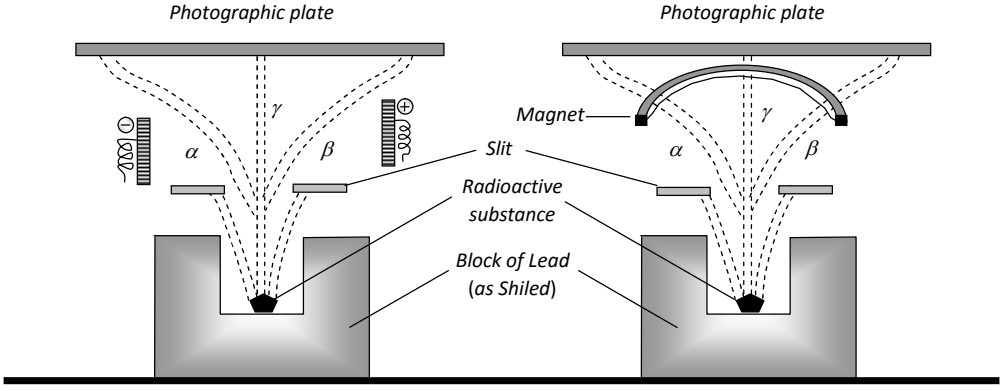
## Radioactivity.

"Radioactivity is a process in which nuclei of certain elements undergo spontaneous disintegration without excitation by any external means.''

- **Henry Becquerel (1891)** observed the spontaneous emission of invisible, penetrating rays from potassium uranyl sulphate $K_2UO_2(SO_4)_2$, which influenced photographic plate in dark and were able to produce luminosity in substances like ZnS.
- Later on, **Madam Marie Curie and her husband P. Curie** named this phenomenon of spontaneous emission of penetrating rays as, **Radioactivity**. They also pointed out that radioactivity is a characteristic property of an unstable or excited nucleus, i.e., a nuclear property is **independent** of all the external conditions such as pressure, temperature, nature of other atoms associated with unstable atom but **depends** upon the amount of unstable atom.
- **Curies** also discovered a new radioactive element **Radium** from pitchblende (an ore of U i.e. $U_3O_8$) which is about 3 million times more radioactive than uranium. Now a day's about 42 radioactive elements are known.
- The elements whose atoms disintegrate and emit radiations are called radioactive elements.
- Radioactivity can be detected and measured by a number of devices like ionization chamber, Geiger Muller counter, proportional counter, flow counter, end window counter, scintillation counter, Wilson cloud chamber, electroscope, etc. The proper device depends upon the nature of the radioactive substance and the type of radiation emitted. GM counter and proportional counter are suitable for solids and liquids, ionization chamber is most suitable for gases.
- Lightest radioactive isotope is tritium ($_1H^3$); other lighter radioactive nuclides are $^{14}C$, $^{40}K$ and $^{99}Tc$.

(1) **Nature of radioactive emissions:**The nature of the radiations emitted from a radioactive substance was investigated by **Rutherford (1904)** by applying electric and magnetic fields to the radiation as shown in figure.




**Study of the nature of radiations emitted form a radioactive substance**

It is observed that on applying the field, the rays emitted from the radioactive substances are separated into three types, called$\alpha$, $\beta$, and $\gamma$-rays. The $\alpha$-rays are deflected in a direction which shows that they carry positive charge; the $\beta$-rays are deflected in the opposite direction showing that they carry negative charge and the $\gamma$-rays are not deflected at all showing that they carry no charge.

(2) **Characteristics of radioactive rays:**Radioactive rays are characterized by the following properties:

(i) They blacken photographic plates.

(ii) They pass through thin metal foils.

(iii) They produce ionization in gases through which they passes.

(iv) They produce luminescence in zinc sulphide, barium platinocyanide, calcium tungstate, etc.

Radioactive radiations are composed of three important rays, namely $\alpha, \beta$ and $\gamma -$rays which differ very much in their nature and properties, e.g. penetrating power, ionizing power and effect on photographic plates. Remember that $\gamma$-rays are not produced simultaneously with $\alpha$ and $\beta$-rays but are produced subsequently.

**Comparison of $\alpha$, $\beta$ and $\gamma$-rays**

| **$\alpha$-Particle or $\alpha$-Ray** | **$\beta$-Particle or $\beta$-Ray** | **$\gamma$-Ray** |
|---|---|---|
| (1) **Charge and mass:**It carries 2 unit's positive charge and 4 unit mass. | It carries 1 unit negative charge and no mass. | These are electromagnetic rays with very short wavelength (app. 0.05 Å) |
| (2) **Nature:**It is represented as helium nucleus or helium ions $_2He^4$ or $He^{++}$. | It is represented as electron $-1e^0$. | It is represented as $_0\gamma^0$ |
| (3) **Action of magnetic field:**These are deflected towards the cathode. | These are deflected to anode. | These are not deflected. |

| | | |
|---|---|---|
| (4) **Velocity :** $2\times10^{9}\ cm/s$ or $2\times10^{7}\ m/\sec$ (1/10th to that of light) | 2.36 to $2.83\times10^{10}\ cm/s$ (2.36 to $2.83\times10^{8}\ m/s$) | Same as that of light $3\times10^{10}\ cm/s$ $(3\times10^{8}\ m/s)$ |
| (5) **Ionizing power:**Very high nearly 100 times to that of β-rays. | Low nearly 100 times to that of γ-rays. | Very low. |
| (6) **Effect on ZnS plate:**They cause luminescence. | Very little effect. | Very little effect. |
| (7) **Penetrating power :** Low | 100 times that of α-particles. | 10 times that of β-particles. |
| (8) **Range:**Very small (8-12 cm.) | More that of α-particles. | More |
| (9) **Nature of product:**Product obtained by the loss of 1 α-particle has atomic number less by 2 units and mass number less by 4 units. | Product obtained by the loss of 1 β-particle has atomic number more by 1 unit, without any change in mass number. | There is no change in the atomic number as well as in mass number. |

Note: β-particles originates in the nucleus; they are not orbital electrons.

β-particles having their velocity almost equal to velocity of light are known as hard β-particles and the others having their velocity $\approx 1\times10^{10}\ cm\ \sec^{-1}$ are called soft **β-particles.**

γ-radiation always accompany alpha or beta emissions and thus are emitted after α- and β-decay.

Only one kind of emission at a time is noticed. No radioactive substance emits both α- and β-particles simultaneously.