<u>The laws of chemical combination</u>:- Whenever reactants react together to form the products or the elements combine together to form a compound, they do so according to certain laws. These laws are called" the laws of chemical combination".

There are three laws of chemical combination:-

1. Law of conservation of Mass:- this law was put forward by Antoine Lavoisier in 1774. It states, "Mass can either be created or destroyed in a chemical reaction. In any chemical reaction, the total mass of the reactants is equal to the total mass of the products".

Suppose a chemical reaction is carried between A and B. the products formed are C and D.

Thus,

$$A + B \longrightarrow C + D$$

$$Caco_3(100g) \longrightarrow CaO(56g) + CO_2(44g)$$

Experiment to verify the law of conservation of mass. Take a clean conical flask fitted with a cork. Also take a small test tube and tie a thread to its neck so that it can be suspended in the flask. Weigh the flask, cork and tube together. Prepare the following two solutions:

(i) Approximate 5% solution of barium chloride ($BaCl_2$) by dissolving 5 g of $BaCl_2$ in 100 mL of water.
(ii) Approximate 5% solution of sodium sulphate (Na_2SO_4) by dissolving 5 g of $Na_2 SO_4$ in 100 mL of water.

Take a small amount barium chloride solution in the conical flask and a small amount of sodium sulphate solution in the test tube. Suspend the test tube in the flask with the thread. Weigh the complete system. Subtract the mass of he empty apparatus. The difference will give the mass of the reactants taken.

Now, loosen the cork so that the thread is loosened and the test tube falls into the flask. As a result, the solution of the tube mixes into the solution of the flask, a white precipitate appears in the flask due to the following reaction taking place:-

$$\underset{\text{(Solution)}}{\text{Barium chloride3}} + \underset{\text{(Solution)}}{\text{Sodium sulphate}} \longrightarrow \underset{\text{(White ppt.)}}{\text{Barium sulphate}} + \underset{\text{(Solution)}}{\text{sodium chloride}}$$

Weigh the complete apparatus again along with the contents. Subtract the initial mass of the empty apparatus. The difference will now give the total mass of the products. We observe that the mass comes out to be same as it was before the reaction. This proves the law of conservation of mass.

2. **Law of Constant Proportion: -** This law was put forward by J.L. Proust in 1799. It states, "a chemical compound is always made up of the same elements combined together in the same fixed proportion by mass".

Water is a compound of hydrogen and oxygen. It can be obtained from various sources or even synthesized in the laboratory. From whatever source we may get it, 9 parts by weight of water is always found to contain 1 part by weight of hydrogen and 8 parts by weight of oxygen. Thus, in water, this proportion of hydrogen and oxygen by weight always remains constant.

3. **The Law of Multiple Proportions:-** When one element combines with a second element to form two or more different compounds, the weights of one of the elements, which combine with a constant weight of the other, bear a simple ratio to one another.

For example, hydrogen and oxygen combine in two different ways to produce two compounds, wate (H_2O) and hydrogen peroxide (H_2O_2).

In water, 2g of hydrogen combines with 16g of oxygen.

In hydrogen peroxide, 2g of hydrogen combines with 2x16=32g of oxygen.

Thus, the weights of oxygen which combine with a constant weigh of hydrogen (2g) bear a simple ratio of 16 : 32 or 1: 2.

DALTON'S ATOMIC THEORY:- John Dalton, a British schoolteacher, developed a theory on the structure of matter. This theory later came to be known as ***Dalton's Atomic Theory***. This theory was a result of inferences drawn from the experiments performed by Dalton himself and some others and also from the laws of chemical combination.

Assumption or Postulates of Dalton's Atomic Theory:-

The main assumptions of Dalton's atomic theory are as follows.

a) All matter is made up of very small particles called atoms which cannot be divided further.
b) Atoms cannot be created or destroyed by any chemical process, i.e., atoms are indestructible.
c) All the atoms of a given element are the same, i.e., identical in size, mass, chemical properties, etc.
d) Atoms of two or more elements join together during chemical combination to form compound atoms.
e) During chemical combination, atoms of different elements combine in simple numerical ratios, e.g., 1 : 1, 1: 2, 2 : 3, etc.
f) Atoms of the same element can combine in more than one ratio to produce more than one compound.

Merits of Dalton's Atomic Theory:-

Dalton's atomic theory has proved to be very useful in various ways.

1. It has enabled us to explain the laws of chemical combination.
2. Dalton was the first to recognize a workable distinction between the ultimate particle of an element (atom) and that of a compound (compound atom).

Demerits of Dalton's Atomic Theory:-

1. Atom is no longer considered as the smallest indivisible particle.
2. Atoms of the same element may have different masses.
3. Atoms of different elements may have same masses.
4. Substances made up of the same kind of atoms may have different properties.
5. The ratio in which the different atoms combine to form compound may be fixed and integral but may not be simple.

ATOM:- An atom is defined as the smallest particle of an element which may or may not be capable of free existence. It is the smallest particle that takes part in a chemical reaction.

Atoms are so small in size that they cannot be seen under a microscope. Their radii are of the order of 10^{-10}m.

Symbols :- Symbol is a short method of representing any thing. It may be represented by a figure or a letter. In case of elements, symbol means a short method of representing the full name of an element.

Dalton's Symbols of Elements:- Dalton was the first Scientist to use the symbols in a very specific sense. The symbol used by him also represented the quantity of the element.

Picture missing

Modern Symbols of Elements:- Different elements have been named either after the name of the place where they were first discovered or after the name of the scientist who discovered it or on the basis of some important property of the element. For example, the name copper came from Cyprus, Rutherfordium after Rutherford etc. Similarly, gold was so named after the English word which means yellow colour and actinium was so named due to its high radioactivity. However, as more and more elements were discovered, an international committee was setup, called international Union of Pure and Applied Chemistry (IUPAC), which approved the names of the different elements.

Some guidelines for writing the symbols of different elements are given below:

(a) The symbol of an element is the "first letter" or "first letter and another letter" of the English name or Latin name of the element. However, in all cases, the first letter is always capital and another letter (if added) is always a small letter.

For example, hydrogen is represented by 'H', oxygen by 'O', carbon by 'C', cobalt by Co, aluminium by Al etc.

Atomic Mass:- Atomic mass may be defined as:

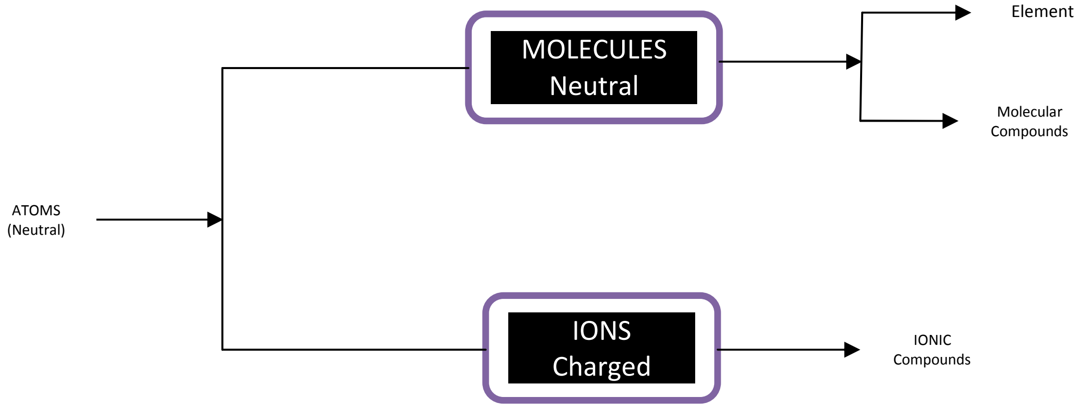
The relative mass of an atom fo the element as compared to an atom of carbon (carbon-12) taken as 12. In other words, atomic mass expresses th number of times an atom of the element is heavier than a carbon atom taken as 12 or $\frac{1}{12}th$ of the mass of carbon atom. Therefore,

$$\text{Atomic mass} = \frac{\text{Mass of an atom}}{\frac{1}{12}th \text{ mass of a carbon atom (carbon-12)}}$$

Atomic Mass Unit:- The quantity of mass equal to $\frac{1}{12}th$ of the mass of an atom of carbon (carbon-12) is called atomic mass unit.

Atomic mass unit = $\frac{1}{12}th$ the mass of standard carbon-12, so its atomic mass is 1 a.m.u. similarly, it is observed that an atom of oxygen is 16 times heavier than $\frac{1}{12}th$ of the mass of carbon atom (1 a.m.u.), therefore, its atomic mass is 16 u.

How do Atoms Occur:- Atoms of most elements do not occur independently. They aggregate (joint together) in different ways to form matter that we are able to see, feel, or touch. The atoms may combine to form neutral molecules or charged ions which further form compounds. For example, atoms join together to form neutral molecules which may exist in elements or molecular compounds. The atoms may also form charged species called ions which form compounds known as ionic compound. This basic type of aggregation of atoms is shown below :



MOLECULES: - The smallest particle of matter (element or compound), made up of two or more atoms combined chemically, which can exist in Free State is called a molecule.

Molecules of an Element:- molecules of an element means one, two or more atoms of the same element existing as one species in the free state.

Molecules of a compound:- Molecule of a compound means two or more atoms of different elements combined together in a definite proportion by mass to form a species that can exist freely.

Atomicity:- The number of atoms present in one molecule of the substance is called its atomicity.

Types of molecules:- based upon the number of atoms they contain, we can classify molecules as follows.

1. Monoatomic molecules Noble gases exist in atomic form, i.e., they are monoatomic. For example, helium (He), neon (Ne) and argon (Ar).
2. Diatomic molecules these molecules consist of two atoms, for example, hydrogen (H_2), oxygen (O_2), nitrogen (N_2) and chlorine (Cl_2).
3. Triatomic molecules these molecules consist of three atoms. For example, ozone (O_3)is a triatomic molecule. Similarly, CO_2, H_2O, and H_2S re examples of triatomic molecules.
4. Tetraatomic molecules these consist of four atoms .for example, p_4 is a tetraatomic molecule of phosphorus.
5. Polyatomic molecules any molecule containing more than four atoms is called polyatomic. For example, S_8, CH_4, and H_2SO_4 are polyatomic molecules.

Difference between atoms and molecules:-

Properties	Atom	Molecule
1. Existence	Smallest particle of an element which does not exist in the free state. Noble gases are exceptions to this rule.	Smallest particle of a substance (element of compound) which exists in the free state in nature
2. Shape	Spherical	May have many shapes, e.g., linear, angular or triangular
3. Reactivity	Highly reactive, except noble gas atoms.	Less reactive
4. Bond	No chemical bond in an atom	Atoms in a molecule are bound by chemical bonds
5. Subdivision	Cannot be subdivided	Can be subdivided into atoms

Ion: - An ion is a charged particle having negative or positive charge. A negatively charged ion is called an 'anion' and the positively charged ion, a 'cation'. Take, for example, sodium chloride (NaCl). Its constituent particles are positively charged sodium ions (Na^+) and negatively charged chloride ions (Cl^-). Ions may consist of a single charged atom or a group of atoms that have a net charge on them.

The positive and negative ions may broadly be classified into two types :

(i) Simple or monoatomic ions, and

(ii) Compound or polyatomic ions.

(i) A simple or monoatomic ion contains only oner atom. For example:

Sodium : Na^+ Potassium : K^+

Chloride :Cl^- sulphide :S^{2-}

(ii) A compound ion contains atoms of more than one atom and behaves as a single unit. These are also known as polyatomic ions. For example :

Ammonium : NH_4^+ Sulphate :SO_4^{2-}

Carbonate :Cl_3^{2-} Nitrate : NO_3^-

Writing chemical formulae:- Chemical formula of a molecular compound represents the actual number of atoms of different elements present in one molecule of the compound.

Rules for writing the chemical formulae:- the following steps are followed for writing the formulae of molecular or ionic compounds :

(i) In case if simple molecular compounds, i.e., Those compounds which are made up of only two elements (and hence also called binary compounds), the symbols of the two elements are written side by side and their respective valencies are written below their symbols.

(ii) In case of simple ionic compounds, i.e., compounds made up of monoatomic ions, the symbol of the metal atom (forming the cation) us written first followed by the symbol of the non-metal atom (forming the anion) and their respective valencies are written below their symbols.

(iii) In case of ionic compounds containing polyatomic ions, the formula of the polyatomic ion is written in brackets and the valencies are written below as in the above cases.

(iv) In any of the above case, if there is a common factor between the valencies of the cation and the anion, the valenicies are divided by the common factor.

(v) Finally, we apply criss-cross, i.e., cross-over of the valencies or the charges so that they appear on the lower right hand side of the symbols. However, ‘1’ appearing on the lower right hand side of the symbol is omitted. Similarly, + and – signs of the charges of the ions are omitted.

(vi) For ‘1’ appearing on the lower right hand side of a polyatomic ion, the brackets of the polyatomic ion are also omitted.

<u>Chemical formulae of simple Molecular Compounds:-</u> Applying the above rules, the chemical formulae of some simple molecular compounds are explained below:-

1. Formula of hydrogen chloride. The elements present are hydrogen and chloride.

Symbol	H	Cl	
			Formula=HCl
Valency	1	1	

2. Formula of water. The elements present are hydrogen and oxygen.

Symbol	H	Cl	
			Formula=H_2O
Valency	1	1	

3. Formula of carbon dioxide. It contains carbon and oxygen.

Symbol	C	O	
			Formula=CO_2
Valency	4	2	
Divided by Common factor	2	1	

<u>Chemical formulae of simple Ionic Compounds</u>:- Applying the same rules, a few examples are given below:

1. Formula of sodium chloride

Symbol	N	Cl	
			Formula= $NaCl_2$
Charge	4	2	
Valency	2	1	

2. Formula of calcium oxide

Symbol	Ca	O	
			Formula=CaO
Valency	2^+	2^-	
Divided by Common factor	1^+	1^-	

<u>Molecular Mass</u>:-

The relative molecular mass of a substance is the mass of a molecule of the substance as compared to one-twelfth the mass of one carbon -12 atom, i.e.,

$$\text{Relative molecular mass} = \frac{\text{Mass of 1 molecule of the substance}}{\frac{1}{12} \times \text{mass of one C-12 atom}}$$

The molecular mass of a molecule, thus, represents the number of times it is heavier than $\frac{1}{12}$ the mass of a carbon –12 isotope.

Calculation of Molecular mass. The molecular mass of a substance is the sum of the atomic masses of its constituent atoms present in a molecule.

1. Molecular mass of water
   The molecular formula of water is H_2O.
   Atomic mass of H = 1.
   Atomic mass of O = 16.

∴ Molecular mass of water
= (2x atomic mass of H)+(1x atomic mass of O)= 2x1+116 = 18

i.e., molecular mass of water =18 amu.

2. Molecular mass of sulphuric acid
   The molecular formula of sulphuric acid is H_2SO_4.
   Atomic mass of H=1.
   Atomic mass of O=16.
   Atomic mass of S= 32.

∴ Molecular mass of H_2SO_4
= (2x atomic mass of H) + (1x atomic mass of S) + (4x atomic mass of O)
= (2x1) + (1x32) + (4x16) =2+32+64=98

i.e., molecular mass of H_2SO_4 = 98 amu.

The Molecule Concept:-

In Latin, mole means heap or collection or pile. A mole of atoms is a collection of atoms whose total mass is the number of grams equal to the atomic mass. Since an equal number of moles of different elements contain an equal number of atoms, it becomes convenient of express the amount of the elements in the terms of moles. A mole represents a definite number of particles, viz., atoms, molecules, ions or electrons. This definite number is called the Avogadro number (now called the Avogadro constant) which is equal to $6.022x10^{23}$.

Avogadro constant = $6.022x10^{23}$.

A mole (mol) is defined as the amount of a substance that contains as many atoms, molecules, ions, electrons or other elementary particles as there are atoms in exactly 12g of carbon-12(^{12}C).the mass of 1 mol of atoms of an element is its relative atomic mass taken in grams.

Significance of the Mole:-

A mole represents the following.

1. I represent 6.022×10^{23} atoms of the element.
2. The mass of 1 mol of an element equals that of 6.022×10^{23} atoms of the element.
3. One mole of substance represents one gram-formula mass of the substance. For example, 1 mol of hydrogen chloride (HCL) = (1 + 35.5)g = 36.5g. This represents the mass of 6.022×10^{23} molecules of hydrogen chloride.
4. One mole of a gas at standard temperature and pressure occupies 22.4 litres. Thus, a mole represents 22.4 litres of a gas at STP (standard pressure = 76 cm of mercury and standard temperature = $0^{\circ}C$ = 273K).

End.......!