SYMBOLS AND FORMULAE

SYMBOLS AND FORMULAE

There are 118 elements discovered so far. 92 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	Auram	Au
7.	Mercury	Hydragyrum	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.	Amerecium	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. Chemical formula tells the number of atoms of various elements present in the molecule.

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

(i) Homo atomic molecules: The molecules which are made up of the atoms of same element are called Homo atomic molecules. These are also called element molecules.

Ex: H_2, O_2, N_2, F_2, Cl_2, I_2, P_4, S_8 etc

(ii) Hetero atomic molecules: The molecules which are made up of atoms of different elements are called Hetero atomic molecules.

Ex: HCl, NaCl, CO_2, H_2O, NH_3 etc.

(iii) Atomicity: The number of atoms present in a molecule of an element is called Atomicity.

Mono atomic ex: All the noble gases, Na, Al, Cu, etc.
Di atomic ex: H_2, O_2, N_2, F_2, Cl_2, I_2 etc
Tri atomic ex: O_3, CO_2, CS_2 etc
Poly atomic ex: S_8, P_4, NH_3, CH_4 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_2
Nitrogen	N_2
Oxygen	O_2
Ozone	O_3
Water	H_2O
Sulphur dioxide	SO_2
Sulphuric acid	H_2SO_4
Nitric acid	HNO_3
Hydrochloric acid	HCl

Valence:

The combining capacity of an atom with the other atoms is called its valence. One Hydrogen atom combines with another Hydrogen atom to form a molecule of Hydrogen, means that the Hydrogen has the capacity to combine with only one Hydrogen atom .

Atoms of Chlorine, Oxygen, Nitrogen and Carbon have capacity to combine with one, two, three and four hydrogen atoms respectively. Hence Hydrogen chloride (HCl), water(H_20), Ammonia (NH_3), Methane (CH_4) are formed. Except noble gases no other element has valance (combining capacity) less than that of hydrogen which is considered as a standard and “1”. So the valence of Chlorine, Oxygen, Nitrogen and Carbon are one, two, three and four respectively.

If the atom of any element does not combine with Hydrogen, then how to find out the valence of .that element ? The valence of the element in terms of Chlorine or oxygen can be determined.

Ex:

i) One atom of Magnesium combines with one atom of Oxygen, to form a molecule of Magnesium oxide. We know, the valance of Oxygen is 2. That means one Magnesium atom can combine with one Oxygen atom and one Oxygen atom can combine with two atoms of Hydrogen. So it can be taken that the Magnesium atom can combine with two atoms of Hydrogen. So the valence of Magnesium is two.

ii) Zinc does not combine directly with Hydrogen. But one atom of Zinc combines with two atoms of Chlorine to form Zinc chloride. We know, the valance of Chlorine is one But Zinc combines with two atoms of Chlorine. So the valance of Zinc is 2.

The valance of an atom in a molecule containing only one such an atom is equal to the number of Hydrogen atoms, twice the number of Oxygen atoms or number of Chlorine atoms to which it can chemically combine.

Ex: i) The valance of Nitrogen in Ammonia (NH_3) is 3.

ii) The valance of Nitrogen in Hydrazine (N_2H_4) is 3 but not 2 .Two valancies of each Nitrogen is satisfied by two Hydrogen atoms and third valance is satisfied by other Nitrogen atom

Variable Valence

Certain elements exhibit more than one valence and these elements are known to be with variable valence.

If an element exhibits variable valence, then the suffix 'ous' used for lower valence and 'ic' for higher valence.

Ex. : i) Valance of Iron in Ferrous oxide is 2 and in ferric oxide is 3.

ii) Valance of Copper in Cuprous oxide is 1 and in cupric oxide is 2.

Ion or Radical :

An atom or a group of atoms of same or different elements having positive or negative charge is called an Ion or a Radical. Ions can be classified into two types basing on the sign of the charge present on them.

a) Cation :

The atom or group of atoms which has positive charge (basic radical) is called cation or electropositive ion. When one or more electrons are removed from an atom or a molecule then it leads to the formation of cation. The positive charge on the cation is equal to number of electrons removed during its formation.

Ex. i) Sodium atom loses one electron to form Sodium ion (Na^+)

$$\underset{(2,8,1)}{Na} \longrightarrow \underset{(2,8)}{Na^+} + 1e^-$$

$$(11p,11e) \quad (11p,10e)$$

ii) Magnesium atom loses two electrons to form Magnesium ion (Mg^{2+}).

$$\underset{(2,8,2)}{Mg} \longrightarrow \underset{(2,8)}{Mg^{2+}} + 2e^-$$

$$(12p,12e) \quad (12p,10e)$$

b) Anion:

The atom or group of atoms which has negative charge (acidic radical) is called anion or Electronegative ion. When One or more electrons are added to the atom or a molecule then it leads to the formation of anion. The total negative charge on the anion is equal to the number of electrons added during its formation.

Ex: i) Chlorine gains one electron to form Chloride ion $\left(Cl^-\right)$

$$\underset{(2,8,7)}{Cl} + e^- \longrightarrow \underset{(2,8,8)}{Cl^-}$$

$$(17p,17e) \quad (17p,18e)$$

ii) Sulphur atom gains two electrons to form Sulphide ion $\left(S^{2-}\right)$.

$$\underset{(2,8,6)}{S} + 2e^- \longrightarrow \underset{(2,8,8)}{S^{2-}}$$

$$(16p,16e) \quad (16p,18e)$$

Example

Find the number of protons and electrons in Fe^{2+} ion ? .

Solution : The atomic number of Iron is 26 :

So In an Iron atom, n(e) = 26 and n(p) = 26

Fe^{2+} is formed by removing two electrons from the Iron atom.

Therefore, in Fe^{2+}, n(e) = 26 – 2 = 24

n(p) = 26

Problem

Find the number of electrons and protons in the Cuprous (Cu^{+}) ion

Classification of ions with respect to composition:

Ions can be classified into two types basing on their composition

1) Simple Ions

2) Compound Ions

1) Simple ions : The ions which are formed from atoms of same element are called simple ions.

Ex. : Simple cations : Na^{+}, Mg^{2+}, Al^{3+}, Fe^{2+}, Zn^{2+} etc.

Simple anions : Cl^{-}, S^{2-} , O^{2-}, N^{3-} etc.

2) Compound ions : The ions which are formed from atoms of different element are called compound ions. |

Ex. : Compound cations : NH_4^{+}, H_3O^{+}, PH_4^{+} etc

Compound anions : SO_4^{2-}, $Cr_2O_7^{2-}$, MnO_4^{-}, CO_3^{2-}, NO_3^{-} etc.

Classification of tons with respect to valance :

The valance of an ion is equal to the magnitude of the charge present on it. Basing on the valnce , ions can be classified into mono, di, tri ,tetra and pentavalent ions

Ex: i) Valence of Na^{+} is 1 so it is a monovalent electropositive ion.

ii) Valance of S^{-2} is 2 so it is a divalent electronegative ion.

Positive Radicals and Positive valence numbers

The atoms with positive valence numbers include the metals, the hydrogen ion H^{+}, and the ammonium radical, (NH_4^{+}), 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_4^{+}
Copper	Cu^{1+}
Hydrogen	H^{1+}
Gold	Au^{1+}
Lithium	Li^{1+}
Mercury	Hg^{1+}

Name	Symbol
Potassium	K^{+}
Phosphorium	PH_4^{+}
Rubidium	Rb^{1+}
Silver	Ag^{1+}
Sodium	Na^{+}
Cuprous	Cu^{+1}

Bivalent Basic radicals

Name	Symbol
Barium	Ba^{2+}
Calcium	Ca^{2+}
Cobalt	Co^{2+}
Cadmium	Cd^{2+}
Magnesium	Mg^{2+}

Name	Symbol
Nickel	Ni^{2+}
Radium	Ra^{2+}
Strontium	Sr^{2+}
Zinc	Zn^{2+}
Ferrous	Fe^{2+}
Cupric	Cu^{2+}

Trivalent Basic radicals

Name	Symbol
Antimony	Sb^{3+}
Gold	Au^{3+}
Arsenic	As^{3+}
Aluminium	Al^{3+}
Chromium	Cr^{3+}
Cobalt	Co^{3+}
Manganese	Mn^{3+}
Ferric	Fe^{3+}

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^{2+} (Fe^{++}) and Ferric acid Fe^{3+} (or Fe^{+++}).

Negative Radicals and Negative valence numbers

The majority of atoms and radicals with negative valence numbers form acids when combined with H^+.

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^- → Hydride ion
F^- → Fluoride ion
O^{2-} → Oxide ion
S^{2-} → Sulfide ion
N^{3-} → nitride ion
P^{3-} → phosphide ion

Only a few common poly atomic ions end in "ide".

OH^- → hydroxide ion CN^- → cyanide ion
O_2^{2-} → Peroxide ion N_3^- → 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_2^- → Nitrite ion (two oxygen atoms)
NO_3^- → 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.

ClO^- → hypochlorite ion (one less oxygen than chlorite)
ClO_2^- → chlorite ion (one less oxygen than chlorate)
ClO_3^- → chlorate ion
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 MnO_4^-; we thus expect that the manganate ion should be MnO_3^- ,but this ion is unknown. So the name manganate is given to the species MnO_4^{2-}.

Many polyatomic anions that have high charges readily add one or more hydrogen ions (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.

HCO_3^- hydrogen carbonate (or bicarbonate) ion
HSO_4^- hydrogen sulfate (or bisulfate) ion
$H_2PO_4^-$ dihydrogen phosphate ion

Mono-valent Acid radicals

Name	Symbol
Fluoride	F^{1-}
Chloride	Cl^{1-}
Bromide	Br^{1-}
Iodide	I^{1-}
Hydride	H^{1-}
Hydroxide	OH^{1-}
Cyanate	CNO^{1-}
Nitrite	NO_2^-
Nitrate	NO_3^-
Azide	N_3^-
Meta Aluminate	AlO_2^-

Name	Symbol
Thiocyanate	SCN^{1-}
Superoxide	O_2^{1-}
Hypophosphite	$H_2PO_2^{1-}$
Biphosphate	$H_2PO_4^{1-}$
Bisulphide	HS^{1-}
Bisulphite	HSO_3^{1-}
Bisulphate	HSO_4^{1-}
Bicarbonate	HCO_3^{1-}
Formate	$HCOO^{1-}$
Acetate	CH_3COO^{1-}
Permanganate	MnO_4^{1-}

Bivalent Acid radicals

Name	Symbol
Oxide	O^{2-}
Peroxide	$(O_2)^{2-}$
Sulphide	$(S)^{2-}$
Carbonate	$(CO_3)^{2-}$
Sulphate	$(SO_4)^{2-}$
Sulphite	$(SO_3)^{2-}$

Name	Symbol
Oxalate	$(C_2O_4)^{2-}$
Chromate	$(CrO_4)^{2-}$
Dicromate	$(Cr_2O_7)^{2-}$
Tartrate	$(C_4H_4O_6)^{2-}$
Zincate	$(ZnO_2)^{2-}$
Manganate	$(MnO_4)^{2-}$

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:

The following steps should be taken while writing the chemical formula.

(i) Write the formulae of electro positive and electro negative ions side by side respectively.

(ii) Rewrite the formulae of radicals by ignoring he positive and negative signs. The numbers indicate the valancies of radicals and are called valance numbers.

(iii) Write the valance number of one radical to the lower right of other radical formula.

(iv) Divide the valence numbers by their highest common factor to get a simple ration.

(v) If a radical is a group of atoms then enclose it with in brackets.

(vi) If the subscript to be written is 1 then no need to represent it in the formula.

Examples :

(a) Formula of Calcium Chloride :

Step1 : Ca^{+2} Cl^{-1}

Step2 : 2 1

Step3 : Ca Cl

The Formula is $CaCl_2$

(b) Formula of Sodium Chloride :

Step1 : Na^{+1} Cl^{-1}

Step2 : 1 1

Step3 : Na Cl

The formula of Sodium Chloride is NaCl

(c) Formula of Sodium carbonate :

Step1 : Na^{+} CO_3^{-2}

Step2 : 1 2

Step3 : Ca (CO_3)

Formula of Sodium carbonate is Na_2CO_3

(d) Formula of Aluminium chloride :

Step1 : Al^{+3} Cl^{-1}

Step2 : 3 1

Step3 : Al Cl

The formula of aluminium chloride is $AlCl_3$.

ASSIGNMENT

SINGLE OPTION CORRECT TYPE

1. Symbol of Mercury is
(A) Ag (B) Hg (C) Mg (D) Au

2. Latin name of Tungsten is
(A) Plumbum (B) Wolfram (C) Hydrargyrum (D) Argentum

3. An atom or a group of atoms which has charge is called as a / an
(A) Molecule (B) Atom (C) Ion (D) Symbol

4. Which of the following is a simple ion
(A) NO_3^- (B) NH_4^+ (C) Mg^{2+} (D) H_3O^+

5. Peroxide ion is
(A) O_2^{2-} (B) O_2^- (C) O^{2-} (D) None

6. Valency of Aluminium is
(A) 1 (B) 2 (C) 3 (D) 4

7. 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

8. Ca^{2+} ion is formed by loss of _____ electrons
(A) 4 (B) 3 (C) 2 (D) 1

9. 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

10. $FeSO_4$ is
(A) Ferric Sulphide (B) Ferrous Sulphite (C) Ferric Sulphate (D) Ferrous Sulphate

11. $5N_2$ represents
(A) 5 atoms of Nitrogen (B) 10 atoms of Nitrogen
(C) 10 molecules of Nitrogen (D) 5 molecules of Nitrogen

12. Homo atomic molecule among the following is
(A) P_4 (B) S_8 (C) O_3 (D) All

13. 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

Single correct option type

1.	**B**	2.	**B**	3.	**C**	4.	**C**
5.	**A**	6.	**C**	7.	**B**	8.	**C**
9.	**C**	10.	**D**	11.	**D**	12.	**D**
13.	**A**	14.	**D**	15.	**C**		

Multi correct option type

16.	**B, D**	17.	**B , C**	18.	**A , C, D**	19.	**A , B**
20.	**A , C , D**						

Matrix Match type

21. **1 – D , 2 – C , 3 – A , 4 – B**