$^{228}_{90}\mathrm{Th}_{138}$

1 Decay Scheme

Th-228 decays 100 % by alpha-particle emission to various excited levels and the ground state of Ra-224, and by a small O-20 cluster-decay branch of 1.13 (22) 10^{-11} %.
Le thorium 228 se désintègre par émission alpha principalement vers le niveau fondamental et le niveau excité de 84,4 keV du radium 224.

2 Nuclear Data

$T_{1/2}(^{228}\mathrm{Th})$	:	1,9126	(9)	a
$T_{1/2}(^{224}\mathrm{Ra})$	:	3,631	(2)	d
$Q^{\alpha}(^{228}\mathrm{Th})$	:	5520,08	(22)	keV

2.1 α Transitions

	Energy keV	Probability × 100	F
$\alpha_{0,8}$	4527,43 (23)	0,0000045 (7)	7,2
$\alpha_{0,7}$	4603,74 (23)	0,000017 (3)	7
$\alpha_{0,6}$	5040,9 (3)	0,000024 (5)	4600
$\alpha_{0,5}$	5087,01 (24)	0,000010 (2)	21400
$\alpha_{0,4}$	5229,72 (22)	0,036 (6)	44
$\alpha_{0,3}$	5269,30 (22)	0,218 (4)	12,5
$\alpha_{0,2}$	5304,10 (22)	0,408 (7)	10,7
$\alpha_{0,1}$	5435,71 (22)	26,0 (5)	0,958
$\alpha_{0,0}$	5520,08 (22)	73,4 (5)	1

2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{4,2}$(Ra)	74,38 (4)	0,015 (5)	[E2]		28,3 (4)	7,71 (11)	38,6 (6)
$\gamma_{1,0}$(Ra)	84,373 (3)	26,4 (7)	E2		15,57 (22)	4,24 (6)	21,2 (3)
$\gamma_{2,1}$(Ra)	131,612 (5)	0,158 (3)	E1	0,194 (3)	0,0406 (6)	0,00977 (14)	0,247 (4)
$\gamma_{5,4}$(Ra)	142,71 (11)	0,0000041 (13)	[E2]	0,279 (4)	1,368 (20)	0,372 (6)	2,14 (3)
$\gamma_{3,1}$(Ra)	166,410 (4)	0,217 (4)	E2	0,225 (4)	0,691 (10)	0,187 (3)	1,164 (17)
$\gamma_{5,3}$(Ra)	182,29 (10)	0,0000057 (20)	[E1]	0,0894 (13)	0,01757 (25)	0,00421 (6)	0,1126 (16)
$\gamma_{4,1}$(Ra)	205,99 (4)	0,0204 (5)	[E1]	0,0671 (10)	0,01292 (18)	0,00309 (5)	0,0841 (12)
$\gamma_{2,0}$(Ra)	215,985 (4)	0,265 (4)	E1	0,0600 (9)	0,01148 (16)	0,00274 (4)	0,0752 (11)
$\gamma_{6,3}$(Ra)	228,42 (18)	0,000025 (6)	[E2]	0,1244 (18)	0,178 (3)	0,0479 (7)	0,366 (6)
$\gamma_{7,2}$(Ra)	700,36 (7)	0,000003 (1)	E1	0,00502 (7)	0,000834 (12)	0,000196 (3)	0,00611 (9)
$\gamma_{8,3}$(Ra)	741,87 (6)	0,0000014 (4)	[E2]	0,01196 (17)	0,00322 (5)	0,000803 (12)	0,01625 (23)
$\gamma_{7,1}$(Ra)	831,97 (10)	0,000014 (2)	E2	0,00970 (14)	0,00240 (4)	0,000594 (9)	0,01289 (18)
$\gamma_{8,1}$(Ra)	908,28 (6)	0,0000017 (5)	[M1+50%E2]	0,0190 (24)	0,0036 (4)	0,00087 (9)	0,024 (3)
$\gamma_{8,0}$(Ra)	992,65 (6)	0,0000014 (4)	[E2]	0,00705 (10)	0,001569 (22)	0,000384 (6)	0,00913 (13)

3 Atomic Data

3.1 Ra

ω_K	:	0,968	(4)
$\bar{\omega}_L$	:	0,452	(18)
n_{KL}	:	0,801	(5)

3.1.1 X Radiations

		Energy keV		Relative probability
X_K				
	$K\alpha_2$	85,43		61
	$K\alpha_1$	88,47		100
	$K\beta_3$	99,432	}	
	$K\beta_1$	100,13	}	
	$K\beta_5''$	100,738	}	35,1
	$K\beta_2$	102,89	}	
	$K\beta_4$	103,295	}	11,5
	$KO_{2,3}$	103,74	}	
X_L				
	$L\ell$	10,622		
	$L\alpha$	12,196 – 12,339		
	$L\eta$	13,662		
	$L\beta$	14,236 – 15,447		
	$L\gamma$	17,848 – 18,412		

3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	65,149 – 72,729	100
KLX	79,721 – 88,466	57
KXY	94,27 – 103,91	8,4
Auger L	5,71 – 12,04	852500

4 α Emissions

	Energy keV	Probability × 100
$\alpha_{0,8}$	4448,00 (23)	0,0000045 (7)
$\alpha_{0,7}$	4522,97 (23)	0,000017 (3)
$\alpha_{0,6}$	4952,5 (3)	0,000024 (5)
$\alpha_{0,5}$	4997,76 (24)	0,000010 (2)
$\alpha_{0,4}$	5137,97 (22)	0,036 (6)
$\alpha_{0,3}$	5176,86 (22)	0,218 (4)
$\alpha_{0,2}$	5211,05 (22)	0,408 (7)
$\alpha_{0,1}$	5340,35 (22)	26,0 (5)
$\alpha_{0,0}$	5423,24 (22)	73,4 (5)

5 Electron Emissions

		Energy keV		Electrons per 100 disint.
e_{AL}	(Ra)	5,71 - 12,04		10,4 (4)
e_{AK}	(Ra)			0,0020 (3)
	KLL	65,149 - 72,729	}	
	KLX	79,721 - 88,466	}	
	KXY	94,27 - 103,91	}	
$ec_{3,1\ K}$	(Ra)	62,497 (4)		0,023 (1)
$ec_{1,0\ T}$	(Ra)	65,14 - 84,36		25,2 (7)
$ec_{1,0\ L}$	(Ra)	65,14 - 68,93		18,5 (5)
$ec_{1,0\ M}$	(Ra)	79,55 - 81,27		5,0 (2)
$ec_{1,0\ N+}$	(Ra)	83,17 - 84,36		1,65 (5)

		Energy keV	Electrons per 100 disint.
$ec_{2,0\ K}$	(Ra)	112,072 (4)	0,015 (6)
$ec_{3,1\ L}$	(Ra)	147,17 - 150,97	0,069 (2)
$ec_{3,1\ M}$	(Ra)	161,59 - 166,40	0,025 (1)

6 Photon Emissions

6.1 X-Ray Emissions

		Energy keV		Photons per 100 disint.	
XL	(Ra)	10,622 — 18,412		8,6 (4)	
$XK\alpha_2$	(Ra)	85,43		0,0180 (3)	} $K\alpha$
$XK\alpha_1$	(Ra)	88,47		0,0295 (5)	}
$XK\beta_3$	(Ra)	99,432	}		
$XK\beta_1$	(Ra)	100,13	}	0,01034 (21)	$K'\beta_1$
$XK\beta_5''$	(Ra)	100,738	}		
$XK\beta_2$	(Ra)	102,89	}		
$XK\beta_4$	(Ra)	103,295	}	0,00339 (9)	$K'\beta_2$
$XKO_{2,3}$	(Ra)	103,74	}		

6.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{4,2}$(Ra)	74,38 (4)	0,00039 (14)
$\gamma_{1,0}$(Ra)	84,373 (3)	1,19 (3)
$\gamma_{2,1}$(Ra)	131,612 (5)	0,127 (2)
$\gamma_{5,4}$(Ra)	142,71 (11)	0,0000013 (4)
$\gamma_{3,1}$(Ra)	166,410 (4)	0,1004 (14)
$\gamma_{5,3}$(Ra)	182,29 (10)	0,0000051 (18)
$\gamma_{4,1}$(Ra)	205,99 (4)	0,0188 (5)
$\gamma_{2,0}$(Ra)	215,985 (4)	0,246 (4)
$\gamma_{6,3}$(Ra)	228,42 (18)	0,000018 (4)
$\gamma_{7,2}$(Ra)	700,36 (7)	0,000003 (1)
$\gamma_{8,3}$(Ra)	741,87 (6)	0,0000014 (4)

	Energy keV	Photons per 100 disint.
$\gamma_{7,1}$(Ra)	831,97 (7)	0,000014 (2)
$\gamma_{8,1}$(Ra)	908,28 (6)	0,0000017 (5)
$\gamma_{8,0}$(Ra)	992,65 (6)	0,0000014 (4)

7 Main Production Modes

Th – 230(p,t)Th – 228

Th – 230(α,α2nγ)Th – 228

Ra – 226(α,2nγ)Th – 228

U – 232(α)

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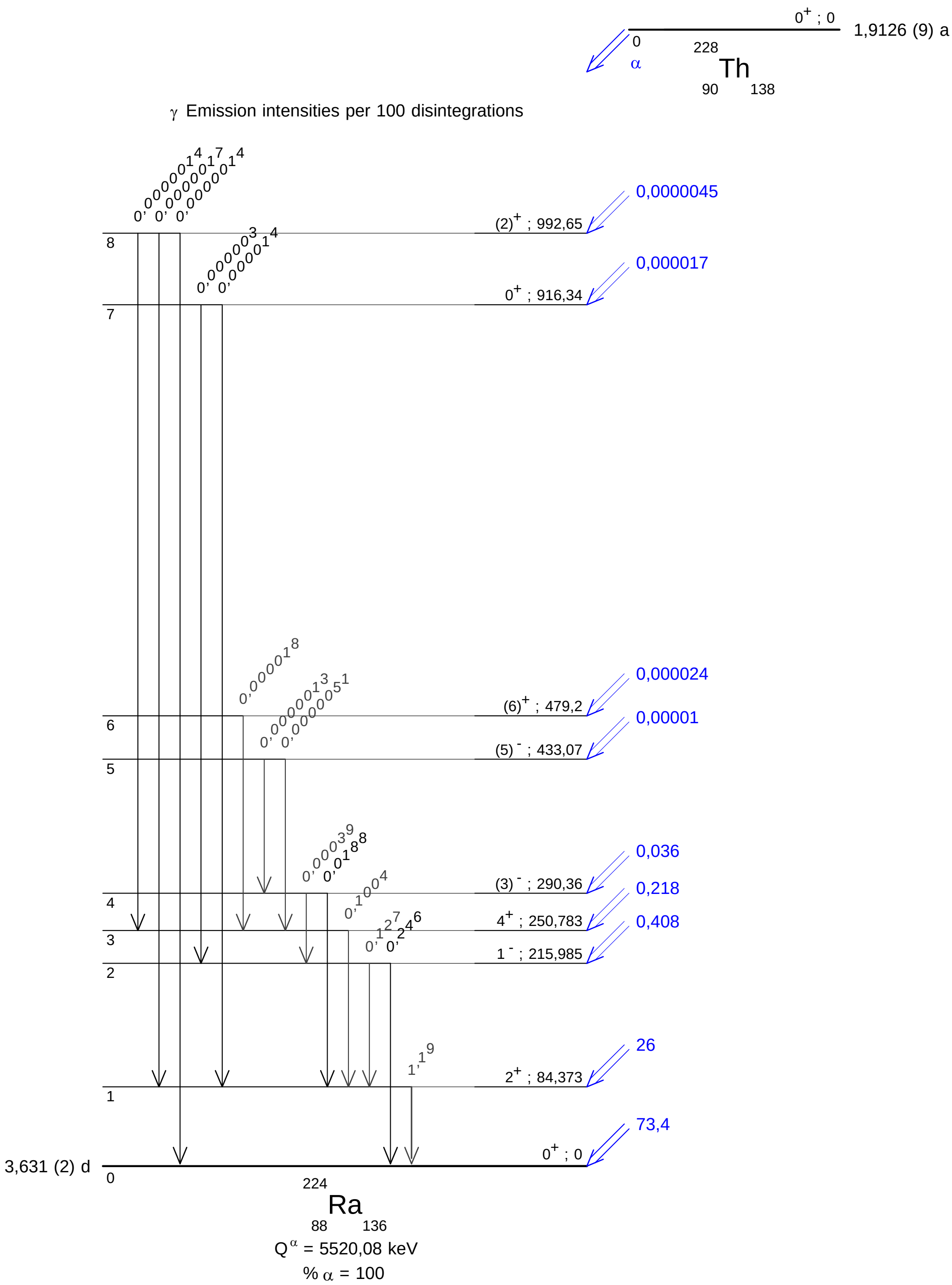
0+ ; 0
1,9126 (9) a
0
α
228
Th
90
138
γ Emission intensities per 100 disintegrations
(2)+ ; 992,65
0,0000045
0+ ; 916,34
0,000017
(6)+ ; 479,2
0,000024
(5)- ; 433,07
0,00001
(3)- ; 290,36
0,036
4+ ; 250,783
0,218
1- ; 215,985
0,408
2+ ; 84,373
26
0+ ; 0
73,4
8
7
6
5
4
3
2
1
0
3,631 (2) d
224
Ra
88
136
Qα = 5520,08 keV
% α = 100