ATOMS AND MOLECULES

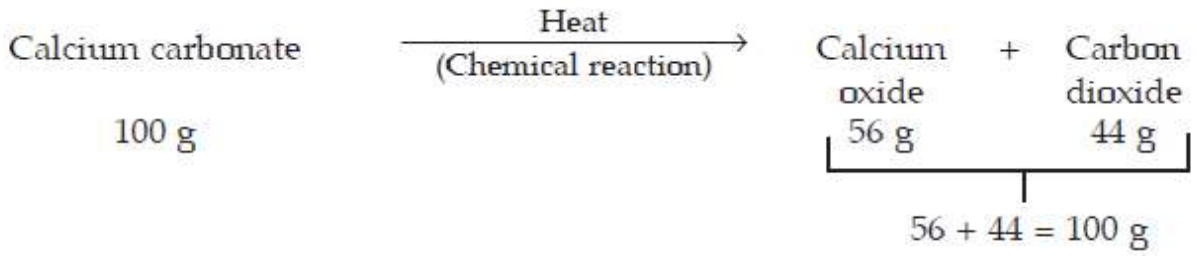
- **All matter is made up of small particles called atoms and molecules. Different kinds of atoms and molecules have different properties due to which different kinds of matter also show different properties.**

LAWS OF CHEMICAL COMBINATION

1. Law of conservation of mass (or matter)

The law of conservation of mass means that in a chemical reaction, the total mass of products is equal to the total mass of reactants. There is no change in mass during a chemical reaction.

- **It has been found by experiments that if 100 grams of calcium carbonate are decomposed completely then 56 grams of calcium oxide and 44 grams of carbon dioxide are formed.**



- **since the total mass of products (100 g) is equal to the total mass of reactant (100 g), there is no change of mass during this chemical reaction. The mass remains the same or conserved.**

2. Law of constant proportions

A chemical compound always consists of the same elements combined together in the same proportion by mass.

- **The only logical explanation of the laws of chemical combination is that matter (say, elements) must be made up of minute 'unit particles', which take part in chemical combination in fixed whole numbers. These 'unit particles' of matter were called atoms.**

DALTON'S ATOMIC THEORY

1. All the matter is made up of very small particles called 'atoms'.
2. Atoms cannot be divided.
3. Atoms can neither be created nor destroyed.
4. Atoms are of various kinds. There are as many kinds of atoms as are elements.
5. All the atoms of a given element are identical in every respect, having the same mass, size and chemical properties.
6. Atoms of different elements differ in mass, size and chemical properties.
7. Chemical combination between two (or more) elements consists in the joining together of atoms of these elements to form molecules of compounds.
8. The 'number' and 'kind' of atoms in a given compound is fixed.
9. During chemical combination, atoms of different elements combine in small whole numbers to form compounds.
10. Atoms of the same elements can combine in more than one ratio to form more than one compound.

Drawbacks of Dalton's Atomic Theory

- **Atoms were thought to be indivisible (which cannot be divided). under special circumstances, atoms can be further divided into still smaller particles called electrons, protons and neutrons.**

- **atoms of the same element can have slightly different masses.**

- **even atoms of different elements can have the same mass.**

ATOMS

An atom is the smallest particle of an element that can take part in a chemical reaction.

- **Atoms are very, very small in size.**

- **The size of an atom is indicated by its radius which is called 'atomic radius' (radius of atom). Atomic radius is measured in 'nanometres' (which is a very, very small unit measuring length). The symbol of a nanometre is nm.**

- **Hydrogen atom is the smallest atom of all.**

SYMBOLS OF ELEMENTS

It was J.J. Berzelius of Sweden who proposed that the first letter (or the first letter and another letter) of the name of an element be used as its symbol.

- **The symbol of an element is the "first letter" or the "first letter and another letter" of the English name or Latin name of the element.**

ATOMIC MASS OF AN ELEMENT

- **one atomic mass unit (1 u) is defined as exactly one-twelfth the mass of an atom of carbon-12.**

- **The atomic masses of all other elements are determined by comparing the mass of their atom with the mass of a carbon-12 atom.**

- **the present standard for the atomic masses is carbon-12 atom which has been assigned an atomic mass of exactly 12 u.**

HOW DO ATOMS EXIST

Atoms usually exist in two ways :

1. in the form of molecules, and
2. in the form of ions.

MOLECULES

A molecule is an electrically neutral group of two (or more) atoms chemically bonded together.

- **A molecule is the smallest particle of a substance (element or compound) which has the properties of that substance and can exist in the free state.**

1. Molecules of Elements

The molecule of an element contains two (or more) similar atoms chemically combined together.

- **Hydrogen gas consists of H_2 molecules and not of single atoms H.**

- **The number of atoms present in one molecule of an element is called its atomicity.**

- **the atomicity of noble gases is 1. the atomicity of hydrogen, nitrogen, oxygen, chlorine, bromine and iodine is 2 each.**

2. Molecules of Compounds

The molecule of a compound contains two (or more) different types of atoms chemically combined together.

Chemical Formulae

A chemical formula represents the composition of a molecule of the substance in terms of the symbols of the elements present in the molecule.

Formulae of Elements

The chemical formula of an element is a statement of the composition of its molecule in which symbol tells us the element and the subscript (lower figure) tells us how many atoms are present in one molecule.

Formulae of Compounds

The chemical formula of a compound is a statement of its composition in which the chemical symbols tell us which elements are present and the subscripts (lower figures) tell us how many atoms of each element are present in one molecule of the compound.

Molecular Mass

The molecular mass of a substance is the relative mass of its molecule as compared with the mass of a carbon-12 atom taken as 12 units.

Calculation of Molecular Mass

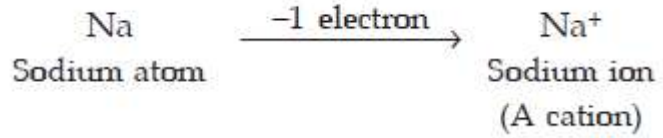
The molecular mass is equal to sum of the atomic masses of all the atoms present in one molecule of the substance.

IONS

- **Every atom normally contains an equal number of 'negative electrons' and 'positive protons' which balance the charges in the atom and make an atom electrically neutral.**
- **If an atom has less electrons than normal, then it gets positive charge**
- **if an atom has more electrons than normal, then it gets negative charge**
- **An ion is a positively or negatively charged atom (or group of atoms).**

1. A Positively Charged Ion is Known as Cation

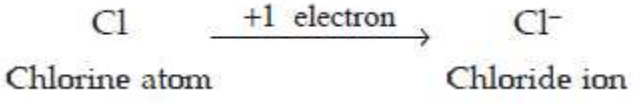
A cation is formed by the loss of one or more electrons by an atom. A cation contains less electrons than a normal atom.



- **The ions of all the metal elements are cations.**
- **Due to more protons than electrons, a cation has a positive charge on it.**
- **All the metal atoms can lose electrons easily, so all the metal elements form cations (or positive ions).**

2. A Negatively Charged Ion is Known as Anion

An anion is formed by the gain of one or more electrons by an atom. an anion contains more electrons than a normal atom.



- **Most of the non-metal atoms can gain (or accept) electrons easily, so most of the non-metal elements form anions (or negative ions).**

Simple Ions and Compound Ions (Polyatomic Ions)

(*i*) Those ions which are formed from single atoms are called simple ions. Simple ions are also known as monoatomic ions.

(*ii*) Those ions which are formed from groups of joined atoms are called compound ions (or polyatomic ions). Compound ions are also known as polyatomic ions.

IONIC COMPOUNDS

The compounds which are made up of ions are known as ionic compounds.

- **whenever we see a compound made up of a metal and a non-metal, we should at once say that it is an ionic compound.**

Formula Unit of Ionic Compounds

The simplest combination of ions that produces an electrically neutral unit, is called a 'formula unit' of the ionic compound.

Chart of some common ions

Name of ion	Symbol (or Formula)	Name of ion	Symbol (or Formula)
1. Sodium ion	Na^+	10. Chloride ion	Cl^-
2. Potassium ion	K^+	11. Bromide ion	Br^-
3. Ammonium ion	NH_4^+	12. Hydroxide ion	OH^-
4. Magnesium ion	Mg^{2+}	13. Nitrate ion	NO_3^-
5. Calcium ion	Ca^{2+}	14. Oxide ion	O^{2-}
6. Copper (II) ion	Cu^{2+}	15. Sulphide ion	S^{2-}
7. Zinc ion	Zn^{2+}	16. Carbonate ion	CO_3^{2-}
8. Iron (II) ion	Fe^{2+}	17. Sulphate ion	SO_4^{2-}
9. Aluminium ion	Al^{3+}	18. Phosphate ion	PO_4^{3-}

CHEMICAL FORMULAE

The chemical formula of a compound represents the composition of a molecule of the compound in terms of the symbols of the elements present in it.

- **Ionic compounds are formed by the combination between metals and non-metals.**
- **A compound made up of only two elements is called a binary compound.**
- **The ability of an atom to attract (or pull) the shared electrons of a bond towards it, is known as electronegativity of its element.**
- **Molecular compounds are formed by the combination between two different non-metal elements.**

WRITING OF FORMULAE OF MOLECULAR COMPOUNDS AND IONIC COMPOUND

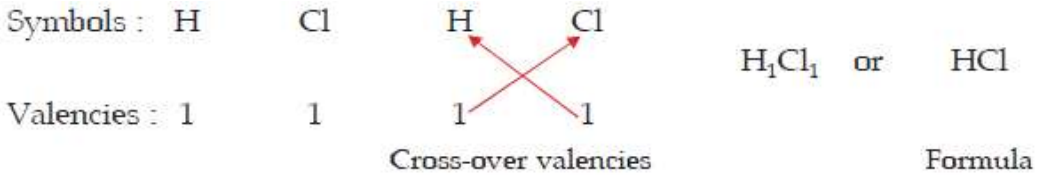
- **If we know the valencies of elements, then we can work out the formulae of their compounds by balancing the valencies of the different atoms which occur in the compound.**

1. We first write the symbols of the elements which form the compound.

2. Below the symbol of each element, we write down its valency.

3. Finally, we cross-over the valencies of the combining atoms. That is, with first atom we write the valency of second atom (as a subscript); and with the second atom we write the valency of first atom (as subscript). This will give us the required formula.

- **the formula of hydrogen chloride.**



VALENCY OF IONS

The valency of an ion is equal to the charge on the ion.

- **We should remember the valencies (or charges) of the following cations and anions because then it will become very easy to write the formulae of various ionic compounds.**

- **Monovalent Cations (Cations Having a Valency of 1+)** Hydrogen ion, H^+
- **Divalent Cations (Cations Having a Valency of 2+)** Iron (II) ion, Fe^{2+} Mercury (II) ion, Hg^{2+}
- **Trivalent Cations (Cations Having a Valency of 3+)** Iron (III) ion, Fe^{3+}

- **Monovalent Anions (Anions Having a Valency of 1–)** Hydride ion, H^-
- **Divalent Anions (Anions Having a Valency of 2–)** Sulphite ion, SO_3^{2-}
- **Trivalent Anions (Anions Having a Valency of 3–)** Nitride ion, N^{3-}

Gram Atomic Mass

The amount of a substance whose mass in grams is numerically equal to its atomic mass, is called gram atomic mass of that substance.

- **The gram atomic mass of a substance represents the mass of 1 mole of atoms (6.022×10^{23} atoms) of that substance.**
- **The molar mass of a substance is the mass of 1 mole of that substance.**
- **The molar mass of an element is the mass of 1 mole of its atoms. The molar mass of an element has 6.022×10^{23} atoms of the element in it.**

Gram Molecular Mass

The amount of a substance whose mass in grams is numerically equal to its molecular mass, is called gram molecular mass of that substance.

- **The gram molecular mass of a substance represents the mass of 1 mole of molecules (6.022×10^{23} molecules) of that substance.**
- **The molar mass of a substance is the mass of 1 mole of its molecules. The molar mass of a substance has 6.022×10^{23} molecules of the substance in it.**

MOLE CONCEPT

A group of 6.022×10^{23} particles (atoms, molecules or ions) of a substance is called a mole of that substance.

- **This number of 6.022×10^{23}, which represents a mole, is known as Avogadro number (L).**

Mole of Atoms

1 mole of atoms of an element has a mass equal to the gram atomic mass of the element.

Mole of Molecules

1 mole of molecules of a substance has a mass equal to the gram molecular mass of the substance.

1 mole of atoms = Gram atomic mass = 6.022×10^{23} atoms

CONVERSION CHART OF MOLE CONCEPT