Session – 36th – Modern Physics – III

(Radiactive Decay & Nuclear Fission)

We will switch to other room

Recap :- Q.1 Find Q-value

$^{25}Al \rightarrow {}^{25}Mg + e^+ + \nu$

(^{25}Al: 24.990432u) (^{25}Mg: 24.985839u)

$m_e = \frac{0.511\ MeV}{c^2}$

$$Q = [\Sigma m_R - \Sigma m_P]c^2$$

$$= \left[[24.99 - (24.98)]u - \frac{2\times 0.511\ MeV}{c^2}\right]c^2$$

$$= \left[(24.99 - 24.98)\times\frac{931.5}{c^2} - \frac{2\times 0.511}{c^2}\right]c^2\ MeV$$

$= 3.254\ MeV$

Q.2 $^{226}Ra \xrightarrow{\alpha\text{-decay}}$

$(K)_\alpha = 4.78\ MeV$

Find Q-value

$$K_\alpha = \frac{m_Y}{m_\alpha + m_Y} Q$$

$$4.78 = \frac{222}{226} \times Q$$

$$\Rightarrow Q = \frac{4.78\times 226}{222}\ MeV = 4.866\ MeV$$

Q.3 $^{64}Cu \rightarrow {}^{64}Ni + e^+ + \nu$

$(K_{max})_{positron} = 0.68\ MeV \rightarrow$ Qvalue

Find energy of neutrino which emitted with positron of 0.18 MeV.

$$K^{max}_{positron} \simeq Q$$

$$K_{neutrino} = Q - 0.18$$

$$= 0.68 - 0.18 = 0.50\ MeV$$

Q.4 Comment on sign of Q-value.

a) Isolated proton $\rightarrow {}^1_0n$

b) — " — neutron $\rightarrow$ proton

Q.5 What is the difference b/w β-rays, cathode rays, thermions, photoelectrons?

Q.6 Can we get γ photons in β-decay also?

Q.7 Can there be other kinds of radioactive processes other than α- β- γ decays?

Q.4. Q-value → sign?

isolated proton → $^{1}_{0}n$ —

—11— neutron → proton +

Q.5. what is the diff. b/w β-rays, thermions, photoelectrons & cathode rays.

ORIGIN

Q.6 Can we have γ photons in β-decay?

Ans. Yes.

Q.7. Other kinds of RA processes except α-β-γ decays.

Ans. Yes → Nuclear fission

→ —11— fusion

β^+-decay

$$ {}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}\beta + \underset{(E_1)}{\nu} + \underset{(E_2)}{\gamma} + Q $$

$p_y = p_\beta$

$$ k_y = \frac{(m_\beta)}{m_y + m_\beta} Q^* $$

$$ k_\beta = \frac{(m_y)}{m_y + m_\beta} Q^* $$

$m_y \gg m_\beta$

$\Rightarrow \boxed{k_\beta \gg k_y}$

$Q^* = Q - (E_1 + E_2)$

Radioactive Decay

Electron Capture → (excess protons)

$$ {}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + \nu + Q + \text{ch. X-rays} $$

$K_y = (Q - E)$

Z: $p \to Z$, $n \to (A-Z)$

$Z-1$: $p \to (Z-1)$, $n \to (A-Z+1)$, (E)

$$ {}^{1}_{1}p + {}^{0}_{-1}e \to {}^{1}_{0}n + {}^{0}_{+\nu}\nu $$

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

$$ Q = \underbrace{\left[\left(m_x - Z m_e\right) + m_e\right]}_{m_{reactants}} - \underbrace{\left(m_y - (Z-1)m_e\right)}_{m_{products}} c^2 $$

Δm

$$ = \left(m_x - Z m_e + m_e - m_y + Z m_e - m_e\right)c^2 $$

$$ = (m_x - m_y)c^2 $$

Note → Q-value is distributed b/w y & ν.

$\beta(-)$ decay (excess neutrons)

$$ {}^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}\beta + \bar{\nu} + Q $$

$$ Q^* = Q - (E_1 + E_2) $$

$$ {}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta + \underset{(E_1)}{\bar{\nu}} + \underset{(E_2)}{\gamma} + Q $$

$$ K_\beta = \left(\frac{m_y}{m_y + m_\beta}\right) Q^* $$

$$ Q = \underbrace{\left[(m_x - Z m_e) - \left\{ [m_y - (Z+1)m_e] + m_e \right\} \right]}_{\Delta m} c^2 $$

$m_{reactants}$ $\qquad$ $m_{products}$

$$ = (m_x - Z\cancel{m_e} - m_y + Z\cancel{m_e} + \cancel{m_e} - \cancel{m_e})c^2 $$

$$ = (m_x - m_y)c^2 $$