^{131}I – Comments on evaluation of decay data
by V. Chisté and M. M. Bé

1) Decay Scheme

^{131}I disintegrates by β^- emission via the excited levels of ^{131}Xe, included the isomeric state ^{131}Xe^m ($T_{1/2}$ = 11,930 (16) d).
The state of ideal balance, where the activity of ^{131}I is equal to the activity of ^{131}Xe^m, is obtained in 13,994 (1) days:

$$tm = \frac{1{,}44 \times T_{1/2}(^{131}I) \times T_{1/2}(^{131}Xe^m) \times \ln\left(T_{1/2}(^{131}Xe^m) / T_{1/2}(^{131}I)\right)}{T_{1/2}(^{131}Xe^m) - T_{1/2}(^{131}I)}$$

The decay of Xe-131m will interfere with the decay of I-131 only with the 163,9 keV gamma line. For this line, the gamma emission intensity is given at *tm* (see above).

2) Nuclear Data

The Q value is from Audi and Wapstra (1995Au04)

Level energies, spins and parities are from Yu. V. Sergeenkov (1994Se10).

The measured ^{131}I half-life values are, in days:

$T_{1/2}$

Reference	Value (d)	Comments
Livingood (1938Li05)	8,0 (2)	
Sreb (1951Sreb)	8,1409 (62)	
Sinclair (1951Si25)	8,04 (4)	
Lockett (1953Lo09)	8,06 (2)	
Seliger (1953Se28)	8,075 (22)	
Bartholomew (1953Ba10)	8,05 (1)	
Burkinshaw (1958Bu14)	8,054 (10)	
Keene (1958Ke26)	8,067 (7)	
Kemeny (1968Ke05)	8,04 (4)	
Zoller (1971Zo02)	8,117 (12)	
Emery (1972Em01)	8,040 (1)	
Karsten (1974Ka37)	8,031 (4)	
Lagoutine (1978La21)	8,020 (3)	
Houtermans (1980Ho17)	8,0213 (9)	
Hoppes (1982HoZF)	8,020 (2)	Superseded by 1992Un01
Walz (1983Wa26)	8,0207 (1)	Superseded by 2004Sc04
Unterweger (1992Un01)	8,0197 (22)	
da Silva (2004Da05)	7,999 (9)	
Schrader (2004Sc04)	8,0252 (6)	

The half-life weighted average has been calculated by the Lweight program (version 3).

The evaluator has chosen to take only the seven most recent values (74Ka37, 78La21, 80Ho17, 92Un01, 2004Da05 and 2004Sc04) for the calculation. The Silva(2004Da05) value is rejected by the Lweight program, based on the Chauvenet's criterion. The largest contribution to the weighted average comes from the value of Schrader (2004Sc04), amounting to 63 %. The program Lweight 3 increases the uncertainty for the 2004Sc49 value from 0,0006 to 0,00079 in order to reduce its relative weight from 63 % to 50 %.

The adopted value is the weighted mean : *8,0233 d*, with an uncertainty of *0,0019 d* (expanded so range includes the most precise value of Schrader (2004Sc04)) and a χ^2 of 4.

2.1) β^- Transitions

The β^- probabilities and the associated uncertainties have been deduced from γ transition intensity balance at each level of the decay scheme, assuming no β^- transition to the ground state. The values of log ft have been calculated with the program LOGFT for the Allowed, 1st Forbidden and 1st Unique Forbidden transitions.

2.2) Gamma Transitions

Probabilities

For the 163 keV gamma transition probability, the adopted value is 1,086 (7), measured by Meyer (1974Me21). Other transition probabilities have been calculated from the gamma emission intensities and the internal conversion coefficients.

Mixing ratios and internal conversion coefficients

For the 177, 272, 318, 324, 325, 364, 404 and 722 keV gamma transitions, the adopted δ (mixing ratio) are from Krane's evaluation (1977Kr13) of experimental values deduced from angular distribution and correlation data. For other transitions, the values of δ are from Yu. V. Sergeenkov (1994Se10).

The internal conversion coefficients have been calculated using the ICC Computer Code (program Icc99v3a – GETICC dialog). The adopted values have been interpolated from Rösel tables. For the 163 keV gamma transition (isomeric state), the adopted value is from the new tables of Band (2002Go45) (see "**Comments on evaluation**" for ^{131}Xe^m).

For the 364 keV gamma transition, many values of δ^2 have been found in the literature, as shown in the following table:

Reference	**Value of δ^2**	**Value of α_T**
Johnson et al – Phys. Rev. 120(1960)1777	44,89 (25)	2,285 10^{-2}
Daniel et al – Z. Phys. 179(1964)62	22,09 (9)	2,290 10^{-2}
Langhoff et al – Nucl. Phys. A158(1970)657	11,56 (36)	2,299 10^{-2}
Krane et al – Phys. Rev. C5(1972)1671	10,89 (36)	2,299 10^{-2}
Koene et al – Nucl. Phys. A219(1974)563	20,521 (14)	2,290 10^{-2}
Irving et al – J. Phys. G5(1979)1595	14,40 (9)	2,295 10^{-2}
Naviliat-Cuncic et al – Nucl. Phys. A514(1990)145	14,40 (9)	2,295 10^{-2}
Krane et al - Atomic Data and Nuclear Data Tables 19(1977)363	20,521 (14) (adopted value)	2,29 10^{-2}

It can be shown that even with values of δ^2 quite different the resulting α_T values are close, and their differences are smaller than 1 %; thus the adopted uncertainty on the ICC value is 1 %.

For the 325 keV gamma transition, a value of δ^2 (= 19 (3)) measured by Koene (1975Ko15) is not close to the adopted one (δ^2 = 0,053 (2)) which is from Krane's evaluation, and the two resulting α_T values deviate from 3 %, that correspond to the uncertainty taken into account for the α_T, α_K and α_L values for this transition.

For the 404 keV gamma transition, a value of δ^2 (= 66 (32)) has been found in the literature, from Irving (79Ir01). The calculated α_T (= 0,01664) for this δ^2 is far from the adopted one (α_T = 0,0179) and the resulting α_T value deviates from the adopted one of 7 %.

For the 722 keV gamma transition, the following values of δ^2 have been found in the literature:

Reference	**Value of δ^2**	**Value of α_T**
Koene – Nucl. Phys. A219(1974)563	0,0428	0,00461
Irving – J. Phys. G5(1979)1595	0,0144	0,00464
Krane - et al - Atomic Data and Nuclear Data Tables 19(1977)363	0,0428 (adopted value)	0,0046

The adopted uncertainty on the α_T, α_K and α_L values for the 722 keV transition is 1 %.

For the other transitions, measurements aren't precise, and only ranges of values are given for δ^2.

Calculations of ICC uncertainties for the other transitions:

∗ For the pure transitions (known E2: 284, 503, 636 keV; presumed E1/ or E2: 232, 295, 302, 642 keV), uncertainties in α_T, α_K and α_L calculated values with ICC Computer Code (program Icc99v3a) are taken to be 3 %.

* For the mixed gamma transitions with unknown mixing ratio (M1+ **X%** E2) (85 and 358 keV), the uncertainties for α_T, α_K and α_L are taken to be 3 % from each possibility and the average values are adopted as uncertainties.

* For the transitions with known δ, the uncertainties calculations were made as follow: α_T was calculated for a pure M1 (or M3) transition and for a pure E2 transition. The difference between these values, normalized by α_T, is the uncertainty (%) of α_T. The same method was used for α_K and α_L uncertainties.

3) Atomic Data

Atomic values (ω_K, ϖ_L and n_{KL}) are from Schönfeld (1996Sc06).

The X-ray and Auger electron emission probabilities have been calculated from γ-ray and conversion-electron data by using the program EMISSION.

4) Radiation emissions

4.1) Gamma ray emissions

Gamma ray energies (in keV) are from Yu. V. Sergeenkov *et al.* (1994Se10) and R. A. Meyer (1990Me15). Energy values are in keV.

The measured emission intensities listed in Table 1 are given in values relative to that of the 364 keV line.

The sets of values from 1952Be95, 1963Ju02, 1963Ha08, 1964Da19, 1967Ga05 and 1967Yt02 were omitted in several cases from the analysis due to discrepancies with those mentioned in Table 1.

Emission probability values from Meyer (1974Me21) have been converted to 100 for the 364 keV line by the evaluator.

The normalization factor to convert the relative emission intensities to absolute intensities was calculated using the formula:

$$N = \left(\frac{100 - P_{abs}(163keV)}{(\sum(1 + \alpha_T)P_{rel})} \right) \times 100$$

where the sum was done over all gamma transition probabilities to the ground state.

For the 163 keV gamma transition probability, P_{abs}*(163 keV)*, an absolute value of 1,086 (7), determined by Meyer, has been accepted.

From the calculated α_T and the evaluated relative emission intensities (Table I), the deduced normalization factor is ***81,2 (8)***. The uncertainties were calculated through their propagation on the above formula.

4.2) Conversion electrons

The conversion electron emission probabilities were deduced from the gamma-ray emission probabilities using theoretical ICC values. To our knowledge, there are no measured values for the conversion electron emission probabilities.

Energy conservation

The available energy for one disintegration is 970,8 (6) keV (Q^{-}), the total average energy calculated from the data of this evaluation is 969 (6) keV confirming the consistency of the decay scheme.

Additional Reference

F. Lagoutine, Table de Radionucléides, CEA-LMRI (1984)

References

1938Li05 J. J. Livingood, G. T. Seaborg, Phys. Rev. 54 (1938) 775 [$T_{1/2}$]
1951Sreb J. H. Sreb, Phys. Rev. 81 (1951) 643 [$T_{1/2}$]
1951Si25 W. K. Sinclair, A. F. Holloway, Nature (London) 167 (1951) 365 [$T_{1/2}$]
1952Be95 R. E. Bell, R. L. Graham, Phys. Rev. 86 (1952) 212 [E_γ , I_γ]
1953Lo09 E. E. Lockett, R. H. Thomas, Nucleonics 11 (1953) 14 [$T_{1/2}$]
1953Se28 H. H. Seliger, L. Cavallo, S. V. Culpepper, Phys. Rev. 90 (1953) 443 [$T_{1/2}$]

1953Ba10 R. M. Bartholomew, F. Brown, R. C. Hawkings, W. F. Merritt, L. Yaffe, Can. J. Chem. 31 (1953) 120 [$T_{1/2}$]

1958Bu14 L. Burkinshaw, Phys. in Med. Biol. 2 (1958) 255 [$T_{1/2}$]

1958Ke26 J. P. Keene, L. A. Mackenzie, C. W. Gilbert, Phys. in Med. Biol. 2 (1958) 360 [$T_{1/2}$]

1963Ju02 H. Jungclaussen, J. Schintlmeiter, H. Sodan, Nucl. Phys. 43 (1963) 650 [E_γ , I_γ]

1963Ha08 C. K. Hargrove, K. W. Geiger, A. Chatterjee, Nucl. Phys. 40 (1963) 566 [E_γ , I_γ]

1964Da19 H. Daniel, O. Mehling, P. Schmidlin, D. Schotte, E. Thummernicht, Z. Phys. 179 (1964) 62 [E_γ, P_γ, δ]

1966Mo10 G. A. Moss, D. O. Wells, D. K. McDaniels, Nucl. Phys. 82 (1966) 289 [E_γ , I_γ]

1967Ga05 G. Graeffe, W. B. Walters, Phys. Rev. 153 (1967) 1321 [E_γ , I_γ]

1967Yt02 C. Ythier, G. Ardisson, C. R. Acad. Sc. Paris 264C (1967) 944 [E_γ , I_γ]

1968Ke05 P. Kemeny, Rev. Roumaine Phys. 13 (1968) 485 [$T_{1/2}$]

1971Zo02 W. H. Zoller, P. K. Hopke, J. L. Fasching, E. S. Macias, W. B. Walters, Phys. Rev. C3 (1971) 1699 [$T_{1/2}$]

1972Em01 J. F. Emery, S. A. Reynolds, E. I. Wyatt, G. I. Gleason, Nucl. Scien. Eng. 48 (1972) 319 [$T_{1/2}$]

1972Singh N. Singh, S. S. Bhati, R. L. Dhingra, P. N. Trehan , Nucl. Phys. and Solid State Phys. Symp., Chandigarth India (1972) [E_γ , I_γ]

1974Ka37 J. H. M. Karsten, P. G. Marais, F. J. Haasbroek, C. J. Visser, Agrochemophysica 6 (1974) 25 [$T_{1/2}$]

1974Ko02 B. K. S. Koene, H. Postman, Nucl. Phys. A219 (1974) 563 [δ]

1974Me21 R. A. Meyer, F. Momyer, W. B. Walters, Z. Phys. 268 (1974) 387 [E_γ , I_γ]

1975Ko15 B. K. S. Koene, H. Postman, H. Ligthart, Nucl. Phys. A250 (1975) 38 [δ]

1977Kr13 K. S. Krane. At. Data Nucl. Data Tables 19 (1977) 363 [δ]

1978La21 F. Lagoutine, J. Legrand, C. Bac, Int. J. Appl. Radia. Isot. 29 (1978) 269 [$T_{1/2}$]

1979Ir01 A. D. Irving, P. D. Forsyth, I. Hall, D. G. E. Martin, J. Phys. G5 (1979) 1595 [δ]

1980Ho17 H. Houtermans, O. Milosevic, F. Reichel, Int. J. Appl. Radia. Isot. 31 (1980) 153 [$T_{1/2}$]

1982HoZF D. D. Hoppes, NBS-SP 626 (1982) 117 [$T_{1/2}$]

1983Wa26 K. F. Walz, K. Debertin, H. Schrader, Int. J. Appl. Radia. Isot. 34 (1983) 1191 [$T_{1/2}$]

1989Ch45 B. Chand, J. Goswamy, D. Mehta, N. singh, P. N. Trethan, Nucl. Inst. Meth. A284 (1989) 393 [E_γ , I_γ]

1990Me15 R. A. Meyer, Fisika (Zagreb) 22 (1990) 153 [E_γ , I_γ]

1992Un01 M. P. Unterweger, D. D. Hoppes, F. J. Schima, Nucl. Instrum. Meth. A312 (1992) 349 [$T_{1/2}$]

1994Se10 Yu. V. Sergeenkov, Yu. L. Khazov, T. W. Burrows, M. R. Bhat, Nucl. Data Sheets 72 (1994) 487 [E_γ , I_γ , Spin]

1995Au04 G. Audi, A. H. Wapstra, Nucl. Phys. A595 (1995) 409 [Q]

1996Sc06 E. Schönfeld, H. Janβen, Nucl. Instrum. Meth. A369 (1996) 527 [Atomic data]

2002Go45 V. M. Gorozhankin, N. Coursol, E. A. Yakushev, Ts. Vylov, C. Briancon, Applied Rad. Isotop. 56 (2002) 189 [M4 transition]

2004Da05 M. A. L. da Silva, M. C. M. de Almeida, C. J. da Silva, J. U. Delgado, Applied Rad. Isotop. 60(2004)301 [$T_{1/2}$].

2004Sc04 H. Schrader, Applied Rad. Isotop. 60(2004)317 [$T_{1/2}$].

Table 1 – Gamma emission intensities, relative and absolute values

Ref	80,1853	85,918	177,214	232,175	272,501	284,3047	295,848	302,444	318,093
1952Be95	2,71(19) (O)					6,6(25) (O)			
1963Ju02	2,6(4) (O)					6,0(10) (O)			
1963Ha08	3,5(8) (O)		0,29(6) (O)			7,9(8) (O)			
1964Da19	3,1(2) (O)		0,27(10) (O)			6,6(3) (O)			
1966Mo10	3,10(18) £		0,313(26)			7,4(6)			
1967Ga05	2,72(15) (O)		0,36(2) (O)		0,08(1)	7,05(40) (O)			0,110(15) (O)
1967Yt02	3,4(4) (O)	~ 0,1	0,38(8) (O)		~ 0,07	8,2(8) £			~ 0,05
1972Singh	3,210(5)		0,30(2)			7,49(5)			0,110(5)
1974Me21	3,226(37)	0,00011(6)	0,3263(25)	0,0017(10)	0,0695(12)	7,457(12)	0,00087(50)	0,0056(11)	0,0980(37)
1989Ch45	3,26(7)		0,334(6)	0,0039(5)	0,0735(18)	7,56(8)	0,0022(10)	0,0057(8)	0,096(2)
1990Me15	3,23(6)	0,00011(6)	0,326(7)	0,0017(10)	0,0695(19)	7,46(15)	0,00087(50)	0,0056(11)	0,0980(42)
Adopted	3,212(9)	0,00011(6)	0,3269(22)	0,00317(47)	0,0705(9)	7,461(12)	0,00102(33)	0,0056(6)	0,0980(15)
N	4	2	5	3	4	5	3	3	4
chi**2/N-1	0,247	0	0,8923	3,23	1,55	0,4973	0,7862	0,004016	2,253
Method	LWM, int. unc.		LWM, int. unc.	LWM, int. unc.	LWM, int. unc.	LWM, int. unc.	LWM, int. unc.	LWM, int. unc.	LWM, int. unc.
Absolute Val.	2,607(27)	0,000089(49)	0,2654(32)	0,00257(38)	0,0572(9)	6,06(6)	0,00083(27)	0,00455(49)	0,0796(15)

(O) = omitted value
£ = Data rejection parameters for deviation weighted average (Chauvenet's criterion)
ext. unc. = external uncertainty
int. unc. = internal uncertainty

Table 1 – Gamma emission intensities, relative and absolute values (Cont.)

Ref	324,6307	325,791	358,419	364,49	404,816	503,005	636,991	642,7237	722,909
1952Be95				100			11,6(19) (O)		3,5(31) £
1963Ju02							9,0(10) (O)		3,0(4) £
1963Ha08		0,35(8) (O)		100		0,52(17) (O)	8,8(7) (O)		2,05(16) (O)
1964Da19		0,26(10) (O)		100		0,54(5) (O)	8,3(3) (O)		1,9(1) (O)
1966Mo10		0,279(25)		100		0,45(6)	9,1(11)		2,05(26)
1967Ga05	0,04(1) (O)	0,45(3) £	0,020(4) (O)	100	0,080(7) (O)	0,36(2) (O)	8,0(4) (O)	0,180(15) (O)	2,10(15) (O)
1967Yt02		0,37(5) (O)		100	~ 0,06	0,37(8) (O)	8,2(8) (O)		1,8(2) (O)
1972Singh		0,32(1)		100	0,022(5) £	0,30(5) £	7,79(10) £	0,13(1) (O)	1,79(9) £
1974Me21	0,0273(50)	0,3089(50)	0,01129(25)	100	0,0695(25)	0,4442(37)	8,945(25)	0,2705(25)	2,221(12)
1989Ch45	0,025(8)	0,361(5)	0,0304(11)	100	0,066(2)	0,438(5)	8,75(9)	0,269(5)	2,19(2)
1990Me15	0,0273(50)	0,309(8)	0,01129(33)	100	0,0695(28)	0,444(12)	8,95(21)	0,270(7)	2,22(7)
Adopted	0,0269(32)	0,329(32)	0,0121(27)	100	0,0679(14)	0,4421(29)	8,940(23)	0,2702(21)	2,213(10)
N	3	5	3		3	4	4	3	4
chi2/N-1**	0,03458	17,05	14,47		0,8191	0,3456	2,353	0,03637	0,723
Method	LWM, int. unc.	LWM, exp. unc.	LWM, ext. unc.		LWM, int. unc.	LWM, int. unc.	LWM, int. unc.	LWM, int. unc.	LWM, int. unc.
Absolute Val.	0,0218(26)	0,267(26)	0,0098(22)	81,2(8)	0,0551(13)	0,3589(43)	7,26(8)	0,2193(28)	1,796(20)

(O) = omitted value
£ = Data rejection parameters for deviation weighted average (Chauvenet's criterion)
ext. unc. = external uncertainty
int. unc. = internal uncertainty