Combustion Analysis

Defination:

"The experimental technique by which amount of various Elements present in an substance are determined by combustion is called Combustion analysis"

(i) It is used to find Emperical and molecular formula of organic Compound.

(ii) Organic Compound that contain carbon, hydrogen and oxygen ($C_aH_bO_c$) can be determined

(iii) The only products will be CO_2 and H_2O and these two Products are collected seperately.

Drawback: • Molecular and emperical formula of Compounds containing Elements other than Carbon, hydrogen and Oxygen cannot be determined.

Procedure:

(i) A weighed quantity of the compound is burned Completely in the Excess of oxygen.

(ii) Hydrogen and carbon contained in the compound are converted into H_2O and CO_2 respectivily.

(iii) The water vapour formed are absorbed by magnesium perchlorate $[Mg(ClO_4)_2]$

(iv) The CO_2 is absorbed by in 50% KOH solution.

imp
∴ MCQs $H_2O \longrightarrow Mg(ClO_4)_2$

$CO_2 \xrightarrow{\text{absorbed by}} 50\%\ KOH$

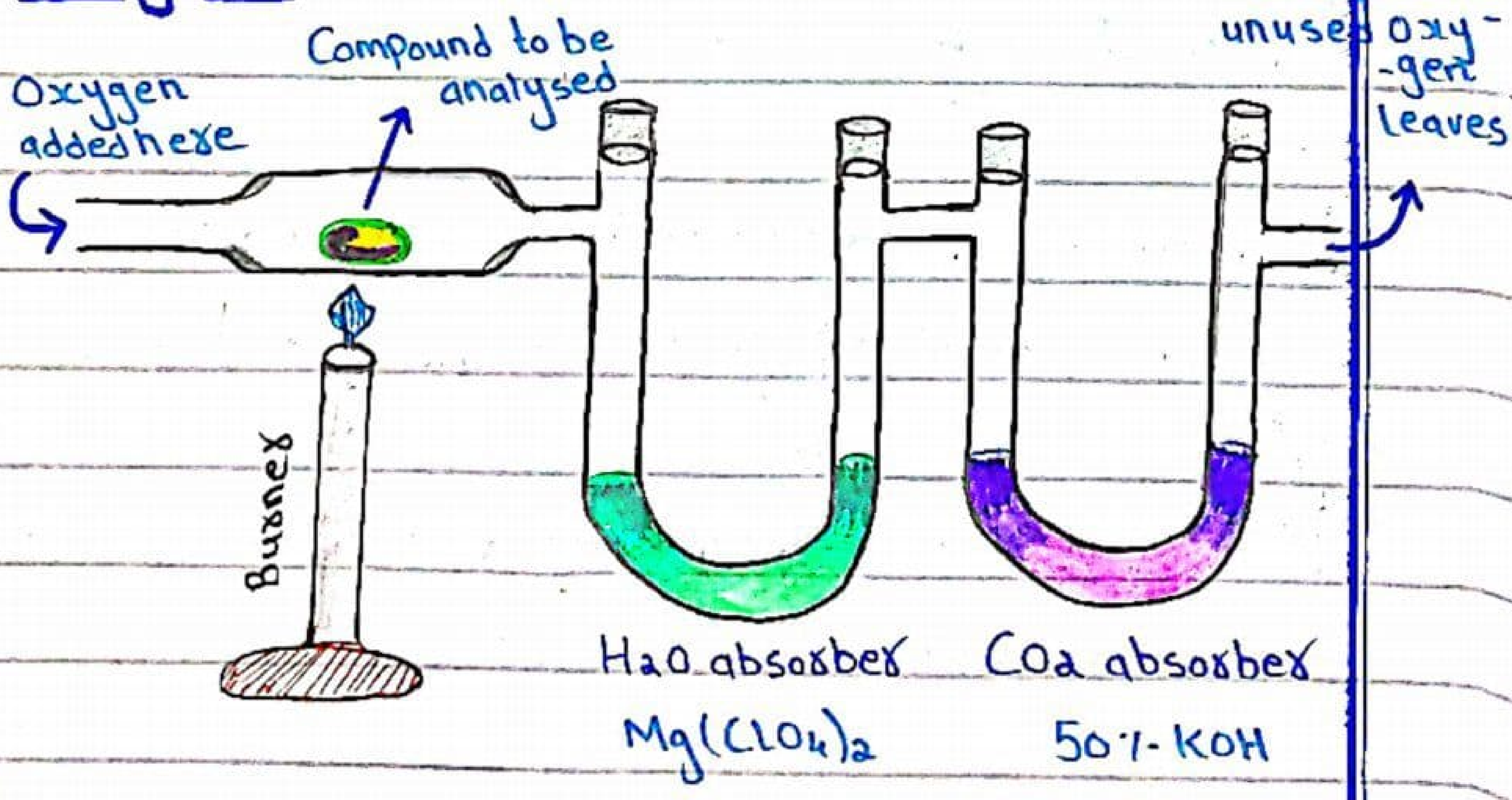
(v) From the masses of H_2O and CO_2 produced, the masses of carbon and hydrogen are Calculated.

(vi) The amount of oxygen is calculated by the methord of difference.

This data is now used to determine the Emperical and molecular formula of Compound.

$$C_xH_yO_z + O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

Diagram:



^ Apparatus for Combustion Analysis

Formula's

following formulas are used to get percentages of carbon, hydrogen and oxygen respectivily.

1) **% of Carbon:**

$$\text{Percentage, \% of Carbon} = \frac{\text{Mass of } CO_2}{\text{Mass of organic Comp.}} \times \frac{12}{44} \times 100$$

2) **% of Hydrogen:**

$$\text{\% of hydrogen} = \frac{\text{Mass of } H_2O}{\text{Mass of organic Compound}} \times \frac{2.016}{18} \times 100$$

3) **% of Oxygen:** $\text{\% of oxygen} = 100 - (\text{\% of hydrogen} + \text{\% of oxygen})$

Calculations: General Steps

Step 1:

Determine the percentage of Each Element using above formulas.

Step 2:

Calculate moles of each element.

By using formula:

$$\text{No. of Moles} = \frac{\text{\%age of Element}}{\text{Molar Mass}}$$

Step: 3 Find atomic ratio.

Divide the moles of all elements by the smallest number of moles to determine emperical formula.

∴ till Step 3: to calculate Emperical formula only

Step: 4 Find value of n;

$$\boxed{n = \frac{\text{Molecular Mass}}{\text{Emperical formula mass}}}$$

Step: 5 Determine Molecular formula;

To determine formula of the compound by using emperical formula use formula;

$$\boxed{\text{Molecular formula} = n \times \text{Emperical formula}}$$

Example 24.1:

Given:

Mass of Compound = 0.240g

Mass of CO_2 = 0.352g

Mass of water = 0.144g

Relative molecular mass = 60g/mol

To Find:

Emperical formula = ?

Molecular formula = ?

Solution:

Step 1:

$$\% \text{ of } C = \frac{\text{Mass of } CO_2}{\text{Mass of Compound}} \times \frac{12}{44} \times 100 = \frac{0.352}{0.24} \times \frac{12}{44} \times 100$$

$$\boxed{\% C = 40\%}$$

$$\% \text{ of } H = \frac{\text{Mass of } H_2O}{\text{Mass of Compound}} \times \frac{2.016}{18} \times 100 = \frac{0.144}{0.24} \times \frac{2.016}{18} \times 100$$

$$\boxed{\% H = 6.66\%}$$

$$\% O = 100 - (\% \text{ of } H + \% \text{ of } C) = 100 - (40 + 6.66)$$

$$\boxed{\% O = 53.33\%}$$

Step 2:

$$\text{Moles of } C = \frac{\% \text{ of } C}{\text{Molar mass}} = \frac{40}{12} = \boxed{3.3 \text{ mol}}$$

$$\text{Moles of } H = \frac{\% \text{ of } H}{\text{Molar mass}} = \frac{6.66}{1.008} = \boxed{6.6 \text{ mol}}$$

$$\text{Moles of } O = \frac{\% \text{ of } O}{\text{Molar mass}} = \frac{53.33}{16} = \boxed{3.3 \text{ mol}}$$

Step 3:

Mole Ratio

C : H : O

3.3 : 6.6 : 3.3

÷ divide by 3.3

1 : 2 : 1

Emperical formula ⇒ CH_2O Ans.-(i)

Step 4:

$$n = \frac{\text{Molecular mass}}{\text{Emperical formula mass}} = \frac{60}{12+1\times2+16}$$

$$= \frac{60}{30}, \quad \boxed{n=2}$$

Molecular formula = n x Emperical formula

Molecular formula = $2 \times (CH_2O)$

Molecular formula => $C_2H_4O_2$ Ans. (ii)

Exercise: Q2

Given:

Mass of Compound = 0.5439g

Mass of CO_2 = 1.039g

Mass of H_2O = 0.6369g

To Find:

(i) Emperical formula = ?

Solution:

(1) Calculation of %ages:

$$\% \text{ of } C = \frac{\text{Mass of } CO_2}{\text{Mass of Comp.}} \times \frac{12}{44} \times 100 = \frac{1.039}{0.5439} \times \frac{12}{44} \times 100$$

$$\boxed{\% \text{ of } C = 52.98\%}$$

$$\% \text{ of } H = \frac{\text{Mass of } H_2O}{\text{Mass of Compound}} \times \frac{2}{18} \times 100 = \frac{2.016}{18} \times \frac{0.6369}{0.5439} \times 100$$

$$\boxed{\% \text{ of } H = 13.11\%}$$

% of O = 100 − (% of H + % of C) = 100 − (52.98 + 13.11)

$\boxed{\% \text{ of } O = 34.78\%}$

(2) Calculation of moles:

Moles of C = $\frac{\% \text{ of } C}{\text{Molar mass}} = \frac{52.98}{12} = \boxed{4.34 \text{ mol}}$

Moles of H = $\frac{\% \text{ of } H}{\text{Molar Mass}} = \frac{13.11}{1.008} = \boxed{13 \text{ mol}}$

Moles of O = $\frac{\% \text{ of } O}{\text{Molar mass}} = \frac{34.78}{16} = \boxed{2.17 \text{ mol}}$

(3) Mole Ratio:

C : H : O

4.43 : 13 : 2.17 dividing by 2.17

$\frac{4.43}{2.17} : \frac{13}{2.17} : \frac{2.17}{2.17}$

2 : 6 : 1

Emperical formula ⇒ C_2H_6O

Exercise: Q3

Given:

% of C = 65.44%

% of H = 5.56%

% of O = 29.06%

Molar mass of Compound = 110.15 g/mol

To Find:

(i) Emperical formula = ?

(ii) Molecular formula = ?

Solution:

Moles of C = $\frac{\% \text{ of } C}{\text{Molar mass}} = \frac{65.44}{12} = \boxed{5.45\text{ mol}}$

Moles of H = $\frac{\% \text{ of } H}{\text{Molar mass}} = \frac{5.5}{1.008} = \boxed{5.45\text{ mol}}$

Moles of O = $\frac{\% \text{ of } O}{\text{Molar mass}} = \frac{29.06}{16} = \boxed{1.81\text{ mol}}$

Atomic Ratio: C : H : O

5.45 : 5.45 : 1.81 ÷ by 1.81

$\frac{5.45}{1.81} : \frac{5.45}{1.81} : \frac{1.81}{1.81}$

3 : 3 : 1

(i) Emperical formula ⇒ $\boxed{C_3H_3O}$

$n = \frac{\text{Molar Mass of Compound}}{\text{Emperical formula mass}} = \frac{110.15}{12\times3+1\times3+16} = \frac{110.15}{55}$

$\boxed{n = 2}$

Molecular formula = n × Emperical formula

Molecular formula = 2 × (C_3H_3O)

(ii) Molecular formula ⇒ $\boxed{C_6H_6O_2}$