

## Question

Complete combustion of 8.50 g of a hydrocarbon produced 26.2 g of CO<sub>2</sub> and 12.1 g of H<sub>2</sub>O. What is the empirical formula for the hydrocarbon?

## Solution

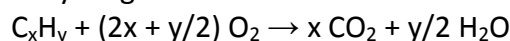
Number of moles of CO<sub>2</sub> and H<sub>2</sub>O are

$$n_{CO_2} = \frac{m_{CO_2}}{M_{CO_2}} = \frac{26.2}{44} = 0.60 \text{ mol}$$

$$n_{H_2O} = \frac{m_{H_2O}}{M_{H_2O}} = \frac{12.1}{18} = 0.67 \text{ mol}$$

In general, formula for the hydrocarbon may be represented as C<sub>x</sub>H<sub>y</sub>.

Then the combustion reaction may be given as



From the equation of combustion we can see that

$$n_{C_xH_y} = \frac{n_{CO_2}}{x} = \frac{0.60}{x}$$
$$n_{C_xH_y} = \frac{2 \cdot n_{H_2O}}{y} = \frac{2 \cdot 0.67}{y} = \frac{1.34}{y}$$

$$M_{C_xH_y} = 12 \cdot x + 1 \cdot y$$

$$n_{C_xH_y} = \frac{m_{C_xH_y}}{M_{C_xH_y}} = \frac{8.50}{12x + y}$$

So, we have set of two equations with two unknown values

$$\begin{cases} \frac{8.50}{12x + y} = \frac{0.60}{x} \\ \frac{8.50}{12x + y} = \frac{1.34}{y} \end{cases}$$

$$\begin{cases} 8.50x = 0.60(12x + y) \\ 8.50y = 1.34(12x + y) \end{cases}$$

$$\begin{cases} 7.20x + 0.60y - 8.50x = 0 \\ 16.08x + 1.34y - 8.50y = 0 \end{cases}$$

$$\begin{cases} 0.60y = 1.30x \\ 7.16y = 16.08x \end{cases}$$

Such set of equations has not one analytical solution.

Numerical solutions found in terms of minimum error (calculated until  $x \approx 10$ ) are given in table.

Numerical solutions		Closest integer values		Difference between solution and closest integer	
x	y	x	y	Δx	Δy
1.996	4.480	2	4	0.004	0.480
2.993	6.721	3	7	0.007	0.279
3.991	8.961	4	9	0.009	0.039
4.989	11.201	5	11	0.011	0.201
5.987	13.441	6	13	0.013	0.441
6.984	15.682	7	16	0.016	0.318
<b>7.982</b>	<b>17.922</b>	<b>8</b>	<b>18</b>	<b>0.018</b>	<b>0.078</b>
8.980	20.162	9	20	0.020	0.162
9.978	22.402	10	22	0.022	0.402

The solutions closest to integer values may be considered to be most feasible.  
Since hydrocarbon of empirical formula  $C_4H_9$  does not exist, the empirical formula most likely is  $C_8H_{18}$ .

**Answer:**  $C_8H_{18}$