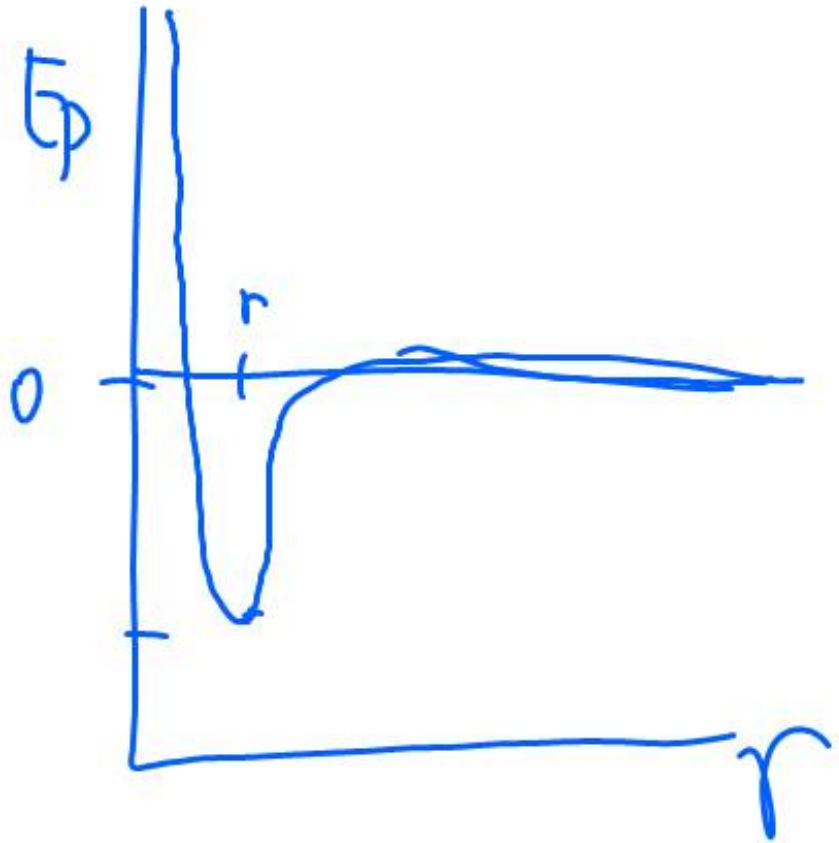
$F = k \frac{Q q}{r^2}$ Coulomb repulsiva

Fuerza nuclear fuerte → No depende de la carga

↓

- Muy intensa
- De corto alcance

Se da entre protones y entre neutrones.



$$r = r_0 . A^{1/3}$$

$$\downarrow$$

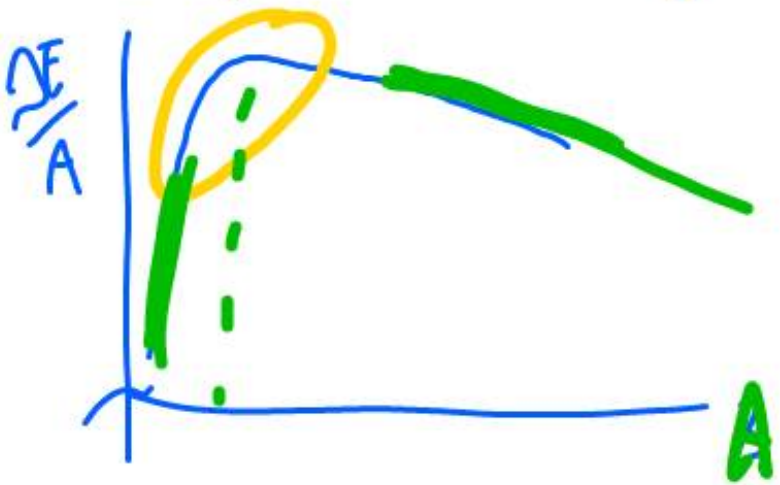
$$1,2 . 10^{-15} m$$

$E = mc^2$ $\Delta E = \Delta m \cdot c^2$

$\Delta m = Z\, m_p + (A-Z) \cdot m_n - m_{\text{núcleo}}$

Z: protones; $(A-Z)$: neutrones

$\frac{\Delta E}{A}$, Energía de enlace por nucleón



Radiactividad natural

- Rad α, + , $^{4}_{2}He$

$$^{56}_{25}X \longrightarrow {}^{4}_{2}He + {}^{52}_{23}Y$$

- Rad β ↗ $^{0}_{-1}e$ electrón

↘ $^{0}_{+1}e$ positrón

$$^{56}_{25}X \longrightarrow {}^{0}_{-1}e + {}^{56}_{26}Y$$

$$^{56}_{25}X \longrightarrow {}^{0}_{+1}e + {}^{56}_{24}Y$$

$$^{1}_{+1}p \longrightarrow {}^{0}_{+1}e + {}^{1}_{0}n + \text{neutrino}$$

$$^{1}_{0}n \longrightarrow {}^{0}_{-1}e + {}^{1}_{+1}p + \text{antineutrino}$$

. Red γ energie

$$^{56}_{25}X^{*} \rightarrow {}^{56}_{25}X + \gamma$$

ley de desintegración radiactiva

N nucleos presentes en una muestra

$$dN = N \cdot \lambda$$

λ cte de desintegración s^{-1}
particular de cada nuclido.

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

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

$$\int_{N_0}^{N} \frac{1}{N} dN = -\int \lambda\, dt$$

$$\ln N \Big]_{N_0}^{N} = -\lambda t$$

$$\ln N - \ln N_0 = -\lambda t$$

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

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

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

$A = N \cdot \lambda$ nucleos/s = Bq

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

Período de semidesintegración (semivida)

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

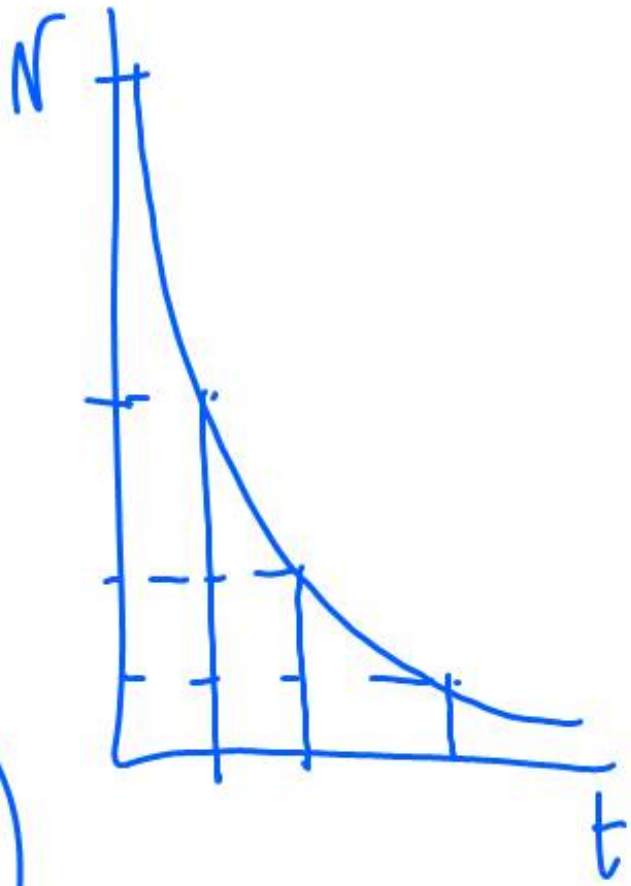
El t para q. $N = \frac{N_0}{2}$

$$\frac{N_0}{2} = N_0 \cdot e^{-\lambda t}$$

$$2^{-1} = e^{-\lambda t}$$

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

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



① $^{7}_{3}Li + ^{1}_{+1}P \rightarrow ^{4}_{2}He + ^{4}_{2}X$ ↳α

$^{7}_{3}Li(P, He)^{4}_{2}X$

(2)

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}X$$

↳ proton

$$^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}X$$

↳ neutron

(4)

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

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

$\lambda = 1{,}54 \cdot 10^{-10}$ año^{-1}

N_0 → $0{,}15$ Kg ^{238}U

$N_{convert}$ → $0{,}04$ Kg ^{206}Pb

$N_{que\ quedan\ sin\ desintegrar}$

238 u cada at

238 g cada mol de at.

$\frac{0{,}15 \cdot 10^3 \text{ g}}{238 \text{ g/mol núcleos}} = 0{,}63$ mol de núcleos

$\frac{0{,}04 \cdot 10^3 \text{ g}}{206 \text{ g/mol núcleos}} = 0{,}19$ mol núcleos

$N = 0{,}63 - 0{,}19 = 0{,}44$ mol de núcleos quedan sin desint.

$0{,}63 \cdot 6{,}022 \cdot 10^{23}$ núcleos $\quad 0{,}19 \cdot 6{,}022 \cdot 10^{23}$ núcleos.

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

$$0{,}44 = 0{,}63 \cdot e^{-1{,}54 \cdot 10^{-10} t}$$

$$t = 2{,}33 \cdot 10^{9} \text{ años}$$

⑤ $t = 332{,}3$ dias

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

$\lambda = 6{,}93 \cdot 10^{-3}\ \text{dias}^{-1}$

$8{,}02 \cdot 10^{-8}\ s^{-1}$

$\frac{6{,}93 \cdot 10^{-3}}{1\,\text{dia}} \times \frac{1\,\text{dia}}{24\,h} \times \frac{1\,h}{3600\,s}$

$0{,}1 = 1 \cdot e^{-6{,}93 \cdot 10^{-3} \cdot t}$

$A = \lambda \cdot N = 4{,}83 \cdot 10^{15}$ Bq

$A = 8{,}02 \cdot 10^{-8} \cdot 0{,}2 \cdot 6{,}022 \cdot 10^{23}$

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

Queda 10% de 1 → 0,1 mol

(6)

$N_0 = 2{,}87 \cdot 10^{19}$ núcleos

$N = 1{,}72 \cdot 10^{19}$ núcleos desint

$\lambda = 5{,}00 \cdot 10^{-3}$ dias

$t = 183$ dias

b) $N = 4{,}6 \cdot 10^{18}$ núcleos

$(2{,}87 \cdot 10^{19} - 1{,}72 \cdot 10^{19})$

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

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

$\ln\left(\frac{N}{N_0}\right) = -\lambda t$

$t = \frac{-\ln\left(\frac{N}{N_0}\right)}{\lambda}$

$N = 2{,}87 \cdot 10^{19} \cdot e^{-5{,}00 \cdot 10^{-3} \cdot 365}$

(7) a) $T_{\frac{1}{2}} = 2{,}33 \cdot 10^5$ años $\rightarrow \lambda = 2{,}97 \cdot 10^{-6}$ años $= 9{,}43 \cdot 10^{-14}\ s^{-1}$

$$\tau = \frac{1}{\lambda} = 3{,}36 \cdot 10^5 \text{ años}$$

b) ~~$5{,}015 \cdot 10^7$ núcleos.~~ 4980000

$$N = 5 \cdot 10^7 \cdot e^{-2{,}97 \cdot 10^{-6} \cdot 1000} = 4{,}98 \cdot 10^7 \text{ núcleos}$$

(8) $\lambda = 0{,}0257\ dias^{-1} = 2{,}97 \cdot 10^{-7}\ s^{-1}$

$\frac{0{,}0257}{dia} \cdot \frac{1dia}{24h} \cdot \frac{1h}{3600s}$

$N = 5{,}89 \cdot 10^{21}$ nucleos

$m = 0{,}5\ g$ $\quad m = \frac{5{,}89 \cdot 10^{21}}{6{,}022 \cdot 10^{23}} \cdot 51$

$N = 6{,}022 \cdot 10^{23} \cdot e^{-2{,}97 \cdot 10^{-7} \cdot 180 \cdot 24 \cdot 3600}$

$1 \cdot e$

$9{,}84 \cdot 10^{-3}$ mol nucleos

9

$A_0 = 2{,}8 \cdot 10^7$ Bq

$A = \lambda N$

$T_{1/2} = 5730$ años

$\lambda = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{1{,}81 \cdot 10^{11}\ s} = 3{,}84 \cdot 10^{-12}\ s^{-1}$

$\lambda\ s^{-1}$

$N = \frac{A}{\lambda} = \frac{2{,}8 \cdot 10^7}{3{,}84 \cdot 10^{-12}} = 7{,}3 \cdot 10^{18}$ núcleos

A después de 1000 años

$N = 7{,}3 \cdot 10^{18} \cdot e^{-3{,}84 \cdot 10^{-12} \cdot 3{,}15 \cdot 10^{10}}$

$N = 6{,}5 \cdot 10^{18}$ núcleos

$A = 3{,}84 \cdot 10^{-12} \cdot 6{,}5 \cdot 10^{18} = 2{,}4 \cdot 10^7$ Bq

$A = A_0 \cdot e^{-\lambda t} = 2{,}48 \cdot 10^7$ Bq

(10) $T_{1/2} = 5$ días

$16 \cdot 10^{-3}$ kg

(10) $^{210}_{83}Bi \longrightarrow {}^{0}_{-1}e + {}^{210}_{84}X$ $\begin{cases} p\ 84 \\ e\ 84 \\ n\ (210-84) \end{cases}$

$m = 16 \cdot 10^{-3}\ kg = 16\ g$

$n = \frac{16}{210} = 0{,}076$ moles núcleos

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

$t = 15$ días

$N = 0{,}076 \cdot e^{-0{,}14 \cdot 15}$

$T_{1/2} = 5$ días $\rightarrow \lambda = \frac{\ln 2}{5} = 0{,}14\ días^{-1}$

$N = 9{,}3 \cdot 10^{-3}$ moles de núcleos

$m = 9{,}3 \cdot 10^{-3} \cdot 210 = 2\ g$

(13) $^{14}_{7}N + {}^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{14}_{6}X$ → C-14

$\Delta E = 0{,}61$ MeV

Δm → disminuido

$0{,}61 \cdot 10^{6}$ eV $\cdot \frac{1{,}6 \cdot 10^{-19}}{1\text{ eV}} = 9{,}76 \cdot 10^{-14}$ J

$\Delta E = \Delta m \cdot c^2$

$\Delta m = \frac{9{,}76 \cdot 10^{-14}}{(3 \cdot 10^{8})^2} = 1{,}08 \cdot 10^{-30}$ kg

$\lambda = \frac{\ln 2}{5600} = 1{,}24 \cdot 10^{-4}$ años

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

$\frac{2}{3} N_0 = N_0 \cdot e^{-\lambda t}$

$\frac{2}{3} = e^{-1{,}24 \cdot 10^{-4} \cdot t}$

$t = 3270$ años

(14) $\Delta m = 15(1,0073) + 16(1,0087) - 30,970 =$

$\Delta m = 0,2787\ u \rightarrow 4,63 \cdot 10^{-28}\ kg$

$\Delta E = m \cdot c^2$

$\Delta E = 4,16 \cdot 10^{-11}\ J$

$\hookrightarrow 260\ MeV$

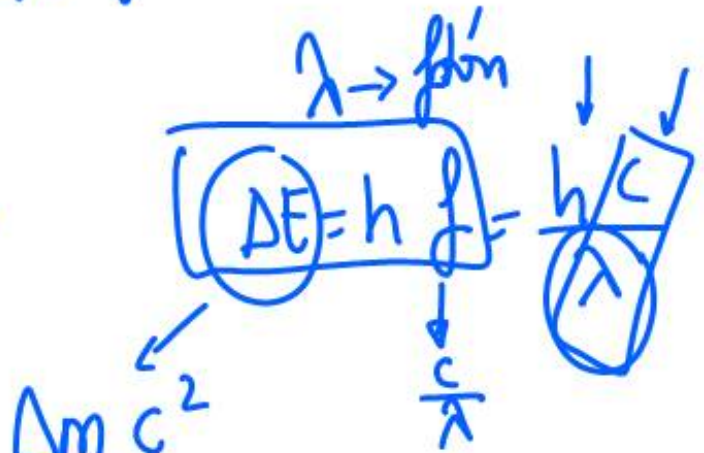
$\frac{\Delta E}{A} = \frac{260}{31} = 8,39\ MeV/nucleón$.

(15) ${}_1^2H + {}_0^1n \rightarrow {}_1^3H + \gamma$

$\Delta m = 2,01474 + 1,008986 - 3,017005$

$\Delta m = 6,721.10^{-3}u$

$1,1157.10^{-29}Kg$



$\Delta m c^2 = \frac{h c}{\lambda}$

$\lambda = \frac{h}{\Delta m c} = \frac{6,63.10^{-34}}{(3.10^8)}$

(18)

$N = \frac{A}{\lambda} = \frac{2,8 \cdot 10^{7}}{5,53 \cdot 10^{-12}} = 5,06 \cdot 10^{18}$ núcleos

$\lambda = \frac{1}{5730} 1,75 \cdot 10^{-4}$ años^{-1} ↓ $5,53 \cdot 10^{-12}$ s^{-1}

$A = A_0 \cdot e^{-\lambda t} = 2.8 \cdot 10^{7} \cdot e^{-1,75 \cdot 10^{-4} \cdot 1000}$

$A = 2,37 \cdot 10^{7}$ Bq

16 $\Delta m = 0{,}02\,u$ $\Delta E = 18{,}63\,MeV$

17 $\Delta E = 17{,}57\,MeV$

19 $m = 0{,}31 \cdot 10^{-3}\,g$ $A = 4{,}7 \cdot 10^{9}$ núcleos/s

20 $t = 19\,188{,}2$ años

21 a) $A = 7{,}91 \cdot 10^{7}\,Bq$ b) $m = 4{,}79 \cdot 10^{-4}\,g$

22 $E = 2{,}28 \cdot 10^{4}\,Kw \cdot h$

23 $t = 5{,}1 \cdot 10^{10}$ años

(24) $^{32}_{15}P \rightarrow {}^{0}_{-1}e + {}^{32}_{16}X$

$\Delta m = 31,972077\,u$

(25) $^{32}_{15}P \rightarrow {}^{0}_{-1}e + {}^{32}_{16}S$ $\quad \Delta E = 1,8690 \cdot 10^{-13}\,J$

$f = 2,82 \cdot 10^{20}\,s^{-1}$

Fract nucleo $= \frac{N}{N_0} = 0,907$ ↳ Quelques

9,3 %

(14) $^{31}_{15}P$ $\approx$ 30,970 u

$$\Delta m = Z \cdot m_p + (A-Z) \cdot m_n - 30{,}97$$

$$\Delta E = \Delta m \cdot c^2$$

$$\frac{\Delta E}{A}$$