

# SYMBOLS AND FORMULAE

## SYMBOLS AND FORMULAE

There are 106 elements discovered so far. Most of the elements have been found to occur in nature. Some of the elements are man made. It is possible that scientist will continue to discover some more elements.

Most of these elements take part in a variety of reactions giving rise to a large number of new substances. Writing their names using the names of elements is cumbersome. Hence there is a need to write the names of elements and compounds in a short form. Chemical symbols and formulae are introduced to represent the elements and compounds respectively. The symbol for element represents the element either in pure state or in combined state.

### Symbols for elements:

For some of the elements the first letter of its English name is used as symbol to represent that element in short form. Only capital letters are used.

#### Example :

S.NO.	NAME	SYMBOL
1.	Hydrogen	H
2.	Carbon	C
3.	Nitrogen	N
4.	Oxygen	O
5.	Fluorine	F
6.	Sulphur	S
7.	Boron	B
8.	Phosphorus	P
9.	Iodine	I
10.	Uranium	U
11.	Vanadium	V

When the names of the two elements start with the same letter, the second letter or a prominent letter is added to the first letter. When two letters are used the first letter is in capital and the second letter is always a small one.

#### Example :

S.NO.	NAME	SYMBOL
1.	Cobalt	Co
2.	Calcium	Ca
3.	Cadmium	Cd
4.	Chlorine	Cl
5.	Nickel	Ni
6.	Platinum	Pt
7.	Palladium	Pd
8.	Chromium	Cr
9.	Barium	Ba
10.	Bromine	Br
11.	Beryllium	Be
12.	Manganese	Mn
13.	Titanium	Ti
14.	Zinc	Zn

Symbols of some elements are derived from their Latin names.

**Example :**

S.NO.	Element	Latin name	Symbol
1.	Sodium	Natrium	Na
2.	Potassium	Kalium	K
3.	Iron	Ferrum	Fe
4.	Copper	Cuprum	Cu
5.	Silver	Argentum	Ag
6.	Gold	Aurum	Au
7.	Mercury	Hydrargyrum	Hg
8.	Lead	Plumbum	Pb
9.	Tin	Stannum	Sn
10.	Tungsten	Wolfram	W

Symbols based on Country names:

S.NO.	Element	City/Country name	Symbol
1.	Indium	India	In
2.	Americium	America	Am
3.	Germanium	Germany	Ge
4.	Berkelium	City of Berkely	Bk
5.	Francium	France	Fr

Symbols based on the Scientist names:

S.NO.	Element	Scientist name	Symbol
1.	Bhorium	Neils Bohr	Bh
2.	Mendaleevium	Mendaleef	Md
3.	Fermium	Enrico Fermi	Fm
4.	Einsteinium	Albert Einstein	Es
5.	Rutherfordium	Ernest Rutherford	Rf
6.	Nobelium	Alfred Noble	No
7.	Curium	Madam Curie	Cm

Symbols based on Planet names:

S.NO.	Element	Planet name	Symbol
1.	Uranium	Uranus	U
2.	Plutonium	Pluto	Pu
3.	Neptunium	Neptune	Np

The symbols of some of the elements along with their atomic weights are given below :

Atomic.No.	Element	Symbol	Atomic Mass
1.	Hydrogen	H	1
2.	Helium	He	4
3.	Lithium	Li	6.9
4.	Beryllium	Be	9
5.	Boron	B	11
6.	Carbon	C	12
7.	Nitrogen	N	14
8.	Oxygen	O	16
9.	Fluorine	F	19
10.	Neon	Ne	20
11.	Sodium	Na	23
12.	Magnesium	Mg	24
13.	Aluminium	Al	27
14.	Silicon	Si	28
15.	Phosphorus	P	31
16.	Sulphur	S	32
17.	Chlorine	Cl	35.5
18.	Argon	Ar	40
19.	Potassium	K	39
20.	Calcium	Ca	40

### Chemical Formula :

The symbol of an element represents an individual atom of the element. Some of the elements no doubt exist independently. Examples : He, Ne, Ar, Kr, Xe, Fe, Hg, Co etc. However, many elements occur in combination with one or more atoms of its own kind or with one or more atoms of other elements as molecules. The number of atoms present in one molecule of an element is called atomicity of that element.

According to the molecular concept of matter a molecule is the smallest unit of matter capable of independent existence. Molecules containing 1, 2 or 3 atoms are called monatomic, diatomic or triatomic molecules respectively. If they contain more than 3 atoms they may be described as polyatomic. Thus the representation of a molecule of an element or a compound in terms of symbols and figures is defined as chemical formula.

**Examples :**  $H_2$ ,  $H_2O$ ,  $SO_2$ ,  $NH_3$ ,  $O_3$ ,  $H_2SO_4$ ,  $P_4$ ,  $S_8$ ,  $Se_8$  etc

$H_2$  stands for a molecule of hydrogen consisting of two hydrogen atoms.  $H_2O$  stands for a molecule of water consisting of 2 atoms of hydrogen and one atom of oxygen. Thus the number of atoms of each element present in the molecule is indicated by the number on its right hand corner as subscript.

Thus  $H_2SO_4$  stands for one molecule of Sulphuric acid which contain 2 atoms of hydrogen, one atom of sulphur and 4 atoms of oxygen. The following are the formulae of some of the molecules of elements/compounds generally used in the laboratory.

Element/Compound	Formula
Hydrogen	H <sub>2</sub>
Nitrogen	N <sub>2</sub>
Oxygen	O <sub>2</sub>
Ozone	O <sub>3</sub>
Water	H <sub>2</sub> O
Sulphur dioxide	SO <sub>2</sub>
Sulphuric acid	H <sub>2</sub> SO <sub>4</sub>
Nitric acid	HNO <sub>3</sub>
Hydrochloric acid	HCl

### FORMULAE FOR COMPOUNDS AND THEIR NAMES

In writing formulas it will be helpful to use the concept of a valence number that can be assigned to atoms or group of atoms called **radicals**. Radicals, which are found in many compounds, are groups of atoms that behave like single atoms ; for example NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup>. The valence number gives the combining power of the atom or radical. Since the compounds as being composed of atoms so combined that the sums of the positive and negative valence numbers is zero so that the molecule is electrically neutral.

For example , if Ca of valence number +2 is combined with Cl of valence valence –1, the formula of the compound, is CaCl<sub>2</sub>; If Ca combines with N of valence number – 3, the compound has the formula Ca<sub>3</sub>N<sub>2</sub>.

### Positive Radicals and Positive valence numbers

The atoms with positive valence numbers include the metals, the hydrogen ion H<sup>+</sup>, and the ammonium radical, (NH<sub>4</sub><sup>+</sup>), which behaves as a metal. A list of the more common metal atoms and their valence numbers follows.

#### Monovalent Basic radicals

Name	Symbol
Ammonium	NH <sub>4</sub> <sup>+</sup>
Copper	Cu <sup>1+</sup>
Hydrogen	H <sup>1+</sup>
Gold	Au <sup>1+</sup>
Lithium	Li <sup>1+</sup>
Mercury	Hg <sup>1+</sup>

Name	Symbol
Potassium	K <sup>+</sup>
Phosphorium	PH <sub>4</sub> <sup>+</sup>
Rubidium	Rb <sup>1+</sup>
Silver	Ag <sup>1+</sup>
Sodium	Na <sup>+</sup>

#### Bivalent Basic radicals

Name	Symbol
Barium	Ba <sup>2+</sup>
Calcium	Ca <sup>2+</sup>
Cobalt	Co <sup>2+</sup>
Cadmium	Cd <sup>2+</sup>
Magnesium	Mg <sup>2+</sup>

Name	Symbol
Nickel	Ni <sup>2+</sup>
Radium	Ra <sup>2+</sup>
Strontium	Sr <sup>2+</sup>
Zinc	Zn <sup>2+</sup>

**Trivalent Basic radicals**

Name	Symbol
Antimony	Sb <sup>3+</sup>
Gold	Au <sup>3+</sup>
Arsenic	As <sup>3+</sup>
Aluminium	Al <sup>3+</sup>
Chromium	Cr <sup>3+</sup>
Cobalt	Co <sup>3+</sup>
Manganese	Mn <sup>3+</sup>
Iron	Fe <sup>3+</sup>

In naming atoms whose valence numbers vary, the root of the name of atom is followed by “ous” for the lower valence and by “ic” for the higher valence. Thus the ferrous ion is Fe<sup>2+</sup> (Fe<sup>++</sup>) and Ferric acid Fe<sup>3+</sup> (or Fe<sup>+++</sup>).

**Negative Radicals and Negative valence numbers**

The majority of atoms and radicals with negative valence numbers form acids when combined with H<sup>+</sup>.

Mono-atomic anions are most commonly formed from atoms of non-metallic elements. They are named by dropping the ending of the name of the element and adding the ending “ide”. For example,

H <sup>-</sup>	→	Hydride ion
F <sup>-</sup>	→	Fluoride ion
O <sup>2-</sup>	→	Oxide ion
S <sup>2-</sup>	→	Sulfide ion
N <sup>3-</sup>	→	nitride ion
P <sup>3-</sup>	→	phosphide ion

Only a few common poly atomic ions end in “ide”.

OH <sup>-</sup>	→	hydroxide ion	CN <sup>-</sup>	→	cyanide ion
O <sub>2</sub> <sup>2-</sup>	→	Peroxide ion	N <sub>3</sub> <sup>-</sup>	→	azide ion

Polyatomic ions containing oxygen are referred to as oxyanions. A particular element such as sulphur may form more than one oxyanion. When this occurs, there are rules for indicating the relative numbers of oxygen atoms in the anion. When an element forms only two oxyanions, the name of the one that contains more oxygen ends in “ate”; the name of the one with less oxygen ends in ite : –

**Example :**

(1)	NO <sub>2</sub> <sup>-</sup>	→	Nitrite ion (two oxygen atoms)
	NO <sub>3</sub> <sup>-</sup>	→	Nitrate ion (three oxygen atoms)

When the series of anions of a given element extends to three or four members, as with the oxyanions of the halogens, prefixes are also employed. The prefix ‘**hypo**’ indicates less oxygen, and the prefix ‘**per**’ indicates more oxygen.

$\text{ClO}^-$	→	hypochlorite ion (one less oxygen than chlorite)
$\text{ClO}_2^-$	→	chlorite ion (one less oxygen than chlorate)
$\text{ClO}_3^-$	→	chlorate ion
$\text{ClO}_4^-$	→	perchlorate ion (one more oxygen than chlorate)

Since many names of ions predate the establishment of systematic rules, there are many exceptions to these rules. For example, the permanganate ion is  $\text{MnO}_4^-$ ; we thus expect that the manganate ion should be  $\text{MnO}_3^-$ , but this ion is unknown. So the name manganate is given to the species  $\text{MnO}_4^{2-}$ .

Many polyatomic anions that have high charges readily add one or more hydrogen ions ( $\text{H}^+$ ) to form anions of lower charge. These ions are named by prefixing the word hydrogen or dihydrogen, as appropriate, to the name of the hydrogen free anion. An older method, is still used, by using prefix by.

$\text{HCO}_3^-$	hydrogen carbonate ( or bicarbonate) ion
$\text{HSO}_4^-$	hydrogen sulfate (or bisulfate) ion
$\text{H}_2\text{PO}_4^-$	dihydrogen phosphate ion

### Mono-valent Acid radicals

Name	Symbol
Fluoride	$\text{F}^{1-}$
Chloride	$\text{Cl}^{1-}$
Bromide	$\text{Br}^{1-}$
Iodide	$\text{I}^{1-}$
Hydride	$\text{H}^{1-}$
Hydroxide	$\text{OH}^{1-}$
Cyanate	$\text{CNO}^{1-}$

Name	Symbol
Thiocyanate	$\text{SCN}^{1-}$
Superoxide	$\text{O}_2^{1-}$
Hypophosphite	$\text{H}_2\text{PO}_2^{1-}$
Biphosphate	$\text{H}_2\text{PO}_4^{1-}$
Bisulphide	$\text{HS}^{1-}$
Bisulphite	$\text{HSO}_3^{1-}$
Bisulphate	$\text{HSO}_4^{1-}$
Bicarbonate	$\text{HCO}_3^{1-}$
Formate	$\text{HCOO}^{1-}$
Acetate	$\text{CH}_3\text{COO}^{1-}$
Permanganate	$\text{MnO}_4^{1-}$

### Bivalent Acid radicals

Name	Symbol
Oxide	$\text{O}^{2-}$
Peroxide	$(\text{O}_2)^{2-}$
Sulphide	$(\text{S})^{2-}$
Carbonate	$(\text{CO}_3)^{2-}$
Sulphate	$(\text{SO}_4)^{2-}$
Sulphite	$(\text{SO}_3)^{2-}$

Name	Symbol
Oxalate	$(\text{C}_2\text{O}_4)^{2-}$
Molybdate	$(\text{MoO}_4)^{2-}$
Tetraborate	$(\text{B}_4\text{O}_7)^{2-}$
Tartrate	$(\text{C}_4\text{H}_4\text{O}_6)^{2-}$
Zincate	$(\text{ZnO}_2)^{2-}$
Fluorosilicate	$(\text{SiF}_6)^{2-}$

Thiosulphate	$(S_2O_3)^{2-}$
Tetrathionate	$(S_4O_6)^{2-}$
Perdisulphate	$(S_2O_8)^{2-}$
Manganate	$(MnO_4)^{2-}$
Stannite	$(SnO_2)^{2-}$
Stannate	$(SnO_3)^{2-}$
Silicate	$(SiO_3)^{2-}$

Titanate	$(TiO_3)^{2-}$
Monohydrogen phosphate	$(HPO_4)^{2-}$
Monohydrogen phosphite	$(HPO_3)^{2-}$
Plumbite	$(PbO_2)^{2-}$
Plumbate	$(PbO_3)^{2-}$
Pyroantimonite	$(H_2Sb_2O_7)^{2-}$

### Trivalent Acid radicals

Name	Symbol
Aluminate	$(AlO_3)^{3-}$
Arsenite	$(AsO_3)^{3-}$
Arsenate	$(AsO_4)^{3-}$
Arsenide	$(As)^{3-}$
Phosphite	$(PO_3)^{3-}$
Phosphate	$(PO_4)^{3-}$
Phosphide	$P^{3-}$
Nitride	$N^{3-}$
Borate	$BO_3^{3-}$

### Criss – Cross method of writing chemical formula:

When a substance is formed from two oppositely charged radicals the formula of the molecule may be written with the help of valencies of the radicals by following the steps given below .

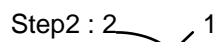
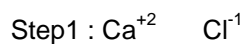
Step 1 : Write the symbol of the positive ion or the radical to the left and the negative ion or the radical to the right.

Step 2: Put the valency number of each of the radical or ion on its top right. Divide the valency number by the highest common factor. If any to get simple ratio. Now ignore the (+) and (-) symbols. Interchange the valency number of the radicals

Step 3: Shift the valency number to the lower right of the ion or the radical. If radical receives a number more than 1, enclose it within brackets. Do not enclose single atom within brackets.

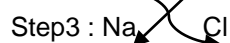
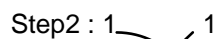
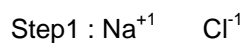
**Examples :**

(a) Formula of Calcium Chloride :



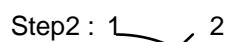
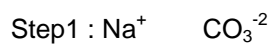
The Formula is  $\text{CaCl}_2$

(b) Formula of Sodium Chloride :



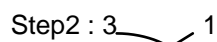
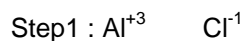
The formula of Sodium Chloride is  $\text{NaCl}$

(c) Formula of Sodium carbonate :



Formula of Sodium carbonate is  $\text{Na}_2\text{CO}_3$

(d) Formula of Aluminium chloride :



The formula of aluminium chloride is  $\text{AlCl}_3$  .



## ASSIGNMENT

### SINGLE OPTION CORRECT TYPE

- Symbol of Mercury is  
(A)  $Ag$  (B)  $Hg$  (C)  $Mg$  (D)  $Au$
- Latin name of Tungsten is  
(A) Plumbum (B) Wolfram (C) Hydrargyrum (D) Argentum
- An atom or a group of atoms which has charge is called as a / an  
(A) Molecule (B) Atom (C) Ion (D) Symbol
- Which of the following is a simple ion  
(A)  $NO_3^-$  (B)  $NH_4^+$  (C)  $Mg^{2+}$  (D)  $H_3O^+$
- Peroxide ion is  
(A)  $O_2^{2-}$  (B)  $O_2^-$  (C)  $O^{2-}$  (D) None
- Valency of Aluminium is  
(A) 1 (B) 2 (C) 3 (D) 4
- A cation is formed by  
(A) gain of one electron (B) loss of one or more electrons  
(C) gain of one or more electrons (D) loss or gain of electrons
- $Ca^{2+}$  ion is formed by loss of \_\_\_\_\_ electrons  
(A) 4 (B) 3 (C) 2 (D) 1
- Choose the divalent anions from the following  
I) Bromide II) Sulphate III) Acetate IV) Sulphide  
(A) I, II (B) II, III (C) II, IV (D) All
- $FeSO_4$  is  
(A) Ferric Sulphide (B) Ferrous Sulphite (C) Ferric Sulphate (D) Ferrous Sulphate
- $5N_2$  represents  
(A) 5 atoms of Nitrogen (B) 10 atoms of Nitrogen  
(C) 10 molecules of Nitrogen (D) 5 molecules of Nitrogen
- Homo atomic molecule among the following is  
(A)  $P_4$  (B)  $S_8$  (C)  $O_3$  (D) All
- Formula of Potassium permanganate is  
(A)  $KMnO_4$  (B)  $K_2MnO_4$  (C)  $K(MnO_4)_2$  (D) None

14. The number of Oxygen atoms in Oxalate ion is  
 (A) 1 (B) 2 (C) 3 (D) 4
15. Perchlorate ion is  
 (A)  $ClO^-$  (B)  $ClO_3^-$  (C)  $ClO_4^-$  (D)  $ClO_2^-$

**MULTIPLE OPTION CORRECT TYPE**

16. Identify compound anions  
 (A)  $S^{2-}$  (B)  $CO_3^-$  (C)  $Cl^-$  (D)  $NO_3^-$
17. Iron can show valencies  
 (A) 1 (B) 2 (C) 3 (D) 4
18. Identify the simple cations  
 (A)  $Na^+$  (B)  $NH_4^+$  (C)  $Cl^-$  (D)  $Ca^{2+}$
19. Bivalent anions  
 (A) Oxide (B) Sulphide (C) Phosphide (D) Nitride
20. Correct statement is / are  
 (A) Atoms combine to form molecules (B) Atoms always has independent existence  
 (C) Molecule always has independent existence  
 (D) An ion is formed by gain or loss of electron  $e^-$  from neutral atom

**MATCHING**

21.

	SET - I		SET - II
1)	Nitrate	(A)	$N^{3-}$
2)	Nitrite	(B)	$N_3^-$
3)	Nitride	(C)	$NO_2^-$
4)	Azide	(D)	$NO_3^-$

**FILL THE TABLE WITH APPROPRIATE FORMULAE**

Metallic Radicals	NON METALLIC RADICALS						
	Chloride	Hydroxide	Oxide	Nitrate	Sulphate	Carbonate	Phosphate
Sodium							
Potassium							
Magnesium							
Aluminium							
Iron (II)							
Zinc							
Calcium							
Iron (III)							

## ANSWERS

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### Single correct option type

- |              |              |              |              |
|--------------|--------------|--------------|--------------|
| 1. <b>B</b>  | 2. <b>B</b>  | 3. <b>C</b>  | 4. <b>C</b>  |
| 5. <b>A</b>  | 6. <b>C</b>  | 7. <b>B</b>  | 8. <b>C</b>  |
| 9. <b>C</b>  | 10. <b>D</b> | 11. <b>D</b> | 12. <b>D</b> |
| 13. <b>A</b> | 14. <b>D</b> | 15. <b>C</b> |              |

### Multi correct option type

- |                    |                 |                    |                 |
|--------------------|-----------------|--------------------|-----------------|
| 16. <b>B, D</b>    | 17. <b>B, C</b> | 18. <b>A, C, D</b> | 19. <b>A, B</b> |
| 20. <b>A, C, D</b> |                 |                    |                 |

### Matrix Match type

21.    **1 – D, 2 – C, 3 – A, 4 – B**