Atoms and Molecules

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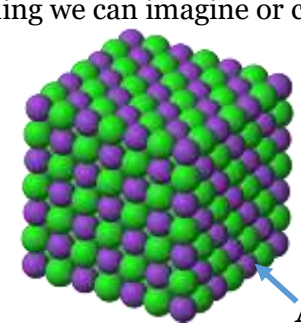
Matter is made up of small particles called atoms. Atom is the smallest building block of matter. Atoms are very small, they are smaller than anything we can imagine or compare with.



Symbols of Atoms of different Elements

- There are 115 elements present on earth till now.
- Many of the symbols are the first one or two letters of the name of the elements.
- First letter of the symbol is always capital. Ex: H for hydrogen, Na for sodium etc.

Properties of Atoms

- Atoms are very small in size. They are of the order 10^{-10}m.
- Atoms of an element are identical in all respect.

Note – Atoms of two different elements are different.

Atomic Mass

Mass of atom is called atomic mass. It is the number which tells that how many times an atom of an element is heavier than 1/12 of mass of one Carbon atom.

Mass of one atom of an element = n × 1/12 of the mass of one atom of carbon

Here, n is atomic mass.

$$\text{Atomic mass} = \frac{Mass\ of\ one\ atom\ of\ an\ element}{\frac{1}{12} of\ the\ mass\ of\ one\ carbon\ atom}$$

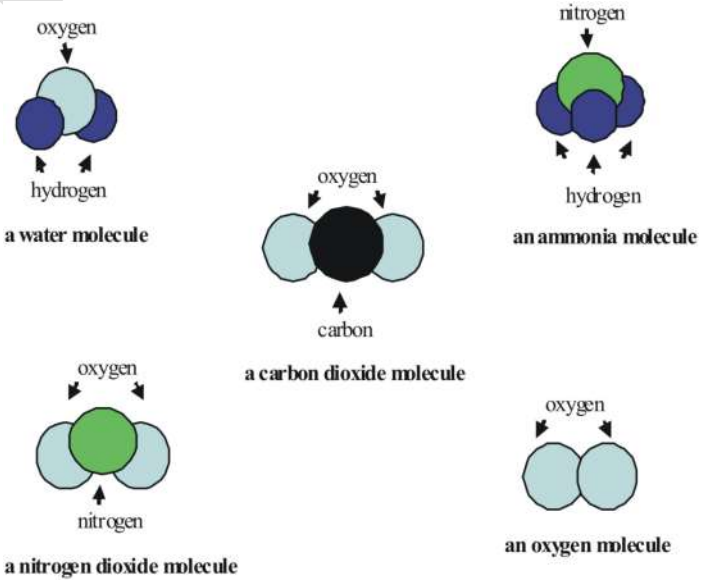
Unit of atomic mass is amu (atomic mass unit).

Note – Here, 1/12 of the mass of one carbon atom is called Relative atomic mass. It doesn't have unit.

Molecules

Molecules are formed by the combination of two or more atoms.

For example; two atoms of hydrogen (H_2) and one atom of oxygen (O_2) react with each other and form one molecule of water.



Atomicity

It is defined as the number of atoms present in a molecule.

On the basis of number of atoms, molecules can be categorize in four types:

1. **Monoatomic:** Molecules containing only atom are said to be monoatomic. For example; He, Ne, Ar etc.
2. **Diatomic:** Molecules containing two atoms are said to be diatomic. For example; O_2, H_2, Br_2 etc.
3. **Triatomic:** Molecules containing three atoms are said to be triatomic. For example; O_3, CO_2, O_2 etc.
4. **Tetra atomic:** Molecules containing four atoms are said to be tetra atomic. For example; P_4, O_3 etc.

Depending on types of atoms, molecules are further divided into two types:

1. **Homo-atomic Molecule:** Molecules formed by only one type of atoms are known as Homo-atomic molecule. For example; H_2, N_2, P_4 etc.
2. **Hetero-atomic Molecule:** Molecules formed by different types of atoms are known as Hetero-atomic molecules. For example; CO_2, NO_2, CH_4, HCl etc.

Molecular Mass

It is defined as the sum of atomic masses of all atoms present in a molecule.

For example;

The molecular mass of CO_2 = 1 x atomic mass of carbon + 2 x atomic mass of oxygen

= 12 + (2 x 16) = 44

Ions

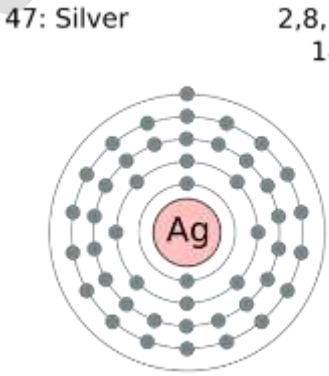
Ions are the atoms or group of atoms which have a net charge on them. For example; Na^+, Cl^-, etc.

Classification of ions

1. **On the basis of charge:**
   - **Cation:** Ions containing positive charge are called cations. For example; Na^+, K^+, Mg^{2+}, etc.
   - **Anion:** Ions containing negative charge are called anion. For example; Br^-, F^-, O^{2-}, etc.
2. **On the basis of number of ions:**
   - **Monoatomic Ions:** Ions containing only one atom are said to be monoatomic. For example; Na^+, K^+, Br^-, F^-, etc.
   - **Polyatomic Ions:** Ions containing more than one atom are said to be polyatomic. For example; CO_3^{2-}, NO_3^-, HCO_3^-, etc.

Valency

- It is defined as the combining capacity of an element.
- The outermost shell of any element is also called valence shell and the number of electrons present in that shell determines the valency.



Silver has 1 electron in its outermost shell. Silver donates one electron to complete its octet so valency of silver is +1.

Note –

- In general metals are said to be electropositive elements because they have the tendency to donate electrons. For example; Sodium has valency of +1, Calcium has valency of +2, etc.
- Non-metals are said to be electronegative elements because they have the tendency to accept electrons. For example; Chlorine has a valency of -1, Oxygen has a valency of -2, etc.
- There are also certain elements which possess more than one valency. For example;

- Iron shows two types of valencies one is Fe^{+2} which is popularly known as ferrous and another is Fe^{+3} which is known as ferric.
- Copper also shows valency of +1 known as Cuprous and +2 known as Cupric.

Classification of Ions on the basis of their Valency:

Monovalent Ions: Ions having the valency of 1 are said to be monovalent. For example; OH^-, NO_3^-, HCO_3^-, HSO_4^-, etc.

Divalent Ions: Ions having the valency of 2 are said to be divalent. For example; SO_4^{2-}, SO_3^{2-}, CO_3^{2-}, etc.

Trivalent Ions: Ions having the valency of 3 are said to be trivalent. For example; PO_4^{3-}, N^{3-} , etc.

Writing Chemical Formulae of Compounds

Rule 1: Cross multiply the valencies of elements to form a compound.

Rule 2: If compound consist of metal and non-metal than metal is written first.
For example; in calcium chloride ($CaCl_2$) and zinc sulphide (ZnS), calcium and zinc are metals, so they are written first, whereas chlorine and sulphur are non-metals.

Rule 3: If compound is formed with polyatomic ions then polyatomic ions are written in brackets.
For example; in aluminium sulphate [$Al_2(SO_4)_3$], the polyatomic sulphate ion SO_4^{2-} is enclosed in a bracket before writing the subscript 3.
Here, the bracket with a subscript 3 indicates that three sulphate groups are joined to two aluminium atoms.

Note – Compounds made up of metal and non – metal are called salts. All the above examples are of salts.

Mole

The quantity of a substance is expressed in terms of mole. One mole is also defined as the amount of substance which contains 6.023×10^{23} units of particle.
1 mole = 6.023×10^{23} units (Avogadro's Number N_A)

For examples; one mole of oxygen atoms represents 6.023×10^{23} atoms of oxygen and 5 moles of oxygen atoms contain $5 \times 6.023 \times 10^{23}$ atoms of oxygen.

Molar mass:

The mass of 1 mole of substance is called molar mass. Atomic mass or molecular mass in gram is equal to molar mass.

Example:

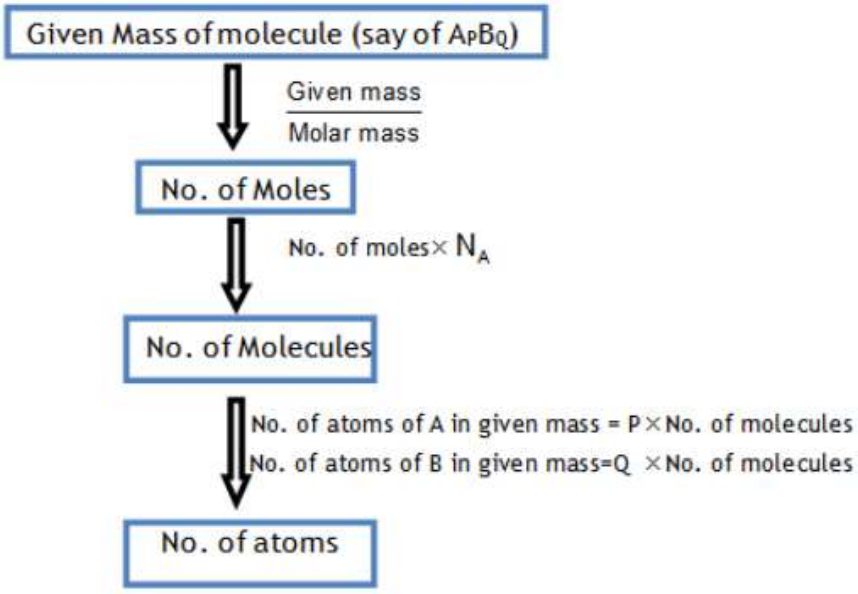
- Atomic mass of Fe is 56 amu
  Molar mass of Fe is 56 gram
- Molecular mass of H_2O is 18 amu
  Molar mass of H_2O is 18 gram

$$\text{Number of moles} = \frac{Given\ mass}{Molar\ mass}$$

For example; number of moles in 112 gm of iron will be

$$\frac{Given\ mass}{Molar\ mass} = \frac{112}{56} = 2 \text{ moles or } 2 \times 6.023 \times 10^{23} \text{ atoms}$$

Calculating number of atoms of each type and total number of atoms from given mass or moles:



Percentage of an element in a compound

A compound is composed of different elements and it tells that how much percentage of different elements is present in a compound.

$$\text{Percentage of Element} = \frac{mass\ of\ element}{total\ mass\ of\ compound} \times 100$$

Laws of Chemical Combination

Compounds are formed by chemical combination of reactants (atoms or molecules) in fixed proportion by weight or by volume. This is achieved by following certain laws known as **Laws of chemical combination**.

1. Law of Conservation of Mass:

The law of conservation of mass states, "*Mass can neither be created nor destroyed in a chemical reaction*".

Total mass of reactants = Total mass of products

Example:

$2H_2 + O_2 \longrightarrow 2H_2O$

(2 mass of hydrogen + mass of oxygen) (2mass of molecules)

(22 + 216) = 36 (2 x 18) = 36

As there is no loss of mass of substances, i.e. mass is conserved, that's why Lavoisier called this the law of conservation of mass.

2. Law of Constant Proportion:

Law of Constant Proportion states that "*a chemical compound always contains exactly the same proportion of elements by mass*".

This law is also known as Law of definite proportions. Joseph Louis Proust gave this law hence, this law is also known as Proust's Law.

Example:

$2H_2 + O_2 \longrightarrow 2H_2O$

(4 : 32) (2 : 16)

1 : 8 1 : 8