A 0.500–g sample burns in excess O2 to yield 1.25 g of CO2 and 0.613 g of H2O. Determine the empirical formula.

Solution:

Suppose that ours sample has a formula $C_xH_yO_z$, then:

$$C_xH_yO_z + (x + {}^{y}/_{4} - {}^{z}/_{2})O_2 = xCO_2 + {}^{y}/_{2}\,H_2O$$

Now calculate the number of mole equivalents:

$$n(CO_2) = \frac{1{,}25g}{x \cdot 44\,{}^{g}/_{mol}} = \frac{0{,}028}{x}(mol);$$

$$n(H_2O) = \frac{0{,}613}{{}^{y}/_{2} \cdot 18} = \frac{0{,}068}{y}(mol);$$

$$n\left(C_xH_yO_z\right) = \frac{0{,}5}{12x + y + 16z}(mol).$$

$$\begin{cases} n(CO_2) = n\left(C_xH_yO_z\right) \\ n(H_2O) = n\left(C_xH_yO_z\right) \end{cases} or \begin{cases} \frac{0{,}028}{x} = \frac{0{,}5}{12x + y + 16z} \\ \frac{0{,}068}{y} = \frac{0{,}5}{12x + y + 16z} \end{cases}$$

$$\begin{cases} 0{,}341x + 0{,}028y + 0{,}454z = 0{,}5x \\ 0{,}818x + 0{,}068y + 1{,}091z = 0{,}5y \end{cases}$$

$$\begin{cases} 0{,}028y + 0{,}454z = 0{,}159x \;\; |/0{,}028 \\ 0{,}818x + 1{,}091z = 0{,}432y \;\; |/0{,}432 \end{cases}$$

$$+\begin{cases} y + 16{,}2z = 5{,}67x \\ 1{,}9x + 2{,}5z = y \end{cases}$$

$1)\ y + 16{,}2z + 1{,}9x + 2{,}5z = 5{,}67x + y$

$18{,}7z = 3{,}77x \mid\ /3{,}77$

$5z = x\ or\ \frac{x}{z} = \frac{5}{1}$

$2)\ 1{,}9x + 2{,}5z = y\ , if\ 5z = x, then\ 2{,}5z = 0{,}5x$

$1{,}9x + 0{,}5x = y$

$2{,}4x = y\ or\ \frac{y}{x} = 2{,}4 = \frac{12}{5}$

$So, \frac{x}{z} = \frac{5}{1}\ and\ \frac{y}{x} = \frac{12}{5}\ we\ can\ see, that \quad x : y : z = 5 : 12 : 1\ or\ C_5H_{12}O_1.$

Answer: empirical formula $\boldsymbol{C_5H_{12}O_1}$.