Class- IX

Chapter- 4 : Structure of the Atom (Chemistry)

Introduction:

Atoms are divisible and consist of charged particles. One of the first indication that atoms are divisible, comes from studying static electricity and the condition under which electricity is conducted by different substances.

Charged Particles in Matter

Rubbing two objects together, they become electrically charged. This shows that atom is divisible and consist of charged particles.

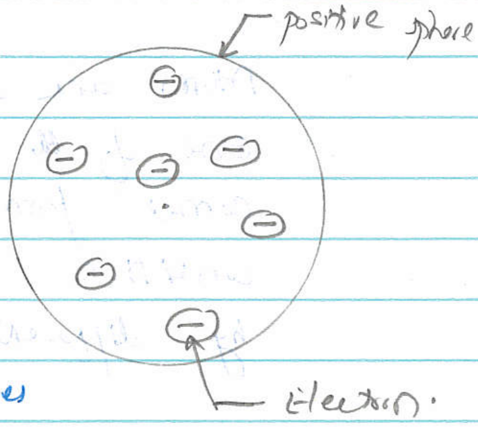
Canal rays are positively charged radiations. These rays consist of positively charged particles known as protons. They were discovered by Goldstein in 1886.

An electron is a negatively charged particle, whereas a proton is a positively charged particle. The magnitude of their charges are equal. Therefore, an atom containing one electron and proton will not carry any charge. Thus, it will be a neutral atom.

Particle	Electron	Proton	Neutron
Symbol	e	p	n
Relative charge	−1	+1	0
Nature	−ve charged	+ve charged	Neutral
Discovered by	JJ Thomson	E. Goldstein	Chadwick

Thomson's Model of an Atom

According to Thomson's model of the atom, an atom consists of both negatively and positively charged particles. The negatively charged particles are embedded in the positively charged sphere. These negative and positive charges are equal in magnitude. Thus, by counter balancing each other's effect, they make an atom neutral.



Thomson's model is also known as Plum pudding model and Water melon model.

Rutherford's model of an atom

Limitations of J.J Thomson's model of the atom:

According to JJ Thomson model of an atom, an atom consists of a positively charged sphere with electrons embedded in it. However, it was later found that the positively charged particles reside at the centre of the atom called the nucleus, and the electrons revolve around the nucleus.

On the basis of Rutherford's model of an atom, protons (positively-charged particles) are present in the nucleus of an atom

In Rutherford experiment, fast moving *alpha (α) - particles were made to fall on a thin gold foil.

* Alpha particle — a positively charged particle consisting of two proton and two neutrons, emitted in radioactive decay or nuclear fission; the nucleus of a helium atom.

Most of the alpha particles passed straight through the gold foil.

Rutherford concluded from the α-particles scattering experiment that —

(i) Most of the space inside the atom is empty because most of the α-particles passed through.

(ii) Positive charge of the atom occupies very little space, since very few particles were deflected.

(iii) All the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

Rutherford nuclear model of an atom:

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

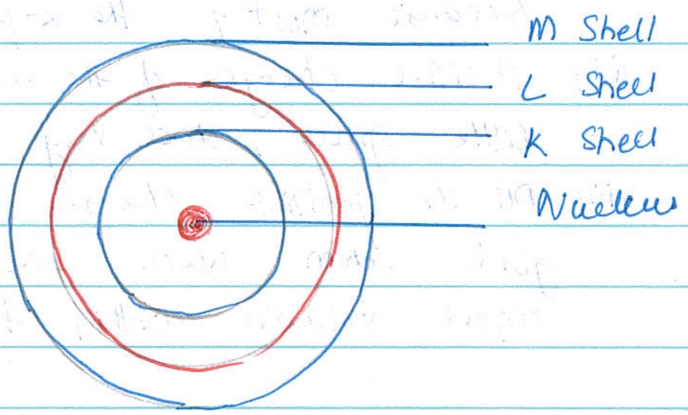
(ii) The electrons revolve around the nucleus in well defined orbits.

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

Limitations of Rutherford's model of the atom.

According to Rutherford's model of an atom, electrons revolve around the nucleus in fixed orbits.
But, an electron revolving in circular orbits will not be stable because during revolution, it will experience acceleration. Due to acceleration, the electrons will loss energy in form of radiation and fall into the nucleus. In such cases, the atom would be highly unstable and collapse.
But we know that atoms are quite stable.

BOHR'S MODEL OF ATOM



Bohr's model of an atom with three shells.

Niels Bohr proposed the following postulates regarding the model of the atom.

(i) Only certain orbits known as discrete orbits of electrons are allowed inside the atom.

(ii) While revolving in these orbit, electrons do not radiate energy.

The first orbit (i.e. for n = 1) is represented by letter K. Similarly, for n = 2, it is L-shell, for n = 3, it is M-shell and for n = 4, it is N-shell. These orbits or shells are called energy shell.

Comparision of all the proposed model

Thomson Model	Rutherford's Model	Bohr Model.
An atom consist of a sphere with electrons embedded in it.	An atom consist of positively charged particles concentrated at the centre known as the nucleus is very small as compared to size of the atom. The electron revolve around the nucleus in well defined orbits.	There are only certain orbits known as discrete orbits inside the atom in which electrons revolve around the nucleus. Electron do not radiate energy while revolving.

Neutrons

Neutrons are another sub-atomic particle which had no charge and a mass nearly equal to that of a proton. Neutrons are present in the nucleus of all atoms, except hydrogen. The mass of atom is given by the sum of the masses of proton and neutron present in the nucleus.

Comparison of electron, protons and neutron :

	Electrons	Proton	Neutron.
(i)	Electrons are present outside the nucleus of an atom	Protons are present in the nucleus of an atom	Neutron are present in the nucleus of an atom
(ii)	Electrons are negatively charged	Proton are positively charged	Neutron are neutral
(iii)	The mass of an electron is considered to negligible	The mass of a proton is approximately 2000 times as the mass of an electron	The mass of neutron is nearly equal to the mass of a proton.

The three sub-atomic particles of an atom are :
(i) Protons (ii) Electrons (iii) Neutron.

Helium atom has two neutron. The mass of an atom is the sum of the masses of proton and neutron present in its nucleus. Since helium atom has two proton, mass contributed by the two protons is $(2\times1)u = 2u$. Then, the remaining mass $(4-2)\,u = 2u$ is contributed by $\frac{2u}{1u} = 2$ neutron.

Bohr- Bury scheme for distribution of electron in different orbits.

1) Maximum number of electrons that can be accomodated in a shell is given by $2n^2$, where n is the shell number i.e. first shell can accomodate 2 electron, second shell can accomodate 8 electron, third shell can accomodate 18 electron and so on.

2) Outermost orbit of an atom can accomodate a maximum number of 8 electron.

3) Electrons are not accomodated in a given shell, unless the inner shells are filled i.e. the shells are filled in a step -wise manner.

Distribution of electron in Carbon and Sodium atom.

(a) The total number of electrons in a carbon atom is 6. The distribution of electrons in carbon atom is given by:

First orbit or K-shell = 2 electrons
Second orbit or L-shell = 4 electron
∴ Distribution of electron in Carbon atom is 2, 4

(b) The total number of electrons in a Sodium atom is 11.
Distribution is given by :
First orbit K-Shell = 2 electron.
Second orbit L-shell = 8 electr..
Third orbit M-shell = 1 electr.

The rules for writing of the distribution of electrons in various shells for the first eighteen elements are given below:

(i) The maximum number of electrons that a shell can accomodate is given by the formula '$2n^2$', where 'n' is the orbit number or energy level index ($n = 1, 2, 3 \ldots$).

The maximum number of electrons present in an orbit of $n = 1$ is given by $2n^2 = 2 \times 1^2 = 2$

Similarly for second orbit, it is $2n^2 = 2 \times 2^2 = 8$

For third orbit, it is $2n^2 = 2 \times 3^2 = 18$
And so on.

(ii) The outermost orbit can be accomodated by a maximum number of 8 electron.

(iii) Shells are filled with electrons in a stepwise manner i.e. the outer shell is not occupied with electron unless the inner shell are completely filled with electron.

Valency

The valency of an element is the combining capacity of that element. The valency of an element is determined by the number of valance electrons present in the atom of that element.

If the number of valance electrons of the atom of an element is less than or equal to four, then the valancy of that element is equal to the number of valance electron.

For example, the atom of silicon has four valance electrons. Thus the valency of silicon is four. On the other hand, if the number of valence electrons of the atom of an element is greater than four, then the valency of that element is obtained by substracting the number of valence electron from eight. For example, the atom of oxygen has six valance electron. Thus, the valency of oxygen is (8-6) i.e. 2.

Valency of chlorine :
Distribution of electrons in chlorine , 2, 8, 7
Valency of chlorine is = 8-7 = 1

Valency of sulpher :
Distribution of electron in sulphure is 2, 8, 6
Valancy of sulphure = 8-6 = 2

Valency of magnesium = 2 (∵ Distribution of e^- = 2, 8, 2)

Atomic Number

Atomic number of an element is the total number of protons present in the atom of that element. For example, nitrogen has 7 protons in its atom. Thus, the atomic number of nitrogen is 7.

Mass Number

The mass number of an element is the sum of the number of protons and neutrons present in atom of that element. For example, the atom of boron has 5 protons and 6 neutrons. So, the mass number of boron is 5+6=11.

Isotopes

Isotopes are atoms of the same element having the same atomic number, but different mass numbers. For example, hydrogen has three isotopes. They are protium (^1_1H), deuterium (^2_1H) and tritium (^3_1H).

The chemical properties of isotopes are similar but their physical properties are different.

Chlorine has two isotopes with masses 35u & 37u in the ratio 3:1

Application of Isotopes

(i) An isotope of uranium is used as a fuel in nuclear reactor.

(ii) An isotope of cobalt is used in the treatment of caner.

(iii) An isotope of iodine is used in the treatment of goitre.

Isobars

Isobars are atoms having the same mass number, but different atomic number i.e. isobars are atoms of different elements having the same mass number.

For example, $^{40}_{20}Ca$ and $^{40}_{18}Ar$ are Isobars.