Recap

properties of α- β- γ rays →

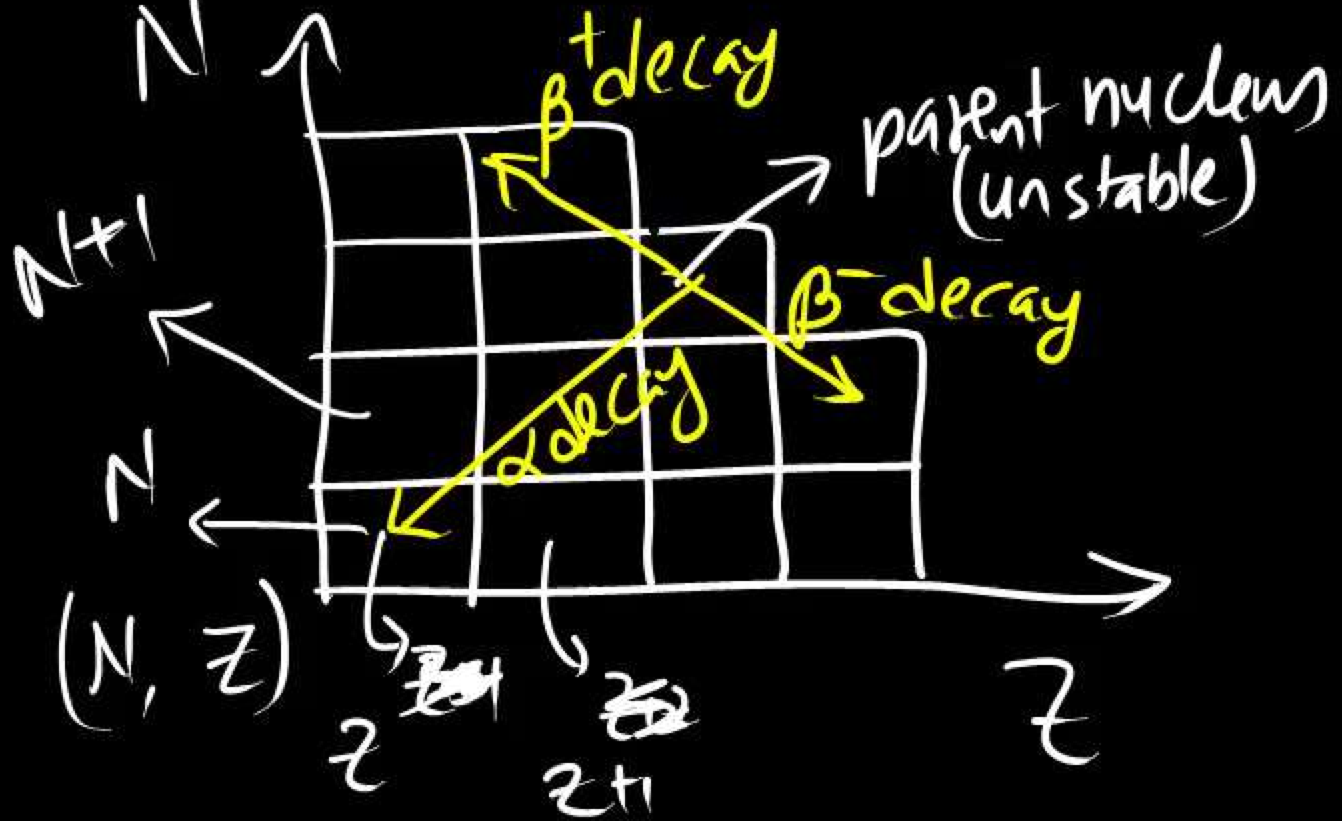
	α	β	γ
1). Symbol	$^{4}_{2}He$	$^{0}_{+1}\beta$ / $^{0}_{-1}\beta$	$^{0}_{0}\gamma$
2). charge	+2e	+e/-e	0
3). mass	$4m_p$	m_e	rest mass = 0
4). speed	10^7 m/s. characteristic of nucleus	1% of c to 99% of c its not a characteristic speed	only c not a characteristic speed.
5). K.E.			
6). Energy spectrum			
7). Ionization power			
8). Penetration power			

37th Session: Modern Physics III
Nuclear Fission & Fusion

- Recap
- Nuclear fission
    - Nuclear fuel
    - Chain reaction
    - Critical size
    - Nuclear reactor & breeder reactors
    - Fast breeder reaction
- Nuclear fusion

	α	β	γ
KE	MeV	MeV	MeV
Energy spectorm	discrete/line	Continuous	discrete/line
Ionization power	100,00	100	1
Penetration power	(1/100,00)	(1/100)	1
Effect of elect & Mag field	deflection	def.	No deflection.

Radioactive Displacement Law



Q.1 In which of the following, element doesn't change?

Q.2 ____"____, at. no decreases?

(A) α - decay

(B) β^+ -"-

(C) β^- -"-

(D) γ -"-

Nuclear Fission

Nuclear fuel

Nuclear fission rxn (role of neutrons)

Chain reaction → How to control

Nuclear reactor

Nuclear Fission → Splitting of an unstable (heavy) nucleus into lighter fragments, when struck by neutrons.

→ There exists an energy barrier to cross to form stable nuclei. To cross that energy barrier, neutrons are ~~strike~~ struck to parent nucleus.

Nuclear fuel → Criteria for using a nuclear fuel is its abundance. Uranium (U^{238}) → most abundant nuclear fuel.

→ On an average, only two ppm concentration of ^{238}U is available.

Nuclear Fuel → $^{238}U \longrightarrow {}^{238}U + {}^{235}U$

^{238}U: 99.3 % → this is stable nucleus.

^{235}U: (0.5 – 0.7 %) → this is radioactive

Enrichment → ^{235}U percentage is increased to 3 %. Rest is ^{238}U.

$$A + n \longrightarrow B + C + Q$$

A → heavy nucleus

B, C → Comparable mass nos.

Q → (energy)

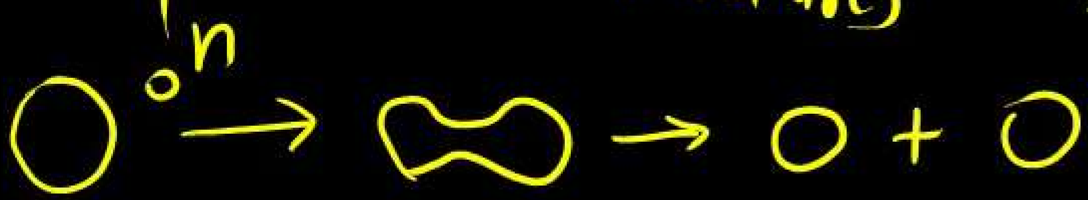
Nuclear fission Reaction →

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{236}_{92}U \rightarrow {}^{140}_{56}Ba + {}^{93}_{36}Kr + 3\,{}^{1}_{0}n + 200\,MeV$$

(Slow moving) (0.04 MeV)

$^{236}_{92}U$ ↓ (not found in nature)

$$^{236}_{92}U \rightarrow {}^{137}_{53}I + {}^{97}_{39}Y + 2\,{}^{1}_{0}n + 200\,MeV$$



→ Energy generated in each fission event → 200 MeV

→ Out of this ~ 15-20 MeV taken by $^{1}_{0}n$

further decays →

$$^{97}Y \xrightarrow{\beta^-} {}^{97}Zr \xrightarrow{\beta^-} {}^{97}Nb \xrightarrow{\beta^-} {}^{97}Mo$$

$$^{137}I \xrightarrow{\beta^-} {}^{137}Xe \longrightarrow {}^{136}Xe + {}^{1}_{0}n$$

Radiation types → β-rays, neutrons, γ rays, α-rays, $\nu, \bar{\nu}$

Chain Reaction → Secondary neutrons can start 2 to 3 more nuclear reactions. And these reaction may further generate upto 9 neutrons & a lot of energy. This is called as an uncontrolled chain reaction.

How can a chain reaction be controlled → If neutrons can be removed or absorbed then it can be controlled.

$$k, \text{reprod}^n \text{ factor} = \frac{\text{rate of prod}^n \text{ of neutrons}}{\text{rate of loss/absorption of neutrons}}$$

if $k > 1 \Rightarrow$ uncontrolled chain rxn, if $k < 1 \Rightarrow$ stoppage of fission.

Nuclear Reactor

ABLES KOTA

→ U^{238} can absorb fast moving neutron

→ k, reprodn factor depends upon the size of uranium fuel.

→ for k = 1, there is a critical size of Uranium fuel.

if size < critical size ⇒ k > 1 ⇒ chain rxn.↑

size > —"— ⇒ k < 1 ⇒ rxn will stop

size = —"— ⇒ k = 1 → controlled rxn

Nuclear Reactor