LANGUAGE OF CHEMISTRY-CLASS 9

INTRODUCTION
Chemistry is an active, experimental and evolving science which has vital importance to our world, in both the realm of nature and the realm of society. It deals with the study of matter and its transformations. Although chemistry is an ancient science, its modern foundation was laid in only the nineteenth century. During this period, intellectual and technological advances enabled scientists to break down substances into even smaller components and consequently to explain many of their physical and chemical properties. Development of sophisticated technology has given us even greater means to study things that cannot be seen with the naked eye.

Almost certainly chemistry will continue to play a pivotal role in all areas of science and technology. Before we enter into the study of matter and its transformation, let us start with the elementary chemistry, where we can learn elements and other materials of which our world is made. We begin our chemistry with the symbols of elements and formulae of compounds which provides the basic knowledge of chemistry. Next we discuss how to represent a chemical substance that is taking part in a chemical change. Then we will familiarize ourselves with the qualitative and quantitative relationship between elements involved in compound formation as well as between reactants and products in a chemical reaction.

ELEMENTS AND COMPOUNDS
Pure substances have a constant, invariable composition, and can be classified into elements or compounds. Element are substances that cannot be decomposed into simpler substances by any physical and chemical processes, whereas compounds can be decomposed by chemical processes into two or more elements. Elements are the basic substances out of which all matter is composed. Some of the more familiar elements are listed in table along with the chemical abbreviations or symbols that are used to denote them. The symbol for an element consists of one or two letters, with the first letter capitalized. These symbols are often derived from the English name for the element, but sometimes they are derived from a foreign name instead.

Symbols

Each **element** is represented by a different **symbol**. For example Helium is represented with symbol He.

Table: Some common elements and their symbols

Carbon (C)	Aluminum (Al)	Copper (Cu, from cuprum)
Fluorine (F)	Barium (Ba)	Iron (Fe, from ferrum)
Hydrogen (H)	Calcium (Ca)	Lead (Pb, from plumbum)
Iodine (I)	Chlorine (Cl)	Mercury (Hg, from hydrargyrum)
Nitrogen (N)	Helium (He)	Potassium (K, from kalium)
Oxygen (O)	Magnesium (Mg)	Silver (Ag, from argentum)
Phosphorus (P)	Platinum (Pt)	Sodium (Na, from Natrium)
Sulfur (S)	Silicon (Si)	Tin (Sn, from Stannum)

FORMULAE FOR COMPOUNDS AND THEIR NAMES

Formulae
A **compound** is formed when different elements are joined together. Compounds are represented by a formula. The **formula** shows the different elements present and the relative number of **atoms** of each element.

For example Carbon dioxide is represented with formula CO_2.

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_4^+ and NO_3^-. 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 –1, the formula of the compound, is $CaCl_2$; If Ca combines with N of valence number – 3, the compound has the formula Ca_3N_2.

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^+
Phosphonium	PH_4^+
Rubidium	Rb^{1+}
Silver	Ag^{1+}
Sodium	Na^+

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+}

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+}
Iron	Fe^{3+}

Tetravalent Basic radicals

Name	Symbol
Platinum	Pt^{4+}
Tin(stannic)	Sn^{4+}
Lead (plumbic)	Pb^{4+}

Pentavalent Basic radicals

Name	Symbol
Antimony	Sb^{5+}
Arsenic	As^{5+}

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^{+++}).

Exercise 1: What is the symbol for mercury?

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 oxy anions. A particular element such as sulphur may form more than one oxy anion. When this occurs, there are rules for indicating the relative numbers of oxygen atoms in the anion. When an element forms only two oxy anions, 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-} .

Exercise 2: What is the charge on manganate ion?

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

Exercise 3: What is the formula for Aluminium di hydrogen phosphate?

Monovalent Acid radicals

Name	Symbol
Fluoride	F^{1-}
Chloride	Cl^{1-}
Bromide	Br^{1-}
Iodide	I^{1-}
Hypobromite	BrO^{1-}
Bromite	BrO_2^{1-}
Bromate	BrO_3^{1-}
Perbromate	BrO_4^{1-}
Hydride	H^{1-}
Hydroxide	OH^{1-}
Cyanate	CNO^{1-}

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	$(S)^{2-}$

Name	Symbol
Oxalate	$(C_2O_4)^{2-}$
Molybdate	$(MoO_4)^{2-}$
Tetraborate	$(B_4O_7)^{2-}$

Carbonate	$(CO_3)^{2-}$		Tartrate	$(C_4H_4O_6)^{2-}$
Sulphate	$(SO_4)^{2-}$		Zincate	$(ZnO_2)^{2-}$
Sulphite	$(SO_3)^{2-}$		Fluorosilicate	$(SiF_6)^{2-}$
Thiosulphate	$(S_2O_3)^{2-}$		Titanate	$(TiO_3)^{2-}$
Tetrathionate	$(S_4O_6)^{2-}$		Monohydrogen phosphate	$(HPO_4)^{2-}$
Perdisulphate	$(S_2O_8)^{2-}$		Monohydrogen phosphite	$(HPO_3)^{2-}$
Manganate	$(MnO_4)^{2-}$		Plumbite	$(PbO_2)^{2-}$
Stannite	$(SnO_2)^{2-}$		Plumbate	$(PbO_3)^{2-}$
Stannate	$(SnO_3)^{2-}$		Pyroantimonite	$(H_2Sb_2O_7)^{2-}$
Silicate	$(SiO_3)^{2-}$			

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-}

Variable valencies:

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;

Fe^{2+} Ferrous ion

Fe^{3+} Ferric ion

The names of the compounds that these ions form with chlorine would thus be

$FeCl_2$ ferrous chloride

$FeCl_3$ ferric chloride

This method of naming ion has some distinct limitations. First, the –"ous" and "–ic" suffixes do not provide information regarding the actual charges of the two cations involved. Thus the ferric ion is Fe^{3+}, but the cation of copper named cupric has the formula Cu^{2+}. In addition, the "–ous" and "–ic" designations provide names for only two different elemental cations. Some metallic elements can assume three or more different positive charges in compounds. Therefore, it has become increasingly common to designate different cations with Roman numerals. The Roman numeral I indicates one positive charge, II means two positive charges, and so on. For example manganese (Mn) atoms can assume several different positive charges:

Mn^{2+} : MnO manganese (II) oxide

Mn^{3+} : Mn_2O_3 manganese (III) oxide

Mn^{4+} : MnO_2 manganese (IV) oxide

Element	Root name	–ous	–ic
Copper	Cupr –	Cu^+	$Cu^{++}(Cu^{2+})$`
Aurum	Aur –	Au^+	$Au^{+++}(Au^{3+})$
Mercury	Mercur–	Hg_2^{++}	$Hg^{++}(Hg^{2+})$
Chromium	Chrom–	$Cr^{++}(Cr^{2+})$	$Cr^{+++}(Cr^{3+})$

Maganese	Mangan–	Mn^{++} (M_n^{2+})	Mn^{+++} (M_n^{3+})
Iron	Ferr–	Fe^{++} (Fe^{2+})	Fe^{+++} (Fe^{3+})
Cobalt	Cobalt	Co^{++} (Co^{2+})	Co^{+++} (Co^{3+})
Nickel	Nickel–	Ni^{++} (Ni^{2+})	Ni^{+++} (Ni^{3+})
Tin	Stann –	Sn^{++} (Sn^{2+})	Sn^{++++} (Sn^{4+})
Lead	Plumb–	Pb^{++} (Pb^{2+})	Pb^{++++} (Pb^{4+})
Arsenic	Arsen–	As^{+++} (As^{3+})	As^{++++} (As^{4+})
Antimony	Antimony	Sb^{+++} (Sb^{3+})	Sb^{+++++} (Sb^{5+})
Bismuth	Bismuth	Bi^{+++} (Bi^{3+})	Bi^{+++++} (Bi^{5+})

Exercise 4: How many variable valence are possible for Iron?

Naming Acids and Salts

The formula of any acid consists of an anionic group whose charge is balanced by one ore more H^+ ions, as shown in the following table. The name of the acid is related to the names of the anion. Anions whose names end in **"–ide"** have associated acids that have the hydro–prefix and an **"–ic"** ending.
When the H^+ of an acid is replaced by a metal, the result is a salt.

Anion	Corresponding acid	Corresponding Salt (or Typical salt)
Cl^- (chloride)	HCl (hydrochloric acid)	NaCl sodium chloride
S^{2-} (sulfide)	H_2S (Hydro sulfuric acid)	CuS Copper sulfide
F^- (fluoride)	HF (hydrofluoric acid)	CsF (Cacsium fluoride)

The above acids do not contain oxygen atoms. Many of the most important acids are derived from oxyanions (that means they contain oxygen). If the anion has an **'–ate'** ending, the corresponding acid is given an **–ic** ending. Anions whose names end in **"– ite"** have associated acids whose names end in **"–ous"**. Prefixes in the name of the anion are retained in the name of the acid. These rules are illustrated by the oxyacids of chloride.

Anion	Corresponding acid	Corresponding Salt (or Typical salt)
ClO^- (hypochlorite ion)	HClO (hypochlorous acid)	NaClO (sodium hypochlorite)
ClO_2^- (chlorite ion)	$HClO_2$ (chlorous acid)	$RbClO_2$ (rubidium chlorite)
ClO_3^- (chlorate ion)	$HClO_3$ (chloric acid)	Cd $(ClO_3)_2$ (cadmium chlorate)
ClO_4^- (perchlorate ion)	$HClO_4$ (perchloric acid)	$Mg(ClO_4)_2$(magnesium perchlorate)

In some cases two different names seem to assigned to the same chemical formula.

HCl hydrogen chloride
HCl hydrochloric acid

The name assigned to the compound depends on its physical state. In the gaseous or pure liquid state, HCl is a molecular compound called hydrogen chloride (exists as molecules only). When it is dissolved in water the molecules break up into H^+ and Cl^- ions, in this state, the substance is called hydrochloric acid.

Some more examples:

Anion	Corresponding acid	Corresponding Salt (or Typical salt)
CrO_4^{2-} (chromate ion)	H_2CrO_4 (chromic acid)	$K_2Cr_2O_4$ (Potassium chromate)
$Cr_2O_7^{2-}$ (dichromate ion)	$H_2Cr_2O_7$ (dichromic acid)	$K_2Cr_2O_7$ (potassium dichromate)
$C_2O_4^{2-}$ (oxalate ion)	$H_2C_2O_4$ (oxalic acid)	CaC_2O_4 (calcium oxalate)
AsO_4^{3-} (arsenate ion)	H_3AsO_4 (arsenic acid)	$Ba_3(AsO_4)_2$ (barium arsenate)
CH_3COO^- (acetate ion)	CH_3COOH (acetic acid)	CH_3COONa (sodium acetate)

Naming Binary Compounds: The element with the more positive nature is named first and also appears first in the chemical formula. The second element is named with an –ide ending. The following are some binary compounds containing one metal atom and another non–metal atom.

Examples:

LiH	lithium hydride
FeO	Ferrous oxide
Sn_3N_4	Tin nitride
Ba_3P_2	Barium phosphide
Al_4C_3	aluminium carbide
Mg_2Si	magnesium silicide

Binary compounds containing two non–metals are designated by the names of the two elements followed by the ending –ide. Before the name of the second element there is a prefix (given in the table) to indicate how many atoms of it are in the molecule. This is never alone for the first element.

Prefixes used in naming binary compounds formed between non–metals

Prefix	Number of atoms
Mono	1
Di	2
Tri	3
Tetra	4
Penta	5
Hexa	6
Hepta	7
Octa	8
Nona	9
Deca	10

When the prefix ends in **'a'** or **'o'** and the name of the anion begins with a vowel (such as oxide), the **'a'** or **'o'** is often dropped. The prefix mono is usually omitted for the first–named element

Binary compounds	Name
CO	Carbon monoxide
CO_2	Carbon dioxide
Cl_2O	Chlorine monoxide
ClO_2	Chlorine dioxide
NO_2	Nitrogen dioxide
CCl_4	Carbon tetrachloride
CS_2	Carbon disulphide
P_2O_5	Phosphorus pentoxide
P_4S_{10}	Tetraphosphorus deca sulphide
N_2O_4	Dinitrogen tetroxide

Binary compounds formed by two non–metals are also called **molecular compounds**. All other compounds which contain positive and negative radicals are called **ionic compounds**. Ionic compounds split into ions (or radicals) when added to water.

Exercise 5: What is the binary compound of NO_2?

Naming Hydrates

Hydrates are compounds that have a specific number of water molecules attached to them. For example, each unit of copper (II) sulphate has five water molecules associated with it, in its normal state. The systematic name for this compound is copper (II) sulphate pentahydrate, and its formula is written as $CuSO_4.5H_2O$. The water molecules can be driven off by heating. After heating, the compound is $CuSO_4$. Which is sometimes called anhydrous copper (II) sulphate. The term **'Anhydrous'** indicates that the compound no longer has water molecules associated with it. Some other hydrates are.

$BaCl_2.\ 2H_2O$	Barium chloride dihyrate
$LiCl.\ H_2O$	Lithium chloride monohydrate
$MgSO_4.\ 7H_2O$	Magnesium sulphate heptahydrate

HOW TO WRITE A CHEMICAL FORMULA

One has to follow the following rules to write the formula of compounds

1. Positive and negative radicals are written side by side with their charge as the subscript on the right hand side (first positive radical and then negative radical).
2. The charges are interchanged and written as the subscript and signs are removed.

3. In the final formula there should be no sign. If the subscripts are same, it can be cancelled. No need of writing 1 in the formula.
4. If the radical contains two or more atoms (compound radical), then it is enclosed in a bracket.

Example: (1) Calcium phosphate

Step–1	Step–2	Step–3
Ca^{2+} PO_4^{3-} Calcium Phosphate	Ca^{2+} PO_4^{3-}	$Ca_3(PO_4)_2$

2. Potassium ferrocyanide

Step–1	Step–2	Step–3
K^{1+} $[Fe(CN)_6]^{4-}$ Potassium Ferrocyanide	K^{1+} $[Fe(CN)_6]^{4-}$	$K_4[Fe(CN)_6]$

CHEMICAL EQUATIONS

Equations

A chemical reaction can be represented by a **word equation** or a **balanced chemical equation**.

The word equation for burning carbon in air is:

carbon + oxygen $\rightarrow$ carbon dioxide

Carbon and oxygen are the **reactants**. Carbon dioxide is the **product**.

The balanced chemical equation for this is:

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

One atom of carbon reacts with one molecule of oxygen to form one molecule of carbon dioxide.

The symbol in brackets refers to the state of the substance.
(g) means it is a gas,
(s) a solid,
(l) a liquid and
(aq) an aqueous solution (solution in water).

Sometimes there is more than one product.

sulphuric acid + sodium hydroxide $\rightarrow$ sodium sulphate + water

The total mass of the products is always the same as the total mass of the reactants.
This is because the products are made up of the same atoms as the reactants.
Symbol equations must therefore be balanced. The total number of each type of atom in the reactants must equal the number of atoms of the same element in the products.

$$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

A balanced chemical equation indicates the exact ratio in which chemicals combine and products are formed.
Two features are required for a balanced equation. Since atoms can be neither created nor destroyed by chemical change, a balanced equation must show the same number of each element symbol on both sides of the equation.

Electrical charge is also conserved during chemical change, so a balanced equation must have the same net charge for both sides of the equation.

Simpler chemical equations can be balanced by trial and error using numerical coefficients until both requirements for 'balancing' are met. More complicated equations like redox reactions, are balanced by a systematic method, because, they take more time to balance by a trial–and–error method.

In this topic we will discuss two methods of balancing equations. They are
(1) Trial – and – error method
(2) Frequency number method.

Trial – and – error method
The following steps are required to balance simple chemical equations such as acid – base reactions or precipitation reactions or simple combinations or decompositions.

Step – 1
When the formulas of all reactants and products are known, careful attention should be given to subscripts. The subscripts will generally give clue to necessary coefficients.

Step – 2
First balance the species having largest subscript, except for subscripts in polyatomic ions (e. g PO_4^{3-}). If that doesn't immediately reveal all necessary coefficients, try multiplying all coefficients by the next largest subscript.

Frequency number method
The number of times (or the frequency) of occurrence of various elements in an equation is called frequency number.

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

F–number: Pb = 2 (one place in reactant and one place in products)
N = 2 (one place in reactant and one place in products)
O = 4 (one place in reactant and three place in products)

Don't count the number of atoms only places should be counted.

Following steps involved in this process

1. Find the F–number of all elements.

2. Balance the element in the increasing order of their F–number, is the element with lowest F–number is balanced first.
   (i) If two or more elements are with the same F number, first balance the metal and then non–metals.
   (ii) If two or more elements and are metals with the same F–number, atomic number is balanced first. Similarly in the case of non–metals also.
   Let us Balance $K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + O_2$

Step – 1
Writing F–number

Element	K	Cr	S	O	H
F–number	2	2	3	6	2

Step – 2
K, Cr and H have same F number. Among three K and Cr are metals and Cr is with higher atomic number. So Cr is balanced first followed by K and H. After this sulphur is balanced and then oxygen.

(i) Balancing Cr is already balanced.
(ii) K is also balanced.

$$K_2Cr_2O_7 + H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + O_2$$

(iii) Hydrogen also balanced

$$K_2Cr_2O_7 + H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + O_2$$

(iv) One sulphur atom is present in the reactant side where as 4 S atoms are present on theproduct side. So, to balance S, H_2SO_4 is multiplied with 4 and to balance hydrogen H_2O is multiplied with 4.

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + O_2$$

(v) Balance O by atomic equation method or since oxygen occurs in pure elementary form, multiply the whole equation by 2 except O_2.

$$2K_2Cr_2O_7 + 8H_2SO_4 \longrightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + O_2$$

There are 46 and 40 atoms of oxygen in the reactants and products respectively. To balance O multiply O_2 with 3.

$$3K_2Cr_2O_7 + 8H_2SO_4 \longrightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2$$

Exercise 6: Write the balanced equation for the reaction between $K_2Cr_2O_7$ and conc.H_2SO_4.

SIGNIFICANCE OF CHEMICAL FORMULA AND CHEMICAL EQUATION

Chemical formulas and chemical equations have a quantitative significance that is, the subscripts in formulas and the coefficients in equations represent precise quantities.
For example: The formula H_2O is not merely an abbreviation for the word water, it indicates that a molecule of this substance contains exactly two atoms of hydrogen and one atom of oxygen.

The chemical equation for the combustion of ethane indicates more than the qualitative idea that ethane reacts with O_2 to form CO_2 and H_2O. It indicates quantitatively that two molecule of C_2H_6 requires seven molecules of O_2 and produces exactly four molecules of CO_2 and six molecules of water.

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

We cannot directly count atoms or molecules but indirectly we can determine. Their numbers provided that we should know the masses of atoms. So, before we pressure the quantitative aspects of chemical formulas or equations further we must explore the concept of atomic and molecular masses [Atomic masses we have studied in the previous chapter].

Formula and Molecular weights

The formula weight (FW) of a substance is merely the sum of the atomic weights of each atom in its chemical formula. For example, H_2SO_4, sulphuric acid, has a formula weight of 98.0 amu.

FW of H_2SO_4 = 2(AW of H) + (AW of S) + 4(AW of O)
= 2 x 1.0 amu + 32.0 amu + 4 x 16.0 amu
= 98.0 amu

AW represents atomic weight.

If the chemical formula of a substance is its molecular formula, then the formula weight is also called molecular weight (MW). For example, the molecular formula of glucose is $C_6H_{12}O_6$. So

MW of glucose = 6 (12.0) amu + 12 (1.0) amu + 6(16.0) amu
= 180.0 amu.

With ionic substances such as NaCl that exist as three dimensional arrays of ions, in appropriate to speak of molecules. In such a case, we use only formula weight. The formula weight of NaCl is 230 amu + 35.5 amu = 58.5 amu.

Chemical formula and percentage composition

A chemical formula can be used to compute the percentage composition of a compound, the percent by weight contributed by each type of atom in the compound.

Let us calculate the percentage composition of $C_6H_{12}O_6$.

In general, the percentage of a given element in a compound is given by

$$\% = \frac{(\text{Atoms of element})\text{AW}}{\text{FW of compound}} \times 100$$

The formula weight of $C_6H_{12}O_6$ is 180. Therefore the percentage composition is

$$\%C = \frac{6(12.0)\text{amu}}{180} \times 100 = 40\%.$$

$$\%\ H = \frac{12(1.0)\text{amu}}{180} \times 100 = 6.66\%$$

$$\%\ O = \frac{6(16.0)}{180} \times 100 = 53.34\%$$

Exercise 7: Nitrogen is made up of two isotopes, N-14 and N-15. Given nitrogen's atomic weight of 14.007, what is the percent abundance of each isotope?

ANSWERS TO EXERCISES

Excesise:1 Hg

Excesise:2 MnO_4^{2-}

Excesise:3 $Al(H_2PO_4)_3$

Excesise:4 Five Fe^{2+}, Fe^{3+}, Fe^{4+}, Fe^{5+}, Fe^{6+}

Excesise:5 N_2O_4

Excesise:6 $3K_2Cr_2O_7 + 8H_2SO_4 \longrightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2$

Excesise:7 N-14 is 99.3% and N-15 is 0.7%