Comparison of Neutron Activation Analysis k0 Data: Preliminary Results

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Data Sources

IUPAC
[1] F. De Corte and A. Simonits, At. Data Nucl. Data Tables 85, 47-67 (2003).
[2] V.P. Kolotov and F. De Corte, Pure Appl. Chem. **76**, 1921-1925 (2004).
Atlas of Neutron Resonances
[3] S.F. Mughabghab, *Atlas of Neutron Resonances*, Elsevier, Amsterdam (2006).
PGAA Handbook
[4] *Handbook of Prompt Gamma Activation Analysis,* ed. G.L. Molnar, Kluwer Academic Publishers, Dordrecht (2004).
DECAY DATA
[5] *Table of Radionuclides*, ed. M.-M. Be et al, Bureau International des Poids et Measures, Pavillon de Breteuil, F-92310 Sevres (2004).
[6] Evaluated Nuclear Structure Data File (ENSDF), a computer file of evaluated experimental nuclear structure data maintained by the National Nuclear Data Center, Brookhaven National Laboratory.
[7] R.B. Firestone et al, *Table of Isotopes, 8th Edition,* John Wiley & Sons, New York, 1996,1998,1999.

Relationship between k_0 and σ_0

$$(k_{0,Au})x = [M_{Au}\theta_x\sigma_{0,x}P_x] / [M_x\theta_{Au}\sigma_{0,Au}P_{Au}]$$

Where M is the atomic mass (M_{Au}=196.96655), θ is the isotopic abundance (θ_{Au}=100), σ_0 is the total thermal radiative cross section ($\sigma_{0,Au}$=98.65 b), and P_x is the γ-ray transition probability (P_{Au}=0.9554).

k_0 and σ_0 data are compiled independently and can be compared.

k_0 comparison (415 values)

Isotope	Half-life		Eγ (keV)	k_0 Values Atlas	±(%)	IUPAC	±(%)	Budapest	±(%)	IUPAC/Atl Ratio	IUPAC/Bud Ratio
20F	11.07 ± 0.06	s	1633.602 ± 0.015	0.001046096	0.9	0.000998	1.2	0.00101	4.0	0.95 ± 0.02	0.99 ± 0.04
24Na	14.9574 ± 0.002	h	1368.626 ± 0.005	0.046993505	0.8	0.0468	0.6	0.04602954	1.5	1.00 ± 0.01	1.02 ± 0.02
24Na	14.9574 ± 0.002	h	2754.007 ± 0.011	0.046936404	0.8	0.0462	0.9	0.04602954	1.5	0.98 ± 0.01	1.00 ± 0.02
27Mg	9.458 ± 0.012	m	170.686 ± 0.15	2.90819E-06	12.6	0.00000302	1.0	0.0000027	14.8	1.04 ± 0.13	1.12 ± 0.15
27Mg	9.458 ± 0.012	m	843.76 ± 0.03	0.00026101	1.7	0.000253	0.4	0.000245	4.9	0.97 ± 0.02	1.03 ± 0.05
27Mg	9.458 ± 0.012	m	1014.44 ± 0.04	0.000101787	2.1	0.000098	2.0	0.000096	5.2	0.96 ± 0.03	1.02 ± 0.06
28Al	2.2414 ± 0.0012	m	1778.85 ± 0.03	0.017891857	1.3	0.0175	0.6	0.0172	1.2	0.98 ± 0.01	1.02 ± 0.01
31Si	157.3 ± 0.3	m	1266.15 ± 0.1	1.72058E-07	28.6	0.0000000145	0.7			0.84 ± 0.29	
37S	5.05 ± 0.02	m	3103.36 ± 0.02	2.89158E-06	6.9	0.00000196	1.8	0.000014	0.5	0.68 ± 0.07	0.14 ± 0.02
38Cl	37.24 ± 0.05	m	1642.714 ± 0.016	0.00197203	3.4	0.00197	1.5	0.0014	21.4	1.00 ± 0.04	1.41 ± 0.21
38Cl	37.24 ± 0.05	m	2167.405 ± 0.009	0.002621131	2.9	0.00266	1.1	0.0018	11.1	1.01 ± 0.03	1.48 ± 0.11
41Ar	109.61 ± 0.04	m	1293.64 ± 0.04	0.034389011	1.5	0.0332	0.0			0.97 ± 0.02	
42K	12.36 ± 0.012	h	312.6 ± 0.25	1.76471E-05	6.3	0.0000159	1.3			0.90 ± 0.06	
42K	12.36 ± 0.012	h	1524.6 ± 0.3	0.00094958	2.1	0.000946	0.6	0.0010213333	0.1	1.00 ± 0.02	0.93 ± 0.01
47Ca	4.536 ± 0.003	d	489.23 ± 0.1	9.56946E-08	23.0	9.14E-08	1.8			0.96 ± 0.23	
47Ca	4.536 ± 0.003	d	807.86 ± 0.1	9.56946E-08	23.0	0.0000000092	0.2			0.96 ± 0.23	
47Ca	4.536 ± 0.003	d	1297.09 ± 0.1	1.09586E-06	13.7	0.0000000954	0.2			0.87 ± 0.14	

σ_0 comparison

Target	Isotope	Energy	Mode	Half-life		σ_0(Atlas)	σ_0(IUPAC)	σ_0(Budapest)
19F	20F	0	B-	11.07 ± 0.06	s	0.00951 ± 0.00009	0.00907 ± 0.00011	0.0096 ± 0.0008
22Ne	23Ne	0	B-	37.24 ± 0.12	s	0.0455 ± 0.0006		0.046 ± 0.001
23Na	24Na	0	B-	14.9574 ± 0.002	h	0.517 ± 0.004	0.515 ± 0.003	0.53 ± 0.008
23Na	24Na	472.2	IT	20.2 ± 0.07	ms	0.4 ± 0.03		0.478 ± 0.004
26Mg	27Mg	0	B-	9.458 ± 0.012	m	0.0384 ± 0.0006	0.0371 ± 0.0005	0.0378 ± 0.0013
27Al	28Al	0	B-	2.2414 ± 0.0012	m	0.231 ± 0.003	0.226 ± 0.002	0.232 ± 0.003
30Si	31Si	0	B-	157.3 ± 0.3	m	0.107 ± 0.002	0.0902 ± 0.0006	
36S	37S	0	B-	5.05 ± 0.02	m	0.236 ± 0.006	0.16 ± 0.003	1.22 ± 0.33
37Cl	38Cl	0	B-	37.24 ± 0.05	m	0.433 ± 0.006	0.436 ± 0.008	0.553 ± 0.016
37Cl	38Cl	671.4	IT	715 ± 3	ms	0.047 ± 0.01		0.05 ± 0.003
40Ar	41Ar	0	B-	109.61 ± 0.04	m	0.66 ± 0.01	0.637 ± 0.001	
41K	42K	0	B-	12.36 ± 0.012	h	1.46 ± 0.03	1.417 ± 0.017	1.644 ± 0.008
46Ca	47Ca	0	B-	4.536 ± 0.003	d	0.74 ± 0.07	0.71 ± 0.017	
48Ca	49Ca	0	B-	8.718 ± 0.006	m	1.09 ± 0.14	1.125 ± 0.01	1.22 ± 0.29
45Sc	46Sc	0	B-	83.788 ± 0.00022	d	27.2 ± 0.2	26.2 ± 0.3	
46Ca	47Sc	0	B-	3.3492 ± 0.0006	d	0.74 ± 0.07	0.602 ± 0.01	
45Sc	46Sc	142.5	IT	18.75 ± 0.04	s	9.8 ± 1.1		7.9 ± 0.3

Complete k_0 database (4659 values)

Target	Half-life	Eγ(keV)	k0(BNL)
98Mo	2.7479 d	2.17	4.78E-14
98Mo	6.0067 h	2.17	5.06E-14
150Nd	28.4 h	4.82	5.13E-07
100Mo	14.61 m	6.28	2.27E-06
180Hf	42.39 d	6.30	6.17E-06
186W	23.72 h	7.10	4.20E-06
168Yb	32.018 d	8.41	1.25E-04
100Mo	14.61 m	9.32	8.79E-06
82Kr	1.83 h	9.41	2.41E-03
136Ce	9.0 h	10.61	1.43E-06
123Sb	93 s	10.86	9.31E-11
133Cs	2.912 h	11.24	4.43E-04
132Ba	38.9 h	12.33	1.18E-07
170Er	7.516 h	12.39	5.04E-06
151Eu	96 m	12.60	7.54E-05
72Ge	0.499 s	13.06	3.54E-06
152Gd	240.4 d	14.06	3.91E-06
74Se	119.79 d	14.88	1.48E-07
100Mo	14.61 m	15.61	5.59E-09
71Ga	39.68 ms	16.40	1.32E-04

Target	Half-life	Eγ(keV)	k0(BNL)
98Mo	2.7479 d	40.58	6.98E-06
186W	23.72 h	40.75	2.45E-06
46Ca	4.536 d	41.06	9.11E-11
232Th	26.975 d	41.66	9.27E-06
190Os	15.4 d	41.85	1.94E-06
102Ru	39.26 d	42.63	4.30E-07
181Ta	114.43 d	42.72	6.57E-04
238U	23.45 m	43.53	9.50E-04
186W	23.72 h	43.66	2.49E-06
238U	2.356 d	44.66	3.04E-05
108Pd	13.7012 h	44.70	4.34E-07
81Br	6.13 m	45.95	6.64E-05
190Os	15.4 d	47.05	1.02E-06
238U	2.356 d	49.41	2.80E-05
198Pt	3.139 d	49.83	9.98E-06
71Ga	14.10 h	50.88	5.53E-06
168Yb	32.018 d	51.51	1.23E-06
232Th	26.975 d	51.80	2.65E-07
154Sm	22.3 m	53.10	3.92E-06
102Ru	39.26 d	53.28	3.67E-05

Target	Half-life	Eγ(keV)	k0(BNL)
150Nd	28.4 h	64.88	1.59E-05
148Nd	1.728 h	65.23	3.31E-07
148Nd	1.728 h	65.42	6.62E-07
181Ta	114.43 d	65.72	6.92E-03
150Nd	28.4 h	65.83	9.68E-06
192Os	30.11 h	65.87	3.31E-07
74Ge	82.78 m	66.00	4.29E-06
74Ge	82.78 m	66.00	6.19E-06
74Se	119.79 d	66.05	1.37E-04
150Nd	12.44 m	67.02	1.57E-07
148Nd	1.728 h	67.20	9.38E-07
164Dy	2.334 h	67.71	1.35E-03
181Ta	114.43 d	67.75	9.76E-02
238U	2.356 d	67.86	2.34E-05
164Dy	1.257 m	67.90	7.00E-04
152Sm	1.92855 d	68.26	9.96E-06
139La	1.6785 d	68.92	1.04E-04
150Nd	12.44 m	68.98	1.07E-05
148Nd	1.728 h	69.51	1.38E-06
152Sm	1.92855 d	69.67	3.62E-02

Problem isotopes

^{36}S – k_0(3103) varies from 68% (IUPAC) to 14% (Budapest) of the Atlas value. This may be due to variations in the 36S isotopic abundance, which is known to be significant for this isotope.

^{70}Zn – k_0(122) and k0(512) (IUPAC) are only 22% and 29%, respectively, of the Atlas value.

^{110}Pd – k_0(172) is 41% (IUPAC) of the Atlas value. Other evaluated Atlas cross sections for palladium also appear to be systematically too high [8].

^{112}Sn – k_0(255) for ^{112}Sn(n,γ)^{113}Sn and k_0(392) for ^{112}Sn(n,γ)^{113}Sn$\rightarrow$^{113}In are both 68% of the Atlas value.

^{124}Sn – all k_0 values for ^{124}Sn(n,g)^{125}Sn$\rightarrow$^{125}Sb are only 3% of the Atlas value.

^{132}Ba – k_0(276) is 66% (IUPAC) higher than the Atlas value. The total ^{132}Ba cross section is not well known and was reported with no uncertainty.

^{190}Os – k_0(129) is 27% (IUPAC) of the Atlas value.

Future plans

- Address discrepancies in the data
- Combine k_0 data using standard statistical methods to obtain a recommended set of k_0 factors for all activation product γ-rays
- Include the results in the Evaluated Gamma-ray Activation File (EGAF) disseminated by the IAEA and LBNL