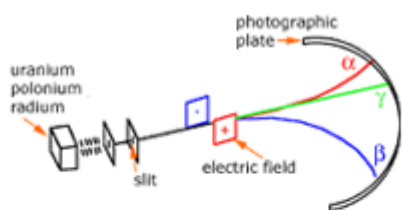


Understanding the Nucleus

key concepts:

- **Radioactivity** provided scientists in the early part of the twentieth century with a new tool for examining the interior of the **atom**.
- Ernest Rutherford discovered the **nucleus** of the atom using a beam of **α particles**.
- James Chadwick used a beam of α particles to indirectly detect **neutrons**.
- Since atoms were found to be divisible, Dalton's **atomic theory of matter** had to be revised.

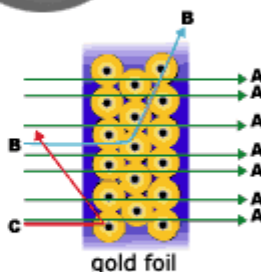
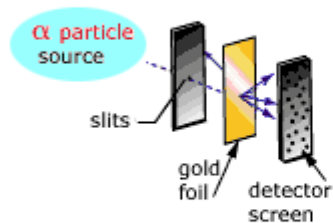
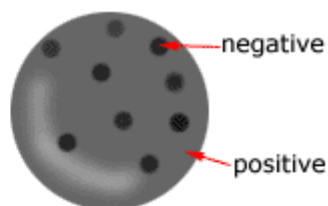


particle	behavior in an electric field	charge	mass/charge ratio
α	bends slightly toward negative	positive	large
β	bends greatly toward positive	negative	small
γ	travels linearly	neutral	—

Radioactivity provided scientists in the early part of the twentieth century with a new tool for examining the interior of the atom.

Certain **elements** (such as uranium, polonium, and radium) were found to emit particles with properties that could be utilized. Alpha particles (α particles) were particularly useful for probing the interior of the atom, due to their relatively large **mass** and easily detectable positive **charge**. In contrast, **gamma rays** (γ rays) have no measurable mass or charge.

Thomson's "Plum-Pudding" Model



The model so far:



We know atoms contain **protons** and **electrons**, but how are they arranged?

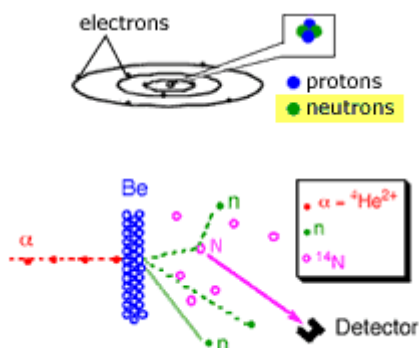
J. J. Thomson proposed a "plum-pudding" model. In Thomson's model, the electrons floated in a positive sea, allowing charge to balance overall.

Ernest Rutherford, with Hans Geiger and Ernest Marsden, discovered the nucleus of the atom using a beam of α particles.

Rutherford bombarded a sheet of gold foil with a stream of α particles. He found that most of the particles passed straight through the foil (A). About 1 in 8000 particles were deflected (B), sometimes at severe angles. Occasionally a particle bounced off the gold foil and moved back toward the source (C).

Rutherford explained these results by hypothesizing that nearly all of the mass of an atom is concentrated in a very small **volume**, called the nucleus. An analogy to the size of the nucleus versus the size of the atom is a light bulb (~10 cm) in the center of downtown Las Vegas (~1 x 10⁴ m).

Understanding the Nucleus



Scientists postulated the presence of a third particle with approximately the same mass as a proton, but with no charge. However, this third particle (now called the neutron) was difficult to observe, since it could not be detected using an electric field.

James Chadwick used a beam of α particles to indirectly detect neutrons. Chadwick sent a beam of α particles at a beryllium target in a nitrogen atmosphere. He then detected the N^- ions that were formed when neutral nitrogen molecules were struck by neutrons.

Dalton's Atomic Theory (published 1808)

1. All matter is composed of ~~indivisible~~ **atoms**.

Atoms are made up of protons, neutrons, and electrons.



2. An **element** is a type of matter composed of one type of atom with a characteristic ~~mass~~.

Each element has a characteristic nuclear charge, but an element can be composed of atoms of more than one mass.

3. A **compound** is a type of matter composed of two or more elements in fixed ratios.
4. A **chemical reaction** consists of the rearrangement of the atoms in the reactants.

The discovery of **subatomic particles** required that Dalton's atomic theory of matter be revised.

All **matter** is composed of atoms, but atoms are divisible into protons, neutrons, and electrons.

Each element has a characteristic nuclear charge (number of protons). However, atoms of a given element can have different numbers of neutrons, and therefore different masses.

However, since **chemical reactions** do not involve rearrangements of protons or neutrons, Dalton's atomic theory of matter still holds for chemical reactions.