

¹⁴¹Ce - Comments on evaluation of decay data by E. Schönfeld

References are given only in those cases where the reference is not already included in the list of references in the Tables Part.

1 Decay Scheme

The decay scheme is complete as there are no other level of ¹⁴¹Pr below the decay energy (Peker, 1985).

2 Nuclear Data

For the half-live evaluation the following set of data was considered ($T_{1/2}$ in d):

1	33.11(23)	Walker	1949	omitted
2	32.50(20)	Freedman and Engelkemeir	1950	
3	32.550(7)	Anspach et al.	1965	superseded by 13
4	32.38(2)	O'Brien and Eldridge	1967	omitted
5	32.60(20)	Baba et al.	1972	outlier
6	32.51(6)	Debertin	1971	superseded by 12
7	32.45(13)	Emery et al.	1972	
8	32.55(3)	Lagoutine et al.	1972	
9	32.51(6)	Merritt and Taylor	1973	
10	32.501(13)	Vaninbroukx and Grosse	1976	
11	32.50(3)	Rutledge et al.	1980	
12	32.51(10)	Schrader et al.	1983	
13	32.510(24)	Unterweger et al.	1992	
14	32.508(10)	Weighted mean of 2 and 7 - 13		

The uncertainties of values 1 and 4 seem to be strongly underestimated. These values were not used for the calculation of a mean. Value 5 is outlier. The value 3 is superseded by the value 13, the value 6 is superseded by the value 12 and were also not used for the mean. The uncertainty of value 8 was multiplied by a factor 3 since the original uncertainty (0.01) seems to be underestimated. The original uncertainty of value 10 (0.04) was given for confidence level of 99.7 % and has therefore been reduced. The weighted mean (adopted value) is influenced mainly by the values 10, 11 and 13.

The Q_{β} value was taken from Audi and Wapstra (1993).

2.1 β^- Transitions

The energy of the $\beta_{0,1}$ transition is deduced from the Q_{β} value and the gamma ray energy. The probability for the $\beta_{0,1}$ transition is equal to $P_{\gamma+ce}$ for the 145 keV transition. The probability of the feeding of the ground state was calculated by $1 - P_{\beta_{0,1}}$.

2.2 Gamma Transition

The energy was taken from Helmer and van der Leun (1997).

The probability P_{g+ce} was calculated by $P_{g+ce} = P_{\gamma}(1 + a_t)$. (P_{γ} see Section 4.2.)

The total conversion coefficient is a weighted mean of 9 values (1966 - 1992); see below. A value for the total conversion coefficient of the 145 keV gamma transition can be derived from special coincidence

measurements (Hansen et al. 1979, Schönfeld et al. 1992). An other useful quantity is the measured ratio of the emission probabilities for K-X rays and gamma rays.

As (with $\mathbf{a}' = \mathbf{a}/(1 + \mathbf{a}_t)$)

$$\frac{P_{XK}}{P_g} = \frac{P_{b_i} \mathbf{a}'_K \mathbf{w}_K}{P_{b_i} (1 - \mathbf{a}'_t)} = \frac{\mathbf{w}_K \mathbf{a}'_K}{1 - \mathbf{a}'_t} = \frac{\mathbf{w}_K \mathbf{a}'_t [1 - (\mathbf{a}'_{LMN} / \mathbf{a}'_t)]}{1 - \mathbf{a}'_t} \quad (1)$$

we obtain

$$\mathbf{a}'_t = \frac{\mathbf{a}'_t}{1 - \mathbf{a}'_t} = \frac{P_{XK} / P_g}{\mathbf{w}_K [1 - (\mathbf{a}'_{LMN} / \mathbf{a}'_t)]} \quad (2)$$

In order to calculate \mathbf{a}'_t we need the knowledge of

$$\frac{\mathbf{a}'_{LMN}}{\mathbf{a}'_t} = \frac{\mathbf{a}_{LMN}}{\mathbf{a}_t} = \frac{\mathbf{a}_{LMN}}{\mathbf{a}_K + \mathbf{a}_{LMN}} = \frac{1}{1 + (\mathbf{a}_K / \mathbf{a}_{LMN})} \quad (3)$$

With $\alpha_K/\alpha_{LMN} = 5.78(18)$ Hansen et al. (1979) this yields $\mathbf{a}_{LMN}/\mathbf{a}_t = 0.1475(38)$. The uncertainty of α_t calculated using Equation (2) is very little influenced by the uncertainty of this value. Including the values derived from (2) with the measured X/ γ ratios (0.349(5) Hansen et al., 1979; 0.339(5) Schönfeld et al., 1992) we have the following set of data for \mathbf{a}'_t :

1	0.440(11)	Dingus et al. 1966	derived from \mathbf{a}_K
2	0.441(9)	Pancholi 1966	derived from \mathbf{a}_K
3	0.456(14)	Hager and Seltzer 1968	derived from theory
4	0.421(21)	Legrand et al. 1975	measured
5	0.439(13)	Hansen et al. 1979	measured
6	0.448(7)	Hansen et al. 1979	calculated from the X_K/γ ratio using equation (2)
7	0.436(17)	Hansen et al. 1979	coinc. meas., extrapol. technique
8	0.452(8)	Schönfeld et al. 1992	coinc. meas., special technique
9	0.435(7)	Schönfeld et al. 1992	calculated from the X_K/γ ratio using equation (2)
10	0.443(4)	weighted mean of values 1-9	

The ratios $\mathbf{a}'_L/\mathbf{a}'_K/\mathbf{a}'_t$ are taken from Hansen et al. (1979).

The theoretical conversion coefficients (interpolated from the tables of Rösel et al.) are by approximately 3% greater than the values based on experimental determinations.

	theory	adopted ¹⁾	ratio
\mathbf{a}_K	0.38809	0.378(4)	1,027
\mathbf{a}_L	0.05360	0.0518(18)	1,035
\mathbf{a}_{M+}	0.01432	0.014(2)	1,023
\mathbf{a}_t	0.45601	0.443(4)	1,029
$\mathbf{a}_K/\mathbf{a}_{LM+}$	5.71	5.78(18)	-

¹⁾ based on the above evaluated α_t and the $\mathbf{a}'_L/\mathbf{a}'_K/\mathbf{a}'_t$ ratio from Hansen et al. (1979)

3 Atomic Data

The atomic data are taken from Schönfeld and Janßen (1996).

3.1 X Radiation

The X ray energies are based on the wave lengths compiled by Bearden (1967). The ratios $P(K_{\alpha_2})/P(K_{\alpha_1})$ and $P(K_{\beta})/P(K_{\alpha})$ are taken from Schönfeld and Janßen. The ratio $P(K'_{b_2})/P(K'_{b_1})$ is taken from the paper of Scofield (1974) (theory).

The relative emission probability of LX rays is calculated from the absolute value (Section 4.2) putting $P(K_{\alpha_1}) = 1$.

3.2 Auger Electrons

The ratios $P(KLX)/P(KLL)$ and $P(KXY)/P(KLL)$ are taken from Schönfeld and Janßen (1996). The relative emission probability of LX rays is calculated from the absolute value (Section 4.1) putting $P(KLL) = 1$.

4 Radiation Emission

4.1 Electron Emission

The number of electrons per disintegration has been calculated using the transition probability $P_{\gamma+ce}$, the conversion coefficients as given in Section 2.2, and the atomic data as given in Section 3. The energies and emission probabilities of the β particles correspond to the data given already in Section 2.1.

4.2 Photon Emission

The number of photons per disintegration have been calculated using the transition probability $P_{\gamma+ce}$ and the conversion coefficients as given in Section 2.2, and the atomic data as given in Section 3. The gamma ray emission probability is the weighted mean of 4 values. The following values (based on absolute activity determinations) were taken into consideration:

1	0.493(6)	Eldridge	1966
2	0.4844(41)	Legrand et al. (LMRI)	1975
3	0.482(3)	Hansen et al.	1979
4	0.485(4)	Rutledge et al.	1980
5	0.489(4)	Schötzig et al.	1980
6	0.480(5)	Schönfeld et al.	1992
7	0.4829(20)	LWM (2, 3, 4, 6) and adopted value	

Value 1 was not used when calculating the average because the uncertainty seems to be underestimated in an unknown amount. Value 5 was also not used because it is considered to be superseded by value 6. The remaining 4 values were used to calculate a weighted mean. (The uncertainty of value 2 is stated to be 3 σ but is assumed here to be also 1 σ as this seems to be more realistic and comparable to the other values.) With $\alpha_t = 0.443$ this yields $P_{\gamma+ce} = 0.697(4)$.

The evaluated data give a ratio P_{X_K} / P_{γ} which can be compared with measured values:

1	0.338(5)	Nemet (1961)
2	0.347(12)	Nemet (1961)
3	0.342(9)	Campbell et al. (1971)
4	0.334(9)	Campbell and Mc Nelles (1972)
5	0.349(5)	Hansen et al. (1979)
6	0.339(5)	Schönfeld et al. (1992)
7	0.346(5)	Present evaluation

The value of the present evaluation is in excellent agreement with the experimental results, especially with the values 2, 3 and 5. The weighted mean of the experimental values 1 to 6 is 0.342(3).

5 Main Production Modes

Taken from the Table des Radionucléides (N. Coursol, 1984) and Nuclear Data Sheets (1985).

6 References

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