21/09/17

Radio activity

* Discovered by Henry becqurrel.

* Further Studyed by Rutherford
* Radioactivity is spontentious decay of nucleus by the emittion of α, β, γ Radiations and the active nuclei is Known as Radio active ~~active~~

*

* α Particles:
doubly ionised helium Particle are Known as α-Particles

mass of α Partices: 4 times of M_P ($+M_P$)
Charge on α Particle: $q_\alpha = +2e$.

* β-Particles: $+\beta$ (Positron)
$-\beta$ (electron)

$+\beta$ – $M_{+\beta} = m_e$
$q_{+\beta} = +e$

$-\beta$ – $M_{-\beta} = M_e$
$q_{-\beta} = -e$.

Antiparticles:

if Two Particle collide with each other and they completely destroy and they annihalate (destroyed) completely ~~is~~ ~~know~~ into ~~and~~ convert into energy. is Known as antiparticle

Ex: Positron and electron are antiparticles of each other

Ex: & Antineutreno and neutrino are antiparticles

* γ Rays / γ Particles:

Energetic Photones emitted from the nucleus of radioactive elements γ rays donot have any rest mass and their do not rest charge

* α decay:

Reaction:

$$X_Z^A \longrightarrow Y_{Z-2}^{A-4} + \alpha + Q$$

[Energy Release]

$Q \Rightarrow$ Q value

$$Q = \Delta m c^2$$

~~Q-value~~ :⇒

Mass of X ⇒ $Z M_p + (A-Z) m_N$

OR

$[\text{Mass of Atom } X - Z m_e]$

Mass of Y ⇒ $[M_y - (z-2) M_e]$

Q value: $E = \Delta m c^2$

$[M_x - 2M_e] - [M_y - Z m_e + 2 M_e + M_{He} - 2 M_e]$

$$Q = [M_x - (M_y + M_{He})] c^2$$

* Calculation of K.E of α Particle / Daughter Nucleus:

$\vec{P_1} = -\vec{P_2}$

$Q = \Delta m c^2$

$K.E_y + K.E_\alpha = Q$

$\frac{P^2}{2 m_y} + \frac{P^2}{2 m_\alpha} = Q$

$\frac{P^2}{2}\left[\frac{m_y + m_\alpha}{m_y m_\alpha}\right] = Q$

aduan Cam

Q-1

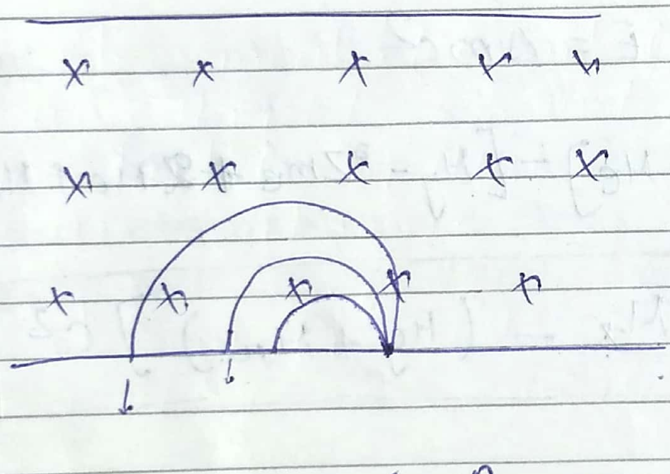
Lacl - ϕ70

$$\frac{P^2}{2} = \left[\frac{Q\, M_y M_\alpha}{M_y + M_\alpha}\right]$$

$$K.E_y = \left(\frac{M_\alpha}{M_y + M_\alpha}\right) Q = \frac{4Q}{A}$$

$$K.E_\alpha = \left(\frac{M_y}{M_y + M_\alpha}\right) Q = \left(\frac{A-4}{A}\right) Q$$

* **Experimental observation:-**



* α Particle emitted in the decay Process is Projected inside a Perpendicular magnetic field this Particle must move in a circular path of definate radius

$$r = \frac{\sqrt{2m\, K.E}}{qB} \qquad K.E = \left(\frac{A-4}{A}\right) Q$$

$$[Q = \Delta mc^2]$$

But it was observed that α Particle have various radius which are discreate in nature (their difference is Const.).

From the our observation we concluded that nucleus daughter nucleus is emitted in excited level (Their may be sub shell inside the nucleus) and it emmitted radiation which are Quantised to come to ground state. These radiation are known as γ Rays.

α-particle is always followed by γ radiation

$K.E_\alpha = \frac{A-4}{A}(Q - E)$ Imp

① Q value

$Q = (M_x - (M_y - M_\alpha) c^2$

②

Imp

$X \longrightarrow Y^{**} + \alpha$

→ γ Rays

$X = Y + \alpha + \gamma$

$Q = (M_{prod.} - M_R) c^2$

* β decay :-

* β^+ decay :- $^{A}X_{Z} \longrightarrow {}^{A}Y_{Z-1} + {}_{+1}e + (\nu) + Q$

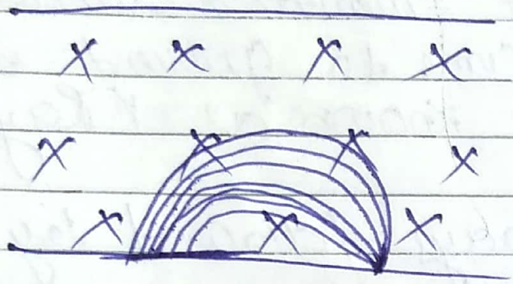
neutrino

mass $X \longrightarrow [M_x - ZM_e]$

$Q = \Delta mc^2$ $Y = [M_y - (Z-1)M_e] + M_e$

$\Delta m = [M_x - M_y - 2M_e]$

$$K.E_{\beta} = \left(\frac{M_y}{M_y + M_e}\right) Q = Q.$$



Continuous

* Energy decriment of β Particle emitted is Continuous. Therefor emitted matter must have Particle nature & they are named as neutrino.

* In β^+ decay one Protone is converted in neutron their fore neutrino is emitted during the Process

* β⁻ decay :

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + (\bar{\nu}) + Q$$

antineutrino

$$X \rightarrow [M_x - ZM_e]$$

$$Y \rightarrow [M_y - (Z+1)M_e] + m_e$$

$$\Delta m = (M_x - M_y)c^2$$

speedup

In $\beta^{\ominus}$ decay ~~Protone~~ neutron is converted in Protone and anti neutrino is emitted during the process.

* **Properties of neutrino and Antineutrino:**

* Their rest mass is zero
* They are chargeless or neutral
* They have spin Quantum no. $\pm\frac{1}{2}$.

* Spin Quantum no. is used to explain momentum and continuous spectrum of β particle are explained by energy distributed (Randomly) in neutrino and antineutrino.

Que:

$$Au^{198} \longrightarrow Hg^{198*} + \beta^{-} + (\text{antineutrino}^{n})$$

Total energy 13.9, 1.88, 0.11

Hg^{**} Represent Nucleus in an excited state at energy 1.088 MeV.

mass
$$\begin{cases} Hg^{198} \longrightarrow 197.9667 \\ Au \longrightarrow 197.9682 \end{cases}$$

find name the element (x) also find Q value of Rxⁿ and find K.E of β particle in the Rxⁿ.

$$Au^{198} \longrightarrow Hg^{198} + {}_{-1}\beta^{\ominus} +$$

Q value $= [M_x - M_y]c^2$

=

Q.2 Calculat the Q value of the following decay

(1) $^{19}O \longrightarrow {}^{19}F + \beta^{-} \; (y)$

(2) $^{25}Al \longrightarrow {}^{25}Mg + \beta^{+} + [z]$

Atomic masses are

^{19}O	^{19}F	^{25}Al	^{25}Mg
19.0035776	18.998403	24.99043	24.98558.

name the element x, y, z

Ans:-1 x → Antineutrino

Qvalue ⇒ 1.39 MeV. $[m_x - m_y]c^2$

$= [197.9682 - 197.9667] \times 3 \times 10^8$

y

Total energy = 1.39 → Three are distributed of total energy

$\frac{1.08}{0.31}$

$K.E_{\alpha} = 0.31$

$\left(\frac{M_{Hg}}{M_{Hg}+} \right) 0.31$

$= 0.31$

(ii) y → Antineutrino.

(iii) $z \rightarrow$ neutrino.

(ii) Q value = $[18.998403 - 19.0035\,76]$

1 amu

$[19.0035\,76 - 18.998403] \times c^2$

$\varepsilon = 4.81$ MeV

(iii) Q value =

$1e^{-}$ energy = 0.51

$[~~24.9858 - 24.99~~$

$[M_{Al} - M_{mg} - 2Me]$

$[24.99043 - 24.9858 - 2x$

~~4.2~~

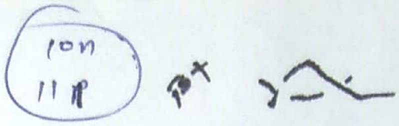
$0.0046 \times 931.2 = 4.31$ MeV.

$4.31 - 2Me$

$[4.31 - 2 \times 0.51] c^2$

-1.02

$= 3.29$



* K – Capture :

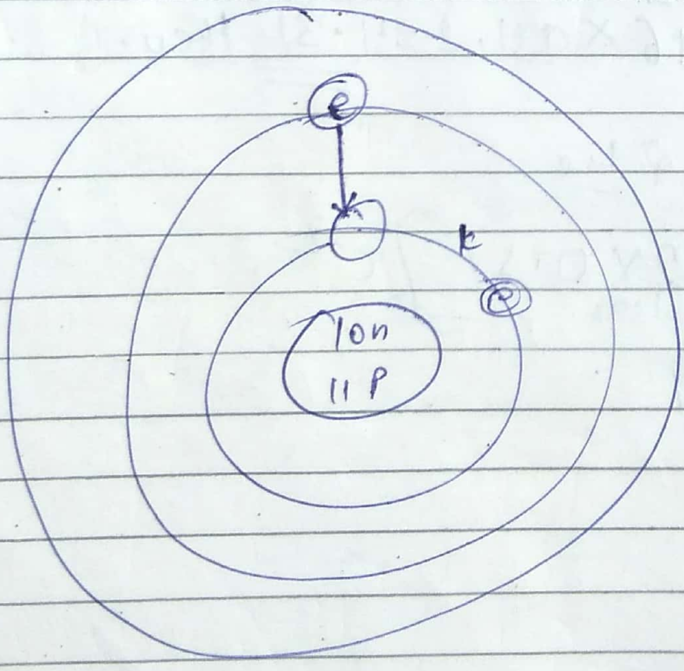
It is a rare Process in which nucleus of an atom Capture $e^{\ominus}$ revolving in it near by Orbit (K-shell) to convert one Protone into neutron

Neutreno is also emitted in the process from the Process

* During K-capture characterstic X-Ray are also emitted from the atom.

(β^+ same)

$$X_Z^A \longrightarrow Y_{Z-1}^A + \bar{\nu} + \theta + \text{X-Rays from } y$$



learn

* **Nuclear force:**

Nuclear force are strong forces acting
* for very short range (10^{-15}) These forces may be attractive or Repulsive depending on dist. b/w Nucleons. generally these forces are attractive.

* Nuclear force is 100 time greater then Electrostatic force

* Nuclear forces act b/w all neculeon
(n – n) (P – P) (n – P)

* It does not depend of property of nucleons
* Nuclear forces is not a central force
(Conservated)

* Nuclear force depends on dist. b/w two nucleons and the direction of the spin of the nucleon.

* Force is stronger if the spin of the nucleon are parallel and it is weaker when spin is antiparallel.

Chew

* Radioactivity decay statistical law:

Rate of decay is ∝ N (no. of active nuclie)

$$\frac{dN}{dt} \propto N$$

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

Where λ is known as decay constant

λ (decay constant) depends on material and it is independent from no. of nuclie or time.

$$\lambda_1 > \lambda_2$$

~~λ_1 is more stabl~~

λ_1 is more unstable and λ_2 is more stable

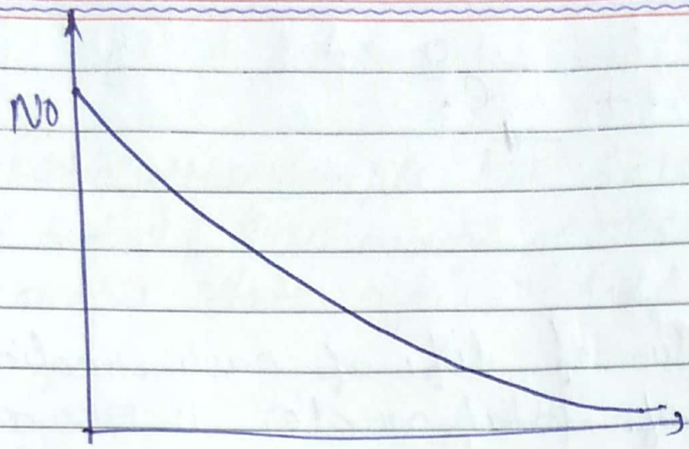
$$\int_{N_0}^{N} \frac{dN}{N} = -\lambda dt$$

$$\left[\log_e N\right]_{N_0}^{N} = -\lambda t$$

$$\ln \frac{N}{N_0} = -\lambda t$$

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

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



where N is No. of active Nuclie at any moment/time

$$N_{Decay} = N_0\left[1 - e^{-\lambda t}\right)$$

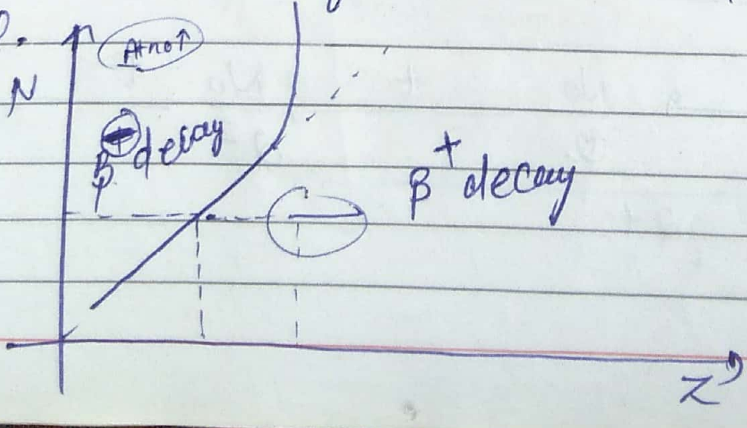
* Stability of Radiactive Nuclie of Nucleus:-

* Generally elements Ranging from atomic no 1 to 83 are Radioactively stable there may be some exception

* Atomic No > 83 shows Radioactivity

if $\frac{N}{Z} = 1$ then elements are stable

where N is no. of neutron and Z is no. of Protone.



M-1 ⇒ of Complete

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

* Average life:

Sum of life of each radioactive nuclei to that of total nuclei is known as Average life.

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

$$dN = \lambda N\, dt$$

$$\langle mean \rangle = \frac{\int_0^\infty (\lambda N_0 e^{-\lambda t} dt)\, t}{N_0} = \frac{1}{\lambda}$$

$$\boxed{\langle mean \rangle = \frac{1}{\lambda}}$$

* half life:

Time in which no. of active nucleus reduces to half of their initial amount is known as half life.

$$\boxed{T_{half} = \frac{\ln 2}{\lambda}} \qquad \boxed{t_{1/2} = \frac{\ln 2}{\lambda}}$$

$$N \xrightarrow{t} \frac{N_0}{2} \xrightarrow{t} \frac{N_0}{2^2} \xrightarrow{t} \frac{N_0}{2^3}$$

$$\underset{2t}{\longrightarrow}$$

$N_0 \xrightarrow{t} 0.9 N_0 \xrightarrow{t} (0.9)^2 N_0$

Que: A Radio active sample has 6×10^{18} active nuclei at certain instant. How many of these nuclei will still be in active state after 2 half life

$\frac{6 \times 10^{18}}{(2)^2}$ $\frac{N_0}{4} = \frac{6}{4} \times 10^{18} = \frac{3}{2} \times 10^{18} =$

Que No. of (Urannium) U_2^{238} Atoms in an ~~instrument~~ Ancient tro equals the no. of Pb^{206} atoms.

The half life of decay of 4.5×10^9 year estimate the age of the rock. assuming that all the Pb atoms are formed by the decay of ~~Pb atom~~ U atom.

U^{238} Atoms $\longrightarrow$ Pb^{206} Atm

$\downarrow t_{1/2}$

4.5×10^9 year

Ans: 4.5×10^9

$N \longrightarrow 0$

$N - n \longrightarrow n$

$n - n = x$

$2x = n.$

$x = \frac{n}{2}$

$\ln 1 = 0$ ↑, ↓

In the above Que if the lead atom are twice that of uranium atom find the age of Rock:

U	Pb
N_0	0
$\frac{N_0}{3}$	$\frac{2N_0}{3}$

$N_0 - 2x = x$

$3x = 2N_0 = x = \frac{2N_0}{3}$

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

$4.5\times10^9 = \frac{\ln 2}{\lambda}$

$\frac{N_0}{3} = N_0 e^{-\lambda t}$

$\ln 3 = \lambda t$

$$t = \frac{\ln 3}{\ln 2}\left[4.5\times10^9\right]$$

Q | Half life of the Radioactive nuclei

Q. Suppose the dauter nucleus in a nuclear decay is itself a Radioactive let

$\lambda_p - \lambda_D$ are the decay Const. of the Parent nuclei and dauter nuclei also N_p and N_D be the no. of Parent and dauter nucli at time t. Find the condition at which no. of dauter nuclei become Constant

Sol

$$(A) \xrightarrow{\lambda_p N_p} (B) \xrightarrow{\lambda_D N_D} (C)$$

$$\boxed{\lambda_p N_p = \lambda_D N_D}$$

A decay at the rate of $\frac{dN_A}{dt} = \lambda_p N_p$

there fore B will produce at the same Rate

Q. In a factory a factory produces radioactive substance A at a constant rate R. which decays with a decay Const. λ to form stable substance

(i) Find no. of nuclei of A and B at time t

(ii) also find max. no. of nuclei of A Present at anytime

(iii) find No. of Nuclei of a stable substance produce in the decay at time t. (B)

$$A \xleftarrow{R} R \quad \text{Rate}$$

(iv) Draw graph

Successive decay

Ans:

$$\text{factory} \xrightarrow{R} \overset{N}{(A)} \xrightarrow{\lambda N} (B)$$

(ii) ⟶ $R = \lambda N$

$\therefore N = \frac{R}{\lambda}$

(i) $\frac{dN}{dt} = R - \lambda N$

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

$$-\frac{1}{\lambda}\left[\ln(R-\lambda N)\right]_0^N = t$$

$$\ln\left(\frac{R-\lambda N}{R}\right) = -\lambda t$$

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

$$R(1-e^{-\lambda t}) = \lambda N \qquad t = \infty$$

$$N = \frac{R}{\lambda}\left[1-e^{-\lambda t}\right] \qquad N = \frac{R}{\lambda}$$

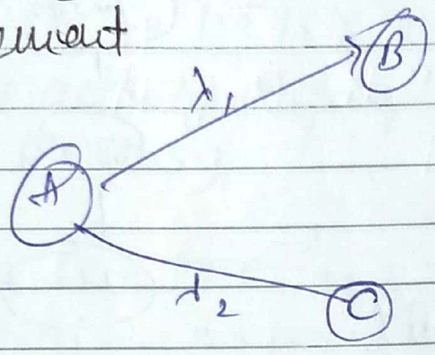
(iii) $\frac{dN_B}{dt} = \lambda \frac{R}{\lambda}\left[1-e^{-\lambda t}\right]$ — Rate

then integrate.

Race - 71
R.A = 0-170
SH = 1 to 5

$$N_B = Rt - \frac{R}{\lambda}\left[1 - e^{-\lambda t}\right)$$

Qu: A Radioactive element will decay into two elements simultaneously with decay constant λ_1 and λ_2 respectively. Find decay constant for the element



$$\lambda_{eq} = \lambda_1 + \lambda_2$$

$$\frac{\ln 2}{T_{eq}} = \frac{\ln 2}{T_1} + \frac{\ln 2}{T_2}$$

$$\boxed{\frac{1}{T_{eq}} = \frac{1}{T_1} + \frac{1}{T_2}}$$

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

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

Q. A Radioactive element undergoes decay. The half life of the element is 100 sec. After 400 second what is the probability of the decay of element in next half life

$$\boxed{100 = \frac{\ln 2}{\lambda} \;=\; \lambda = \frac{\ln 2}{100}}$$

N_0 $\qquad \frac{N_0}{2}$

Q. Radioactive Element having ~~100~~ half life 100 s is left for 400 sec. find Probability of decay of a nucleus in 400 seconds

(Ex)

$$\frac{20000 - 1250}{20000}$$

$$= \frac{18750}{20000} = \frac{15}{16}$$

20000 → (100) 10000 → (200) 5000 → (300) 2500 → (400) 1250

Probability of survival.

$$\frac{1250}{20000} = \frac{5}{80} = \frac{1}{16}$$

* Activity :

Activity is defined as the rate of Radioactive decay of a nuclei it is denoted by A and R.

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

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

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

Unit of Activity is Becquerel, dps, or Curie

1 Becquerel = 1Bq = 1 dPS   dPS ⇒ disintegration per second.

1 Curie = 3×10^7 dPS.

Que: Decay Const. for a Radioactive nuclei, 64 is

$Cu^{64} \rightarrow 1.516 \times 10^{-5} s^{-1}$

find the activity of sample. 1 microg of Cu at (at. wt is 63.5)

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

$A = 1.516 \times 10^{-5} e^{-}$

$A = \lambda N$

$= 1.516 \times 10^{-5} \times \frac{1 \times 10^{-6}}{63.5} \times 6.023 \times 10^{23}$

$= 9.45 \times 10^{15}$

Learn

Nuclear fission:-

(1) Nuclear fission heavy nuclei of mass no. above 200 breaks up into two or more frequents of Comparable masses.

(2) This Rx^n evolves energy / high energy.

(3) Generally ^{236}Uranium is used for fission. during fission neutron moving with energy 0.04 ev Called thermal nuetrons is Bombarded on the Uranium

Which absorves a slow neutron to form unstable nuclei and split in to nuclei

* In nuclear fission about 200 mega ev energies released which appears in the form of K.E of the two fragments.

* Mass lost per R_x^n in nuclear fission is 0.2 amu.

$n_0^1 + U^{235} \longrightarrow U^{236} \longrightarrow x^1 + y^1 + 2n_0^1$

0.5 ev

$U^{235} \longrightarrow U^{236} \longrightarrow x + y + 3n_0$

* Nuclear fussion:

Some unstable light nuclei of mass no. below 20 fused together to increase their B.E per Nucleon and Released excess amount of Energy

* These R_x^n takes place at ultra high temp. of ~~10~~ 10^7 to 10^9 k.

* at high Pressure it can take place at low ~~Pressure~~ Pressure for these R_x^n

u

upto a distance of 1 fermi (10^{-15}m)
which Requires very K.E.