Marwari college Darbhanga

Subject---physics (sub)

Class--- B.Sc. part 2

Group----C

Topic—size of Nucleus and it's determination (Nuclear physics)

Lacture series---02

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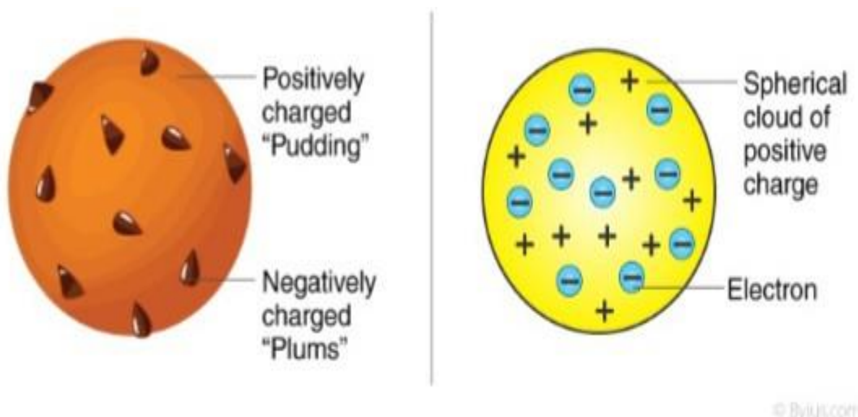
Rutherford Gold Foil Experiment

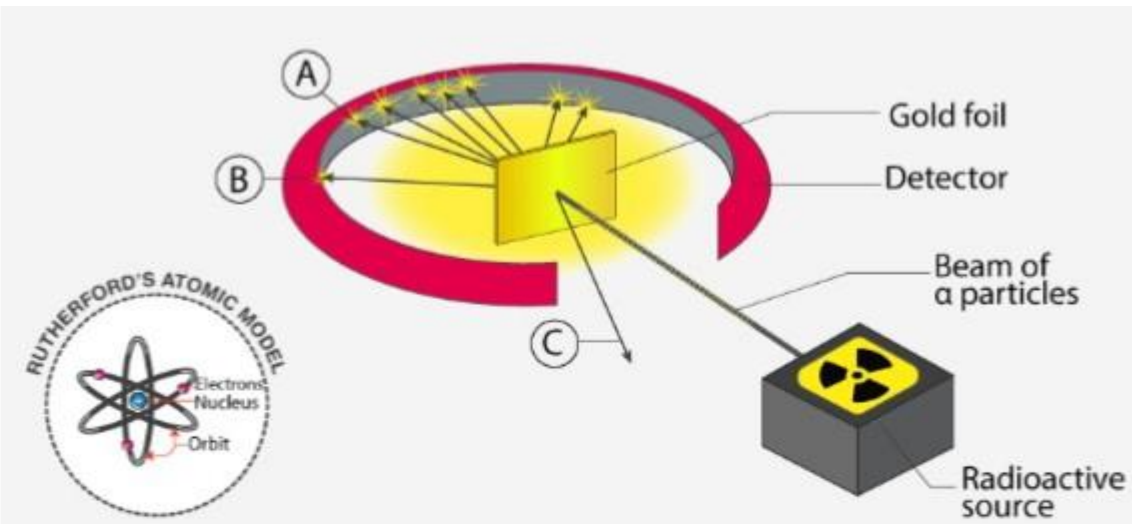
Before Rutherford's experiment, the best model of the atom that was known to us was the Thomson or "plum pudding" model. In this model, the atom was believed to consist of a positive material "pudding" with negative "plums" distributed throughout. Later, Rutherford’s alpha-particle scattering experiment changed the way we think of the atomic structure. Rutherford directed beams of alpha particles at thin gold foil to test this model and noted how the alpha particles scattered from the foil.

JJ Thompson Plum Pudding Model



In the experiment, Rutherford showed us that the atom was mainly an empty space with the nucleus at the Center and electrons revolving around it. When alpha particles were fired towards the gold foil, Rutherford noticed that 1 in 20000 particles underwent a change in direction of motion of more than 90 degrees. The rest 19999 particles deviated from their trajectory by a very small margin. This led to a conclusion that the atom consisted of an empty space with most of the mass concentrated at the Centre in tiny volumes. This volume at the Centre was named as 'the nucleus'; Latin for 'little nut'.

Rutherford's Gold Foil Experiment



Through this experiment, Rutherford made 3 observations as follows:

- Highly charged alpha particles went straight through the foil undeflected. This would have been the expected result for all of the particles if the plum pudding model was correct.
- Some alpha particles were deflected back through large angles.

- A very small number of alpha particles were deflected backwards! To this Rutherford remarked, “It was as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back at you!”

To explain these observations, a new model of the atom was needed. In the new model, the positive material was considered to be concentrated in a small but massive region called the nucleus. Electrons were considered to be revolving around the nucleus preventing one atom from trespassing on its neighbour’s space to complete this model.

Size of the Nucleus

It was possible to obtain the size of the nucleus through Rutherford’s experiment. We can calculate the size of the nucleus, by obtaining the point of closest approach of an alpha particle. By shooting alpha particles of kinetic energy 5.5 MeV, the point of closest approach was estimated to be about 4×10^{-14}m. Since the

repulsive force acting here is Coulomb repulsion, there is no contact. This means that the size of the nucleus is smaller than 4×10^{-14}m.

The sizes of the nuclei of various elements have been accurately measured after conducting many more iterations of the experiment. Having done this, a formula to measure the size of the nucleus was determined.

$$R = R_0 A^{\frac{1}{3}}$$

Where $R_0 = 1.2\times10^{-15}$m.

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From the formula, we can conclude that the volume of the nucleus which is proportional to R^3 is proportional to A (mass number). Another thing to be noticed in the equation is that there is no mention of density in the equation. This is due to the fact that the density of the nuclei does not vary with elements. The density of the nucleus is approximately 2.3×10^{17} kg.m^{-3}.