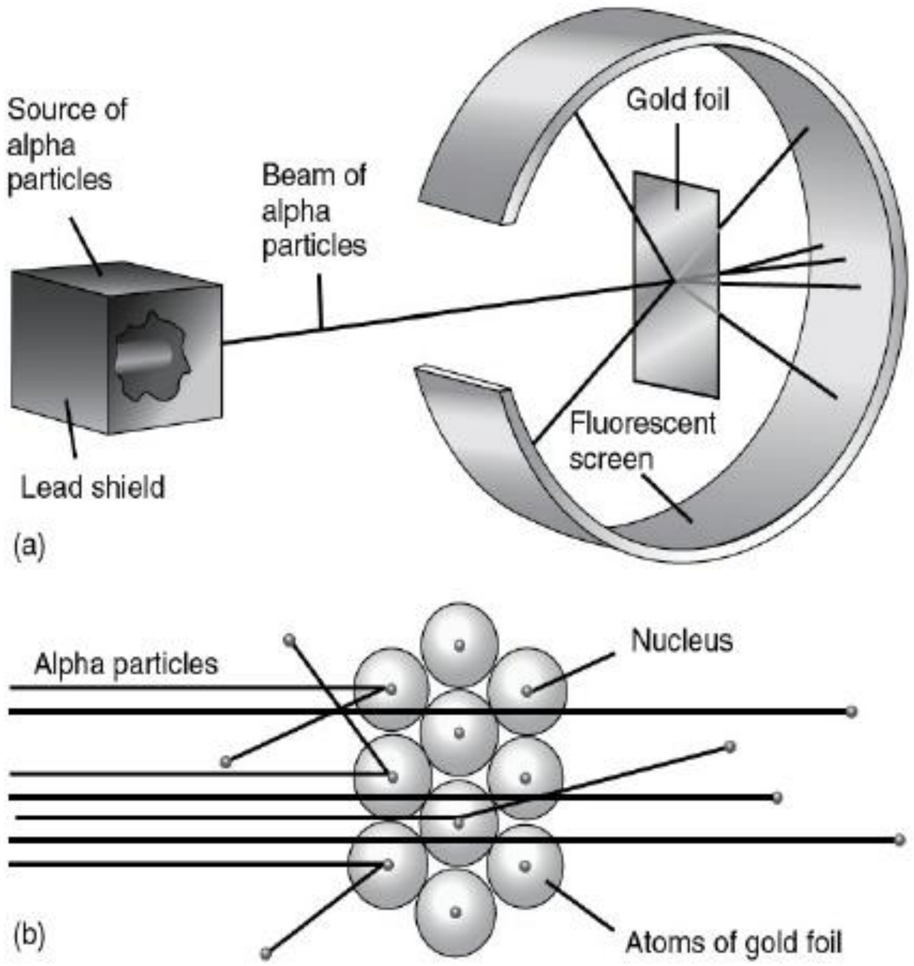
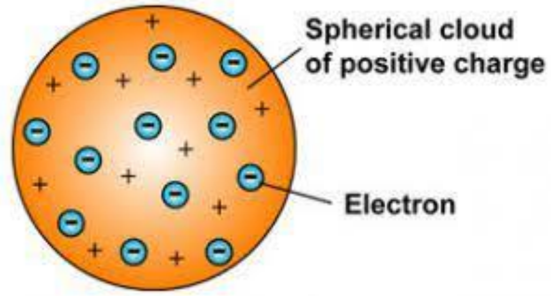
Rutherford's Model of the Atom:

- While bombarding, he observes the number of scattering of particles:
- **Most of the particles passed either un-deviated or with a very small deviation** and **very few deviated by large angles**
    - **1 out of 8000 was deflected by more than 90°**
- **The conclusion to this deflection:**
    - Most of the **space of an atom is empty and a**t the **center of an atom** having a **tiny positively charged** particle called a **nucleus.**
    - The center **nucleus has all the mass of an atom** and all the **electrons revolve** around the **nucleus** and coulomb force provides the centripetal force

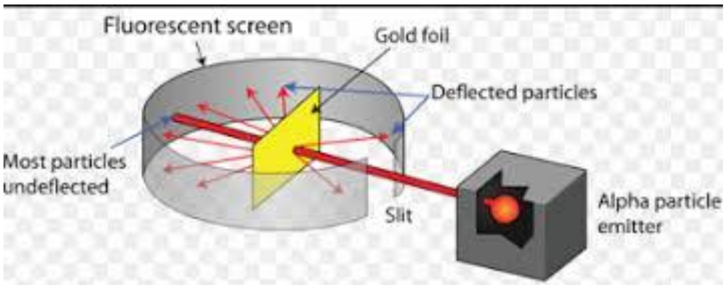


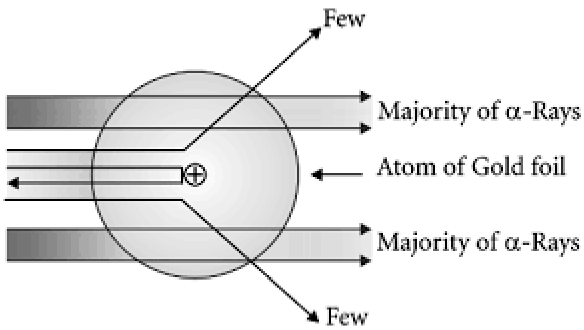
Atomic Models :

(A) Thomson's Model of the atom : An atom is electrically neutral. It contains positive charges (due to the presence of protons) as well as negative charges (due to the presence of electrons). It assumes that mass is equally distributed in the atom. Hence, J.J. Thomson assumed that an atom is a uniform sphere of positive charges with electrons embedded in it.



(B) Rutherford's Experiment :





Observation :

1. Most of the α-particles passed straight through the gold foil undeflected.
2. A few of them were deflected through small angles, while a very few were deflected to a large extent.
3. A very small percentage (1 in 20000) was deflected through angles ranging from nearly 180°.

Rutherford's nuclear concept of the atom.

(i) The atom of an element consists of a small positively charged 'nucleus' which is situated at the centre of the atom and which carries almost the entire mass of the atom.

(ii) The electrons are distributed in the empty space of the atom around the nucleus in different concentric circular paths, called orbits.

(iii) The number of electrons in orbits is equal to the number of positive charges (protons) in the nucleus. Hence, the atom is electrically neutral.

(iv) The volume of the nucleus is negligibly small as compared to the volume of the atom.

(v) Most of the space in the atom is empty.

Drawbacks of rutherford's model :

1. This was not according to the classical theory of electromagnetism proposed by maxwell. According to this theory, every accelerated charged particle must emit radiations in the form of electromagnetic waves and loses it total energy. Since energy of electrons keep on decreasing, so radius of the circular orbits should also decrease and ultimately the electron should fall in nucleus.

2. It could not explain the line spectrum of H-atom.

3. It says nothing about the electronic structure of atom i.e. how the e– are distributed around the nucleus and what are the energies of these e–.

Properties of charge :

1. Q = ne (charge is quantized)
2. Charge are of two types : (i) Positive charge (ii) Negative Charge e = -1.6×10^{-19} p = $+1.6 \times 10^{-19}$ C This does not mean that a proton has a greater charge but it implies that the charge is equal and opposite. Same charge repel each other and opposite charges attract each other.
3. Charge is a SCALAR qty. and the force between the charges always acts along the line Joining the charges. The magnitude of the force between the two charge placed at a distance 'r' is given by $F_E = \frac{1}{4\pi\varepsilon_\circ}\frac{q_1 q_2}{r^2}$ (electrical force)
4. If two charge q_1 and q_2 are separated by distance r then the potential energy of the two charge system is given by P.E. = $\frac{1}{4\pi\varepsilon_\circ}\frac{q_1 q_2}{r^1}$
5. If a charged particle q is placed on a surface of potential V then the potential energy of the charge is q × V.

Estimation of closest distance of approach (derivation)

An α-particle is projected from infinity with the velocity v_0 towards the nucleus of an atom having atomic number equal to Z then find out

(i) closest distance of approach (R)

(ii) what is the velocity of the α- particle at the distance R_1 (R_1> R) from the nucleus.

From energy conservation $P.E_1 + KE_1 = P.E_2 + KE_2$

$$\Rightarrow \quad 0 + \frac{1}{2}m_\alpha V_\alpha^2 = \frac{K(Ze)(2e)}{R} + 0$$

$$R = \frac{4KZe^2}{m_\alpha V_\alpha^2} \quad \text{(closest distance of approach)}$$

Let velocity at R_1 is V_1.

From energy conservation $P.E_1 + KE_1 = P.E_3 + KE_3$ $\Rightarrow$ $0 + \frac{1}{2}m_\alpha V_\alpha^2 = \frac{K(Ze)(2e)}{R_1} + \frac{1}{2}m_\alpha V_1^2$

THE BOHR'S ATOMIC MODEL

In 1913, Prof. Niel Bohr removed the difficulties of Rutherford's atomic model by the application of Planck's quantum theory. For this he proposed the following postulates

(1) An electron moves only in certain circular orbits, called stationary orbits. In stationary orbits electron does not emit radiation, contrary to the predictions of classical electromagnetic theory.

(2) According to Bohr, there is a definite energy associated with each stable orbit and an atom radiaties energy only when it makes a transition from one of these orbits to another. If the energy of electron in the higher orbit be E2 and that in the lower orbit be E1, then the frequency ν of the radiated waves is given by

$$h\nu = E_2 - E_1 \quad \text{or} \quad \nu = \frac{E_2 - E_1}{h} \quad \text{...(i)}$$

(3) Bohr found that the magnitude of the electron's angular momentum is quantized, and this magnitude for the electron must be integral multiple of $\frac{h}{2\pi}$. The magnitude of the angular momentum is L = mvr for a particle with mass m moving with speed v in a circle of radius r. So, according to Bohr's postulate, (n = 1, 2, 3....) Each value of n corresponds to a permitted value of the orbit radius, which we will denote by r_n The value of n for each orbit is called principal quantum number for the orbit. Thus,

$$m v_n r_n = mvr = \frac{nh}{2\pi}$$