J S U N I L   T U T O R I A L

P U N J A B I   C O L O N Y   G A L I   0 1

Language of Chemistry

Symbol

The symbol of an element is a short way of representing an element. Symbols can be formed as follows: 1) By using the first letter of the English name of the element.

Hydrogen	H	Phosphorus	P
Oxygen	O	Sulphur	S

2) By using the first and second letters of the English name of the element.

Helium	He	Calcium	Ca
Lithium	Li	Cobalt	Co

3) By using the first letter and any other prominent sounding letter of the English name of the element.

Magnesium	Mg	Chromium	Cr
Chlorine	Cl	Manganese	Mn

4) By using the first letter of the Latin name of the element. Example: Potassium - Kalium - K. 5) By using the first and the second letter of the Latin name of the element, Sodium- Natrium- Na.

Sodium	Natrium	Na	Gold	Aurrum	Au
Copper	Cuprum	Cu	Iron	Ferrum	Fe

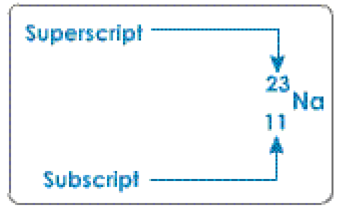
6) By using the first and any other prominent sounding letter of the Latin name.

Silver	Argentum	Ag	Tin	Stannum	Sn
Lead	Plumbum	Pb	Mercury	Hydrargyrum	Hg

Remember! If the symbol has only one letter of the alphabet like in H, O, K, etc., it must be a capital letter. If it has 2 letters, the first is always a capital letter, while the second is always a small letter. Examples: Na, Cr, Mn etc.

What Does A Symbol Represent?

A symbol represents one atom of an element. Example: H stands for one atom of hydrogen. However, if a symbol has a subscript and a superscript, as given along side, then more in formation can be derived from it.



The subscript 11 shows that one atom of sodium has 11 protons and 11 electrons in it or 11 positively charged, and 11 negatively charged particles and also that the net charge of the atom is NIL. The distribution of the 11 electrons around the nucleus can be found out as: 2,8,1.... i.e., 2 in the first orbit,8 in the second orbit and 1 in its third orbit. This distribution also tells us that it is a metal, and that its valency is + 1. The superscript 23, shows that the atom contains 23 dense particles in the nucleus of the atom. The superscript also allows us to calculate the number of neutrons in an atom; this is done by subtracting the subscript from the superscript i.e., 23 - 11=12.

Chemical Formula

The chemical formula of a substance is the symbolic representation of the actual number of atoms present in one molecule of that substance. Example 1: Formula of one molecule of oxygen is O_2. It shows that one molecule of oxygen is made up of 2 atoms of it. Example 2: Formula of one molecule of water is H_2O. It shows that one molecule of water is made up of 2 atoms of hydrogen and one atom of oxygen. Example 3: Formula of one molecule of sulphuric acid is H_2SO_4. It shows that one molecule of sulphuric acid is made up of 2 atoms of hydrogen, 1 atom of sulphur and 4 atoms of oxygen.

Valency

Valency is the combining capacity of an atom. It is equal to the number of electrons the atom loses, or gains or shares when it combines with one or more atoms. Depending on whether the atom loses, gains or shares electrons, the valency may be positive or negative or neutral respectively. Example: Valency of sodium is + 1, because it can lose one electron. It is represented as Na^+. Valency of oxygen may be - 2 if it accepts 2 electrons i.e., O^{2-}. If two or more atoms combine by sharing electrons i.e., not losing or gaining electrons, then the valency numbers are neither positive nor negative. In the case of carbon dioxide, carbon and oxygen atoms, do not, lose or gain electrons, and their valencies are 4 and 2 respectively. Certain atoms exhibit different kinds of valencies. This is because such elements can loose more than one electron from their outer most shell depending on the available conditions. When such atoms exhibit variable valency, the name of the atom with the lower valency ends as **-ous**, and the one with the higher valency, ends as **-ic**.

Lower Valency		Higher Valency	
Cuprous	Cu^{+}	Cupric	Cu^{++}
Ferrous	Fe^{++}	Ferric	Fe^{+++}
Plumbous	Pb^{++}	Plumbic	Pb^{++++}
Mercurous	Hg^{+}	Mercuric	Hg^{++}
Aurous	Au^{+}	Auric	Au^{+++}

Lower Valency Higher

Remember! Atoms with

Lower Valency Higher

variable valencies have their symbols same but are named differently. Example 1: Copper (Cu) has a variable valency of 1 and 2. It is shown as Cu^{+} and Cu^{++}. Cu^{+} is read as Cuprous and Cu^{++} is read as Cupric. Example 2: Ferrous (Fe^{++}) and Ferric (Fe^{+++}). Example 3: Plumbous (Pb^{++}) and Plumbic (Pb^{++++}).

Variable valencies are also represented, using the symbols along with the respective valency number in roman numerals in bracket.

Cuprous Cu (I)	Cupric Cu (II)
Ferrous Fe (II)	Ferric Fe (III)
Plumbous Pb (II)	Plumbic Pb (IV)

Atoms also combine in a group when the atoms of different elements combine in a group they are called radicals. They behave as a single unit and the valency of radicals is the overall net charge of the group. The radicals maintain their identity in the chemical changes but are incapable of independent existence.

Remember!

Radicals Formulae

Hydroxide - OH^{-} Sulphate - SO_4^{-} Nitrate - NO_3^{-}

Positive Radicals

Valency 1		Valency 2		Valency 3		Valency 4		Valency 5		Valency6	
Potassium	K^+	Barium	Ba^{2+}	Aluminium	Al^{3+}	Plumbic	Pb^{4+}				
Sodium	Na^+	Calcium	Ca^{2+}	Chromium	Cr^{3+}	Manganic	Mn^{4+}				
Cuprous	Cu^+	Ferrous	Fe^{2+}	Ferric	Fe^{3+}	Platinum	Pt^{4+}				
Mercurous	Hg^+	Cupric	Cu^{2+}	Auric	Au^{3+}						
Silver	Ag^+	Mercuric	Hg^{2+}								
Hydrogen	H^+	Plumbous	Pb^{2+}								
		Zinc	Zn^{2+}								
Ammonium	NH_4^+	Nickel	Ni^{2+}								
		Magnesium	Mg^{2+}								
		Manganese	Mn^{2+}								
Hydrogen	H	Carbon	C	Phosphorus	P	Carbon	C	Phosphorus	P		
Nitrogen	N	Nitrogen	N	Nitrogen	N	Nitrogen	N	Nitrogen	N		
		Sulphur	S			Sulphur	S			Sulphur	S
						Silicon	Si				

Negative Radicals

Valency 1		Valency 2		Valency 3		Valency 4	
Fluoride	F^-						
Chloride	Cl^-	Carbonate	CO_3^{2-}	Nitride	N^{3-}	Carbide	C^{4-}
Bromide	Br^-	Sulphide	S^{2-}	Phosphide	P^{3-}		
Iodide	I^-						
Bisulphite	HSO_3^-	Sulphite	SO_3^{2-}	Phosphate	PO_4^{3-}		
Bisulphate	HSO_4^-	Sulphate	SO_4^{2-}				
Bicarbonate	HCO_3^-						
Hydroxide	OH^-	Oxide	O^{2-}				
Nitrate	NO_3^-	Chromate	CrO_4^{2-}				
Nitrite	NO_2^-	Dichromate	$Cr_2O_7^{2-}$				
Hydride	H^-						
Permanganate	MnO_4^-						
Chlorate	ClO_3^-	Manganate	MnO_4^{2-}				

Table of Symbols, Atomic Number and Relative Atomic Masses

Element	Symbol	Atomic Number	Relative atomic mass
Actinium	Ac	89	227
Aluminium	Al	13	27
Americium	Am	95	243
Antimony	Sb	51	122

Element	Symbol	Atomic Number	Relative atomic mass
Argon	Ar	18	40
Arsenic	As	38	75
Astatine	At	85	210
Barium	Ba	56	137
Berkelium	Bk	97	247
Beryllium	Be	4	9
Bismuth	Bi	83	209
Boron	B	5	11
Bromine	Br	35	80
Cadmium	Cd	48	112
Caesium	Cs	55	133
Element	**Symbol**	**Atomic Number**	**Relative atomic mass**
Calcium	Ca	20	40
Californium	Cf	98	251
Carbon	C	6	12
Cerium	Ce	58	140
Chlorine	Cl	17	35.5
Chromium	Cr	24	52
Cobalt	Co	27	59
Copper	Cu	29	63.5
Curium	Cm	96	247
Dysprosium	Dy	66	162.5
Einsteinium	Es	99	254
Erbium	Er	68	167
Europium	Eu	63	152
Fermium	Fm	100	253
Element	**Symbol**	**Atomic Number**	**Relative atomic mass**
Fluorine	F	9	19

Francium	Fr	87	223
Gadolinium	Gd	64	157
Gallium	Ga	31	70
Germanium	Ge	32	72.5
Gold	Au	79	197
Hafnium	Hf	72	178
Helium	He	2	4
Holmium	Ho	67	164
Hydrogen	H	1	1
Indium	In	49	115
Iodine	I	53	127
Iridium	Ir	77	192
Iron	Fe	26	56
Krypton	Kr	36	84

Element	Symbol	Atomic Number	Relative atomic mass
Lanthanum	La	57	139
Lawrencium	Lr	103	257
Lead	Pb	82	207
Lithium	Li	3	7
Lutecium	Lu	71	175
Magnesium	Mg	12	24
Manganese	Mn	25	55
Mendelevium	Md	101	256
Mercury	Hg	80	201
Molybdenum	Mo	42	96
Neodymium	Nd	60	144
Neon	Ne	10	20
Neptunium	Np	93	237

Element	Symbol	Atomic Number	Relative atomic mass
Nickel	Ni	28	59
Element	Symbol	Atomic Number	Relative atomic mass
Niobium	Nb	41	93
Nitrogen	N	7	14
Nobelium	No	102	254
Osmium	Os	76	190
Oxygen	O	8	16
Palladium	Pb	46	106
Phosphorus	P	15	31
Platinum	Pt	78	195
Plutonium	Pu	94	242
Polonium	Po	84	210
Potassium	K	19	39
Praesodymium	Pr	59	141
Promethium	Pm	61	147
Protactinium	Pa	91	231
Element	Symbol	Atomic Number	Relative atomic mass
Radium	Ra	88	226
Radon	Rn	86	222
Rhenium	Re	75	186
Rhodium	Rh	45	103
Rubidium	Rb	37	85
Ruthenium	Ru	44	101
Samarium	Sm	62	150
Scandium	Sc	21	45
Selenium	Se	34	79
Silicon	Si	14	28

Silver	Ag	47	108
Sodium	Na	11	23

(i) The number of protons or electrons in an atom constitutes its atomic number.

(ii) The relative atomic mass of an element is the mass of its atom expressed in atomic mass unit, which is exactly 1/12th the mass of one atom of carbon-12.

Framing of Formulae of compounds with the Help of Valency

A compound is a substance formed by the combination of atoms of two or more elements.

To be able to frame formulae, one should be thorough with the valencies.

1) Frame the formula of the compound formed when sodium and chlorine combine. Write down the symbol of sodium and chlorine and draw a short line next to each as shown. The short lines represent the valency (just the number and not the charge) of each atom.

Connect each valency, with the valency of the other.

Now there are no free valencies. So the formula is NaCl.

2) Frame the formula of the compound formed when calcium and chlorine combine.

Write down the symbol of calcium and chlorine, and draw 2 small lines next to calcium (valency= 2) and 1 small the next to chlorine.

Join the valencies of calcium with that of chlorine.

Here one valency of calcium is free. So take one more chlorine.

Join them.

So we get the formula $CaCl_2$.

3) Similarly, frame the formula of the compound formed between aluminium and chlorine. (Al, valency= 3, Cl, valency = 1). Draw 3 small lines next to aluminium (valency= 3) and 1 small the next to chlorine.

Here two valency of aluminium is free. So take two more chlorine and join them.

4) Formula of compound formed between magnesium (valency = 2) and nitrogen (valency = 3).

Draw 2 lines next to Mg and 3 lines next to N.

Connect 2 valencies of Mg with 2 of the 3 valencies of N, as shown.

Now N has 1 valency free. So take one more Mg, and join one valency of Mg to the free valency of N.

That leaves Mg with 1 free valency. So take another N.

That leaves N with 2 free valencies. So take one more Mg.

Now all the valencies are connected. So we get the formula Mg3N2.

Remember!

Now this formula can be derived by an easier method. The valency of Mg = 2 and that of N = 3 and the formula is Mg_3N_2. So the number of magnesium atoms is equal to the valency of Nitrogen (3), and the number of nitrogen atoms is equal is equal to the valency of Mg (2). So, to frame this formula, write Mg and N and write their respective valencies just above them as:

Then place 3 near Mg and 2 near N. In other words, interchange their valency numbers.

More Examples:

Sodium chloride	$\overset{1}{Na}\ \overset{1}{Cl}$	NaCl	Sodium sulphide	$\overset{1}{Na}\ \overset{2}{S}$	Na_2S
Sodium nitride	$\overset{1}{Na}\ \overset{3}{N}$	Na_3N	Calcium chloride	$\overset{2}{Ca}\ \overset{1}{Cl}$	$CaCl_2$
Calcium oxide	$\overset{2}{Ca}\ \overset{2}{O}$	CaO	Calcium Phosphide	$\overset{2}{Ca}\ \overset{3}{P}$	Ca_3P_2
Aluminium chloride	$\overset{3}{Al}\ \overset{1}{Cl}$	$AlCl_3$	Aluminium oxide	$\overset{3}{Al}\ \overset{2}{O}$	Al_2O_3
Aluminium Phosphide	$\overset{3}{Al}\ \overset{3}{P}$	AlP			

Names of Compounds

Binary compounds Binary compounds are compounds containing only two elements. If one of the two is a metal (or ammonium), then the suffix - **ide**, is added to the non-metal atom.

Remember!

NaCl - Sodium chloride   CaO - Calcium oxide   AlN - Aluminium nitride

If atoms of two elements form more than one type of compound, then, the prefix mono, di, tri, tetra, penta, etc. are used, to show the number of atoms in the compound.

Remember!

Dinitrogen monoxide - N_2O Mononitrogen monoxide - NO   Dinitrogen trioxide - N_2O_3 Mononitrogen dioxide - NO_2 Dinitrogen Pentoxide - N_2O_5

Ternary compounds Ternary compounds are compounds, which contain atoms of three elements. If one of them is a metal, it is used first and if oxygen is present along with another non-metal, then the suffix - ate is added to part of the name of the other non-metal. Example: $KClO_3$ - Potassium chlorate. This suffix is used, if it is the only compound formed of the three elements. If there is one more compound formed by the same elements, but with a lesser number of oxygen, then instead of the suffix - ate, suffix - ite is used. Example: $KClO_2$ - Potassium chlorite. If a third compound is formed, with still lesser number of oxygen atoms, then, it is called - hypo chlorite. Example: KClO - Potassium hypochlorite.

Suffix - ate		Suffix - ite	
Chlorate	- ClO_3	Chlorite	- ClO_2
Nitrate	- NO_3	Nitrite	- NO_2
Sulphate	- SO_4	Sulphite	- SO_3
Phosphate	- PO_4	Phosphite	- PO_3
Carbonate	- CO_3		
Silicate	- SiO_3		
Oxalate	- $(COO)_2$		
Acetate	-CH_3COO		
Aluminate	- AlO_2		
Zincate	- ZnO_2		
Plumbate	- PbO_2		
Chromate	- CrO_4		

Manganate	$-MnO_4$		

Remember!

In the case of $-AlO_2$, $-ZnO_2$ and $-PbO_2$, the metals being amphoteric, they behave as non-metals.

Binary acids All acids contain hydrogen. Binary acids contain only two elements one of which is hydrogen. They are named as Hydro, and then the name of the non-metal with the suffix - **ic** is added.

Remember!

HCl - Hydrochloric acid HBr - Hydrobromic acid HI - Hydroiodic acid

Non - binary acids They contain more than 2 kinds of atoms. The term 'hydro' is not used. Instead, the name is based on the second element in the formula.

Remember!

H_2SO_4 - Sulphuric acid

If the same elements form two acids, then the one containing greater number of oxygen atoms gets the suffix - **ic** at the end, and the one containing less oxygen atoms gets the suffix - **ous**.

Acids with suffix - ic		Acids with suffix-ous	
Sulphuric	H_2SO_4	Sulphurous	H_2SO_3
Nitric	HNO_3	Nitrous	HNO_2
Phosphoric	H_3PO_4	Phosphorus	H_3PO_3
Carbonic	H_2CO_3		

Chemical Equation

A chemical equation is a "balanced account of a chemical transaction." In any chemical transaction or reaction, the number of atoms of all the participating elements will remain proportionately constant before and after the reaction (The Law of Conservation of Mass). In a chemical equation, the formulae of the reactants and products are used. Reactants are substance(s) that undergo the chemical reaction. The products are the substances produced during the chemical reaction. The reactants and products are connected by an arrow ($\rightarrow$). The arrow may be read as "to yield" or "to form" or "to give". The reactants are placed on the left side of the arrow and the products on the right side. The different reactants as well as products are connected by a plus sign (+). To be able to write a chemical equation, you must know the reactants, products, and their chemical formulae. Initially, write the word equation, and below it, write the molecular equation. Example 1:

$$\text{Hydrogen} + \text{Oxygen} \longrightarrow \text{Water}$$

$$H_2 + O_2 \longrightarrow H_2O$$

This is an unbalanced equation, because, in the reactant side, there are 2 atoms of oxygen, but on the product side, there is only one atom of oxygen. Since the number of atoms of all the participating elements should remain proportionately constant before and after the reaction, add 2 in front of H_2O, to make the number of oxygen atoms equal to 2. $H_2 + O_2 \longrightarrow 2H_2O$

Now there are 4 hydrogen on the right side, but only 2 on the left side. So add 2, in front of H_2, to make it equal to 4 i.e., $2H_2 + O_2 \longrightarrow 2H_2O$

Now it is balanced. Example 2:

$$\text{Calcium Carbonate} + \text{Hydrochloric acid} \longrightarrow \text{Calcium Chloride} + \text{Water} + \text{Carbon dioxide}$$

$$CaCO_3 + HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

On the right side, there are 2 atoms of chlorine and 2 atoms of hydrogen. So add 2 in front of HCl.

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

To Check

Ca = 1	Ca = 1
C = 1	C = 1
O = 3	O = 3
H = 2	H = 2
Cl = 2	Cl = 2

Example 3:

$$\text{Lead nitrate} \longrightarrow \text{Lead monoxide} + \text{Nitrogen dioxide} + \text{Oxygen}$$

$$Pb(NO_3)_2 \longrightarrow PbO + NO_2 + O_2$$

The number of oxygen atoms on the reactant side is (3 x 2 = 6) is an even number, where as, on the product side (1+ 2 + 2 = 5) is an odd number. Make it into an even number, by adding 2 in front of PbO. (Remember, we cannot place 2 between Pb and O, such as Pb_2O, or 2 after PbO, such as PbO_2). If you want to double the oxygen, double the whole molecule.

$$\therefore Pb(NO_3)_2 \longrightarrow 2PbO + NO_2 + O_2$$

So if you add 2 in front of PbO, you must add 2 in front of $Pb(NO_3)_2$, also. So it will be

$$2\,Pb(NO_3)_2 \longrightarrow 2\,PbO + NO_2 + O_2$$

Now on the left side, there are 4 atoms of N. So add 4 in front of NO_2. So it will be

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

There are 12 atoms of O on both the sides. $\therefore$ The equation is now balanced. Example 4:

$KMnO_4$	+	HCl	$\longrightarrow$	KCl	+	$MnCl_2$	+	H_2O	+	Cl_2
Potassium permanganate		Hydrochloric acid		Potassium chloride		Manganese chloride		Water		Chlorine

Whenever H_2O is present on any side, the number of hydrogen on both the sides should be an even number (2 atoms of hydrogen in water). If there are $4H_2O$, then 4 x 2 = 8 hydrogen atoms. If there are $7H_2O$, then 7 x 2 = 14 hydrogen atoms i.e., all are even numbers). $\therefore$ On the reactant side, there must be an even number in front of HCl. (What that number is, we will see later). As a result, the number of chlorine atoms will also be even. But on the product side, the number of chlorine atoms is odd (i.e., KCl = 1, $MnCl_2$= 2, Cl_2 = 2. i.e., 1 + 2 + 2 = 5). The only odd number of chlorine atoms is in KCl. So let us change it into the simplest even number possible i.e., 2.

$$\therefore KMnO_4 + HCl \longrightarrow 2KCl + MnCl_2 + H_2O + Cl_2$$

Since number of K atoms in 2 KCl = 2, place 2 in front of $KMnO_4$.

$$2KMnO_4 + HCl \longrightarrow 2KCl + MnCl_2 + H_2O + Cl_2$$

In 2 $KMnO_4$, there are 2 K, 2 Mn, and 8 O. So add these numbers in front of K, Mn and O, (K is already done).

$$\therefore 2KMnO_4 + HCl \longrightarrow 2KCl + 2MnCl_2 + 8H_2O + Cl_2$$

If there are 8 H_2O on the product side, there should be 16 H (8 x 2) on the reactants side.

$$\therefore 2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 8H_2O + Cl_2$$

Now the only unbalanced one is $\rightarrow$ Chlorine. On the left hand side, there are 16 Cl. On the right hand side, there are 2 Cl in 2 KCl + 4 Cl in 2 $MnCl_2$, making total of 6(2 + 4). So 10 more Cl are to be accounted. So place 5 in front of Cl_2 to make it 10 (5 x 2).

$$\therefore 2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$$

It is not possible to discuss all equations here. You will expertise in writing reactions by repeated practice and help from your teacher.

Remember!

Limitation of a chemical equation

It does not mention the state of the substances. So (s) for solid, (l) for liquid, (g) for gas and (vap) for vapor may be added.

The reaction may or may not be complete. Equation does not reveal it.

It does not give any information regarding the speed of the reaction.

It does not give the concentration of the substances. In some cases, terms like diluted and concentrated may be added.

It does not give the conditions of temperature, pressure, catalyst, etc. This is overcome by mentioning these above or below the arrow e.g.,

$$2SO_2 + O_2 \xrightarrow[450-500^{0}C]{Pt\ catalyst} 2SO_3$$

It does not give any idea about color changes, which has to be mentioned separately.

$$\underset{\text{Chocolate brown}}{PbO_2} \longrightarrow \underset{\text{Yellow}}{2PbO} + \underset{\text{Colorless}}{O_2}$$

It does not give any indication regarding the production or absorption of heat. This is mentioned separately.

$$C + O_2 \longrightarrow CO_2 + Heat \quad C + CO_2 \longrightarrow 2CO - Heat$$

Some reactions are reversible. They are represented by $\rightleftharpoons$ or $\longleftrightarrow$.

$$3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$$