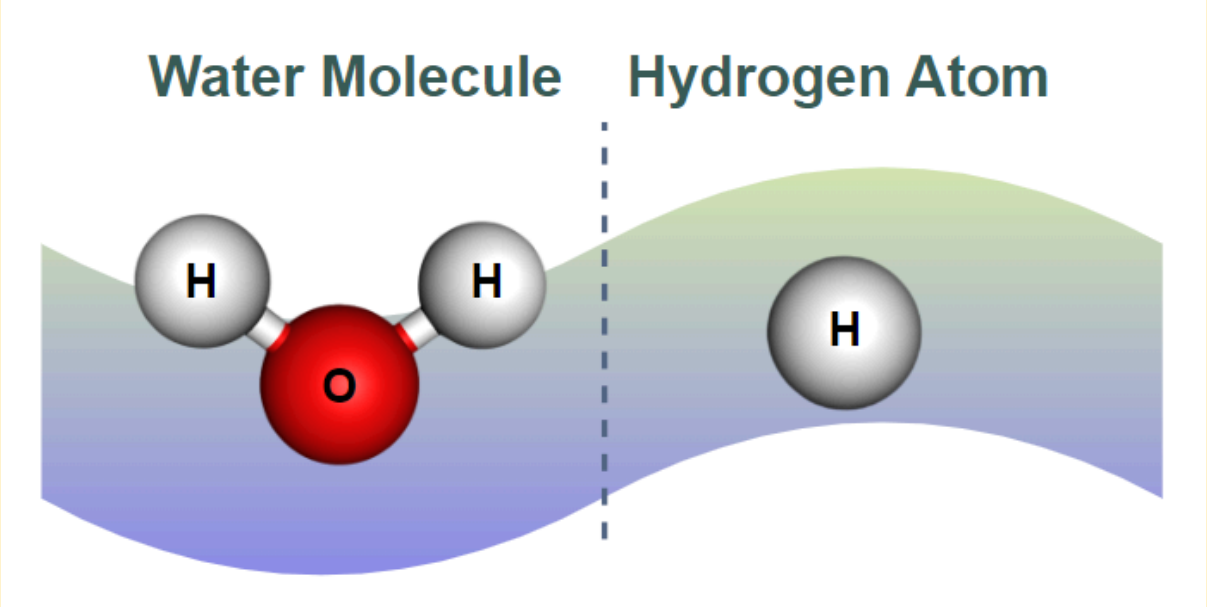
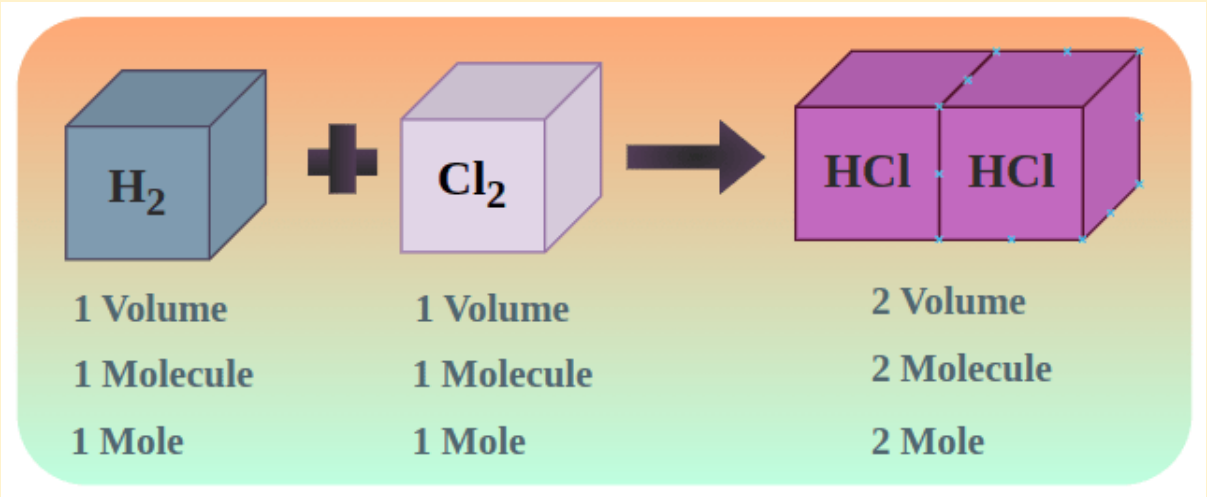
Chapter-03 : Atoms and molecules



Laws of chemical combination : It includes law of conservation of mass and law of constant proportions.



Law of conservation of mass : Mass can neither be created nor destroyed in a chemical reaction. This means that during a chemical reaction the sum of the masses of the reactants and products remain unchanged.

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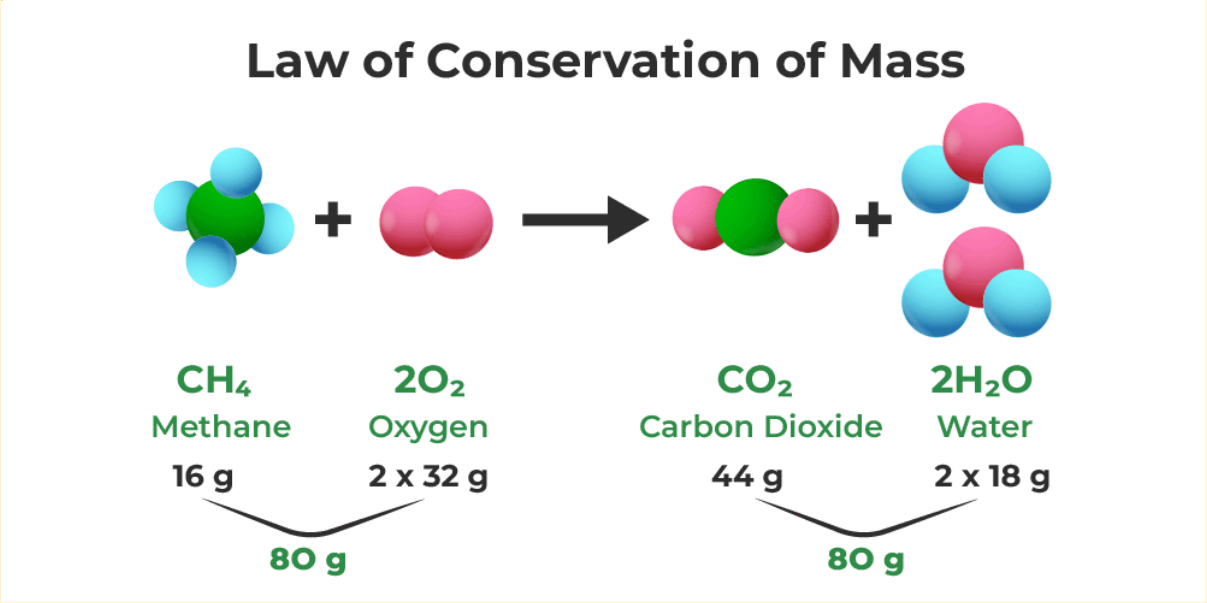
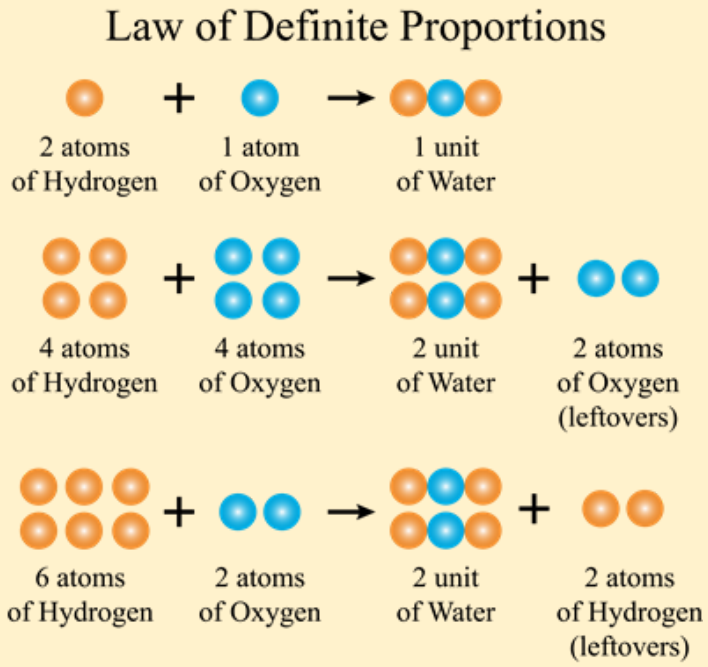


Law of constant proportions : In a chemical compound the elements are always present in a definite proportion by mass. E.g.- Water (H_2O) always contains two elements hydrogen and oxygen combined together in the same ratio of 2:16 or 1:8 by mass. If 9 g of water is decomposed we get 1 g of hydrogen and 8 g of oxygen. Ammonia (NH_3) always contains two elements nitrogen and hydrogen combined together in the same ratio of 14:3 by mass.



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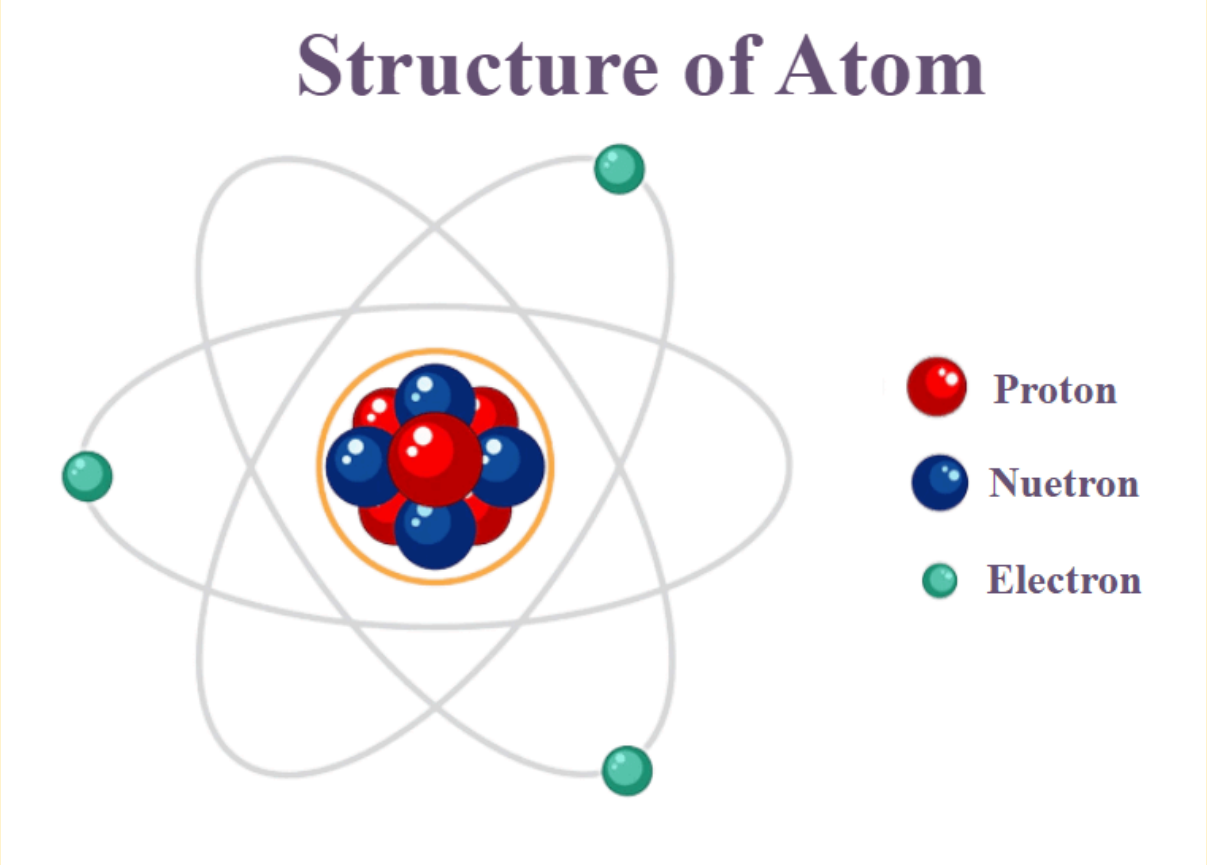
Dalton's atomic theory :

- Matter is made up of tiny particles called atoms.
- Atoms are indivisible and cannot be created or destroyed in a chemical reaction.
- Atoms of a given element are similar in mass and properties.
- Atoms of different elements have different masses and properties.
- Atoms combine in small whole number ratios to form compounds.
- In a given compound the relative number and kind of atoms are constant.

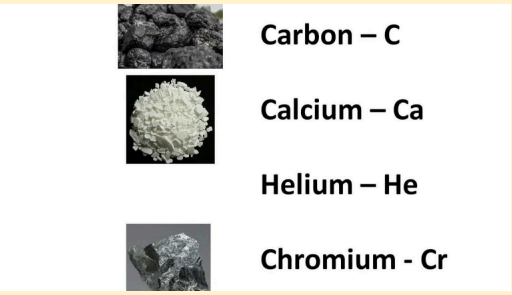
Atom : An atom is the smallest particle of an element that may or may not exist independently and retains all its chemical properties.



- Atoms are very small in size and smaller than anything we can imagine or compare with.
- Atomic radius is measured in nanometres (nm).
- 1 nanometer = 10^{-9}m or, 1 meter = 10^{9}nm
- The atomic radius of an atom of hydrogen is 10^{-10}m.
- The radius of a molecule of water is 10^{-9}m.

Symbols of atoms of different elements :

- The symbols of elements are represented by letters.
- The symbols of some elements are represented by one letter and the symbols of some elements are represented by two letters.



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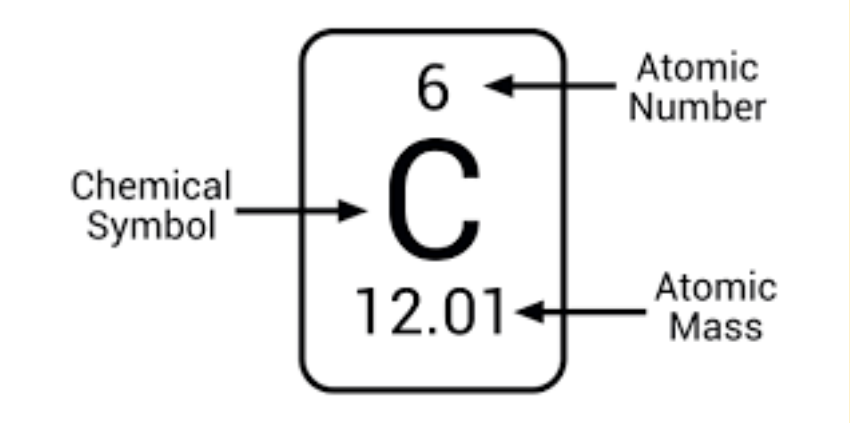
- If the symbol has only one letter it should be written as capital letter and if the symbol has two letters then the first letter should be capital letter and the second letter should be small letter.

Atomic mass:

- Since atoms are very small in size its mass is very small and determining its mass is very difficult. So, the mass of an atom is compared with the mass of a standard atom.
- The atom which is considered as a standard atom for comparing the masses of other atoms is carbon-12 atom whose atomic mass is 12u (atomic mass unit).
- One atomic mass unit (u) is the mass of $1/12^{th}$ the mass of a carbon-12 atom.
- The atomic mass of an element is defined as the average mass of one atom of the element compared with $1/12^{th}$ the mass of a carbon-12 atom.



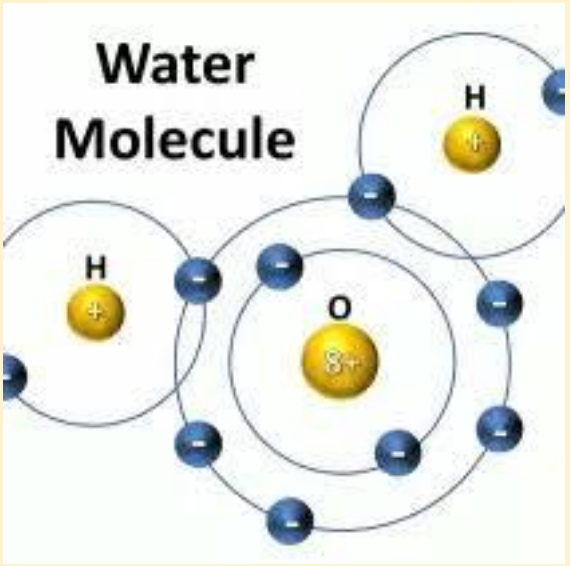
Molecule :

- A molecule is the smallest particle of an element or compound which exists independently and shows all the properties of that substance.

- A molecule is a group of two or more elements that are held together by attractive forces.
- Atoms of the same element or different elements can join together to form molecules.

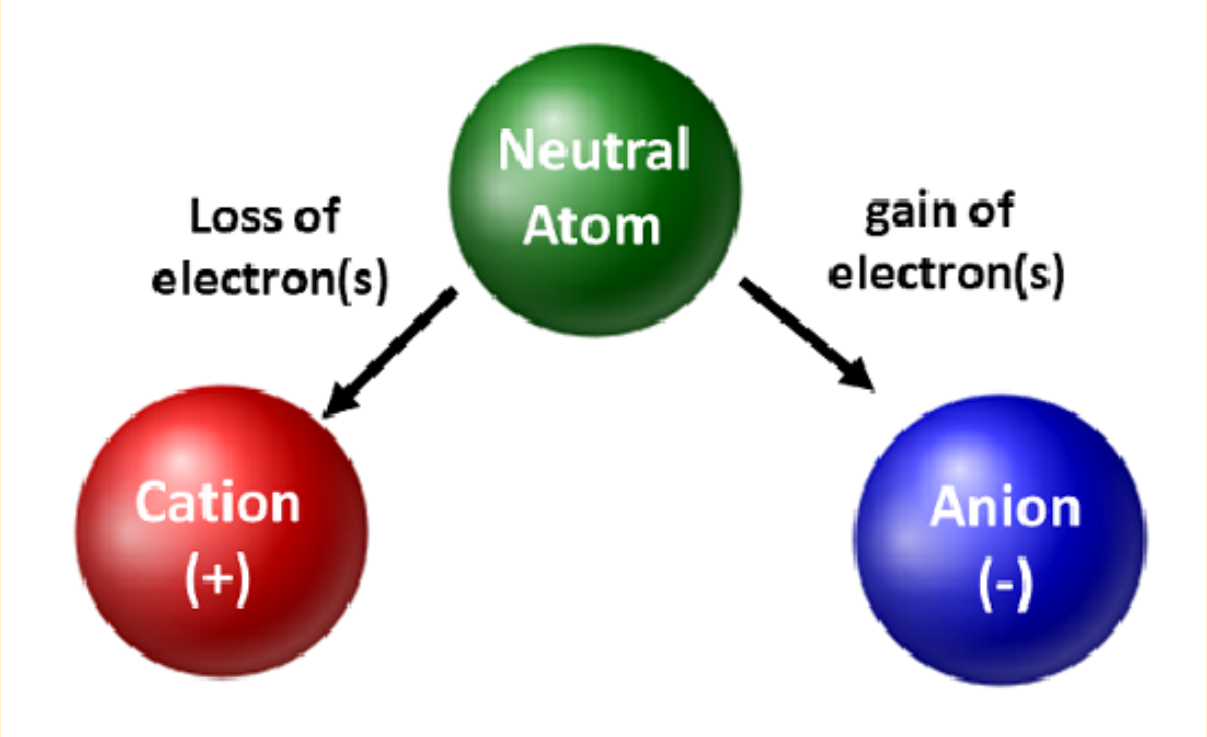
Molecule of elements and compounds :

- Molecules of some elements contain two or more atoms of same element.
- Molecule of a compound contains atoms of two or more different types of elements.
- Atomicity of an element is the number of atoms present in one molecule of the element.

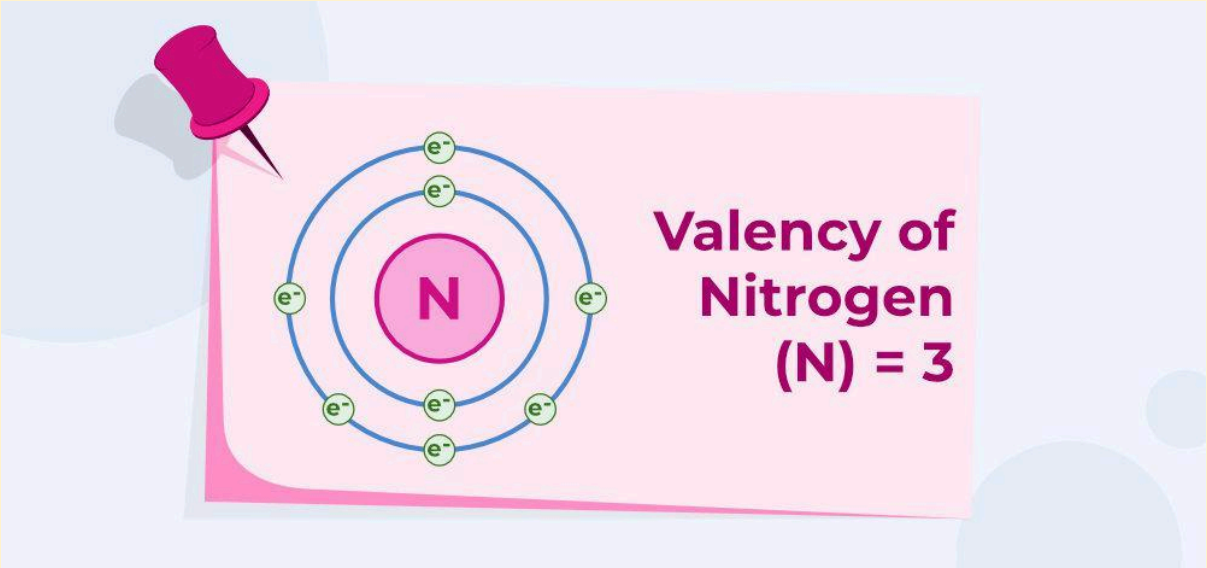


Ions:

- Compounds containing metal and non-metal elements contain charged particles called ions.
- An ion is a charged particle having positive or negative charge. A positively charged ion is called 'cation' and a negatively charged ion is called 'anion'.



Valency : The combining capacity of an element.



Writing chemical formulae :

- Write the symbols/formula of the elements or ions so that the symbol of the metal or positive ion is on the left and symbol/formula of the non-metal or negative ion is on the right.
- Write the valencies of the elements or ions below the elements or ions.

- Cross over the valencies of the combining ions.
- Polyatomic ions should be enclosed in bracket before writing the formula.

Atomic Number	Element	Symbol	Atomic Mass
1	Hydrogen	H	1.008
2	Helium	He	4.003
3	Lithium	Li	6.941
4	Beryllium	Be	9.012
5	Boron	B	10.81
6	Carbon	C	12.01
7	Nitrogen	N	14.01
8	Oxygen	O	16
9	Fluorine	F	19
10	Neon	Ne	20.18
11	Sodium	Na	22.99
12	Magnesium	Mg	24.31
13	Aluminum	Al	26.98
14	Silicon	Si	28.09
15	Phosphorus	P	30.97
16	Sulfur	S	32.07
17	Chlorine	Cl	35.45
18	Argon	Ar	39.95
19	Potassium	K	39.1
20	Calcium	Ca	40.08

Examples of chemical formulae of some compounds :

(i) Formula of hydrogen chloride

Symbol	H	Cl
Valency	1	1
Formula	HCl	

(ii) Formula of hydrogen sulphide

Symbol	H	S
Valency	1	2
Formula	H_2S	

(iii) Formula of Magnesium chloride

Symbol	Mg	Cl
Valency	2	1
Formula	$MgCl_2$	

(iv) Formula of Carbon tetrachloride

Symbol	C	Cl
Valency	4	1
Formula	CCl_4	

(v) Formula of Calcium oxide

Symbol	Ca	O
Valency	2	2
Formula	$Ca_2O_2 = CaO$	

(vi) Formula of Aluminium oxide

Symbol	Al	O
Valency	3	2
Formula	Al_2O_3	

(vii) Formula of Sodium nitrate

Symbol	Na	NO^{3-}
Valency	1	3
Formula	$NaNO_3$	

(viii) Formula of Calcium hydroxide

Symbol	Ca	OH^{1-}
Valency	2	1
Formula	$Ca(OH)_2$	

(ix) Formula of Sodium carbonate

Symbol	Na	CO_3^{2-}
Valency	1	2
Formula	Na_2CO_3	

(x) Formula of Ammonium sulphate

Symbol	NH^{4+}	SO_4^{2-}
Valency	1	2
Formula	$(NH_4)_2SO_4$	

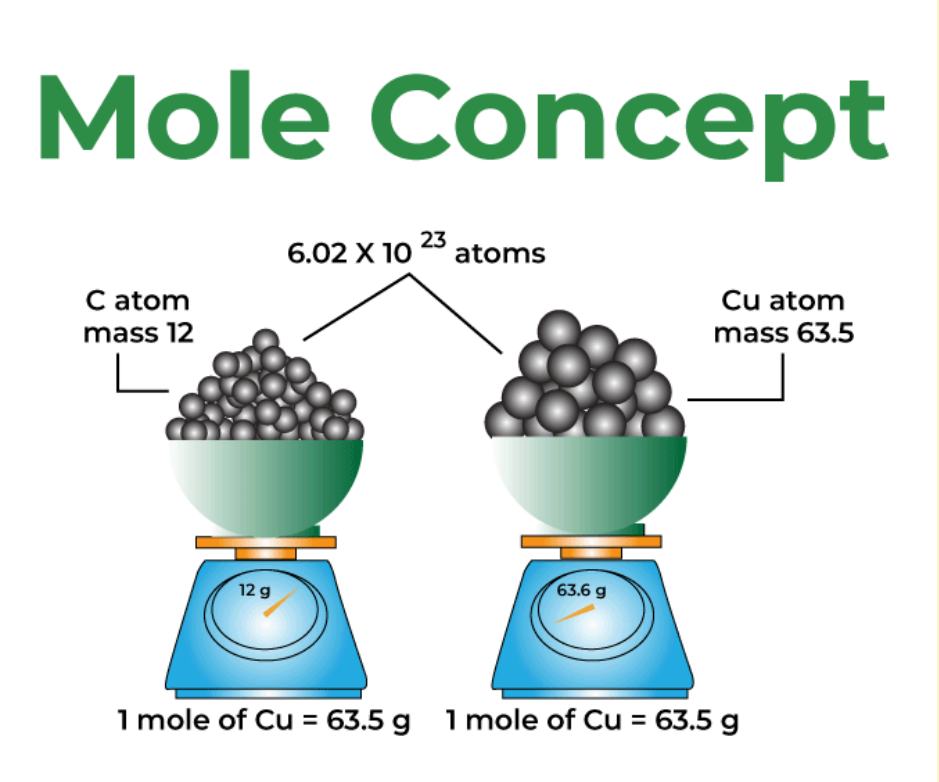
Molecular mass/Formula unit mass : The molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance. Molecular mass is expressed in atomic mass units (u). E.g.- Molecular mass of Nitric acid (HNO_3) : Atomic mass of H = 1 u

Atomic mass of N = 14 u

Atomic mass of O = 16 u

Molecular mass of HNO_3 = 1+14+16x3 = 1+14+48 = 63 u

Mole concept :



- A mole of a substance is that amount of the substance which contains the same number of particles (atoms, molecules or ions) that are present in 12g of Carbon-12.
- The number of particles (atoms) present in 12g of Carbon-12 is $6.022x10^{23}$. This number is called Avagadro's Number or Avagadro's Constant.
- A mole represents two things :
    - It represents a definite number of particles (atoms, molecules or ions) equal to $6.022x10^{23}$

- It represents a definite mass of a substance equal to the gram-atomic mass of an element or the gram-molecular mass of a compound.

- Gram-atomic mass of an element is its atomic mass expressed in grams. E.g.-Gram-atomic mass of Oxygen = O_2= 16 x 2 = 32g.
- Gram-molecular mass of a compound is its molecular mass expressed in grams. E.g.-Gram-molecular mass of water = H_2O = 1 x 2 + 16 = 2 + 16 = 18g.

Relationship between number of moles (n), mass (m), molar mass (M), Number of atoms or molecules (N) and Avagadro's number (N_0) :

- n = m / M,
- m = n x M,
- M = m / n,
- n = N / N_0