Atom and Molecules

Laws of Chemical Combination

Antoine L. Lavoisier, known as 'Father of Modern Chemistry' laid the foundation of chemical science.

Law of conservation of mass

It states that ' mass can neither be created nor destroyed in a chemical reaction'.

Total mass of reactants must be equal to total mass of products i.e., why all chemical reactions are balanced.

Example: $C + O_2 \rightarrow CO_2$

$12 + 32 = 12 + 2 \times 16$

$4 \quad 4\ u = 44\ u$

Mass reactants = Mass of products

Law of constant proportion or Law of Definite proportion

It states 'In a pure chemical substance (compound) , the elements are always present in definite proportions of mass'.

Compound prepared by any method contains the same elements in the fixed ratio by mass, e.g., H_2O, the ratio of mass of hydrogen to mass of oxygen is always 1:8, whatever may be the source.

$2H_2O \rightarrow 2H_2 + O_2$

If we decompose 9g of H_2O , we shall get 1 g of hydrogen and 8g of oxygen.

$2H_2 + O_2 \rightarrow 2H_2O$
$2 \times 2 + 2 \times 16$

$=4 \quad = 32$

4g of H_2 reacts with 32 g of Oxygen; 1g of H_2 will react with 8 g of O_2.

If we react 5g of hydrogen with 8 g of oxygen, 1 g of hydrogen will react with 8 g of oxygen to form 9 g of water and 4 g of hydrogen will remain unreacted.

Similarly in ammonia, nitrogen and hydrogen are always present in the ratio 14:3 by mass, whatever the method or the source from which it is obtained.

All matter whether element, compound or mixture is composed of small particles called 'atoms'.

Postulates of Dalton's atomic Theory:

- All matter is made up of tiny particles called atoms.
- Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction.
- Atoms of a given element are identical in mass and chemical properties.
- Atoms of different elements have different masses and chemical properties.
- Atoms combine in the ratio of small whole numbers to form compounds.
- The relative number and kinds of atoms are constant in a given compound.

Advantages of Dalton's Atomic theory

- This theory could explain the existing laws at that time.
- It could predict the law of multiple proportion.
- It proposed concept of atomic mass.

Drawbacks

Today, we know atoms are not indivisible, i.e., they themselves are made up of protons, electrons and neutrons.

Accordinig to Dalton, all atoms of an element have exactly the same mass. It is, however, now known that atoms of the same element can have slightly different masses.eg .$^{35}_{17}Cl$ *and* $^{37}_{17}Cl$

According to Dalton, the atoms of different elements have different masses. It is, however, not known that even atoms of different elements can have the same masses.

Atoms

Atom is smallest particle which takes part in physical and chemical processes. It may or may not exist freely. Atoms form molecules and ions.

Atomic radius is measured in nanometers. 1 / 10^9 m= 1nm 1= 109nm

Dalton was the first scientist to use the **symbols** for elements in a very specific sense. The symbol also meant a definite quantity of that element ,i.e., one atom of that element. Earlier the names were derived from the places where they were found , specific colors , etc. Other symbols have been taken from the names of elements in Latin.

Significance of symbol:

- It represents name of the symbol.
- It represents an atom of the element.
- It represents one mole of element.
- It represents atomic mass of element.

Atomic mass

Each element has a characteristic atomic mass. Since determining the mass of an individual atom was a difficult task, relative atomic masses were determined using laws of chemical combinations and the compounds formed.

Atomic mass unit: Earlier it was (amu).

Scientists took 1 /16 of the mass of an atom of naturally occurring oxygen as the unit because-

- Oxygen reacted with large no. of elements and formed compounds.
- This atomic mass gave masses of most of the elements as whole numbers

At present

In 1961 Universally accepted atomic mass unit, **carbon – 12 isotope** was chosen as the standard reference for measuring atomic masses.

Atomic mass unit (u)

Atomic mass unit (u) is mass units equal to exactly 1/12th the mass of one atom of carbon-12.

Relative atomic mass :

It is the average mass of the atom as compared to 1/12th the mass of one carbon-12 atom.(Hydrogen is the lightest element as its Atomic mass is 1)

Molecule

It is the smallest particle of an element or a compound that is capable of independent existence and shows all the properties of that substance.

Atoms of the same element or of different elements can join together to form molecules.

Molecules of elements

The molecules of an element are constituted by the same type of atoms. Molecules of Argon(Ar) , helium (He) , etc. are made up of only one atom of that element. But it is not so in case of non-metals. Eample. A molecule of oxygen consists of two atoms of oxygen; so it is called **diatomic molecule , O_2.** If 3 atoms of oxygen form one molecule , we get **ozone.**

Atomicity

The number of atoms constituting a molecule .

Molecules of compounds

Atoms of different elements join together in definite proportions to form molecules of compounds.

Ions

Compounds composed of metals and non-metals contain charged species known as ions. It can be negatively **(anion)** or positively **(cation)** charged.

Polyatomic ions

A group of atoms carrying a charge is called polyatomic ions.

Writing Chemical Formulae

The chemical formula of a compound is a symbolic representation of its composition.

For writing a chemical formula we use symbols and the combining capacity (valency) of an element.

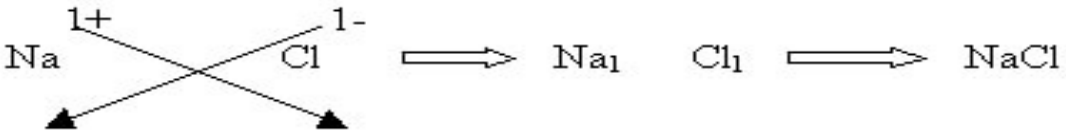
Rules for writing a chemical formula

- The valencies or charges on the ions must balance.
- When a compound consists of a metal and a non-metal , the name or symbol of metal is written first. (CaO , FeS, etc.)
- In compounds with polyatomic ions, the ion is enclosed in a bracket before writing the number to indicate the ratio. If no. of polyatomic ion is one , bracket is not needed (NaOH)

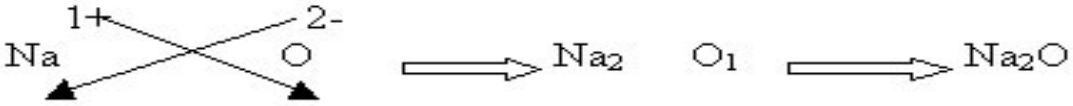
Valency

- The charge of an ion or radical which has either lost or gained electrons
- Note that metals lose electrons easily to become positive ions. This is why most metals are good conductors of electricity.

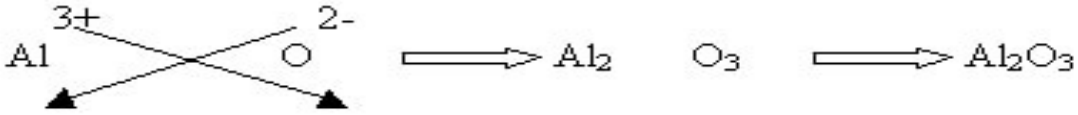
Example 1 – Sodium chloride (common salt)



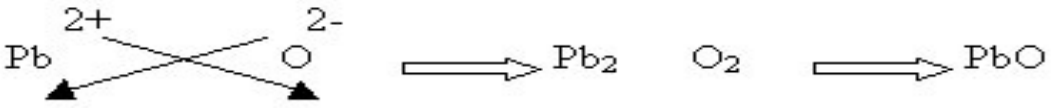
Example 2 – Sodium oxide



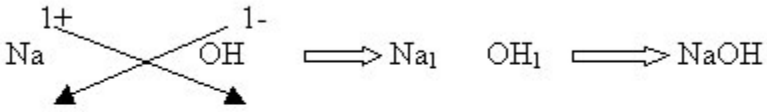
Example 3 – Aluminium oxide



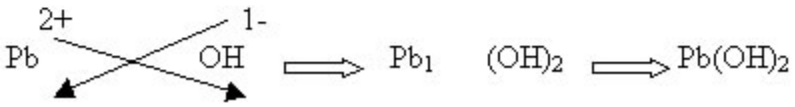
Example 4 – Lead oxide



Example 5 – Sodium hydroxide (caustic soda)



Example 6 – Lead hydroxide



Molecular Mass

It is the sum of the atomic masses of all atoms in a molecule of the substance.

Formula unit mass

The formula unit mass is the sum of the atomic masses of all atoms in a formula unit of a compound. It is used for those substances whose constituent particles are ions.

Example: NaCl

The formula unit mass of NaCl = 1 x 23 + 1 x 35.5 = 58.5 μ

Mole Concept

- The word mole was introduced by Wilhelm Ostwald around 1896 and it means heap or pile.
- **Mole** is that quantity in number having a mass equal to its atomic or molecular mass in grams. The number of particles present in 1 mole of any substance is fixed, with a value of 6.022×10^{23} . This is called the **Avocado Constant or Avocado Number (represented by N_o)1 mole = 6.022×10^{23} in number**
- Mass of one mole is also fixed. It is equal to its relative atomic or molecular mass in grams. Molar mass of atoms is also known as grain atomic mass. For this 'μ' is changed to 'g'. Atomic mass of hydrogen is 1 μ and its gram atomic mass is 1 g.
- Chemists need the no. of atoms and molecules while carrying out reactions so, they need mass in grams to the number. Thus, a mole is the chemist's counting unit.