CHAPTER - 3 "Atoms and Molecules"

CONCEPT DETAILS

KEY CONCEPTS

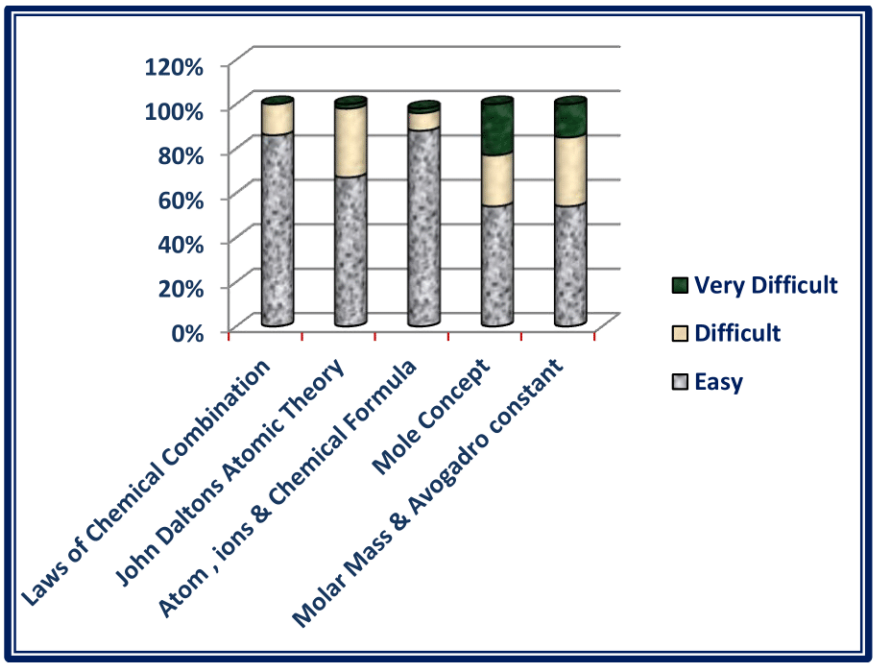
1. Laws of Chemical Combination
2. John Daltons Atomic Theory
3. Atoms, ions & Chemical Formula
4. Mole Concept
5. Molar Mass & Avogadro constant

- **Pre requisites**

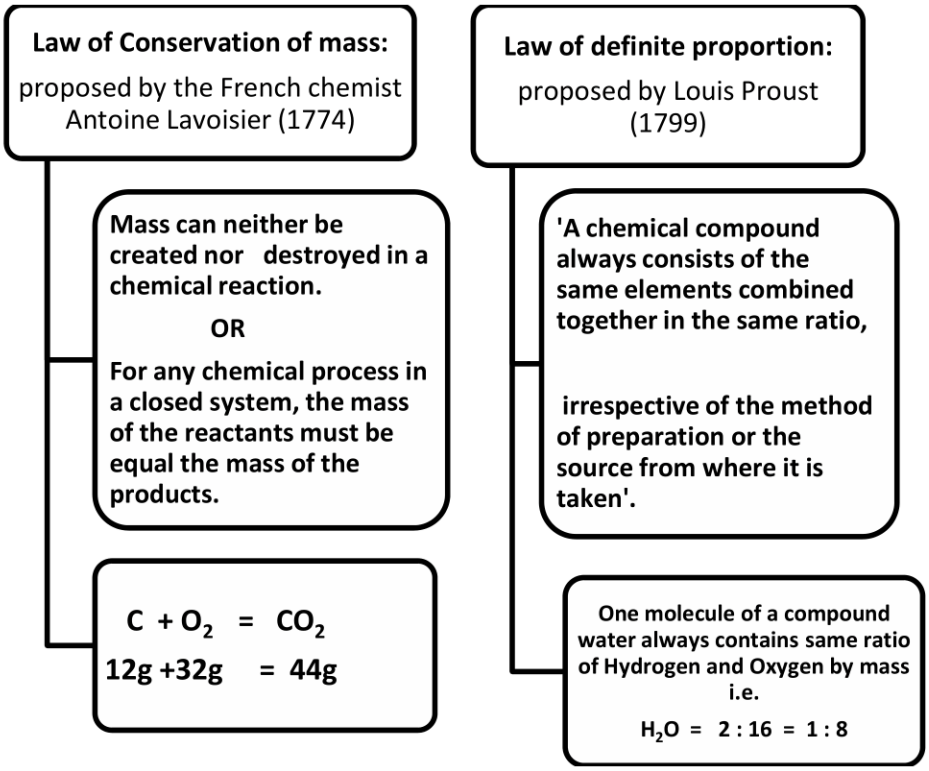
Basic knowledge all states of matter.
Difference in the different states of matter .

SURVEY ANALYSIS

Conceptual levels of comprehension on the basis of feedback taken from the students



1.Laws of Chemical Combination



Verification of "Law of Conservation of mass"

A solution of sodium chloride and silver nitrate are taken separately in the two limbs of an 'H' shaped tube. The tube is sealed and weighed precisely. The two reactants are made to react by inverting the tube. The following reaction takes place.

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

The whole tube is kept undisturbed for sometime so that the reaction is complete.

When the tube is weighed again it is observed that:

Weight before the reaction = Weight after the reaction

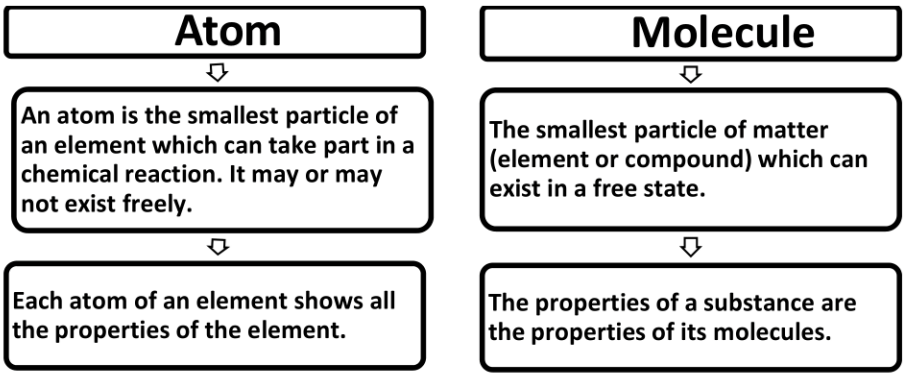
Limitation of "Law of definite proportion"

This law does not hold good when the compound is obtained by using different isotopes of the combining elements .

2. John Daltons Atomic Theory

Using his theory, Dalton rationalized the various laws of chemical combination which were in existence at that time. However, ***he assumed that the simplest compound of two elements must be binary.***

3. Atoms ,Molecules, Ions & Chemical Formula



- ***MOLECULES OF ELEMENT :*** *The molecules of an element are constituted by the same type of atoms.*
- ***MOLECULES OF COMPOUND:*** *Atoms of different elements join together in definite proportions to form molecules of compounds.(hetero atomic molecules)*

- **ATOMICITY** : The number of atoms contained in a molecule of a substance (element or compound) is called its atomicity.

Element	Formula	Atomicity
Ozone	O_3	3
Phosphorus	P_4	4
Sulphur	S_8	8
Oxygen	O_2	2

- Based upon atomicity molecules can be classified as follows.

  Monoatomic molecules: Noble gases helium, neon and argon exist as He Ne and Ar respectively.

  Diatomic molecules: H_2 , O_2, N_2,Cl_2, CO , HCl .

  Triatomic molecules: O_3 ,CO_2 , NO_2.

- **SYMBOLS**

  - The abbreviation used to represent an element is generally the first letter in capital of the English name of element.

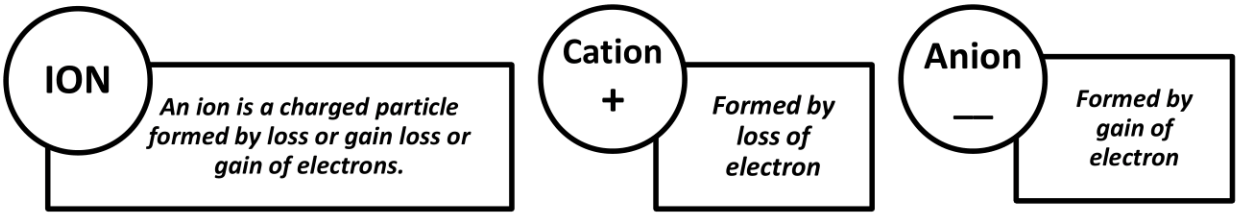
    Oxygen → O Nitrogen → N

  - When the names of two or more elements begin with the same initial letter, the initial letter followed by the letter appearing later in the name is used to symbolize the element

    Barium → Ba Bismuth → Bi

<u>Symbols of some elements are derived from their Latin names</u>

ELEMENT	LATIN NAME	SYMBOL
Sodium	**Natrium**	**Na**
Copper	**Cuprum**	**Cu**
Potassium	**Kalium**	**K**
Iron	**Ferrum**	**Fe**
Mercury	**Hydragyrum**	**Hg**
Tungsten	**Wolfram**	**W**



Polyatomic Ion : A group of atoms carrying a charge is as polyatomic ion.

eg: **NH_4^+** - Ammonium Ion ; **CO_3^{2-}** - Carbonate ion

Valency : The number of electrons which an atom can lose , gain or share to form a bond.

OR

It is the combining capacity of an atom of the element.

- **Chemical Formula:** A chemical formula is a short method of representing chemical elements and compounds.

Writing a Chemical Formula -CRISS-CROSS rule

RULE 1 [a]	**write the correct symbols of two elements.**
	Ex : Aluminium & Oxygen Al O
[b]	**above each symbol, write the correct valence**
	Al^{3+} O^{2-}
[c]	**Criss-cross the valence and drop the algebraic sign.**
	Al_2O_3

RULE 2 >	**When the subscript is number 1, subscript is not written.**
	Ex. Sodium Chloride - Na^{1+} Cl^{1-} --- NaCl

RULE 3>	**When the valence of both elements are numerically equal , the subscripts are also not written.**
	Ex. Calcium Oxide- - Ca^{2+} O^{2-} --- CaO

RULE 4 > When there are multiple numbers of an individual polyatomic ion , parentheses must be used to separate the polyatomic ion from the subscirpt.
Ex. Ammonium Sulphate- - NH_4^{1+} SO_4^{2} ------ $(NH_4)_2\ SO_4$

RULE 5 > All subscripts must be reduced to lowest term (except for molecular or covalent copound).
Ex. Tin (IV) Chloride ~ $Sn^{4+}O^{2-}$ ------ SnO_2

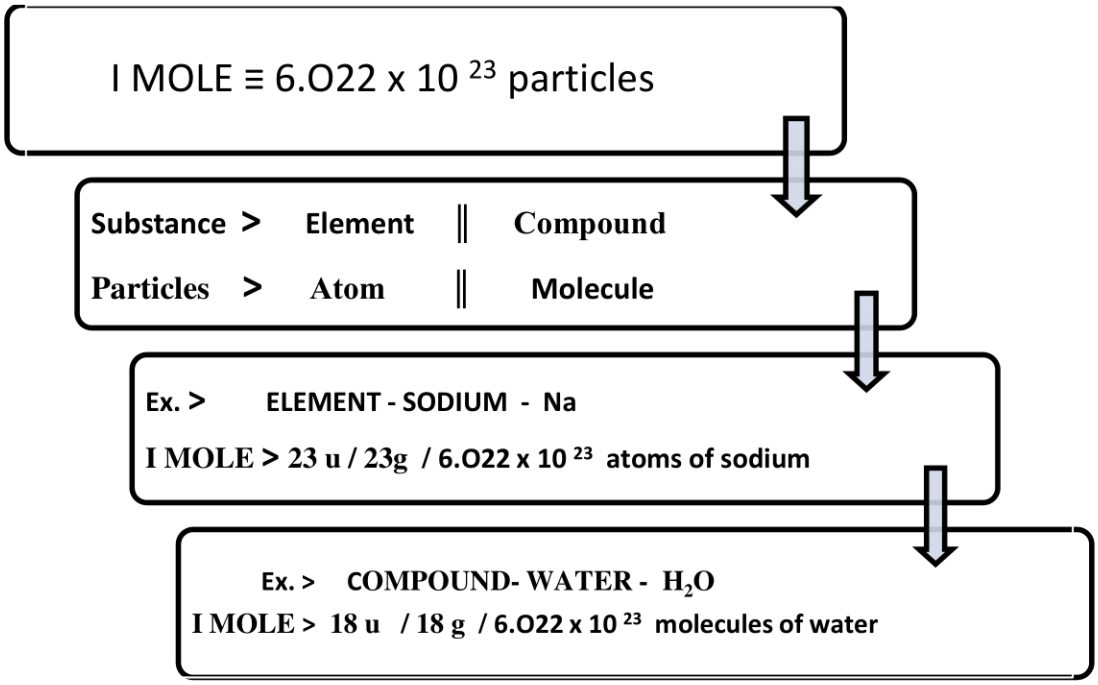
EXAMPLES

CATION	ANION	FORMULA	NAME
Al^{3+}	SO_4^{2-}	$Al_2(SO_4)_3$	Aluminium sulphate
Ca	HCO_3^-	$Ca(HCO_3)_2$	Calcium bicarbonate
NH_4^+	Cl^-	NH_4Cl	Ammonium chloride
Na^+	CO_3^{2-}	Na_2CO_3	Sodium carbonate
Mg^{2+}	OH^-	$Mg(OH)_2$	Magnesium hydroxide
Na^+	PO_4^{3-}	Na_3PO_4	Sodium phosphate

4. Mole Concept

The *mole (mol)* is the amount of a substance that contains as many elementary entities as there are atoms in exactly 12.00 grams of ^{12}C

The Avogadro constant is named after the early nineteenth century Italian scientist Amedeo Avogadro.



S.No.	Symbol / formula of atom / molecule	Atomic / molecular mass (u)	1mole (in g)	Avogadro no.	Molar mass (g mol $^{-1}$)
1.	O	16 u	16 g	6.022 x 10^{23} atoms	16 g mol $^{-1}$
2.	N_2	28 u	28 g	6.022 x 10^{23} molecules	28 g mol $^{-1}$
3.	HCl	36.5 u	36.5 g	6.022 x 10^{23} molecules	36.5 g mol $^{-1}$

GRAM MOLECULAR MASS

Gram molecular mass is the mass in grams of one mole of a molecular substance.

Ex: The molecular mass of N_2 is 28, so the gram molecular mass of N_2 is 28 g.

ATOMIC MASS UNIT

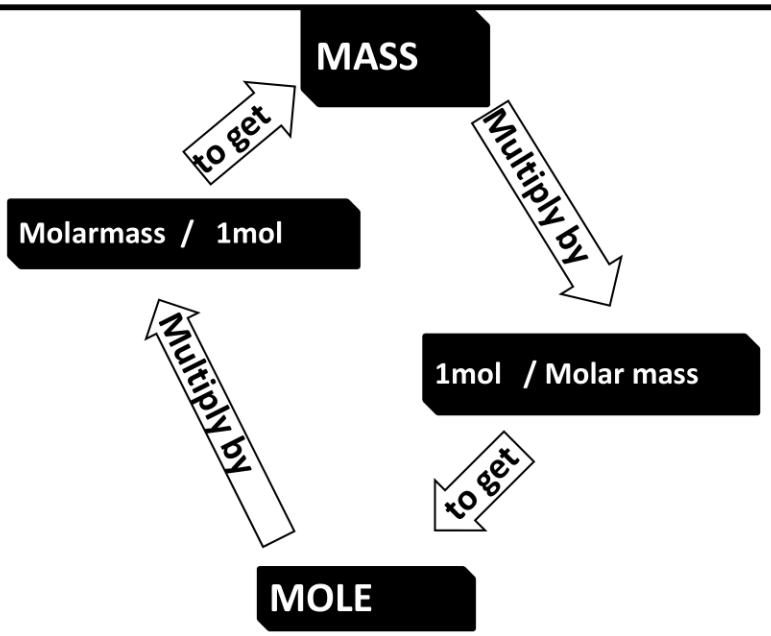
An atomic mass unit or amu is one twelfth of the mass of an unbound atom of carbon-12. It is a unit of mass used to express atomic masses and molecular masses.

Also Known As: Unified Atomic Mass Unit (u).

MOLECULAR MASS : A number equal to the sum of the atomic masses of the atoms in a molecule. The molecular mass gives the mass of a molecule relative to that of the ^{12}C atom, which is taken to have a mass of 12.

Examples: The molecular mass of C_2H_6 is approximately 30 or [(2 x 12) + (6 x 1)] . Therefore the molecule is about 2.5 times as heavy as the ^{12}C atom or about the same mass as the NO atom with a molecular mass of 30 or (14+16) .

5.Molar Mass & Avogadro Constant



Ex: i) Convert 35 g of Al into mol.

A: Molar mass of Al= 27 g

27 g = 1mol

$$= 35\ g \times \frac{1\ mol}{27\ g}$$

= 1.3 mol of Al

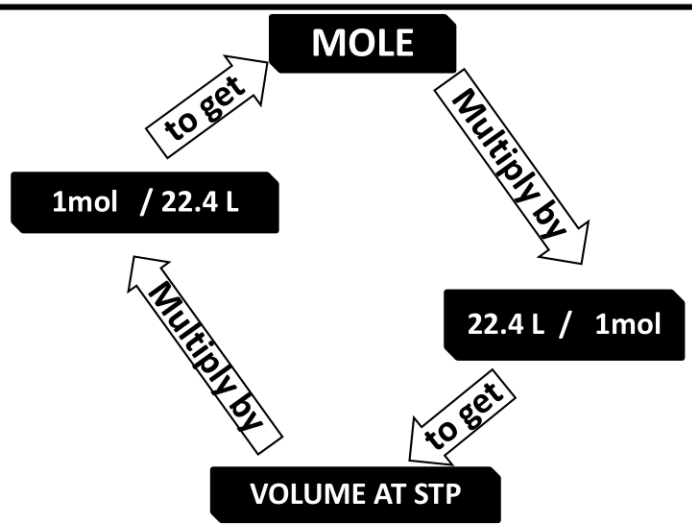
ii) How many grams of SiO_2 are present in 0.8 mol ?

A: Molar mass of SiO_2 = 60.1 g

1 mol = 60.1 g

$$= 0.8\ mol\ of\ SiO_2 \times \frac{60.1\ g\ of\ SiO_2}{1\ mol\ of\ SiO_2}$$

= 48.1 g SiO_2

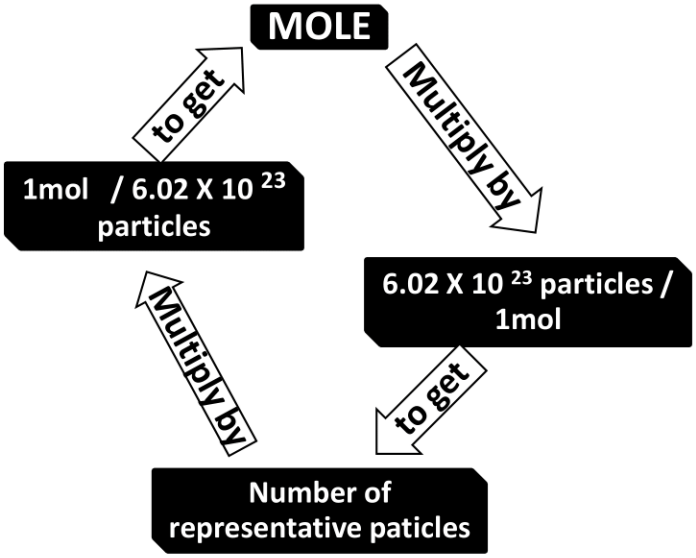


Ex . How many mol of CO_2 are present in 55.5 L ?

A: 22.4 L = 1mol

$$= 55.5\ L \times \frac{1\ mol}{22.4\ L}$$

$= 2.48$ mol of CO_2.



Ex Calculate number of molecules in 200 g of N_2O.

Molar mass of N_2O = 44 g

i) to find number of moles:-

44 g = 1 mol

$$= 200\ g \times \frac{1\ mol}{44.0\ g}$$

$= 4.55$ mol of N_2O

ii) to find number of molecules

1 mol $= 6.02 \times 10^{23}$ molecules

$$= \frac{6.02 \times 10^{23}\ \text{molecules } N_2O}{1/\ 4.55}$$

$= 2.74 \times 10^{24}$ molecules N_2O