CHEMISTRY

Basics of Chemistry

Symbol

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

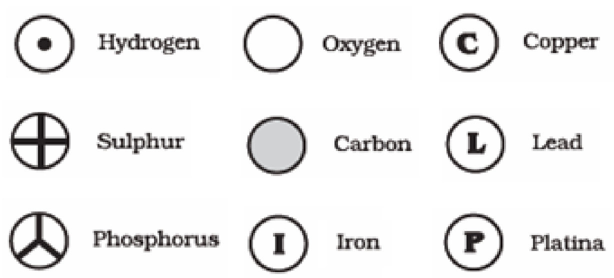
Significance of a Symbol

1. A symbol represents a short form of an element.
2. A symbol 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, gram atomic mass or atomic mass unit (amu).

   For example, the symbol C

   1. Stands for the element Carbon
   2. Represents one atom of Carbon
   3. Indicates the atomic mass of Carbon, i.e. 12 amu

In 1807, the scientist **John Dalton** tried to name the various elements based on pictorial symbols. Symbols of some elements as proposed by Dalton are shown in the diagram.



Dalton's symbols

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. 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	**A**r**g**entum	Ag
Gold	**Au**rum	Au
Mercury	**H**ydra**g**yrum	Hg
Lead	**P**lum**b**um	Pb
Tin	**S**ta**n**num	Sn

- Symbols of elements used 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	—	Nickel	Ni	—
Oxygen	O	—	Manganese	Mn	—
Boron	B	—	**Ca**lcium	Ca	—
Carbon	C	—	**C**h**l**orine	Cl	—
Fluorine	F	—	**Br**omine	Br	—
Iodine	I	—	**C**h**r**omium	Cr	—
Nitrogen	N	—	**Co**balt	Co	—
Phosphorus	P	—	Lead	Pb	**P**lum**b**um
Sulphur	S	—	Mercury	Hg	**H**ydrar**g**yrum
Barium	Ba	—	Phosphorus	P	—
Iron	Fe	**Fe**rrum	Sodium	Na	**Na**trium
Gold	Au	**Au**rum	Potassium	K	**K**alium
Silver	Ag	**A**r**g**entum	Tin	Sn	**S**ta**n**num
Tungsten	W	**W**olfram (German name)	**U**ranium	U	—
Lithium	Li	—	Zinc	Zn	—

Valency

Valency is the combining capacity of an atom or a radical.

For example, the 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 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.

Valance 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.

If an element exhibits two positive valencies, then for lower valency, use the suffix **–ous** at the end of the name of the element, and for higher valency, use the suffix **–ic** at the end of the name of the element.

Example: (a) Iron shows two valencies.

Fe^{2+} or Fe (II) is ferr**ous**.

Fe^{3+} or Fe (III) is ferr**ic**.

(b) Mercury also shows two valencies.

Hg^{+} or Hg (I) is Mercur**ous**.

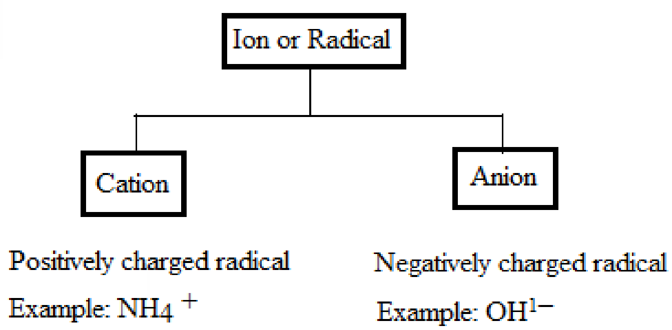
Hg^{2+} or Hg (II) is Mercur**ic**.

Examples of variable valency

Element	Symbol	Valencies exhibited (variable valencies)
Copper	Cu	1, 2
Mercury	Hg	1, 2
Silver	Ag	1, 2
Gold	Au	1, 3
Tin	Sn	2, 4
Manganese	Mn	2, 4
Platinum	Pt	2, 4
Iron	Fe	2, 3
Sulphur	S	2, 3, 4
Lead	Pb	2, 4
Phosphorus	P	3, 5

Ions or Radicals

An ion or radical is an atom or a group of atoms of the same or different elements which behaves 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**, 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 chemical formula, is a combination of elemental symbols and subscript numbers used to show the composition of a compound.

Examples:

Silica is represented as SiO_2.

Marble is represented as $CaCO_3$.

Writing Chemical Formulae

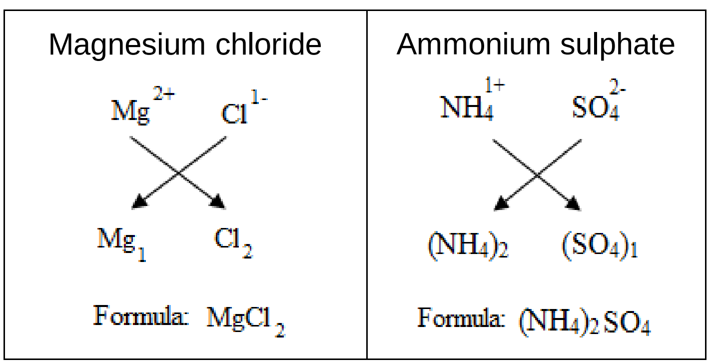
Step 1: Write the symbol of a basic radical (element with positive valency) to the left-hand side and that of the acid radical (element with negative valency) to the right-hand side.

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.

Example of magnesium chloride and ammonium sulphate (refer to the diagram below)



Significance of Molecular Formula

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

1. The name of the substance.
2. Both molecule and 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.
   Example: The formula CO_2 means that
1. CO_2 represents carbon dioxide.
2. The molecular formula of carbon dioxide is CO_2.
3. Each molecule contains one carbon atom joined by chemical bonds with two oxygen atoms.
4. The molecular mass of carbon dioxide is 44, given that the atomic mass of carbon is 12 and that of oxygen is 16.

Rules in Naming Certain Chemical Compounds

<table>
<tr>
<th>1. A metal and non-metal</th>
<th>2. Two non-metals</th>
<th>3. Two elements and oxygen</th>
</tr>
<tr>
<td>
<u>Rule:</u>
Metal – is written first.
Non-metal – given a suffix – ide

<u>Example</u>:
Compound containing potassium and chlorine.

Potassium + Chlorine → Potassium chloride
(metal) (non-metal)

<u>Formula:</u>
Potassium chloride
</td>
<td>
<u>Rule:</u>
Non-metals – written side by side and given a prefix mono, di, tri, tetra etc., indicating the number of atoms.

<u>Example</u>:
<table>
<tr><th>Formula</th><th>Oxides of nitrogen</th><th>Oxidation number of nitrogen</th></tr>
<tr><td>N_2O</td><td>Dinitrogen oxide</td><td>+1</td></tr>
<tr><td>NO</td><td>Nitrogen monoxide</td><td>+2</td></tr>
<tr><td>N_2O_3</td><td>Dinitrogen trioxide</td><td>+3</td></tr>
<tr><td>NO_2</td><td>Nitrogen dioxide</td><td>+4</td></tr>
<tr><td>N_2O_5</td><td>Dinitrogen pentoxide</td><td>+5</td></tr>
</table>
</td>
<td>
<u>Rule:</u>
Two elements – written side by side.
Oxygen written after it.

(1) The prefix hypo is used when the number of oxygen atoms is less than 2.
<u>Example</u>: Potassium hypo-chlorite – KClO

(2) The suffix –ite is used if the number of oxygen atoms is 2.
<u>Example</u>: Potassium chlorite – $KClO_2$

(3) The suffix –ate is used if the number of oxygen atoms is 3.
<u>Example</u>: Potassium chlorate – $KClO_3$

(4) The prefix per- is used when the number of oxygen atoms is more than 3.
<u>Example</u>: Potassium per-chlorate – $KClO_4$
</td>
</tr>
</table>

4. Nomenclature of acids

- **Binary acids**

  The names of binary acids are given by adding the prefix **hydro–** and the suffix **–ic** to the name of the second element.

  Example: HCl – **Hydro**chlor**ic** acid
  HF – **Hydro**fluor**ic** acid

- **Acids containing radicals of polyatomic groups**

  The names of acids containing radicals of polyatomic groups such as sulphate SO_4, nitrate NO_3 etc. are given on the basis of the second element present in the molecule, and the prefix **hydro–** is not used.

  Example: H_2SO_4: The second element is sulphur; thus, the name sulphuric acid.
  HNO_3: The second atom is nitrogen; thus, the name nitric acid.

5. Trivial names

Names of certain compounds do not follow any systematic rule. Such names are called trivial names or common names, and they are widely accepted.

Formula of a compound	Name of compound	Trivial name or Common name
NH_3	Nitrogen trihydride	Ammonia
H_2O	Hydrogen monoxide or dihydrogen oxide	Water