Rutherford's Explanation for the Deflection of Alpha Particles

Classical Model
J.J. Thomson believed that the atom is supposed to consist of a number of electrons distributed throughout a positively charged sphere. The deflection of a negatively charged particle passing through this atom is attributed to the repulsion of the electrons distributed throughout the atom as well as the attraction of the positively charged sphere of the atom. Any deflection that takes place is should be relatively small (1).

Gold Foil Experiment Disproved the Plum Pudding Model
Results from the gold foil experiment showed that the angle of deflection was quite large as much as 90°. In fact some particles would bounce directly backwards (1).

Rutherford constructed a new theory of the atom and compared the theory to the experimental results.

- Rutherford assumed the atom in the gold foil contained a central charge surrounded by a uniform distribution of an electric field.
- For the force required to repel an alpha-particle, which is positive, Rutherford assumed the central charge was positive and the surrounding distribution was made of electrons.
- If an alpha particle is shot at the center of the atom there must be enough electric force to bring the alpha particle to a rest at a certain distance from the center, b (1).
- Through his derivations he found that the alpha particles penetrate so close to the central positive charge that the field of the surrounding electrons can be neglected.
- Rutherford also found that if the velocity of the particle remains constant, even with the collision, the angle of deflection depends on the angular momentum of the particle as well as how close it penetrates the central charge (1).
- Rutherford found that at a given distance between the glass tube and the metal reflector, the number of particles to hit the zinc sulfide detector is proportional to the angle of deflection, thickness of the metal, magnitude of central charge and the speed of the particle (1).
- Since more particles increase the chance of more than one collision the thickness of the metal was reduced to limit the probability of second encounters. In the experiment 0.0004cm thick gold foil was used (1).

- Rutherford also accounted for the recoil of the atom itself as well as the difference between single encounters and multiple encounters (1).
- In the experiment it was assumed that the central charge was proportional to the atomic weight (1).
- The probability of a single deflection of an angle greater than θ, which was considered to be small in J. J. Thomson's theory, is equal to the equation below

$$b = \frac{2NeE}{mu^2}$$

- Where b, is the distance from the central charge where the alpha particles stops; Ne, is the charge of the central "mass"; E, is the charge of the alpha particle; m, the mass of the alpha particle; and u^2 is the (average) velocity of the alpha particle (1)

This equation is simply Coulomb's law rearranged which examines the attractive force between two point charges.

Rutherford also concluded that the mass of the of this central charge would be small in comparison to the alpha particle, however, if this mass is distributed over a very small volume, the large deflections are due to the central charge as a whole rather than when the mass is distributed over a larger space.

References

1. Rutherford, E. The Scattering of α and β Particles by Matter and the Structure of the Atom. *Philoso. Mag*. **1911** 6:21, 669-688.