CLASS-VIII

CH- 4 (ATOMIC STRUCTURE)

The word "atom" comes from the Greek "atomos", meaning uncuttable or indivisible.

An atom is the smallest particle of an element that retains the chemical properties of that element.

Everything on our earth is made from 96 stable and 12 unstable elements. Each element has a different atomic structure. The basic structure of an atom involves a nucleus and the orbiting electrons.

Atoms are made up of three particles: protons, neutrons, and electrons.

Nucleus: It is the centre of the atom. It contains protons and neutrons.

- Protons are always positively charged. The number of protons in the atom is called its atomic number(also called proton number). In the Periodic Table, atoms are arranged in atomic number order. Protons have a relative charge of +1.
- Neutrons have a neutral charge.

Electron cloud: It is the outer portion of the atom.

- Electrons: They are negatively charged and are arranged around the nucleus in shells or orbits. They have a relative charge of –1
- The total number of electrons in an atom is always the same as the number of protons in the nucleus.

The nucleus diameter is only about 1/100000 of the atoms diametre, so much of the volume of the atom consists of empty space.

Let us have a detailed study of the structure of the atom in this chapter.

Dalton’s Atomic theory

- Matter is made of atoms which cannot be broken down further.
- Atoms cannot be created or destroyed in a chemical reaction.
- Atoms of the same element are identical to each other while atoms of different elements differ in mass and chemical properties.

- Atoms combine in definite ratios of whole numbers to form compounds.

- The number and composition of atoms are constant for a given compound..

Modern Atomic Concept

Particle	Electron
Charge	-1
Mass	1/1837 of H atom
Symbol	$-_1e^0$ or e^-
Discovered by	J.J.Thomson

Particle	Proton
Charge	+1
Mass	1.008 amu
Symbol	$+_1p^1$
Discovered by	Rutherford, subsequent to discovery of canal rays by Goldstein

Particle	Neutron
Charge	Neutral
Mass	1.008 amu

Symbol	${}_{0}e^{1}$
Discovered by	Chadwick

The nucleus of the atom

- The number of protons and electrons are equal in atom which is therefore electrically neutral
- Protons and neutrons are called nucleons since they occur inside the nucleus
- Atomic number (Z) = Number of protons in the nucleus. In a neutral atom, number of protons=number of electrons (not in ions)
- Mass number (A) = number of protons+ number of neutrons

Discovery of cathode rays and anode rays

Cathode rays were found to be made of negatively charged particles or electrons because they were deflected by positive electric potential
Anode rays were found to be made of positively charged particles or protons and were deflected towards negative electric potential

Thomson's Plum pudding model

- Thomson regarded atoms as a positive charged sphere, where electrons are embedded like plums in a pudding. This model is also similar to a water melon.
- Cannot explain how positive and negative particles could be shielded from each other without getting neutralized

Rutherford's model and discovery of the nucleus

- Rutherford's model of atom (similar to solar system)
    - The volume occupied by an atom is mostly empty space
    - The nucleus is inside the atom and has positive charge
    - The size of the nucleus is small compared to the total volume of the atom
    - The electrons revolve at high speed around the nucleus

Drawbacks: if the electron continuously moves around the nucleus, it will lose energy and will fall into the nucleus. But the atom is one of the most stable structures known. This stability could not be explained by Rutherford's model

Bohr's atomic model

Electrons revolve in fixed orbits around the nucleus
An electron cannot lose or gain energy as long as it is in its own orbit. If it gains energy, it moves to a higher orbit and if it loses energy, it moves to a lower energy level
Explains stability of atom

Modern Atomic Concept

- The mass of the atom is due to the nucleus because electrons have negligible mass. The nucleus is positively charged due to the protons; neutrons have no charge.
- Electrons revolve in fixed orbits around the nucleus called shells or energy levels (K, L, M, N…)
- Each shell has a fixed amount of energy. The orbit nearest the nucleus has minimum energy and the one farthest away has highest energy

How electrons are arranged in the atom

- The number of electrons in every shell or energy level is given by the formula $2n^2$ where n is the number of the shell

First shell (K-shell)	$2 \times 1^2 = 2$
Second shell (L-shell)	$2 \times 2^2 = 8$
Third shell (M-shell)	$2 \times 3^2 = 18$
Fourth shell (N-shell)	$2 \times 4^2 = 32$

- The outermost shell cannot have more than 8 electrons; the penultimate shell cannot have more than 18 electrons
- A new shell is formed as soon as the octet is complete in each inner shell

- An atom becomes stable if it reaches octet configuration (or duplet in the case of hydrogen and helium)

- The electrons in the outermost shell are called valence electrons. Therefore, valency is the number of electrons gained or lost to achieve the nearest noble gas configuration

Element	Hydrogen
Number of protons = atomic number (Z)	1
Number of electrons	1
Number of neutrons = Mass number- Atomic number (A – Z)	1 – 1 = 0
Electronic configuration	1
Valency	1

Element	Helium
Number of protons = atomic number (Z)	2
Number of electrons	2
Number of neutrons = Mass number- Atomic number (A – Z)	4 – 2 = 2
Electronic configuration	2
Valency	2

Element	Lithium
Number of protons = atomic number (Z)	3

Number of electrons	3
Number of neutrons = Mass number – Atomic number (A – Z)	7 – 3 = 4
Electronic configuration	2, 1
Valency	1

Element	Beryllium
Number of protons = atomic number (Z)	4
Number of electrons	4
Number of neutrons = Mass number – Atomic number (A – Z)	9 – 4 = 5
Electronic configuration	2,2
Valency	2

Element	Boron 151B511B
Number of protons = atomic number (Z)	5
Number of electrons	5
Number of neutrons = Mass number – Atomic number (A – Z)	11 – 5 = 6
Electronic configuration	2,3

Element	Fluorine
Number of protons = atomic number (Z)	9
Number of electrons	9
Number of neutrons = Mass number – Atomic number (A – Z)	19 – 9 = 10
Electronic configuration	2,7
Valency	1

Element	Neon
Number of protons = atomic number (Z)	10
Number of electrons	10
Number of neutrons = Mass number – Atomic number (A – Z)	20 – 10 = 10
Electronic configuration	2,8
Valency	0
Element	Magnesium
Number of protons = atomic number (Z)	12

Number of electrons	12
Number of neutrons = Mass number – Atomic number (A – Z)	24 – 12 = 12
Electronic configuration	2,8,2
Valency	2

Geometric representation of magnesium atom

https://youtu.be/tfOaJpPPS4M

Atomic number
Atomic number (z) is the number of protons in an atom; it is also equal to the number of electrons in the atom.
Atomic number = Number of protons
Example: The atomic number of an element is 12 then its atom contains 12 protons and 12 electrons.

Mass Number
The mass number (A) is defined as the sum of the number of protons and neutrons present in the nucleus of an atom. Example: Mass number of Nitrogen atom is 14 then it contains 7 protons and 7 neutrons.
Mass number = Protons + Neutrons

Notation of element
$_{\text{Atomic number}}\text{Element}^{\text{Mass number}}$; $_{Z}X^{A}$
Example: Nitrogen atom has notation as $_{7}N^{14}$.

Electronic configuration
Electrons are placed in fixed energy levels called shells. These shells are also called orbits. These orbits or shells are represented by the letters K, L, M, N,… or the numbers n=1, 2, 3, 4,….
The arrangement of electrons in the shells is known as electronic configuration.

Rules for accommodating electrons in various shells (Bohr-bury scheme)
The maximum number of electrons that can be accommodated in any energy level of the atom is given by a formula $2n^2$. Where n is the number of that energy level.
According to Bohr's model of an atom, the first energy level K can have 2 electrons, the maximum number of electrons which can be accommodated in shell L is $2X2^2 = 8$.
Similarly, for M and N shells, maximum number of electrons that can be accommodated are $2X3^2 = 18$ and

$2X4^2$= 32 respectively.

Electrons in an atom do not occupy a new shell unless all inner shells like K, L, M, N….. are completely filled. Hence, filling of e

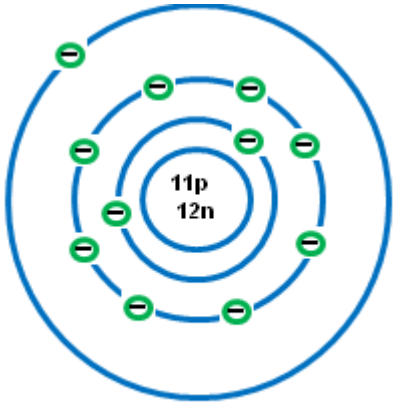
follows a stepwise approach.
The maximum number of electrons that can be filled in a valence shell is eight even if it has capacity to accommodate more than eight.

After a series of experiments and a detailed study by scientists like Louis de Broglie, Schrodinger, Somerfeld and others proved that shells or energy levels have sub shells within them. Electrons are distributed in these sub-shells.

The various sub shells are s, p, d and f.
Every sub-shell can accommodate a fixed number of electrons.
"s" sub shell can hold a maximum of 2 electrons,
"p" sub shell can hold a maximum of 6 electrons,
"d" sub shell can hold a maximum of 10 electrons,
"f" sub shell can hold a maximum of 14 electrons.

Structure of Sodium atom
Sodium has atomic number 11 and mass number 23.
The nucleus of sodium has 11protons and 12 neutrons and it is surrounded by 11 electrons.
The electronic configuration of sodium:
K shell or I shell = 2 electrons
L- shell or II shell = 8 electrons

M-Shell or III shell = 1 electron
∴ Electronic configuration of sodium atom = 2, 8, 1



The structure of sodium atom

Valence electrons
The electrons, which are present in the outermost shell of an atom are called valence electrons.

Example: Sodium.

Atomic number of sodium is 11
Electronic configuration of sodium is 2 8 1
In sodium 3rd shell is the outermost shell (valence shell) .In this shell it has 1 electron. Hence the number of valence electrons present in sodium is 1.

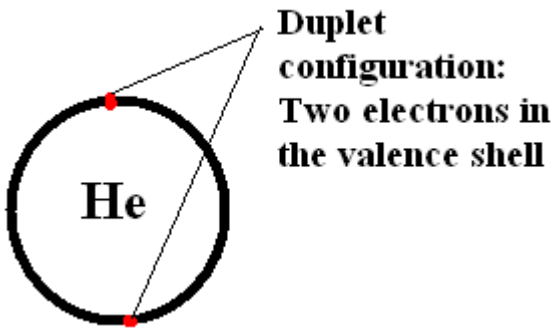
The chemical properties of an atom are dependent on these valence electrons. Since they are ones that are participate in a chemical reaction.
Elements having valence electrons 1, 2 or 3 are called metals.
Exception: Hydrogen has 1 valence electron but it is not consider as a metal.

These elements lose electrons easily and form a positively charged ion called cation.
Example: $Na - e^- \rightarrow Na^+$
Elements having valence electrons 4, 5, 6 or 7 are called as Non-metals
These elements gain electrons and forms a negatively charged ion called anion.
Example: $F + e^- \rightarrow F^-$
Elements with same number of valence electrons will have similar chemical properties. Whereas the elements wit

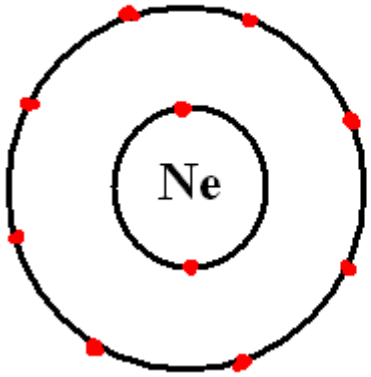
will have different chemical properties.

Octet configuration

An element with 8 electrons in an outermost-shell is said to possess an octet.
Elements with octet configuration are stable.
Example:
Except helium all other noble gases possess octet configuration.
The presence of two electrons in the first shell, called a duplet configuration.



Presence of eight electrons in the valence shell is called an octet configuration.



Octet configuration: Eight electrons in the valence shell

Valency

The combining capacity of an element is known as valency.
The combining capacity of the atoms to form molecules either with same or different elements is defined as valency.
Atom contains less than four electrons in its outermost shell, the valency of an atom is equal to the number of electrons present in

the valence shell.
Example: Sodium has one electron in its outermost shell, so the valency of sodium is 1.
Calcium has two electrons in its outermost shell, so the valency of calcium is 2.
Aluminum has three electrons in its outermost shell, so the valency of aluminum is 3.
If the outer shell has more than four electrons, the valency = 8 - the number of electrons in the outer sh