not in Jee Main syllabus
But in Jee Advance syllabus.

21/06/17 chapter:

Radio activity

1) Spontanious disintegration of unstable nuclie into a stable neuclie by emmitting certain type of radiations (α, β, γ) called radioactivity.

2) Radioactivity is a Probability based finomina so it follow result of 1st order kinetics.

Rate of disintegration of dt

(unstable nuclei) A ⟶ stable nuclei

$t = 0$ N_0

$t = t$ N_t

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

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

$$-\int_{N_0}^{N_t} \frac{dN}{N} = \int_0^t \lambda dt$$

$$\boxed{\lambda t = \ln\left(\frac{N_0}{N_t}\right)} \text{ or } \boxed{N_t = N_0 e^{-\lambda t}}$$

$$\frac{N_0}{N_t} = \frac{n_0}{n_t} = \frac{m_0}{m_t} = \frac{100\%}{(100-x)\%} = \frac{A_0}{A_t}$$ ← Activity

SBG STUDY

* Activity of Radioactive substance: [A]

Rate of disintegration of unstable nuclei is called its activity

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

$$\boxed{A = \lambda N}$$

Here λ is decay constant it value will not depend of any physical perameter like temperature, pressure etc.

(3) Unit of [A] Activity = disintegration per second (d.p.s)

1 Bq (Baquerrel) = 1 dps
1 Curie = 3.7×10^{10} dps
1 Rutherford = 10^6 d.p.s
1 d.p.m = 60 d.p.s

(4) Activity of 1 gram substance is called α Activity or specific activity of substance

$$\boxed{A_{specific} = \lambda\left[\left(\frac{1}{\text{molarmass}}\right)\cdot N_A\right]}$$

(5) half life ($t_{1/2}$):

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

$t_{75\%} \quad 2t_{50\%}$

* After n half life Remaning amount will be equal to $\frac{\text{inital amount}}{2^n}$ $\left(\frac{[N]_0}{2}\right)$

* Average life (Mean life) (t_{avg}) of Radioactive

$$t_{avg} = \frac{\int t\, dN_0}{N_0}$$

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

$$t_{avg} = -\frac{\lambda N_0 \int_0^\infty e^{-\lambda t} \cdot t \cdot dt}{N_0}$$

$$dN = -\lambda N dt$$

$$dN = -\lambda N_0 e^{-\lambda t} dt$$

$$\boxed{t_{avg} = \frac{1}{\lambda}}$$

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

$$t_{1/2} = (\ln 2)\, t_{avg}$$

$$\boxed{t_{avg} = 1.44\, t_{1/2}}$$

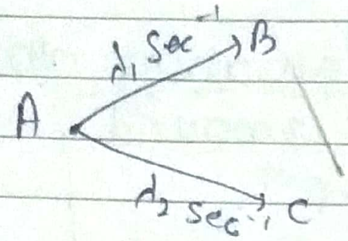
* After One Average life 37% Nuclei will remain in the sample.

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

$$N_t = N_0 e^{-\lambda \times \frac{1}{\lambda}}$$

$$N_t = \frac{N_0}{e} \approx 0.37\, N_0.$$

* Kinetics of Parallel disintegration :



m_0

$m_0 - x$

% Conversion of A in first Path

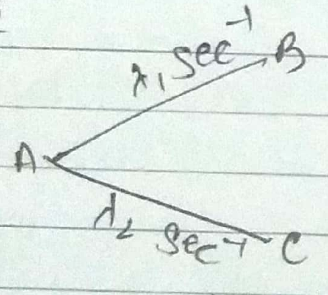
$$\frac{\frac{\lambda_1}{\lambda_1+\lambda_2} \cdot x}{x} \times 100 = \boxed{\frac{\lambda_1}{\lambda_1+\lambda_2} \times 100}$$

% Conversion of A in 2nd Path

$$\boxed{\frac{\lambda_2}{\lambda_1+\lambda_2} \times 100}$$

$$\boxed{\lambda_{net} = \ln \frac{N_0}{N_t}}$$

Que :



overall half Rea^n is 13.86 min
if % conversion of A by 1st path is 40%
then Calculate half life of individual path
in given ||el decay or Rea^n.

Ans:

half Rea^n = 13.86 min. $\left(\frac{40}{100}\right)$

$$\frac{\lambda_1}{\lambda_1+\lambda_2} \times 100 = \frac{40}{100\left(\frac{40}{100} - \lambda_2\right)} = 13.86$$

1 milli ci = 10^{-3} ci

H.W ⇒ Q-2 + S-1 56 due.
↳ 1 to 10

$$= 13.86 = \frac{0.693}{\lambda_1 + \lambda_2}$$

$$\lambda_1 + \lambda_2 = \frac{1}{20}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_1 + \lambda_2} \times 100 = 40$$

$$\lambda_1 \times 2000 = 40$$

Que-2 Calculate activity of ·9gm sample of Radioactive nuclei of ~~ota~~ A^{90} in milicurie per second if half life of A is 2 day.

Ans

$$A = \lambda N$$

$$A = \left(\frac{\ln 2}{2}\right)\left(\frac{0.9}{90} \times N_A\right) \text{ disintegration per day}$$

$$= \frac{\left(\frac{\ln 2}{2}\right)\left(\frac{0.9}{90} \times N_A\right)}{24 \times 60 \times 60} \text{ d.p.s}$$

$$= \frac{\left(\frac{\ln 2}{2}\right)\left(\frac{0.9}{90} \cdot N_A\right)}{24 \times 60 \times 60 \times 3.7 \times 10^{10}} \text{ Ci} = 1$$

C_{12}

C_{14}

Que: Activity of a certain solution of X_{100} is 1000 d.P.M if amount of its solution is 10 litre then calculate initial concn of X_{100} in solution in gram per litre

Ans: ($t_{1/2}$ for X^{100} is = 5 year)

$$A = \lambda N$$

$$= \left(\frac{\ln 2}{5}\right)(N) =$$

Molarity = $\frac{\text{mole}}{10}$

$$A = 0.693$$

$$1000 = \frac{0.693}{5} N \times \frac{1}{365} \times \frac{1}{24} \times \frac{1}{60}$$

$\therefore$ mol of $A^{100} = \frac{N}{N_A}$

* Application of Radioactivity:

1) Carbon dating (To finding Age of fossils):

Due to these two reactions Ration of C^{12} to C^{14} remains constant in atmosphere

$$\Rightarrow {}_{6}C^{14} \longrightarrow {}_{7}N^{14} + {}_{-1}\beta^{0}$$

$${}_{7}N^{14} + {}_{0}n^{1} \xrightarrow{\text{Cosmic rays}} {}_{6}C^{14} + {}_{1}H^{1}$$

$C^{12} : C^{14}$

2 atmosphric carbon exist in form of CO_2 (carbondioxide) this CO_2 is used by plants in photosynthisis. so Ratio of $C^{14}:C^{12}$ in plants remains constant & that must be equal to ratio in atmosphric

3) Carbon then transfer from Plants to animals because animals directly or indirectly depend on plants for their food intake. So in body of animal $C^{14}:C^{12}$ will be also equals to ratio of in atmospheric.

4) After ~~deth~~ of death of Plant or animal C^{14} in their body ~~is~~ start decaying and by ~~me~~ ~~measuring~~ measure Present amount C^{14} age of fossil can be find out

$$\boxed{\lambda t = \ln \frac{n_0}{n_t}}$$

n_0 → initial amount of C^{14}

n_t → Remaining amount of C^{14}

$$\lambda t = \ln \frac{n_0/n_{12}}{n_t/n_{12}} = \ln \frac{C_0}{C_t}$$

C_0 and C_t initial and Present time ratio of $C^{14}:C^{12}$.

$$\boxed{\lambda t = \ln \frac{A_0}{A_t}}$$

Que: In a specimen activity of C^{14} is 15 count / Per 3 min/gm
In a fresh specimen activity is 15 count / min / gram
then calculate ~~th~~ age of specimen
($t_{1/2}$ for C^{14} is 5770 years).

Ans:

$$\lambda t = \ln\frac{(A_0)}{A_t}$$

$$=$$

$$\left(\frac{\ln 2}{5770}\right)t = \ln\frac{15^{3}}{5}$$

* **Rock - dating:**

It is assume that initially formation of rock or minerals could be only due to radioactive substance suppose one of such a minerals sample initial formed by U^{238} currently have x gm U^{238} and Y gm lot 206. then age of this mineral can be find out as

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

$$n_0 = \frac{x}{238} + \frac{y}{206} \ldots\ldots$$

$$n_t = \frac{x\,gm}{238} \qquad \frac{y\,gm}{206}$$

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

$$\lambda t = \ln \frac{n_0}{n_t}$$

$$\left(\frac{\ln 2}{t_{1/2}}\right) t = \left(\ln \frac{\frac{x}{238} + \frac{y}{206}}{\frac{x}{238}}\right)$$

* Radioactive Particles and Radiations:

1.) **α-particle** : or He^{++} or $_2He^4$

1) α particle is a neculius of He atom.

2) Neculi which have $Z > 83$ and $A > 210$ can only ammite He α Particle.

3) This Particle will be affected by electrostatic fied and magnetic field.

4) After α ammition $\frac{n}{p}$ ratio will increase dauter neculi as compared to Parent neculi:

$$_{92}U^{238} \longrightarrow {_{90}Th^{234}} + {_2He^4}$$

$$\frac{n}{p} = \frac{146}{92} < \frac{n}{p} = \frac{144}{90}$$

2) **β Particle**: β Partical can be of Two type,

H.W J.A → #2 and 3.

1) $\beta^{\ominus}$ Particle are $_{-1}\beta^{0}$ or $_{-1}e^{0}$

* Basically $\beta^{\ominus}$ Particle is a electron
* It will be affected by both electrostatic and magnetic field
* After $\beta^{\ominus}$ ommittion $\frac{n}{p}$ ratio will decrease in dauter neculi as compared to Parent neculi.

$$_{6}C^{14} \longrightarrow {}_{7}N^{14} + {}_{-1}\beta^{0}$$

$$\frac{n}{p} = \frac{8}{6} > \frac{7}{7}$$

* In $\beta^{\ominus}$ ammittion neutron will convert in Protone. By defalt mean of β Particle is taken from $\beta^{\ominus}$

* β^{+} Particle $_{+1}\beta^{0}$ or $_{+1}e^{0}$

* β^{+} Particle Basically this is a Positron
* It will be affected by magnetic and electrostatic field
* $\frac{n}{p}$ ratio will increase in dauter neculi as compared to Parent neuclie

$$_{16}S^{31} \longrightarrow {}_{15}P^{31} + {}_{+}\beta^{0}$$

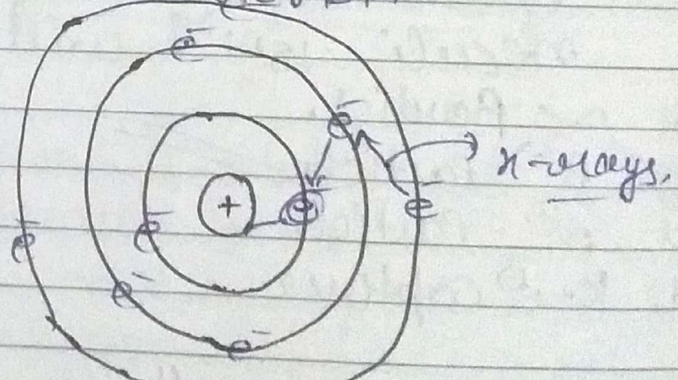
$$\frac{n}{p} = \frac{15}{16} < \frac{n}{p} = \frac{16}{15}$$

* In $\beta^{\oplus}$ amittion Protone will convert in neutron.

* Gama (γ) rays :- (γ°) :- It is assumed that neculions (neutron and Protone combinely) neculions exist in neculier orbit after ammition of α and β Partiale neculion Come in exts existed state or upper orbit for Achiving stability neculions returned to ground state by ammitting certian type of radiation these radiations are called (γ) gama rays.

*4) **K-e⁻ capture:** Some time for increasing n/p ratio neculius Capture its k-shell electron this is called k electron capture.
captured e⁻ with in neculius Combine with Protone and convert protone in neuchon

In Process of k e⁻ capture energy emitted in form of x rays due to transmission of e⁻ from upper orbit to lower orbit.



Important Point:

* order of velocity of penetration power

$\gamma > \beta > \alpha$

* Order of Energy or Ionization power

$\alpha > \beta > \gamma$

dy6esn sme..

Isotopes - P equal
Isotones - n equal
Isoelectronic : e^- equal
Isobars : A equal.
Isodiaphers : (n-P) equal.

* After α amittion parent neculi will be Isodiapher with daughter neculi
* After β amittion Parent neculi will be Isobar with daughter neculi.

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

Q. Stable neculi of Al is $_{13}Al^{27}$ the neculi $_{13}Al^{29}$ will likly to emitt.

(A) α Particle
(B) $\beta^{\ominus}$ Particle
(C) $\beta^{\oplus}$ - Particle
(d) K-$e^{\ominus}$ capture

$_{13}Al^{27}$ — $_{13}Al^{26}$

$\frac{14}{13}$ $\frac{13}{13}$

Ans : C, d.

* Neculiear Reactions :-

Reaction of a neculiy with another neculiey or particle called neculiear Reaction

for Ex:- $_7N^{14} + _0n^1 \longrightarrow _6C^{14} + _1H^1$

or

$_7N^{14}\ (_0H^1,\ _1H^1)\ _6C^{14}$

projectile particle. (→ $_0H^1$)

emitted particle (→ $_1H^1$)

* Conversion of an element into another type of element by bombardment of certain type of partice called artifisial tramistation

* Ist artificial tramission is obtained by rutherford by following rex^n.

$$_7N^{14} + _2He^4 \rightarrow _8O^{17} + _1H^1$$

Que:- Identify $_ZX^A$ & $_{Z'}Y^{A'}$ in given neculiear reaction.

$_{Z}x^{A}$

$$_{90}Th^{232} \longrightarrow {}_{Z}x^{A} + {}_{Z'}y^{A'}$$

$$\downarrow$$

$$_{89}Ac^{228} + {}_{-1}\beta^{0} \text{ or } {}_{-1}\beta^{0}$$

This mean th... (e...)

$Z = 88 \quad A = 228$

$Z' = 2 \quad , A' = 4$

Que: Calculate mole of α particle and β Particle that will amitte on disintegration of Certain 4 mole sample $_{92}U^{238}$ to $_{82}Pb^{206}$?

$$_{92}U^{238} \longrightarrow {}_{82}Pb^{206} + n\, {}_{2}He^{4} + y\, {}_{-1}\beta^{0}$$

4 mol (Solid) 32 mol 24

$238 = 206 + 4n$

$n = 8$

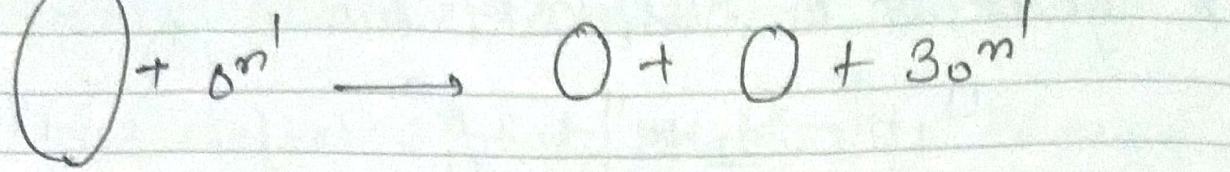
$92 = 82 + 2n - y$

$92 = 98 - y$

$y = 6$

* **Some specific types of neuclear Rxn:**

1) **neuclear fission Rxn:** By Bombardment of neutron Conversion of heavy heavier neuclie into to liter neculi called neculear fission.



Example! Reaction in Atomic bomb.
or
Reaction in neuclear reactor

$$_{92}U^{235} + {_0n^1} \longrightarrow {_{56}Ba^{141}} + {_{36}Kr^{92}} + 3\,{_0n^1}$$

$$_{92}U^{235} + {_0n^1} \longrightarrow {_{54}Xe^{139}} + {_{38}Sr^{95}} + 2\,{_0n^1}$$

$$_{92}U^{235} + {_0n^1} \longrightarrow {_{53}I^{137}} + {_{39}Y^{97}} + 2\,{_0n^1}$$

* Product of neuclieau fission will not be unlike.

* Neculieau fusion Rxn!

Two or more than two liter neculi are combine to produce a heavier neculia in neculieal fussion Rxn.

Ex: Reaction of Hydrogen bomb.
⇒ Two Hydrogen Isotopes Combine to form a Helium neculi.

$$_1H^1 + {_1T^3} \longrightarrow {_2He^4}$$

$$_1D^2 + {_1D^2} \longrightarrow {_2He^4}$$

T.T.S ⇒ Chemical Eq. H.W ⇒ S-2 + J.A. £ 2,3
Complete. CK

* Reaction on Surface of Sun.

$$4\,{}_1H^1 \rightarrow {}_2He^4 + 2\beta^0_{+1}$$

* Radioactive disintegration series: P. No. - 5.

Disintegration Series	First nuclei	last nuclei	α-particle	β particle
1) 4n or thorium series	${}_{90}Th^{232}$	${}_{82}Pb^{208}$	6	4
2. 4n+1 or Neptunium series	${}_{94}Pu^{241}$	${}_{83}Bi^{209}$	8	5
3. 4n+2 or uranium series	${}_{92}U^{238}$	${}_{82}Pb^{206}$	8	6
4. 4n+3 or Actinium series	${}_{92}U^{235}$	${}_{82}Pb^{207}$	7.	4

(4n+1) ⇒ on division 4, 1 is Remainder

$${}_{90}Th^{232} \longrightarrow {}_{82}Pb^{208}$$

$$232 = 208 + 4n$$

$$n = \frac{232 - 208}{4} =$$

* Theory Relative to nuclear Stability

(i) Mass defect theory or Binding Energy theory :

At the time of nucleus formation nucleon loose some of their mass in form of energy to achieve stability for nucleus this released energy is called binding energy of nucleus and mass difference b/w nucleon and nucleus called mass defect of nucleus

Let for a nucleus $_{Z}X^{A}$ mass defect will be equal to Δm =

$$\Delta m = [Z m_p + (A-Z) m_n] - \text{mass of } _{Z}X^{A} \text{ nucleus}$$

$$B.E. = \Delta m c^2$$ if Δm = amu

$$= \Delta m \times 931.5 \text{ mev.}$$ [mega e volt

* Binding energy per nucleon ($\overline{B.E.}$)

$$\overline{B.E.} = \frac{B.E}{\text{no. of nucleon}}$$

$\overline{B.E.}$ ↑ stability of nucleon ↑

Important point ! law of mass conservation does not follow in nuclear rxn. In nuclear Rxn mass of product will be less than mass of Reactant

This mass difference is called mass defect for nuclear Rxn.

This mass defect for nuclear Rxn convert in energy this released energy for nuclear thermal energy called Q-value for nuclear Rxn.

$$R \rightarrow P$$

$$\Delta m = \Sigma \text{mass of reactant} - \Sigma \text{mass of product}$$

$$Q\text{-value} = \Delta m \times 931.5 \text{ MeV}$$

$$Q\text{value} = \Sigma B.E. \text{ of reactant} - \Sigma B.E. \text{ of Product}$$

Q. B.E. per nucleon for deuterium nuclei and Helium nuclei is 1.1 MeV and 7 MeV respectively. If two deuterium nuclei are fused to obtain a He nuclei then calculate Q value in this rxn.

$$2\,{}_1D^2 \longrightarrow {}_2He^4$$

$$Q = 2(2.2) \quad - 28$$

$$1.1 = \frac{B.E.({}_1D^2)}{2}$$

$$B.E.({}_1D^2) = 2.2 \text{ MeV}$$

$$7 = \frac{B.E.({}_2He^4)}{4}$$

$$B.E.({}_2He^4) = 28 \text{ MeV}.$$

* Que:

$${}_{6}C^{14} \longrightarrow {}_{7}N^{14} + {}_{-1}e^{0}$$

mass defect for the rxn can be given as.

(A) Δm = Atomic mass of ${}_{6}C^{14}$ − At. mass of ${}_{7}N^{14}$

(B) Δm = Atomic mass of ${}_{6}C^{14}$ − Atomic mass of ${}_{7}N^{14}$ − mass of $e^{\ominus}$

(C) Δm = Atomic mass of ${}_{6}C^{14}$ − Atomic mass of ${}_{7}N^{14}$ − 2 × mass of $e^{\ominus}$

D none of these.

14−

$${}_{6}C^{14} \longrightarrow {}_{7}N^{14} + {}_{-1}e^{0}$$

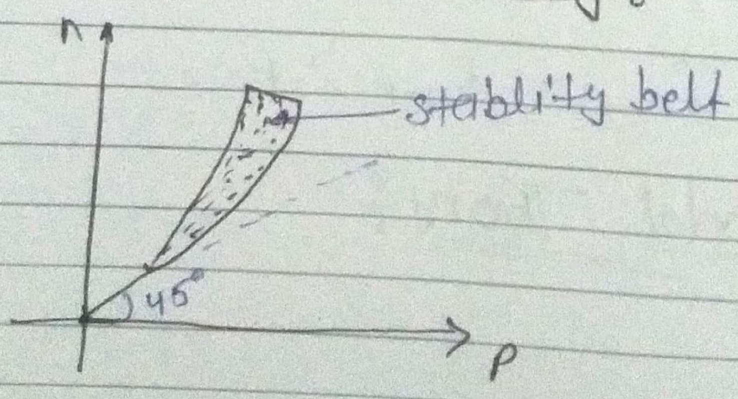
Δm = (mass of ${}_{6}C^{14}$ ~~nucle~~ neclius) − (mass of ${}_{7}N^{14}$ nucleus + mass of $e^{\ominus}$).

= (Atomic mass of ${}_{6}C^{14}$ − mass of $6e^{\ominus}$) −

− (Atomic mass of ${}_{7}N^{14}$ − mass of $7e^{\ominus}$ + mass of $e^{\ominus}$)

= Atomic mass of ${}_{6}C^{14}$ − Atomic mass of ${}_{7}N^{14}$.

(2) Stability belt theory:



- for a stable nucleus n v/s p point come with in stability belt for a nucleus if n v/s p point is outside from stability belt then such a neuclei will be considered unstable nucleus

* This unstable nucleus will come with in stability belt for achiving stability. by either decreasing or increasing it n/p ratio.

* for neculi which have atomic no. 1 to 20 n/p ratio will be aproximately 1.

* for a neculi z > 20 n/p ratio will be greater than one.

* In a heavy nucleus neutron will be more in no. as compared to protone to over come electrostatic Repulsion force b/w protone and protone.

* Neculiar force (f):

$$F_{n-n} = f_{n-p} = f_{p-p}$$

Net force $f_{n-n} = f_{n-p} > f_{p-p}$.

(3) Even odd Theory:

Read. A = 0-1 = 1 to 10

Stable nuclei	n	p
165	even	even
55	odd	even
50	Even	odd
5	odd	odd

. If a nucleus have no. of P and n in even no. then its Probability to be a stable nuclei will be high.

*4) Magic No. Theory :-

In nucleus n and P seperatly exist in nuclear orbits. No. 2, 8, 20, 50, 82, 126. represent completely filled nuclear orbit. If nuclear orbit is completely filled then stability of such a nucleus will be very high.

Ex:- $_2He^4$ $n = 2$
$P = 2$

$_{20}C^{40}$ = $n = 20$
$P = 20$