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WORKSHEET 20

SCHOOL:BA SANGAM COLLEGE YEAR 12

SUBJECT: PHYSICS NAME OF STUDENT: _____________

STRAND	*ATOMIC PHYSICS*
SUB-STRAND	*RADIOACTIVITY*
Content Learning Outcome	

CHAPTER 7: ATOMIC PHYSICS

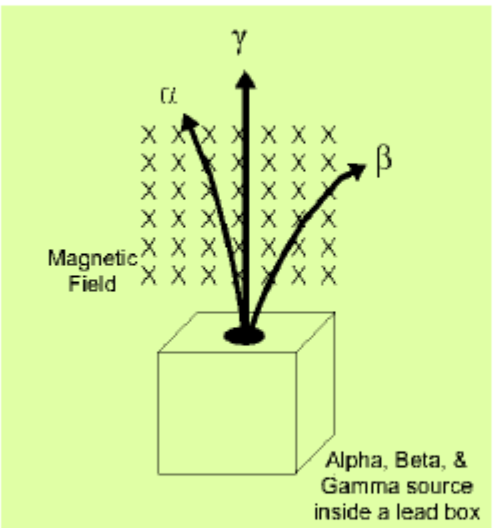
7.1 RADIOACTIVITY

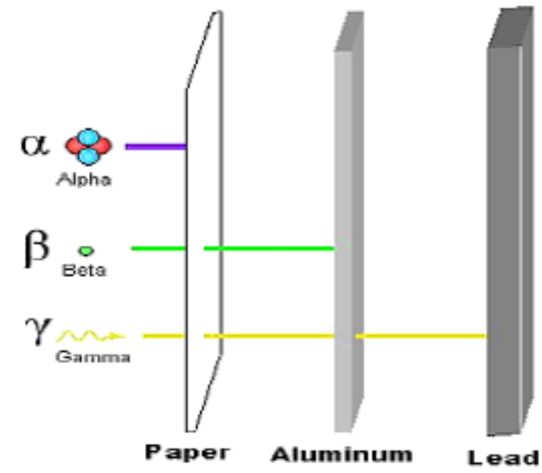
There are three distinct forms of radiation, originally divided up based on their ability to pass through certain materials and their deflection in magnetic fields.

Alpha (a **):** could barely pass through a single sheet of paper. Alpha particles are deflected as a positive particle in a magnetic field.

Beta (b **):** can pass through about 3mm of aluminum. Beta particles are deflected as a negative particle in a magnetic field.

Gamma (g **):** can pass through several centimeters of LEAD! It is not deflected in a magnetic field.





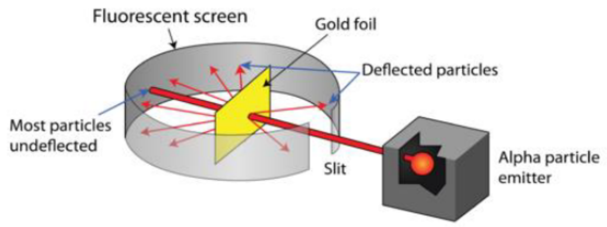
Radioactive decay, also known as **nuclear decay** or **radioactivity**, is the process by which a nucleus of an unstable atom loses energy by emitting ionizing radiation

RUTHERFORD'S EXPERIMENTS

In 1911, Ernest Rutherford (1871–1937) and his students Hans Geiger and Ernest Marsden performed a critical experiment that showed that Thomson's model could not be correct. In this experiment, a beam of positively charged alpha particles (helium nuclei) was projected into a thin metallic foil such as the target shown in Figure below.

Most of the particles passed through the foil as if it was empty space, but some of the results of the experiment were astounding.

Many of the particles deflected from their original direction of travel were scattered through *large* angles. Some particles were even deflected backward, completely reversing their direction of travel!

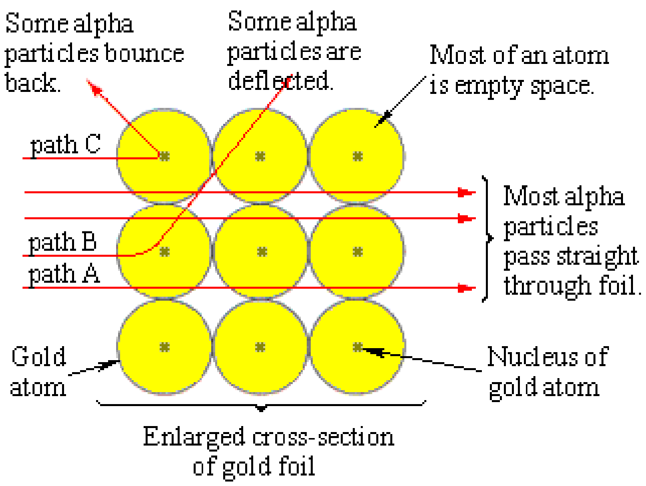


Rutherford made 3 observations:

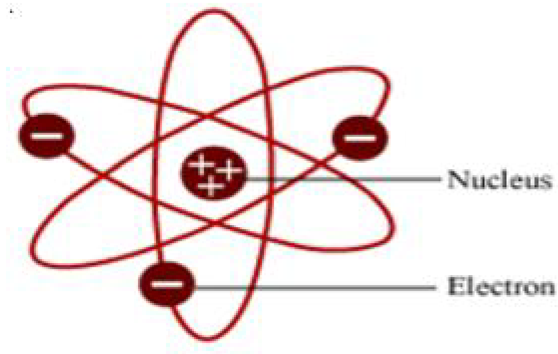
Most of the fast, highly charged alpha particles went whizzing straight through undeflected. This was the expected result for all of the particles if the plum pudding model was correct.

Some of the alpha particles were deflected back through large angles. This was not expected.

A very small number of alpha particles were deflected backwards! This was definitely not as expected. Rutherford later remarked "It was as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back at you.



Rutherford reasoned that the only way the alpha particles could be deflected backwards was if most of the mass in an atom was concentrated in a nucleus. He thus developed the planetary model of the atom which put all the protons in the nucleus and the electrons orbited around the nucleus like planets around the sun.



On the basis of these observations Rutherford made the following conclusions:
- Since most of the alpha particles passed straight through the gold foil without any deflection, most of the space within the atoms is empty.

-Since some of the alpha particles (which are big in size) were deflected by large angles or bounced backwards, they must have approached some positively charged region responsible for the deflection. This positively charged region is now called the nucleus

As very few alpha particles undergone the deflection, it was concluded that the volume occupied by the central region (nucleus) is very small.

-Since alpha particles which are relatively denser, were deflected by the central volume of charge, it shows that almost the complete mass of the atom must be within the central volume.

Drawbacks of Rutherford's Model

The Rutherford's atomic model explains the structure of an atom in a very simple way. But it suffers from the following drawbacks:
(i) An electron revolving around the nucleus gets accelerated towards the nucleus. An accelerating charged particle must emit radiation and lose energy. Thus, the electron in an atom must continuously emit radiation and lose energy and would slow down and will not be able to withstand the attraction of the nucleus. As a result it should follow a spiral path and ultimately fall into nucleus.

(ii) Rutherford model of atom does not say anything about the arrangement of electron in an atom.

Alpha Decay

During an alpha decay, a nucleus is able to reach a more stable state be allowing 2 protons and 2 neutrons to leave the nucleus. This will result in a smaller nucleus, which is often the more stable arrangement. Because 2 protons and 2 neutrons are really just helium-4, the particle that is emitted is really helium. Because this helium is not just regular helium floating around in the air, but is “born” from nuclear decay, we usually don't call it a helium atom. Instead we call it an alpha particle. Alpha particles come out of the nucleus as just nucleons without any electrons. So, each alpha particle has a charge of +2e

$$^{235}_{92}U \longrightarrow ^{231}_{90}Th + ^{4}_{2}He$$

A **helium nucleus**, the **alpha particle**, of 2 protons and 2 neutrons is **emitted** at high speed/kinetic energy **from the nucleus**.

Example: The iridium-168 isotope is known to go through alpha decays. Write out a decay equation that shows this process.

$$^{168}_{77}Ir \rightarrow ^{4}_{2}\alpha + ^{164}_{75}Re$$

Beta- Decay e.g. the nuclear equation

In the beta negative decay, the neutron becomes a proton (which stays in the nucleus) and an electron that goes out (the beta particle)

$$^{14}_{6}C \longrightarrow ^{14}_{7}N + ^{0}_{-1}e$$

Potassium-40 is known to go through beta positive decays. Write out the decay equation for this decay

$$^{40}_{19}K \rightarrow ^{0}_{1}\beta + ^{40}_{18}Ar$$

Gamma emission (g **): The emission of gamma radiation** from a nucleus does not involve any change in the atomic (proton) number or mass number.

Gamma radiation can only be stopped by stuff like a few inches of lead. This is because unlike the other two forms of decay, gamma decays emit a form of EMR, not a particle which allows it to pass through anything but the densest of matter.

The argon-40 that was produced in Example 4 is in an excited state, so it releases a burst of gamma radiation. Write the equation for this.

$$^{40}_{18}Ar \rightarrow \gamma + ^{40}_{18}Ar$$

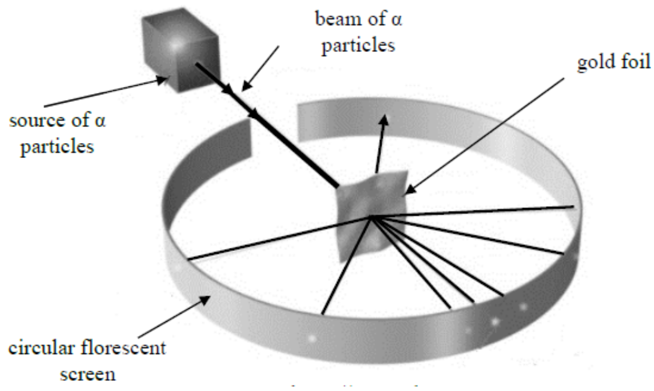
Exercise 1

Ernest Rutherford performed an experiment to determine the structure of an atom.

The experiment involved firing a beam of alpha particles from a radioactive source

towards a thin film of gold foil. The sketch below shows the three observed paths

of the alpha particles.



State one observation made in this experiment

Exercise 2

State **one** drawback of Rutherford’s atomic model.

Exercise 3

Draw and label the paths of **Alpha**, **Beta**, and **Gamma**, particles

passing through the magnetic field on the diagram given