CHAPTER 5
STRUCTURE OF THE ATOM

NOTES

INTRODUCTION:

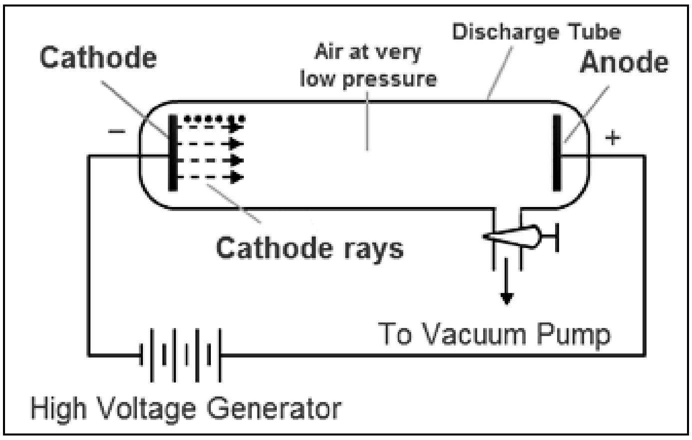
- Atoms are the basic building blocks of matter.
- Different kinds of matter exist because there are different kinds of atoms present in them.

CHARGED PARTICLES IN MATTER:

- Whenever we rub two objects together, they become electrically charged. This is because atoms contain charged particles in them.
- Michael Faraday for the first time established relationship between electricity and matter. He stated that electricity is made up of particles called "atoms of electricity".
- G.J Stoney suggested the name 'electron' for the atoms of electricity
- The real credit for the discovery of electron goes to J.J Thomson.

DISCOVERY OF ELECTRON:

- Cathode ray experiment was a result of ***English physicists named J. J. Thomson*** experimenting with cathode ray tubes. During his experiment he discovered electron.
- The cathode rays are emitted from the cathode irrespective of the nature of the metal electrode or the nature of the gas contained in the tube
- Thomson concluded that the negatively charged particles, now called electrons as an integral part of all atoms.
- Electrons have both definite mass and definite electric charge.
- The mass of an electron is nearly 1/1837 of the mass of the hydrogen atom. However for all practical purposes it may be taken as negligible. The charge of an electron has been assigned a value of -1.



Thomson's Cathode Ray Tube Experiment

DISCOVERY OF PROTON:

- The existence of protons in the atoms was given by ***E. Goldstein.***
- When electricity was passed at high voltage through a gas at a very low pressure in a discharge tube, streams of heavy particles were given at anode (positive electrode).These streams of particles are called as anode rays.
- These particles were positively charged and the mass and charge of the anode ray particles depend on the nature of the gas taken in the discharge tube
- Mass of proton is equal to the mass of hydrogen atom. Therefore relative mass of proton is 1u.
- The charge of a proton is +1.

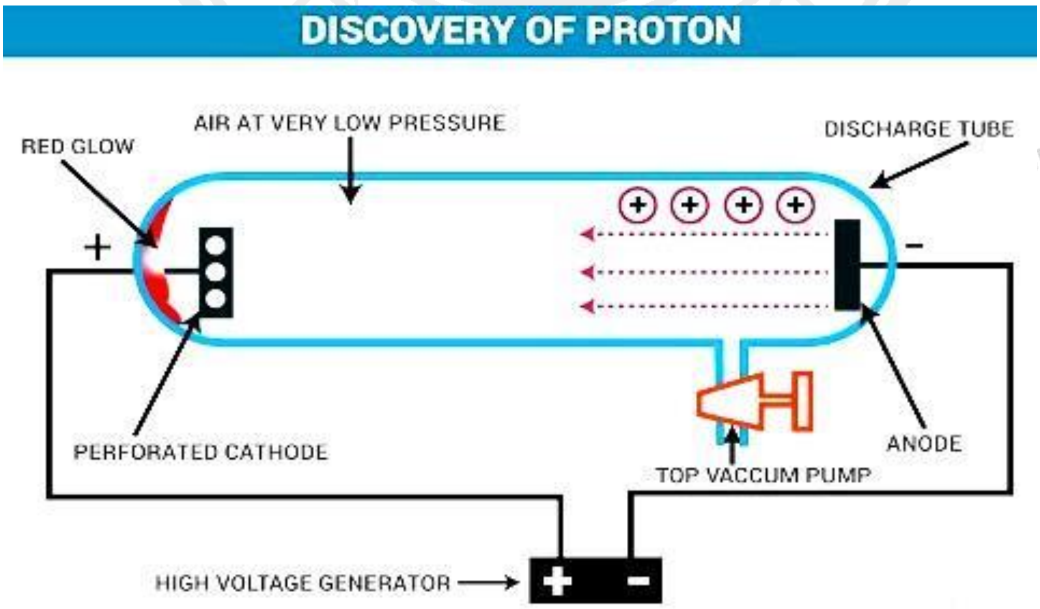


Fig. A schematic diagram of Discovery of Proton

DISCOVERY OF THE NUCLEUS (RUTHERFORD'S EXPERIMENT):

Ernest Rutherford was interested in knowing how the electrons are arranged within an atom. Rutherford designed an experiment for this. In this experiment, fast moving alpha (α)-particles were made to fall on a thin gold foil.

- He selected a gold foil because he wanted as thin a layer as possible. This gold foil was about 1000 atoms thick.
- α-particles are doubly-charged helium ions. Since they have a mass of 4u, the fast-moving α-particles have a considerable amount of energy.

The following observations were made from his experiment:-

(Probable Question: What are the observations made by Ernest Rutherford from his gold foil experiment by bombarding with a beam of alpha particles?)

- Most of the α-particles (nearly 99%) passed through the gold foil undeflected.
- A few of them got deflected through small angles.
- Very few (about one in 100,000) did not pass through the foil at all but suffered large deflections (more than 90 degrees) or even returned back in the direction from which they came.

Conclusion of Rutherford's scattering experiment:

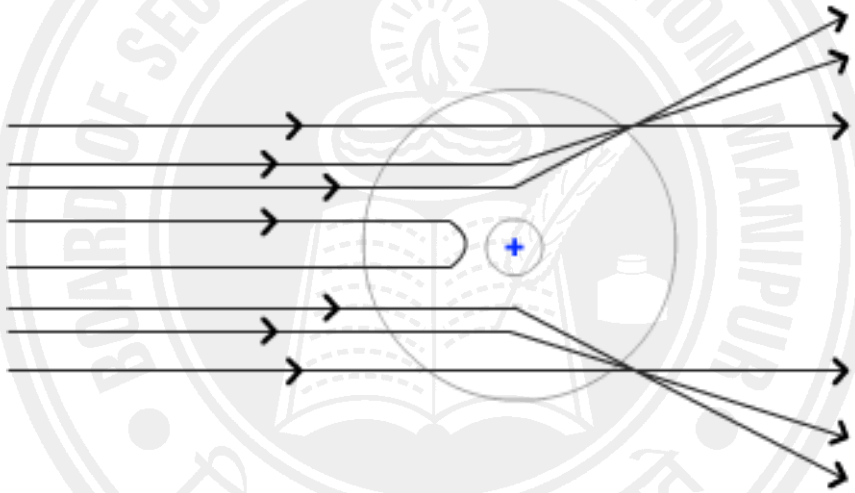
1. Most of the space inside the atom is empty because most of the α-particles passed through the gold foil without getting deflected.
2. Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.
3. A very small fraction of α-particles were deflected by very large angles, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.
4. The strong deflections, bouncing or even bouncing back ofα-particles from the foil were explained to be the result of a direct collision with the positively charged nucleus of the atom.

***On the basis of his experiment, Rutherford put forward the model of an atom, which had the following features*:**

(Probable Question: What are the features of Rutherford's nucleus model of the atom?)

1. There is a tiny positively charged centre in an atom called the nucleus. Nearly all the mass of an atom resides in the nucleus. The positive charge of the nucleus is due to the protons.
2. The electrons revolving around the nucleus in well-defined orbits and forms the outsides surface (extra nuclear part) of the atom.
3. The size of the nucleus is very small as compared to the size of the atom.
4. Between the nucleus and the outer electrons is empty space except for other electrons.

Rutherford's alpha particle scattering experiment shows the presence of nucleus in the atom.



Rutherford's Alpha-ray Experiment

ATOMIC NUMBER

(Probable question: Define atomic number)

- The total number of proton contained in the nucleus of any atom is called the atomic number.
- An atomic number is the identity of an atom, changing atomic number means changing the atom.
- Atomic number is denoted by 'Z'.
- Atomic number = Nuclear charge or number of protons = Number of electrons.

DISCOVERY OF NEUTRON

In 1932, the scientist James Chadwick conducted an experiment where he bombarded a thin sheet of beryllium with α-particles. He observed the emission of electrically neutral particles with a mass slightly greater than that of protons. As a result, these were named neutrons.

- The discovery of neutrons made it clear that the nucleus of the atom consists of protons and neutrons.
- Since the electrons have negligible mass, the entire mass of the atom is mainly due to protons and neutrons present in the nucleus.

Fundamental Particles of an Atom

Particle	Mass		Charge (unit charge is 1.062 x 10-19 coulombs)
	In gram	In u (amu)	
Electron	9.110×10^{-28}	0.00055	-1
Proton	1.673×10^{-24}	1.00728	+1
Neutron	1.675×10^{-24}	1.00866	No charge

ISOTOPES AND ISOBARS

(Probable question: What are isotopes? What is the main cause of the isotopes of an element?)

- Those elements that have the same atomic number but a different mass number are referred to as isotopes. Isotopes occur due to the presence of a different number of neutrons in elements having the same atomic number as mass number is the sum of the number of neutrons and protons. Many but not all elements have isotopes. The isotopes of Hydrogen are Protium (has one proton and no neutrons), deuterium (has one proton and one neutron) and tritium (has one proton and two neutrons). The chemical properties of isotopes are same owing to the fact that they have the same number of protons and hence same number of electrons which determines the chemical properties of an element. However, the physical properties of the isotopes of an element may be slightly different due to difference in their mass numbers.

- Isobars, on the other hand, are the atoms having the same mass number but a different atomic number. For example, the atomic number of carbon and nitrogen is 6 and 7 respectively. Carbon-14 an isotope of carbon has a mass number of 14 which is same as that of nitrogen and hence carbon-14 and nitrogen are isobars.
- Some isotopes are found useful in various fields.

Examples are:

(i) Use of isotope of uranium known as Uranium-235 as fuel in nuclear reactors

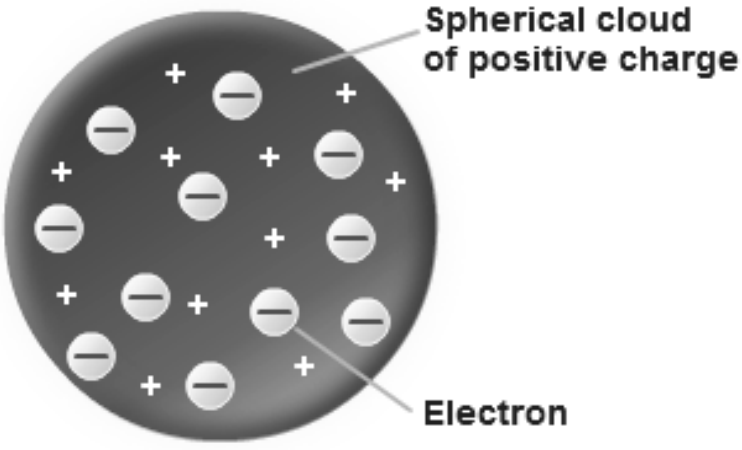
(ii) An isotope of cobalt known as cobalt-60 is used in the treatment of Cancer.

(iii) An isotope of iodine (Iodine-131) finds application in the treatment of diseases like goitre.

MODELS OF ATOM

Thomson's Model:

The description of Thomson's atomic model is one of the many scientific models of the atom. It was proposed by J.J Thomson in the year 1904 just after the discovery of electrons. However, at that time the atomic nucleus was yet to be discovered. So, he proposed a model on the basis of known properties available at that time. The known properties are:



Thomson's Model of an Atom

- Atoms are neutrally charged
- Negatively charged particles called electrons are present in an atom.

Hence Thomson assumed that an atom is a uniform sphere of positive charges with electrons embedded in it.

- **Rutherford's Model:**

Features of Rutherford proposed model of an atom

(i) There is positively placed nucleus in an atom. Nearly all the mass resides in nucleus

(ii) Electrons revolve round the nucleus in well-defined orbits.

(iii) Size of nucleus is very small compared to the size of atom.

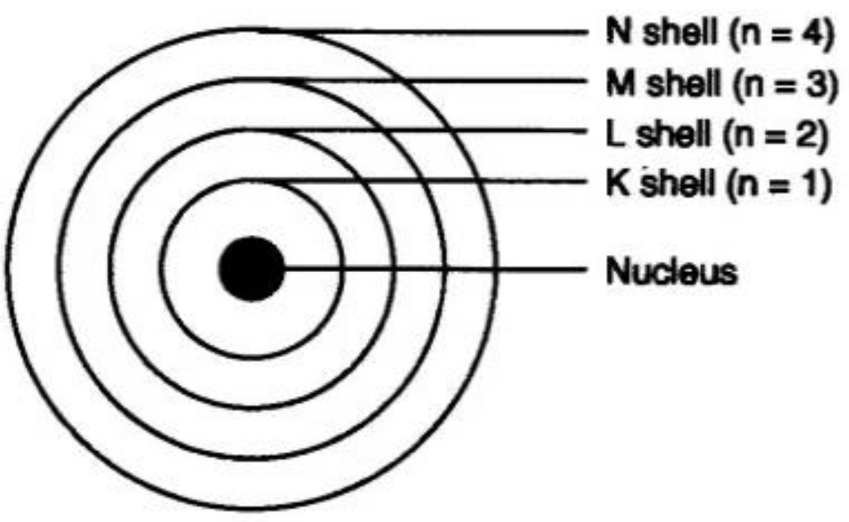
Drawbacks of Rutherford's Model

(i) According to electromagnetic theory, if a charged particle (electron) revolve round the positively charged nucleus, the electron would continuously lose energy and will finally fall into the nucleus

(ii) This will make atom highly unstable

Bohr's Model of Atom:

- The nucleus is situated at the centre of the atom.
- Only certain special orbits known as discrete orbits of electrons are allowed inside the atom.
- The orbits or shells are numbered as 1, 2, 3, 4…etc. or are designated as K, L, M, N…etc. shells.
- While revolving in discrete orbits, the electrons do not radiate energy.
- Energy is emitted or absorbed by an atom when an electron moves from one orbit to another.



Bohr's model

- ***How are electrons distributed in different orbits (shells):***

The distribution of electrons in an atom is called as Electronic Configuration. Formula $2n^2$ helps in the determination of the maximum number of electrons present in an orbit, here n = orbit number.

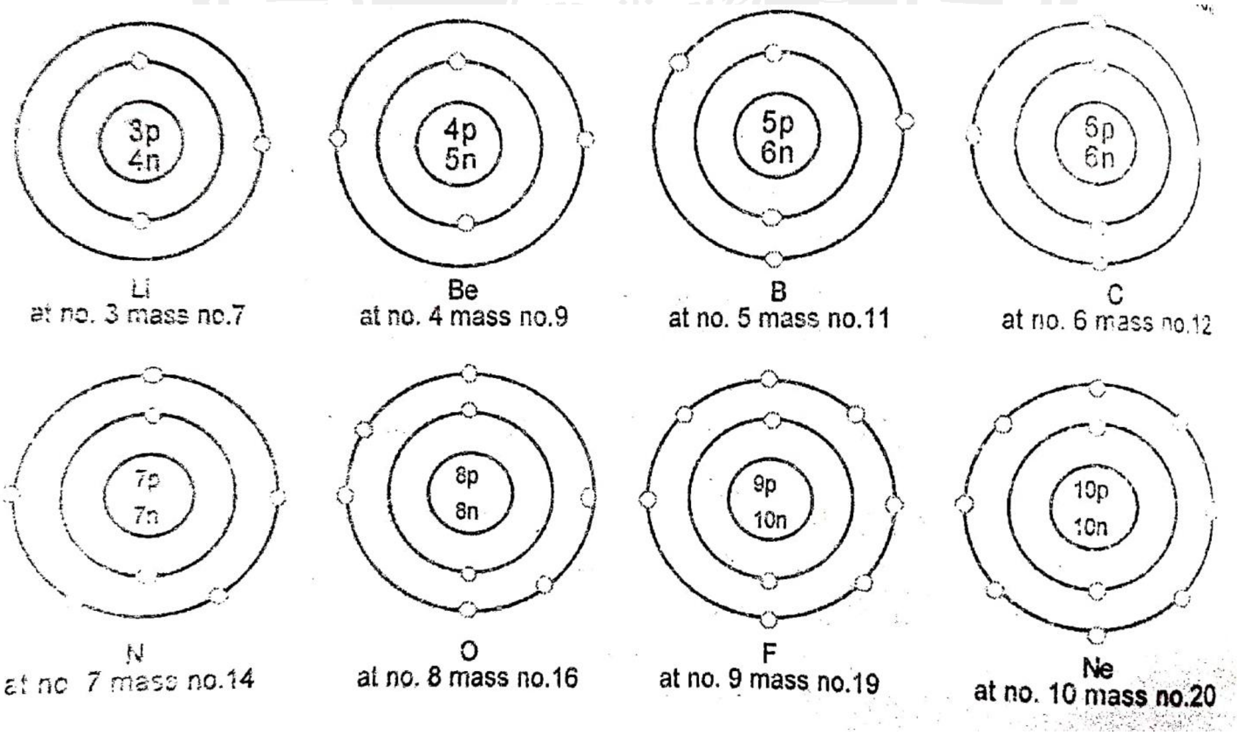
Electrons are negatively charged subatomic particles arranged like a cloud of negative charges outside the nucleus of an atom. The arrangement depends upon of their potential energies in different orbits. The different energy levels are known as 1, 2, 3, 4….. and the corresponding shells are known as K, L, M, N and so on.

For instance,

- 1st energy level- K shell/orbit
- 2nd energy level- L shell/orbit
- 3rd energy level- M shell/orbit and so on.
- ***Electronic configuration of atoms (Elements):***

The distribution of electrons in various shells in an atom is called as Electronic Configuration

Atomic structures of Lithium to Neon:



- ***Valence Electrons:***

- The electrons present in the outermost shell of an atom are known as valence electrons (or valency electrons) because they decide the valency (combining capacity) of the atom.
    - For Example: - The atomic number of sodium is 11, which means sodium atom has 11 electrons in it.
    - So the electronic configuration K (2), L (8), M (1).
    - In the sodium atom, M shell is the outermost shell or valence shell.
    - There is 1 electron in the outermost shell of sodium atom; therefore, sodium atom has 1 valence electron.
- Those electrons of an atom which take part in chemical reactions are called valence electrons.
- Valence electrons are located in the outermost shell of an atom. In order to find out the number of valence electrons in an atom of the element, we should write down the electronic configuration of the element by using its atomic number.

- The outermost shell will be the valence shell and the number of electrons present in it will give us the number of valence electrons.
- Valency of a metal = No. of valence electrons in the atom
- Valency of a non-metal = (8 – No. of valence electrons in its atom)

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