Answer on Question #54718 - Chemistry – General Chemistry

Question

Combustion analysis was performed on 1.00 g of a compound containing C, H, and N, and 2.79 g of CO_2 and 0.57 g of H_2O were produced.

What is the empirical formula? Express your answer as a chemical formula.

Answer:

The reaction of combustion of compound containing C, H, and N:

$$C_xH_yN_z + O_2 = CO_2 + H_2O + N_2$$

Numbers of moles of CO_2 and H_2O produced:

$$n(CO_2) = \frac{m(CO_2)}{M(CO_2)} = \frac{2.79}{44.0} = 0.0634\ mol$$

$$n(H_2O) = \frac{m(H_2O)}{M(H_2O)} = \frac{0.57}{18.0} = 0.0317\ mol$$

So, the number of moles of CO_2 is twice as big as that of H_2O, and stoichiometric coefficient for CO_2 is two times bigger then that for H_2O:

$$\_?\_ C_xH_yN_z + \_?\_ O_2 = \_2\_ CO_2 + \_1\_ H_2O + \_?\_ N_2$$

The number of moles of oxygen atoms is:

$$n(O) = 2n(CO_2) + n(H_2O) = 2 \cdot 0.0634 + 0.0317 = 0.1585\ mol = 5n(H_2O)$$

or:

$$n(O_2) = 2.5n(H_2O)$$

$$\_?\_ C_xH_yN_z + \_2.5\_ O_2 = \_2\_ CO_2 + \_1\_ H_2O + \_?\_ N_2$$

Then the mass of oxygen is:

$$m(O) = n(O) \cdot M(O) = 0.1585 \cdot 15.99 = 2.54\ g = m(O_2)$$

The mass of nitrogen is (the total mass of substances before reaction is equal to the total mass of reaction products after reaction):

$$m(N_2) = m(C_xH_yN_z) + m(O_2) - m(CO_2) - m(H_2O) = 1 + 2.54 - 2.79 - 0.57 = 0.18\ g$$

$$n(N_2) = \frac{m(N_2)}{M(N_2)} = \frac{0.18}{28.0} = 0.0064\ mol = 0.1n(CO_2)$$

Multiple all stoichiometric coefficients by 10, using $n(N_2) = 0.1n(CO_2)$:

$$\_?\_ C_xH_yN_z + \_25\_ O_2 = \_20\_ CO_2 + \_10\_ H_2O + \_2\_ N_2$$

$$\_?\_ C_{20}H_{20}N_4 + \_25\_ O_2 = \_20\_ CO_2 + \_10\_ H_2O + \_2\_ N_2$$

Divide indexes in formula by 4, then the reaction is:

$$\_4\_ C_5H_5N + \_25\_ O_2 = \_20\_ CO_2 + \_10\_ H_2O + \_2\_ N_2$$

Answer: the empirical formula of the compound is C_5H_5N.