CHEMICAL FORMULAE

The chemical formula of a compound serves as a symbolic representation that encapsulates crucial information regarding its chemical composition. These formulae act as concise codes, offering valuable insights into the specific elements that make up the molecules of a compound and the precise ratio in which the atoms of these elements unite to form these molecules.
To illustrate, consider the chemical formula of water, denoted as H_2O. This formula communicates that within one molecule of water, there is a combination of two hydrogen atoms and one oxygen atom. Therefore, the chemical formula not only identifies the types of atoms present but also quantifies their arrangement and combination in the compound. In essence, chemical formulae play an integral role in providing a structured and universally recognized means of conveying the elemental composition and proportions within various chemical compounds.

Significance of Chemical Formulae

- **Understanding Chemical Composition:** Chemical formulae play a pivotal role in offering a deep understanding of the chemical composition of a compound. By employing a concise symbolic representation, they convey the types and quantities of elements present in a compound.
- **Ratio Representation:** Additionally, chemical formulae serve as effective tools for representing the ratios in which the constituent elements combine to give rise to the compound. This ratio information is crucial for comprehending the molecular structure and behavior of the compound.
- **Essential in Chemical Equations:** The chemical formula of a compound is indispensable when expressing chemical reactions through equations. It enables a clear and standardized representation of the reactants and products involved, facilitating accurate communication of chemical transformations.
- **Versatility in Representation:** Chemical formulae extend beyond compounds and can be applied to represent ions, free radicals, and various other chemical species. This versatility enhances their utility in describing a wide range of chemical entities beyond simple molecular compounds.
- In summary, chemical formulae serve as fundamental tools in the language of chemistry, providing a means to convey and comprehend the composition, structure, and behavior of chemical compounds and entities in a systematic and universally accepted manner.

Types of Formulae

As mentioned in section 1.10, a formula comprises symbols of elements that represent a single molecule of the substance. The formula serves to depict the chemical composition of the substance. In the realm of compounds, there exist three types of formulae.

(i) Empirical formula:

It signifies the most straightforward whole number ratio of atoms for each element within the molecule of the substance.
For instance, CH is the empirical formula for benzene, indicating a 1:1 ratio between carbon and hydrogen atoms. Additionally, it implies that the mass ratio of carbon to hydrogen is 12:1.

(ii) Molecular formula:

The molecular formula of a compound denotes the precise count of atoms for each element within a single molecule.
For example, C_6H_6 is the molecular formula of benzene, specifying that a molecule of benzene contains six carbon atoms and six hydrogen atoms.
Thus,

$$\text{Molecular formula} = n \times \text{Empirical formula}$$

where, $n = \frac{\text{Molecular formula mass}}{\text{Empirical formula mass}}$

Molecular formula gives the following information:

(i) Various elements present in the molecule.

(ii) Number of atoms of various elements in the molecule.

(iii) Mass ratio of the elements. present in the molecule. The mass ratio of carbon and oxygen in CO_2 molecule is 12: 32 or 3: 8.

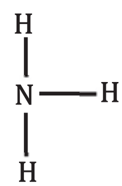
(iv) Molecular mass of the substance.

(v) The number written before the formula indicates the number of molecules, e.g., $2C0_2$ means 2 molecules of carbon dioxide.

(iii) Structural formula:

It represents the way in which atoms of various elements present in the molecule is linked with one another.

For example, ammonia is represented as:



The formula indicates that three hydrogen atoms are linked to one nitrogen atom by three single covalent bonds.

Determination Of Empirical and Molecular Formulae

The. following steps are followed to detinning he empirical formula of the compound:

(i) Quantitative analysis determines the percentage composition of the compound.

(ii) The atomic ratio of elements within the compound is obtained by dividing the percentage of each element by its atomic mass.

(iii) To attain the simplest ratio of atoms for the elements in the compound, the atomic ratio of each element is divided by the smallest value among the atomic ratios.

(iv) If the simplest ratio is fractional, each element's simplest ratio values are multiplied by the smallest integer to obtain a whole number for each element.

(v) To derive the empirical formula, the symbols of the various elements present are arranged side by side with their respective whole number ratios as subscripts placed at the lower right-hand corner of the symbol.

The molecular formula of a substance can be deduced from the empirical formula when the molecular mass is known. The molecular formula is consistently a straightforward multiple of the empirical formula, and this multiple is determined by dividing the molecular mass by the mass of the empirical formula.

Compute the empirical formula for a compound with 26.6% potassium, 35.4% chromium, and 38.1% oxygen.

[Given K 39.1; Cr= 52; 0 =16]

Solution:

Element	Per-centage	Atomies mass	Relative number of atoms	Simplest ratio	Simplest whole number ratio
Potassium	26.6	39.1	$\frac{26.6}{39.1} = 0.68$	$\frac{0.68}{0.68} = 1$	$1 \times 2 = 2$
Chromium	35.4	52.0	$\frac{35.4}{52} = 0.68$	$\frac{0.68}{0.68} = 1$	$1 \times 2 = 2$
Oxygen	38.1	16.0	$\frac{38.1}{16} = 2.38$	$\frac{2.38}{0.68} = 3.5$	$3.5 \times 2 = 7$
Therefore, empirical formula is K, Cr, O_7.					

A compound of carbon, hydrogen and nitrogen contains these elements in the ratio 9: 1: 3.5. Calculate the empirical formula. If its molecular mass is 108, what is the molecular formula?

Solution:

Element	Per- centage	Atomies mass	Relative number of atoms	Simplest ratio
Carbon	9	12	$\frac{9}{12} = 0.75$	$\frac{0.75}{0.25} = 3$
Hydrogen	1	1	$\frac{1}{1} = 1$	$\frac{1}{0.25} = 4$
Nitrogen	3.5	14	$\frac{3.5}{14} = 0.25$	$\frac{0.25}{0.25} = 1$
The empirical formula $= C_3H_4\ N$ Empirical formula mass $= (3 \times 12) + (4 \times 1) + 14 = 54$ $n = \frac{\text{Mol. mass}}{\text{Emp. mass}} = \frac{108}{54} = 2$				

Thus, molecular formula of the compound

$$= 2 \times \text{Empirical formula}$$

$$= 2 \times C_3H_4\ N = C_6H_3N_2$$

A carbon compound containing only carbon and oxygen has an approximate molecular mass of 290. On analysis, it is found to contain 50% by mass of each element.
What is the molecularformula of the compound?

Solution:

Element Per- centage	Atomic mass	Relative number of atoms	Simplest ratio	Simplest whole number ratio
Carbon 50.0	12	4.166	$\frac{4.166}{3.125} = 1.33$	4
Oxygen 50.0	16	3.125	$\frac{3.125}{3.125} = 1$	3
The empirical formula $= C_4O_3$ Empirical formula mass $= (4 \times 12) + (3 \times 16) = 96$ Molecular mass $= 290$				

$$n = \frac{\text{Mol. mass}}{\text{Emp. mass}} = \frac{290}{96} = 3 \text{ approximately}$$

$$\text{Molecular formula} = n \times \text{ Empirical formula}$$
$$= 3 \times C_4O_3 = C_{12}O_9$$

Balancing Chemical Equations

Achieving balance in chemical equations is a process that entails introducing stoichiometric coefficients to the reactants and products. This step is crucial due to the necessity for a chemical equation to adhere to the laws of conservation of mass and constant proportions. In essence, the number of atoms for each element must be consistent on both the reactant and product sides of the equation.

This article delves into two expedient methods for balancing chemical equations. The first method is the conventional or traditional balancing approach, a widely-used technique in which coefficients are manually assigned to achieve balance. The second method is the algebraic balancing approach, an alternative method that leverages algebraic principles to systematically determine the coefficients needed for equilibrium.

In summary, the process of balancing chemical equations is essential to ensure the accurate representation of chemical reactions while adhering to fundamental principles in chemistry. The article explores two distinct methods, providing readers with a choice between the traditional and algebraic approaches for achieving equilibrium in chemical equations.