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COMMISSION ON ATOMIC WEIGHTS

ATOMIC WEIGHTS OF THE ELEMENTS 1977

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ATOMIC WEIGHTS OF THE ELEMENTS 1977

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Abstract - The biennial review of atomic weight determinations and other cognate data has resulted in the following changes in recommended values (1975 values in parentheses): V 50.9415 (50.9414*); Lu 174.967* (174.97). These values are considered to be reliable to ± 1 in the last digit or ± 3 when followed by an asterisk (*) and are incorporated in the full Table of Atomic Weights of the Elements 1977. Atomic mass numbers were added for elements 104 to 106. These elements are designated by the names and symbols provisionally suggested by IUPAC: 261 Unq; 262 Unp; 263 Unh. The Report outlines various problems which arise from the present imprecise definition of "atomic weight (relative atomic mass)" and has made a proposal to overcome the difficulties. The importance of having informative labels on commercially available chemicals is emphasized, particularly in order to warn or reassure users of the presence or absence of materials containing elements with unusual atomic weights due to the enrichment or depletion of isotopes. The Report includes a complete review of the natural isotopic composition of the elements and also tabulates the Relative Atomic Masses for Selected Radioisotopes.

INTRODUCTION

The Commission on Atomic Weights met on 13-16 August 1977, during the XXIXth IUPAC General Assembly in Warsaw. Work done by the Commission members during the preceding two years in assessing atomic weights and other cognate data was reviewed and, as a result, the recommended values for the atomic weights of two elements were changed and atomic mass values for three new elements were added. The new values were immediately disseminated through an IUPAC News Release. The justifications for these changes are set out in the next section. This is followed by the definitive Table of Atomic Weights of the Elements 1977 of the International Union of Pure and Applied Chemistry.

General problems of terminology are discussed in the next section, and the Commission has advanced a proposal for a new definition of "atomic weight (relative atomic mass)." It is hoped that this will remove various operational difficulties which at present face the Commission in preparing its recommendations for the atomic weights of the elements, and place the whole concept of an atomic weight on a sounder basis.

An increasing number of commercially available materials contain elements whose isotopic composition has been altered, either intentionally or inadvertently, from that of the element in nature. This problem afflicts some elements more than others and the Commission has been active in seeking to alert both manufacturers and suppliers to the need for appropriate phrases on labels. Suggestions are made for such explanatory statements which, in many cases, may well add to the value of the products described.

A working group had been constituted as a Subcommittee for the Assessment of Isotopic Composition, at the request of the Inorganic Division (the parent body of the Commission). This will, in due course, enable the Commission to publish a completely self-consistent set of isotopic compositions and atomic weights of the elements incorporating not only mass-spectrometric data but also results obtained from all other relevant methods. The present Report tabulates the range of published mass-spectrometrically determined isotopic abundances for each of the naturally occurring elements, together with the result of what is considered to be the best available mass-spectrometric measurement for a single natural source of each element, and an interim value for the isotopic composition for average elemental properties. This best mass spectrometric measurement is not necessarily a good one in terms of 1977 knowledge nor does it necessarily provide the best atomic weight value in terms of all techniques. In future years the definitive self-consistent tabulation of isotopic compositions will also include the precise relative atomic mass of each nuclide and this will obviate the need for their separate tabulation. As an interim measure, however, the present Report continues the practice of tabulating the relative atomic masses of selected nuclides, but restricts these to certain nuclides of radioactive elements, including those such as technetium, promethium, and the heaviest elements, for which the Table of Atomic Weights lists only the atomic mass number in parentheses.

CHANGES IN ATOMIC WEIGHT VALUES

Vanadium

A relatively precise atomic weight value can be expected for this element because it has two isotopes, only one of which is predominant. The value of $\underline{A}_r(V)$ = 50.942 for the atomic weight of vanadium was adopted by the Atomic Weights Commission in its 1961 Report (Ref. 1) based on an average of mass spectrometric abundance data by Hess (Ref. 2), Leland (Ref. 3), and White (Ref. 4). The average abundance of ^{50}V was 0.24%. In its 1969 Report (Ref. 5), the Atomic Weights Commission considered the uncertainty of the above value and recommended an atomic weight value $\underline{A}_r(V)$ = 50.9414±0.0003. Since that time the Commission has studied more papers dealing with mass spectrometric determinations (Ref. 6-9). The abundance of ^{50}V is now judged to be 0.250%. Using the latest mass table (Ref. 10), the Commission recommends $\underline{A}_r(V)$ = 50.9415±0.0001 as the most reliable value.

Lutetium

The value of $\underline{A}_r(Lu)$ = 174.97 for the atomic weight of lutetium was adopted by the Atomic Weights Commission in its 1961 Report (Ref. 1) based on a chemical determination by Hönigschmid (Ref. 11) and an average abundance for ^{176}Lu of 2.59% from Collins (Ref. 12) and Hayden (Ref. 13). In its 1969 Report (Ref. 5), the Atomic Weights Commission considered the uncertainty of the above value and recommended $\underline{A}_r(Lu)$ = 174.97±0.01. A new measurement of the isotopic abundance values of lutetium has been made by McCulloch (Ref. 14). Using an abundance value for ^{176}Lu of 2.6%, the Commission recommends $\underline{A}_r(Lu)$ = 174.967±0.003 as the most reliable value.

Elements 104-106

For certain radioactive elements, the Commission has been listing the mass number of the isotope of longest half-life instead of the atomic weight value. New half-life determinations occasionally change the listed isotope: thus (98) is now listed for technetium instead of (97) as in the 1975 Atomic Weights Report (Ref. 15) and (252) replaces (254) for einsteinium. Previously, the Commission has chosen to recommend no value for elements above lawrencium because names and chemical symbols had not been agreed upon for these elements. With a recent decision by the IUPAC Bureau, systematic names and symbols are now available. The mass numbers 261, 262, and 263 are listed for unnilquadium, unnilpentium, and unnilhexium respectively, i.e. elements Z=104, Z=105, and Z=106.

THE TABLE OF ATOMIC WEIGHTS 1977

The changes listed in the previous Section are incorporated in the 1977 Table of Atomic Weights. As has been customary, the Table is presented, firstly, in alphabetic order by English names of the elements (Table 1) and, secondly, in order of atomic numbers (Table 2). This year, as in the past, the Commission considered carefully all significant experimental or interpretative evidence bearing on atomic weights. The fact that no change is recommended for a given element should not be held to imply that a new published determination has been overlooked. A review of the literature is generally given in these reports only when a change is being made. For example, the Commission at its Warsaw meeting has specifically reviewed data on cerium, gallium, gold, holmium, hydrogen, nickel, ruthenium, silver, thallium, and zinc, and recommended no change at this time.

For example in the case of hydrogen, the problem with which the Commission was confronted was typical; the largest amount of natural waters (ocean and continental fresh water) show an average deuterium content of 0.015±0.001% giving, combined with the latest atomic mass data (Ref. 10) an atomic weight of 1.00798±0.00010. However the Commission's practice of quoting only figures with errors of either 1 or 3 in the last digit does not allow the use of this number. Indeed quite frequent, although less massive, sources of hydrogen (electrolytic hydrogen, polar ices) have deuterium contents as low as 0.0044% leading to a 1.00787 atomic weight value, which is lower by more than 3 units in the last significant figure than 1.00798.

1.0080 would seem closer to 1.00798 but adopting this figure leads to a deuterium content of 0.0174% which, though less than the highest recorded deuterium content of 0.023%, is very rarely found. Therefore, it was decided that the case of hydrogen is one of those that will be reconsidered only in the light of an overall review of the policy of the Commission in quoting uncertainties on atomic weights.

The need for new and better atomic weight determinations is felt as strongly as ever. The margin in precision between the best atomic weight determinations and the results of routinely available analytical techniques is shrinking and is nonexistent for elements such as Ti and Ge.

TERMINOLOGY

Previous discussions by the Commission on Atomic Weights (see especially the 1975 Report (Ref. 15)) have revealed difficulties arising from the current definition of "atomic weight." These stem from the fact that, for some elements, there can be more than one atomic weight value stated to the precision available with present experimental techniques, because these elements occur with different isotopic composition (in nature or artifically

TABLE 1. Atomic Weights 1977

(Scaled to the relative atomic mass, $\underline{A}_r$ (^{12}C)=12)

The atomic weights of many elements are not invariant but depend on the origin and treatment of the material. The footnotes to this Table elaborate the types of variation to be expected for individual elements. The values of $\underline{A}_r$(E) given here apply to elements as they exist naturally on earth and to certain artificial elements. When used with due regard to the footnotes they are considered reliable to ± 1 in the last digit or ± 3 when followed by an asterisk*. Values in parentheses are used for radioactive elements whose atomic weights cannot be quoted precisely without knowledge of the origin of the elements; the value given is the atomic mass number of the isotope of that element of longest known half life.

Alphabetical order in English

Name	Symbol	Atomic number	Atomic weight	Footnotes
Actinium	Ac	89	227.0278	z
Aluminium	Al	13	26.98154	
Americium	Am	95	(243)	
Antimony (Stibium)	Sb	51	121.75*	
Argon	Ar	18	39.948*	w,x
Arsenic	As	33	74.9216	
Astatine	At	85	(210)	
Barium	Ba	56	137.33	x
Berkelium	Bk	97	(247)	
Beryllium	Be	4	9.01218	
Bismuth	Bi	83	208.9804	
Boron	B	5	10.81	w,y
Bromine	Br	35	79.904	
Cadmium	Cd	48	112.41	x
Caesium	Cs	55	132.9054	
Calcium	Ca	20	40.08	x
Californium	Cf	98	(251)	
Carbon	C	6	12.011	w
Cerium	Ce	58	140.12	x
Chlorine	Cl	17	35.453	
Chromium	Cr	24	51.996	
Cobalt	Co	27	58.9332	
Copper	Cu	29	63.546*	w
Curium	Cm	96	(247)	
Dysprosium	Dy	66	162.50*	
Einsteinium	Es	99	(252)	
Erbium	Er	68	167.26*	
Europium	Eu	63	151.96	x
Fermium	Fm	100	(257)	
Fluorine	F	9	18.998403	
Francium	Fr	87	(223)	
Gadolinium	Gd	64	157.25*	x
Gallium	Ga	31	69.72	
Germanium	Ge	32	72.59*	
Gold	Au	79	196.9665	
Hafnium	Hf	72	178.49*	
Helium	He	2	4.00260	x
Holmium	Ho	67	164.9304	
Hydrogen	H	1	1.0079	w
Indium	In	49	114.82	x
Iodine	I	53	126.9045	
Iridium	Ir	77	192.22*	
Iron	Fe	26	55.847*	
Krypton	Kr	36	83.80	x,y
Lanthanum	La	57	138.9055*	x
Lawrencium	Lr	103	(260)	
Lead	Pb	82	207.2	w,x
Lithium	Li	3	6.941*	w,x,y
Lutetium	Lu	71	174.967*	
Magnesium	Mg	12	24.305	x
Manganese	Mn	25	54.9380	
Mendelevium	Md	101	(258)	
Mercury	Hg	80	200.59*	
Molybdenum	Mo	42	95.94	
Neodymium	Nd	60	144.24*	x
Neon	Ne	10	20.179*	y

TABLE 1. Atomic Weights 1977 (cont'd)

Name	Symbol	Atomic number	Atomic weight	Footnotes
Neptunium	Np	93	237.0482	z
Nickel	Ni	28	58.70	
Niobium	Nb	41	92.9064	
Nitrogen	N	7	14.0067	
Nobelium	No	102	(259)	
Osmium	Os	76	190.2	x
Oxygen	O	8	15.9994*	w
Palladium	Pd	46	106.4	x
Phosphorus	P	15	30.97376	
Platinum	Pt	78	195.09*	
Plutonium	Pu	94	(244)	
Polonium	Po	84	(209)	
Potassium (Kalium)	K	19	39.0983*	
Praseodymium	Pr	59	140.9077	
Promethium	Pm	61	(145)	
Protactinium	Pa	91	231.0359	z
Radium	Ra	88	226.0254	x,z
Radon	Rn	86	(222)	
Rhenium	Re	75	186.207	
Rhodium	Rh	45	102.9055	
Rubidium	Rb	37	85.4678*	x
Ruthenium	Ru	44	101.07*	x
Samarium	Sm	62	150.4	x
Scandium	Sc	21	44.9559	
Selenium	Se	34	78.96*	
Silicon	Si	14	28.0855*	
Silver	Ag	47	107.868	x
Sodium (Natrium)	Na	11	22.98977	
Strontium	Sr	38	87.62	x
Sulfur	S	16	32.06	w
Tantalum	Ta	73	180.9479*	
Technetium	Tc	43	(98)	
Tellurium	Te	52	127.60*	x
Terbium	Tb	65	158.9254	
Thallium	Tl	81	204.37*	
Thorium	Th	90	232.0381	x,z
Thulium	Tm	69	168.9342	
Tin	Sn	50	118.69*	
Titanium	Ti	22	47.90*	
Tungsten (Wolfram)	W	74	183.85*	
(Unnilhexium)	(Unh)	106	(263)	
(Unnilpentium)	(Unp)	105	(262)	
(Unnilquadium)	(Unq)	104	(261)	
Uranium	U	92	238.029	x,y
Vanadium	V	23	50.9415*	
Xenon	Xe	54	131.30	x,y
Ytterbium	Yb	70	173.04*	
Yttrium	Y	39	88.9059	
Zinc	Zn	30	65.38	
Zirconium	Zr	40	91.22	x

w Element for which known variations in isotopic composition in normal terrestrial material prevent a more precise atomic weight being given; $\underline{A}_r$(E) values should be applicable to any "normal" material.

x Element for which geological specimens are known in which the element has an anomalous isotopic composition, such that the difference between the atomic weight of the element in such specimens and that given in the Table may exceed considerably the implied uncertainty.

y Element for which substantial variations in $\underline{A}_r$ from the value given can occur in commercially available material because of inadvertent or undisclosed change of isotopic composition.

z Element for which the value of $\underline{A}_r$ is that of the radioisotope of longest half-life.

TABLE 2. Atomic Weights 1977

(Scaled to the relative atomic mass $\underline{A}_r(^{12}C) = 12$)

The atomic weights of many elements are not invariant but depend on the origin and treatment of the material. The footnotes to this Table elaborate the types of variation to be expected for individual elements. The values of $\underline{A}_r$ (E) given here apply to elements as they exist naturally on earth and to certain artificial elements. When used with due regard to the footnotes they are considered reliable to ±1 in the last digit or ±3 when followed by an asterisk.* Values in parentheses are used for radioactive elements whose atomic weights cannot be quoted precisely without knowledge of the origin of the elements; the value given is the atomic mass number of the isotope of that element of longest known half life.

Order of Atomic Number

Atomic Number	Name	Symbol	Atomic Weight	Footnotes
1	Hydrogen	H	1.0079	w
2	Helium	He	4.00260	x
3	Lithium	Li	6.941*	w,x,y
4	Beryllium	Be	9.01218	
5	Boron	B	10.81	w,y
6	Carbon	C	12.011	w
7	Nitrogen	N	14.0067	
8	Oxygen	O	15.9994*	w
9	Fluorine	F	18.998403	
10	Neon	Ne	20.179*	y
11	Sodium (Natrium)	Na	22.98977	
12	Magnesium	Mg	24.305	x
13	Aluminium	Al	26.98154	
14	Silicon	Si	28.0855*	
15	Phosphorus	P	30.97376	
16	Sulfur	S	32.06	w
17	Chlorine	Cl	35.453	
18	Argon	Ar	39.948*	w,x
19	Potassium (Kalium)	K	39.0983*	
20	Calcium	Ca	40.08	x
21	Scandium	Sc	44.9559	
22	Titanium	Ti	47.90*	
23	Vanadium	V	50.9415	
24	Chromium	Cr	51.996	
25	Manganese	Mn	54.9380	
26	Iron	Fe	55.847*	
27	Cobalt	Co	58.9332	
28	Nickel	Ni	58.70	
29	Copper	Cu	63.546*	w
30	Zinc	Zn	65.38	
31	Gallium	Ga	69.72	
32	Germanium	Ge	72.59*	
33	Arsenic	As	74.9216	
34	Selenium	Se	78.96*	
35	Bromine	Br	79.904	
36	Krypton	Kr	83.80	x,y
37	Rubidium	Rb	85.4678*	x
38	Strontium	Sr	87.62	x
39	Yttrium	Y	88.9059	
40	Zirconium	Zr	91.22	x
41	Niobium	Nb	92.9064	
42	Molybdenum	Mo	95.94	
43	Technetium	Tc	(98)	
44	Ruthenium	Ru	101.07*	x
45	Rhodium	Rh	102.9055	
46	Palladium	Pd	106.4	x
47	Silver	Ag	107.868	x
48	Cadmium	Cd	112.41	x
49	Indium	In	114.82	x
50	Tin	Sn	118.69*	
51	Antimony (Stibium)	Sb	121.75*	
52	Tellurium	Te	127.60*	x
53	Iodine	I	126.9045	
54	Xenon	Xe	131.30	x,y
55	Caesium	Cs	132.9054	
56	Barium	Ba	137.33	x

TABLE 2. Atomic Weights 1977 (cont'd)

Atomic Number	Name	Symbol	Atomic Weight	Footnotes
57	Lanthanum	La	138.9055*	x
58	Cerium	Ce	140.12	x
59	Praseodymium	Pr	140.9077	
60	Neodymium	Nd	144.24*	x
61	Promethium	Pm	(145)	
62	Samarium	Sm	150.4	x
63	Europium	Eu	151.96	x
64	Gadolinium	Gd	157.25*	x
65	Terbium	Tb	158.9254	
66	Dysprosium	Dy	162.50*	
67	Holmium	Ho	164.9304	
68	Erbium	Er	167.26*	
69	Thulium	Tm	168.9342	
70	Ytterbium	Yb	173.04*	
71	Lutetium	Lu	174.967*	
72	Hafnium	Hf	178.49*	
73	Tantalum	Ta	180.9479*	
74	Wolfram (Tungsten)	W	183.85*	
75	Rhenium	Re	186.207	
76	Osmium	Os	190.2	x
77	Iridium	Ir	192.22*	
78	Platinum	Pt	195.09*	
79	Gold	Au	196.9665	
80	Mercury	Hg	200.59*	
81	Thallium	Tl	204.37*	
82	Lead	Pb	207.2	w,x
83	Bismuth	Bi	208.9804	
84	Polonium	Po	(209)	
85	Astatine	At	(210)	
86	Radon	Rn	(222)	
87	Francium	Fr	(223)	
88	Radium	Ra	226.0254	x,z
89	Actinium	Ac	227.0278	z
90	Thorium	Th	232.0381	x,z
91	Protactinium	Pa	231.0359	z
92	Uranium	U	238.029	x,y
93	Neptunium	Np	237.0482	z
94	Plutonium	Pu	(244)	
95	Americium	Am	(243)	
96	Curium	Cm	(247)	
97	Berkelium	Bk	(247)	
98	Californium	Cf	(251)	
99	Einsteinium	Es	(252)	
100	Fermium	Fm	(257)	
101	Mendelevium	Md	(258)	
102	Nobelium	No	(259)	
103	Lawrencium	Lr	(260)	
104	(Unnilquadium)	(Unq)	(261)	
105	(Unnilpentium)	(Unp)	(262)	
106	(Unnilhexium)	(Unh)	(263)	

w Element for which known variations in isotopic composition in normal terrestrial material prevent a more precise atomic weight being given; $\underline{A}_r$(E) values should be applicable to any "normal" material.

x Element for which geological specimens are known in which the element has an anomalous isotopic composition, such that the difference between the atomic weight of the element in such specimens and that given in the Table may exceed considerably the implied uncertainty.

y Element for which substantial variations in $\underline{A}_r$ from the value given can occur in commercially available material because of inadvertent or undisclosed change of isotopic composition.

z Element for which the value of $\underline{A}_r$ is that of the radioisotope of longest half-life.

altered). In some fields of modern chemistry and technology an operational problem therefore exists which can no longer be disregarded. Such different "atomic weight" values are more precise than indicated by the uncertainties associated with the present definition of atomic weight. At the 1975 IUPAC General Assembly in Madrid, the Commission was fortunate to receive the comments and advice from an Open Meeting conducted in cooperation with the IUPAC Inorganic Division, the Interdivisional Committee on Education and other IUPAC commissions concerned with terminology. After that open meeting, the Atomic Weights Commission accepted the responsibility to propose a new definition of an atomic weight of an element at the 1977 Warsaw General Assembly. At a joint meeting in Warsaw of IUPAC Commissions on Inorganic Nomenclature, Atomic Weights, Organic Nomenclature, Analytical Nomenclature, and Committees on Teaching of Chemistry and Nomenclature and Symbols, the definition proposed for an atomic weight of an element was "the ratio of the mass per mole of atoms of that element to 1/12 of the mass of one mole of nuclide ^{12}C" (see Footnote on page 433).
There are several implications and consequences of this proposal:
(1) The new definition differs from the current one by the omission of the phrase "of a natural nuclidic composition," and the substitution of mass per mole of atoms for average mass per atom. Even the current definition does not claim uniqueness for "a natural nuclidic composition." This proposed omission, therefore, would eliminate the difficulty of defining "natural" (presumably terrestrial) as opposed to "artificially" altered isotopic compositions (including presumably in the latter group such compositions as have been influenced by human intervention). Mass per mole of atoms avoids the difficulty of not having defined the population over which the average was taken.
(2) Another consequence of the omission of a natural nuclidic composition is that an element in a sample of an enriched isotope or synthetic isotopic mixture can also be said to have an atomic weight. This effect the Commission considers desirable.
(3) The fact that atomic weights may not be unique is still not directly contained in the definition but is implied by stating that the definition is of "an" atomic weight rather than "the" atomic weight of an element.
(4) There was a consensus at the Madrid meeting that further refinement of the definition by specifying the electronic, or nuclear ground states, rest mass, etc., of the nuclides concerned is for the time being irrelevant and therefore undesirable for the present frame of chemical precision and nuclear industrial activity.
(5) The need for qualifying adjectives for the elements such as "non-radiogenic," "terrestrial," "normal" or "of natural nuclidic composition" would largely disappear. A formal definition would no longer be needed or appropriate to this Commission. However, when the use of such a term is involved, Commission members will probably tend to use "terrestrial" with isotopic composition that of the most abundant source of the element.
(6) The new definition by itself does not solve the principal problem of the Commission namely how to present the most accurate available values for those who need to use them. The concept of accuracy implies the existence of a true value and the definition purposely denies or at any rate fails to recognize the existence of one true value for every element.

LABELLING OF WELL CHARACTERIZED MATERIALS

As pointed out in the 1973 and 1975 reports (Ref. 15,16) the Commission is concerned that the useful practice of quoting atomic or molecular weights on bottles could be misleading for compounds prepared from residues of an undisclosed isotope separation process. One of the following statements continues to be recommended when additional labelling is judged advisable to avoid possible (misconceptions or) errors by the user or to reassure the user of the "normality" of the material.
(1) Atomic weights conform with values published in the IUPAC Table of Atomic Weights. (It might be considered desirable, though not essential, to include the date of the IUPAC Table referred to.)
(2) The actual atomic weight of element(s)....in this particular sample is (are)....(In this statement "atomic weight(s)" could be replaced by "isotopic composition(s).")
(3) Element X is enriched (depleted) in isotope ^{y}X.
In some materials statement (1) can be applied to some elements and statement (2) can be made for one or more other elements in the same sample. Probable error limits would often be helpful in statement (2), and also in statement (3) when it is combined with quantitative data expressed as isotopic composition. Some manufacturers have already started quoting isotopic composition on their labels.
The Commission has requested the widest possible dissemination of these proposals and welcomes comments especially before its next meeting in 1979. Such comments and related questions should be directed to the Commission's Secretary, Dr. N.E. Holden, Department of Nuclear Energy, Brookhaven National Laboratory, Upton, New York 11973, U.S.A.

THE ISOTOPIC COMPOSITION OF THE ELEMENTS

At the request of the IUPAC Inorganic Division, a Subcommittee for the Assessment of Isotopic Composition (SAIC) was formed within the Atomic Weights Commission (Ref. 15). SAIC is concerned with all measurements for deriving isotopic compositions. SAIC has produced another interim version of the "Table of Isotopic Compositions of the Elements as Determined by Mass Spectrometry," and it is reproduced here (Table 3). The interim values when

TABLE 3. ISOTOPIC COMPOSITIONS OF THE ELEMENTS AS DETERMINED BY MASS SPECTROMETRY

The letters appended in the "notes" column have the following significance:

"R" is appended when the range corresponds to that of established natural variations,
"D" is appended when the range corresponds to differences between published values not supported by established natural variations,
"G" is appended when the element is known to have an anomalous composition in certain, natural terrestrial specimens,
"X" is appended when data from only one measurement (believed reliable) are available,
"C" is appended when there is a best measurement which has been calibrated and is thus believed to be "absolute" within the errors stated in the original publication,
"I" is appended when, as a result of reliable surveys, the isotopic composition is not believed to vary in terrestrial samples within the limits established.

The values for isotopic compositions are expressed in atom percent. The values given for the isotopic compositions for average elemental properties are believed reliable to ±1 in the last figure quoted except when otherwise stated (in brackets). The reader should consult the original literature for an estimate of errors for the values quoted as the best measurement from a single natural source, but he should be aware that in certain cases the values for the abundances have been adjusted to satisfy the constraint that the sum of the individual compositions be equal to 100 percent. The reader should be aware that for certain elements (B, Li, U, H, N, and the noble gases) samples are commonly found which differ significantly from the compositions recommended for average properties.

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
1	H	1	99.9915 - 99.9770	R,G	99.984426 (C)	70HAG1	IAEA-V-SMOW	99.985
		2	0.0230 - 0.0085		0.015574		IAEA-SLAP	0.015
							C.E.A.	
2	He	3	0.0041 - 5×10^{-7}	R,G	0.000139	76CLA1	AIR	0.00014
		4	100 - 99.9959		99.999861			99.99986
3	Li	6	8.251 - 7.30	R	7.6809 (C)	73FLE1	NBS-RS LSVEC	7.5
		7	92.61 - 91.749		92.3191			92.5
4	Be	9	---		100			100
5	B	10	20.306 - 19.098	R	19.824 (C)	69BIE1	NBS-SRM 951,	20.0 (.2)
		11	80.902 - 79.694		80.176		EEC-GEEL	80.0 (.2)

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
6	C	12	98.99 - 98.86	R	98.889	57CRA1	NBS-RS 20	98.89
		13	1.14 - 1.01		1.111			1.11
7	N	14	99.650 - 99.625	R	99.634 (C)	58JUN1	AIR	99.63
		15	0.375 - 0.350		0.366		NBS-RS NSVEC	0.37
8	O	16	99.777 - 99.7539	R	99.7628 (C)	76BAE1	NBS-RS 20	99.76
		17	0.0407 - 0.035		0.0372		IAEA-V-SMOW,	0.04
		18	0.2094 - 0.188		0.2000		SLAP	0.20
9	F	19	---		100			100
10	Ne	20	90.514 - 88.47	R	90.514 (C)	66WAL1	AIR	90.51
		21	1.71 - 0.266		0.266			0.27
		22	9.96 - 9.20		9.220			9.22
11	Na	23	---		100			100
12	Mg	24	---	I	78.992 (C)	66CAT1	NBS-SRM 980	78.99
		25			10.003			10.00
		26			11.005			11.01
13	Al	27	---		100			100
14	Si	28	92.41 - 92.14	R	92.229 (C)	75BAR1	NBS-SRM 990	92.23
		29	4.73 - 4.57		4.670			4.67
		30	3.14 - 3.01		3.101			3.10
15	P	31	---		100			100
16	S	32	95.253 - 94.638	R	95.018	50MAC1	TROILITE	95.02
		33	0.780 - 0.731		0.750			0.75
		34	4.562 - 4.001		4.215			4.21
		36	0.0199 - 0.0153		0.017			0.02

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
17	Cl	35	---	I	75.7705 (C)	62SHI2	NBS-SRM 975	75.77 (.05)
		37			24.2295			24.23 (.05)
18	Ar	36	---	G,I	0.337 (C)	50NIE1	AIR	0.34
		38			0.063			0.06
		40			99.600			99.60
19	K	39	---	I	93.25811 (C)	75GAR1	NBS-SRM 985	93.2581
		40			0.01167			0.0117
		41			6.73022			6.7302
20	Ca	40	---	G,I	96.941	72MOO1	NBS-SRM 915	96.941 (.002)
		42			0.647			0.647 (.002)
		43			0.135			0.135 (.002)
		44			2.086			2.086 (.002)
		46			0.004			0.004 (.002)
		48			0.187			0.187 (.002)
21	Sc	45	---		100			100
22	Ti	46	8.24 - 7.99	D	8.24	68BEL1		8.1
		47	7.44 - 7.29		7.44			7.4
		48	73.99 - 73.71		73.71			73.8
		49	5.46 - 5.38		5.43			5.4
		50	5.35 - 5.18		5.18			5.3
23	V	50	---	G,I	0.2497 (C)	63SVE1		0.250
		51	---		99.7503			99.750
24	Cr	50	4.357 - 4.3452	D	4.3452 (C)	66SHI1	NBS-SRM 979	4.35
		52	83.7895 - 83.760		83.7895			83.79
		53	9.508 - 9.5006		9.5006			9.50
		54	2.375 - 2.3647		2.3647			2.36
25	Mn	55	---		100			100

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
26	Fe	54	6.04 - 5.77	D	5.81	47VAL1		5.8
		56	91.79 - 91.52		91.75			91.8
		57	2.25 - 2.11		2.15			2.1
		58	0.34 - 0.28		0.29			0.3
27	Co	59	---		100			100
28	Ni	58	68.274 - 67.76	D	68.274	73BAR1		68.27
		60	26.424 - 26.095		26.095			26.10
		61	1.25 - 1.134		1.134			1.13
		62	3.711 - 3.593		3.593			3.59
		64	1.16 - 0.904		0.904			0.91
29	Cu	63	69.24 - 68.98	R	69.174 (C)	64SHI1	NBS-SRM 976	69.17 (.02)
		65	31.02 - 30.76		30.826			30.83 (.02)
30	Zn	64	48.9 - 48.6	D	48.63	72ROS1		48.6
		66	27.9 - 27.6		27.90			27.9
		67	4.17 - 4.07		4.10			4.1
		68	18.75 - 18.48		18.75			18.8
		70	0.69 - 0.62		0.62			0.6
31	Ga	69	60.5 - 59.988	D	60.08 (C)	76LAE1		60.1
		71	40.012 - 39.5		39.92			39.9
32	Ge	70	21.11 - 20.38	D	20.52	53REY1		20.5 (.3)
		72	27.67 - 27.37		27.43			27.4 (.3)
		73	7.86 - 7.62		7.76			7.8 (.1)
		74	36.74 - 36.09		36.53			36.5 (.3)
		76	7.82 - 7.45		7.76			7.8 (.1)
33	As	75	---		100			100

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
34	Se	74	0.888 - 0.877	R*	0.88	48WHI1		0.9
		76	9.002 - 8.932		8.95			9.0
		77	7.680 - 7.640		7.65			7.6
		78	23.560 - 23.497		23.51			23.5
		80	49.538 - 49.655		49.62			49.6
		82	9.331 - 9.399		9.39			9.4
35	Br	79	---	I	50.686 (C)	64CAT1	NBS-SRM 977	50.69 (.05)
		81			49.314			49.31 (.05)
36	Kr	78	0.36 - 0.341	G,D	0.36	73WAL1	AIR	0.35
		80	2.29 - 2.223		2.27			2.25
		82	11.58 - 11.49		11.56			11.6
		83	11.55 - 11.44		11.49			11.5
		84	57.14 - 56.90		56.99			57.0
		86	17.44 - 17.24		17.33			17.3
37	Rb	85	72.24 - 72.14	G,D	72.1654 (C)	69CAT1	NBS-SRM 984	72.17
		87	27.86 - 27.76		27.8346			27.83
38	Sr	84	0.58 - 0.55	G,R	0.5572	73MOO1	NBS-SRM's 987, 988, 607	0.5
		86	9.99 - 9.75		9.8601			9.9
		87	7.14 - 6.94		7.0021			7.0
		88	82.75 - 82.29		82.5806			82.6
39	Y	89	---		100			100
40	Zr	90	51.7 - 51.12	D,G	51.46	48WHI1		51.5
		91	11.23 - 10.8		11.23			11.2
		92	17.4 - 17.1		17.11			17.1
		94	17.57 - 17.38		17.40			17.4
		96	2.9 - 2.79		2.80			2.8

* A range has been established which is smaller than that reported in the literature.

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
41	Nb	93	---		100			100
42	Mo	92	15.05 - 14.74	D,G	14.8362	74MOO1		14.84
		94	9.35 - 9.11		9.2466			9.25
		95	15.93 - 15.78		15.9201			15.92
		96	16.71 - 16.56		16.6756			16.68
		97	9.6 - 9.48		9.5551			9.55
		98	24.42 - 24.00		24.1329			24.13
		100	9.63 - 9.60		9.6335			9.63
43	Tc	--	---		---			---
44	Ru	96	5.57 - 5.46	D,G	5.52	76DEV1		5.5
		98	1.91 - 1.84		1.86			1.9
		99	12.77 - 12.7		12.74			12.7
		100	12.69 - 12.56		12.60			12.6
		101	17.1 - 17.01		17.05			17.0
		102	31.7 - 31.52		31.57			31.6
		104	18.67 - 18.5		18.66			18.7
45	Rh	103	---		100			100
46	Pd	102	1.02 - 0.96	D,G	0.96	53SIT1		1.0
		104	11.06 - 10.97		10.97			11.0
		105	22.23 - 21.82		22.23			22.2
		106	27.66 - 27.33		27.33			27.3
		108	27.24 - 26.71		26.71			26.7
		110	12.20 - 11.81		11.81			11.8
47	Ag	107	---	I	51.830 (C)	62SHI1	NBS-SRM 978	51.83 (.03)
		109			48.170			48.17 (.03)

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
48	Cd	106	1.25 - 1.215	D,G	1.25	75ROS1		1.3
		108	0.98 - 0.871		0.90			0.9
		110	12.51 - 12.32		12.51			12.5
		111	12.86 - 12.67		12.81			12.8
		112	24.15 - 23.79		24.13			24.1
		113	12.34 - 12.21		12.22			12.2
		114	28.93 - 28.71		28.71			28.7
		116	7.66 - 7.47		7.47			7.5
49	In	113	4.33 - 4.16	D,G	4.33	56WHI1		4.3
		115	95.84 - 95.67		95.67			95.7
50	Sn	112	1.017 - 0.90	D,G	1.011	65LAE1		1.0
		114	0.681 - 0.61		0.670			0.7
		115	0.376 - 0.33		0.376			0.4
		116	14.78 - 14.07		14.760			14.7
		117	7.767 - 7.51		7.746			7.7
		118	24.31 - 23.84		24.300			24.3
		119	8.68 - 8.45		8.555			8.6
		120	33.11 - 32.34		32.382			32.4
		122	4.78 - 4.559		4.559			4.6
		124	6.11 - 5.626		5.641			5.6
51	Sb	121	---	X	57.25	48WHI1		57.3
		123			42.75			42.7
52	Te	120	0.091 - 0.088	D,G	0.09	48WHI1		0.1
		122	2.49 - 2.43		2.49			2.5
		123	0.89 - 0.85		0.89			0.9
		124	4.74 - 4.59		4.63			4.6
		125	7.03 - 6.97		7.01			7.0
		126	18.72 - 18.70		18.72			18.7
		128	31.85 - 31.72		31.72			31.7
		130	34.51 - 34.27		34.45			34.5

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
53	I	127	---		100			100
54	Xe	124	0.102 - 0.095	D,G	0.10	50NIE2	AIR	0.1
		126	0.098 - 0.088		0.09			0.1
		128	1.93 - 1.91		1.92			1.9
		129	26.51 - 26.24		26.44			26.4
		130	4.07 - 3.68		4.07			4.1
		131	21.24 - 21.04		21.18			21.2
		132	27.12 - 26.88		26.89			26.9
		134	10.54 - 10.43		10.44			10.4
		136	8.98 - 8.87		8.87			8.9
55	Cs	133	---		100			100
56	Ba	130	0.106 - 0.098	D,G	0.106	69EUG1		0.1
		132	0.1017 - 0.091		0.101			0.1
		134	2.42 - 2.33		2.417			2.4
		135	6.605 - 6.42		6.592			6.6
		136	7.87 - 7.77		7.853			7.9
		137	11.32 - 11.13		11.232			11.2
		138	72.11 - 71.66		71.699			71.7
57	La	138	**	G	0.089	56WHI1		0.09
		139			99.911	47ING2		99.91
58	Ce	136	0.195 - 0.190	D,G	0.190	62UME1		0.2
		138	0.265 - 0.250		0.254			0.3
		140	88.48 - 88.449		88.475			88.4
		142	11.098 - 11.07		11.081			11.1
59	Pr	141	---		100			100

** Only two measurements are available, and they give identical values.

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
60	Nd	142	27.3 - 26.80	D,G	27.157	74BAR1		27.16
		143	12.32 - 12.12		12.177	76NAK1		12.18
		144	23.97 - 23.795		23.795			23.80
		145	8.35 - 8.23		8.293			8.29
		146	17.35 - 17.06		17.188			17.19
		148	5.78 - 5.66		5.755			5.75
		150	5.69 - 5.53		5.635			5.63
61	Pm		---		---			---
62	Sm	144	3.16 - 2.87	D,G	3.12	75LUG1		3.1
		147	15.10 - 14.87		15.10			15.1
		148	11.35 - 11.22		11.30			11.3
		149	13.96 - 13.82		13.86			13.9
		150	7.47 - 7.36		7.38			7.4
		152	26.90 - 26.55		26.65			26.6
		154	22.88 - 22.43		22.59			22.6
63	Eu	151	47.86 - 47.75	D,G	47.86	57COL1		47.9
		153	52.25 - 52.14		52.14			52.1
64	Gd	152	0.205 - 0.20	D,G	0.20	48HES1		0.2
		154	2.23 - 2.1		2.15			2.1
		155	15.1 - 14.68		14.78			14.8
		156	20.67 - 20.36		20.59			20.6
		157	15.73 - 15.64		15.71			15.7
		158	24.96 - 24.5		24.78			24.8
		160	22.01 - 21.6		21.79			21.8
65	Tb	159	---		100			100
66	Dy	156	0.064 - 0.0524	D,G	0.06	57COL1		0.06
		158	0.105 - 0.0902		0.10			0.10
		160	2.36 - 2.294		2.34			2.34
		161	19.0 - 18.73		19.0			19.0
		162	25.53 - 25.36		25.5			25.5
		163	24.97 - 24.9		24.9			24.9
		164	28.47 - 28.1		28.1			28.1

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
67	Ho	165	---		100			100
68	Er	162	0.154 - 0.136	D,G	0.14	50HAY1		0.1
		164	1.60 - 1.56		1.56			1.6
		166	33.41 - 33.36		33.41			33.4
		167	22.94 - 22.82		22.94			22.9
		168	27.07 - 27.02		27.07			27.1
		170	15.04 - 14.88		14.88			14.9
69	Tm	169	---		100			100
70	Yb	168	0.140 - 0.130	D,G	0.15	57COL1		0.1
		170	3.14 - 3.03		3.15			3.1
		171	14.4 - 14.27		14.4			14.4
		172	21.9 - 21.77		21.9			21.9
		173	16.2 - 16.08		16.2			16.2
		174	31.91 - 31.6		31.6			31.7
		176	12.80 - 12.6		12.6			12.6
71	Lu	175	97.412 - 97.393	D,G	97.393	76MCC1		97.39
		176	2.607 - 2.588		2.607			2.61
72	Hf	174	0.199 - 0.163	D	0.16	56WHI1		0.2
		176	5.23 - 5.15		5.21			5.2
		177	18.56 - 18.39		18.56			18.6
		178	27.23 - 27.08		27.10			27.1
		179	13.78 - 13.73		13.75			13.7
		180	35.44 - 35.07		35.22			35.2
73	Ta	180	0.0123 - 0.0117	D	0.0123	56WHI1		0.012
		181	99.9883 - 99.9877		99.9877			99.988
74	W	180	0.16 - 0.126	D	0.13	48WHI1		0.1
		182	26.41 - 26.09		26.31			26.3
		183	14.43 - 14.24		14.28			14.3
		184	30.68 - 30.63		30.64			30.7
		186	28.85 - 28.38		28.64			28.6

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
75	Re	185	---	I	37.398 (C)	73GRA1	NBS-SRM 989	37.40
		187			62.602			62.60
76	Os	184	0.018 - 0.018	D,G	0.02	37NIE1		0.02
		186	1.67 - 1.59		1.59			1.58 (.10)
		187	1.67 - 1.60		1.64			1.6
		188	13.27 - 13.15		13.27			13.3
		189	16.21 - 16.08		16.14			16.1
		190	26.42 - 26.15		26.38			26.4
		192	41.21 - 40.96		40.96			41.0
77	Ir	191	---	X	37.3	54BAL1		37.3 (.2)
		193			62.7			62.7 (.2)
78	Pt	190	0.0127 - 0.0127	D	0.01***	56WHI1		0.01
		192	0.78 - 0.78		0.79			0.79
		194	32.9 - 32.8		32.9			32.9
		195	33.8 - 33.7		33.8			33.8
		196	25.4 - 25.2		25.3			25.3
		198	7.23 - 7.19		7.2			7.2
79	Au	197	---		100			100
80	Hg	196	0.16 - 0.147	D	0.15	55DIB1		0.2
		198	10.12 - 10.02		10.12			10.1
		199	17.01 - 16.83		16.98			17.0
		200	23.21 - 23.07		23.07			23.1
		201	13.27 - 13.12		13.26			13.2
		202	29.81 - 29.64		29.64			29.6
		204	6.85 - 6.69		6.78			6.8

*** A more precise measurement for ^{190}Pt is reported in the original reference.

Atomic Number	Element	Mass Number	Evaluated Range of Published Values	Notes	Best Measurement from a Single Natural Source	Reference (Appendix A)	Available Reference Materials (Appendix B)	Interim Isotopic Composition for Average Elemental Properties
81	Tl	203	30.07 - 29.08	D	29.46	48WHI1		29.5
		205	70.92 - 69.93		70.54			70.5
82	Pb	204	1.65 - 1.04	R,G	1.4245 (C)	68CAT1	NBS-SRM 981	1.4
		206	27.48 - 20.84		24.1447			24.1
		207	23.65 - 17.62		22.0827			22.1
		208	56.21 - 51.28		52.3481			52.4
83	Bi	209	---		100			100
84	Po	---	---					---
85	At	---	---					---
86	Rn	---	---					---
87	Fr	---	---					---
88	Ra	---	---					---
89	Ac	---	---					---
90	Th	232	---		100			100
91	Pa	---	---					---
92	U	234	0.0059 - 0.0050	R,G*	0.0054 (C)		NBS-SRM's	0.005
		235	0.7246 - 0.7131		0.7200	71GAR1	U0002-U970	0.720
		238	99.2818 - 99.2699		99.2746		C.E.A.	99.275
93	Np	237	---					---

* **A range has been established which is smaller than that reported in the literature.**

Appendix A

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Appendix B

Sources of Reference Materials

I.A.E.A.

Samples such as V-SMOW, SLAP, and SLAC may be obtained from:

International Atomic Energy Agency
Section of Hydrology
A-1011 Vienna, Kaerntnerring, (Austria)

TROILITE

Canon Diablo Troilite may be obtained from:

Mr. Glenn I. Huss
Director, American Meteorite Laboratory
P.O. Box 2098
Denver, Colorado 80201 (U.S.A.)

NBS-SRM's

NBS Standard Reference Materials may be purchased through:

Office of Standard Reference Materials
National Bureau of Standards
B311 Chemistry Building
Washington, D. C. 20234 (U.S.A.)

EEC-GEEL

Standards may be obtained through:

Dr. Paul De Bievre
Central Bureau for Nuclear Measurements
European Economic Community
B-2440 Geel, (Belgium)

NBS-RS (Reference Samples)

Samples may be obtained through:

Chief, Analytical Spectrometry Section
National Bureau of Standards
A25 Physics Building
Washington, D. C. 20234 (U.S.A.)

NOTE: Samples of N and Li previously available from Professor H. J. Svec have been sent to NBS for distribution.

C.E.A.

Standards may be obtained through:

Bureau Des Isotopes Stables
Centre d'Etudes de Saclay
B.P. n°2 - 91190 Gif-sur-Yvette (France)

converted to atomic weights will not always be fully consistent with the 1977 Table of Atomic Weights. Discrepancies are most noticeable in the cases of nickel, zinc, germanium, and selenium where the interim values lie outside the limit of uncertainty on the recommended atomic weight. For germanium, this corresponds to a difference of 0.06%.
For the 1979 meeting of the Commission, SAIC has been asked to include uncertainties on all isotopic compositions quoted and while selecting the recommended values to look into the problem of harmonizing atomic weights calculated from them and the IUPAC adopted atomic weights.
Present members of SAIC are P. De Bièvre (Chairman), I.L. Barnes, A.E. Cameron, R. Hagemann, N.E. Holden and H. Thode.

RELATIVE ATOMIC MASSES AND HALF-LIVES OF SELECTED RADIONUCLIDES

For many years the Commission on Atomic Weights has included in its Reports tables of relative atomic masses of selected nuclides and half-lives of some radionuclides, although it has no prime responsibility for the dissemination of such values. No attempt has, therefore, been made to state these values at the best precision possible or to make them any more complete than is needed to enable users to calculate the atomic weights of materials of abnormal or changing isotopic composition. In future years the Commission intends to tabulate the relative atomic masses within the isotopic composition tables. In this year's Table of relative atomic masses of selected radionuclides (Table 4) the values are those recommended by A.H. Wapstra (Ref. 10) and the half-lives were provided by N.E. Holden (Ref. 17).

NON-TERRESTRIAL DATA

Data on atomic weights and isotopic compositions of non-terrestrial material were presented to the Commission. The Commission has decided to undertake a continuing review of such data and in the future to present such data in a Table similar in format to Table 3.

OTHER PROJECTS

The Commission contemplates issuing a four or five place table of atomic weights in order to provide practicing chemists with all the necessary data but no more, and to avoid at the same time quoting uncertainties that do not affect everyday use of the data.
The four and five place values will change very infrequently, if at all, compared to the definitive table. In addition, the Commission will continue to publish the definitive Table of Atomic Weights biennially, and plans to unify, as far as possible, the footnotes in all tables to simplify their understanding.

TABLE 4. Relative Atomic Masses and Half-Lives of Selected Radionuclides

Name	Symbol	Atomic number	Mass number	Relative atomic mass	Half-life	+
Technetium	Tc	43	97	96.906	2.6×10^6	a
			98	97.907	4.2×10^6	a
			99	98.906	2.13×10^5	a
Promethium	Pm	61	145	144.913	18.	a
			147	146.915	2.62	a
Polonium	Po	84	208	207.981	2.90	a
			209	208.982	102.	a
			210	209.983	138.38	d
Astatine	At	85	209	208.986	5.4	h
			210	209.987	8.1	h
			211	210.987	7.21	h
Radon	Rn	86	211	210.991	14.6	h
			222	222.018	3.824	d
Francium	Fr	87	212	211.996	19.3	m
			222	222.018	15.	m
			223	223.020	22.	m
Radium	Ra	88	226	226.025	1600.	a
			228	228.031	5.75	a
Actinium	Ac	89	225	225.023	10.0	d
			227	227.028	21.77	a

TABLE 4. Relative Atomic Masses and Half-Lives of Selected Radionuclides (Cont'd)

Name	Symbol	Atomic number	Mass number	Relative atomic mass	Half-life	+
Thorium	Th	90	230	230.033	$7.7x10^4$	a
			232	232.038	$1.40x10^{10}$	a
Protactinium	Pa	91	230	230.035	17.4	d
			231	231.036	$3.28x10^4$	a
			233	233.040	27.0	d
Uranium	U	92	233	233.040	$1.59x10^5$	a
			234	234.041	$2.44x10^5$	a
			235	235.044	$7.04x10^8$	a
			236	236.046	$2.34x10^7$	a
			238	238.051	$4.47x10^9$	a
Neptunium	Np	93	236	236.047	$1.1x10^5$	a
			237	237.048	$2.14x10^6$	a
Plutonium	Pu	94	238	238.050	87.7	a
			239	239.052	$2.41x10^4$	a
			240	240.054	$6.54x10^3$	a
			241	241.057	14.7	a
			242	242.059	$3.8x10^5$	a
			244	244.064	$8.3x10^7$	a
Americium	Am	95	241	241.057	$4.32x10^2$	a
			243	243.061	$7.37x10^3$	a
Curium	Cm	96	242	242.059	163.	d
			243	243.061	28.5	a
			244	244.063	18.1	a
			245	245.065	$8.5x10^3$	a
			246	246.067	$4.7x10^3$	d
			247	247.070	$1.55x10^7$	a
			248	248.072	$3.5x10^5$	a
			250	250.078	$8.x10^3$	a
Berkelium	Bk	97	247	247.070	$1.4x10^3$	a
			249	249.075	$3.2x10^2$	d
Californium	Cf	98	248	248.072	334.	d
			249	249.075	$3.51x10^2$	a
			251	251.080	$9.0x10^2$	a
			252	252.082	2.64	a
			254	254.087	6.x10	d
Einsteinium	Es	99	252	252.083	472.	d
			253	253.085	20.47	d
			254	254.088	276.	d
Fermium	Fm	100	255	255.090	20.1	h
			257	257.095	100.5	d

+a=year; d=day; h=hour; m=minute.

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Footnote from page 413

Although this change of definition has been agreed in basic concept, the exact wording which will finally be endorsed by IUPAC is still under discussion.