# JEE–MAIN EXAMINATION – JANUARY 2025

**(HELD ON THURSDAY 23rd JANUARY 2025)** **TIME : 3 : 00 PM TO 6 : 00 PM**

## CHEMISTRY

## TEST PAPER WITH SOLUTION

### SECTION-A

**51.** The effect of temperature on spontaneity of reactions are represented as:

| | ΔH | ΔS | Temperature | Spontaneity |
|---|---|---|---|---|
| (A) | + | – | any T | Non spontaneous |
| (B) | + | + | low T | spontaneous |
| (C) | – | – | low T | Non spontaneous |
| (D) | – | + | any T | spontaneous |

(1) (B) and (D) only
(2) (A) and (D) only
(3) (B) and (C) only
(D) (A) and (C) only

**Ans.** **(3)**

**Sol.** $\because \Delta G = \Delta H - T\Delta S$

For spontaneity of reaction : $\Delta G = -ve$

**52.** Standard electrode potentials for a few half cells are mentioned below:

$E^{o}_{Cu^{2+}/Cu} = 0.34V, E^{o}_{Zn^{2+}/Zn} = -0.76V$

$E^{o}_{Ag^{+}/Ag} = 0.80V, E^{o}_{Mg^{2+}/Mg} = -2.37V$

Which one of the following cells gives the most negative value of $\Delta G^{o}$ ?

(1) $Zn|Zn^{2+}(1M)||Ag^{+}(1M)|Ag$
(2) $Zn|Zn^{2+}(1M)||Mg^{2+}(1M)|Mg$
(3) $Ag|Ag^{+}(1M)||Mg^{2+}(1M)|Mg$
(4) $Cu|Cu^{2+}(1M)||Ag^{+}(1M)|Ag$

**Ans.** **(1)**

**Sol.** $\because \Delta G^{\circ} = -nFE^{\circ}$

Option (1) $E^{\circ} = 0.8 + 0.76$
$= 1.56$ V
$\therefore \Delta G^{\circ} = -2 \times F \times 1.56$
$= -3.12$ V

Option (2) $E^{\circ} = -2.37 + 0.76$
$= -1.61$ V
$\therefore \Delta G^{\circ} = -2 \times F \times (-1.61)$
$= +3.22$ V

Option (3) $E^{\circ} = -2.37 - 0.8$
$= -3.17$ V
$\therefore \Delta G^{\circ} = -2 \times F \times (-3.17)$
$= +6.34$

Option (4) $E^{\circ} = 0.8 - 0.34$
$= 0.46$ V
$\Delta G^{\circ} = -2 \times F \times 0.46$
$= -0.92$ V

**53.** The α - Helix and β - Pleated sheet structures of protein are associated with its:

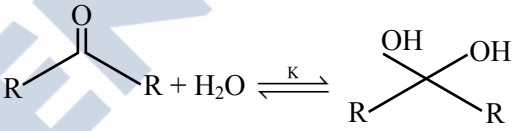
(1) quaternary structure
(2) primary structure
(3) secondary structure
(4) tertiary structure

**Ans.** **(3)**

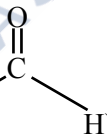
**Sol.** α-helix and β-pleated sheet belongs to secondary structure of protein, which have hydrogen bonds.

**54.** Given below are two statements:

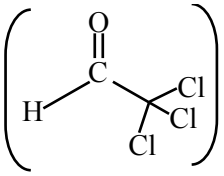
Consider the following reaction



**Statement (I) :** In the case of formaldehyde



(H H), K is about 2280, due to small substituents, hydration is faster.

**Statement (II) :** In the case of trichloro acetaldehyde  , K is about 2000 due to – I effect of – Cl.

In the light of the above statements, choose the **correct** answer from the options given below:

(1) **Statement I** true but **Statement II** is false
(2) Both **Statement I** and **Statement II** are true
(3) **Statement I** is false but **Statement II** is true
(4) Both **Statement I** and **Statement II** are false

**Ans.** **(2)**

**Sol.** $k_{eq} = 2280$ is for HCHO

$k_{eq} = 2000$ is for chloral

Both data is given in clayden and warren book.

$k_{eq} > 1$ because HCHO and chloral are more electrophilic.

**55.** Consider the reaction

$$X_2Y(g) \rightleftharpoons X_2(g) + \frac{1}{2}Y_2(g)$$

The equation representing correct relationship between the degree of dissociation (x) of $X_2Y(g)$ with its equilibrium constant Kp is_____.
Assume x to be very very small.

(1) $x = \sqrt[3]{\frac{2Kp}{p}}$ (2) $x = \sqrt[3]{\frac{2Kp^2}{p}}$

(3) $x = \sqrt[3]{\frac{Kp}{2p}}$ (4) $x = \sqrt[3]{\frac{Kp}{p}}$

**Ans. (2)**

**Sol.** 1 mole

$$X_2Y_{(g)} \rightleftharpoons X_{2(g)} + \frac{1}{2}Y_{2(g)}$$

1-x mole x mole $\frac{x}{2}$ mole

$$\therefore P_{X_2Y} = \frac{1-x}{1+\frac{x}{2}} \times P$$

$$P_{X_2} = \frac{x}{1+\frac{x}{2}} \times P$$

$$P_{Y_2} = \frac{x/2}{1+\frac{x}{2}} \times P$$

$$\therefore K_p = \left(\frac{x}{1+\frac{x}{2}}P\right)\left(\frac{x}{2\left(1+\frac{x}{2}\right)}P\right)^{\frac{1}{2}} \Big/ \left(\frac{1-x}{1+\frac{x}{2}} \times P\right)$$

$$\therefore K_p = \left(\frac{x}{1-x}\right)\left(\frac{x}{2\left(1+\frac{x}{2}\right)}\right)^{\frac{1}{2}} \times p^{\frac{1}{2}}$$

$\because$ x to be very very small

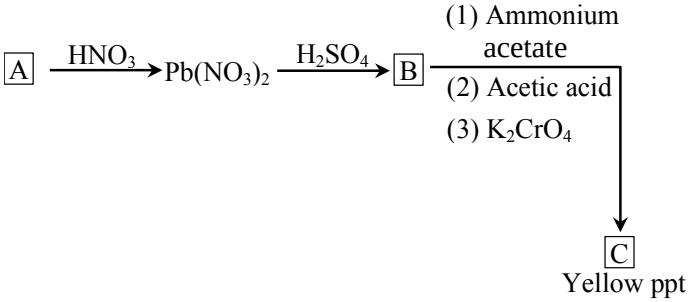
$$\therefore K_p = \frac{x^{3/2}}{(2)^{\frac{1}{2}}} \times P^{\frac{1}{2}}$$

$$\therefore x^{\frac{3}{2}} = \frac{K_p \times 2^{\frac{1}{2}}}{P^{\frac{1}{2}}}$$

$$\therefore x^3 = \frac{K_p^2 \times 2}{P}$$

$$x = \left(\frac{K_p^2 \times 2}{P}\right)^{\frac{1}{3}}$$

**56.** Identify A, B and C in the given below reaction sequence




(1) $PbCl_2$, $PbSO_4$, $PbCrO_4$

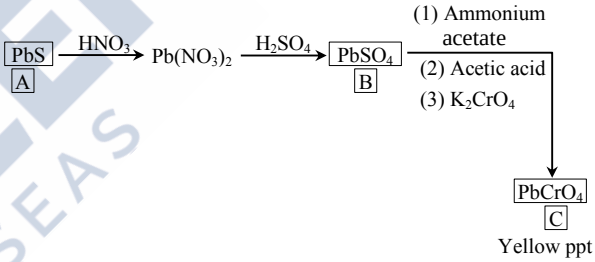
(2) PbS, $PbSO_4$, $PbCrO_4$

(3) PbS, $PbSO_4$, $Pb(CH_3COO)_2$

(4) $PbCl_2$, $Pb(SO_4)_2$, $PbCrO_4$

**Ans. (2)**

**Sol.**




**57.** Given below are two statements:

**Statement (I):** The boiling points of alcohols and phenols increase with increase in the number of C-atoms.

**Statement (II):** The boiling points of alcohols and phenols are higher in comparison to other class of compounds such as ethers, haloalkanes.

In the light of the above statements, choose the **correct** answer from the options given below:

(1) Both **Statement I** and **Statement II** are false

(2) **Statement I** is false but **Statement II** is true

(3) **Statement I** is true but **Statement II** is false

(4) Both **Statement I** and **Statement II** are true

**Ans. (4)**

**Sol.** B.P. $\propto$ M.W.

B.P. $\propto$ Inter molecular hydrogen bonding

Alcohol & Phenol have intermolecular H-bonding

**58.** When a non-volatile solute is added to the solvent, the vapour pressure of the solvent decreases by 10 mm of Hg. The mole fraction of the solute in the solution is 0.2. What would be the mole fraction of the solvent if decrease in vapour pressure is 20 mm of Hg ?

(1) 0.6 (2) 0.4

(3) 0.2 (4) 0.8

**Ans.** **(1)**

**Sol.** $\because P^\circ - P \propto X_{solute}$

and $\because 10 \propto 0.2$

$\therefore 20 \propto 0.4$

$\therefore X_{solvent} = 1 - X_{solute}$

$= 1 - 0.4$

$= 0.6$

**59.** Given below are two statements:

**Statement (I) :** For a given shell, the total number of allowed orbitals is given by $n^2$.

**Statement (II) :** For any subshell, the spatial orientation of the orbitals is given by $-l$ to $+l$ values including zero.

In the light of the above statements, choose the **correct** answer from the options given below:

(1) **Statement I** is true but **Statement II** is false

(2) **Statement I** is false but **Statement II** is true

(3) Both **Statement I** and **Statement II** are true

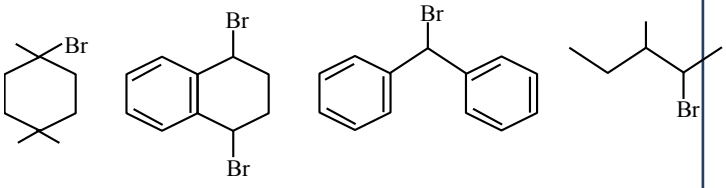
(4) Both **Statement I** and **Statement II** are false

**Ans.** **(3)**

**Sol.** For a shell total number of orbitals = $n^2$

Magnetic quantum number have values ($-\ell$ to $+\ell$) including 0.

**60.** The ascending order of relative rate of solvolysis of following compounds is



(A) (B) (C) (D)

(1) (D) < (A) < (B) < (C)

(2) (C) < (B) < (A) < (D)

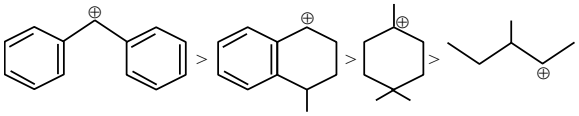
(3) (D) < (B) < (A) < (C)

(4) (C) < (D) < (B) < (A)

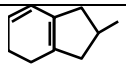
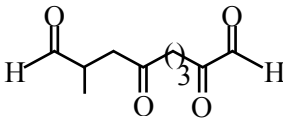
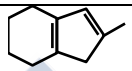
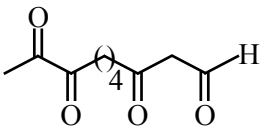
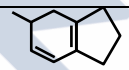
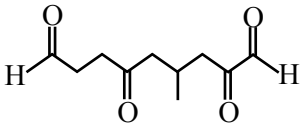
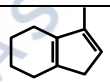
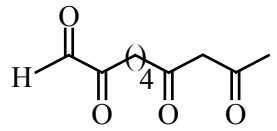
**Ans.** **(1)**

**Sol.** Solvolysis or $S_N1 \propto$ stability of carboccation

Stability order



**61.** Match **List - I** with **List - II**.

| **List - I (Isomers of $C_{10}H_{14}$)** | | **List - II (Ozonolysis product)** | |
|---|---|---|---|
| (A) |  | (I) |  |
| (B) |  | (II) |  |
| (C) |  | (III) |  |
| (D) |  | (IV) |  |

Choose the **correct** answer from the options given below :

(1) (A)-(II), (B)-(III), (C)-(I), (D)-(IV)

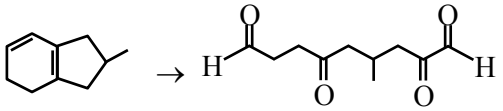
(2) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

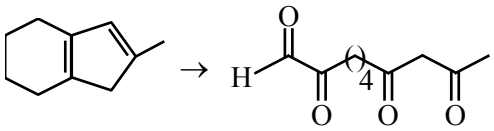
(3) (A)-(III), (B)-(II), (C)-(I), (D)-(IV)

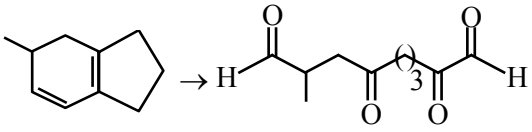
(4) (A)-(I), (B)-(IV), (C)-(III), (D)-(II)

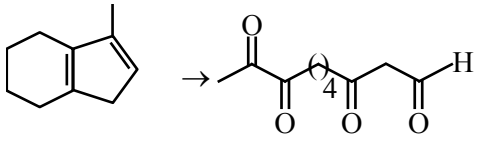
**Ans.** **(2)**

**Sol.** **Ozonolysis product**

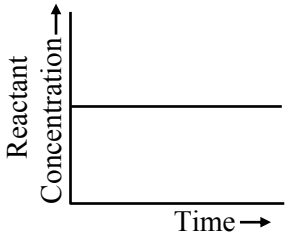
(A) 

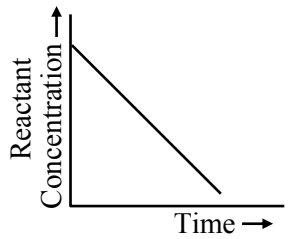
(B) 

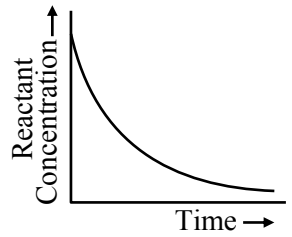
(C) 

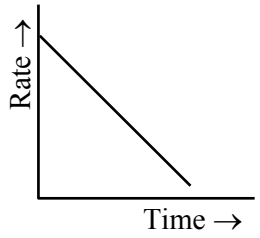
(D) 

**62.** Which of the following graphs most appropriately represents a zero order reaction ?

(1)



(2)



(3)


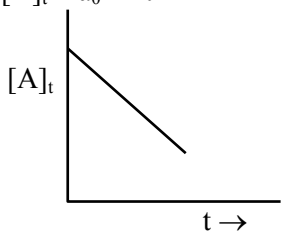

(4)



**Ans.** **(2)**

**Sol.** For zero order reaction : A → P

Rate = k

$[A]_t = a_0 - kt$




**63.** Match **List - I** with **List - II**.

| List - I | | List - II | |
|---|---|---|---|
| (A) | Bronze | (I) | Cu, Ni |
| (B) | Brass | (II) | Fe, Cr, Ni, C |
| (C) | UK silver coin | (III) | Cu, Zn |
| (D) | Stainless Steel | (IV) | Cu, Sn |

Choose the **correct** answer from the options given below :

(1) (A)-(IV), (B)-(II), (C)-(III), (D)-(I)

(2) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)

(3) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)

(4) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)

**Ans.** **(2)**

**Sol.** Bronze → Cu, Sn

Brass → Cu, Zn

UK silver coin → Cu, Ni

Stainless steel → Fe, Cr, Ni, C

**64.** Identify the coordination complexes in which the central metal ion has $d^4$ configuration.

(A) $[FeO_4]^{2-}$

(B) $[Mn(CN)_6]^{3-}$

(C) $[Fe(CN)_6]^{3-}$

(D) $Cr_2(O-\overset{\overset{O}{\|}}{C}-Me)_4(H_2O)_2$

(E) $[NiF_6]^{2-}$

Choose the **correct** answer from the options given below :

(1) (C) and (E) only (2) (B), (C) and (D) only

(3) (B) and (D) only (4) (A), (B) and (E) only

**Ans.** **(3)**

**Sol.** $Fe^{+6} = [Ar]3d^2$

$Mn^{+3} = [Ar]3d^4$

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

$Cr^{+2} = [Ar]3d^4$

$Ni^{+4} = [Ar]3d^6$

**65.** Given below are the atomic numbers of some group 14 elements. The atomic number of the element with lowest melting point is :

(1) 14 (2) 6

(3) 82 (4) 50

**Ans.** **(4)**

**Sol.** Order of M.P. of group 14 : C > Si > Ge > Pb > Sn

| element | M.P. (°C) |
|---|---|
| Z = 6 = C | 3730 |
| Z = 14 = Si | 1410 |
| Z = 32 = Ge | 937 |
| $\boxed{Z=50}$ = Sn | 232 |
| Z = 82 = Pb | 327 |

**66.** pH of water is 7 at 25°C. If water is heated to 80°C, it's pH will :

(1) Decrease

(2) Remains the same

(3) $H^+$ concentration increases, $OH^-$ concentration decreases

(4) Increase

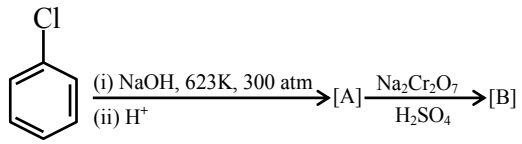
**Ans.** **(1)**

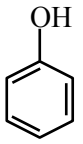
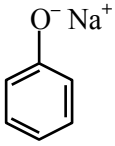
**Sol.** With increase in temperature, $K_w$ of water increases

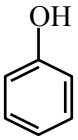
So, degree of dissociation of water increase

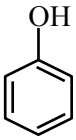
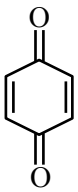
∴ pH as well as pOH of water decrease.

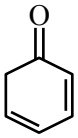
**67.** Identify the products [A] and [B], respectively in the following reaction :




(1) [A]  , [B] 


(2) [A]  , [B] 


(3) [A]  , [B] 


(4) [A]  , [B] 


**Ans.** **(3)**

**Sol.** A is phenol and B is para benzoquinone.

**68.** Consider a binary solution of two volatile liquid components 1 and 2 $x_1$ and $y_1$ are the mole fractions of component 1 in liquid and vapour phase, respectively. The slope and intercept of the linear plot of $\frac{1}{x_1}$ vs $\frac{1}{y_1}$ are given respectively as :

(1) $\frac{P_1^0}{P_2^0}, \frac{P_2^0 - P_1^0}{P_2^0}$ (2) $\frac{P_2^0}{P_1^0}, \frac{P_1^0 - P_2^0}{P_2^0}$

(3) $\frac{P_1^0}{P_2^0}, \frac{P_1^0 - P_2^0}{P_2^0}$ (4) $\frac{P_2^0}{P_1^0}, \frac{P_2^0 - P_1^0}{P_2^0}$

**Ans.** **(1)**

**Sol.** $\because$ For liquid solution of two liquids '1' and '2'

$P_1 = P_T y_1 = P_1^o x_1$

$\therefore \frac{P_T}{x_1} = \frac{P_1^o}{y_1}$

$\therefore \frac{P_2^o + x_1(P_1^o - P_2^o)}{x_1} = \frac{P_1^o}{y_1}$

$\therefore \frac{P_2^o}{x_1} + (P_1^o - P_2^o) = \frac{P_1^o}{y_1}$

$\therefore \frac{1}{x_1} = \left(\frac{P_1^o}{P_2^o}\right)\left(\frac{1}{y_1}\right) + \left(\frac{P_2^o - P_1^o}{P_2^o}\right)$

$\therefore$ Slope $= \left(\frac{P_1^o}{P_2^o}\right)$

$\therefore$ Intercept $= \left(\frac{P_2^o - P_1^o}{P_2^o}\right)$

**69.** Given below are two statements about X-ray spectra of elements :

**Statement (I) :** A plot of $\sqrt{\nu}$ ($\nu$ = frequency of X-rays emitted) vs atomic mass is a straight line.

**Statement (II) :** A plot of $\nu$($\nu$ = frequency of X-rays emitted) vs atomic number is a straight line.

In the light of the above statements choose the **correct** answer from the options given below :

(1) **Statement I** is true but **Statement II** is false

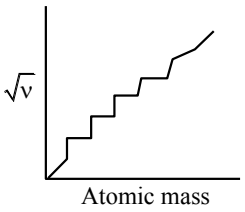
(2) Both **Statement I** and **Statement II** are true

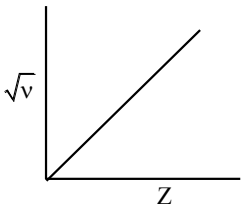
(3) Both **Statement I** and **Statement II** are false

(4) **Statement I** is false but **Statement II** is true

**Ans.** **(3)**

**Sol.**




**70.** Consider the following reactions

$K_2Cr_2O_7 \xrightarrow[-H_2O]{KOH} [A] \xrightarrow[-H_2O]{H_2SO_4} [B] + K_2SO_4$

The products [A] and [B], respectively are :

(1) $K_2Cr(OH)_6$ and $Cr_2O_3$

(2) $K_2CrO_4$ and $Cr_2O_3$

(3) $K_2CrO_4$ and $K_2Cr_2O_7$

(4) $K_2CrO_4$ and CrO

**Ans.** **(3)**

**Sol.** $K_2Cr_2O_7 \xrightarrow[-H_2O]{KOH} \underset{[A]}{K_2CrO_4} \xrightarrow[-H_2O]{H_2SO_4} \underset{[B]}{K_2Cr_2O_7} + K_2SO_4$

## SECTION-B

**71.** 0.01 mole of an organic compound (X) containing 10% hydrogen, on complete combustion produced 0.9 g $H_2O$. Molar mass of (X) is _____ g $mol^{-1}$.

**Ans.** **(100)**

**Sol.** Organic compound $\xrightarrow{\text{combustion}}$ $\underset{0.9\text{gm}}{H_2O}$

$\therefore$ mole of $H_2O = \frac{0.9}{18} = 0.05$ mole

$\therefore$ mole of H in $H_2O = 0.05 \times 2 = 0.1$ mole

= mole of H in 0.01 mole Organic compound

$\therefore$ wt of H atom in 0.01 mole compound $= 0.1 \times 1$

$= 0.1$ gm

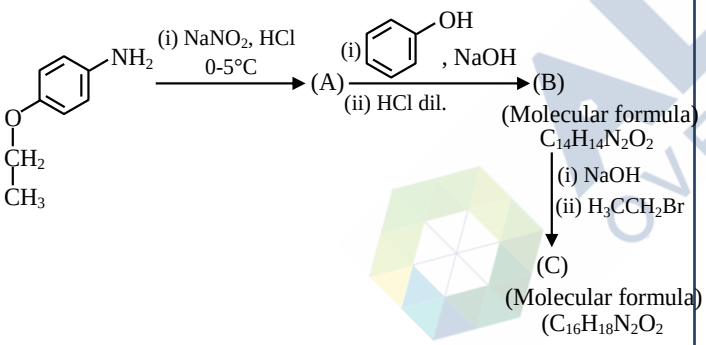
$\therefore$ wt of H atom in one mole compound $= \frac{0.1}{0.01} = 10\text{gm}$

$\because$ wt. % of H $= \frac{\text{wt. of H in one mole compound}}{\text{Molar mass of compound}} \times 1$

$10 = \frac{10}{M} \times 100$

$\therefore$ $\boxed{M = 100}$

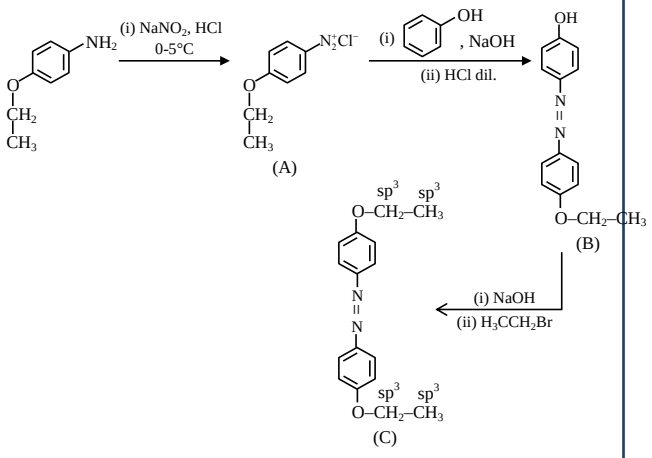
**72.** Consider the following sequence of reactions.




Total number of $sp^3$ hybridised carbon atoms in the major product C formed is _____.

**Ans.** **(4)**

**Sol.**




**73.** When 81.0 g of aluminium is allowed to react with 128.0 g of oxygen gas, the mass of aluminium oxide produced in grams is ____. (Nearest integer)

Given :

Molar mass of Al is 27.0 g $mol^{-1}$

Molar mass of O is 16.0 g $mol^{-1}$

**Ans.** **(153)**

**Sol.** $4Al + 3O_2 \longrightarrow 2Al_2O_3$

$\frac{81}{27} = 3\,\text{mole}$ $\quad \frac{128}{32} = 4\,\text{mole}$

Limiting reagent

$\therefore$ mole of $Al_2O_3$ formed $= \frac{1}{2} \times 3$ mole

$\therefore$ wt. of $Al_2O_3$ formed $= \frac{3}{2} \times 102$

$= 153$ gm

**74.** The bond dissociation enthalpy of $X_2$ $\Delta H^{\circ}_{bond}$ calculated from the given data is _____ kJ $mol^{-1}$. (Nearest integer)

$M^+X^-(s) \rightarrow M^+(g) + X^-(g)$ $\Delta H^{\circ}_{lattice} = 800$ kJ $mol^{-1}$

$M(s) \rightarrow M(g)$ $\Delta H^{\circ}_{sub} = 100$ kJ $mol^{-1}$

$M(g) \rightarrow M^+(g)^- + e^-(g)$ $\Delta H^{\circ}_{i} = 500$ kJ $mol^{-1}$

$X(g) + e^-(g) \rightarrow X^-(g)$ $\Delta H^{\circ}_{eg} = -300$ kJ $mol^{-1}$

$M(s) + \frac{1}{2}X_2(g) \rightarrow M^+X^-(s)$ $\Delta H^{\circ}_{f} = -400$ kJ $mol^{-1}$

[Given : $M^+X^-$ is a pure ionic compound and X forms a diatomic molecule $X_2$ is gaseous state]

**Ans.** **(200)**

**Sol.**

$$M_{(s)} + \frac{1}{2}X_{2(g)} \longrightarrow M^{\oplus}X^{\ominus}_{(s)}$$

$$\downarrow \qquad \downarrow$$

$$M_{(g)} \quad X_{(g)}$$

$$\downarrow \qquad \downarrow$$

$$M^+_{(g)} + X^-_{(g)} \longrightarrow$$

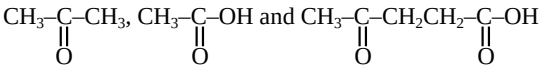
$\therefore$ $\Delta H_f(MX) = \Delta H_{sub}(M) + I.E.(M) + \frac{1}{2}[B.E.(X-X)]$

$+ EG(X) + L.E.(MX)$

$-400 = (100) + (500) + \frac{1}{2}(B.E.) + (-300) + (-800)$

$\therefore$ B.E. = 200 kJ $mole^{-1}$

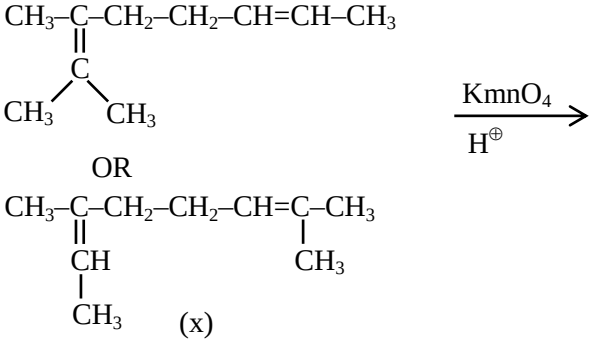
**75.** A compound 'X' absorbs 2 moles of hydrogen and 'X' upon oxidation with $KMnO_4 \mid H^+$ gives



The total number of σ bonds present in the compound 'X' is _____.

**Ans.** **(27)**

**Sol.**



OR



(x)