



## CHEMISTRY

## THE MOLECULAR FORMULA

Determining the molecular formula of a substance has become increasingly more important in recent years with the development sampling technologies and the popularity of criminal forensics.

In order to determine the molecular formula of a compound, one first needs to calculate its empirical formula.

Then, multiply the empirical subscripts by a constant to get the molecular formula.

$$\text{Molecular Formula Subscripts} = n \times \text{Empirical Formula Subscripts}$$

Where  $n = 1, 2, 3 \dots$

ALSO ...

$$\text{Molar Mass of Compound} = n \times \text{Molar Mass of Empirical Formula}$$

Where  $n = 1, 2, 3 \dots$

**Example:**

*The empirical formula of Ribose (a sugar) is  $\text{CH}_2\text{O}$ . Given that the molar mass of Ribose is 150 g/mol, what is the molecular formula?*

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A combustion chamber is a tool used to determine the composition of organic compounds (hydrocarbons). It works by completely combusting a sample hydrocarbon and then collects and masses the resulting carbon dioxide and water. With this data, an empirical formula can be achieved.

*Ex: A 1.00g sample of a pure compound containing only carbon and hydrogen is completely combusted. The combustion produces 0.6919 grams of water and 3.338 grams of carbon dioxide.*

**a) Calculate the masses of carbon and hydrogen in the sample.**

**b) Find the empirical formula of the compound.**

**c) In another experiment, the molar mass of the compound is found to be 78 grams. Find the molecular formula.**



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Homework

17. The empirical formula of butane, the fuel used in disposable lighters, is  $C_2H_5$ . In an experiment, the molar mass of butane was determined to be 58 g/mol. What is the molecular formula of butane?
18. Oxalic acid has the empirical formula  $CHO_2$ . Its molar mass is 90 g/mol. What is the molecular formula of oxalic acid?
19. The empirical formula of codeine is  $C_{18}H_{21}NO_3$ . If the molar mass of codeine is 299 g/mol, what is its molecular formula?
20. A compound's molar mass is 240.28 g/mol. Its percentage composition is 75.0% carbon, 5.05% hydrogen, and 20.0% oxygen. What is the compound's molecular formula?
21. A 0.539 g sample of a compound that contained only carbon and hydrogen was subjected to combustion analysis. The combustion produced 1.64 g of carbon dioxide and 0.807 g of water. Calculate the percentage composition and the empirical formula of the sample.
22. An 874 mg sample of cortisol was subjected to carbon-hydrogen combustion analysis. 2.23 g of carbon dioxide and 0.652 g of water were produced. The molar mass of cortisol was found to be 362 g/mol using a mass spectrometer. If cortisol contains carbon, hydrogen, and oxygen, determine its molecular formula.

16.  $C_{12}H_{14}O_3$  17.  $C_4H_{10}$  18.  $C_2H_2O_4$  19.  $C_{18}H_{21}NO_3$   
20.  $C_{15}H_{12}O_3$  21.  $C_5H_{12}$ ; 83.3% C; 16.7% H. 22.  $C_{21}H_{30}O_5$