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Radioactivity

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* Nuclear Physics.

* Fundamental Particles.

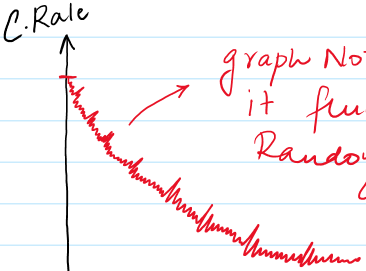
Nuclear Physics.

① Process of Radio Activity is a Random & a spontaneous process ∴

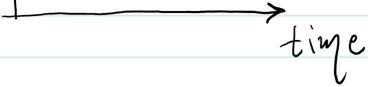
Random ∴ Count rate emitted from any Radio active Source fluctuates over time.

How can we confirm the Random Nature of Radio Activity.

* Plot a graph of Count Rate against time. If the graph is not smooth then this confirms the random nature



graph Not smooth i.e it fluctuates ∴ Random nature confirmed



Spontaneous :- The term spontaneous nature means that the process of Radioactivity does NOT depend on any changes taking place in the external environmental conditions i.e changes in Pressure, changes in Temperature ; Presence or absence of Electric field or magnetic field etc etc.

Q:- How can we check for Spontaneous nature

Ans. Take two identical R. Sources. Place them at different Temperatures. Obtain the Count-rate at specific time intervals from both sources & plot a Graph of Count-Rate against time.

If the value of half life obtained from both graphs is almost the same than it indicates / confirms the Spontaneous nature of Radio Activity

Types of Radiations & their Properties.

① Alpha Particles :-

- α
- resembles a helium nuclei
- consists of 2 protons & 2 neutrons
- denoted as $^{4}_{2}\alpha$ or $^{4}_{2}He$
- carries a charge of $+2e$ where $1e = 1.6 \times 10^{-19} C$ i.e charge of a proton
- Carries a mass of $4u$ where $1u = 1.67 \times 10^{-27}$ kg.
- α particles travel with Speed of 10% of speed of Light
- All α particles have the same Kinetic Energy ∴ They travel approximately the same distance in Air.
- They have a range of 4-5 cm in Air
- They have least Penetration Power i.e they can be stopped by a piece of paper
- They have maximum ionization effect in Air
- They deflect in Electric & mag. fields.

- During an alpla decay i.e (α emission), the mass number of the Parent nucleus decreases by 4 & the proton # of the parent nucleus decreases by 2 as shown

$$\underbrace{{}^{220}_{82}X}_{\text{Parent nucleus}} \longrightarrow {}^{4}_{2}\alpha + \underbrace{{}^{216}_{80}Y}_{\text{Daughter nucleus}}$$

$${}^{A}_{Z}X \longrightarrow {}^{4}_{2}\alpha + {}^{A-4}_{Z-2}Y$$

Beta Particles

- Resembles an electron
- denoted by the symbol of ${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$
- carries a charge of $-1e$ where e = charge of an electron i.e 1.6×10^{-19} C
- mass of β particle is equal to the mass of an electron i.e 9.11×10^{-31} kg.

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- They travel with speeds ranging from 90% to 99% of the speed of light
- They have a range of Kinetic Energy.
- They will pass through Paper but can be stopped by a few mm thick Aluminium sheets
- They offer moderate ionization
- They also deflect in Electric & magnetic fields
- During a β emission, the mass number of parent nuclei remains unchanged whereas the proton # increases by one

$$\underbrace{{}^{40}_{20}X}_{\text{Parent nuclei}} \longrightarrow {}^{0}_{-1}\beta + \underbrace{{}^{40}_{21}Y}_{\text{Daughter nucleus}}$$

$${}^{A}_{Z}X \longrightarrow {}^{0}_{-1}\beta + {}^{A}_{Z+1}Y$$

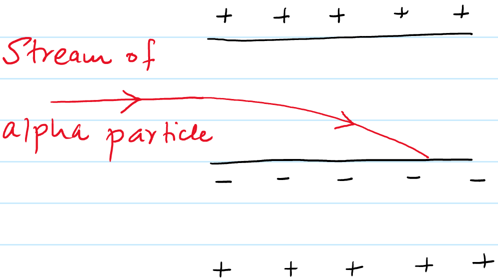
Q:: Why Proton # increases by 1 and mass number remains unchanged during a β emission?

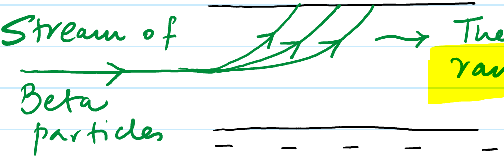
Ans:- During a β emission it is believed that a neutron inside the nucleus, splits to form a proton and an electron.
The proton stays inside the nucleus & the electron is emitted from the nucleus in the form of a β particle hence mass # remains unchanged

n reduces by 1 & p increases by 1

proton # increases by one b/c of this extra proton

- β particles have a range of a few meters in Air.
- Since β are lighter than α $\therefore$ they deflect more easily in electric & magnetic fields.





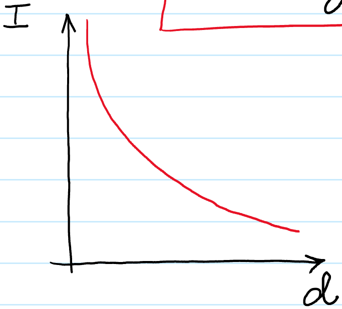
Stream of Beta particles

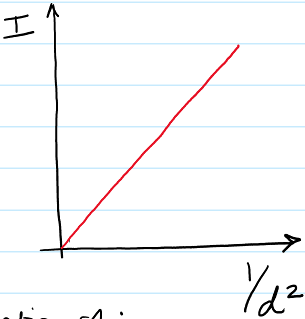
They have range of K.E

Gamma Radiations.

- high freq E.M.R
- neither any mass nor any charge
- symbol γ
- Speed of light
- negligable / zero ionization
- max / infinite Range in Air
- stopped by a few cm thick Lead sheets
- No deflection in Electric & magnetic fields.
- Produced in almost all Nuclear Reactions
- Being Electromagnetic WAVES, they follow wave properties. i.e The Intensity (I) of gamma rays is known to be inversely proportional to the square of the distance (d).

$$\boxed{I \propto \frac{1}{d^2}}$$





Note :- The above relationship means that if we double the distance from the source emitting γ-rays, the Intensity reaching us will reduce to become $\frac{1}{4}$th.