2. ATOMIC THEORY OF MATTER

An Indian philosopher kanad was one of the first persons to propose that matter is made up of very small particles called 'parmanu' John Dalton called these particles 'atoms'. The word 'atom' means 'something which cannot be cut or divided'. In 1808, Dalton gave his atomic theory of matter which was confirmed by experiments. According to Dalton's atomic theory:

1. Each element (or other matter) is made up of very small and indivisible particles called atoms.
2. Atoms of the same element are identical in every respect, having the same mass, size and chemical properties. Atoms of different elements differ in mass, size and chemical properties.
3. Atoms of one element cannot be changed into atoms of others elements by chemical reactions. Atoms can neither be created nor destroyed in a chemical reaction.
4. Atoms of different elements combine to form compounds.
5. The 'number' and 'kind' of atoms in a given compound is fixed.

One of the drawbacks of Dalton's atomic theory is that atoms were thought to be indivisible (which cannot be divided). We now know that atoms can be divided). We now know that atoms can be further divided into still smaller particles called electrons, protons and neutrons. So, atoms are themselves made up of three particles: electrons, protons and neutrons.

Law of chemical combination. We shall now state three important laws of chemical combination and try to explain them on the basis of Dalton's atomic theory.

1. Law of conservation of matter (or mass). According to this law: "Matter can neither be created nor destroyed in a chemical reaction". This law means that the mass of the substances before a chemical reaction is exactly equal to the mass of the substances after the reaction. That is, the mass of reactants is exactly equal to the mass of the products and there is no change in mass in a chemical reaction.

Explanation: Dalton's atomic theory says that "atoms can neither be created nor destroyed in a chemical reaction". Since all the matter is made up of atoms, we can also say that "matter can neither be created nor destroyed in a chemical reaction".

The reaction between silver nitrate solution and sodium chloride solution can be written as:

$AgNO_3$ + NaCl → AgCl
(Silver nitrate) (Sodium choride) (Silver Chloride)
+ $NaNO_3$
(Sodium nitrate)

When silver nitrate reacts with sodium chloride, there is simply a rearrangement of atoms, the total number of atoms before the reaction and after the reaction, remains the same. So the mass or matter is conserved in this reaction.

2. Law of constant composition or Law of definite proportion. According to this law: "The composition of a pure compound is always the same". This law can also be stated as: "A compound always contains the same elements combined together in the same proportion by weight". This law means that whatever be the source from which a compound is obtained, it is always made up of the same elements in the same percentage.

Explanation. According to one of the postulates of Dalton's atomic theory: "The number and kind of atoms in a given compound is fixed". Since the number of atoms and the type of atoms in a given compound is fixed, a compound will always have the same percentage of the same elements, hence it will have a constant composition.

Water molecule (H_2O) always contains 2 atoms of hydrogen and 1 atom of oxygen. Since water molecule always contains the same number of hydrogen and oxygen atoms, hence it always contains the same percentage of the two elements. So, water has a constant composition.

3. Law of Multiple Proportions. This law states that when two elements combine to form two (or more than two) compounds, then the weights of one of these elements which combine with a fixed weight of the other element, bear a simple ratio to one another.

Explanation. According to Dalton when two elements combine to form more than one compound, if we fix the weight of one, we also fix the number of atoms of that element. In each compound with that number of atoms, a whole number of atoms of other element will combine. For example, peroxide (H_2O_2) by the combination of hydrogen and oxygen atoms.

In water two atoms of hydrogen combine with one atom of oxygen. In hydrogen peroxide, two atoms of hydrogen combine with two atoms of oxygen. Hence the ratio of oxygen combining with the fixed amount of hydrogen is 1:2 between water and hydrogen peroxide. This is also the ratio of their weights.

Law of Equivalent Weights. Each elements has a characteristic combining weight by which it can be represented whenever calculating the weight relationships expected for chemical reactions. The chemist defines this equivalent weight as equal to the atomic weight divided by valence. In the case of oxygen this is $16_{+}2 = 8$; for hydrogen it is $1_{+}1 = 1$; for chlorine it is $35.5_{+}1 = 35.5$.

AVOGADRO'S HYPOTHESIS

In 1811 Amedeo Avogadro proposed that 'equal volumes of different gases at the same temperature and pressure contain equal number of molecules'. This statement was initially known as Avogadro's hypothesis which is now firmly established and is known as Avogadro's law. This hypothesis gave a relationship between gram molecular mass, volume and number of molecules present therein. It was found that at STP (Standard Temperature and Pressure i.e. at 0ºC and 760 mm of mercury) one gram molecular mass or one mole of all the gases occupy a volume of 22.4 litres or 22400 ml. This volume of the gas is known as standard molar volume. Now we can say that: At constant temperature and pressure, the volume of gas is directly proportional to number of molecules. This may be expressed as:

V á n (P and T constant), where n is the number of moles. According to Avogadro's hypothesis, equal volume of gases contain equal number of molecules.

A gram molecule of any substance (not only gases) will contain the same number of molecules. No doubt, in the case of a gas this number of molecules always occupies the same volume, but this not so for liquids and solids. The actual number of molecules in a gram-molecule is known as Avogadro's number and its value is 6.023×10^{23} molecules.

MOLE CONCEPT

A group of 6.023×10^{23} particles (atoms or molecules) of a substance is called a mole of that substance.

1 mole of atoms = 6.023×10^{23} atoms

1 mole of molecules = 6.23×10^{23} molecules

Mole of Atoms. One mole of atoms of an element has a mass equal to the gram atomic mass of the element. For example:

1 mole of oxygen atoms (O) = Gram atomic mass of oxygen (O) = 16g.

Mole of Molecules. One mole of molecules of a substance has mass equal to the gram molecular mass of the substance. For example 1 mole of oxygen molecules (O_2) = 32g (Since molecular mass of O_2 is 32).

From the above discussion a mole of a substance may also be defined as that amount of substance which contains the same number of particles (atoms or molecules) as there are carbon-12 atoms in 12 grams of carbon-12 element. Thus, the unit of amount of a substance is mole which is represented as mol.