STRUCTURE OF THE ATOM

- An Indian philosopher Maharshi Kanad postulated that matter is made up of tiny particles known as paramanu.
- Ancient Greek philosophers-Democritus and Leucippus suggested that matter is made of tiny particles which can not be divisible. Democritus called these indivisible particles atoms.
- In 1806, John Dalton presented his atomic theory stating that:
  (i) All matter is made of very tiny particles called atoms.
  (ii) Atoms are indivisible particles.
  (iii) Atoms of different elements have different masses and chemical properties.
- Based on series of experiments like studying static electricity, it was observed that atoms are divisible.
- While combing dry hair or rubbing a glass rod with silk cloth, it was observed that both the objects become electrically charged. This indicates that atoms are divisible containing charged particles.
- From the Cathode Ray Tube experiments, J.J. Thomson invented the electrons. These are the one of the constituent particles present in an atom.
  (i) Electrons are indicated with e^-
  (ii) These are negatively charged. Charge is equal to '-1'.
  (iii) Mass of electron is negligible. It is approximately equal to (1/2000)of a proton.
- In 1886, E. Goldstein discovered the presence of positively charged particles in atom through Cathode Ray Tube experiments. These particles are named as protons.
  (i) Protons are indicated with p^+.
  (ii) These are positively charged. Charge is equal to +1.
  (iii) Mass of proton is 2000 times to that of electron. This mass was taken as 1 unit.
- In 1932, J. Chadwick discovered another sub atomic particle known as neutron.
  (i) Neutrons are indicated with 'n'.
  (ii) Charge of neutrons is '0'.

(iii) Mass of neutron is slightly greater than mass of proton. It was also taken as one unit.

STRUCTURE OF AN ATOM –THOMSON'S MODEL

1. Thomson model of an atom is similar to Christmas pudding.
2. Electrons are in sphere of positive charge like dry fruits in Christmas pudding or like seeds in water melon spread all over.
3. Atom is neutral as the number of positively charged particles is equal to negatively charged particles.

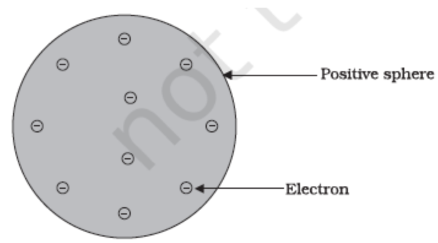


Fig.4.1: *Thomson's model of an atom*

Thomson proposed that:

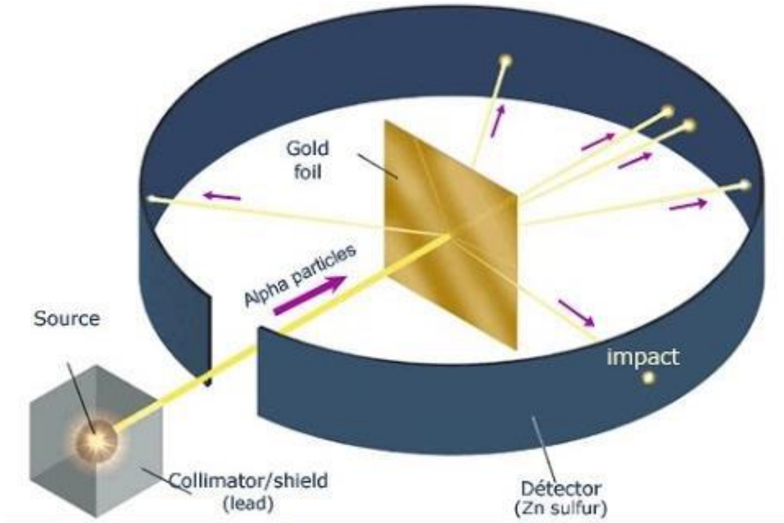
(i) An atom consists of a positively charged sphere and the electrons are embedded in it.

(ii) The negative and positive charges are equal in magnitude. So, the atom as a whole is electrically neutral.

Drawbacks:- It could not explain the results of Rutherford's α-ray scattering experiment.

STRUCTURE OF AN ATOM –RUTHERFORD'S MODEL

- He selected a gold foil because he wanted as thin a layer as possible.
- α-particles are doubly-charged helium ions. Since they have a mass of 4 u, thefast-moving a-particles have a considerable amount of energy.
- It was expected that α-particles would be deflected by the sub-atomic particles in the gold atoms. Since the α-particles were much heavier than the protons, he did not expect to see large deflections.



Rutherford's observations:

(i) Most of the fast moving a-particles passed straight through the gold foil.
(ii) Some of the a-particles were deflected by the foil by small angles.
(iii) Surprisingly one out of every 12000 particles appeared to rebound.

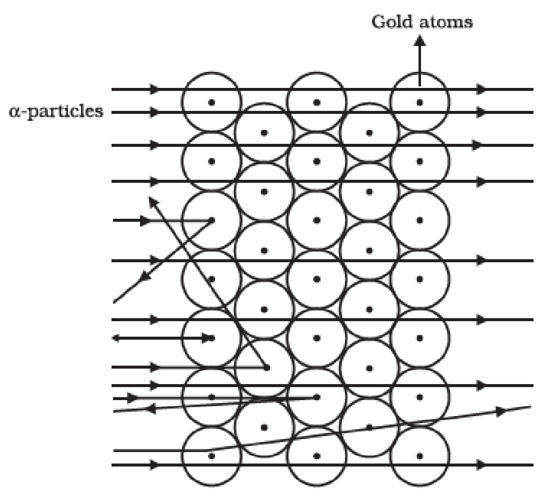


Fig. 4.2: Scattering of α-particles by a gold foil

Rutherford's conclusions:

(i) Most of the space inside the atom is empty because most of the a-particles passed through the gold foil without getting deflected.
(ii) Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.

(iii) A very small fraction of a-particles were deflected by 180^0, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

Rutherford's nuclear model:

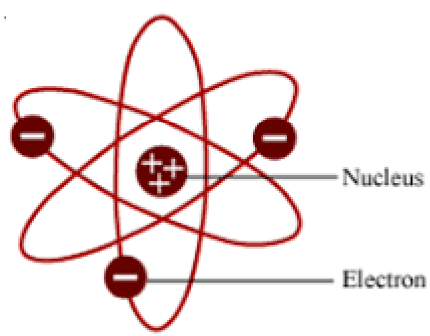
(i) There is a positively charged centre in an atom called the nucleus. Nearly all the mass of an atom resides in the nucleus.

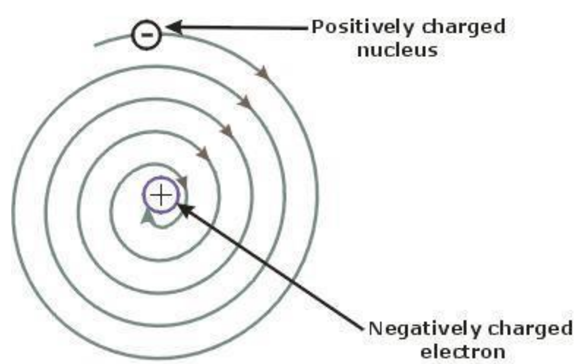
(ii) The size of the nucleus is very small as compared to the size of the atom. It is 1/100000 of size of atom.

(iii) The electrons revolve around the nucleus in circular paths.

Drawbacks of Rutherford's model:

1. **It did not account for the stability of the atom.**
2. **It did not explain why electrons do not lose energy and fall into nucleus.**
3. **It did not explain energy source of electrons to revolve around the nucleus.**





Bohr's model of an Atom

1. **Electrons revolve around the nucleus only in certain circular orbits.**
2. **These circular orbits are known as discrete orbits.**
3. **The energies of these discrete orbits are fixed. Hence these are also called stationary states or Energy levels or shells. These are designated by letters K, L, M, N etc or numbers, n = 1, 2, 3, 4 etc.**
4. **As long as the electron revolves in these shells, it does not lose energy.**

5. **Energy is emitted or absorbed by an atom only when electron moves from one orbit to another.**

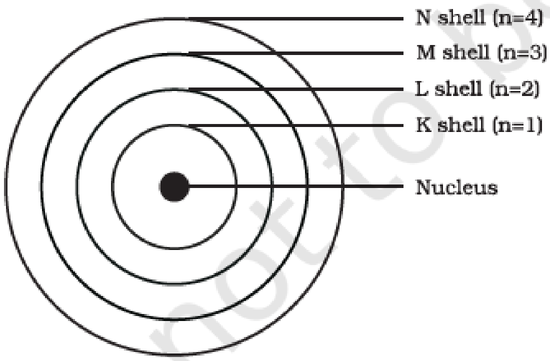


***Fig. 4.3:** A few energy levels in an atom*

Distribution of electrons in different shells (Bohr-Bury scheme)

(i) The maximum number of electrons present in a shell is given by the formula $2n^2$, where 'n' is the orbit number or energy level index, 1,2,3,….

(ii) maximum number of electrons in different shells are

a) first orbit or K-shell will be = $2 \times 1^2 = 2$,

b) second orbit or L-shell will be = $2 \times 2^2 = 8$,

c) third orbit or M-shell will be = $2 \times 3^2 = 18$

d) fourth orbit or N-shell will be = $2 \times 4^2 = 32$ and so on.

(iii) The maximum number of electrons that can be accommodated in the outermost orbit is 8.

(iv) Electrons are not accommodated in a given shell, unless the inner shells are filled. That is, the shells are filled in a step-wise manner.

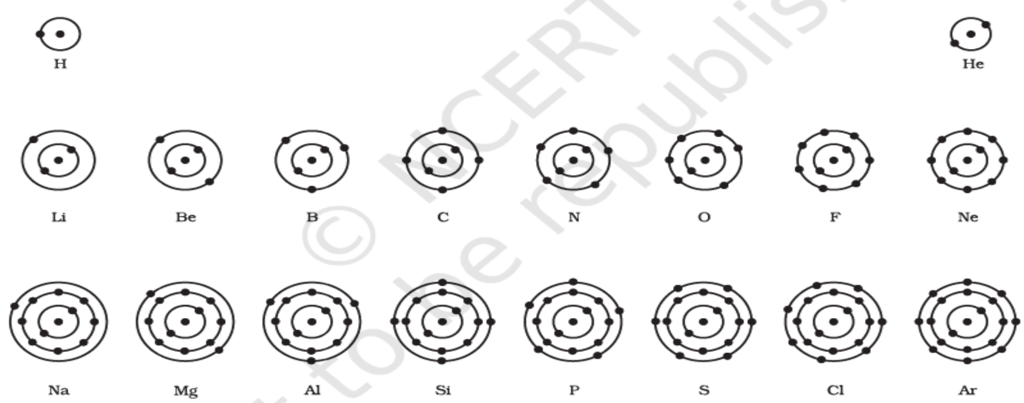


***Fig.4.4:** Schematic atomic structure of the first eighteen elements*

Table 4.1: Composition of Atoms of the First Eighteen Elements with Electron Distribution in Various Shells

Name of Element	Symbol	Atomic Number	Number of Protons	Number of Neutrons	Number of Electrons	Distribution of Electrons				Vale-ncy
						K	L	M	N	
Hydrogen	H	1	1	-	1	1	-	-	-	1
Helium	He	2	2	2	2	2	-	-	-	0
Lithium	Li	3	3	4	3	2	1	-	-	1
Beryllium	Be	4	4	5	4	2	2	-	-	2
Boron	B	5	5	6	5	2	3	-	-	3
Carbon	C	6	6	6	6	2	4	-	-	4
Nitrogen	N	7	7	7	7	2	5	-	-	3
Oxygen	O	8	8	8	8	2	6	-	-	2
Fluorine	F	9	9	10	9	2	7	-	-	1
Neon	Ne	10	10	10	10	2	8	-	-	0
Sodium	Na	11	11	12	11	2	8	1	-	1
Magnesium	Mg	12	12	12	12	2	8	2	-	2
Aluminium	Al	13	13	14	13	2	8	3	-	3
Silicon	Si	14	14	14	14	2	8	4	-	4
Phosphorus	P	15	15	16	15	2	8	5	-	3,5
Sulphur	S	16	16	16	16	2	8	6	-	2
Chlorine	Cl	17	17	18	17	2	8	7	-	1
Argon	Ar	18	18	22	18	2	8	8		0

Valency

"Valency is the combining capacity of an atom of an element".

Valence shell

It is the outermost electron shell of an atom.

Valence electrons

These are the electrons present in the outermost shell of an atom.

1. **Number of electrons gained, lost or shared to possess an octet gives the valency of that atom.**

2. **Completely filled outer most shell is called octet. Helium atom can only accommodate 2 electrons i.e.duplet.**
3. **Octet and duplet are highly stable and atoms with these don't react with other atoms. So they only exist as monoatom ie gases or inert gases.**
4. **Helium is only inert gas with two electrons in its outer most shell.**
5. **Valency of elements having ≤ 4 electrons in valence shell= No. of valence electrons.**
6. **Valency of elements having > 4 electrons in valence shell= 8- No. of valence electrons.**

Atomic number and Mass number

Atomic number: Atomic number of an element is the number of protons present in the nucleus of the atom of that element. It is denoted by ‘Z’. All the atoms of that element will have the same number of protons.

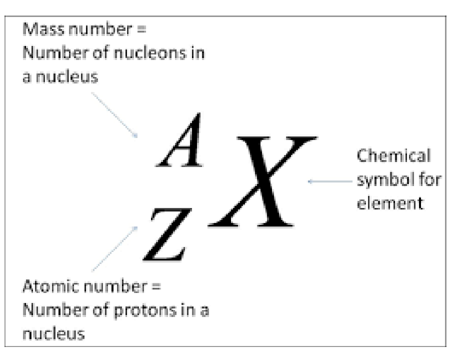
Eg:- Hydrogen(Z) = 1 (1 proton)
Helium (Z) = 2 (2 protons)
Lithium (Z) = 3 (3 protons)

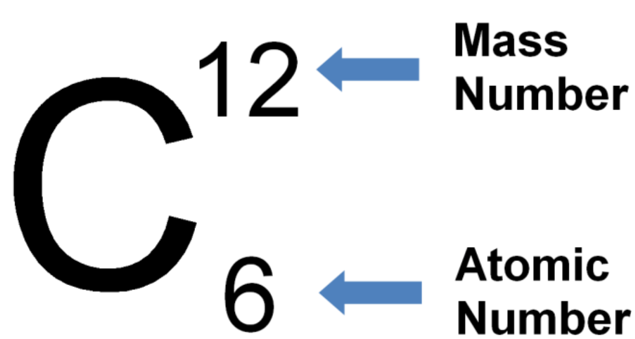
b)Massnumber(A):The mass number of an element is the sum of the number of nucleons (protons and neutrons) present in the nucleus of an atom.

Mass of an atom is almost equal to the mass of the protons and neutrons in the nucleus of the atom as mass of electrons is negligible as compared to them.

Eg:-Carbon –Mass number = 12 (6 protons + 6 neutrons) Mass = 12u
Aluminium–Mass number = 27 (13 protons + 14 neutrons) Mass = 27u
Sulphur–Mass number = 32 (16 protons + 16 neutrons) Mass = 32u

Notation of an atom





- In a neutral atom, Number of protons = Number of electrons.
- No. of neutrons = Mass number – No. of protons.

Isotopes

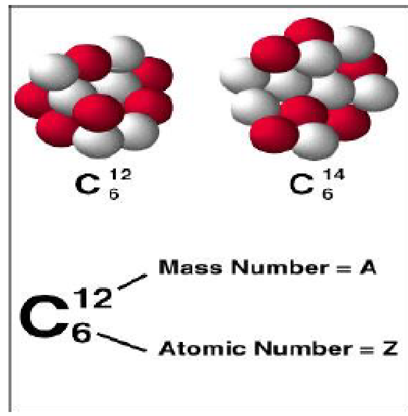
Isotopes are atoms of the same element having the same atomic number but different mass number.

Eg :- Hydrogen has three isotopes. They are Protium, Deuterium (D) and Tritium (T).

${}^{1}_{1}H$ Protium ${}^{2}_{1}H$ Deuterium ${}^{3}_{1}H$ Tritium

Carbon has two isotopes. They are :-

${}^{12}_{6}C$ ${}^{14}_{6}C$

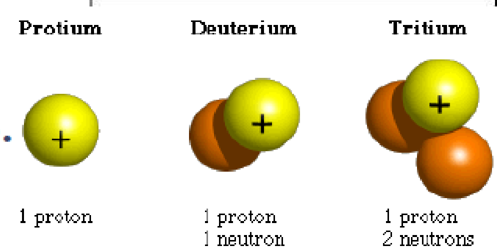


Chlorine has two isotopes They are :-

${}^{35}_{17}Cl$ ${}^{37}_{17}Cl$

Isotopes of oxygen are O-16 & O-17.

Isotopes of nitrogen are N-14 & N-15.



Uses of Isotopes:
(i) An isotope of uranium(U-235) is used as a fuel in nuclear reactors.
(ii) An isotope of cobalt(Co-60) is used in the treatment of cancer.
(iii) An isotope of iodine (I-131)is used in the treatment of goitre.

ISOBARS

- **Isobars are atoms of different elements having different atomic numbers but same mass numbers.**
- **These pairs of elements have the same number of nucleons.**
- **Eg:-Calcium (Ca: Z=20 & A=40) and Argon (Z=18 & A=40)**
  This is due to equal number of nucleons:

Ca:20 protons + 20 neutrons

Ar:18 protons + 22 neutrons

Note: 1. The chemical properties of Isotopes are similar but their physical properties are different.(Both atoms are same)

2. The properties of Isobars are different. (Both atoms are different)
3. Generally we will consider average atomic mass of an element as it occurs in isotopic forms.
For example, Chlorine occurs in two Isotopic forms i.e. Cl-35 (75%) and Cl-75 (25%).Hence Its average atomic mass is calculated as 35.5u
[35(75/100) + 37(25/100)] = 35.5

END