1 $A = Z + N$ ${}^{A}_{Z}X$ N Z

2 N Z

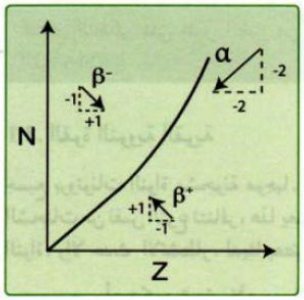
3

4 ${}^{12}C$ $\frac{1}{12}$ $\boldsymbol{u}$

$$1u = \frac{1}{12}\, m_c = \frac{1}{N_A} = 1.66 \times 10^{-27}\ kg$$

5 γ β α

$(\boldsymbol{N}, \boldsymbol{Z})$



التناقص الإشعاعي يؤدي إلى
إنسحاب النواة نحو وادي الإستقرار.

- $Z < 20$ $Z = N$
- $Z > 20$ $Z = N$
- β^- -
- β^+ -
- α -

$${}^{A_1}_{Z_1}X_1 + {}^{A_2}_{Z_2}X_2 \rightarrow {}^{A_3}_{Z_3}X_3 + {}^{A_4}_{Z_4}X_4$$

- $A_1 + A_2 = A_3 + A_4$
- $Z_1 + Z_2 = Z_3 + Z_4$

$A > 200\ ; Z > 83$ ${}^{4}_{2}He$ **α**

$\boldsymbol{\beta^-}$

$\boldsymbol{\beta^+}$

γ

- γ β α

${}^{A}_{Z}X^*$ ${}^{A}_{Z}X^* \rightarrow {}^{A}_{Z}X + \gamma$

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$\frac{dN}{dt}+\lambda N=0$	$N=N_0e^{-\lambda t}$		$\boldsymbol{N}$
$N`=N_0-N=N_0-N_0e^{-\lambda t}$ $=N_0(1-e^{-\lambda t})$	$N`=N_0(1-e^{-\lambda t})$		$\boldsymbol{N`}$
$A=-\frac{dN(t)}{dt}\Rightarrow A=-\frac{d(N_0e^{-\lambda t})}{dt}$ $=\lambda N_0e^{-\lambda t}$ $t=0\Rightarrow A_0=\lambda N_0$ $\Rightarrow A=\lambda N_0e^{-\lambda t}\Rightarrow A=A_0e^{-\lambda t}$	$A=-\frac{dN(t)}{dt}$ $A=\lambda N(t)$ $A_0=\lambda N_0$ $A=A_0e^{-\lambda t}$	Bq $\boldsymbol{Bq}$ •	$\boldsymbol{A}$
$t=\tau\Rightarrow N(t)=N_0e^{-\lambda\tau}=N_0e^{-1}$ $=0.37N_0$ $t=\tau\Rightarrow N`=N_0-N$ $=N_0-N_0e^{-\lambda\tau}$ $=N_0-0.37N_0=0.63N_0$	$\tau=\frac{1}{\lambda}$	63%	τ
$t=t_{\frac{1}{2}}\Rightarrow N=\frac{N_0}{2}\Rightarrow \frac{N_0}{2}$ $=N_0e^{-\lambda t_{\frac{1}{2}}}$ $\Rightarrow\frac{1}{2}=e^{-\lambda t_{\frac{1}{2}}}\Rightarrow -\ln 2=-\lambda t_{\frac{1}{2}}$ $\Rightarrow t_{\frac{1}{2}}=\frac{\ln 2}{\lambda}$	$t_{\frac{1}{2}}=\frac{\ln 2}{\lambda}$		$\boldsymbol{t_{\frac{1}{2}}}$
$t=t_{\frac{1}{2}}\Rightarrow N=\frac{N_0}{2}\Rightarrow \frac{N_0}{2}$ $=N_0e^{-\lambda t_{\frac{1}{2}}}$ $\Rightarrow\frac{1}{2}=e^{-\lambda t_{\frac{1}{2}}}\Rightarrow -\ln 2=-\lambda t_{\frac{1}{2}}$ $\Rightarrow \lambda=\frac{\ln 2}{t_{\frac{1}{2}}}$	$\lambda=\frac{\ln 2}{t_{\frac{1}{2}}}$	s^{-1}	$\boldsymbol{\lambda}$
$t=nt_{\frac{1}{2}}\Rightarrow N=N_0e^{-\lambda nt_{\frac{1}{2}}}$ $\Rightarrow\frac{N}{N_0}=e^{-\lambda nt_{\frac{1}{2}}}$ $\Rightarrow\ln\frac{N}{N_0}=-\lambda nt_{\frac{1}{2}}$ $\Rightarrow\ln\frac{N}{N_0}=-\lambda n\times\frac{\ln 2}{\lambda}$ $\Rightarrow-\ln\frac{N_0}{N}=-\ln 2^n\Rightarrow\frac{N_0}{N}=2^n$ $\Rightarrow N=\frac{N_0}{2^n}$	$t=nt_{\frac{1}{2}}\Rightarrow N=\frac{N_0}{2}$		$\boldsymbol{t=nt_{\frac{1}{2}}}$

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$\Delta E = \Delta m c^2$ ΔE Δm

- هي وحدة لقياس كتلة الجسيمات الصغيرة جدا وهي تمثل $\frac{1}{12}$ من كتلة الكربون ^{12}C

$$1u = \frac{1}{12}\frac{M}{N_A} = \frac{1}{12} \times \frac{12}{N_A} = \frac{1}{N_A} = 1.66054 \times 10^{-27}\ kg$$
$$1eV = 1.602177 \times 10^{-19}$$
$$1MeV = 10^6 eV = 1.6 \times 10^{-13} J$$
$$1u = 931.5\ MeV/c^2$$

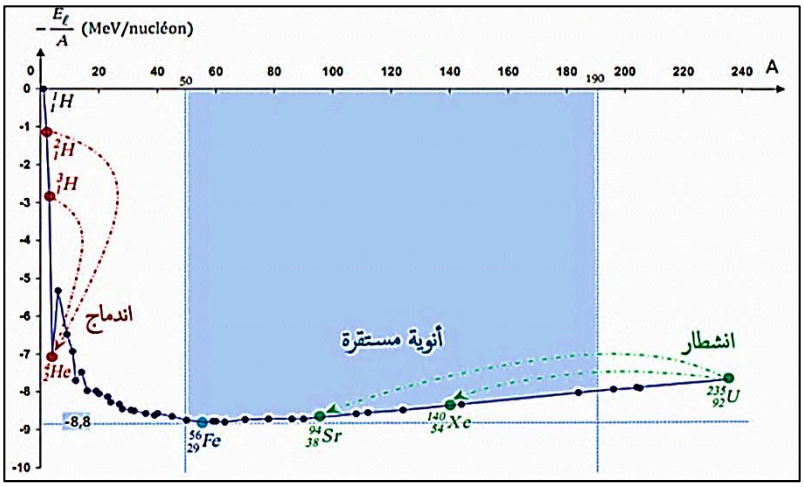
$\boldsymbol{E_l}$

$E = \frac{E_l}{A}$

A

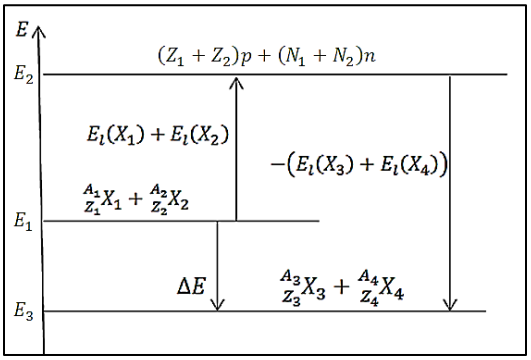
A

- $A < 20$
- $50 < A < 190$
- $50 < A < 75$
- $A > 190$



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$\Delta m = \left[Zm_p + (A-Z)m_n\right] - m(^A_ZX)$	^A_ZX Δm
$E_l = \lvert\Delta m\rvert c^2 = \left\lvert\left[Zm_p + (A-Z)m_n\right] - m(^A_ZX)\right\rvert c^2$	^A_ZX E_l
$E = \frac{E_l}{A}$	^A_ZX
$\Delta E = E_l(X_1) + E_l(X_2) - E_l(X_3) - E_l(X_4)$	$^{A_1}_{Z_1}X_1 + {}^{A_2}_{Z_2}X_2 \rightarrow {}^{A_3}_{Z_3}X_3 + {}^{A_4}_{Z_4}X_4$
$E_{lib} = \left[m_{X_1} + m_{X_2} - \left(m_{X_3} + m_{X_4}\right)\right] \times c^2$	$^{A_1}_{Z_1}X_1 + {}^{A_2}_{Z_2}X_2 \rightarrow {}^{A_3}_{Z_3}X_3 + {}^{A_4}_{Z_4}X_4$

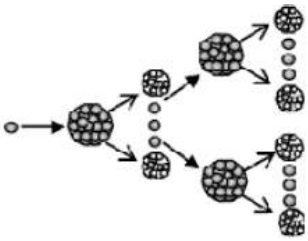


$^{A_1}_{Z_1}X_1 + {}^{A_2}_{Z_2}X_2 \rightarrow {}^{A_3}_{Z_3}X_3 + {}^{A_4}_{Z_4}X_4$

-

$E_{lib} = E_1 - E_3$

-



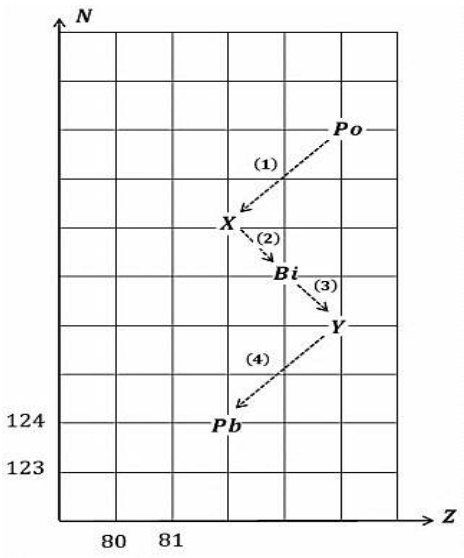
-

-

$10^8 K$

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1



238

1

Y X 2

Po Y 3

4 3 2 1 4

-

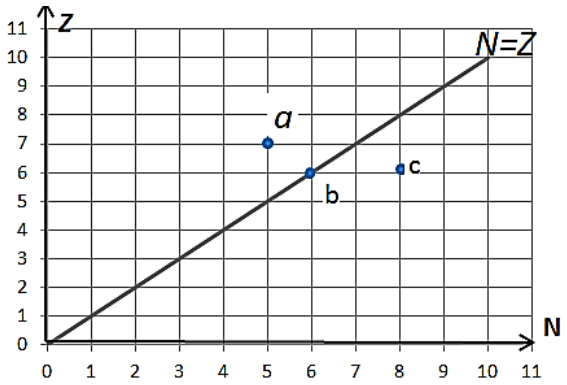
2

c b a $(N-Z)$

$^{A}_{Z}X$ 1

2

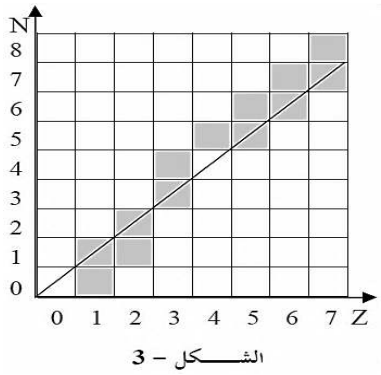
3



	Li	B	C	N	O
Z	3	5	6	7	8

2010 3

1



الشـــكل – 3

-
-
-
-

$1 \le Z \le 7$ 2

3 (N,Z) -

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$^{12}_{7}N, ^{13}_{7}N, ^{16}_{7}N$ $^{11}_{6}C, ^{14}_{6}C, ^{8}_{5}B, ^{12}_{5}B, ^{14}_{5}B$ 3

β^-

β^+

14

2010 4

$t_{1/2} = 30,2 ans$ 137

$A_0 = 3,0 \times 10^5 Bq$

β^- $^{137}_{55}Cs$ 1

137

λ

137 m_0

$A(t)$ 2

$A = \frac{A_0}{10}$ 3

$_{53}I$	$_{54}Xe$	$_{55}Cs$	$_{56}Ba$	$_{57}La$

$N_A = 6,02 \times 10^{23} mol^{-1}$

$M\left(^{137}Cs\right) = 136,9 g/mol$

2012 5

2012 04 10

γ β^- $^{137}_{55}Cs$ 137

$m_0 = 5.02 \times 10^{-2} g$ $t_{1/2} = 30.15 ans$

$A = 14.97 \times 10^{10} Bq$ A

γ β^- 1

N_0 2

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s^{-1} بـ λ 3

A_0 A 4

5

365.25 $N_A = 6.02 \times 10^{23} mol^{-1}$

$_{53}I$ ، $_{54}Xe$ ، $_{55}Cs$ ، $_{56}Ba$

2008 6

137 192

γ β^- $^{137}_{55}Cs$ 1

γ γ β^-

$^{A}_{Z}Y$

$^{138}_{57}La$, $^{137}_{56}Ba$, $^{131}_{54}Xe$

$.t = 0s$ $m = 10^{-6}g$ $^{137}_{55}Cs$ 2

N_0

(06) 3

أ/

ب/

1% 4

τ

$M(Cs) = 137\ g/mol$ $\tau = 43.3\ ans$ $:Cs$ $N_A = 6{,}023 \times 10^{23}$

2009 7

1898 84 Po

210

α

1

$^{A}_{Z}Pb$ α 210 2

Z A

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$t=0$ $t_{1/2}=138\,j$ 210 3

$A_0=10^8\,Bq$

λ

$t=0$ 210 N_0

$t=0$

2010 8

13 12

$t_{1/2}=5570 ans$ 14

$^{14}_{7}N$ 14 $^{13}_{6}C$ 13 $^{12}_{6}C$ 12

14 1

$^{14}_{7}N+{}^{1}_{0}n\rightarrow {}^{A}_{Z}Y_1+{}^{1}_{1}H$ 2

$^{A}_{Z}Y_1$

β^- $^{A'}_{Z'}Y_2$ 14

Y_2

$N(t)=N_0e^{-\lambda t}$ 3

$\lambda=\frac{ln2}{t_{1/2}}$ $N(t),N_0,t$

λ

14 λ

A 2000 $m(g)$ 4

13.6 A_0 11.3

t λ A_0 $A(t)$

2008 9

18 $(-OH)$

$(t_{1/2}=110\min)$ $^{18}_{9}F$

$^{18}_{8}O$ 18 $2,6\times10^8\,Bq$

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1

$\lambda = \frac{ln2}{t_{1/2}}$ λ 2

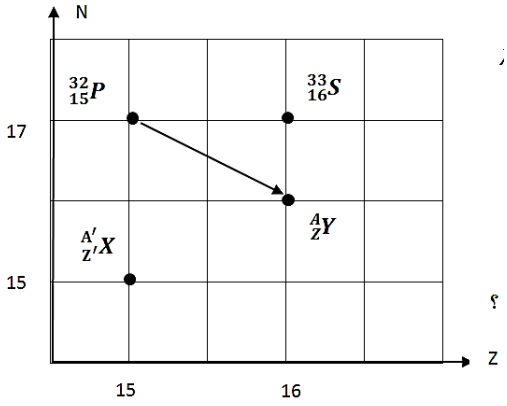
$^{18}_{9}F$ 3

$^{18}_{9}F$

1%

2015 10

$^{32}_{15}\mathrm{P}$



32

$\lambda = 4{,}48.10^{-2} jours^{-1}$

(Z, N) 1

$^{A}_{Z}\mathrm{Y}$

$^{A}_{Z}\mathrm{Y}$ $^{32}_{15}\mathrm{P}$

$(t = 0)$ 2

$A_0 = 4.2 \times 10^{15} Bq$ 32

B $N = Be^{-\lambda t}$ $\lambda N + \frac{dN}{dt} = 0$

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

1%

.

$(jours)$

$N_A = 6.02 \times 10^{23} mol^{-1}$

2013 11

$^{36}_{17}Cl$ ^{37}Cl ^{35}Cl

$301 \times 10^3 ans$ ؛ $^{36}_{17}Cl$ 36 36

36 37 35 1

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36 2

36 3

38% 36

2010 12

(b) (a)

-
-

70

14

(β^-) 14

$A_0 = 6000Bq$ $A_{(b)} = 4500Bq$ $A_{(\alpha)} = 5000Bq$

$t_{1/2} = 5570ans$ ^{14}C

$^{19}_{9}F$ $^{14}_{7}N$ $^{16}_{8}O$ $^{14}_{6}C$ 1

$A_0, t, t_{1/2}$ $A(t)$ 2

3

2015 13

$(^{12}_{6}C, ^{14}_{6}C)$ C

$^{14}_{6}C$ $\frac{N(^{14}_{6}C)}{N(^{12}_{6}C)} = 1.2 \times 10^{-12}$

$^{A}_{Z}X$ β^- 14 1

$_8O$ $_7N$ $_9F$ $_6C$ $_5B$ 14

0.023 $m = 300mg$ 2

$150mg$ 12

$^{14}_{6}C$ $^{12}_{6}C$

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A_0

$N_A = 6.02 \times 10^{23} mol^{-1}. t_{1/2}(^{14}_{6}C) = 5730 ans\ .\ M_{^{14}_{6}C} = 14\ g/mol\ .$

$1 ans = 31536 \times 10^3 s$

14

β^-

$^{60}_{27}Co$

α

β^- α 1

$^{60}_{27}Co$ 2

3

$m = 1\mu g$ 60 4

t λ $t = 0$ A_0 A

A_0 t $\frac{A(t)}{A(t+5)} = 2.177$ λ

$2.2 \times 10^7 Bq$

$_{25}Mn$	$_{26}Fe$	$_{27}Co$	$_{28}Ni$	$_{29}Cu$

$N_A = 6.02 \times 10^{23} mol^{-1}$

2016 15

32

$m(^{32}_{15}P) = 31.9657\ u$
$m(^{32}_{16}S) = 31.9633\ u$
$m(^{1}_{1}p) = 1.00728\ u$
$m(^{1}_{0}n) = 1.00866\ u$
$1u = 931.5\ MeV/C^2$

$(N-)$		
$^{32}_{15}P$	$^{33}_{16}S$	$^{34}_{17}Cl$
$^{31}_{15}P$	$^{32}_{16}S$	$^{323}_{17}Cl$
$^{30}_{15}P$	$^{31}_{16}S$	$^{32}_{17}Cl$

32	
$^{32}_{15}P$	
β^-	
$8.46\ MeV$	
$14\ jours$	$t_{\frac{1}{2}}$

1

32

$N(t)$

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$m'(t)$ 32 2

32 m_0 t

λ $m'(t) = m_0(1 - e^{-\lambda t})$

$(N - Z)$ 3

$\frac{A(t)}{A_0} = \frac{1}{4}$ $^{32}_{15}P$ 4

$t = 2t_{\frac{1}{2}}$

16

$^{206}_{82}Pb$ 238

$^{238}_{92}U \longrightarrow {}^{206}_{82}Pb + x\alpha + y\beta^-$ β α

$m(^{206}_{82}Pb) = 10mg$ 238 $m(^{238}_{92}U) = 1g$ t

1

$t_{\frac{1}{2}}$ λ 2

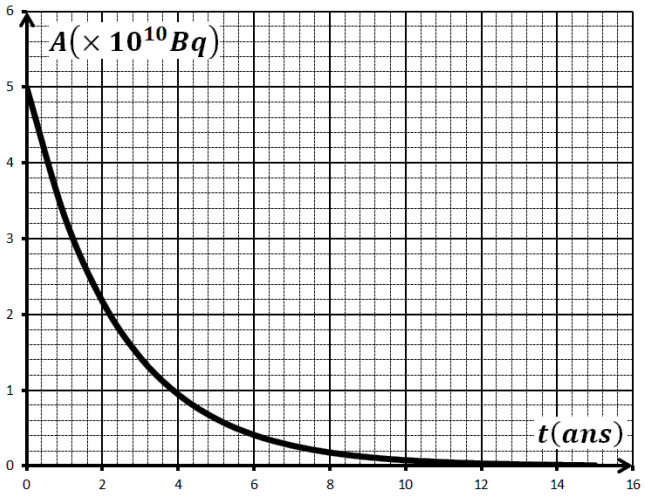
$N(^{206}_{82}Pb)$ $N = N_0 e^{-\lambda t}$ 238 3

$\varepsilon \ll 1$ $e^{\varepsilon} = 1 + \varepsilon$ $t = \frac{N(^{206}_{82}Pb) \times t_{\frac{1}{2}}}{N_0 \times ln\,2}$ $t \ll t_{\frac{1}{2}}$ 4

$t_{\frac{1}{2}} = 4.5 \times 10^9 ans$

2014 17

β^- ^{134}Cs



β^- 1

^{134}Cs 2

3

$A = f(t)$

134 A

m_0

A_0

$t = 0$

τ $t = \tau$

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$t_{\frac{1}{2}} = \tau \ln 2$ $^{134}_{55}Cs$ $t_{\frac{1}{2}}$

134 $m`(t)$ m_0

$m`(t) = m_0(1 - e^{-\lambda t})$

	Xe	Cs	Ba	La
z	54	55	56	57

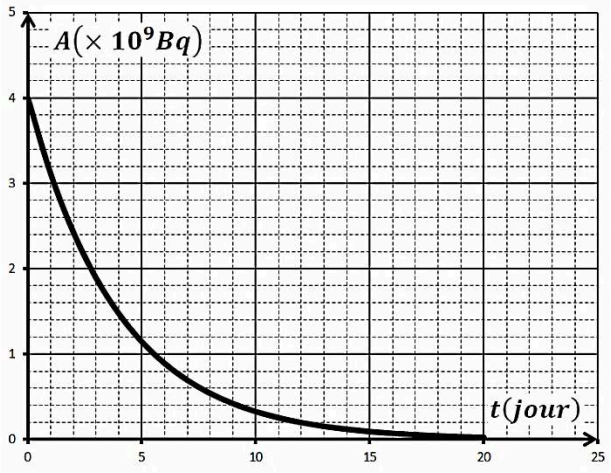
t $m`(t)$

$N_A = 6.02 \times 10^{23} mol^{-1}$

2015 18

$V_0 = 10ml$ $^{186}_{75}Re$

$^{186}_{76}O$ $^{186}_{75}Re$ 1



1 2

$A = f(t)$

A_0

$t_{1/2}$

$^{186}_{75}Re$ λ

3

$t_1 = 10jours$

$^{186}_{75}Re$ 1.2×10^{14} V t_1 4

V

19

γ β^- 131

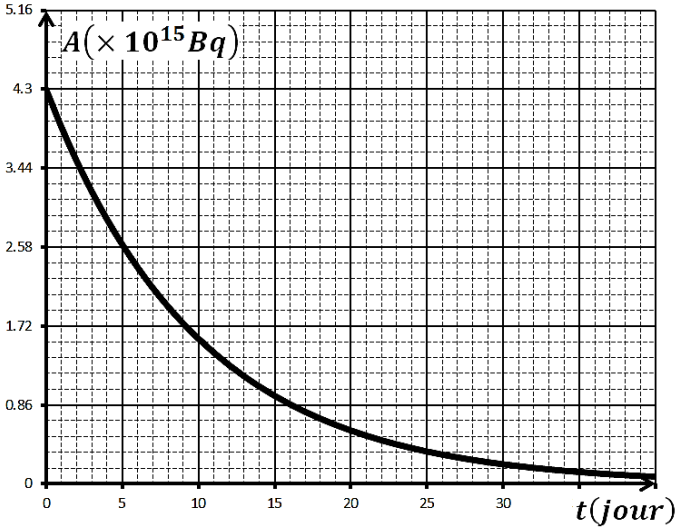
1

γ 2

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$^{A}_{Z}Xe$ $^{131}_{53}I$ 3

131 4



A_0

$t_{\frac{1}{2}}$

N_0 λ

5

48 77%

48

20

210

α

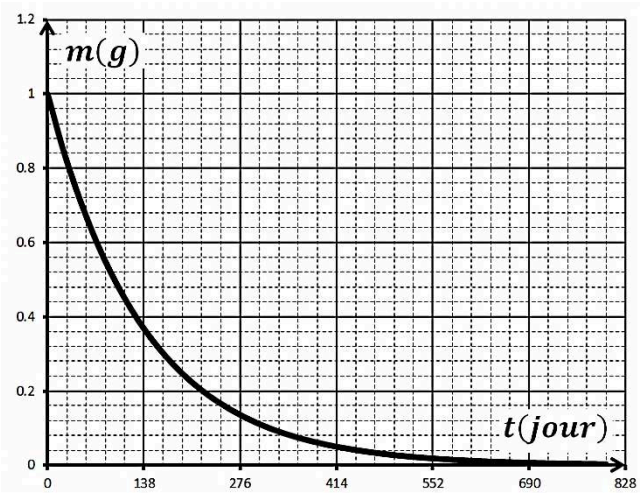
α 1

$^{210}_{84}Po$ 2

$N(t) = N_0 e^{-\lambda t}$ 3

$m(t) = m_0 e^{-\lambda t}$ $m(t)$

m_0 4



m_0

$t_{\frac{1}{2}}$

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

N_A $m(t)$ λ $A(t)$ 5

M

A_0

α

$10^{-6} g$

$_{81}Tl$	$_{82}Pb$	$_{83}Bi$	$_{84}Po$	$_{85}At$	$_{86}Rn$

$N_A = 6.02 \times 10^{23} mol^{-1}$

$M(Po) = 210\ g/mol$

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2016 21

$N_A = 6.02 \times 10^{23} mol^{-1}$ $1ans = 365.25jour$ ${}_6C$ ${}_5B$ ${}_4Be$ ${}_3Li$

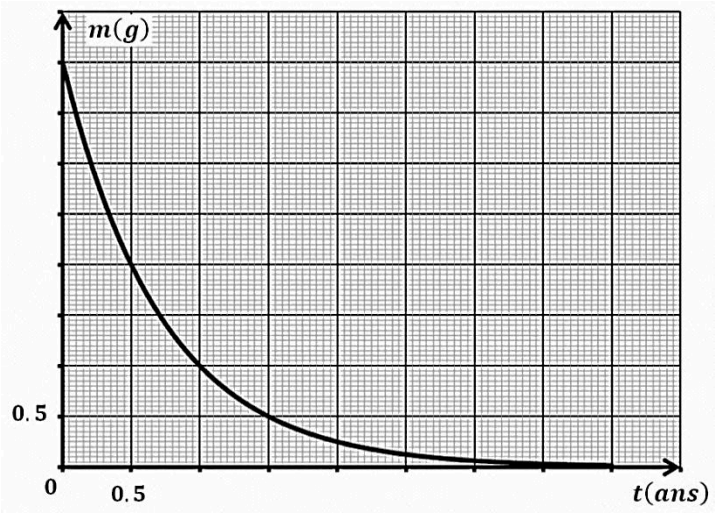
${}^A_Z X$ β^- ${}^{10}_4 Be$

Z A 1

β^-

m_0 m 2

λ N_0



$m(t)$

m_0 t

λ

λ $t_{\frac{1}{2}}$ 3

a^{-1} λ

$t = 1ans$

A 4

$A = 1.06 \times 10^{15} Bq$ 10

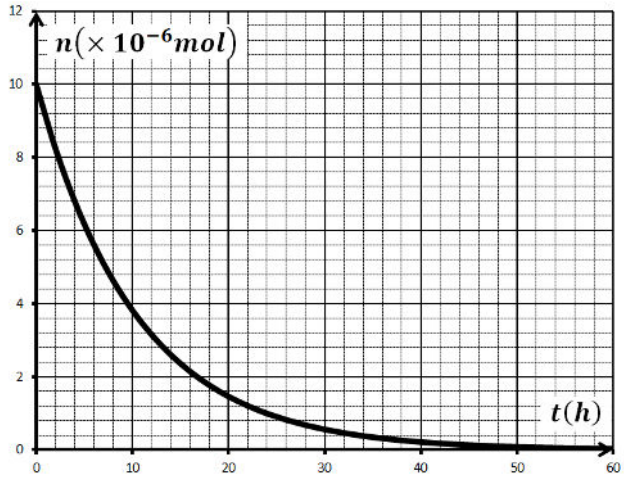
10 m

$m_0 = 4g$

2013 22

${}^{23}_{11}Na$ 24 ${}^{23}_{11}Na$

1



${}^{24}_{11}Na$

β^- 24 2

${}^{24}_{11}Na$

${}_{10}\mathrm{Ne}$ ، ${}_{12}\mathrm{Mg}$ ، ${}_{13}\mathrm{Al}$ ، ${}_{14}\mathrm{Si}$

$V_1 = 10ml$ 3

$t = 0h$ 24

24

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24 n_0

$t = 0h$ 24 4

$n = n_0 e^{-\lambda t}$ 24

$n_1 = 7.6 \times 10^{-6} mol$ $t_1 = 6h$ 24

$V_2 = 10ml$ $t_1 = 6h$ 5

$n_2 = 1.5 \times 10^{-8} mol$ 24

24 V 6

23

$^{24}_{11}Na$

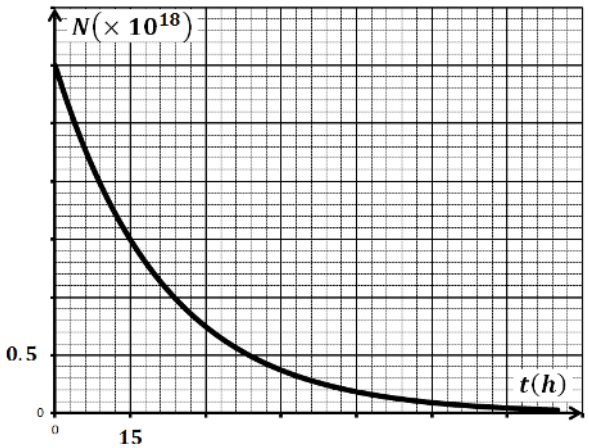
$^{23}_{11}Na$ 24 1

$^{24}_{11}Na$

$^{24}_{12}Mg$ 24 2

24

24 3



N_0

λ $t_{\frac{1}{2}}$

4

24 N_0 $t_0 = 0$

$^{24}_{11}Na$ n_1

$t_1 = 3h$

$2ml$ $t_1 = 3h$

24 $n_2 = 2.1 \times 10^{-9} mol$

24 $5L$

A 23 -1

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24

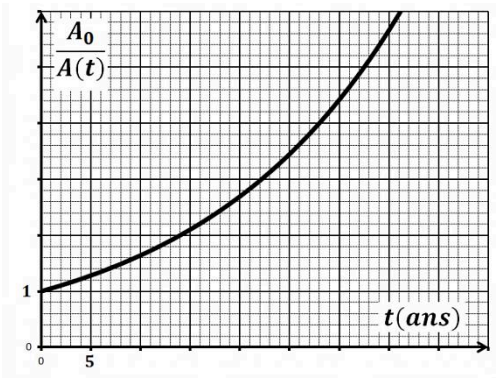
$^{238}_{92}U$ $^{241}_{94}Pu$

$^{238}_{92}U + x\,^{1}_{0}n \rightarrow {}^{241}_{94}Pu + y\,^{0}_{-1}e$

y x

$^{A}_{Z}Am$ β^- $^{241}_{94}Pu$

$t = 0$ $^{241}_{94}Pu$ $m_0 = 4 \times 10^{-6} g$ 2



$A(t)$ $\frac{A_0}{A(t)}$

$t = 0$ A_0 t

N_0

$t_{\frac{1}{2}}$

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

A_0

$N_A = 6.02 \times 10^{23} mol^{-1}$

2016 25

$^{241}_{94}Pu$ Pu

$^{238}_{92}U + x\,^{1}_{0}n \rightarrow {}^{241}_{94}Pu + y\beta^-$ $^{238}_{92}U$

β^- 1

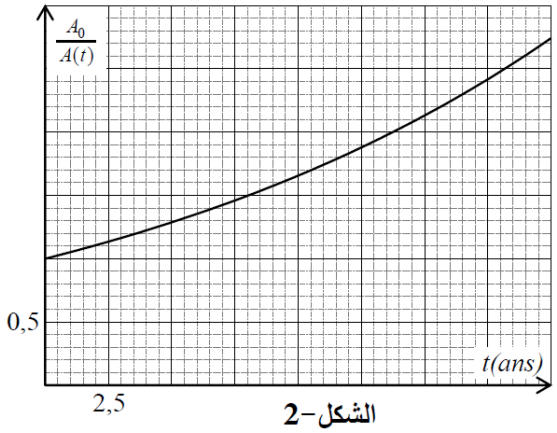
y x 2

$^{241}_{94}Pu$ 3

β^- $^{A}_{Z}Am$

Z A

$^{241}_{94}Pu$ 4



الشكل-2

$A(t)$ $\frac{A_0}{A(t)} = f(t)$ $\frac{A_0}{A(t)}$

2 $t = 0$ A_0 t

λ t λ $\frac{A_0}{A(t)}$

λ $^{241}_{94}Pu$ $t_{\frac{1}{2}}$

$\frac{A(t)}{A_0} = g(t)$

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2008 26

$^{35}_{17}Cl$ $^{35}_{17}Cl$

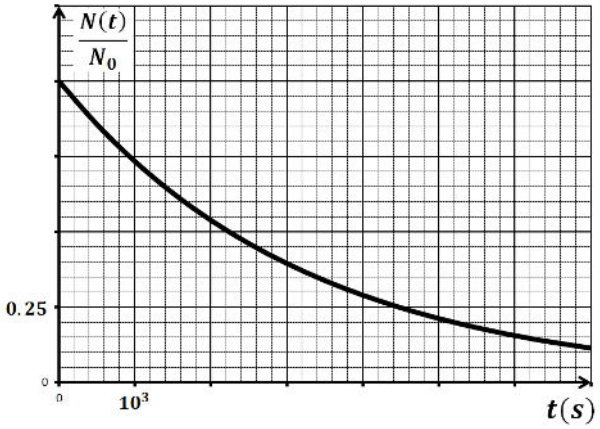
$^{A}_{Z}X$

	$^{38}_{17}Cl$	$^{39}_{17}Cl$	$^{31}_{14}Si$	$^{18}_{9}F$	$^{13}_{7}N$
$t_{1/2}(s)$	2240	3300	9430	6740	594

$\frac{N(t)}{N_0} = f(t)$ $^{A}_{Z}X$

$t = 0$ N_0

t $N(t)$



$(t_{1/2})$ 1

$^{A}_{Z}X$

λ $(t_{1/2})$ 2

$^{A}_{Z}X$ λ

3

$^{A}_{Z}X$

$^{A}_{Z}X$ $^{35}_{17}Cl$ 4

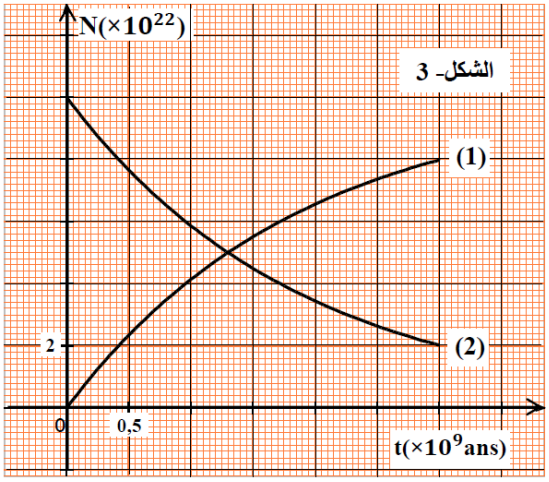
2016 27

$^{40}_{20}Ca$ $^{40}_{19}K$

1

40

40 40 3 2



40

40

40 t_1 3

40

t_1

$1ans =$

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2009 28

$^{206}_{82}Pb$ $^{210}_{84}Po$

$^{210}_{84}Po$ 1

$m_0 = 10^{-5}\,g$ N_0 2

N t 3

$t(jours)$	0	40	80	120	160	200	240
$\frac{N(t)}{N_0}$	1,00	0,82	0,67	0,55	0,45	0,37	0,30

$1cm \to 0,2$ $1cm \to 40\,j$ $\left(-\frac{N(t)}{N_0}\right)$

$^{210}_{84}Po$ λ

(m_0) $\frac{1}{100}$

$M(Po) = 210g/mol$ $N_A = 6,023\times10^{23}\,mol^{-1}$

2008 29

(Po) 1

α $\left(^{206}_{82}Pb\right)$ $\left(^{A}_{Z}Po\right)$

Z A $\left(^{A}_{Z}Po\right)$

$N(t)$ $t=0$ $\left(^{A}_{Z}Po\right)$ N_0 2

α t

$t(jours)$	0	20	50	80	100	120
$\frac{N(t)}{N_0}$	1.00	0.90	0.78	0.67	0.61	0.55
$-ln\frac{N(t)}{N_0}$						

$$-ln\frac{N(t)}{N_0} = f(t)$$

$1cm \to 0.10$ $1cm \to 20\,jours$

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$\left({}^{A}_{Z}Po\right)$ λ

$\left({}^{A}_{Z}Po\right)$

2010 30

x ${}^{238}_{92}U$ ${}^{241}_{94}Pu$

${}^{238}_{92}U + x\,{}^{1}_{0}n \rightarrow {}^{241}_{94}Pu + y\,{}^{0}_{-1}n$

y x 1

${}^{A}_{Z}Am$ β^- ${}^{241}_{94}Pu$

Z A

N_0 $t=0$ ${}^{241}_{94}Pu$ 2

$t=0$ A_0 t $A(t)$ $\frac{A(t)}{A_0}$

$t(ans)$	0	3	6	9	12
$\frac{A(t)}{A_0}$	1.00	0.85	0.73	0.62	0.53

$$ln\frac{A(t)}{A_0} = f(t)$$

t λ $ln\frac{A(t)}{A_0}$

${}^{241}_{94}Pu$ $t_{1/2}$ λ

2009 31

α ${}^{226}_{88}Ra$

${}^{226}_{88}Ra$ 88 226 1

${}^{A}_{Z}X$ ${}^{226}_{88}Ra$ 2

${}^{226}_{88}Ra$ $\lambda = 1,36\times10^{-11}\,s^{-1}$ 3

t m $t_0=0$ ${}^{226}_{88}Ra$ $m_0 = 1mg$ 4

n $m=\frac{m_0}{2^n}$ $t = nt_{1/2}$ $t_{1/2}$

t	t_0	$t_{1/2}$	$2t_{1/2}$	$3t_{1/2}$	$4t_{1/2}$	$5t_{1/2}$
$m(mg)$						

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τ $t = 5\tau$

$m = f(t)$

$_{83}Bi$, $_{82}Pb$, $_{86}Rn$, $_{89}Ac$

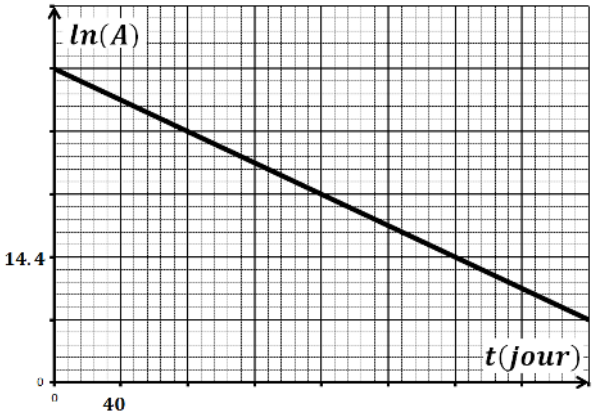
2015 32

$N_A = 6.02 \times 10^{23} mol^{-1}$ $M = 131\ g/mol$ 131

	Sb	Te	I	Xe	Cs
Z	51	52	53	54	55

$t_{1/2}$ β^- 131

$ln(A) = f(t)$ 131



(t) A

131 1

131 2

131

$ln(A_0)$ $t_{1/2}$ t $ln(A)$ 3

A_0 4

131 $t_{1/2}$ $t = 0$

131 m_0 5

2014 33

$_{20}Ca$	$_{82}Pb$	$_{22}Ti$	$_{23}V$	$_{84}Po$	$_{25}Mn$

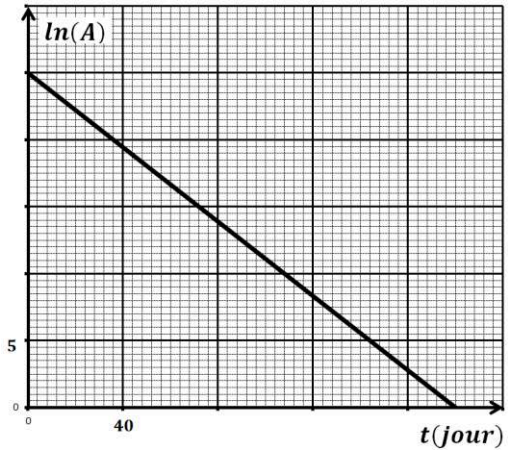
γ β^- $^{210}_{83}Bi$

1

$N_b(t)$ t $N(t)$ 210 2

λ N_0 t

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$ln\,A = f(t)$ 3

t A

t N_0 λ $ln\,A$

210 λ

A_0

34

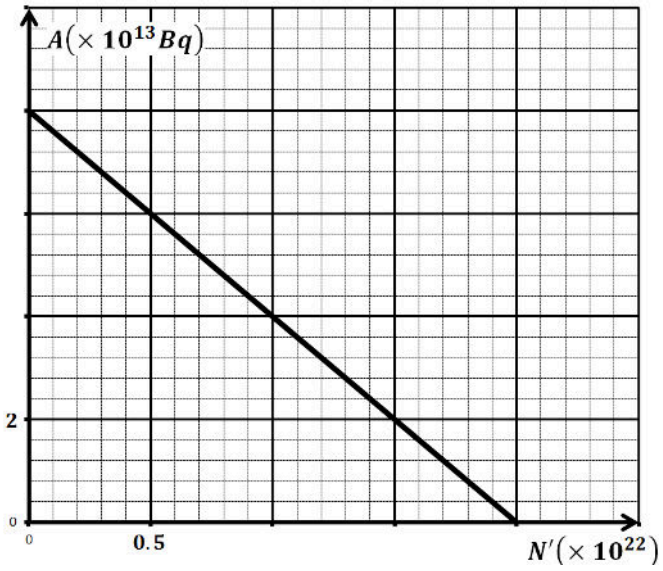
$(radiothérapie)$

$^{60}_{27}\mathrm{Co}$

$N`$ A 1 $^{1}_{1}p$ $^{1}_{0}n$ $^{60}_{27}Co$

1

2



$_{26}Fe$ $_{28}Ni$

$N`$ 3

A

4

A_0

60 λ

N_0

$N_A = 6.023 \times 10^{23}$

5

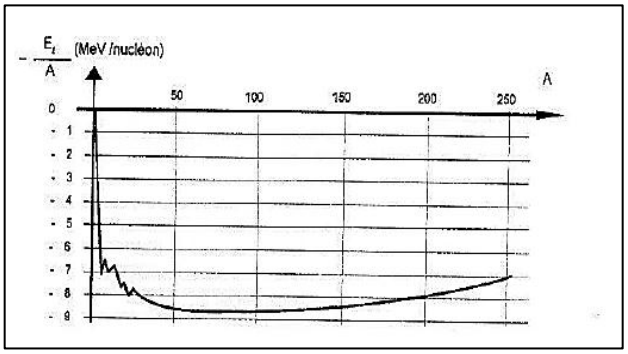
N $N`$ $\frac{N`}{N} = 3$

$\frac{N`}{N} = e^{\lambda t} - 1$ $\frac{N`}{N}$

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2012 35

^4_2He 1



2

^A_ZX E_l 3

$|\Delta E|$

$$|\Delta E| = |E_l(^4_2He) - E_l(^2_1He) - E_l(^3_1He)|$$

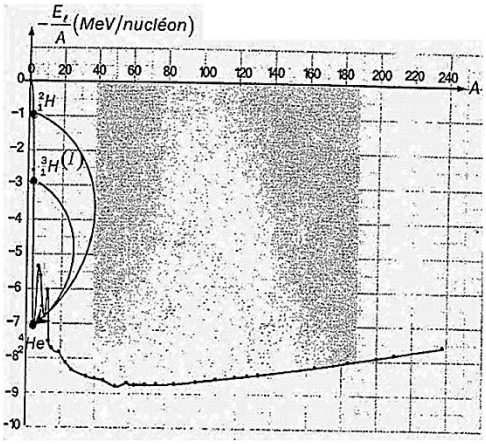
MeV

النواة	^2_1H	^3_1H	^4_2He
طاقة الربط MeV	2.22	8.48	28.29

2015 36

^3_1H T ^2_1H D

1



2

3

E_l 4

$^2_1H + {}^3_1H$ 5

(I) ^4_2H

MeV

$\frac{E_l}{A}(^3_1H) : 2.8\,MeV/nucléon$ $\frac{E_l}{A}(^4_2He) : 7.1\,MeV/nucléon$ $\frac{E_l}{A}(^2_1H) : 1.1\,MeV/nucléon$

$1u = 931.5MeV/c^2$ $^3_1H = 3.3.0155u$ $^4_2He = 4.0015u$ $^1_0n = 1.00866u$. $^2_1H = 2.01355u$

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2009 37

$1u = 931Mev/C^2 \quad C = 3\times10^8 m.s^{-1} \quad m_e = 0,00055u \quad m_n = 1,0087u \quad m_p = 1,0073u$

أنوية العناصر	${}^{2}_{1}H$	${}^{3}_{1}H$	${}^{4}_{2}He$	${}^{14}_{6}C$	${}^{14}_{7}N$	${}^{94}_{38}Sr$	${}^{140}_{54}Xe$	${}^{235}_{92}U$
(كتلة النوة) $M(u)$	2,0136	3,0155	4,0015	14,0065	14,0031	93,8945	139,8920	234,9935
$E(Mev)$ (طاقة ربط النواة)	2,23	8,57	28,41	99,54	101,44	810,50	1164,75	
$\frac{E}{A}(Mev)$ (طاقة الربط لكل نيكليون)	1,11		7,10		7,25	8,62		

(u)

$Z \quad A \quad m_p \quad m_n \quad (m_x)$

(C)

(MeV)

${}^{14}_{7}N \quad {}^{14}_{6}C$

${}^{4}_{2}He$

${}^{94}_{38}Sr \quad {}^{140}_{54}Xe \quad {}^{235}_{92}U$

(MeV)

2010 38

${}^{A}_{Z}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$ ${}^{A}_{Z}Ra$ ${}^{222}_{86}Rn$

1

$Z \quad A$

u ${}^{226}Ra \quad \Delta m$ 2

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$27,36\times10^{-11}J$ ^{222}Rn E_l 3

E_l

^{222}Rn Δm

^{222}Rn

4

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{94}_{38}Sr + ^{139}_{54}Xe + 3\,^{1}_{0}n$$

(J) MeV

$m(Xe)=138,889u$ $m(Rn)=221,970u$ $1u=1,66\times10^{-27}kg$ $c=3\times10^{8}m/s$ $1MeV=1,6\times10^{-13}J$

$m(^{1}_{1}p)=1,007u$ $m(^{1}_{0}n)=1,009u$ $m(Ra)=225,977u$ $m(U)=234,994u$ $m(Sr)=93,894u$

2016 39

$H=1g/mol$ $C=12g/mol$ $N_A=6.02\times10^{23}mol^{-1}$

النواة	^{94}Sr	^{140}Xe	^{235}U
طاقة الربط $E_l\ (MeV)$	807.46	1160	1745.6

1986

$30ans$ $^{137}_{55}Cs$ $2ans$ $^{134}_{55}Cs$ $^{137}_{55}Cs$ $^{134}_{55}Cs$

2016 1

β^- $^{137}_{55}Cs$ 2

$^{134}_{55}Cs$ $^{131}_{53}I$ $^{137}_{56}Ba$

$^{137}_{55}Cs$

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{54}Xe + ^{94}_{z}Sr + x\,^{1}_{0}n$ ^{235}U 3

z x

^{235}U $m=1mg$

$m=1mg$ C_4H_{10}

$1126Kj$ $1mol$ ^{235}U

2011 40

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{94}_{38}Sr + ^{140}_{Z}Xe + x\,^{1}_{0}n$ 235

1

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2

3

Δm 4

235 E_{lib}

235 $m = 2,5g$

CH_4 5

$8,0\times10^5 J$ $1mol$ 235 $m = 2,5g$

$m\left({}^{1}_{0}n\right)=1,00866u$ ، $m\left({}^{140}_{Z}Xe\right)=139,89194u$ ، $m\left({}^{94}_{38}Sr\right)=93,89446u$ ، $m\left({}^{235}_{92}U\right)=234,99332u$

. $M\left(CH_4\right)=16g.mol^{-1}$ ، $N_A=6,02\times10^{23}mol^{-1}$ ، $c=3\times10^8 m.s^{-1}$ ، $1u=1,66\times10^{-27}kg$

2012 41

1

γ $^{192}_{78}Pt$ $^{192}_{77}Ir$

γ

$A = 3.4 \times 10^{14}Bq$ $(m = 1g)$

$m = 1g$ N

$t_{1/2}$

2

$4\,^{1}_{1}H \longrightarrow {}^{4}_{2}He + 2\,^{0}_{1}e$

MeV u Δm

$1eV = 1.602 \times 10^{-19}j$ $C = 3 \times 10^8 m/s$ $1u = 1.66 \times 10^{-27}kg$

النواة	$^{4}_{2}He$	$^{1}_{1}p$	$^{1}_{0}n$	$^{0}_{1}e$
الكتلة (u)	4.0015	1.0073	1.0087	0.0005

42

$^{A}_{Z}Po$ α $^{226}_{88}Rn$

$3.825our$

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1

$t = 0$ $2cm^3$

$V_M = 25\ L/mol$ A_0 N_0

12

α 2

$2{}^3_2He \rightarrow {}^4_2He + 2{}^1_1H$

3 4 $\frac{E_l}{A}$

MeV

3 $1g$

${}^3_2He = 3.0072u$ ${}^4_2He = 4.0015u$ ${}^1_0n = 1.0087u$. ${}^1_1H = 1.0073u$

$N_A = 6.02 \times 10^{23} mol^{-1}$, $1u = 931.5MeV/c^2$. $1MeV = 1.602 \times 10^{-13} j$

2013 43

${}^2_1H + {}^3_1H \longrightarrow {}^A_ZX + {}^1_0n$

Z A 1

2

${}^A_ZX$ ${}^3_1H$ ${}^2_1H$ 3

${}^3_1H$ ${}^2_1H$ MeV ؛ 4

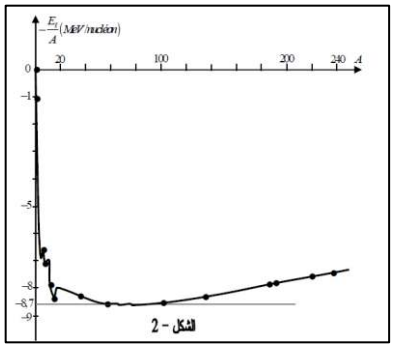
5

$E_l({}^2_1H) = 2.23MeV$ $E_l({}^3_1H) = 8.75MeV$ $E_l({}^A_ZX) = 28.41MeV$

2014 44

239

${}^{239}_{94}Pu + {}^1_0n \rightarrow {}^{102}_{42}Mo + {}^{135}_{z}Te + x{}^1_0n$ ${}^{239}_{94}Pu$



z x 1

239 2

Δm

239

$35g$ 239 $(24h)$ 3

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4

$^{135}_{z}Te$ $^{102}_{42}Mo$ $^{239}_{94}Pu$

$^{239}_{94}Pu : 7.5\ MeV/nucléon$ $^{102}_{42}Mo : 8.6\ MeV/nucléon$ $^{135}_{z}Te : 8.3\ MeV/nucléon$

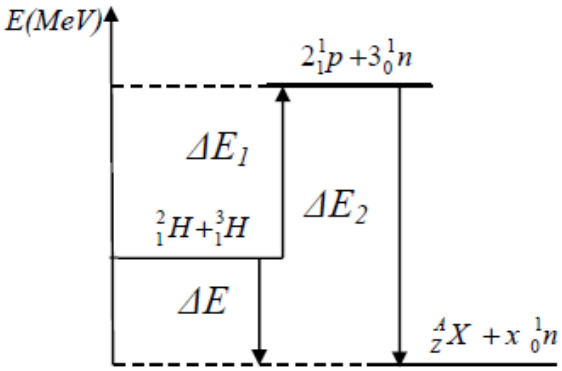
$1MeV = 1.6 \times 10^{-13} j$ $N_A = 6.02 \times 10^{23} mol^{-1}$ $1u = 931.5\ MeV/c^2$

2013 45

$^{3}_{1}H$ $^{2}_{1}H$ $ITER$

$^{A}_{Z}X$ $^{3}_{1}H$ $^{2}_{1}H$ 1

ب



•

$E_l(^A_ZX)$ 2

MeV ب ^A_ZX ^3_1H ^2_1H

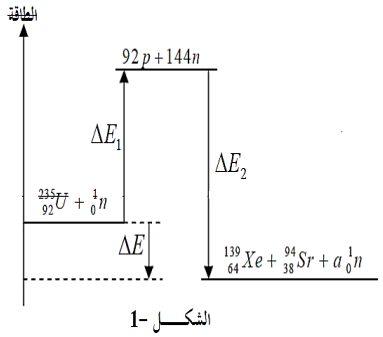
^3_1H ^2_1H 3

^3_1H $1.5g$ ^2_1H $1g$

$m(^1_1p) = 1.00728\ u$, $m(^4_2He) = 4.0015\ u$, $m(^1_0n) = 1.00866\ u$

$m(^3_1H) = 3.0155\ u$, $1u = 931.5\ MeV/C^2$. $m(^2_1H) = 2.01355\ u$. $N_A = 6.02 \times 10^{23} mol^{-1}$

2010 46



الشكـــل -1

1

^1_0n $^{139}_{54}Xe$ $^{94}_{38}Sr$ $^{235}_{92}U$

E_l 1

$^{235}_{92}U$ 2

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ΔE ΔE_2 ΔE_1 MeV 3

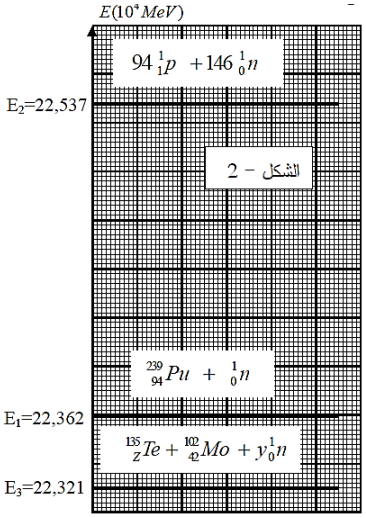
$^{235}_{92}U$ $1g$

$\frac{E_\ell}{A}\left(^{94}_{38}Sr\right)=8,62MeV/nucléon$ ، $\frac{E_\ell}{A}\left(^{139}_{64}Xe\right)=8,34MeV/nucléon$ ، $\frac{E_\ell}{A}\left(^{235}_{92}U\right)=7,62MeV/nucléon$

. $N_A=6,02\times10^{23}mol^{-1}$ ، $1MeV=1,6\times10^{-13}J$

2014 47

$^{239}_{94}Pu + {}^{1}_{0}n \longrightarrow {}^{135}_{Z}Te + {}^{102}_{42}Mo + y\,{}^{1}_{0}n$ 1



y Z

c 239

$m(^{135}_{Z}Te)$ $m(^{239}_{94}Pu)$ $m(^{102}_{42}Mo)$ $m(^{1}_{0}n)$

239 2

239 E_l

102

$\frac{E_l}{A}(^{102}_{42}Mo) = 8.35\ MeV/nu$

$^{239}_{94}Pu$ $^{102}_{42}Mo$

239 $1g$ (j)

$N_A = 6.02 \times 10^{23}mol^{-1}$, $1MeV = 1.6 \times 10^{-13}j$

48

$^{1}_{0}n$ $^{139}_{54}Xe$ $^{94}_{38}Sr$ $^{235}_{92}U$

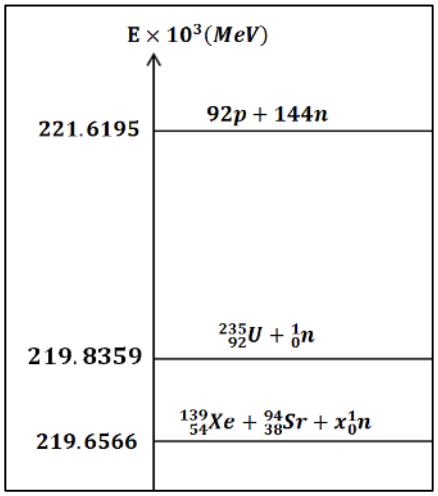
1

235 2

3

4

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$\frac{E_l}{A}(^{94}_{38}Sr)$ $\frac{E_l}{A}(^{235}_{92}U)$

5

6

$P = 9 \times 10^8 W$

235

$N_A = 6.02 \times 10^{23} mol^{-1}$ $\frac{E_l}{A}(^{139}_{54}Xe) = 8.34\, MeV/nuc$

$1MeV = 1.6 \times 10^{-13} j$

2016 49

$m(^{1}p) = 1.00728\, u$ $m(^{95}Ze) = 94.8861u$ $m(^{138}Te) = 137.9007u$ $m(^{235}U) = 234.9935u$

$N_A = 6.02 \times 10^{23} mol^{-1}$ $1MeV = 1.6 \times 10^{-13} j$ $1u = 931.5\, MeV/C^2$ $m(^{1}n) = 1.00866\, u$

E E_e $\rho = \frac{E_e}{E}$

235

^{235}U

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{95}_{40}Ze + ^{138}_{52}Te + 3^{1}_{0}n$

^{235}U 1

235 2 2

ΔE_2 ΔE_1

235 3

$\rho = 30\%$ $P = 30MW$

$\Delta t =$

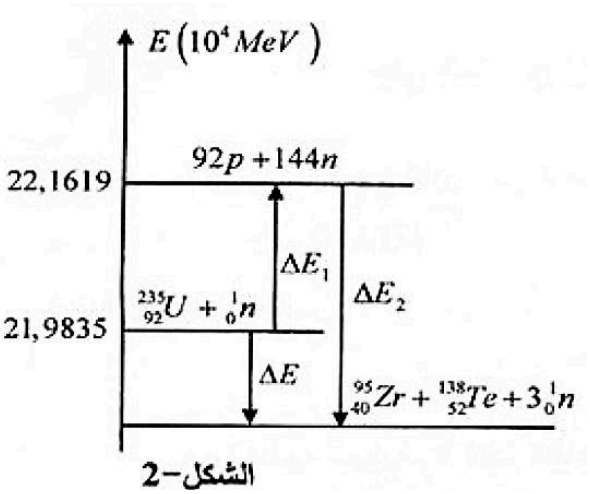
$30 jours$

β^- $^{138}_{52}Te$ 4

β^-

$^{138}_{52}Te$

5



الشكل-2

$^{53}_{}I$	$^{54}_{}Xe$	$^{55}_{}Cs$	$^{56}_{}Ba$

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50

$$^{3}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

1

$^{3}_{1}H$ $^{2}_{1}H$ $^{4}_{2}He$ $\frac{E_l}{A}$ 2

MeV 3

$^{3}_{1}H$ $2.5g$ $^{2}_{1}H$ $2g$ 4

$^{3}_{1}H$ $^{2}_{1}H$ $1g$ 6

$P = 3.9 \times 10^{26} W$ 7

$4.6 \times 10^{9} ans$ $1.99 \times 10^{30} kg$

$m(^{3}_{1}H) = 3.0155\,u$ $^{4}_{2}He = 4.0015u$. $1MeV = 1.602 \times 10^{-13} j$ $N_A = 6.02 \times 10^{23} mol^{-1}$,
, $m(^{2}_{1}H) = 2.0135\,u$. $^{1}_{1}H = 1.0073u$; $1u = 931.5MeV/c^2$, $^{1}_{0}n = 1.0087u$

51

$\lambda = 2.5 \times 10^{-10} s^{-1}$ $^{238}_{94}Pu$ α

λ α 1

238 2

$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ $t_{\frac{1}{2}}$ 3

238 4

$P =$ 0.056W 5

30% 6

$m(^{238}_{94}Pu) = 3.952073 \times 10^{-25}\,kg$; $m(^{4}_{2}He) = 6.644691 \times 10^{-27}\,kg$
$1ans = 365.25\,j$; $m(^{234}_{92}U) = 3.885528 \times 10^{-25}\,kg$; $c = 3 \times 10^{8}\,m/s$

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