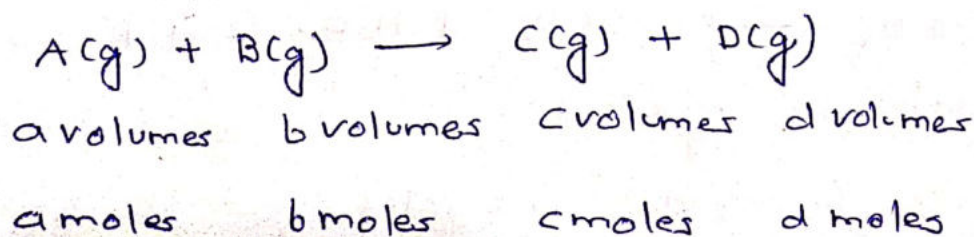


:- EUDIOMETRY OR GAS ANALYSIS :- (1)

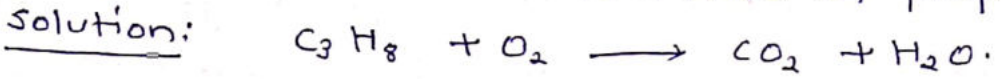
Gaseous reactions are carried out in a special type of tube known as eudiometer tube. The tube is graduated in millimeter for volume measurement. The reacting gases taken in eudiometer tube are exploded by sparks, produced by passing electricity through the platinum terminal provided in the tube. The volumes of the products of a gaseous explosion are determined by absorbing them in suitable reagents. e.g. SO_2 , & CO_2 absorbed in KOH solution, O_2 is absorbed in a solution of alkaline pyrogallol, & CO is absorbed in a solution of ammonical cuprous chloride.

Since H_2O vapour produced during the reaction changes to liquid on cooling, the volume of water is neglected, but while applying POAC, moles of H_2O produced cannot be neglected.

Eudiometry is mainly based on Avogadro's Law, which states that equal volumes of all gases under similar conditions of temperature & pressure contain equal number of molecules also have equal number of moles. The mole concept may be applied in solving the problem.



Example: What volume of oxygen will be required for the complete combustion of 18.2 litres of propane at NTP?



Applying PoAc for Carbon Atom, we have;

Mole of C in C_3H_8 = Moles of C in CO_2 .

$3x$ moles of C_3H_8 = $1x$ moles of CO_2 . — (1)

Applying PoAc for H & O atoms,

$8x$ moles of C_3H_8 = $2x$ moles of H_2O — (2)

$2x$ moles of O_2 = $2x$ moles of CO_2 + $1x$ moles of H_2O — (3)

From eq (1) & (2) & (3)

$2x$ moles of O_2 = $2x3x$ moles of C_3H_8 + $1x4x$ moles of C_3H_8

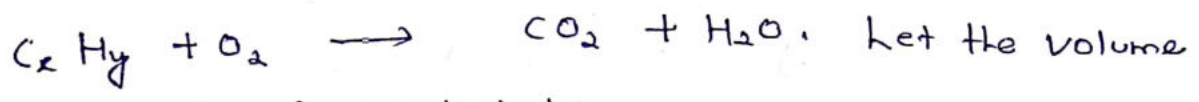
Moles of O_2 = $5x$ moles of C_3H_8 .

$\frac{\text{Vol. of } O_2 \text{ at NTP}}{22.4} = 5 \times \frac{\text{Volume of } C_3H_8 \text{ NTP}}{22.4}$

Vol. of O_2 at NTP = $5 \times 18.2 = 91$ litres.

Example: 10 ml of a gaseous hydrocarbon was burnt completely in 80 ml of O_2 at NTP. The remaining gas occupied 70 ml at NTP. The volume became 50 ml on treatment with KOH solution. What is the formula of the hydrocarbon?

Solution: Let the hydrocarbon be C_xH_y .



occupied by water is neglected.

Volume of CO_2 produced + unreacted O_2 = 70 ml

Volume of unreacted O_2 (CO_2 absorbed by KOH) = 50 ml

Volume of O_2 needed with 10 ml of Hydrocarbon = $(80 - 50) \text{ ml} = 30 \text{ ml}$

and, Volume of CO_2 produced by 10 mL of hydrocarbon & 30 mL of $\text{O}_2 = (70 - 50) \text{ mL} = 20 \text{ mL}$.

Applying POAC for Oxygen atoms,

$$2 \times \text{moles of } \text{O}_2 = 2 \times \text{moles of } \text{CO}_2 + 1 \times \text{moles of } \text{H}_2\text{O}$$

$$2 \times 30 = 2 \times 20 + \text{moles of } \text{H}_2\text{O}$$

$$\text{moles of } \text{H}_2\text{O} = 20$$

Applying POAC for C atoms,

$$x \times \text{moles of } \text{C}_x\text{H}_y = 1 \times \text{moles of } \text{CO}_2$$

$$x \times 10 = 1 \times 20 \quad \therefore x = 2$$

Applying POAC for H atoms,

$$y \times \text{moles of } \text{C}_x\text{H}_y = 2 \times \text{moles of } \text{H}_2\text{O}$$

$$y \times 10 = 2 \times 20 \quad \therefore y = 4$$

The formula of hydrocarbon is C_2H_4 .

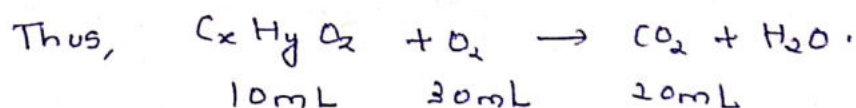
Example: 10 mL of a gaseous organic compound containing C, H and O only was mixed with 100 mL of oxygen and exploded under conditions which allow the water formed to condense. The volume of the gas after explosion was 90 mL. On treatment with potash solution, a further contraction of 10 mL in volume was observed. Given that the vapour density of the compound is 23, deduce the molecular formula. ~~AH~~

Solution: Volume of unreacted O_2 + vol. of $\text{CO}_2 = 90 \text{ mL}$.

$$\text{Volume of } \text{CO}_2 \text{ (absorbed by KOH)} = 20 \text{ mL}$$

$$\text{Volume of unreacted } \text{O}_2 = (90 - 20) = 70 \text{ mL}$$

$$\begin{aligned} \text{Volume of } \text{O}_2 \text{ reacted with 10 mL of compound} \\ = (100 - 70) \text{ mL} = 30 \text{ mL} \end{aligned}$$



Applying POAC for C atom,

$$x \times \text{moles of } C_x H_y O_z = 1 \times \text{moles of } CO_2.$$

$$x \times 10 = 1 \times 20 \quad ; \quad x = 2.$$

Applying POAC for H & O atoms, we get respectively;

$$y \times \text{moles of } C_x H_y O_z = 2 \times \text{moles of } H_2O.$$

$$10y = 2 \times \text{moles of } H_2O \quad \text{--- (1)}$$

$$2 \times \text{moles of } C_x H_y O_z + 2 \times \text{moles of } O_2 = 2 \times \text{moles of } CO_2 + 1 \times \text{moles of } H_2O.$$

$$10z + 2 \times 30 = 2 \times 20 + \text{moles of } H_2O \quad \text{--- (2)}$$

From eq (1) & (2)

$$y - 2z = 4 \quad \text{--- (3)}$$

$$\text{Molecular wt. of the compound} = 2 \times 23 = 46.$$

For the compound, $C_x H_y O_z$

$$2 \times 12 + y \times 1 + z \times 16 = 46$$

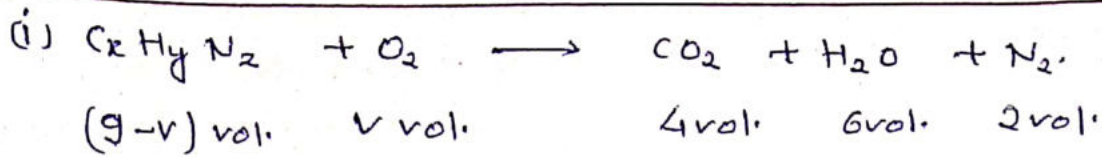
$$y + 16z = 22 \quad \text{--- (4)}$$

From eq (3) & (4), we get; $y = 6$ & $z = 1$.

Formula of the compound is $C_2 H_6 O$.

Example: 9 volumes of gaseous mixture consisting of a gaseous organic compound A and just sufficient amount of oxygen required for complete combustion, yielded on burning, 4 volume of CO_2 , 6 volume of water vapour & 2 volume of N_2 , all volume measured at the same temperature & pressure. If the compound A contained only C, H and N. (i) How many volumes of oxygen are required for complete combustion (ii) What is the molecular formula of the compound A?

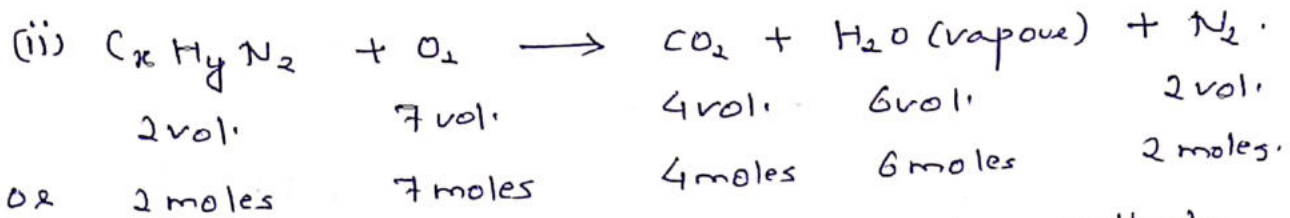
Solution: The compound A is $C_x H_y N_z$.



Applying POAC for Oxygen Atoms,

$$2x \text{ moles of } O_2 = 2x \text{ moles of } CO_2 + 1x \text{ moles of } H_2O$$

$$2v = 2 \times 4 + 1 \times 6 = 14 \quad ; \quad v = 7 \text{ volumes.}$$



Applying POAC for C, H & N, we get respectively,

$$x \times \text{ moles of } C_x H_y N_z = 1 \times \text{ moles of } CO_2$$

$$x \times 2 = 1 \times 4 \quad ; \quad x = 2$$

$$y \times \text{ moles of } C_x H_y N_z = 2 \times \text{ moles of } H_2O \text{ (vapour)}$$

$$y \times 2 = 2 \times 6 \quad ; \quad y = 6$$

$$z \times \text{ moles of } C_x H_y N_z = 2 \times \text{ moles of } N_2$$

$$z \times 2 = 2 \times 2 \quad ; \quad z = 2$$

Hence, the compound is $C_2 H_6 N_2$.

Example: 50 mL of mixture of CO & CH₄ was exploded with 85 mL of O₂. The volume of CO₂ produced was 50 mL. Calculate the percentage composition of the gaseous mixture if all volumes are measured under the same conditions, and the given vol. of O₂ is just sufficient for the combustion of 50 mL of the mixture CO & CH₄.

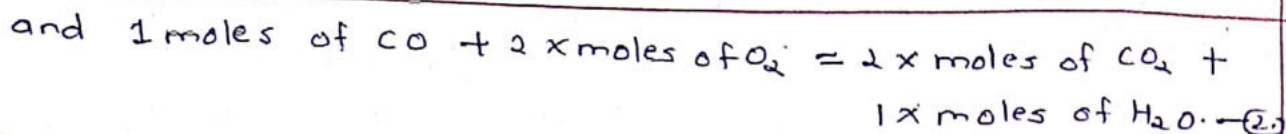


$$(50-x) \text{ mL} \quad x \text{ mL} \quad 85 \text{ mL} \quad 50 \text{ mL.}$$

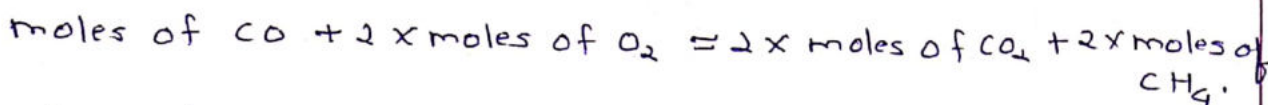
$$(50-x) \text{ mole} \quad x \text{ mole} \quad 85 \text{ mole} \quad 50 \text{ moles.}$$

Applying POAC for H and O atoms,

$$4x \text{ moles of } CH_4 = 2x \text{ moles of } H_2O \quad \text{--- (1)}$$



From eq (1) & (2)



$$(50-x) + 2 \times 85 = 2 \times 50 + 2 \times x$$

$$x = 40.$$

Hence, volume of CH₄ = 40 mL.

$$\text{volume of CO} = (50 - 40) = 10 \text{ mL.}$$

$$\% \text{ of CH}_4 \text{ in the mixture} = \frac{40}{50} \times 100 = 80\%$$

$$\text{Percentage of CO} = 20\%$$

Example: A sample of coal gas contained H₂, CH₄ & CO. 20 mL of this mixture was exploded with 80 mL of oxygen. On cooling, the volume of gases was 68 mL. There was contraction of 10 mL when treated with KOH. Find the composition of the original mixture.

Solution: Volume of total O₂ = 80 mL.

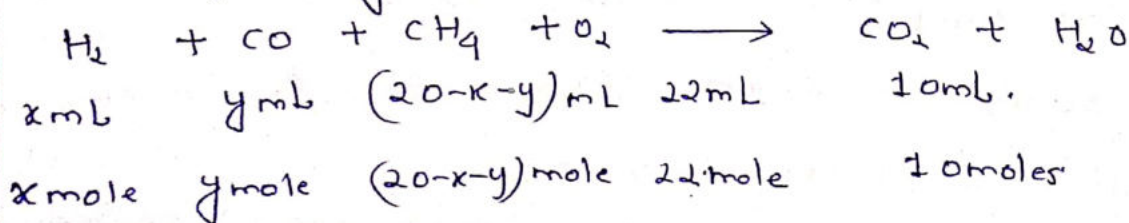
$$\text{Volume of CO}_2 + \text{unreacted O}_2 = 68 \text{ mL.}$$

$$\text{Volume of CO}_2 = 10 \text{ mL (absorbed in KOH)}$$

$$\therefore \text{Volume of unreacted O}_2 = (68 - 10) \text{ mL} = 58 \text{ mL.}$$

$$\text{Volume of O}_2 \text{ Used in explosion} = (80 - 58) = 22 \text{ mL.}$$

Let the Volume of H₂ & CO in the mixture be x mL and y mL respectively.



Applying POAC for H, O & C atoms,

$$2x \text{ moles of H}_2 + 4x \text{ moles of CH}_4 = 2x \text{ moles of H}_2\text{O}$$

$$2x + 4(20 - x - y) = 2x \text{ moles of H}_2\text{O} \quad \text{--- (1)}$$

$$1x \text{ moles of CO} + 1x \text{ moles of CH}_4 = 1x \text{ moles of CO}_2$$

$$y + (20 - x - y) = 10 \quad \text{--- (2)}$$

$$1x \text{ moles of CO} + 2x \text{ moles of O}_2 = 2x \text{ moles of CO}_2 + 1x \text{ moles of H}_2\text{O}$$

$$y + 2 \times 22 = 2 \times 10 + \text{moles of H}_2\text{O} \quad \text{--- (3)}$$

From eq (1) & (3): $x = 10 \text{ mL}$.

Eliminating moles of H₂O, we get:

$$y + 44 = 20 + x + 2(20 - x - y)$$

$$3y = 6$$

$$y = 2 \text{ mL}$$

$$\text{Volume of CH}_4 = 20 - (10 + 2) = 8 \text{ mL}$$

$$\% \text{ of H}_2 \text{ in the mixture} = \frac{10}{20} \times 100 = 50\%$$

$$\% \text{ volume of CO in the mixture} = \frac{2}{20} \times 100 = 10\%$$

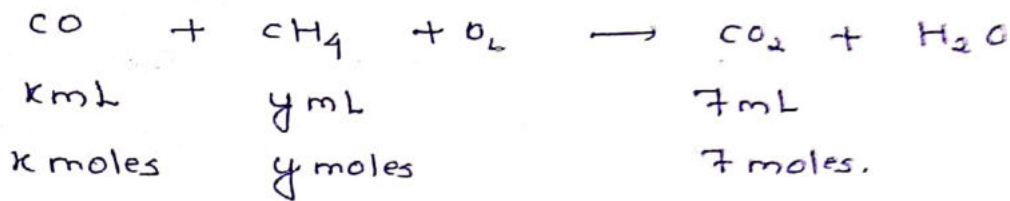
$$\% \text{ volume of CH}_4 \text{ in the mixture} = \frac{8}{20} \times 100 = 40\%$$

Example: 10 mL of mixture of CO, CH₄ & N₂, exploded with excess of oxygen gave a contraction of 6.5 mL. There was a further contraction of 7 mL when the residual gas was treated with KOH. What is the composition of the mixture?

Solution: In the explosion, N₂ does not take part in the reaction, while CO & CH₄ changes to CO₂ & H₂O, volume of H₂O (water) being zero.

Let the volume of $\text{CO} = x \text{ mL}$, $\text{CH}_4 = y \text{ mL}$, $\text{N}_2 = (10 - x - y) \text{ mL}$.

The reaction is



Applying POAC for C, O, & H atoms, we get respectively,

moles of $\text{CO} + \text{moles of CH}_4 = \text{moles of CO}_2$.

$$x + y = 7 \quad \text{--- (1)}$$

moles of $\text{CO} + 2 \times \text{moles of O}_2 = 2 \times \text{moles of CO}_2 + \text{moles of H}_2\text{O}$

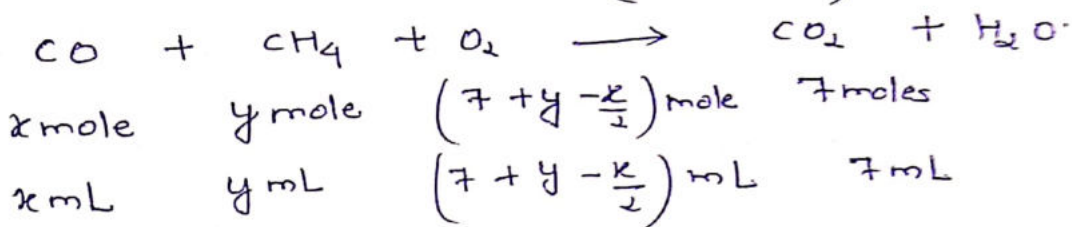
$$x + 2 \times \text{moles of O}_2 = 14 + \text{moles of H}_2\text{O} \quad \text{--- (2)}$$

$$4 \times \text{moles of CH}_4 = 2 \times \text{moles of H}_2\text{O} \quad \text{--- (3)}$$

$$4y = 2 \times \text{moles of H}_2\text{O}$$

From eq (2) & (3),

$$\text{moles of O}_2 = \left(7 + y - \frac{x}{2}\right)$$



Volume of reactants - volume of products = 6.5 mL.

Volume of $(\text{CO} + \text{CH}_4 + \text{O}_2) - \text{Vol. of CO}_2 = 6.5 \text{ mL}$.

$$x + y + \left(7 + y - \frac{x}{2}\right) - 7 = 6.5$$

$$x + 4y = 13. \quad \text{--- (4)}$$

From eq (1) & (4), $x = 5, y = 2$.

$$\left. \begin{array}{l} \text{Vol. of CO} = 5 \text{ mL} \\ \text{Vol. of CH}_4 = 2 \text{ mL} \\ \text{Vol. of N}_2 = (10 - 5 - 2) = 3 \text{ mL} \end{array} \right\}$$

Exercise:

- 1) 10ml of a mixture of CH_4 , C_2H_4 and CO_2 was exploded with excess of air. After explosion there was contraction of 17ml and after treatment with KOH , there was a further reduction of 14ml. What was composition of the mixture? [Ans: vol. of $\text{NO} = 44\text{mL}$
vol. of $\text{N}_2\text{O} = 16\text{mL}$]
- (2) A mixture of formic acid and oxalic acid is heated with concentrated H_2SO_4 . The gas is produced is collected and on its treatment with KOH solution the volume of the gas decreased by $\frac{1}{6}\text{th}$. Calculate the molar ratio of the two acids in the original mixture? Ans: [4:1]
- (3) 40ml of a mixture of H_2 , CH_4 and N_2 was exploded with 10ml of oxygen. On cooling, the gases occupied 36.5ml. After treatment with KOH , the volume reduced by 3ml and again on treatment with alkaline pyrogallol, the volume further decreased by 1.5ml. Determine the composition of the mixture? Ans: [$\text{H}_2 = 12.5\%$, $\text{CH}_4 = 7.5\%$, $\text{N}_2 = 80\%$]
- (4) 20ml of a mixture of C_2H_2 and CO was exploded with 30ml of oxygen. The gases after the reaction had a volume of 34ml. On treatment with KOH , 8ml of oxygen remained. Calculate the composition of the mixture? [Ans: $\text{C}_2\text{H}_2 = 6\text{mL}$, $\text{CO} = 14\text{mL}$]
- (5) One volume of a compound of carbon, hydrogen and oxygen was exploded with 2.5 volume of oxygen. The resultant mixture contained 2 volumes of water vapour & 1 volume of CO_2 . Determine the formula of compound. Ans: [$\text{C}_2\text{H}_4\text{O}$].