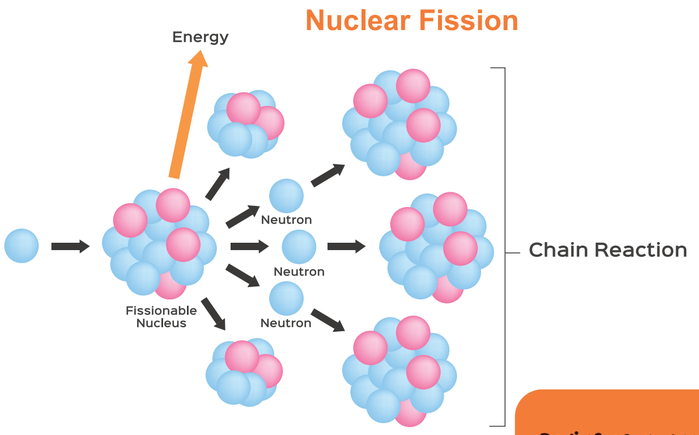
Nuclear

Nuclear fission

- Splitting of a heavy nucleus into or more lighter nucler.

e.g ⇒ $_{92}U^{235} + 0^{n^1} \rightarrow_{56} Ba^{141} +_{36} kr^{92} + 30^{n^1}$ + 200Mev

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



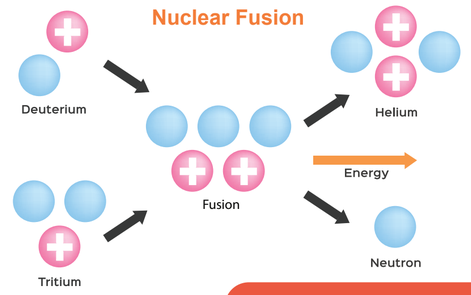
Nuclear fusion

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

$^1_1H + ^1_1H \rightarrow ^2_1H + e^+ + v + 0.42$ (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.

Nuclei can be

- Isotoper (Same Z but different A)
- Isobars (Same A but different Z)
- Isotores (Same N but different A)

Representation

2xA
A = mass number
Z = Atomic number

Radio activity

discoverd by henri Becauerel in 1896

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

α decay

- radiations are the helium nuclei. These are emitted as

$$^A_Z X \rightarrow ^4_2 He + ^{A-4}_{Z-2} Y$$

α-particle ↓ Daughter nuclei

- highest ionizing power but least penetrating power.

β– decay

two types

β + (positron) — β (Electrons)

$$^A_Z X \rightarrow ^0_{-1}\beta + ^A_{Z+1} Y + \bar{v}$$

(electron) ↓ (antineutrina) ↓ (Product)

$$^A_Z X \rightarrow ^0_{+1}\beta + ^A_{Z-1} Y + V$$

(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, $t = NT_{1/2}$

Mean life or any life

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

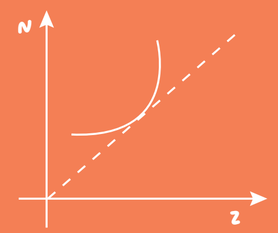
decay rate or activity

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

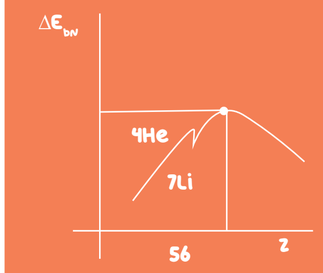
$R = \lambda N_0 e^{-\lambda t}$ or $R = R_0 e^{-\lambda t}$

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 ∠A ∠120. these are stable elements.

Rodius of a nucleus

R = R0 A 1/3 { R0 = 1-2fm}

- Density of nucleus (S)

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

- 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

⇒ $B.E = DMC^2$

⇒ $B.E = (ZM_p + (A - Z)\ M_N - M_N)c^2$

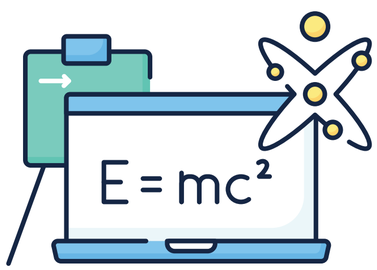
(where, c is the speed of light $c = 3 \times 10^8$ m/sec)

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

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	=	$((k.E_C + k.E_D) - (K.E_A + K.E_B)]$