ATOMIC STRUCTURE

Introduction:

From a long time ago, people have tried to imagine what matter is made up of. All substances in the universe-solids, liquids and gases are made up of minute particles which are called atoms. It is really difficult to imagine anything as small as an atom, which cannot be seen even under the electron microscope.

Element

An element is a pure substance which cannot be broken into simpler substances by chemical means. For example, iron, gold, sodium, etc.

Atom

An atom is the smallest unit of an element which can take part in a chemical reaction. Atoms may or may not exist freely or independently. Atoms combine to form a molecule.

Molecule

A molecule is the smallest unit of a substance which can exist freely or independently. Atoms of one element may unite with atoms of another element as in water (H_2O), common salt (NaCl), etc. These unions of atoms give us molecules of the substances.

Structure of an Atom (Atomic Structure)

At the very beginning, atoms were considered to be the smallest indivisible particles of an element. Later on, it was found that an atom is made up of even smaller particles called electrons, protons and neutrons. These smaller particles of an atom are called **sub-atomic particles.**

(i) Electrons: The negatively charged particles present in an atom are called electrons. They revolve around the *nucleus* of an atom in certain definite circular paths called **shells or orbits.** An electron is represented by e^-. [The central dense portion of an atom is called *nucleus*.]

(ii) Protons: The positively charged particles present inside the nucleus of an atom are called protons. A proton is represented by p^+.

(iii) Neutrons: The neutral or charge less particles found inside the nucleus of an atom are called neutrons. A neutron is represented by n^o.

An atom is electrically neutral or charge less because in an atom the number of protons is equal to the number of electrons, i.e. the number of positive charges is equal to the number of negative charges.
The atomic model can be compared with the solar system. Protons and neutrons are located at the centre of an atom as the sun in the solar system and the electrons revolve round the nucleus as planets.

Atomic Number

The number of protons present in the nucleus of an atom is called the atomic number. As there are equal number of protons and electrons in an atom, atomic number is also equal to the number of electrons present in that atom.
i.e. Atomic number = number of protons = number of electrons.
For example: Atomic number of magnesium is 12. It means, in an atom of magnesium, there are 12 protons and 12 electrons.

Mass Number/Atomic Mass

The total number of protons and neutrons present in the nucleus of an atom is known as the mass number of the element.
i.e. Mass number = number of protons + number of neutrons.

Electronic Configuration

The arrangement and the distribution of electrons in different orbits or shells of an atom is called electronic configuration. The shells which are around the nucleus are either numbered 1,2,3,4 and so on or are denoted by letters K, L, M, N and so on in the order of their distance from the nucleus.

Thus,

1st shell is denoted by K

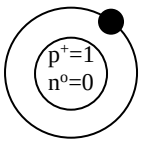
2nd shell is denoted by L

3rd shell is denoted by M and so on.

The first 20 elements with their symbol, atomic number, atomic mass, number of protons, neutrons and electrons and electronic configuration are given below:

Name	Symbol	Atomic Number	No. of p^+	No. of e^-	Number of n^o	Atomic mass	Electronic Configuration			
							K	L	M	N
Hydrogen	H	1	1	1	0	1	1			
Helium	He	2	2	2	2	4	2			
Lithium	Li	3	3	3	4	7	2	1		
Beryllium	Be	4	4	4	5	9	2	2		
Boron	B	5	5	5	6	11	2	3		
Carbon	C	6	6	6	6	12	2	4		
Nitrogen	N	7	7	7	7	14	2	5		
Oxygen	O	8	8	8	8	16	2	6		
Fluorine	F	9	9	9	10	19	2	7		
Neon	Ne	10	10	10	10	20	2	8		
Sodium	Na	11	11	11	12	23	2	8	1	
Magnesium	Mg	12	12	12	12	24	2	8	2	
Aluminium	Al	13	13	13	14	27	2	8	3	
Silicon	Si	14	14	14	14	28	2	8	4	
Phosphorus	P	15	15	15	16	31	2	8	5	
Sulphur	S	16	16	16	16	32	2	8	6	
Chlorine	Cl	17	17	17	18	35	2	8	7	
Argon	Ar	18	18	18	22	40	2	8	8	
Potassium	K	19	19	19	20	39	2	8	8	1
Calcium	Ca	20	20	20	20	40	2	8	8	2

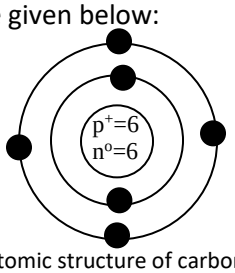
The atomic structures of some elements are given below:



Atomic structure of hydrogen

Electronic Configuration

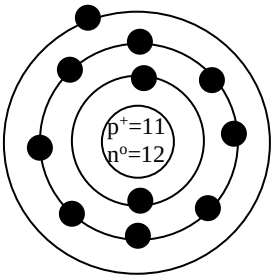
Shells	K
Electrons	1



Atomic structure of carbon

Electronic Configuration

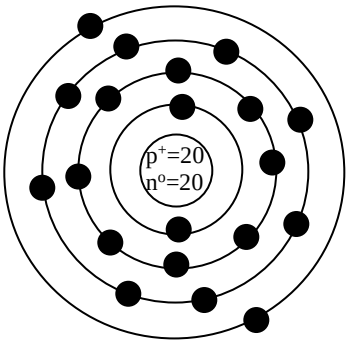
Shells	K	L
Electrons	2	4



Atomic structure of sodium

Electronic Configuration

Shells	K	L	M
Electrons	2	8	1



Atomic structure of calcium

Electronic Configuration

Shells	K	L	M	N
Electrons	2	8	8	2

Radical/Ion

A radical is an atom or group of atoms of different elements having positive or negative charge which behaves as a single unit during chemical reaction. Radicals have their own symbols and valencies. They cannot exist independently. They exist in combination with atoms of other elements or other radicals.
For example: hydroxide (OH^-), ammonium (NH_4^+), sulphate (SO_4^{--}) etc.

Valency

The combining capacity of an atom or radical is called its valency.

The combining capacity or valency of an atom depends on the number of electrons present in the outermost shell of that atom. If the outermost shell of an atom is full, then it will not combine with other element in a chemical reaction. The atom of this element will neither gain nor lose electrons. But if the outermost shell of an atom of an element is not full, then the atom will be reactive. It will gain, lose or share electrons with other atoms to make a group of 8 electrons in its outermost shell.
For example: the chlorine atom has 7 electrons in its outermost shell, so it should gain 1 electron from other atom to make a group of 8 electrons in its outermost shell. So, the valency of chlorine is 1

Some elements and their valencies:

1	2	3	4
Hydrogen (H)	Calcium (Ca)	Aluminium (Al)	Carbon (C)
Potassium (K)	Oxygen (O)	Nitrogen (N)	Silicon (Si)
Sodium (Na)	Magnesium (Mg)	Phosphorus (P)	
Silver (Ag)	Copper (Cu)		
Chlorine (Cl)	Zinc (Zn)		

Some radicals and their valencies:

S. No.	Radicals	Valency
1	Ammonium (NH_4^+)	1
2	Hydroxide (OH^-)	1
3	Carbonate (CO_3^{--})	2
4	Bicarbonate (HCO_3^-)	1
5	Nitrate (NO_3^-)	1
6	Sulphate (SO_4^{--})	2
7	Phosphate (PO_4^{---})	3

Molecular formula

Molecular formula is the symbolic representation of molecule of a substance.
For example:
H_2 is the molecular formula of hydrogen.
CO_2 is the molecular formula of carbon dioxide.
NaCl is the molecular formula of sodium chloride.

Ways of Writing Molecular Formula

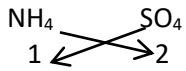
(1) The symbols of the elements or radicals present in the compound are written side by side and their valencies are written below their symbols.
(2) The common factor in the valency, if any, is removed.
(3) The valencies are interchanged and written at the bottom of each element or radical as subscripts.

Examples:

(a) Aluminium oxide

∴ Molecular formula = Al_2O_3

(b) Ammonium sulphate



∴ Molecular formula = $(NH_4)_2SO_4$

(c) Carbon dioxide

∴ Molecular formula = C_2O_4 = CO_2 (The common factor 2 is removed)

Exercise:

1) Define atom and molecule.
2) Write three differences between electron and proton.
3) Is an atom electrically neutral? Justify your answer.
4) If an atom contains 16 protons inside its nucleus, what is its atomic number?
5) What do you mean by mass number? Write down the mass numbers of the following elements:
   (i) Hydrogen (ii) Sodium (iii) Magnesium (iv) Chlorine (v) Calcium
6) What do you mean by electronic configuration? Write down the electronic configuration of the following elements: (i) Aluminium (ii) Phosphorus (iii) Potassium (iv) Beryllium (v) Fluorine
7) Draw the atomic structures of Helium, Oxygen, Neon, and Argon.
8) Define radical and valency with examples.
9) Write down the molecular formula of the following compounds:

(a) Calcium carbonate	(b) Sodium chloride
(c) Magnesium hydroxide	(d) Sodium bicarbonate
(e) Sodium hydroxide	(f) Sodium oxide
(g) Ammonium chloride	(h) Aluminium chloride
(i) Magnesium oxide	(j) Ammonium hydroxide
(k) Calcium oxide	(l) Potassium nitrate
(m) Potassium chloride	(n) Calcium hydroxide
(o) Potassium hydroxide	(p) Phosphorus pentoxide
(q) Calcium phosphate	(r) Ammonium sulphate
(s) Copper sulphate	(t) Zinc nitrate
(u) Silver nitrate	(v) Silicon dioxide