The Language of Chemistry

Symbol

The specific abbreviation used to denote the name of an element is called its symbol.

Significance of a Symbol

1. A symbol represents a short form of an element.
2. It represents one atom of the element.
3. It indicates the atomic weight of an element. The quantity of the element is equal to its atomic mass or gram atomic mass or atomic mass unit (amu).

Symbol of Elements

- In 1807, **John Dalton**, a scientist, tried to name the various elements based on pictorial symbols. Symbols of some elements as proposed by Dalton are shown in the diagram.
- In 1814, the Swedish Chemist **Jöns Jakob Berzelius** devised a system using letters of the alphabet. He put forward certain points for presentation.
  1. In most cases, the first letter of the name of an element was taken as the symbol for that element and written in capitals.

Name	Symbol
Carbon	C
Nitrogen	N
Hydrogen	H

  2. In some cases, the initial letter of the name in capital along with its second letter in small was used.

Name	Symbol
Calcium	Ca
Aluminium	Al
Silicon	Si

  3. The symbols for some elements were derived from their Latin names.

English name of the element	Latin name of the element	Symbol
Sodium	**Na**trium	Na
Potassium	**K**alium	K
Iron	**Fe**rrum	Fe
Copper	**Cu**prum	Cu
Silver	**Ar**gentum	Ag
Gold	**Au**rum	Au
Mercury	**H**ydra**g**yrum	Hg
Lead	**P**lum**b**um	Pb
Tin	**St**a**n**num	Sn

- The symbols of elements in use today are those as first suggested by the Swedish chemist Berzelius.
- The method suggested by Berzelius forms the basis of the IUPAC (International Union of Pure and Applied Chemistry) system of chemical symbols and formulae.
- The names and symbols decided by IUPAC are used all over the world for international trade.

Modern Symbols of Elements

The modern symbols of elements are derived from their English or Latin names which are made up of either the first letter or a letter appearing later in the name.

Name of the element	Symbol	Latin Name	Name of the element	Symbol	Latin Name
Hydrogen	H	—	**Ni**ckel	Ni	—
Oxygen	O	—	**Ma**nganese	Mn	—
Boron	B	—	**Ca**lcium	Ca	—
Carbon	C	—	**Cl**orine	Cl	—
Fluorine	F	—	**Br**omine	Br	—
Iodine	I	—	**Cr**omium	Cr	—
Nitrogen	N	—	**Co**balt	Co	—
Phosphorus	P	—	Lead	Pb	**Plumb**um
Sulphur	S	—	Mercury	Hg	**H**ydrar**g**yrum
Barium	Ba	—	**P**hosphorus	P	—
Iron	Fe	**Fe**rrum	Sodium	Na	**Na**trium
Gold	Au	**Au**rum	Potassium	K	**K**alium
Silver	Ag	**Ag**entum	Tin	Sn	**Sn**annum
Tungsten	W	**W**olfram (German name)	**U**ranium	U	—
Lithium	Li	—	**Zn**c	Zn	—

- **Valency**
  Valency is the combining capacity of an atom or a radical.
  For example, valency of carbon is 4 because it combines with four atoms of hydrogen to yield methane (CH_4).
- **Valency with respect to Hydrogen atom**
  The number of hydrogen atoms which combines with or displaces one atom of that element or radical. The valency is taken to be 1 and is considered as standard.
- **Modern definition of valency**
  The number of electrons which an atom can lose, gain or share during a chemical reaction to attain the stable configuration of the nearest inert gas element is called its valency.
- **Valence electrons**
  The electrons present in the outermost shell or valence shell are known as valence electrons.
- **Definition of valency with respect to valence electrons**
  The number of electrons donated or accepted or shared by its atom during a chemical reaction is called valence electrons, and the number of these electrons is called the valency of that element.
- **Variable valency**
  Sometimes, the same element may exhibit one valency in one compound and another valency in other compound. This property is called variable valency.

Examples:

Element	Symbol	Valencies exhibited (variable valencies)
Copper	Cu	1, 2
Iron	Fe	2, 3
Sulphur	S	2, 3, 4

Ions or Radicals

An ion or radical is an atom or a group of atoms of same or different elements which behave as a single unit with a positive or negative ion.
Radicals have their own combining power based on which they form chemical formulae.

Classification of ions or radicals depending on their number of charges

The number of charges indicates the number of electrons lost or gained by the atom or group of atoms. Depending on the number of charges, **1, 2, 3** or **4**, the ions or radicals are described as **monovalent, divalent, trivalent** and **tetravalent**, respectively.

List of common electrovalent positive ions or radicals

1. **Monovalent electropositive ions**
   - Ammonium NH_4^+
   - Cuprous Cu^+
   - Mercurous Hg^+

2. **Bivalent electropositive ions**
   - Argentic Ag^{2+}
   - Ferrous Fe^{2+}
   - Stannous Sn^{2+}
   - Cupric Cu^{2+}

3. **Trivalent electropositive ions**
   - Aluminium Al^{3+}
   - Chromium Cr^{3+}
   - Arsenic As^{3+}

4. **Tetra positive ions**
   - Plumbic Pb^{4+}
   - Stannic Sn^{4+}

List of common electrovalent negative ions or radicals

1. **Monovalent electronegative ions**

Acetate	CH_3COO^-	Permanganate	MnO_4^-
Bisulphite	HSO_3^-	Cyanide	CN^-
Bisulphate	HSO_4^-	Hypochlorite	ClO^-

2. **Bivalent electronegative ions**

Carbonate	CO_3^{2-}	Silicate	SiO_3^{2-}
Oxide	O^{2-}	Chromate	CrO_4^{2-}
Sulphate	SO_4^{2-}	Oxalate	$(COO)_2^{2-}$

3. **Trivalent electronegative ions**

Arsenate	$A_5O_4^{3-}$
Phosphide	P^{3-}
Phosphate	PO_4^{3-}
Borate	BO_3^{3-}

4. **Tetravalent electronegative ions**

Carbide	C^{4-}
Ferro cyanide	$[Fe(CN)_6]^{4-}$

Molecular Formula or Chemical formula

A molecular formula, also known as a chemical formula, is a combination of elemental symbols and subscript numbers which is used to show the composition of a compound.

Examples:

Silica is represented as SiO_2.

Marble is represented as $CaCO_3$.

Writing the Chemical Formulae

Step 1: Write the symbol of a basic radical (element with positive valency) to the left-hand side and that of the acid radical (element with negative valency) to the right-hand side.

Step 2: Write the valency of each of the respective radicals at the right-hand top of its symbol.

Step 3: Divide the valency by their highest common factor (HCF), if any, to get the simple ratio. Ignore (+) or (−) symbols of the radicals.

Step 4: Cross the reduced valencies. If 1 appears, then ignore it. If a group of atoms receives a valency more than 1, then enclose it within brackets.

Magnesium chloride	Ammonium sulphate
Mg^{2+} Cl^{1-} Mg_1 Cl_2 Formula: $MgCl_2$	NH_4^{1+} SO_4^{2-} $(NH_4)_2$ $(SO_4)_1$ Formula: $(NH_4)_2SO_4$

Example of magnesium chloride and ammonium sulphate

Significance of Molecular Formula

The molecular formula of a compound has quantitative significance. It represents

1. The name of the substance.
2. Both the molecule and the molecular mass of the compound.
3. The respective numbers of different atoms present in one molecule of a compound.
4. The ratios of the respective masses of the elements present in the compound.

Chemical Equation

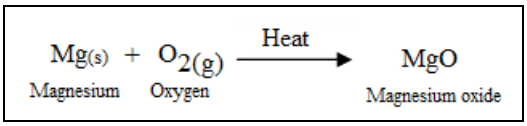
A chemical equation is the symbolic representation of a chemical reaction with the help of chemical formulae of the reactants and products in the reaction.

The reaction can be represented by either a word equation or by a chemical equation using symbols and formulae.

Word equation

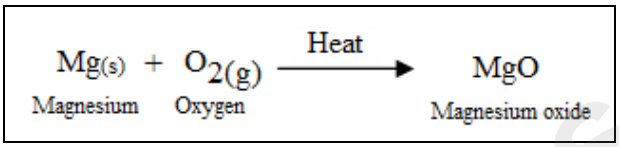
$$\text{Magnesium} + \text{Oxygen} \xrightarrow{\text{Heat}} \text{Magnesium oxide}$$

Chemical equation



Skeletal Equation

A chemical equation in which the total number of atoms of each element on the reactant's side is not equal to the number of atoms of the same element on the product's side is called an unbalanced equation. This equation is also called a skeletal equation.



The number of oxygen atoms in the reactant on the left-hand side is not equal to the number of oxygen atoms on the right-hand side.

Balanced Chemical Equation

The equation in which the total number of atoms of each element in the reactants on the left-hand side of the equation is the same as the number of atoms in the products formed on the right-hand side of the equation is called a balanced chemical equation.

Balancing of a Chemical Equation

A. Hit and Trial Method

In this method of balancing chemical equations, trials are made to balance the equation by using the smallest whole number coefficient. Hence, this method is called the hit and trial method.

i. Count the number of times an element occurs on both sides.
ii. An element with the least frequency of occurrence is balanced first.
iii. When two or more elements have same frequency, metallic elements are balanced first.

Example: $Pb(NO_3)_2 \rightarrow PbO + NO_2 + O_2$

In this equation,

Component	Reactant	Product
Lead	1	1
Nitrogen	2	1
Oxygen	6	5

The balanced equation is

$$2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$$

B. Balancing a chemical equation by the partial equation method

A chemical equation can be balanced easily by supposing a stepwise complex reaction to take place. Write equations for these steps and then add these equations. This method is known as balancing by the partial equation method.

Equation 1: Hydrogen peroxide decomposes to give water and nascent oxygen.

$H_2O_2 \rightarrow H_2O + [O]$
Hydrogen peroxide — Water — Nascent Oxygen

Equation 2: Nascent oxygen obtained oxidises potassium iodide in the presence of water to give potassium hydroxide and iodine.

$2KI + H_2O + [O] \rightarrow 2KOH + I_2$
Potassium iodide — Water — Nascent Oxygen — Potassium hydroxide — Iodine

Add the steps and cancel what is common on opposite sides.

$H_2O_2 \rightarrow H_2O + [O]$ Equation 1
$2KI + H_2O + [O] \rightarrow 2KOH + I_2$ Equation 2

$2KI_{(s)} + H_2O_{2\,(l)} \rightarrow 2KOH_{\,(l)} + I_{(s)}$ Final equation
Potassium Iodide — Hydrogen peroxide — Potassium hydroxide — Iodine

Information conveyed by a balanced chemical equation

- The chemical nature of the reactants and products.
- The nature of elements and radicals involved.
- Chemical composition of the respective molecules.
- The direction of the reaction, i.e. whether the reaction is irreversible ($\rightarrow$) or reversible ($\rightleftharpoons$).
- The states of matter, i.e. whether the substances are present in the solid (s), liquid (l) or gaseous (g) state.

Limitations of a Chemical Equation

- Concentration of both reactants and products.
- Speed of the reaction.
- Colour change occurring during the reaction.
- Completion of the reaction.
- Change in the evolution of heat, light or sound energy during the reaction.

Molecular Mass

The molecular mass of a substance is the sum of the atomic masses of its constituent atoms present in a molecule.
The atomic mass unit (amu) is equal to one-twelfth ($1/12^{th}$) the mass of an atom of carbon-12.