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Problem: 1

i) $^{37}_{17}Cl + ? \longrightarrow ^{37}_{18}Ar + e^-$

Here mass number is already conserved & hence the unknown particle cannot be n/p.

i.e if $^{A}_{Z}X$ is the unknown one then

$A = 0$; $Z = 0$ (because of charge conservation)

But the lepton number is not conserved.

in R.H.S the lepton number $= +1$ (for e^-)

i.e for X: lepton " $= +1$

So it is chargeless lepton with (+1) electron lepton number.

i.e It must be ν_e or electron neutrino.

i.e $^{37}_{17}Cl + ^{0}_{0}\nu_e \longrightarrow ^{37}_{18}Ar + ^{0}_{-1}e^-$

ii) $^{25}_{13}Al \longrightarrow e^+ + ?$

Clearly this is one positron decay.

i.e in R.H.S we must have one nucleus $^{A}_{Z}X$ (for mass & charge conservation) and one ν_e (for lepton no conservation) i.e $\,^{25}_{13}Al \rightarrow \beta^+ + \nu_e + \,^{A}_{Z}X$

for mass conservation: $A = 25$

charge " : $Z = 12$

i.e $\,^{A}_{Z}X = \,^{25}_{12}X$

i.e $X = Mg$

So $\,^{25}_{13}Al \rightarrow e^+ + \boxed{\nu_e + \,^{25}_{12}Mg}$

Problem: 2

The reaction will be:

i) β^+ decay: $\,^{133}_{56}Ba \rightarrow \,^{133}_{55}Cs + \beta^+ + \nu_e$

ii) e^- capture: $\,^{133}_{56}Ba + e^- \rightarrow \,^{133}_{55}Cs + \nu_e$

computing the Q values,

i) for β^+:

$$Q = \left\{M(^{133}Ba) - M(^{133}Cs) - 2m_e\right\} \times 931.5 \text{ MeV}$$

$$= \left[(132.90601 - 132.905) \times 931.5 - 2 \times 0.511\right] \text{MeV.}$$

$$= -0.0811 \text{ MeV} < 0$$

i.e β^+ is not possible.

ii) for EC:

$$Q = \{M(^{133}Ba) - M(^{133}Cs)\}c^2 - B_n$$

B_n = Binding energy of the e^- $\ll$ Mev
($\sim < 1$ kev)

i.e $$Q \approx [M(^{133}Ba) - M(^{133}Cs)]c^2$$

$$= (132.9060 - 132.905) \times 931.5 \text{ Mev}$$

$$= 0.94 \text{ Mev} > 0$$

i.e E.C is energetically possible.

Problem: 6

A breeder reactor is a type of nuclear reactor which generates more fissile material (i.e some nuclear material which is capable of sustaining nuclear chain reaction) than it consumes. The performance is measured by the conversion ratio of the reactor, which is the ratio of no of fissile atoms produced over consumed. For economical power generation purpose breeder reaction needs conversion ratio > 1.

(commonly used light water reactor have a conversion ratio of 0.6 - 0.8.)

example: breeding / production of ^{239}Pu:

$$^{238}U + n \longrightarrow {}^{239}U \xrightarrow{\beta \text{ decay}} {}^{239}Pu \text{ (fissile)}$$

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Problem: 7

i) $\frac{7}{2}^- \longrightarrow \frac{5}{2}^-$

here $\Delta\pi$ = no And $\Delta I = \left(\frac{5}{2}+\frac{7}{2}\right)$ to $\left|\frac{7}{2}-\frac{5}{2}\right|$

i.e 6 to 1

i.e 1, 2, 3, 4, 5, 6

So the possible transitions: M_1 ; E_2, M_3, E_4, M_5, E_6

Clearly M_1 is the most intense one due to order.

ii) $2^+ \longrightarrow 2^+$

$\Delta\pi$ = no ; $\Delta I = (2+2)$ to $|2-2|$

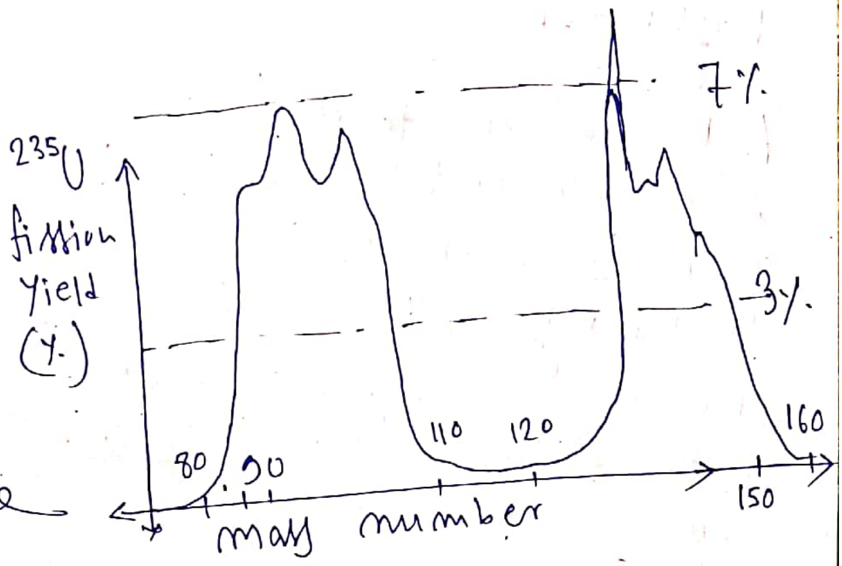
i.e 0, 1, 2, 3, 4

Here the possible transitions: M_1, E_2, M_3, E_4

($\Delta I = 0$ not possible)

Again M_1 is the most intense.

Problem: 5



We see that the fission yield is not symmetric.

This is because of the stability factor due to shell model. From liquid drop model we get the fission yield should be symmetric. But the stability factor (magic no etc) from shell model disrupts the symmetry for ~~fast~~ fission by thermal neutron.

Problem: 4

i) $(\vec{r} \times \vec{L}) \cdot \vec{p}$

The nuclear potential should go to zero as they are taken far apart ($r \to \infty$). Here the potential term containing $\vec{r}$ in numerator and the value is like

$V \sim rL \sin\theta_{rL}\, p \cos\phi$

i.e $V(r) \to \infty$ as $r \to \infty$

(Any term with $\frac{1}{r^m}$ will rather satisfy the above mentioned condition ($m > 0$).

So this term is not applicable for nuclear potential.

ii) $(\vec{L} \cdot \vec{S})(\vec{L} \cdot \vec{L})$

Same reason. This term also don't have $\frac{1}{r^m}$ type proportionality. So the interaction is effective @ same even if ~~they~~ the nucleons are far apart ($r \to \infty$) which is not physical.

So this term is not applicable.

Problem: 8

$$B.E = a_v A - a_s A^{2/3} - a_c Z(Z-1) A^{-1/3} - a_{sym} \frac{(A-2Z)^2}{A} + \delta$$

from data:
(wikipedia least sq fit 2)

~~$a_v = 15.5$ MeV~~
~~$a_s = 16.8$ MeV~~
~~a_c~~

$a_v = 15.76$ MeV
$a_s = 17.81$ MeV
$a_c = 0.711$ MeV
$a_{sym} = 23.7$

$$\delta = \begin{cases} +\dfrac{34}{A^{3/4}} & \text{(even - even)} \\ -\dfrac{34}{A^{3/4}} & \text{(odd - odd)} \\ 0 & \text{(o/w)} \end{cases}$$

i) For $^{18}_{8}O$ (even-even) : $Z = 8$; $A = 18$

B.E (using values)

$$= \left\{ 15.76 \times 18 - 17.81 \times 18^{2/3} - \frac{0.711 \times 56}{18^{1/3}} - \frac{(18-16)^2}{18} \times 23.7 + \frac{34}{18^{3/4}} \right\} \text{MeV}$$

$$= 144.79 \text{ MeV}.$$

Coloumb energy $= -\frac{3}{5} \frac{e^2}{4\pi\epsilon_0 R_0} \frac{Z(Z-1)}{A^{1/3}}$ $(R_0 = 1.2 \text{ fm})$

$= -15.38$ MeV (using values)

ii) $^{254}_{102}No$ (even-even): $Z = 102$; $A = 254$.

B.E (using values)

$= 1899$ MeV.

coloumb energy $= -\frac{3}{5} \frac{e^2 Z(Z-1)}{4\pi\epsilon_0 R_0 A^{1/3}}$

$= -1171.23$ MeV.

Problem: 16

The Gamow peak energy is the particular value of energy E of the incoming proton to maximize the fusion ~~enter~~ reaction rate ~~maximum~~ at some given temperature T.

Let the incoming beam has a particle density n & velocity v and the target has a cross sectional area of σ. The ~~number~~ total number of reaction is N_R in some given time Δt then the reaction rate $\frac{dN_R}{dt}$ is proportional to the impact parrameter $n\sigma v$

i.e $\frac{dN_R}{dt} \propto n\sigma v$

Now ~~~~ σ, v, n all are fn of E and hence

$$\frac{dN_R(E)}{dt} = n(E)\cdot\sigma(E)\cdot v(E)$$

(Absorbing the constant in σ)

To get the total rate for all energy value we need to integrate w.r.t E.

i.e $$\frac{dN_R}{dt} = \int_0^\infty \frac{dN_R(E)}{dt}\, dE = \int_0^\infty \sigma(E)\cdot v(E)\cdot\frac{dn}{dE}\cdot dE$$

But we know from Maxwell's distribution that the Energy distribution for a classical gas is given by:

$$\frac{dn}{dE} = \frac{2n}{\sqrt{\pi}\,(K_B T)^{3/2}} \sqrt{E}\, e^{-\frac{E}{K_B T}}$$

And $v(E) = v(p)$ And $E = \frac{p^2}{2m} = \frac{1}{2} m v^2$

(good approximation assuming non-relativistic case)

i.e $v(E) = \sqrt{\frac{2E}{m}}$

Finally for the cross section $\sigma(E)$ we assume two things:

i) The interaction will only happen when the wavefns of the two particles overlap. i.e the distance between the two particles become $\lesssim \lambda$ (De-Broglie wavelength)

In that case the cross section is proportional to λ^2

$$\text{i.e } \sigma(E) \propto \lambda^2 = \frac{h^2}{p^2} = \frac{1}{E}$$

$$\text{i.e } \sigma(E) \propto \frac{1}{E}.$$

ii) $\sigma(E)$ is associated by the tunneling probability factor from Gamow theory.

$$\text{i.e } P \propto e^{-2\gamma} \propto e^{-\frac{2\pi^2 U}{E}}$$

(There is another term in exp which is not fn of energy we don't need that here for our calculation.)

Here U = height of coloumb barrier at $(r = \lambda)$

$$= \frac{e^2}{4\pi\epsilon_0 \lambda} = \frac{e^2}{4\pi\epsilon_0 h}\sqrt{2\mu_H E}$$

$$\left(\mu_H = \frac{m_p^2}{2m_p} = \frac{m_p}{2}\right) \qquad \left(\text{for proton-proton } Z = 1\right)$$

i.e $P \propto e^{-\frac{b}{\sqrt{E}}}$

$$b = \frac{e^2\sqrt{2\mu_H}}{4\pi\epsilon_0 h} = 1.4003 \text{ MeV}^{1/2}$$

i.e Collecting all

$$\frac{dN_R}{dt} \propto \int_0^\infty \sqrt{E}\, e^{-\frac{E}{KT}} \times \sqrt{\frac{2E}{m}} \times \frac{e^{-\frac{b}{\sqrt{E}}}}{E}\, dE$$

i.e $R_{tot} \propto \int_0^\infty e^{-\frac{E}{KT}}\, e^{-\frac{b}{\sqrt{E}}}\, dE$

i.e $R_{tot} = \int_0^\infty R(E)\, dE$

& $R(E) \propto e^{-\left(\frac{E}{KT} + \frac{b}{\sqrt{E}}\right)}$

at Gamow peak the rate is maximum

i.e $\left.\frac{dR(E)}{dE}\right|_{E=E_0} = 0$

i.e $0 = \left.-\left(\frac{E}{KT} + \frac{b}{\sqrt{E}}\right)\left(\frac{1}{KT} - \frac{b}{2E^{3/2}}\right) e^{-\left(\frac{E}{KT} + \frac{b}{\sqrt{E}}\right)}\right|_{E=E_0}$

i.e $E_0 = \left(\frac{bKT}{2}\right)^{2/3}$

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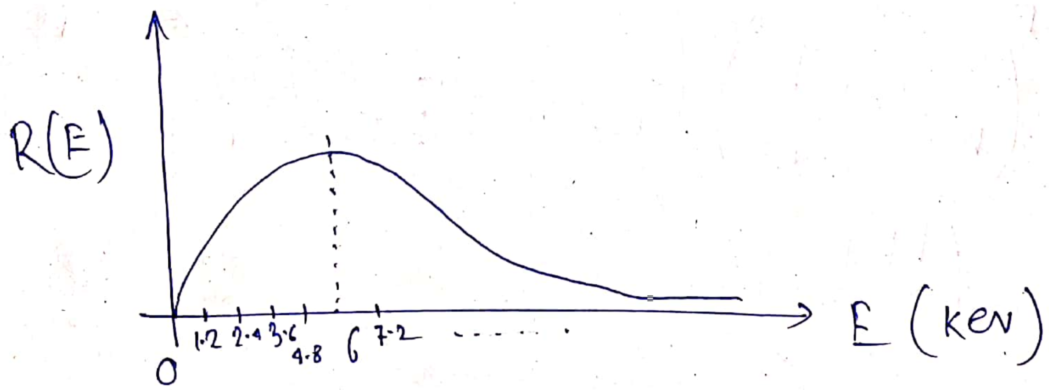
Using values:

$$E_0 = 1.22 \times \left[\frac{1}{2} \times \left(\frac{T\,(\text{in } K)}{10^6}\right)^2\right]^{1/3} \text{ in keV}$$

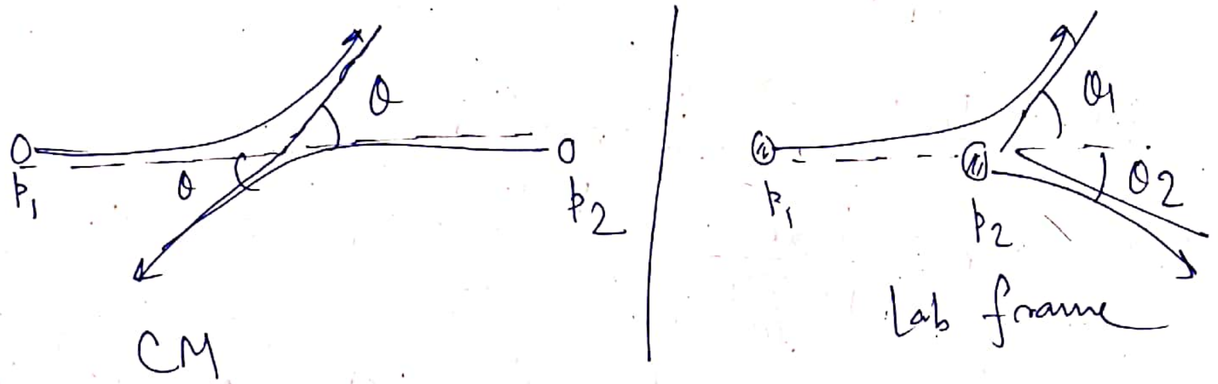
$$= 1.22 \times \left(\frac{1}{2} \times 15^2\right)^{1/3} \text{ keV}$$

$$= 5.89 \text{ keV. (Appx)}$$



Problem: 14

We need to go from lab frame to C.O.M frame



The relation between θ_1 & θ_2 is: (from book)

$$\cos\theta_1 = \frac{\cos\theta + \frac{m_1}{m_2}}{\sqrt{1 + \frac{m_1^2}{m_2^2} + \frac{2m_1}{m_2}\cos\theta}}$$

here they are identical particle.

i.e $$\cos\theta_1 = \frac{1+\cos\theta}{\sqrt{1+1+2\cos\theta}} = \left(\frac{1+\cos\theta}{2}\right)^{1/2}$$

i.e $$1+\cos\theta = 2\cos^2\theta_1$$

i.e $$\frac{d(\cos\theta)}{d(\cos\theta_1)} = 4\cos\theta_1$$

Now $$\left.\frac{d\sigma}{d\Omega}\right|_{lab} = 0.1 \text{ b}\cdot\text{Str}^{-1} = \left.\frac{d\sigma}{d\Omega}\right|_{CM} \times \frac{d(\cos\theta)}{d(\cos\theta_1)}$$

i.e $$\left.\frac{d\sigma}{d\Omega}\right|_{CM} = \frac{1}{4\cos\theta_1}\left.\frac{d\sigma}{d\Omega}\right|_{lab}$$

given $\theta_1 = 30°$

i.e $\left.\frac{d\sigma}{d\Omega}\right|_{CM} = \left(\frac{1}{4\cos 30°} \times 0.1\right)$ b. Str^{-1}

i.e $D(\theta) = 0.0288$ b. Str^{-1}
$= 0.0288 \times 10^{-28}$ m^2/ Str

Now $E_{CM} = \frac{E_{lab}}{1+\frac{m_1}{m_2}} = \frac{E_{lab}}{2} = 2.5$ Mev.

Now we know from partial wave analysis.

$$D(\theta) = \frac{d\sigma(\theta)}{d\Omega} = |f(\theta)|^2 = \frac{1}{k^2}\left|\sum_{l=0}^{\infty}(2l+1)e^{i\delta_l}\sin(\delta_l)\right|^2$$

for s wave i.e $l=0$

$$D(\theta) = \frac{1}{k^2}(2\times 0+1)\sin^2(\delta_0)$$

$$= \frac{\hbar^2}{2mE}\sin^2(\delta_0)$$

i.e $\sin(\delta_0) = \frac{\sqrt{2mE\,D(\theta)}}{\hbar}$

$$= \frac{\sqrt{2\times\frac{1.67\times10^{-27}}{2}\times 2.5\times10^{-13}\times 0.0288}}{1.054\times10^{-34}}$$

(in CM we need to use μ_p instead of m_p as reduced mass is effective
i.e $\mu = \frac{m_p^2}{2m_p} = \frac{m_p}{2}$)

i.e $\sin(\delta_0) = 0.32$

i.e δ_0 = phase shift = $19.207°$

Ans

Problem: 12

i) $^{9}_{4}Be$ $\quad Z = 4 \rightarrow$ even
$\qquad N = 5 \rightarrow$ odd

i.e the last odd neutron will decide the spin & parity.

	$1S_{1/2}$	$1P_{3/2}$
p:	↑↓	↑↓
n:	↑↓	↑↓↑

Spin = 3/2

$\pi = (-1)^1 = -1$

ii) $^{16}_{7}N$: $\quad Z = 7 \rightarrow$ odd
$\qquad N = 9 \rightarrow$ odd

	$1S_{1/2}$	$1P_{3/2}$	$1P_{1/2}$	$1d_{5/2}$
p:	↑↓	↑↓↑↓	↑	
n:	↑↓	↑↓↑↓	↑↓	↑

$$\text{Spin} = \left|\frac{5}{2} - \frac{1}{2}\right| \text{ to } \left(\frac{5}{2} + \frac{1}{2}\right)$$
$$= 2, 3$$
$$\pi = (-1)^1 \times (-1)^2 = -1$$

due to residual interaction $I = 2$ is lower energy i.e G.S

iii) $^{42}_{19}K$: $\quad Z = 19$
$\qquad N = 23$

	$1S_{1/2}$	$1p_{3/2}$	$1p_{1/2}$	$1d_{5/2}$	$2S_{1/2}$	$1d_{3/2}$	$1f_{7/2}$
p:	↑↓	↑↓↑↓	↑↓	↑↓↑↓↑↓	↑↓	↑↓↑	
n:	↑↓	↑↓↑↓	↑↓	↑↓↑↓↑↓	↑↓	↑↓↑↓	↑↓↑

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Spin: $\left(\frac{7}{2} - \frac{3}{2}\right)$ to $\left(\frac{7}{2} + \frac{3}{2}\right)$

$= 2, 3, 4, 5$

$\pi = (-1)^2 \times (-1)^3 = -1$

Again due to residual interaction

$I = 2$ is G.S.

iv) ${}^{96}_{40}Zr$: $\longrightarrow$ even-even nucleus

i.e spin $= 0$

$\pi = +1$

v) ${}^{207}_{83}Bi$: $Z = 83$
$N = 124 \longrightarrow$ even

last proton (83 rd) is at $1h_{9/2}$

i.e spin: $\frac{9}{2}$; parity: $(-1)^5 = -1$

Problem: 11

1) ${}^{6}_{2}He \rightarrow {}^{6}_{3}Li + \beta^- + \bar{\nu}_e$

for ${}^{6}_{2}He$ (even - even): G.S is 0^+

Now for ${}^{6}_{3}Li$: G.S = 1^+ (from N.N.D.C)

i.e $0^+ \longrightarrow 1^+$ transition.

Clearly Super allowed transition is not possible.

$$\vec{I}_i = \vec{I}_f + (\vec{L} + \vec{S})$$

Fermi: $S = 0$

$$\vec{I}_i = \vec{I}_f + \vec{L}$$

Here $\vec{I}_f = 1^+$

And L = even $(\because \Delta\pi = \text{no}) = 0, 2, 4, \ldots$

i.e $\vec{I}_i = \vec{1}, \vec{2}, \vec{3}, \ldots$ are possible

but $|I_i| = 0$ is not

G.T: $S = 1$

i.e if $L = 0$; the treatment be like:

$$\vec{I}_i = \vec{I}_f + \vec{S}$$

as $I_f = 1$; $S = 1$

so $I_i = 0, 1, 2$

i.e G.T is possible.

ii) $^{56}_{27}Co \rightarrow ^{56}_{26}Fe / ^{56}_{28}Ni + \beta^{\pm} + \nu_e / \overline{\nu_e}$

$$Q_{\beta^+} = \left(M(^{56}Co) - M(^{56}Fe) - 2m_e\right) \times 931.5 \text{ MeV}$$

$$= 3.549 \text{ MeV.}$$

$$Q_{\beta^-} = \left(M(^{56}Co) - M(^{56}_{28}Ni)\right) \times 931.5 \text{ MeV.}$$

$$= -2.133 \text{ MeV.}$$

i.e β^+ is allowed but β^- is not

Now from NNDC Data the most intense transition is

$$^{56}_{27}Co(4+) \longrightarrow ^{56}_{26}Fe(4+)$$

as the GS of Co is 4+ so superallowed transition is not possible.

Clearly $\Delta\pi$ = no i.e L = even.

Fermi: $\vec{I_i} = \vec{I_f} + \vec{L}$

for $L = 0$; $I_i = 4$, $I_f = 4$ is possible.

G.T: $\vec{I_i} = \vec{I_f} + \vec{L} + \vec{S}(S=1)$

for $L = 0$

$I_i = (4-1)$ to $(4+1)$ i.e 3, 4, 5.

i.e G.T is possible

i.e lowest order $(L=0)$ transition is mixed type.
(Fermi + GT)

iii) $^{24}_{11}Na \longrightarrow ^{24}_{12}Mg + e^- + \overline{\nu_e}$

$$Q_\beta = \left(M(^{24}Na) - M(^{24}Mg) \right) \times 931.5 \text{ MeV}$$

$$= 5.5142 \text{ MeV} > 0.$$

The transition occurs between $1^+ \longrightarrow 0^+$

$\Delta\pi = NO$; i.e $l =$ even.

Fermi: $\vec{I_i} = \vec{I_f} + \vec{L}$

$$\left.\begin{array}{ll} \text{for } L = 0: & I_i = 0 \\ L = 2: & I_i = 2 \\ \text{.... and so on} & \end{array}\right\} I_i = 1 \text{ not possible}$$

i.e Fermi transition is not possible

G.T: $\vec{I_i} = \vec{I_f} + \vec{L} + \vec{S}$

for $L = 0$: $I_i = 1$

i.e lowest $(L=0)$ order G.T is possible

Problem 17

a) Isospin is mathematically analogous to spin. proton & neutron has different value for the 3rd component of Isospin.

for the 3rd component $I_3 = +\frac{1}{2}$ for proton

$= -\frac{1}{2}$ for neutrons.

for two nucleon if $\chi_I(I_1, I_2)$ is the isospin part then for total isospin $I = 1$ we have

$$\left.\begin{aligned} \chi_I(I_1, I_2) &= |pp\rangle \quad I_3 = +1 \\ \chi_I(I_1, I_2) &= \frac{1}{\sqrt{2}}(|pn\rangle + |np\rangle) \quad I_3 = 0 \\ \chi_I(I_1, I_2) &= |nn\rangle \quad I_3 = -1 \end{aligned}\right\}$$

And for total isospin $I = 0$

$$\chi_I(I_1, I_2) = \frac{1}{\sqrt{2}}(|pn\rangle - |np\rangle) \}$$

So this 4 can be possible isospin wave fn for $(p-p)$, $(n-p)$ or $(n-n)$ coupling.

i.e for (p,p) : $\chi_I = |pp\rangle$; $I_3 = 1$, $I = 1$

(n,n) : $\chi_I = |nn\rangle$; $I_3 = -1$; $I = 1$

$(p-n)$: $\chi_I = \frac{1}{\sqrt{2}}(|pn\rangle \pm |np\rangle)$; $I_3 = 0$, $I = 1, 0$

b) $V(1,2) = -\frac{V_0}{2}\left(1+\vec{\tau_1}\cdot\vec{\tau_2}\right)$

$$\langle V(1,2)\rangle = -\frac{V_0}{2} - \frac{V_0}{2}\langle\vec{\tau_1}\cdot\vec{\tau_2}\rangle$$

Now $\langle\vec{\tau_1}\cdot\vec{\tau_2}\rangle = \left\langle\frac{\tau^2-\tau_1^2-\tau_2^2}{2}\right\rangle$

i.e $\langle V(1,2)\rangle = -\frac{V_0}{2}\left(1+\frac{\tau(\tau+1)-\tau_1(\tau_1+1)-\tau_2(\tau_2+1)}{2}\right)$

as $\sigma_i = \frac{1}{2}\tau_i$

$$\langle V(1,2)\rangle = -\frac{V_0}{2}\left(1+\frac{2\sigma(2\sigma+1)-2\sigma_1(2\sigma_1+1)-2\sigma_2(2\sigma_2+1)}{2}\right)$$

$$= -\frac{V_0}{2}\left(1+\sigma(2\sigma+1)-\sigma_1(2\sigma_1+1)-\sigma_2(2\sigma_2+1)\right)$$

$\left.\begin{array}{l}\sigma_{1,2} = \text{isospin of particle } 1,2 \\ \sigma = \text{total isospin}\end{array}\right\}$

Prob: 15

Given that: $^{236}A \longrightarrow {}^{232}B + \alpha$

i.e $^{236}_{Z}A \longrightarrow {}^{232}_{Z-2}B + {}^{4}_{2}He$

(Assuming A has atomic number of Z)

Energy released (i.e Q value)

$$Q = \left\{ M\left({}^{236}_{Z}A\right) - M\left({}^{232}_{Z-2}B\right) - M\left({}^{4}_{2}He\right) \right\} c^2$$

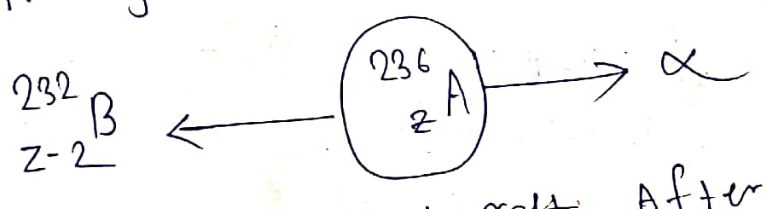
$$= \left\{ Z m_p + (236 - Z) m_n - \Delta_A - (Z-2) m_p - (232 - Z + 2) m_n + \Delta_B - M(\alpha) \right\} c^2$$

$$= \left\{ 2 m_p + 2 m_n - \Delta_A + \Delta_B - M(\alpha) \right\} c^2$$

$$= \left[\left(2 \times 1.0073 + 2 \times 1.0087 - 4.0015\right) \times 931.5 - 42.904 + 34.1095 \right] \text{MeV}$$

$$= 20.11625 \text{ MeV.}$$

Now from momentum conservation we get:



Assume A was at rest. After breaking α & B has momentum $\vec{p}_\alpha$ and $\vec{p}_B$

So $\vec{p}_\alpha + \vec{p}_B = 0$ i.e. $|\vec{p}_\alpha| = |\vec{p}_B|$

Now as α & B are heavy and hence we assume that their velocity is non relativistic after decay and we get:

$$E = KE(\alpha) + KE(B)$$

$$= \frac{p_\alpha^2}{2m_\alpha} + \frac{p_B^2}{2m_B} = p_\alpha^2\left(\frac{1}{2m_\alpha} + \frac{1}{2m_B}\right)$$

$$= \frac{p_\alpha^2}{2}\left(\frac{1}{m_\alpha} + \frac{1}{(Z-2)m_p + (232-Z+2)m_n + \Delta}\right)$$

i.e $$p_\alpha^2 = \frac{2E}{\left\{\frac{1}{m_\alpha} + \frac{1}{(Z-2)m_p + (234-Z)m_n - \Delta}\right\}}$$

$$E = E_\alpha + E_B$$

And $|p_\alpha| = |p_B|$ i.e $p_\alpha^2 = p_B^2$

i.e $2m_\alpha E_\alpha = 2m_B E_B = 2m_B(E - E_\alpha)$

(assuming non relativistic eq; $E \sim \frac{p^2}{2m}$)

i.e $$E_\alpha = \frac{E m_B}{m_\alpha + m_B} = \frac{E}{1 + \frac{m_\alpha}{m_B}}$$

The energy of α will be maximum if $\left(1 + \frac{m_\alpha}{m_B}\right)$ is minimum; i.e m_B is maximum.

for all possible isobars (same A; different Z) m_B will be maximum for lowest Z.

For all available materials (shown in NNDC) this is $^{236}_{89}Ac$

But the mass excess for ^{236}Pu matches with Δ_A given value.

So we take $A = {}^{236}_{94}Pu \to \Delta = 44.901$ } from NNDC

And $B = {}^{234}_{92}U \to \Delta = 34.609$ }

i.e $m_B = (92 \times 1.0073 + 140 \times 1.0087 - \underset{231.5}{34.609})$ U

$= 233.852449$ U

i.e $E_\alpha = \dfrac{20.11625}{1 + \dfrac{4.0015}{233.852449}}$ Mev.

$= 19.77783$ Mev.

This is the maximum energy of α particle if the decay happens to the lowest energy state of ${}^{232}_{92}U$. o/w α will have lower energy.