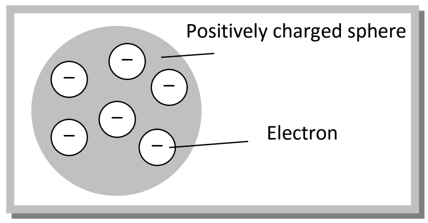
Important Atomic Models.

(1) Thomson's model

J.J. Thomson gave the first idea regarding structure of atom. According to this model.

(i) An atom is a solid sphere in which entire and positive charge and its mass is uniformly distributed and in which negative charge (i.e. electron) are embedded like seeds in watermelon.



Success and failure

Explained successfully the phenomenon of thermionic emission, photoelectric emission and ionization.

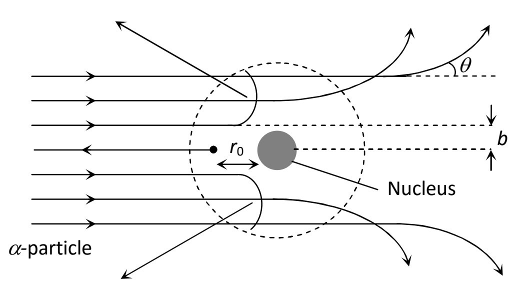
The model fail to explain the scattering of α- particles and it cannot explain the origin of spectral lines observed in the spectrum of hydrogen and other atoms.

(2) Rutherford's model

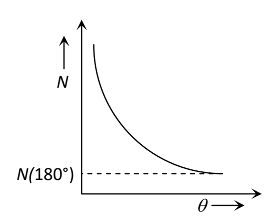
Rutherford's α-particle scattering experiment

Rutherford performed experiments on the scattering of alpha particles by extremely thin gold foils and made the following observations

Number of scattered particles:



$$N \propto \frac{1}{\sin^4(\theta/2)}$$



(i) Most of the α-particles pass through the foil straight away undeflected.

(ii) Some of them are deflected through small angles.

(iii) A few α-particles (1 in 1000) are deflected through the angle more than 90o.

(iv) A few α -particles (very few) returned back i.e. deflected by 180o.

(v) Distance of closest approach (Nuclear dimension)

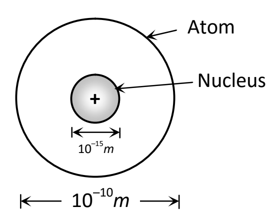
The minimum distance from the nucleus up to which the α-particle approach, is called the distance of closest approach (r0). From figure $r_0 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Ze^2}{E}$; $E = \frac{1}{2}mv^2 =$ K.E. of α-particle

(vi) Impact parameter (b): The perpendicular distance of the velocity vector ($\vec{v}$) of the α-particle from the center of the nucleus when it is far away from the nucleus is known as impact parameter. It is given as

$$b = \frac{Ze^2\cot(\theta/2)}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)} \Rightarrow b \propto \cot(\theta/2)$$

Note: If t is the thickness of the foil and N is the number of α-particles scattered in a particular direction (θ = constant), it was observed that $\frac{N}{t} =$ constant $\Rightarrow \frac{N_1}{N_2} = \frac{t_1}{t_2}$.

After Rutherford's scattering of α-particles experiment, following conclusions were made as regard as atomic structure:



Size of the nucleus = 1 Fermi = $10^{-15}m$

Size of the atom 1 Å = $10^{-10}m$

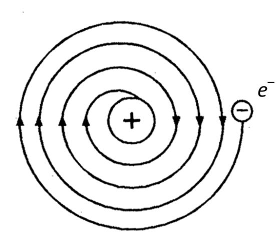
(a) Most of the mass and all of the charge of an atom concentrated in a very small region is called atomic nucleus.

(b) Nucleus is positively charged and its size is of the order of 10–15 m ≈ 1 Fermi.

(c) In an atom there is maximum empty space and the electrons revolve around the nucleus in the same way as the planets revolve around the sun.

Draw backs

(i) Stability of atom: It could not explain stability of atom because according to classical electrodynamics theory an accelerated charged particle should continuously radiate energy. Thus an electron moving in a circular path around the nucleus should also radiate energy and thus move into smaller and smaller orbits of gradually decreasing radius and it should ultimately fall into nucleus.



Instability of atom

(ii) According to this model the spectrum of atom must be continuous whereas practically it is a line spectrum.

(iii) It did not explain the distribution of electrons outside the nucleus.

(3) Bohr's model

Bohr proposed a model for hydrogen atom which is also applicable for some lighter atoms in which a single electron revolves around a stationary nucleus of positive charge Ze (called hydrogen like atom)

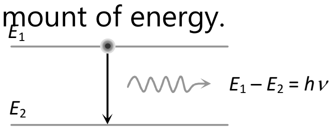
Bohr's model is based on the following postulates.

(i) The electron can revolve only in certain discrete non-radiating orbits, called stationary orbits, for which total angular momentum of the revolving electrons is an integral multiple of $\frac{h}{2\pi}\ (=\hbar)$

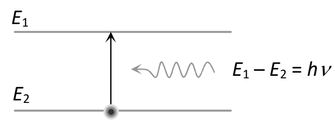
i.e. $L = n\left(\frac{h}{2\pi}\right) = mvr$; where n = 1, 2, 3, ...= Principal quantum number

(ii) The radiation of energy occurs only when an electron jumps from one permitted orbit to another.

When electron jumps from higher energy orbit (E1) to lower energy orbit (E2) then difference of energies of these orbits i.e. E1 – E2 emits in the form of photon. But if electron goes from E2 to E1 it absorbs the same amount of energy.



Emission



Absorption

Note: According to Bohr Theory the momentum of an e^- revolving in second orbit of H_2 atom will be $\frac{h}{\pi}$

For an electron in the nth orbit of hydrogen atom in Bohr model, circumference of orbit $= n\lambda$; where λ = de-Broglie wavelength.