Chemistry Lecture #18: Rutherford's Gold Foil Experiment

By 1908 it was known that the atom consisted of positive and negative particles. The next step was to determine how these particles were put together.

J.J. Thomson (1856-1940), who discovered the electron, proposed that the atom was made of a large positive region, with smaller electrons distributed throughout the region. This would make the atom look like plum pudding, which is an English pastry that has plums baked into bread.

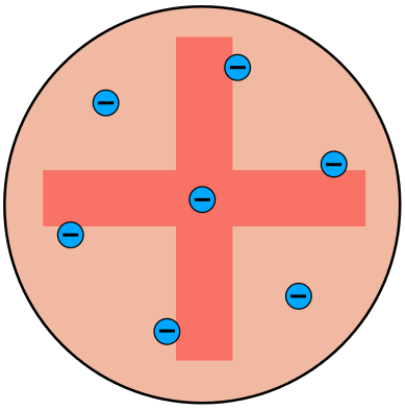


Diagram on the right By Kurzon (Own work) [CC BY-SA 4.0 (http://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

Thomson's model became known as the plum pudding model. I suppose the American equivalent would be something like the blueberry muffin model or the chocolate chip cookie model. In any case, Thomson believed that small electrons were embedded in a large, positive piece of matter.

Opposite charges attract, and like charges repel. If two positive charges came close to each other, they would repel each other.

In the plum pudding model, the positive charge is spread over a large area. We can say the charge is being spread thin, like a small amount of peanut butter over a large slice of bread.. Since the charge is thin, the strength of the charge at a particular location would be weak.

Since the positive charge at a particular location in the atom is weak, another positive charge that approaches the atom would experience a weak repulsion.

An alpha particle has a positive charge. According to the plum pudding model, if an alpha particle was shot at an atom, the particle would pass through or past the atom with very little repulsion.

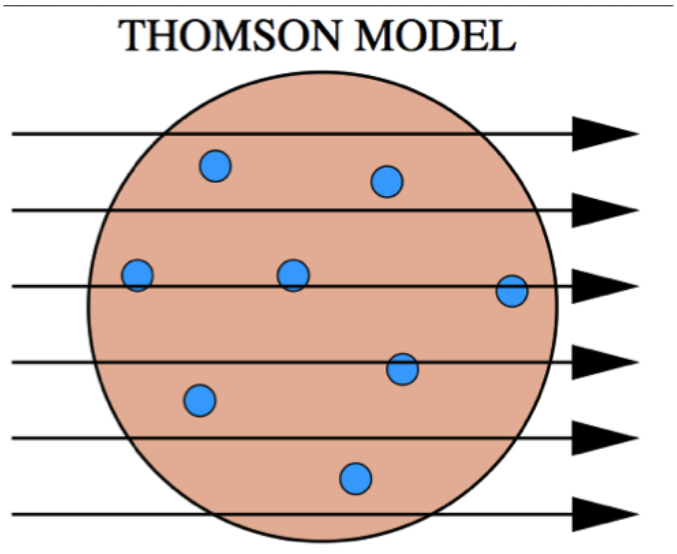


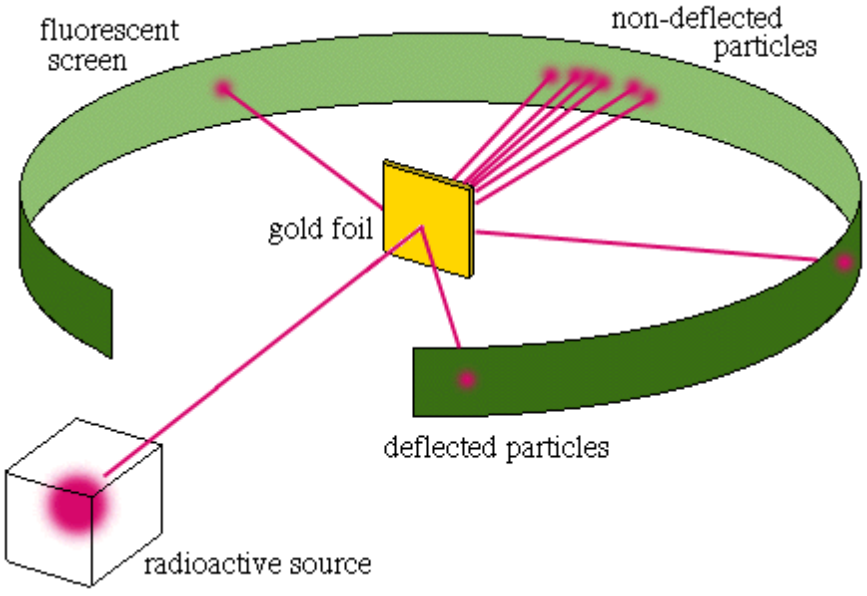
Fig – Thomson Lpum Pudding Model Source - Wikipedia

Ernst Rutherford (1871-1937) and his team (Geiger and Marsden) conducted a series of experiments that tested the plum pudding model. They took a very thin sheet of gold foil and bombarded it with alpha particles. If the alpha particles passed through, it would hit a barrier behind the foil.

The barrier was chemically treated to give flashes of light when it was struck. This barrier surrounded the gold foil in a circle. Thus, if the alpha particles bounced off the foil, a flash of light could also be seen on the barrier in front of the foil.

The plum pudding model predicted that the alpha particles would pass through the foil and hit the barrier behind the foil.

As expected, most of the alpha particles passed through the gold foil. Unexpectedly, however, some particles were deflected at wide angles, and some even bounced off the foil. This would not happen if the positive charge of an atom was spread out.



Rutherford suggested that the only way alpha particles could be scattered at wide angles is for the positive charge in the atom to be highly concentrated in a small region..

As a result of the work done by Rutherford, Geiger, and Marsden, our current model of the atom is as follows:

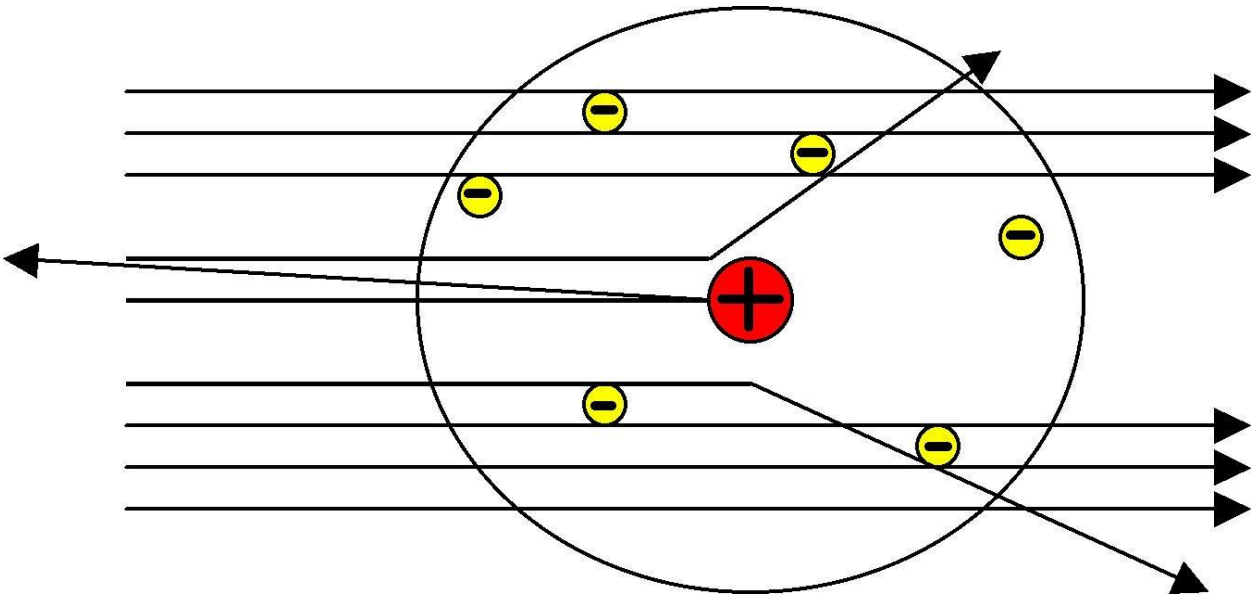
1. Protons and neutrons occupy the center of the atom, called the nucleus. Protons and neutrons are called nucleons.

2. The nucleus is very small.

3. Electrons orbit far from the nucleus.

4. This structure creates a lot of space in the atom, allowing positive particles to pass through.

5. If a positive charge approaches the nucleus, it is strongly repelled by the concentrated charge in the nucleus, causing a deflection at a wide angle.



To give you an idea of how much empty space there is in the atom, imagine that the nucleus is the size of a Ping-Pong ball. At that size, the electron would be the size of a tennis ball, and it would be more than 14 football fields away from the nucleus (14.76 football fields).