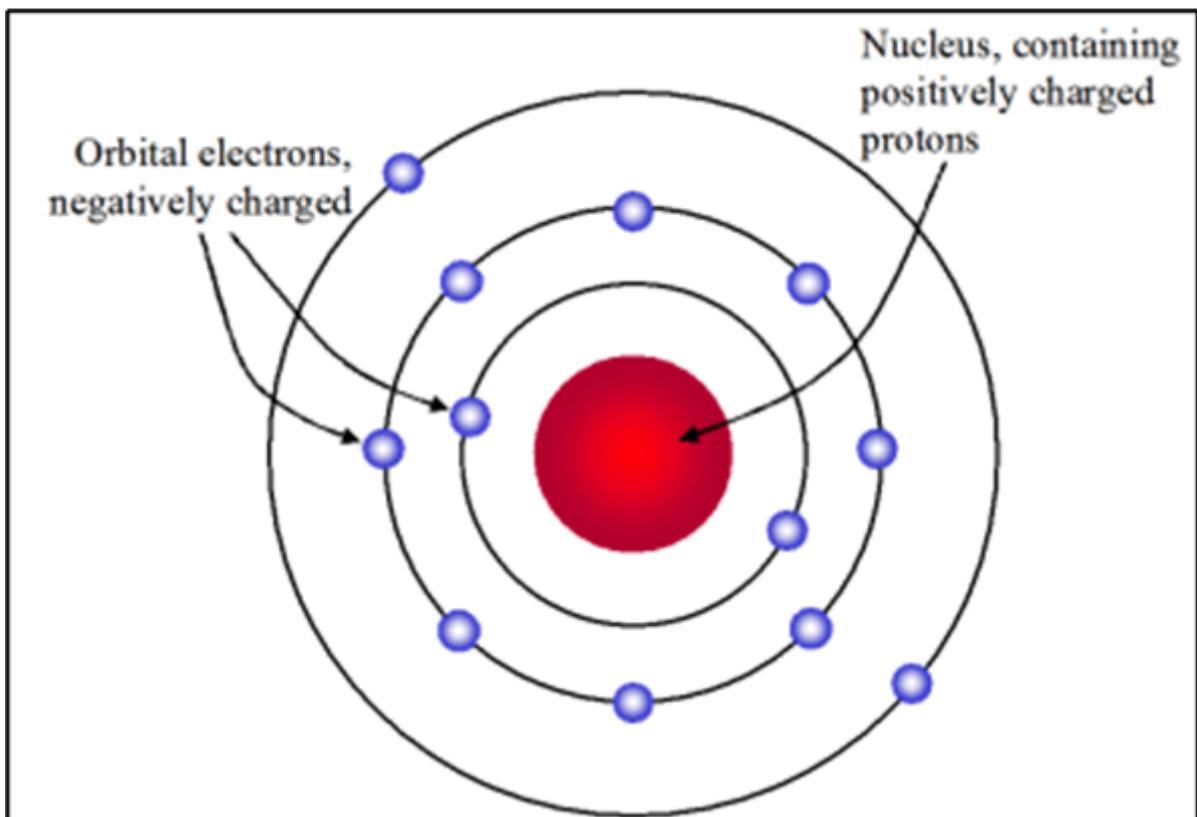


## *FlexiPrep*

### Rutherford's Model, Experiments Performed, Rutherford Atomic Model and Limitations (For CBSE, ICSE, IAS, NET, NRA 2022)

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Rutherford was always curious in knowing about the arrangement of electrons in an atom. By performing an experiment using alpha particles and gold foil he came to some conclusions.



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Rutherford's Model

### **Experiments Performed**

Experiments he performed

- A 1000 atoms thick gold foil was selected because he wanted as thin a layer as possible.

- Alpha particles are nothing but doubly charged helium ions. As its mass is  $4u$ , the fast-moving alpha particles have good amount of energy.
- He also expected that the alpha particles will be deflected as they are heavier than the protons. But what he observed was completely unexpected, he made the following observations:
  - Most of the alpha particles passed straight through that gold foil.
  - There was a deflection by small angle by some of the alpha particles.
  - Very small number of alpha particles rebounded.

Rutherford concluded the following points after the observation:

- As there was very less deflection of alpha particles so he concluded that most of the space was empty in an atom.
- He also concluded that positive charge contains very less amount of space in an atom as very few articles were deflected from their path.
- A very small number of alpha particles deflected with an angle of  $180^\circ$ , which indicated that the mass of the atom and the positive charge was concentrated at a small volume in an atom.

From all these observations he calculated that the radius of the nucleus is around  $10^5$  times less than the radius of the atom.

The following final model was put by Rutherford after all the observations:

- The nucleus is at the centre and is positively charged and nearly all the mass of the nucleus resides in the nucleus.
- Around the nucleus, electrons revolve in a circular path.
- The size of the nucleus is very less as compared to the size of the atom.

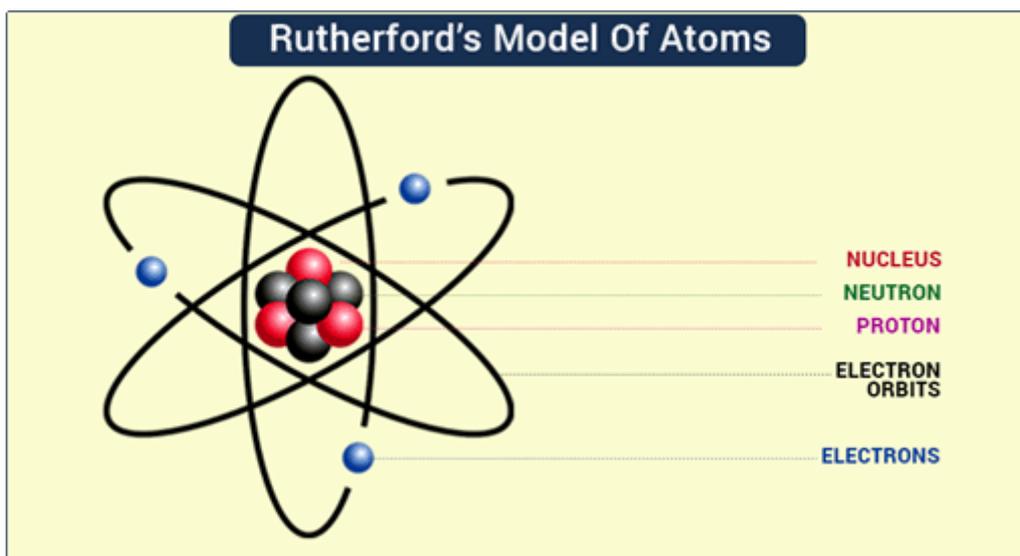
### **Rutherford Atomic Model and Limitations**

Rutherford Atomic Model – The plum pudding model is given by J. J. Thomson failed to explain certain experimental results associated with the atomic structure of elements.

Ernest Rutherford, a British scientist conducted an experiment and based on the observations of this experiment, he proposed the atomic structure of elements and gave Rutherford Atomic Model.

### **Rutherford's Alpha Scattering Experiment**

Rutherford's conducted an experiment by bombarding a thin sheet of gold with  $\alpha$ -particles and then studied the trajectory of these particles after their interaction with the gold foil.



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Rutherford, in his experiment, directed high energy streams of  $\alpha$ -particles from a radioactive source at a thin sheet (100 nm thickness) of gold. In order to study the deflection caused to the  $\alpha$ -particles, he placed a fluorescent zinc sulphide screen around the thin gold foil. Rutherford made certain observations that contradicted Thomson's atomic model.

### Observations of Rutherford's Alpha Scattering Experiment

The observations made by Rutherford led him to conclude that:

- A major fraction of the  $\alpha$ -particles bombarded towards the gold sheet passed through it without any deflection, and hence most of the space in an atom is empty.
- Some of the  $\alpha$ -particles were deflected by the gold sheet by very small angles, and hence the positive charge in an atom is not uniformly distributed. The positive charge in an atom is concentrated in a very small volume.
- Very few of the  $\alpha$ -particles were deflected back, that is only a few  $\alpha$ -particles had nearly  $180^\circ$  angle of deflection. So, the volume occupied by the positively charged particles in an atom is very small as compared to the total volume of an atom.

### Rutherford Atomic Model

Based on the above observations and conclusions, Rutherford proposed the atomic structure of elements. According to the Rutherford atomic model:

- The positively charged particles and most of the mass of an atom was concentrated in an extremely small volume. He called this region of the atom as a nucleus.
- Rutherford model proposed that the negatively charged electrons surround the nucleus of an atom. He also claimed that the electrons surrounding the nucleus revolve around it with very high speed in circular paths. He named these circular paths as orbits.
- Electrons being negatively charged and nucleus being a densely concentrated mass of positively charged particles are held together by a strong electrostatic force of attraction.

### **Limitations of Rutherford Atomic Model**

Although the Rutherford atomic model was based on experimental observations it failed to explain certain things.

- Rutherford proposed that the electrons revolve around the nucleus in fixed paths called orbits. According to Maxwell, accelerated charged particles emit electromagnetic radiations and hence an electron revolving around the nucleus should emit electromagnetic radiation. This radiation would carry energy from the motion of the electron which would come at the cost of shrinking of orbits.
- Ultimately the electrons would collapse in the nucleus. Calculations have shown that as per the Rutherford model, an electron would collapse in the nucleus in less than  $10^{-8}$  seconds. So, Rutherford model was not in accordance with Maxwell's theory and could not explain the stability of an atom.
- One of the drawbacks of the Rutherford model was also that he did not say anything about the arrangement of electrons in an atom which made his theory incomplete.
- Although the early atomic models were inaccurate and failed to explain certain experimental results, they were the base for future developments in the world of quantum mechanics.

### **Questions**

Explain the Drawbacks of Rutherford's Model of the Atom?

**Answer:**

- Before explaining the drawbacks of the Rutherford atomic model, we can see the experiment and conclusions which he came up with.
- Rutherford performed an experiment using alpha particle and gold foil. most of the alpha particles passed through the gold foil and there observed a deflection of alpha particles by a small angle.

- Few alpha particles rebounded and he came up with a certain conclusion.
- Most of the space in an atom is empty.
- The space occupied by the positive charge is very small.
- The positive charges and mass of the atom were concentrated in a very small volume within the atom.
- The centre of atom is called nucleus.
- Electron spin around the nucleus in a circular path.
- Size of nucleus is comparatively small than the size of atom.
- The drawbacks of this model where he failed to explain the stability of electrons in a circular path.
- He failed to explain about the arrangement of electrons in an atom.

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