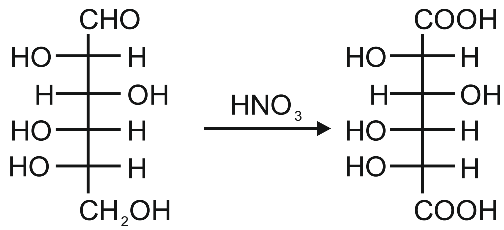

$\alpha = +52.7^\circ$

(P)

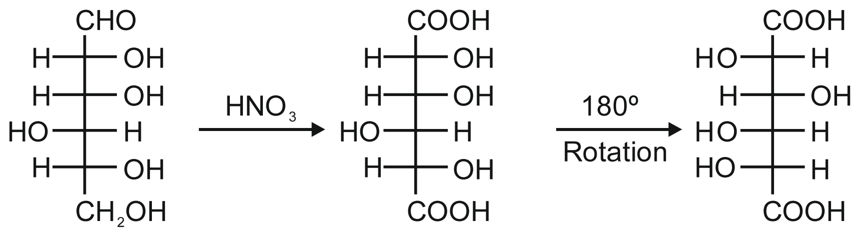
The enantiomer of (P) will have –52.7° rotation. So the reactant must be an isomer of D-glucose which can given the mirror image of (P)

(B) 


Same as P

(C) 

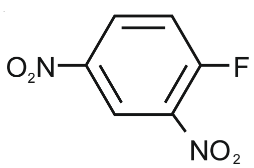
Enantiomer of (P)

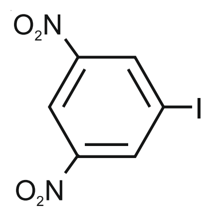
(D) 

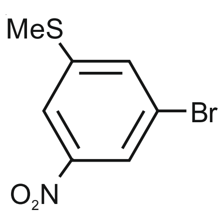
Enantiomer of (P)

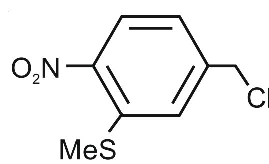
So answer must be C and D

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)

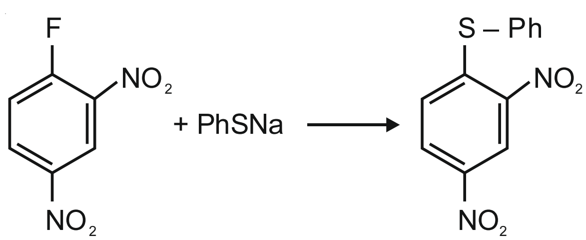
(A) 

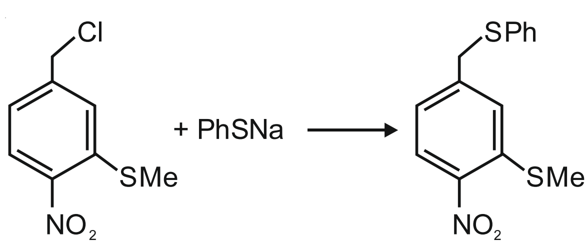
(B) 

(C) 

(D) 

Answer (A, D)

**Sol.** 



Answer should be (A) and (D)

Compounds given in option - B and C do not react with PhSNa.

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

Answer (B, C)

**Sol.** Select the correct statements.

(A) The process of precipitating colloidal sol by an electrolyte is called peptization - False, (It is process of converting precipitate into colloid)

(B) Colloidal solution freezes at a higher temperature than the true solution at the same concentration - True (colligative properties)

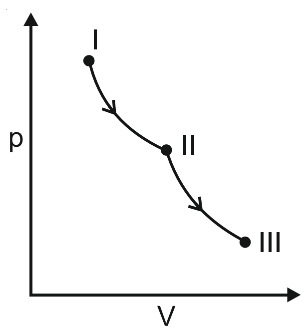
(C) Surfactants form miscelle above critical miscelle concentration (CMC). CMC depends on temperature - True

(D) Miscelles are macromolecular colloids - False, As misceles are associated colloids.

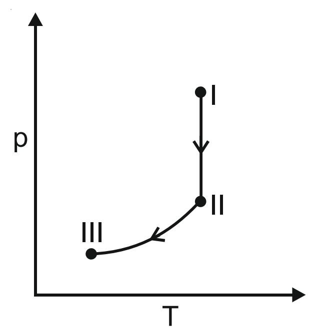
14. An ideal gas undergoes a reversible isothermal expansion from state I to state II followed by a reversible adiabatic expansion from state II to state III. The correct plot(s) representing the changes from state I to state III is(are)

(p: pressure, V: volume, T: temperature, H: enthalpy, S: entropy)

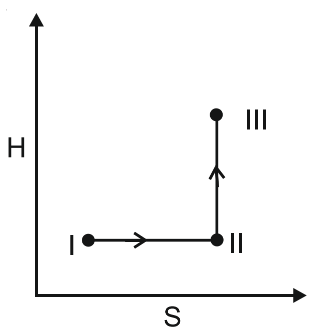
(A)



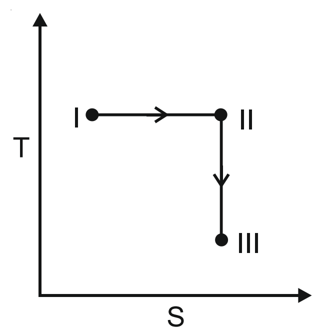

(B)




(C)




(D)




Answer (A, B, D)

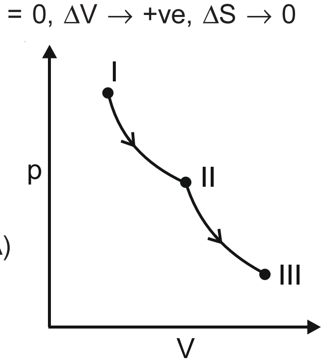
**Sol.** I $\rightarrow$ II $\rightarrow$ reversible, isothermal expansion,

T $\rightarrow$ constant, $\Delta V \rightarrow$ +ve, $\Delta S \rightarrow$ +ve $\Delta H \Rightarrow 0$

II $\rightarrow$ III $\rightarrow$ Reversible, adiabatic expansion

$Q = 0$, $\Delta V \rightarrow$ +ve, $\Delta S \rightarrow 0$

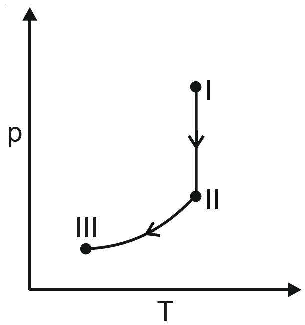
(A)



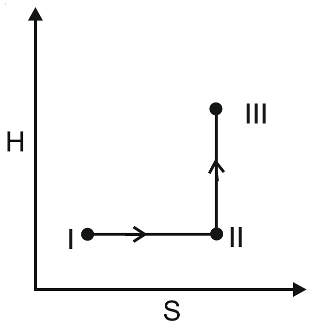

–ve slope - isothemal < adiabatic

I $\rightarrow$ II $\rightarrow$ Isothermal

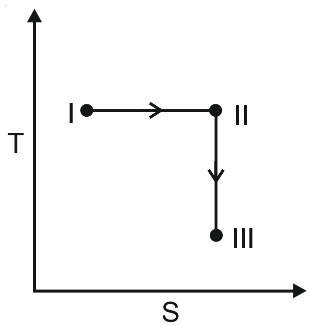
II $\rightarrow$ III $\rightarrow$ Adiabatic

(B) 


$I \rightarrow II \rightarrow T$ constant
$II \rightarrow III \rightarrow$ adiabatic

(C) 


$I \rightarrow II \rightarrow \Delta S \rightarrow +ve, \Delta H \Rightarrow 0$
$II \rightarrow III \rightarrow \Delta S \rightarrow 0, \Delta H \rightarrow -ve$

(D) 


$I \rightarrow II \rightarrow \Delta S \rightarrow +ve, \Delta T = 0$
$II \rightarrow III \rightarrow \Delta S \rightarrow 0$

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 $Na[Au(CN)_2]$

Answer (A, C, D)

**Sol.** $PbS + 2PbO \rightarrow 3Pb + SO_2$

Self reduction is taking place between PbS and PbO.

**In the Bessemer converter :** The raw material for the Bessemer converter is matte, i.e., $Cu_2S$ + FeS (little). Here air blasting is initially done for slag formation and $SiO_2$ is added from external source.

$$FeS + \frac{3}{2}O_2 \rightarrow FeO + SO_2 \uparrow$$

$$SiO_2 + FeO \rightarrow FeSiO_3 \text{ (slag)}$$

During slag formation, the characteristic green flame is observed at the mouth of the Bessemer converter which indicates the presence of iron in the form of FeO. Disappearance of this green flame indicates that the slag formation is complete. Then air blasting is stopped and slag is removed.

Again air blasting is restarted for partial roasting before self reduction, until two-thirds of $Cu_2S$ is converted into $Cu_2O$. After this, only heating is continued for the self reduction process.

$$Cu_2S + \frac{3}{2}O_2 \rightarrow Cu_2O + SO_2 \uparrow$$

$$Cu_2S + 2Cu_2O \rightarrow 6Cu(l) + SO_2 \uparrow \qquad \text{(self reduction)}$$

and $Cu_2S + 2O_2 \rightarrow Cu_2SO_4$

$$Cu_2S + Cu_2SO_4 \rightarrow 4Cu + 2SO_2 \uparrow \qquad \text{(self reduction)}$$

Thus the molten Cu obtained is poured into large container and allowed to cool and during cooling the dissolved $SO_2$ comes up to the surface and forms blisters. It is known as blister copper.

$$2Na[Au(CN)_2] + Zn \rightarrow Na_2[Zn(CN)_4] + 2Au \downarrow$$

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

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

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 $Hg(NO_3)_2$

Answer (A, B)

**Sol.** $Pb(NO_3)_2 \xrightarrow[\text{Room temp.}]{\text{dil HCl}} \underset{\text{(white ppt)}}{PbCl_2}$

$Pb(NO_3)_2 \xrightarrow[\text{Room temperature}]{\text{Dilute NaOH (aq)}} \underset{\text{(white ppt)}}{Pb(OH)_2}$

$Zn(NO_3)_2 \xrightarrow[\text{Room temperature}]{\text{dil HCl}} \underset{\text{(soluble)}}{Zn^{2+} + 2Cl^-}$

$Zn(NO_3)_2 \xrightarrow[\text{Room temperature}]{\text{dil NaOH(aq)}} \underset{\text{(white ppt)}}{Zn(OH)_2}$

$Bi(NO_3)_3 \xrightarrow[\text{Room temperature}]{\text{dil HCl(aq)}} \underset{\text{(White ppt)}}{BiOCl}$

$Bi(NO_3)_3 \xrightarrow[\text{Room temperature}]{\text{dil NaOH(aq)}} \underset{\text{(White ppt)}}{Bi(OH)_3}$

$AgNO_3 \xrightarrow[\text{Room temperature}]{\text{dil HCl}} \underset{\text{(White ppt)}}{AgCl}$

$$AgNO_3 \xrightarrow[\text{Room temperature}]{\text{dilute NaOH(aq)}} \underset{\text{(Brownish black ppt)}}{Ag_2O}$$

$$Hg(NO_3)_2 \xrightarrow[\text{Room temperature}]{\text{dil HCl}} \underset{\text{(soluble)}}{Hg^{2+} + 2Cl^-}$$

$$Hg(NO_3)_2 \xrightarrow[\text{Room temperature}]{\text{dilute NaOH(aq)}} \underset{\text{(Yellow precipitate)}}{HgO}$$

## SECTION - 4

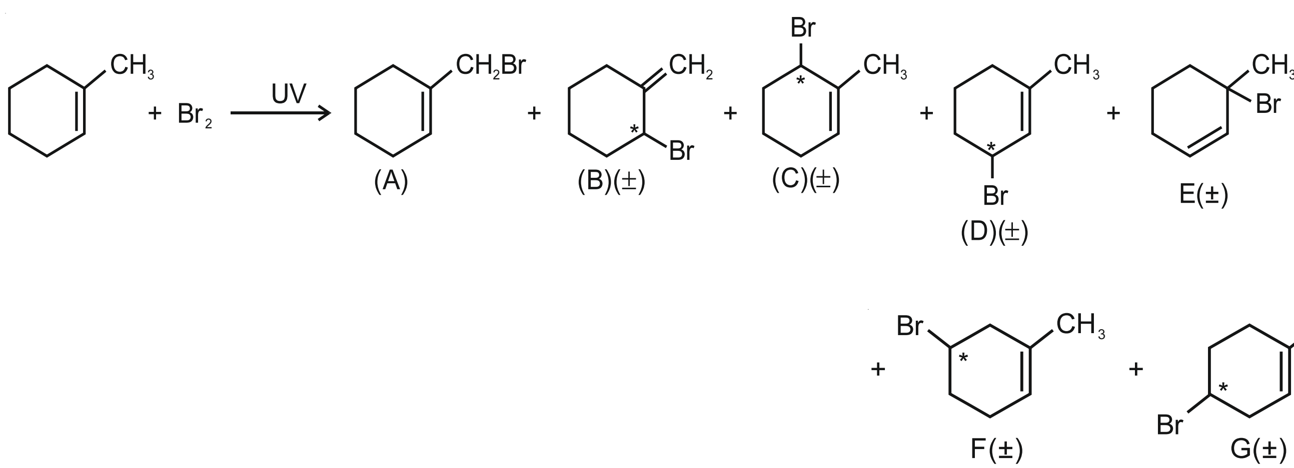
- This section contains **THREE (03)** questions.
- The answer to each question is a NON-NEGATIVE INTEGER.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

| | | | |
|---|---|---|---|
| *Full Marks* | : | +4 | If ONLY the correct numerical value 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 ______.

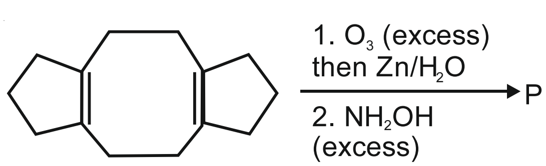
Answer (13)

**Sol.**



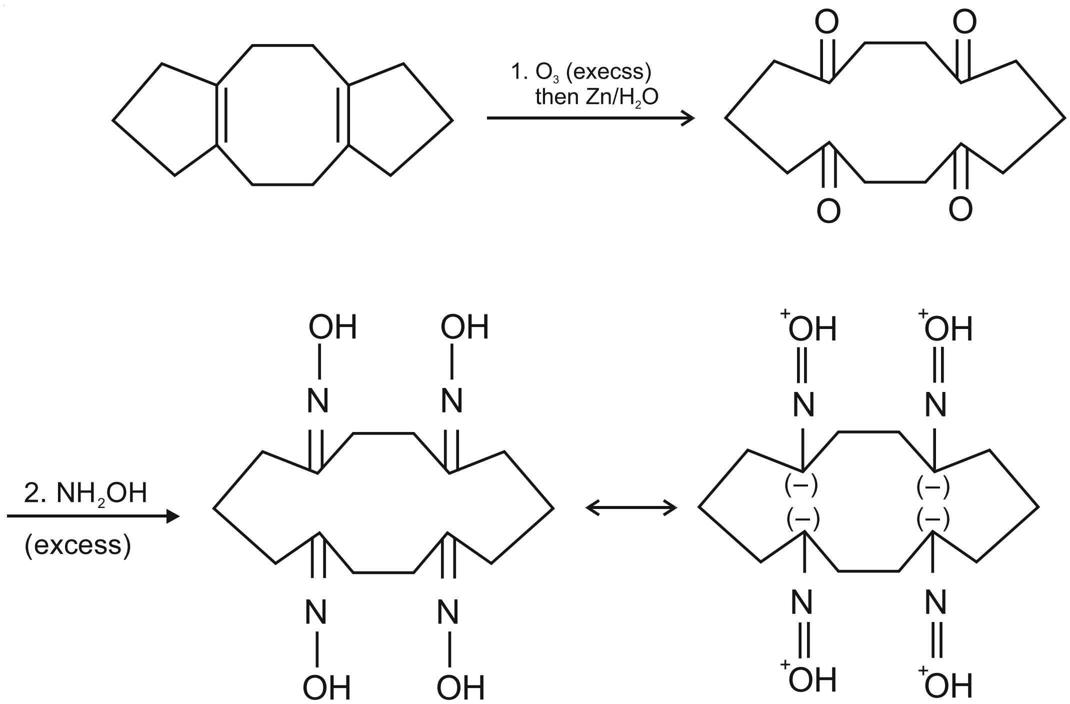

Monobromination of 1-methylcyclohexene in presence of UV light proceeds by free radical mechanism. The allyl radicals are formed which are stabilised by resonance. The secondary alkyl radicals are also formed which are stabilised by hyperconjugation. Of the seven products formed, six of them are optically active. So, 13 possible isomers are formed.

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



Answer (12)

**Sol.**




(P)

The total number of atoms having $sp^2$ hybridisation in the major product (P) = 12

This includes 4 C-atoms, 4 N-atoms and 4 O-atoms.

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

Answer (6)

**Sol.** The given complex $[Pt(NH_3)_4Cl_2]Br_2$ has three ionisation isomers and each of them has two geometrical isomers.