# Chemistry

**SECTION 1 (Maximum Marks: 12)**

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated 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.** During sodium nitroprusside test of sulphide ion in an aqueous solution, one of the ligands coordinated to the metal ion is converted to

(A) $NOS^-$ (B) $SCN^-$ (C) $SNO^-$ (D) $NCS^-$

**Ans.** (A)

**Sol.** $Na_2[Fe(CN)_5NO] + S^{2-} \xrightarrow{\text{Basic}} Na_2[Fe(CN)_5NOS]$

Purple coloration

$NO^+ + S^{2-} \rightarrow NOS^-$

**2.** The complete hydrolysis of $ICl, ClF_3$ and $BrF_5$, respectively, gives

(A) $IO^-, ClO_2^-$ and $BrO_3^-$ (B) $IO_3^-, ClO_2^-$ and $BrO_3^-$

(C) $IO^-, ClO^-$ and $BrO_2^-$ (D) $IO_3^-, ClO_4^-$ and $BrO_2^-$

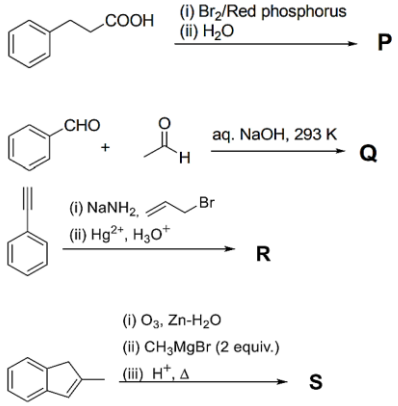
**Ans.** (A)

**Sol.** $ICl + H_2O \rightarrow HOI + HCl \rightarrow IO^{\ominus}$

$ClF_3 + 3H_2O \rightarrow HClO_2 + 3HF \rightarrow ClO_2^-$

$BrF_5 + 5H_2O \rightarrow HBrO_3 + 5HF \rightarrow BrO_3^-$

**3.** Monocyclic compounds P, Q, R and S are the major products formed in the reaction sequences given below.

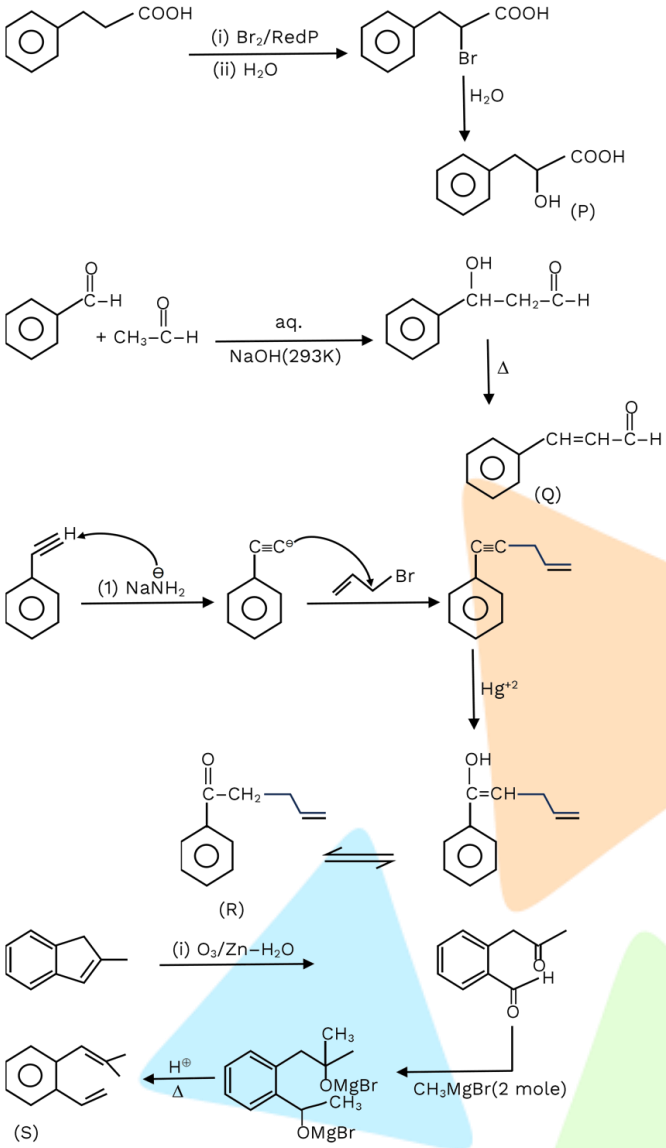



The product having the highest number of unsaturated carbon atom(s) is

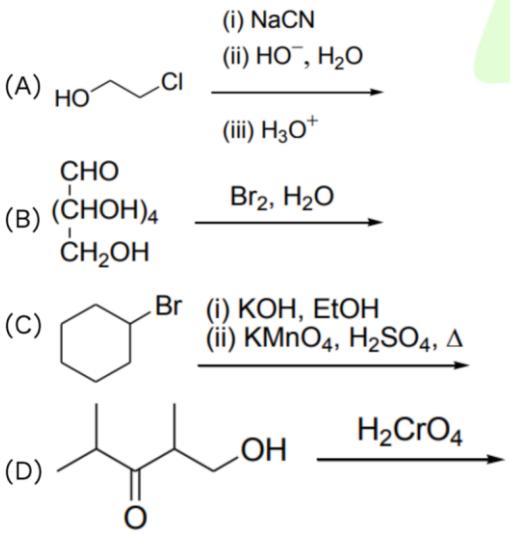
(A) P (B) Q (C) R (D) S

**Ans.** (D)

**Sol.**

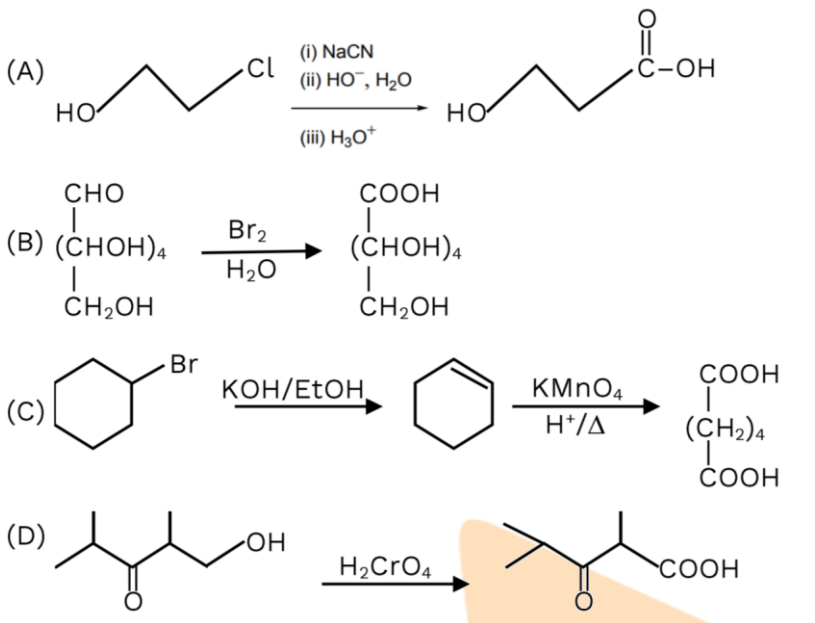



**4.** The correct reaction/reaction sequence that would produce a dicarboxylic acid as the major product is



**Ans.** (C)

**Sol.**


(A)
HO
Cl
(i) NaCN
(ii) HO⁻, H₂O
(iii) H₃O⁺
HO
O
C–OH
(B)
CHO
(CHOH)₄
CH₂OH
Br₂
H₂O
COOH
(CHOH)₄
CH₂OH
(C)
Br
KOH/EtOH
KMnO₄
H⁺/Δ
COOH
(CH₂)₄
COOH
(D)
OH
O
H₂CrO₄
COOH
O

**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 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.

**5.** The correct statement(s) about intermolecular forces is(are)

(A) The potential energy between two point charges approaches zero more rapidly than the potential energy between a point dipole and a point charge as the distance between them approaches infinity.

(B) The average potential energy of two rotating polar molecules that are separated by a distance $r$ has $1/r^3$ dependence.

(C) The dipole-induced dipole average interaction energy is independent of temperature.

(D) Nonpolar molecules attract one another even though neither has a permanent dipole moment

**Ans.** (D)

**Sol.** (A) lon-ion $\Rightarrow E \propto \frac{1}{r}$ ion-Dipole $\Rightarrow E \propto \frac{1}{r^2}$

(B) For rotating molecules $F_{alt} \propto \frac{1}{r^6}$ (False)

(C) False

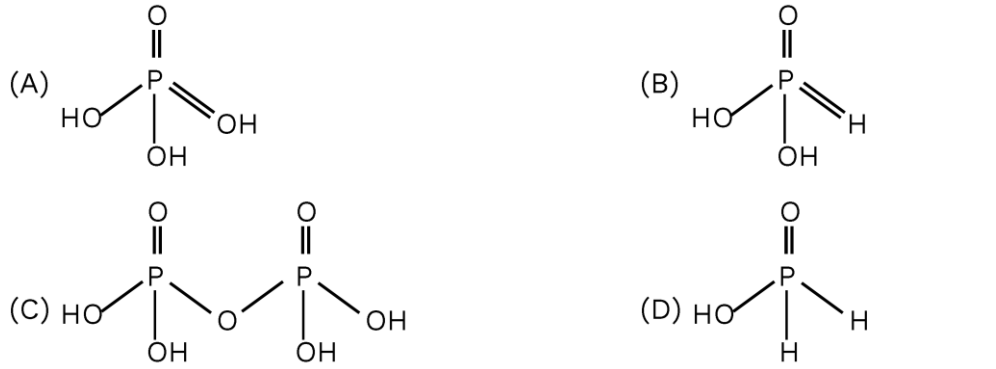
(D) True, due to London dispersive force attraction b/w non polar molecules occur.

**6.** The compound(s) with $P-H$ bond(s) is(are)

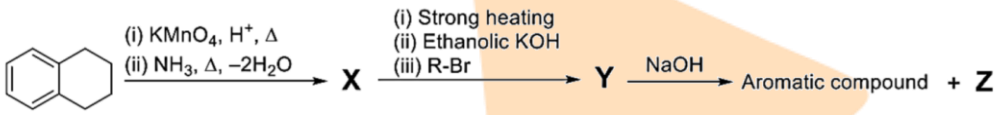
(A) $H_3PO_4$ (B) $H_3PO_3$ (C) $H_4P_2O_7$ (D) $H_3PO_2$

**Ans.** (BD)

**Sol.**




**7.** For the reaction sequence given below, the correct statement(s) is(are)




(A) Both $X$ and $Y$ are oxygen containing compounds.

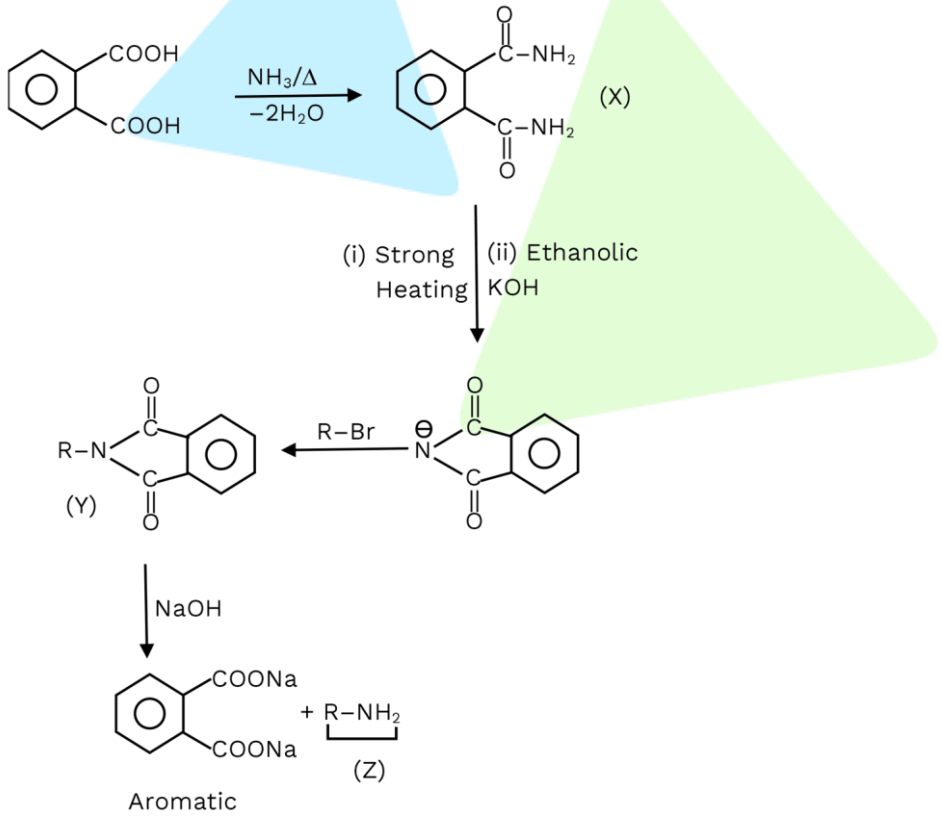
(B) Y on heating with $CHCl_3$ / KOH forms isocyanide.

(C) $Z$ reacts with Hinsberg's reagent.

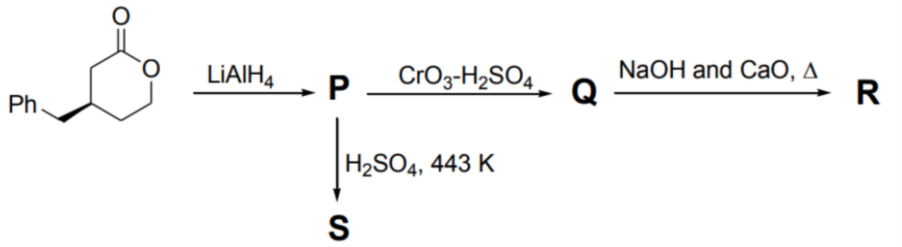
(D) $Z$ is an aromatic primary amine.

**Ans.** (AC)

**Sol.**



**8.** For the reaction sequence given below, the correct statement(s) is(are)




(A) **P** is optically active.

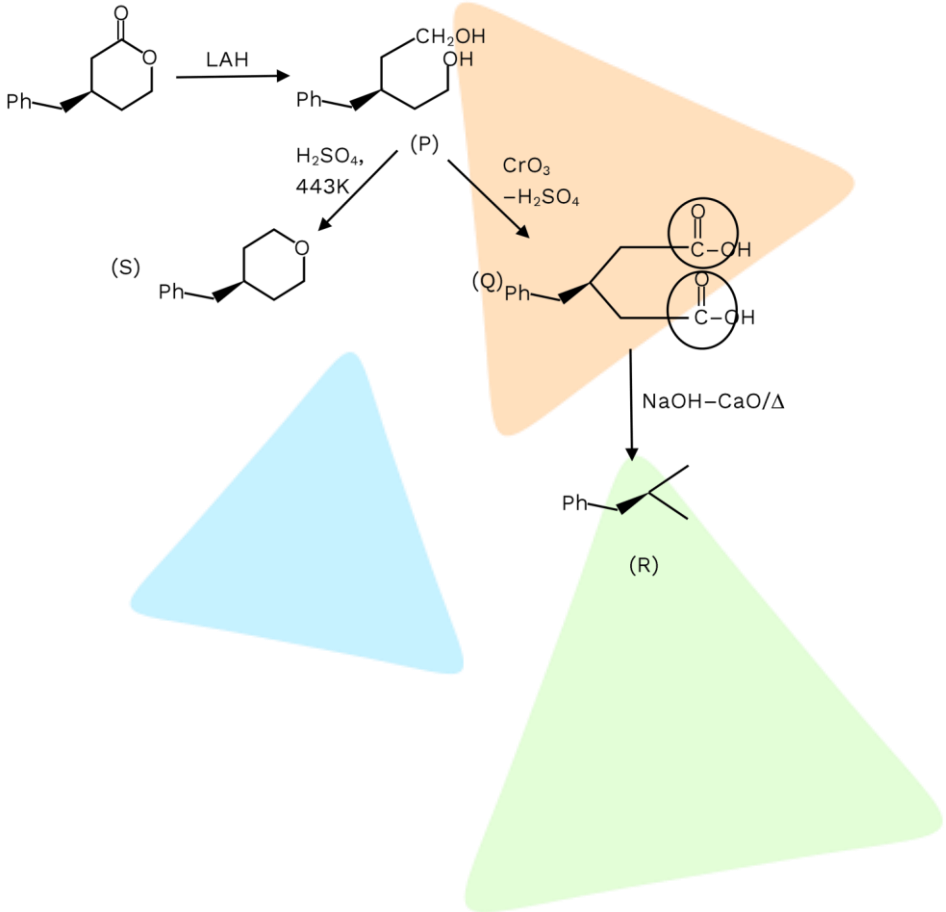
(B) **S** gives Bayer's test.

(C) **Q** gives effervescence with aq. $NaHCO_3$.

(D) **R** is an alkyne.

**Ans.** (C)

**Sol.**



**SECTION 3 (Maximum Marks: 24)**

- This section contains SIX (06) 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/roundoff the value to TWO decimal places.
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +4 ONLY if the correct numerical value is entered;
  Zero Marks : 0 In all other cases.

**9.** The density (in $gcm^{-3}$) of the metal which forms a cubic close packed (ccp) lattice with an axial distance (edge length) equal to 400 pm is_____.

**Use:** Atomic mass of metal $=105.6$ amu and Avogadro's constant $=6\times10^{23}\ mol^{-1}$

**Ans.** 11

**Sol.** $\text{Density} = \dfrac{Z\times \text{ Molar mass}}{N_A\times V}$

$$d=\frac{4\times105.6}{6\times10^{23}\times\left(400\times10^{-10}\right)^3}$$

$$=\frac{4\times105.6\times10}{6\times4\times4\times4}$$

$$=11gm/cm^3$$

**10.** The solubility of barium iodate in an aqueous solution prepared by mixing 200 mL of 0.010 M barium nitrate with 100 mL of 0.10 M sodium iodate is $\mathbf{X}\times10^{-6}$ $moldm^{-3}$. The value of **X** is

**Use:** Solubility product constant ($K_{sp}$) of barium iodate $=1.58\times10^{-9}$

**Ans.** 3.95

**Sol.** $Ba(NO_3)_2+2NaIO_3\rightarrow Ba(IO_3)_2(s)+2NaNO_3$

$t=02$ m.mol. $10$ m.mol

m. mol of $NaIO_3$ left $=10-4=6$

$$\left[IO_3^-\right]\text{in solution}=\frac{6}{300}=0.02M$$

$$\left[Ba^{2+}\right]\text{ in solution}=\frac{1.58\times10^{-9}}{\left[IO_3^-\right]^2}$$

$$=\frac{1.58\times10^{-9}}{(0.02)^2}$$

$$=3.95\times10^{-6}M$$

$$=X\times10^{-6}M$$

$$\therefore X=3.95$$

**11.** Adsorption of phenol from its aqueous solution on to fly ash obeys Freundlich isotherm. At a given temperature, from $10\text{mgg}^{-1}$ and $16\text{mgg}^{-1}$ aqueous phenol solutions, the concentrations of adsorbed phenol are measured to be $4\text{mgg}^{-1}$ and $10\text{mgg}^{-1}$, respectively. At this temperature, the concentration (in $\text{mgg}^{-1}$) of adsorbed phenol from $20\text{mgg}^{-1}$ aqueous solution of phenol will be Use: $\log_{10}2=0.3$

**Ans.** 16

**Sol.** Freundlich isotherm for adsorption from aqueous solution

$$\frac{x}{m}=k'(\text{conc})^{1/n}$$

at $C=10\text{mgg}^{-1}\Rightarrow\frac{x}{\text{m}}=4\text{mgg}^{-1}$

at $C=16\text{mgg}^{-1}\Rightarrow\frac{x}{\text{m}}=10\text{mgg}^{-1}$

$$4=K'(10)^{1/n} \quad .....(1)$$

$$10=K'(16)^{1/n} \quad .....(2)$$

$$\Rightarrow\frac{(1)}{(2)}\frac{4}{10}=\left(\frac{10}{16}\right)^{1/n}$$

$$\frac{1}{n}=\frac{\log10-\log4}{\log16-\log10}=\frac{1-0.6}{1.2-1}=2$$

Now, $C=20\text{mgg}^{-1}$

$$\frac{x}{m}=K'(20)^{1/n'} \quad .....(3)$$

$$\frac{(3)}{(1)}\frac{x/m}{4}=\left(\frac{20}{10}\right)^{1/n'}=2^{1/n'}=2^2=4$$

$$\frac{x}{m}=16\text{mg g}^{-1}$$

**12.** Consider a reaction $A+R\rightarrow$ Product. The rate of this reaction is measured to be $k[A][R]$. At the start of the reaction, the concentration of $R,[R]_0$, is 10-times the concentration of $A,[A]_0$. The reaction can be considered to be a pseudo first order reaction with assumption that $k[R]=k'$ is constant. Due to this assumption, the relative error (in %) in the rate when this reaction is $40\%$ complete, is

[k and k' represent corresponding rate constants]

**Ans.** 4.17

**Sol.** $A + R \rightarrow$ Product

$r = k[A][R]$

$[R]_0 = 10[A]_0$ reaction is considered as Pseudo $1^{st}$ order

$r = (k[R])[A]_0 = k'[A]_0$

Now 40% reaction complete

If we consider Pseudo Ist order reaction

rate $= r_1 = k'0.6[A]_0$

If we consider $2^{nd}$ order reaction

rate $= r_2 = k[R][A]$

$= k9.6[A]_0 \times 0.6[A]_0$

$= k(5.76)[A]_0^2$

$$\% \text{ relative error in rate} = \frac{[6[A]_0 - 5.76[A]_0]}{5.76[A]_0} \times 100$$

= 4.167%

**13.** At 300 K , an ideal dilute solution of a macromolecule exerts osmotic pressure that is expressed in terms of the height $(h)$ of the solution (density $= 1.00 \text{gcm}^{-3}$ ) where $h$ is equal to 2.00 cm . If the concentration of the dilute solution of the macromolecule is 2.00 $\text{gdm}^{-3}$, the molar mass of the macromolecule is calculated to be $\mathbf{X} \times 10^4$ g $\text{mol}^{-1}$. The value of **X** is

Use: Universal gas constant $(R) = 8.3$ J $\text{K}^{-1}$ $\text{mol}^{-1}$ and acceleration due to gravity $(g) = 10$ m $\text{s}^{-2}$

**Ans.** 2.49

**Sol.** Osmotic pressure $= \rho gh = cRT$

Osmotic pressure $= 10^3 \times 10 \times 2 \times 10^{-2}$ Pa

$$= \frac{2}{M} \times 10^3 \times 8.3 \times 300 = 10^3 \times 10 \times 0.02$$

$$M = \frac{2 \times 8.3 \times 300}{10 \times 0.02} = 24900 \text{ g mol}^{-1}$$

$= 2.49 \times 10^4$ g $\text{mol}^{-1}$

**14.** An electrochemical cell is fueled by the combustion of butane at 1 bar and 298 K . Its cell potential is $\frac{\mathbf{X}}{\text{F}} \times 10^3$ volts, where F is the Faraday constant. The value of **X** is .

Use: Standard Gibbs energies of formation at 298 K are:

$\Delta_f G^o_{CO_2} = -394$ kJ $\text{mol}^{-1}$; $\Delta_f G^0_{water} = -237$ kJ $\text{mol}^{-1}$; $\Delta_f G^0_{butane} = -18$ kJ $\text{mol}^{-1}$

**Ans.** 105.5

**Sol.** $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

$\Delta_r G^0 = \left[8\Delta_f G^0(CO_2) + 10\Delta_f G^0(H_2O)\right] - 2\Delta_f G^0$ (Butane)

$= 8(-394) + 10(-237) - 2(-18)$

$= -5486$ kJ / mol

number of electrons transferred $= 13 \times 4 = 52$

$$\therefore E^0_{cell} = -\frac{\Delta_r G^0}{nF} = \frac{5486 \times 10^3}{52 \text{ F}}$$

$$\frac{X}{F} \times 10^3 = \frac{105.5 \times 10^3}{F}$$

$X = 105.5$

**15.** The sum of the spin only magnetic moment values (in B.M.) of $[Mn(Br)_6]^{3-}$ and $[Mn(CN)_6]^{3-}$ is_____.

**Ans.** 7.73

**Sol.** $[Mn(Br)_6]^{3-}$ $Mn^{+3} = 3\ d^4$

Due to presence of weak field splitting is low

$\Delta_0$ < P.E, No pairing will occur

$[Mn(CN)_6]^{3-}$ $Mn^{+3} = 3\ d^4$

Due to presence of strong field ligand splitting is high.

$\Delta_0 >$ P.E. $\Rightarrow$ Pairing will occur

Number of unpaired electron $= 2$

$(\mu)_{1\ st\ complex} + (\mu)_{2\ nd\ complex} = \sqrt{4(4+2)} + \sqrt{2(2+2)} = 7.73$ B.M

**16.** A linear octasaccharide (molar mass $= 1024\ g\ mol^{-1}$) on complete hydrolysis produces three monosaccharides: ribose, 2-deoxyribose and glucose. The amount of 2-deoxyribose formed is $58.26\%(w/w)$ of the total amount of the monosaccharides produced in the hydrolyzed products. The number of ribose unit(s) present in one molecule of octasaccharide is .

**Use:** Molar mass (in $g\ mol^{-1}$) : ribose = 150, 2-deoxyribose = 134, glucose = 180; Atomic mass (in amu): $H = 1, O = 16$

**Ans.** **2**

**Sol.** Octasaccharide $\xrightarrow{H2O^{\oplus}}$ Ribose +2 -deoxyribose + glucose

1024 $\xrightarrow[7H_2O]{18\times7}$ 58.26%

1150 gm

2-deoxyribose is 58.26% of 1150 gm

$\frac{1150\times58.26}{100} = 670gm$

M.M. of 2-deoxyribose $= 134$

$\frac{670}{134} = 5$

Total mass $\rightarrow 1150$

Mass of ribose + glucose = 480

$\therefore$ Number of ribose $= 2$

Number of glucose $= 1$