

Empirical and molecular formulae.

- 1) An unknown hydrocarbon is found to contain 85.7% carbon and an atomic mass of 84.0 g/mol. What is its molecular formula?

Step 1 mole ratio

$$\Rightarrow 85.7 / 12 \text{ C} : 14.3 / 1 \text{ H}$$

$$\Rightarrow 7.141 \text{ C} : 14.3 \text{ H}$$

Step 2 Simplest mole ratio

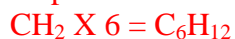
$$\Rightarrow 1 : 2$$



Step 3 Find the number the empirical formula must be multiplied by to get to the molecular formula.

$$\Rightarrow x = \text{molecular formula} / \text{empirical formula} = 84 / 14 = 6$$

Step 4 Obtain the molecular formula



- 2) A 1.50 g sample of a hydrocarbon gas undergoes complete combustion to produce 4.40 g of CO_2 and 1.80 g of H_2O .

a) What is the empirical formula of this compound?

Step 1 Find the mol of hydrogen and carbon atoms present.

$$\Rightarrow n_{\text{Carbon dioxide}} = 4.4 / 44 = 0.1 \Rightarrow n_{\text{C}} = 0.1$$

$$\Rightarrow n_{\text{water}} = 1.8 / 18 = 0.1 \Rightarrow n_{\text{H}} = 0.20$$

Step 2 Find the simplest ratios

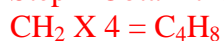


b) If its molecular weight has been determined to be 56 g/mol. What is the molecular formula?

Step 1 Find the number the empirical formula must be multiplied by to get to the molecular formula.

$$\Rightarrow x = \text{molecular formula} / \text{empirical formula} = 56 / 14 = 4$$

Step 2 Obtain the molecular formula



c) Write a balanced chemical equation for the combustion reaction.



- 3) An organic compound has the following percent composition: carbon 49.48%, hydrogen 5.19%, oxygen 16.48% and nitrogen 28.85%. Its molecular weight is determined to be around 288 g/mol.

a) What is the empirical formula?

Step 1 mole ratio

$$\Rightarrow 49.48 / 12 \text{ C} : 5.19 / 1 \text{ H} : 16.48 / 16 \text{ O} : 28.85 / 14 \text{ N}$$

=> 4.17 C : 5.19 H : 1.03 O : 2.06

Step 2 Simplest mole ratio

=> 4 C : 5 H : 1 O : 2 N

=> C₄H₅ON₂

b) What is its molecular formula?

Step 1 Find the number the empirical formula must be multiplied by to get to the molecular formula.

=> x = molecular formula / empirical formula = 288 / 97 = 3

Step 2 Obtain the molecular formula

C₁₂H₁₅O₃N₆

- 4) What are the empirical and molecular formulae for a compound with 86.88% carbon and 13.12% hydrogen and a molecular weight of about 345 g/mol?

Step 1 mole ratio

=> 86.88 / 12 C : 13.12 / 1 H

=> 7.24 C : 13.12 H

Step 2 Simplest mole ratio

=> 1 : 1.8

=> CH_{1.8}

Step 3 Multiply by 5 to change the H_{1.8} to a whole number.

=> C₅H₉

Step 4 Find the number the empirical formula must be multiplied by to get to the molecular formula.

=> x = molecular formula / empirical formula = 345 / 69 = 5

Step 4 Obtain the molecular formula

C₅H₉ X 5 = C₂₅H₄₅

- 5) What are the empirical and molecular formulae for a compound with 83.625% carbon and 16.375% hydrogen and a molecular weight of 388.78?

Step 1 mole ratio

=> 83.625 / 12 C : 16.375 / 1 H

=> 7.0 C : 16.375 H

Step 2 Simplest mole ratio

=> 1 : 2.34

=> CH_{2.34}

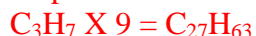
Step 3 Multiply by 3 to change the H_{2.34} to a whole number.

=> C₃H₇

Step 4 Find the number the empirical formula must be multiplied by to get to the molecular formula.

=> x = molecular formula / empirical formula = 388.78 / 43 = 9.0

Step 4 Obtain the molecular formula



- 6) A 3.10 g sample of an unknown organic gas molecule composed of carbon, hydrogen and oxygen, undergoes complete combustion to produce 4.40 g of CO_2 and 2.70 g of H_2O .
a) What is the empirical formula of this compound?

Step 1 Find the mol of hydrogen and carbon atoms present.

$$\Rightarrow n_{\text{Carbon dioxide}} = 4.4 / 44 = 0.1 \Rightarrow n_{\text{C}} = 0.1$$

$$\Rightarrow n_{\text{water}} = 1.8 / 18 = 0.1 \Rightarrow n_{\text{H}} = 0.30$$

Step 2 Find the combined mass of carbon and hydrogen in the sample and use it to work out the mass of oxygen present in the sample..

$$\Rightarrow 3.10 \text{ g} = 0.1 \times 12 + 0.3 \times 1 + x \times 16$$

$$\Rightarrow 3.10 \text{ g} = 1.2 \text{ g} + 0.3 \text{ g} + 16x$$

$$\Rightarrow 1.6 = 16x$$

$$\Rightarrow 0.1 = x$$

$$\Rightarrow \text{mol of oxygen present in the sample is } 0.1$$

Step 3 get the mol ratio

$$\Rightarrow 0.1 \text{ C} : 0.3 \text{ H} : 0.1 \text{ O}$$

Step 4 Simplest ratio



- b) If its formula mass of about 62 g/mol find its molecular formula?

Step 1 Find the number the empirical formula must be multiplied by to get to the molecular formula.

$$\Rightarrow x = \text{molecular formula} / \text{empirical formula} = 62 / 31 = 2$$

Step 2 Obtain the molecular formula

