Science Class 9th

ATOMS AND MOLECULES

Symbols of Atoms of Different Elements

Atomic Mass

Molecules

Ions

Mole Concept

Atom

An atom is a particle of matter that uniquely defines a chemical element. An atom consists of a central nucleus that is usually surrounded by one or more electrons. Each electron is negatively charged. The nucleus is positively charged, and contains one or more relatively heavy particles known as **protons** and **neutrons.**

A proton is positively charged. The number of protons in the nucleus of an atom is the **atomic number** for the chemical element. A proton has a rest mass, denoted m_p, of approximately 1.673×10^{-27} kilogram (kg). A neutron is electrically neutral and has a rest mass, denoted m_n, of approximately 1.675×10^{-27} kg. The mass of a proton or neutron increases when the particle attains extreme speed, for example in a cyclotron or linear accelerator.

The total mass of an atom, including the protons, neutrons and electrons, is the **atomic mass** or **atomic weight.**

Atoms having the same number of protons, but different numbers of neutrons, represent the same element, but are known as different **isotopes** of that element. The isotope for an element is specified by the sum of the number of protons and neutrons. Examples of different isotopes of an element are carbon 12(the most common, non-radioactive isotope of carbon) and carbon 14 (a less common, radioactive isotope of carbon).

Protons and electrons have equal and opposite charge, and normally an atom has equal numbers of both. Thus, atoms are usually neutral. An **ion** is an atom with extra electrons or with a deficiency of electrons, resulting in its being electrically charged. An ion with extra electrons is negatively charged and is called an **anion**; an ion deficient in electrons is positively charged and is called a **cat ion.**

Isotones- Nuclei of atoms with the same neutron number. Example: S-36, Cl-37, Ar-38, K-39, Ca-40. These nuclei contain 20 neutrons each, but a different number of protons: sulphur 16, chlorine 17, argon 18, potassium 19 and calcium 20 protons.

Isobars are nuclides having the same mass number; i.e. sum of protons plus neutrons; Carbon-12 and Boron-12.

SYMBOLS OF ATOMS OF DIFFERENT ELEMENTS

Dalton was the first scientist to use the symbols for elements in a very specific sense.

Symbol for some elements

Element	Symbol	Element	Symbol	Element	Symbol
Aluminum	Al	Copper	Cu	Nitrogen	N
Argon	Ar	Fluorine	F	Oxygen	O
Barium	Ba	Gold	Au	Potassium	K
Boron	B	Hydrogen	H	Silicon	Si
Bromine	Br	Iodine	I	Silver	Ag
Calcium	Ca	Iron	Fe	Sodium	Na
Carbon	C	Lead	Pb	Sulphur	Si
Chlorine	Cl	Magnesium	Mg	Uranium	U
Cobalt	Co	Neon	Ne	Zinc	Zn

ATOMIC MASS

The most remarkable concept that Dalton's atomic theory proposed was that of the atomic mass. According to him, each element had a characteristic atomic mass. One atomic mass unit is a mass unit equal to exactly one twelfth (1/12th) the mass of one atom of carbon-12. The relative atomic masses of all elements have been found with respect to an atom of carbon-12.

The relative atomic mass of the atom of an element is defined as the average mass of the atom, as compared to 1/12th the mass of one carbon-12 atom.

Atomic Masses of Few Elements

Element	Atomic Mass (u)
Hydrogen	1
Carbon	12
Nitrogen	14
Oxygen	16
Sodium	23
Sodium	24
Sulphur	32
Chlorine	35.5
Calcium	40

HOW DO ATOMS EXIST?

Atoms of most elements are not able to exist independently. Atoms form molecules and ions. These molecules or ions aggregate in large numbers to form the matter that we can see, feel or touch.

Molecule

A molecule is in general a group of two or more atoms that are chemically bonded together that is, tightly held together by attractive forces. A molecule can be defined as the smallest particle of an element or a compound that is capable of an independent existence and shows all the properties of that substance. Atoms of the same element or of different elements can join together to form molecules.

MOLECULES OF ELEMENTS

The molecules of an element are constituted by the same type of atoms. Molecules of many elements, such as argon (Ar), helium (He) etc. are made up of only one atom of that element. But this is not the case with most of the nonmetals.
For example, a molecule of oxygen consists of two atoms of oxygen and hence it is known as a diatomic molecule, O_2. If 3 atoms of oxygen unite into a molecule, instead of the usual 2, we get ozone. The number of atoms constituting a molecule is known as its atomicity. Molecules of metals and some other elements, such as carbon, do not have a simple structure but consist of a very large and indefinite number of atoms bonded together.

Atomicity of Some Elements

Types of Element	Name	Atomicity
Non-Metal	Argon	Monoatomic
	Helium	Monoatomic
	Oxygen	Diatomic
	Hydrogen	Diatomic
	Nitrogen	Diatomic
	Chlorine	Diatomic
	Phosphorus	Tetra-atomic
	Sulphur	Poly-atomic
Metal	Sodium	Monoatomic
	Iron	Monoatomic
	Aluminium	Monoatomic
	Copper	Monoatomic

MOLECULES OF COMPOUNDS

Atoms of different elements join together in definite proportions to form molecules of compounds.

Molecules of Some Compounds

Compound	Combining Elements	Ratio by Mass
Water	Hydrogen, Oxygen	1:08
Ammonia	Nitrogen, Hydrogen	14:03
Carbon Dioxide	Carbon, Oxygen	3:08

ION

Compounds composed of metals and nonmetals contain charged species. The charged species are known as *ions*. An ion is a charged particle and can be negatively or positively charged. A negatively charged ion is called an 'anion' and the positively charged ion, a 'cation'. For an example, sodium chloride (NaCl). Its constituent particles are positively charged sodium ions (Na^+) and negatively charged chloride ions (Cl^-). Ions may consist of a single charged atom or a group of atoms that have a net charge on them. A group of atoms carrying a charge is known as a polyatomic ion.

Some Iconic Compounds

Iconic Cimpound	Constituting Elements	Ratio by Mass
Calcium oxide	Calcium and oxygen	5:02
Magnesium Sulphide	Magnesium and Sulphur	3:04
Sodium Chloride	Sodium and Chlorine	23:35.5

Chemical Formulae

The chemical formula of a compound is a symbolic representation of its composition.

The combining power (or capacity) of an element is known as its valency. Valency can be used to find out how the atoms of an element will combine with the atom(s) of another element to form a chemical compound. The valency of the atom of an element can be thought of as hands or arms of that atom.

Rules to follow while writing a chemical formula are as follows:

- the valencies or charges on the ion must balance.
- when a compound consists of a metal and a non-metal, the name or symbol of the metal is written first.

For example:

calcium oxide (CaO), sodium chloride (NaCl), iron sulphide (FeS), copper oxide (CuO) etc., where oxygen, chlorine, sulphur are non-metals and are written on the right, whereas calcium, sodium, iron and copper are metals, and are written on the left.

- in compounds formed with polyatomic ions, the ion is enclosed in a bracket before writing the number to indicate the ratio.

Some Common & Simple Ions

Valency	Name of Ions	Symbol	Non Metallic Elements	Symbol
1	Sodium Potassium Silver Copper (I)*	Na^+ K^+ Ag^+ Cu^+	Hydrogen Hydride Chloride Bromide Iodide	H^+ H^- Cl^- Br^- I^-
2	Magnesium Calcium Zinc Iron (II)* Copper (II)*	Mg_2^+ Ca_2^+ Zn_2^+ Fe_2^+ Cu_2^+	Oxide Sulphide	O^- S_2^-
3	Aluminum Iron (III)*	Al_3^+ Fe_3^+	Nitride	N_3^-

**** Some elements show more than one valency.***

The rules to follow while writing a chemical formula are as follows:

- The valencies or charges on the ion must balance.
- when a compound consists of a metal and a non-metal, the name or symbol of the metal is written first.

For example: calcium oxide (CaO), sodium chloride (NaCl), iron sulphide (FeS), copper oxide (CuO) etc., where oxygen, chlorine, sulphur are non-metals and are written on the right, whereas calcium, sodium, iron and copper are metals, and are written on the left.

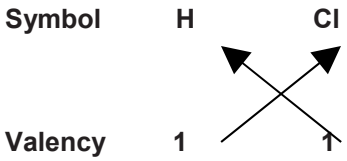
- In compounds formed with polyatomic ions, the ion is enclosed in a bracket before writing the number to indicate the ratio.

FORMULAE OF SIMPLE COMPOUNDS

The simplest compounds, which are made up of two different elements are called binary compounds. While writing the chemical formulae for compounds, we write the constituent elements and their valencies as shown below. Then we must crossover the valencies of the combining atoms.

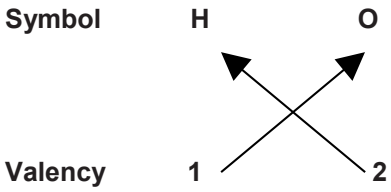
Examples

1. Formula of hydrogen chloride

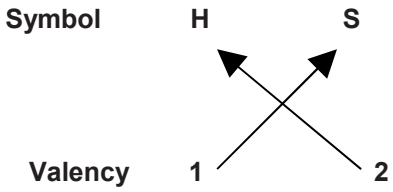


Formula of the compound would be HCl.

2. Formula of hydrogen sulphide

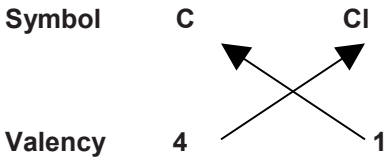


Formula: H_2O



Formula: H_2S

3. Formula of carbon tetrachloride



Formula: CCl_4

The formulae of ionic compounds are simply the whole number ratio of the positive to negative ions in the structure. For magnesium chloride, we write the symbol of cation (Mg2+) first followed by the symbol of anion (Cl-). Then their charges are criss-crossed to get the formula.

4. Formula of magnesium chloride

Formula: $MgCl_2$

Thus, in magnesium chloride, there are two chloride ions (Cl^-) for each magnesium ion (Mg_2^+). The positive and negative charges must balance each other and the overall structure must be neutral.

Molecular Mass and Mole Concept

MOLECULAR MASS:- The molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance. It is therefore the relative mass of a molecule expressed in *atomic mass units (u).*

Example (a) Calculate the relative molecular mass of water (H_2O).

(b) Calculate the molecular mass of HNO_3.

Solution:
(a) Atomic mass of hydrogen = 1u,
oxygen = 16 u
So the molecular mass of water, which contains two atoms of hydrogen and one atom of oxygen is = 2 x1+ 1x16
= 18 u
(b) The molecular mass of HNO_3 = the atomic mass of H + the atomic mass of N+ 3 X the atomic mass of O
= 1 + 14 + 48 = 63 u

FORMULA UNIT MASS

The formula unit mass of a substance is a sum of the atomic masses of all atoms in a formula unit of a compound. Formula unit mass is calculated in the same manner as we calculate the molecular mass.

For example,
Sodium chloride has a formula unit NaCl. Its formula unit mass can be calculated as–
1 x23 + 1 x35.5 = 58.5 u

Example- Calculate the formula unit mass of $CaCl_2$.

Solution:
Atomic mass of Ca
+ (2 x atomic mass of Cl)
= 40 + 2 x35.5 = 40 + 71 = 111 u

MOLE CONCEPT

Take an example of the reaction of hydrogen and oxygen to form water:
$2H_2 + O_2 \rightarrow 2H_2O$.

The above reaction indicates that
(i) two molecules of hydrogen combine with one molecule of oxygen to form two molecules of water, or
(ii) 4 u of hydrogen molecules combine with 32 u of oxygen molecules to form 36 u of water molecules. We can infer from the above equation that the quantity of a substance can be characterised by its mass or the number of molecules. But, a chemical reaction equation indicates directly the number of atoms or molecules taking part in the reaction.

Therefore, it is more convenient to refer to the quantity of a substance in terms of the number of its molecules or atoms, rather than their masses. So, a new unit “mole” was introduced. One mole of any species (atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecular mass in grams.