BROOKHAVEN
NATIONAL LABORATORY

BNL-74880-2005-CP

Radioactive Chemical Elements in the Atomic Weights Table

Norman E. Holden

Presented at the "43rd IUPAC General Assembly"
Beijing, China, August 2005

XXX Energy Sciences & Technology Department xxx

Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11973-5000
www.bnl.gov

Managed by
Brookhaven Science Associates, LLC
for the United States Department of Energy under
Contract No. DE-AC02-98CH10886

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Presented at the 43rd
IUPAC General Assembly in
Beijing, China August 2005

RADIOACTIVE CHEMICAL ELEMENTS IN THE ATOMIC WEIGHTS TABLE

Norman E. Holden
National Nuclear Data Center
Brookhaven National Laboratory
Upton, New York 11973-5000

Introduction

In the 1949 Report of the Atomic Weights Commission[1], a series of new elements were added to the Atomic Weights Table. Since these elements had been produced in the laboratory and were not discovered in nature, the atomic weight value of these artificial products would depend upon the production method. Since atomic weight is a property of an element as it occurs in nature, it would be incorrect to assign an atomic weight value to that element. As a result of that discussion, the Commission decided to provide only the mass number of the most stable (longest-lived) known isotope as the number to be associated with these entries in the Atomic Weights Table.

As a function of time, the mass number associated with various elements has changed as longer-lived isotopes of a particular elements has been found in nature, or as improved half-life values of an element's isotopes might cause a shift in the longest-lived isotope from one mass number to another.

In the 1957 Report of the Atomic Weights Commission[2], it was decided to discontinue the listing of the mass number in the Atomic Weights Table on the grounds that the kind of information supplied by the mass number is inconsistent with the primary purpose of the Table, i.e., to provide accurate values of "these constants" for use in chemical calculations. In addition to the Table of Atomic Weights, the Commission included an auxiliary Table of Radioactive Elements for the first time, where the entry would be the isotope of that element which was most stable, i.e., it had the longest known half-life.

In their 1973 report[3], the Commission noted that the users of the Atomic Weights Table were dissatisfied with the omission of values in the Table for some elements and it was decided to reintroduce the mass number for elements.

In their 1983 report[4], the Commission decided that radioactive elements were considered to lack a characteristic terrestrial isotopic composition, from which an atomic weight value could be calculated to five or more figure accuracy, without prior knowledge of the sample. These elements were again listed in the table with no further information, i.e., no mass number or atomic weight value.

Table of Radioactive Elements

For the elements, which have no stable or long-lived isotopes, the data on radioactive half-lives and relative atomic masses for the nuclides of interest have been evaluated. The values of the half-lives their uncertainties are listed. The uncertainties are given in the last digit quoted of the half-life vale and shown in parentheses. The criteria for consideration of entries in this Table continue to be the same as it has been for over fifty years. It is the same criteria, which are used for all data that are evaluated for inclusion in the Atomic Weight's Table. If a report of data is published in a peer-reviewed journal, that data is evaluated and considered for inclusion in the appropriate table of the biennial report of the Atomic Weights Commission. As better data might become available in the future, the information that is contained in either of the tables may be modified.

The information contained in the Table of Radioactive Elements should enable the user to calculate the atomic weight for any sample of radioactive material, which might have a variety of isotopic compositions. The atomic mass values have been taken from the 2003 Atomic Mass Table[5]. Most of these half-lives have already been documented in various sources[6,7,8,9,10].

Acknowledgement

This manuscript has been authored by Brookhaven Science Associates, LLC, under Contract No. DE-AC02-98CH1-886, with the Department of Energy. The United States Government retains, and the publisher, by accepting the article for publication, acknowledges a world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for the United States Government purposes.

References

1. E. Wichers, J. Am. Chem. Soc. 72 pp 1431-1432 (1950).

2. E. Wichers, J. Am. Chem. Soc. 80 pp 4121-4126 (1958).

3. "Atomic Weights of the Elements 1973", Pure Appl. Chem. 37 pp 591-603 (1974).

4. N.E. Holden and R.L. Martin, Pure Appl. Chem. 56 pp 653-674 (1984).

5. G. Audi, A.H. Wapstra and C. Thibault, Nucl. Phys. A 729 pp 337-675 (2003).

6. N.E. Holden, Pure Appl. Chem. 61 pp 1483-1504 (1989).

7. N.E. Holden, Pure Appl. Chem. 62 pp 941-958 (1990).

8. N.E. Holden, R.N. Reciniello and J-P Hu, Health Phys. 87 pp 410-415 (2004).

9. N.E. Holden, AIP Conference Proceedings 769, International Conference on Nuclear Data for Science and Technology, Santa Fe, New Mexico, 26 September–1 October 2004, pp 426-429, American Institute of Physics, Melville, NY (2005).

10. N.E. Holden, "Table of the Isotopes (Revised 2002)" Handbook of Chemistry & Physics 86th edition, edited by D.R. Lide, Boca Raton, Fl. CRC Press Inc., section 11, pp 50-184 (2005).

TABLE OF THE RADIOACTIVE ELEMENTS

At. No.	Element Name	Elem. Symbol	Mass No.	Atomic Mass	Half-life ± (Uncertainty)	Units
43	Technetium	Tc	97	96.9064	$4.2\ (2) \times 10^{6}$	a
			98	97.9072	$6.6\ (10) \times 10^{6}$	a
			99	98.9063	$2.1\ (3) \times 10^{5}$	a
61	Promethium	Pm	145	144.9127	17.7 (4)	a
			147	146.9151	2.623 (3)	a
84	Polonium	Po	209	208.9824	102. (5)	a
			210	209.9829	138.4 (1)	d
85	Astatine	At	210	209.9871	8.1 (4)	h
			211	210.9875	7.21 (1)	h
86	Radon	Rn	211	210.9906	14.6(2)	h
			220	220.0114	55.6 (1)	s
			222	222.0176	3.823 (4)	d
87	Francium	Fr	223	223.0197	22.0 (1)	min
88	Radium	Ra	223	223.0185	11.43 (1)	d
			224	224.0202	3.66 (2)	d
			226	226.0254	1599. (4)	a
			228	228.0311	5.76 (3)	a
89	Actinium	Ac	227	227.0278	21.77 (2)	a
90	Thorium	Th	230	230.0331	$7.54\ (3) \times 10^{6}$	a
			232	232.0381	$1.40\ (1) \times 10^{10}$	a
91	Protactinium	Pa	231	231.0359	$3.25\ (1) \times 10^{4}$	a
92	Uranium	U	233	233.0396	$1.592\ (2) \times 10^{5}$	a
			234	234.0410	$2.455\ (6) \times 10^{5}$	a
			235	235.0439	$7.04\ (1) \times 10^{8}$	a
			236	236.0456	$2.342\ (4) \times 10^{7}$	a
			238	238.0508	$4.468\ (3) \times 10^{9}$	a
93	Neptunium	Np	237	237.0482	$2.14\ (1) \times 10^{6}$	a
			239	239.0529	2.355 (6)	d
94	Plutonium	Pu	238	238.0496	87.7 (1)	a
			239	239.0522	$2.410\ (3) \times 10^{4}$	a
			240	240.0538	$6.56\ (1) \times 10^{3}$	a
			241	241.0569	14.4 (1)	a
			242	242.0587	$3.75\ (2) \times 10^{5}$	a
			244	244.0642	$8.00\ (9) \times 10^{7}$	a

TABLE OF THE RADIOACTIVE ELEMENTS (Continued)

At. No.	Element Name	Elem. Symbol	Mass No.	Atomic Mass	Half-life ± Uncertainty	Units
95	Americium	Am	241	241.0568	432.7 (6)	a
			243	243.0614	$7.37 (2) \times 10^3$	a
96	Curium	Cm	243	243.0614	29.1 (1)	a
			244	244.0628	18.1 (1)	a
			245	245.0655	$8.48 (6) \times 10^3$	a
			246	246.0672	$4.76 (4) \times 10^3$	a
			247	247.0704	$1.56 (5) \times 10^7$	a
			248	248.0723	$3.48 (6) \times 10^5$	a
97	Berkelium	Bk	247	247.0703	$1.4 (3) \times 10^3$	a
			249	249.0750	$3.20 (3) \times 10^2$	d
98	Californium	Cf	249	249.0749	351. (2)	a
			250	250.0764	13.1 (1)	a
			251	251.0796	$9.0 (5) \times 10^2$	a
			252	252.0816	2.65 (1)	a
99	Einsteinium	Es	252	252.0830	472. (2)	d
100	Fermium	Fm	257	257.0951	100.5 (2)	d
101	Mendelevium	Md	258	258.0984	51.5 (3)	d
			260	260.1037	27.8 (3)	d
102	Nobelium	No	259	259.1010	58. (5)	min
103	Lawrencium	Lr	262	262.1096	3.6 (3)	h
104	Rutherfordium	Rf	267	267.1215	1.3	min
105	Dubnium	Db	268	268.1255	~ 0.7	d
106	Seaborgium	Sg	271	271.1335	~ 21.	s
107	Bohrium	Bh	272	272.1380	~ 10.	s
108	Hassium	Hs	277	277.150	16.5	min
109	Meitnerium	Mt	276	276.1512	0.7	s
110	Darmstadtium	Ds	281	281.162	~ 9.6	s
111	Roentgenium	Rg	280	280.1645	~ 3.6	s
112	Ununbium	Uub	285	285.174	~ 34.	s
113	Ununtrium	Uut	284	284.178	~ 0.5	s
114	Ununquadium	Uuq	289	289.189	~ 2.7	s
115	Ununpentium	Uup	288	288.192	~ 87.	ms
116	Ununhexium	Uuh	293		~ 0.05	s
118	Ununoctium	Uuo	294		~ 1.8	ms