

4.3 Discovery of the atom

An atom is the smallest constituent of an element. The word atom comes from the Greek word 'atomos' meaning 'indivisible'. Up until the end of the 19th Century, atoms were considered to be the smallest components of matter. Two important discoveries overturned this picture of the atom. First, the electron was discovered (in 1897), and subsequently the nucleus (in 1911). These discoveries led to the picture of the atom being revised.



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Discovery of the electron

A British scientist, J.J. Thompson, discovered the electron in 1897. He used a

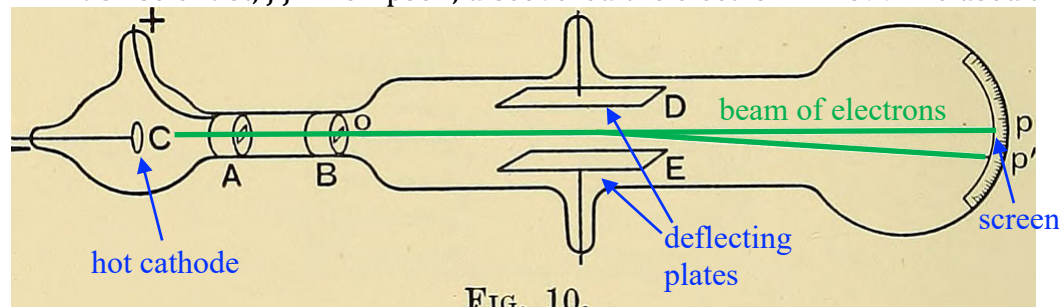


FIG. 10.

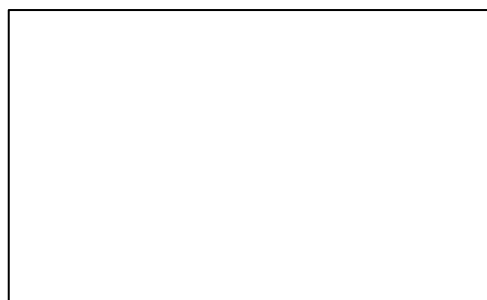
piece of equipment called a Crookes' tube. This produced a stream of electrons from a hot cathode. At the time these were referred to as 'cathode rays'. These were passed between two charged plates. The beam of electrons was deflected towards the positively charged plate and detected at the far end on a screen.

(1) *Why is the electron deflected towards the positively charged plate?*

By adjusting the potential difference across the plates and recording how much the electrons were deflected, Thompson was able to deduce the particles were negatively charged and at least one thousandth the mass of the least massive atom, hydrogen.

(2) *How would the angle of deflection compare for a more massive particle compared to a less massive particle (with the same charge)? Explain?*

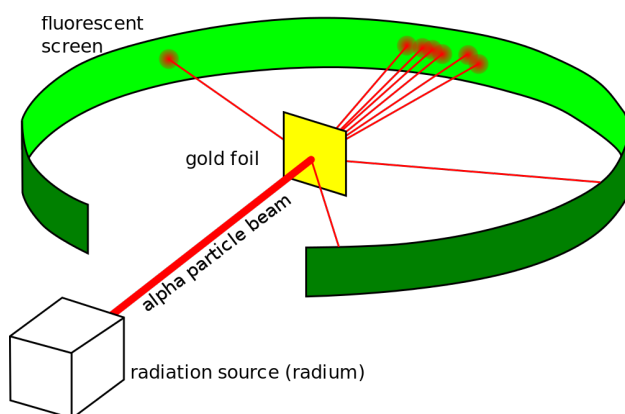
Having discovered the electron, a new model for the atom was proposed. This was called the 'plum pudding' model. A plum pudding is essentially a Christmas pudding. In this model the cake mixture represents 'positive stuff', whereas the raisins in the pudding represent electrons embedded in the 'positive stuff'.



(3) *Sketch a picture (left) of the 'plum pudding' model of the atom. Label the 'positive stuff' and the electrons.*

Discovery of the nucleus

Ernest Rutherford was a New Zealand scientist working in the UK. Along with his assistants Hans Geiger and Ernest Marsden, he discovered that the atom has a small, dense, positive nucleus. They came to this conclusion as the result of firing alpha particles at a thin sheet of gold, to probe the internal structure of the atom.



A radioactive source was used to produce a narrow stream of alpha particles which were directed at a thin sheet of gold.

(4) *Why do you think gold foil was used? (Hint: What is a property of gold that allows it to be made into thin sheets?)*

The experiment was contained in a container in which the air had

been evacuated.

(5) *Why do you think the air needed to be removed? (Hint: What do you know about how far alpha particles travel in air?)*

They used a fluorescent screen to detect the angle through which the alpha particles were deflected. A flash of light was produced (a 'scintillation') when an alpha particle hit the fluorescent screen.

(6) *Why do you think the beam of alpha particles needed to be narrow?*

Their findings:

- 1) Most of the alpha particles passed through without being deflected.
- 2) Some alpha particles (about 1 in 2000) were deflected through angles larger than predicted by the 'plum pudding' model.
- 3) A very small number (about 1 in 10000) were deflected by more than 90° .

(7) *Which of the findings, above, shows that the atom consists mostly of empty space?*

(8) *Which of the findings, above, shows that charge is concentrated in a nucleus. Explain.*

(9) *Which of the findings, above, shows that mass and charge are concentrated in a nucleus. Explain.*

A new model was proposed in which electrons are in orbit around a positively charged 'nucleus'.

(10)  Sketch a diagram showing the revised model of the atom. Label the positively charged nucleus and the orbiting electrons.

