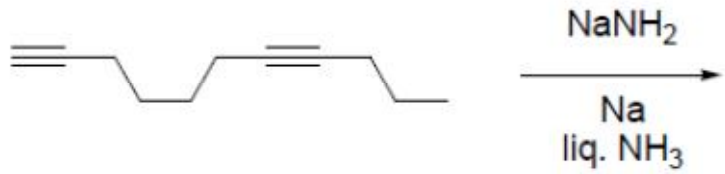
# PART II: CHEMISTRY

**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.
- Four each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated <u>according to the following marking scheme</u>:

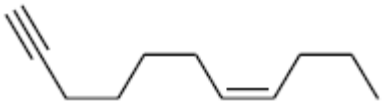
| | | | |
|---|---|---|---|
| *Full Mark* | : | +3 | If only the correct option is chosen; |
| *Zero Marks* | : | 0 | If none of the options is chosen (i.e. the question is unanswered) |
| *Negative Marks* | : | –1 | In all other cases. |

*Q.1 The major product formed in the following reaction is



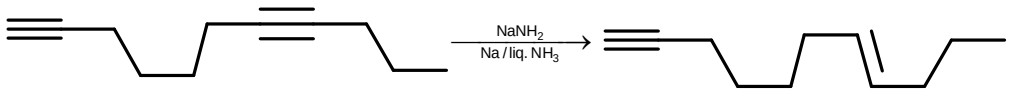

(A) 

(B) 

(C) 

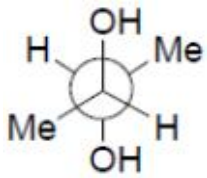
(D) 

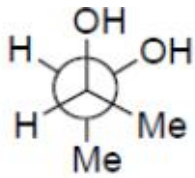
**Sol.** **B**

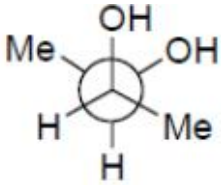


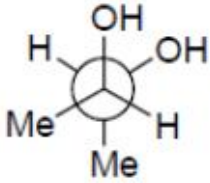

Na in liquid $NH_3$ reduces non terminal alkyne into trans alkene.

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

(A) 


(B) 

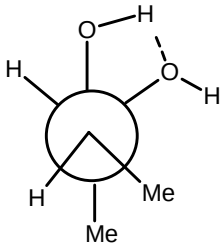

(C) 


(D) 

**Sol.** **B**

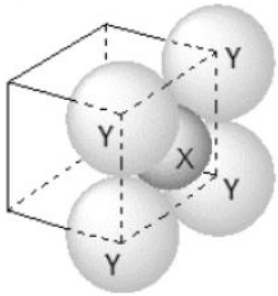
In option (B), given configuration represents meso – butane – 2, 3-diol and due to intramolecular hydrogen bonding, the gauche form is more stable.

Option (C) and (D) does not represent meso – isomer.




Q.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

$$\left(\text{packing fraction} = \frac{\text{packing efficiency}}{100}\right)$$




(A) 0.74 (B) 0.63

(C) 0.52 (D) 0.48

**Sol.** **B**

$$\text{Packing fraction (f)} = \frac{3\times\frac{4}{3}\pi r_+^3 + 1\times\frac{4}{3}\pi r_-^3}{a^3}$$

$$= \frac{1\times\frac{4}{3}\pi\left[3\left(\frac{r_+}{r_-}\right)^3 + 1\right]}{\left(\frac{a}{r_-}\right)^3}$$

Now $2r_- = a$

$$\therefore \frac{a}{r_-} = 2$$

Also, $\frac{r_+}{r_-} = 0.414$

So, $f = \frac{1\times\frac{4}{3}\times 3.14\left[3\times(0.414)^3 + 1\right]}{(2)^3}$

$= 0.634 \approx 0.63$

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

(Atomic number 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

**Sol.** **A**

$\left[Cr(NH_3)_6\right]^{3+}$ has $d^3$ configuration, so as per CFT,

N = 3 and $\mu = \sqrt{3(3+2)} = 3.87$ BM

$\left[CuF_6\right]^{3-}$, has $d^8$ configuration and weak field ligand.

So N = 2 and $\mu = \sqrt{2(2+2)} = 2.84$ 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 <u>according to the following marking scheme</u>:

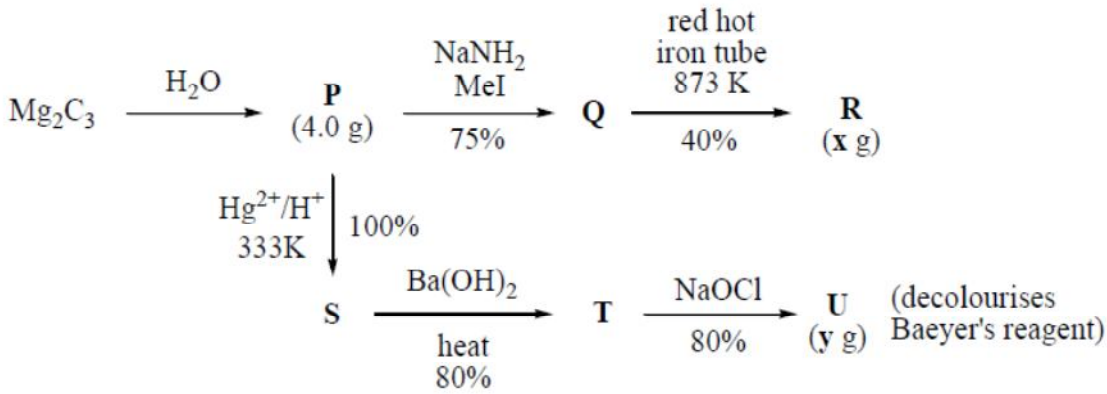
*Full Mark* : +2 If ONLY the correct numerical value is entered at the designated place;

*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:

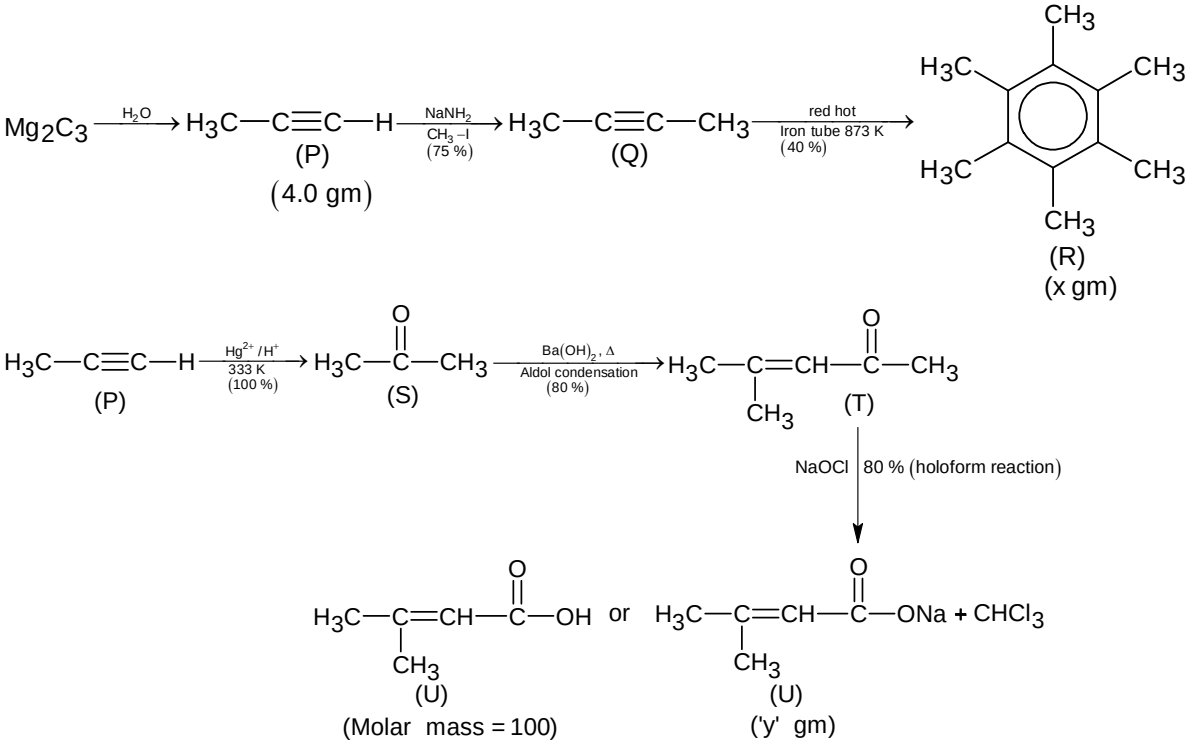



**X** g and **y** g are mass of **R** and **U,** respectively.

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

Q.5 The value of **x** is ___.

**Sol.** **1.62**




Molar mass of P = 40

$$\underset{(0.1\,\text{mole})}{P} \xrightarrow{75\ \%} \underset{\left(0.1\times\frac{3}{4}\right)}{Q}$$

$$\underset{\left(0.1\times\frac{3}{4}\right)}{3Q} \xrightarrow{40\ \%} \underset{\left(\frac{1}{3}\times 0.1\times\frac{3}{4}\times 0.4\right)}{R}$$

So, moles of R = 0.01 mole

Molar mass of (R) = 162

So, x = 0.01 × 162 = 1.62 g

Q.6 The value of **y** is ___.

**Sol.** **3.20 - 3.90**

Molar mass of 'U' = 122 g or 100 g

$$\underset{(0.1\,\text{mole})}{P} \xrightarrow{100\ \%} \underset{(0.1\,\text{mole})}{S}$$

$$\underset{(0.1\,\text{mole})}{2S} \xrightarrow[(80\ \%)]{\text{Aldol condensation}} \underset{\left(\frac{0.1}{2}\times 0.8\right)}{T} \xrightarrow{80\ \%} \underset{\left(\frac{0.1}{2}\times 0.8\times 0.8\right)}{U}$$

So, mass of 'U' = $\frac{0.1}{2}\times 0.8\times 0.8\times 100 = 3.20$ gm

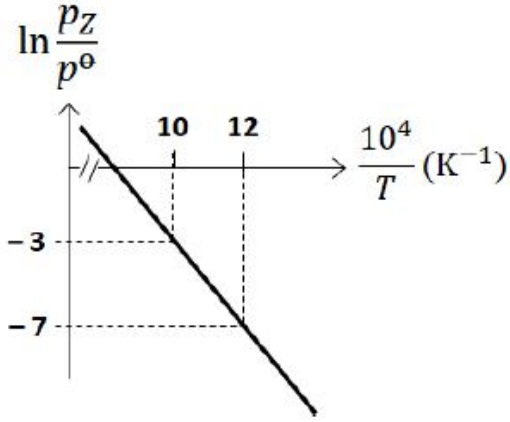
Or

Mass of 'U' = $\frac{0.1}{2}\times 0.8\times 0.8\times 122 = 3.90$ gm

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

**Question Stem**

For the reaction, $\mathbf{X}(s) \rightleftharpoons \mathbf{Y}(s) + \mathbf{Z}(g)$, the plot of $\ln \frac{p_{\mathbf{Z}}}{p^{\ominus}}$ versus $\frac{10^4}{T}$ is given below (in solid line), where $p_{\mathbf{Z}}$ is the pressure (in bar) of the gas $\mathbf{Z}$ at temperature $T$ and $p^{\ominus} = 1$ bar.




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

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

**Sol. 166.28**

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

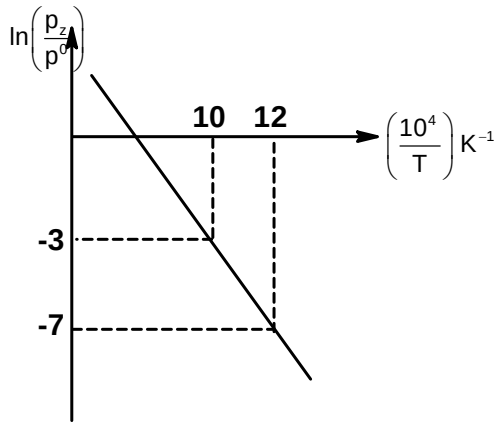
$K_p = \frac{p_z}{p^0}$, also $\Delta G^0 = -RT \ln k_p$

$$= -RT \ln\left(\frac{p_z}{p^0}\right)$$

Now, $\Delta G^0 = \Delta H^0 - T\Delta S^0$

$$-RT\, kn\left(\frac{p_z}{p^0}\right) = \Delta H^0 - T\Delta S^0$$

$$\ln\left(\frac{p_z}{p^0}\right) = -\left(\frac{\Delta H^0}{R}\right)\frac{1}{T} + \frac{\Delta S^0}{R} \qquad ...(1)$$




$$(1) \Rightarrow \ln\left(\frac{p_z}{p^0}\right) = -\left(\frac{\Delta H^0}{10^4 R}\right) \times \frac{10^4}{T} + \frac{\Delta S^0}{T} \quad ....(2)$$

$$\text{Slope of the line} = -\frac{\Delta H^0}{10^4 R} = \frac{\left[-7-(-3)\right]}{12-10} = -2$$

$\therefore \Delta H^0 = 2\ R \times 10^4$

$= 2 \times 8.314 \times 10^{-3} \times 10^4 = 1.66.28\ \text{kJ mol}^{-1}\ \text{K}^{-1}$

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

**Sol.** **141.34**

Putting the value of $\Delta H^0$ in equation (2), we get

$$-3 = -\left(\frac{2R \times 10^4}{10^4 R}\right) \times \frac{10^4}{7} + \frac{\Delta S^0}{R}$$

$$-3 = -2R \times \frac{10^4}{T} + \frac{\Delta S^0}{R}$$

$$-3 = -2 \times \frac{10^4}{1000} + \frac{\Delta S^0}{R}$$

$$-3 = -20 + \frac{\Delta S^0}{R}$$

$$\therefore \frac{\Delta S^0}{R} = 17$$

$\therefore \Delta S^0 = 17 \times 8.314 = 141.34\ \text{JK}^{-1}\ \text{mol}^{-1}$

**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 $\mathbf{x}^{\circ}\mathrm{C}$**.** 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 $\mathbf{y}\times10^{-2}{}^{\circ}\mathrm{C}$.

(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 $100^{\circ}$C.)

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

**Sol.** **100.10 °C**

0.1 molal $AgNO_3$ (aq) solution

$$AgNO_3 \longrightarrow Ag^{+}(aq) + NO_3^{-}(aq)$$

$$i = 1 + (2-1)\times 1 = 2 \quad (\alpha = 1, \text{ given})$$

$$\Delta T_b = i \times k_b \times m$$

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

So, boiling point of solution 'A' is = 100.10°C = x

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

**Sol.** **2.5**

Let solution 'B' is prepared by mixing 1 L (=1000 g) of solution 'A' with 1 L (= 1000 g) of solution of $BaCl_2$.

| | $BaCl_2$ | + $2AgNO_3$ | $\longrightarrow$ $2AgCl(s)$ | + $Ba(NO_3)_2$ |
|---|---|---|---|---|
| Initial moles | 0.1 moles | 0.1 moles | – | 0 |
| Moles after reaction | 0.1 – 0.05 = 0.05 moles | 0 | – | 0.05 moles |

So, molality of new solution $= \left(\frac{i_1 \times m_1 + i_2 \times m_2}{2}\right)$

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

$$= 0.15$$

Now, Elevation of boiling point of solution 'B' be $(\Delta T_b{}^1)$

$$\Delta T_b^1 = 0.15 \times k_b$$

$$= 0.15 \times \frac{1}{2}$$

$$= 0.075$$

Now, $T_b{}^1 = 100.075$ °C

So, difference of boiling point of 'A' and 'B' = 100.10 – 100.075 = 0.025 = $y \times 10^{-2}$ (given)

So, y = 2.5

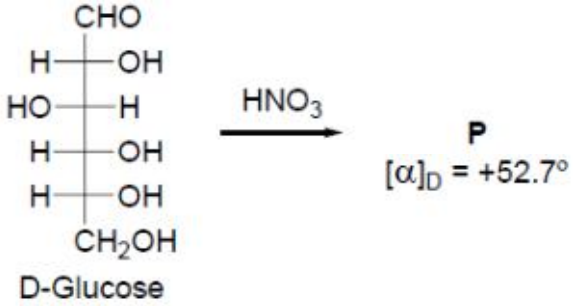
**SECTION 3**

- This section contains **SIX (06)** question.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MOER 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 <u>according to the following marking scheme</u>:

| | | | |
|---|---|---|---|
| *Full Mark* | : | +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. |

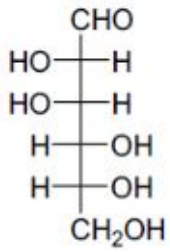
- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then
  choosing ONLY (A), (B) and (D) will get +4 marks;
  choosing ONLY (A) and (B) will get +2 marks;
  choosing ONLY (A) and (D) will get +2 marks;
  choosing ONLY (B) and (D) will get +2 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.11 Given:

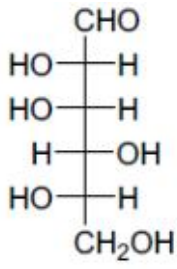


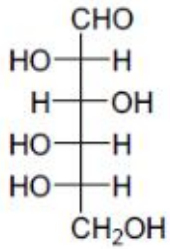

The compound(s), which on reaction with $HNO_3$ will give the product having degree of rotation, $[\alpha]_D = -52.7^\circ$ is(are)

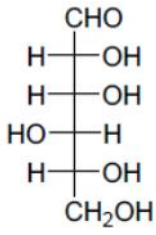
(A)



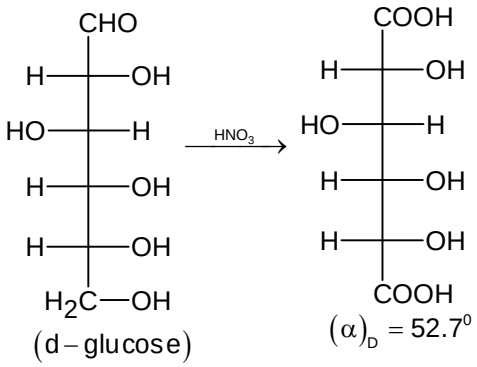

(B)



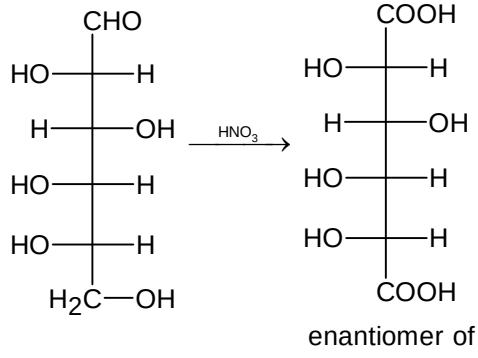
(C) 

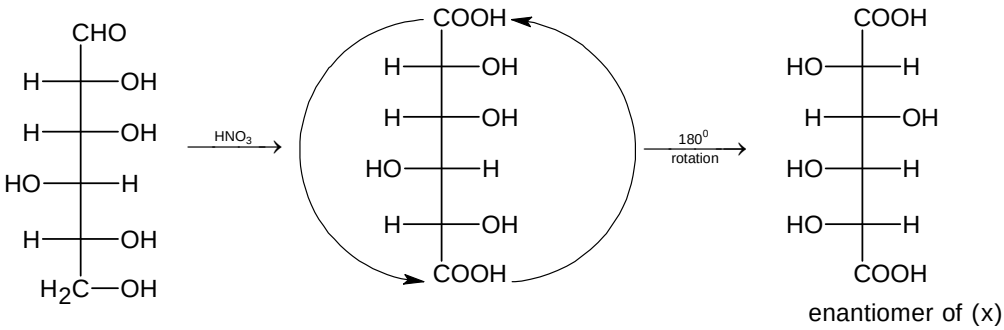

(D) 


**Sol.** **C, D**

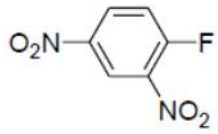


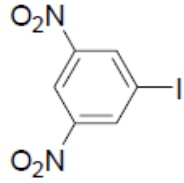

Since, we have to get the product (x) of $(\alpha)_D = -52.7^0$, i.e. the enantiomer of above product. Which is only possible from (C) & (D).

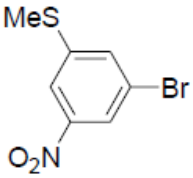
(C) 

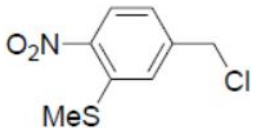

(D) 

Q.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) 

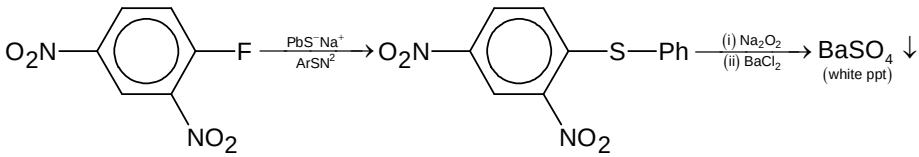
(C) 

(D) 

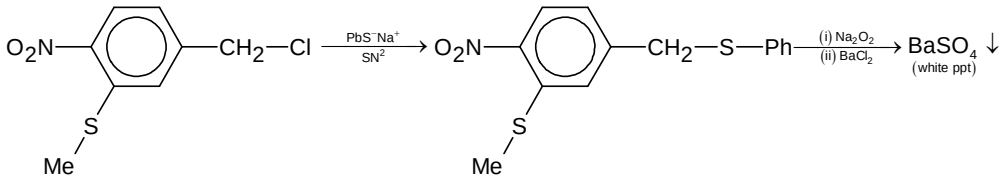
**Sol.** **A, D**

In option (B) and (C), $NO_2$ group (an EWG) is not present ortho or para position wrt the leaving group, so $ArSN^2$ reaction will not be possible.

(A)




(D)




Q.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.

**Sol.** **B, C**

(A) Process of precipitating colloidal solution by using an electrolyte is called "COAGULATION" and not peptisation.

(B) Since, molar mass of sol is much higher than true solutions, so magnitude of any colligative properties is smaller than true solutions.

$(\Delta T_f)_{sol} < (\Delta T_f)_{true\ solution}$

So, freezing point of sols > freezing point of true solution.

So, option (B) is correct.

(C) Micells are formed greater than or equal to CMC and above KRAFT temperature.

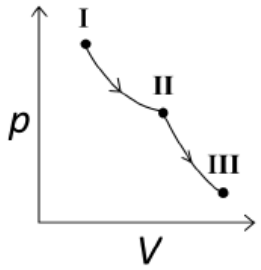
So option (C) is also correct.

(D) Micelles are ASSOCIATED colloids and not Macromolecular colloids.

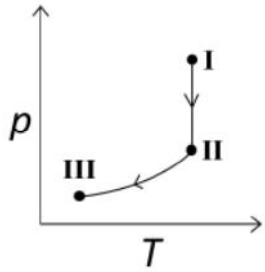
*Q.14 An ideal gas undergoes a reversible isothermal expansion from state **I** to state **II** followed by a reversible adiabatic expansion from state **II** to state **III**. The correct plot(s) representing the changes from state **I** to state **III** is(are)

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

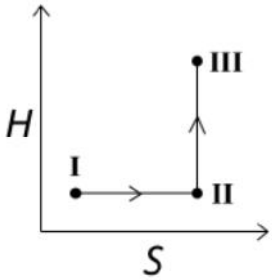
(A)



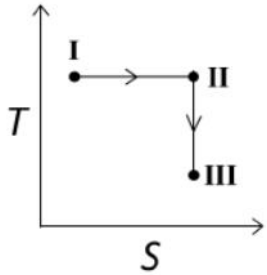

(B)




(C)




(D)

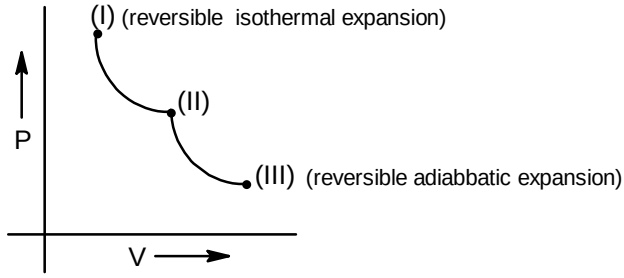



**Sol.** **A, B, D**

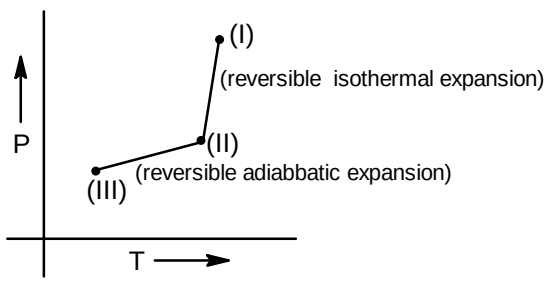
$$(I) \xrightarrow[\text{expansion}]{\text{Reversible isothermal}} (II) \xrightarrow[\text{expansion}]{\text{Reversible adiabatic}} (III)$$

So, the correct option is/are:

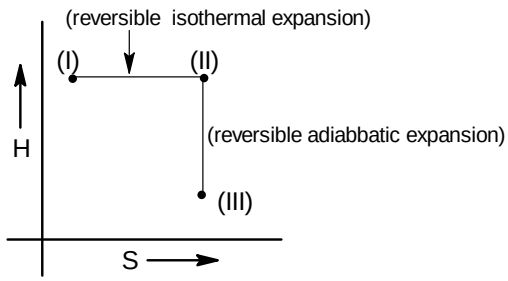
(A)




(B)



(D)




Reversible isothermal process is isoenthalpic while reversible adiabatic process is isoentropic.

Q.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 SO2.

(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 $Na\left[Au(CN)_2\right]$.

**Sol.** **A, C, D**

(A) $PbS + 2PbO \xrightarrow{\text{self reduction}} 3Pb + SO_2 \uparrow$

So option (A) is correct.

(B) In the extraction Cu from copper pyrite $CuFeS_2$

$SiO_2$ is added to remove FeO as slag $FeSiO_3$.

So option (B) is wrong.

(C) $\underset{\text{concentrated ore}}{CuFeS_2} \xrightarrow{\text{roasting}} \underbrace{Cu_2S + FeS}_{\text{(matte)}} + SO_2$

$FeS + O_2 \longrightarrow FeO + SO_2$

$Cu_2S + O_2 \longrightarrow Cu_2O + SO_2$

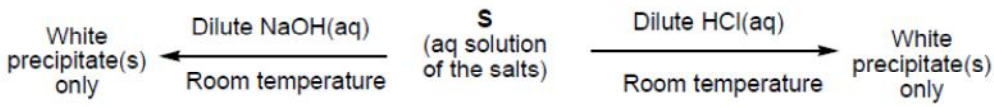
$Cu_2S + 2Cu_2O \longrightarrow \underset{\text{(Blister copper)}}{6Cu} + SO_2$

So, option (C) is correct.

(D) $Zn + 2Na\left[Au(CN)_2\right] \longrightarrow Na_2\left[Zn(CN)_4\right] + 2Au \downarrow$

So, option (D) is correct.

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




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 $Hg(NO_3)_2$

**Sol.** **A, B, C**

$Pb(OH)_2$, $Zn(OH)_2$ and $Bi(OH)_3$ are white precipitates but $Hg(OH)_2$ (unstable) is not.

$PbCl_2$ is white ppt.

So, option (A), (B) and (C) are correct.

**SECTION 4**

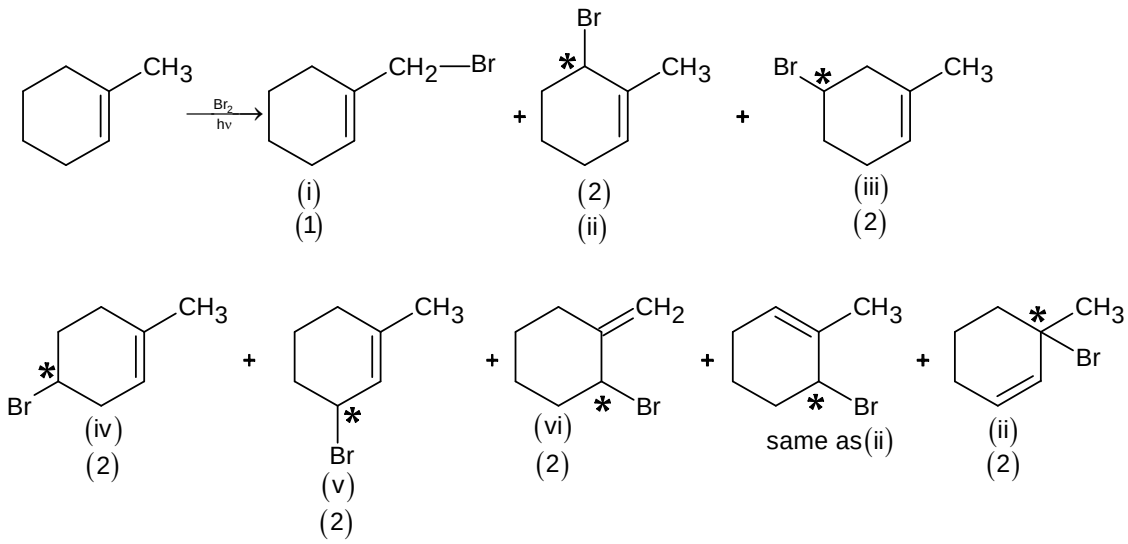
- This section contains **THREE (03)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER.**
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designed to enter the answer.
- Answer to each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

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

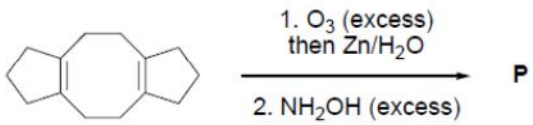
  *Zero Marks* : 0 In all other cases.

*Q.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 ___.

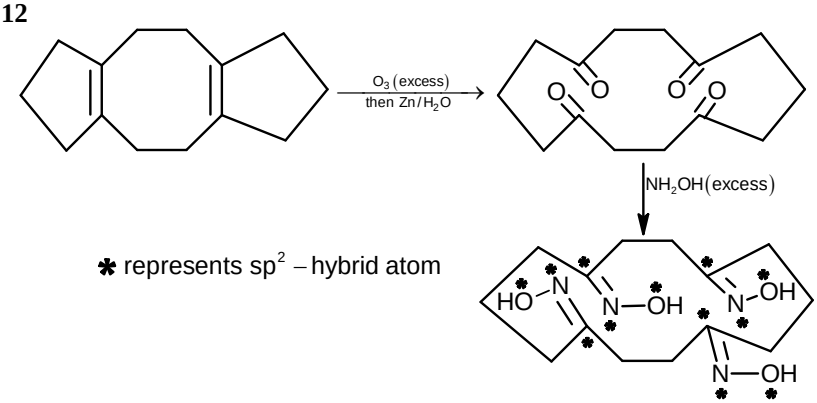
**Sol. 13**




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




**Sol. 12**



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

**Sol.** **6**

Possible structural isomers are: