Empirical Formula

The empirical formula of a compound shows the basic ratio of elements within that compound. For example, consider the hydrocarbon alkane, ethane, which has a molecular formula of C_2H_6. It's empirical formula would be CH_3, because the ratio of Carbon to Hydrogen atoms in the molecule is 1 : 3.

For some compounds like H_2O, the empirical and molecular formula are the same

Empirical formulae are determined experimentally by finding the mass of each element within the compound.

Consider the following example

A sample of an unknown hydrocarbon of mass 1.452 g was burnt completely in oxygen forming 4.401 g of CO_2 and 2.252 g of H_2O. What was its empirical formula.

we have an equation of the following form

$C_xH_y + O_2 \rightarrow CO_2 + H_2O$

if we can work out the mole ratio of CO_2 and H_2O, then we can work out the molecular formula of the hydrocarbon

$$n(CO_2) = \frac{4.401}{44} = 0.10 \text{ mol}$$

$$n(H_2O) = \frac{2.252}{18} = 0.125 \text{ mol}$$

So the mole ratio of CO_2 to H_2O, is .01 : .125 or 4 : 5

$\rightarrow CO_2 + H_2O$ becomes

$\rightarrow 4CO_2 + 5H_2O$

however, this leaves us with an odd number of O on the RHS and since we have O_2 on the LHS, we need to double the numbers on the RHS

$\rightarrow 8\ CO_2 + 10\ H_2O$

Some simple arithmetic gives us an equation

$C_8H_{20} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

Hence the empirical formula is C_2H_5

The molecular formula can be verified as follows

mole ratio of C_8H_{20} to CO_2 is 1 : 8

we calculated $n(CO_2) = 0.10$ mol above

so

$$n(C_8H_{20}) = \frac{0.10}{8} = 0.0125 \text{ mol}$$

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We are told that there was 1.452 g of the hydrocarbon, so we can calculate its Molar Mass

$$n(C_8H_{20}) = \frac{mass}{Molar\_Mass}$$

$$0.0125 = \frac{1.452}{MM}$$

$$MM = \frac{1.452}{0.0125}$$

MM = 116

this is in fact the MW of C_8H_{20}