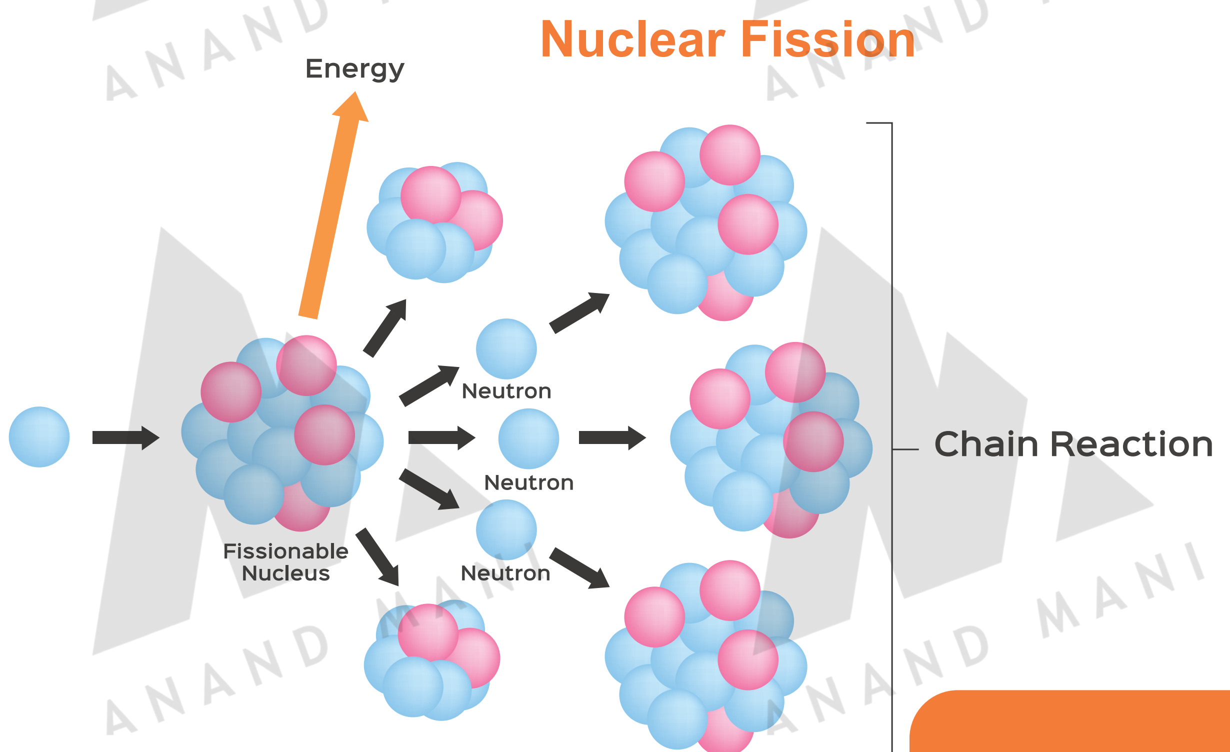
Nuclear

Nuclear fission
- Splitting of a heavy nucleus into or more lighter nuclei.

e.g $\Rightarrow$ $_{92}U^{235} + 0^{n^1} \rightarrow _{56}Ba^{141} + _{36}kr^{92} + 3 0^{n^1} + 200Mev$

- Uncontrolled chain reaction: principle of atomic bank.
- Contralled chain reation: principle of nuclear reactors.

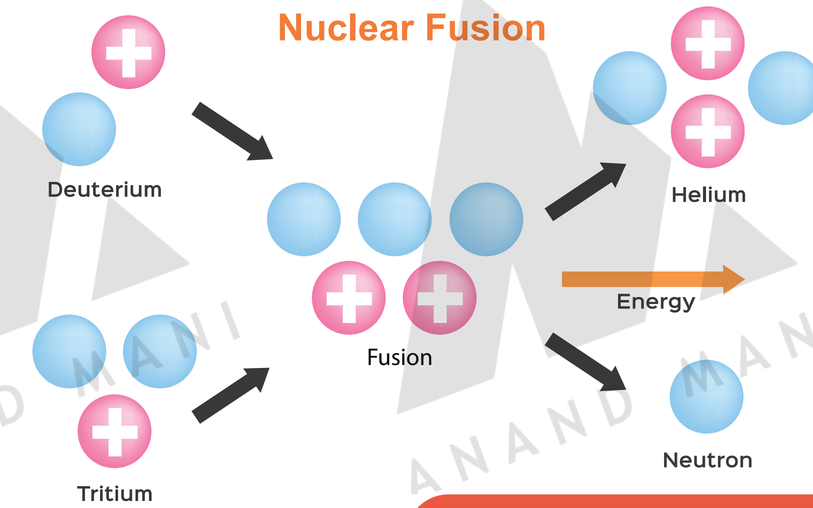


Nuclear fusion
- Combining two lighter nuclei to form a heavy nucle us.

$^1_1H + ^1_1H \rightarrow ^2_1H + e^+ + \nu + 0.42$ (energy)

Application

Nuclear fussion is the source of energy in the sun and stars.



Nuclear of an atom onsists of proton and neutrons collectively called nucleons.

Representation

$_ZX^A$

A = mass number

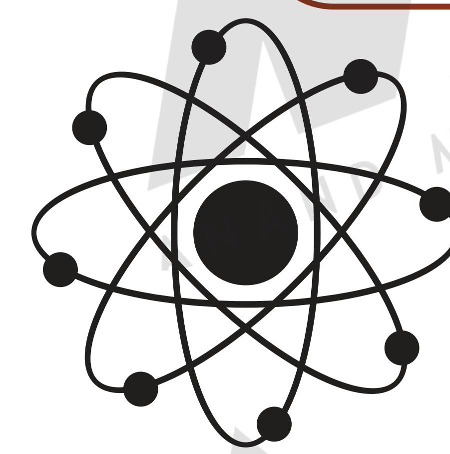
Z = Atomic number

Nuclei can be
- Isotoper (same Z but different A)
- Isobars (same A but different Z)
- Isotores (same N but different A)

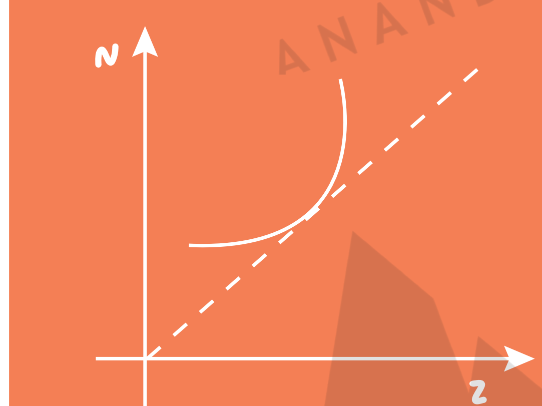
Radio activity

Discovered by henri Becquerel in 1896

Phenomenon of disintegrakon of heavy elements into comparatively lighter elements by emission of α, β, & γ radiations.



Nuclear force theory
- Nuclear force is a force which holds the nucleons together.



- For atomic number $<$ 20, most stable nuclei have N:P ratio nearly 1:1
- For atomic number $>$83, there are no stable nuclei.
- A nucleus is stable when its Binding energy per nucleus value is around 8 mev per nucleon or more.
- Following are observations from Binding energy per nucleon versus mass number cerve.

- B.E. per nucleon is more for some nuclei than their neighbours. This andicates a shell type structure of nucleus.
- B.E. per nucleon is around 8mev FOR 30 $\angle$A $\angle$120. these are stable elements.

Rodius of a nucleus
R = R0 A 1/3 { R0 = 1-2fm}

- Density of nucleus (S)

$$\frac{Mass}{Volume} = \frac{Mass\ of\ 1\ nucleon \times A}{\frac{4}{3}\pi R^3 = \frac{1}{2}\pi R_0^3 A}$$

- Nuclear density is constant its value is nearly 2.38 × 1017 kg/m3
- Mass of nucleus is measured in atomic mass unit (u) or (amu) 1 amu (or u) = 1/12 (mass of C^{12}) atom = 1.6 × 10^{-27} kg
- Mass defect

The difference (Δm) between mars of constituent nucleons and nucleus is called mass defect of nucleus.

[Δm = sum of the masles of nucleons – mass of nucleus]

= {Zm^p + (A – Z)m_n} – M_N

Binding Energy of Nucleus
$\Rightarrow$ B.E = Dmc^2

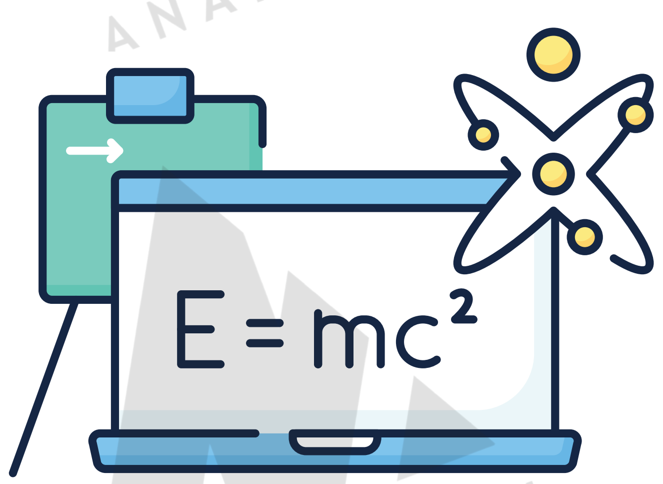
$\Rightarrow$ B.E = $[Zm_p + (A - Z) m_N - m_N]c^2$

(where. c is the speed of light c = 3 × 10^8 m/sec)

$\Rightarrow$ B.E per nucleon = $\frac{B.E}{No.\ of\ nucleons}$

Nuclear binding energy is maximum for mass number 50-60.

Mass and energy
- Mass m of a particle is equivalent to energy given by E = mc^2
- Also known as rest mass energy.



Q-value

A + B	–	C + D + Energy
mA mB	mc	md
Reactants		Product + Q- value
Q value	=	B.E of product - B.E. of reactants
Q-value	=	[(m_A + m_B) - (mC + mD)] C^2
Q-value	=	[(k.E_C + k.E_D) -(K.E_A + K.E_B)]

α decay
- radiations are the helium nuclei. These are emitted as

$^A_ZX \rightarrow ^4_2He + _{Z-2}^{A-4}Y$

α-particle

Daughter nuclei

- highest ionizing power but least penetrating power.

β– decay
two types

β+ (positron) β (electrons)

$^A_ZX \rightarrow ^0_{-1}\beta + ^A_{Z+1}Y + \bar{\nu}$

(electron) (antineutrina) (product)

$^A_ZX \rightarrow ^0_{+1}\beta + ^A_{Z-1}Y + \nu$

(position) (nutrino)

- less ionizing power than α -particle and moderate penetrating power.

γ decay
γ-decay office an α or - decay, nucleus vibrates with the energy shared by it and electromagnetic waves of very high frequency (α-radition) are emitted least ionizing power but highest penetrating power.

Law of radio activity

$$\frac{-dN}{dt} = \lambda N$$

$$N = N_0 e^{-\lambda t}$$

Half - life
where $N = \frac{N_0}{2}$

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

Fraction of nuclei left undcayed after n half lives is

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

where, t = n$T_{1/2}$

Mean life or any life

$$\tau = \frac{1}{\lambda} = \frac{T_{1/2}}{0.693} = 1.44\ T_{1/2}$$

Decay rate or activity

$$R = -\frac{dN}{dt}$$

$R = \lambda N_0 e^{-\lambda t}$ or $R = R_0 e^{-\lambda t}$