CHEMISTRY

CLASS NOTES FOR CBSE

Chapter 02. Structure of Atom

01. Introduction

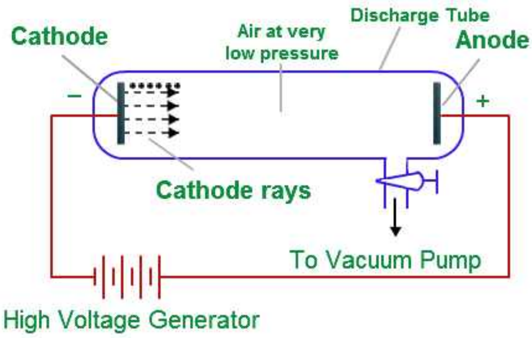
John Dalton 1808, believed that matter is made up of extremely minute indivisible particles, called atom which takes part in chemical reactions. These particle can neither be created nor be destroyed. However, modern researches have conclusively proves that atom is no longer an indivisible particle. Modern structure of atom is based on Rutherford's scattering experiment, quantization of energy and wave mechanical model.

Composition of Atom

The works of J.J. Thomson and Ernst Rutherford actually laid the foundation of the modern picture of the atom. If is now verified that the atom consists of several sub-atomic particles like electron, proton, neutron, positron, neutrino, meson etc. Out of these particles the electron, proton and the neutron are called fundamental subatomic particles.

02. ELECTRON ($_{-1}e^{0}$, e)

Electron was discovered by J.J. Thomson(1897) and it is a negatively charged particle.
Cathode rays were discovered by William Crooke & J.J. Thomson using a cylindrical hard glass tube fitted with two metallic electrodes. This tube was known as discharge tube. They passed electricity (10,000V) through a discharge tube at very low pressure. Blue rays emerged from the cathode. These reys were termed as Cathode rays.



Properties of Cathode rays

(i) Cathode rays travel in straight line.

(ii) Cathode rays produce mechanical effect, as they can rotate the wheel placed in their path.

(iii) Cathode rays consist of negatively charged particles known as electron.

(iv) Cathode rays travel with high speed.
(v) Cathode rays can cause fluorescence.
(vi) Cathode rays heat the object on which they fall due to transfer of kinetic energy to the object.
(vii) When cathode rays fall on heavy metals, X-rays are produced.
(viii) Cathode rays possess ionizing power i.e., they ionize the gas through which they pass.
(ix) The cathode rays produce scintillation on the photographic plates.
(x) They can penetrate through thin metallic sheets.
(xi) The nature of these rays does not

03. Thomson's Model of Atom [1904]

- Thomson was the first to propose a detailed model of the atom.
- Thomson proposed that an atom consists of a uniform sphere of positive charge in which the electrons are distributed more or less uniformly.
- This model of atom is known as "Plum-Pudding model" or "Raisin Pudding Model" or "Water Melon Model".

Drawbacks:

- An important drawback of this model is that the mass of the atoms is considered to be evenly spread over that atom.
- It is a static model. It does not reflect the movement of electron.
- It could not explain the stability of an atom.

04. Rutherford's Scattering Experiment

Rutherford observed that

(i) Most of the α-particles (nearly 99.9%) went straight without suffering any deflection.
(ii) A few of them got deflected through small angles.
(iii) A very few (about one in 20,000) did not pass through the foil at all but suffered large deflections (more than 90°) or even came back in the direction from which they have come i.e. a deflection of 180°.

Following conclusions were drawn from the above observations-

(i) Since most of the α-particle went straight through the metal foil undeflected, it means that there must be very large empty space within the atom.
(ii) Since few of the α-particles were deflected from their original paths through moderate angles; it was concluded that whole of the +ve charge is concentrated and the space occupied by this positive charge is very small in the atom.
  - When α-particles come closer to this point, they suffer a force of repulsion and deviate from their paths.
  - The positively charged heavy mass which occupies only a small volume in an atom is called nucleus. It is supposed to be present at the centre of the atom.

(iii) A very few of the α-particles suffered strong deflections on even returned on their path indicating that the nucleus is rigid and α-particles recoil due to direct collision with the heavy positively charged mass.

Drawbacks of rutherford model-

(i) This theory could not explain stability of atom. According to Maxwell electron loose its energy continuously in the form of electromagnetic radiations. As a result of this, the e- should loose energy at every turn and move close and closer to the nucleus following a spiral path. The unlimited result will be that it will fall into the nucleus, thereby making the atom unstable.

(ii) If the electrons loose energy continuously, the observed spectrum should be continuous but the actual observed spectrum consists of well defined lines of definite frequencies. Hence the loss of energy by electron is not continuous in an atom.

05. Distance of closest approach :

When the α-particles approaches the nucleus to made a head-on collision with a the nucleus, the α-particle approaches the nucleus until coulombic potential energy of repulsion, $k\frac{Z_1Z_2e^2}{r}$, becomes equal to its initial K.E., $\frac{1}{2}$ m.v^2.

Thus $\frac{1}{2}\ mv^2 = k\frac{Z_1Z_2e^2}{r}$

Hence, the distance of closest approach, $r = \frac{k\,z_1\,z_2\,e^2}{\left(\frac{1}{2}mv^2\right)}$.

The nucleus must be further smaller than the distance of closest approach.

06. Moseley Experiment (Discovery of Atomic Number)

Moseley (1912-1913), investigated the X-rays spectra of 38 different elements, starting from aluminium and ending in gold. He measured the frequency of principal lines of a particular series (the α-lines in the K series) of the spectra. It was observed that the frequency of a particular spectral line gradually increased with the increase of atomic mass of the element. But, it was soon realised that the frequency of the particular spectral line was more precisely related with the serial number of the element in the periodic table which he termed as atomic number (Z). He presented the following relationship:

$$\sqrt{v} = a(Z-b)$$

where, v=frequency of X-rays, Z=atomic number, 'a' and 'b' are constants. When the values of square root of the frequency were plotted against atomic number of the elements producing X-rays, a straight line was obtained.