NUCLEAR PHYSICS

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MASS DEFECT

Mass Defect = $M_{expected} - M_{observed}$

$\Delta m = [Zm_p + (A - Z)m_n - [M_{atom} - Zm_e]$

BINDING ENERGY

It is the minimum energy required to break the nucleus into its constituent particles.

Binding Energy (B.E.) = $\Delta mc^2 = \Delta m \times 931$ MeV

● Binding energy per nucleon is more for medium nuclei than for heavy nuclei. Hence, medium nuclei are highly stable.

● *The heavier nuclei* being unstable have tendency to split into medium nuclei. This process is called Fission.

● *The Lighter nuclei* being unstable have tendency to fuse into a medium nucleus. This process is called Fusion.
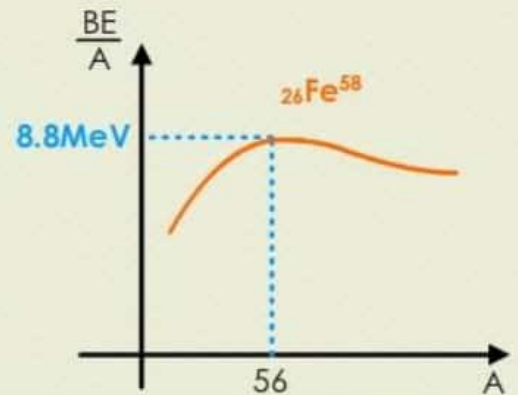
RADIOACTIVITY

● It was discovered by Henry Becquerel.

● Spontaneous emission of radiations (α, β, γ) from unstable nucleus is called radioactivity. Substances which show radioactivity are known as radioactive substance.

● *In radioactive decay,* an unstable nucleus emits α particle or β particle. After emission of α or β particle the remaining nucleus may emit γ- particle, and convert into a more stable nucleus.

α- particle

It is a doubly charged helium nucleus. It contains two protons and two neutrons.

Mass of α - particle = Mass of $_2H$ e^4 atom $- 2m_e = 4\,m_p$

Charge of α - particle = $+ 2e$

β- particle

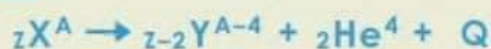| β^- (electron)	β^+ (positron)
Mass = m_e : Charge = $- e$	Mass = m_e : Charge = $+ e$
	positron is an antiparticle of electron.

γ- particle

They are energetic photons of energy of the order of MeV and having zero rest mass.

RADIOACTIVE DECAY (DISPLACEMENT LAW)

1 α - DECAY

$$_zX^A \longrightarrow _{z-2}Y^{A-4} + _2He^4 + Q$$

Q value is definied as energy released during the decay process.

Q value = rest mass energy of reactants − rest mass energy of products

Let, M_x = mass of atom $_zX^A$, M_y = mass of atom $_{z-2}Y^{A-4}$, M_{He} = mass of atom $_2He^4$
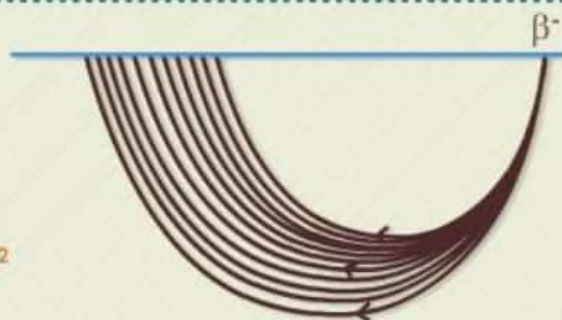
$$Q \text{ value} = [M_x - M_y - M_{He}]c^2$$

$$_zX^A \longrightarrow Y + _2He^4 + Q$$

2 β⁻ - DECAY

$$_zX^A \longrightarrow _{z+1}Y^A + _{-1}e^0 + Q$$

$$T_e = \frac{m_y}{m_e + m_y}Q, \quad T_y = \frac{m_e}{m_e + m_y}Q,$$

Q value = $[M_x - \{(M_Y - m_e) + m_e\}]c^2 = [M_x - M_y]c^2$

β⁻

3 β⁺ - DECAY

$$_zX^A \longrightarrow _{z-1}Y^A + _{+1}e^0 + \nu + Q$$

Q value = $[M_x - \{(M_Y + m_e) + m_e\}]c^2 = [M_x - M_y - 2M_e]c^2$

RADIOACTIVE DECAY : STATISTICAL LAW

- Rate of radioactive decay **is directly proportional to N**
- where N = number of active nuclei.
- Rate of radioactive decay of $A = \dfrac{-dN}{dt} = \lambda N$
- where λ = decay constant of the radioactive substance.
- Number of nuclei decayed (i.e., the number of nuclei of B formed)

$$N = N_0(1 - e^{-\lambda t})$$

1 HALF LIFE (T₁/₂)

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

2 ACTIVITY

Activity is defined as the rate of radioactive decay of nuclei

$$A = A_0 e^{-\lambda t}$$

3 AVERAGE LIFE

$$T_{avg} = \frac{\text{sum of ages of all the nuclei}}{N_0} = \frac{\int_0^\infty \lambda N_0 e^{-\lambda t} dt \cdot t}{N_0} = \frac{1}{\lambda}$$

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