Ch-3 Atoms and Molecules

1. **Laws of Chemical Combination –** Given by Lavoisier and Joseph L. Proust as follows –
    a. Law of conservation of mass – Mass can neither be created nor destroyed in a chemical reaction. E.g., A + B → C + D (Mass of reactants = Mass of products)
    b. Law of constant proportion – In a chemical substance the elements are always present in definite proportions by mass. E.g., in water, the ratio of the mass of hydrogen to the mass of oxygen is always 1 : 8 respectively.
    Note – These laws lacked explanation. Hence, John Dalton gave his theory about the matter. He said that the smallest particle of matter is called 'atom'.
2. **Dalton's Atomic Theory –**
    a. Every matter is made up of very small or tiny particles called atoms.
    b. Atoms are not divisible and cannot be created or destroyed in a chemical reaction.
    c. All atoms of a given element it are same in size, "mass and chemical properties.
    d. Atoms of different elements are different in size, mass and chemical properties.
    e. Atoms combine in the ratio of small whole number to form compounds.
    f. The relative number and kinds of atoms are constant in a given compound.
3. **Atom –** Atoms are the smallest particles of an element which can take part in a reaction.
    a. **Size of an atom –** Atomic radius is measured in nano metres.
    1 nm = $\frac{1}{10^9}$ m
    i.e., 1 m = 10^9 nm.
    Atomic radii of hydrogen atom = 1×10^{-10} m.
    b. Symbols of some common elements –

Name of the Element	Symbol
Hydrogen	H
Helium	He
Carbon	C
Copper	Cu
Cobalt	Co
Boron	B
Barium	Ba
Bromine	Br
Bismuth	Bi
Sodium	Na
Potassium	K
Iron	Fe
Gold	Au
Silver	Ag
Mercury	Hg

4. **Molecule –** It is the smallest particle of an element or a compound which can exist independently.
    a. Molecules of an element constitutes same type of atoms.
    b. Molecules may be monoatomic, di-atomic or polyatomic.

c. Molecules of compounds join together in definite proportions and constitutes different type of atoms.

5. **Atomicity –** The number of atoms constituting a Molecule is known as its atomicity.

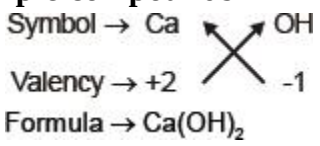
Name of the Element	Atomicity	Molecular Formula
Helium	Monoatomic	He
Neon	Monoatomic	Ne
Argon	Monoatomic	Ar
Sodium	Monoatomic	Na
Iron	Monoatomic	Fe
Aluminium	Monoatomic	Al
Hydrogen	Di-atomic	H_2
Oxygen	Di-atomic	O_2
Chlorine	Di-atomic	Cl_2
Nitrogen	Di-atomic	N_2
Phosphorus	Polyatomic (Tetra)	P_4
Sulphur	Polyatomic (Octa)	S_8

6. **Ions –** The charged particles (atoms) are called ions, they have a positive charge or a negative charge on it –
   a. Negatively charged ion is called anion (Cl^-).
   b. Positively charge ion is called cation (Na^+).
7. **Valency –** The combining capacity of an element is known as its valency. Valency is used to find out how atom of an element will combine with the atom of another element to form a chemical compound. (Every atom wants to become stable, to do so it may lose, gain or share electrons.)
   a. If an atom consists of 1, 2 or 3 electrons in its valence shell then it will lose 1, 2 or 3 electrons respectively and its valency will be 1, 2 or 3 respectively
   b. If an atom consists of 5, 6 or 7 electrons in the outermost shell, then it will gain 3, 2 or 1 electron respectively and its valency will be 3, 2 or 1 respectively.
   c. If an atom has 4 electrons in the outermost shell than it will share these electrons and, hence, its valency will be 4.
   d. If an atom has 8 electrons in the outermost shell then its valency is 0.

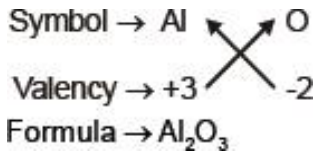
Name of the Element	Symbol	Valency	Ion
Hydrogen	H	1	H^+
Helium	He	2	-
Lithium	Li	3	Li^+
Beryllium	Be	4	Be^{2+}
Boron	B	3	B^{3+}
Carbon	C	4 (Share)	-
Nitrogen	N	3	N^{3-}
Oxygen	O	2	O^{2-}
Fluorine	F	1	F^-
Neon	Ne	0	-

Sodium	Na	1	Na^+
Magnesium	Mg	2	Mg^{2+}
Aluminium	Al	3	Al^{3+}

8. **Chemical Formulae – Rules –**
   a. The valency or charges on the ion must balance.
   b. A metal and non-metal compound should show the name or symbols of the metal first. E.g., $Na^+ + Cl^- \rightarrow NaCl$
   c. If a compound consist of polyatomic ions. The ion before writing the number to indicate the ratio. E.g., $[SO_4]^{2-}$ → polyatomic radical, $H^{1+} + SO_4^{2-} \rightarrow H_2SO_4$.
9. **Chemical formula of some simple compounds –**
   a. Calcium Hydroxide –



   b. Aluminium Oxide –



10. **Molecular Mass –** It is the sum of the atomic masses of all the atoms in a molecule of the substance. It is expressed in atomic mass unit (u). E.g., $2H^+ + O_2 \rightarrow H_2O$ [H = 1, 0 = 16]
    $1 \times 2 + 16 = 18$ u
11. **Formula Unit Mass –** It is the sum of the atomic masses of all atoms in a formula unit of a compound. The constituent particles are ions. E.g., $Na^+ + Cl^- \rightarrow NaCl$ [Na = 23, Cl = 35.5]
    $1 \times 23 + 1 \times 35.5 = 58.5$ u
12. **Mole Concept –**
    a. **Definition of mole –** It is defined as one mole of any species (atom, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecular mass in grams. 1 mole = 6.022×10^{23} in number
    b. **Molar mass** – mass of 1 mole is always expressed in grams, and is also known as gram atomic mass.
       1 u of hydrogen = 1 atom of hydrogen
       1 g of hydrogen = 1 mole of hydrogen = 6.022×10^{23} atoms of hydrogens