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INORGANIC CHEMISTRY DIVISION
COMMISSION ON ATOMIC WEIGHTS AND ISOTOPIC ABUNDANCES*
SUBCOMMITTEE FOR ISOTOPIC ABUNDANCE MEASUREMENTS†

ISOTOPIC COMPOSITIONS OF
THE ELEMENTS
1989

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‡ died January 1990

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Isotopic compositions of the elements 1989*

ABSTRACT- The Commission's biennial review of isotopic compositions, as determined by mass spectrometry and other relevant methods, has been undertaken by the Subcommittee for the Isotopic Composition of the Elements (SIAM). The Subcommittee's critical evaluation of the published literature element by element forms the basis of the Table of Isotopic Compositions of the Elements as Determined by Mass Spectrometry 1989, which is presented in this Report. Atomic Weights calculated from the tabulated isotopic abundances are consistent with $A_r(E)$ values listed in the Table of Standard Atomic Weights 1989.

INTRODUCTION

The "Table of Isotopic Compositions of the Elements as Determined by Mass Spectrometry 1983", published in 1984 (Ref. 1), was the culmination of a 10 year effort by the Commission on Atomic Weights and Isotopic Abundances (CAWIA) to assemble a set of abundances yielding atomic weights consistent with the Commission's "Table of Standard Atomic Weights 1983" (Ref. 2, 3, 4).

The Commission, through its Subcommittee for Isotopic Abundance Measurements (SIAM), has continued to assemble and evaluate new data which has led to changes in the representative isotopic compositions of nine chemical elements. Also in 1984 the statistical guidelines for assigning uncertainties to the representative abundances were re-examined by the Commission's Working Party on Statistics for Atomic Weights which led to changes in the uncertainties on some representative isotopic compositions.

At the 35th IUPAC General Assembly in Lund in 1989 the Commission therefore decided to publish an updated table incorporating these changes as a companion paper to the Report on the Atomic Weights of the Elements 1989. The present paper is the result of this decision.

Members of SIAM from 1987 to 1989 were I.L. Barnes (Chairman), T.L. Chang, T.B. Coplen, P. De Bièvre, J.W. Gramlich, J. Ch. R. Hagemann, N.E. Holden, T.J. Murphy, K.J.R. Rosman and M. Shima.

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4. N.E. Holden, R.L. Martin and I.L. Barnes, Isotopic Compositions of the Elements 1981, *Pure and Appl. Chem.*, **55**, 1119-1136 (1983).

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

Introduction

The Subcommittee for Isotopic Abundance Measurements (SIAM) has examined all of the literature available to it through July 1989. The Subcommittee has evaluated these data to produce a table of recommended isotopic abundances for the elements. The table is intended to include values for normal terrestrial samples only and does not include values published for meteoritic or other extra-terrestrial materials.

*The Commission dedicates this report to Dr I. Lynus Barnes who died in January, 1990. Dr Barnes was an associate and titular member of the Commission for 14 years, Secretary of the Subcommittee on the Assessment of the Isotopic Compositions of the Elements (SAIC) from 1975 to 1983, and Chairman of the Commission's Subcommittee for Isotopic Abundance Measurements (SIAM) from 1983 to 1989.

Description of the contents of each of the Columns

Column 1: The elements are tabulated in ascending order of their atomic numbers.

Column 2: The names of the elements are listed using the abbreviations recommended by IUPAC.

Column 3: The mass number for each isotope is listed.

Column 4: Evaluated limits of published values

Given are the highest and lowest abundances published for each isotope from measurements which have been evaluated and accepted by the Subcommittee. The limits given include known natural variations and published data which may exceed those variations. No data are given in this Column when the absence of a range has been reliably established. The limits given do not include certain exceptional samples, these are noted with a "g" in Column 5.

Column 5: Annotations

The letters appended in this Column have the following significance:

- g geologically exceptional specimens are known in which the element has an isotopic composition outside the limits of reported values.
- m modified isotopic compositions may be found in commercially available material because it has been subjected to an undisclosed or inadvertent isotopic separation. Substantial deviations from the isotopic compositions given can occur.
- r range in isotopic composition in normal terrestrial material is responsible for part, or all, of the difference between limits of reported values.

Column 6: The best measurement from a single terrestrial source.

The values are reproduced from the original literature. The uncertainties on the last digits are given in parenthesis as reported in the original publication. As they are not reported in any uniform manner in the literature, SIAM indicates this as follows: 1, 2, 3s indicates 1, 2, or 3 standard deviations, P indicates some other error as defined by the author, and se (standard deviation of the mean) indicates standard error. Where no errors are listed, none were given by the author. "C" is appended when the measurement has been calibrated and is thus believed to be "absolute" within the errors stated in the original publication. "D" is appended when the data have been corrected for fractionation by the use of the "double spike" technique.

The user is cautioned that:

- a) Since the data are reproduced from the literature, the sum of the isotopic abundances may not equal 100 percent.
- b) When a range of compositions has been established, the samples used for the best measurement may come from any part of the range.
- c) A "Best Measurement" is not necessarily a good one in SIAM's opinion.

Column 7: The reference shown is that from which the data shown in column 6 was taken.

The complete citation is given in Appendix A.

Column 8: Reference materials or samples which are known to be available and which relate to the best measurement are listed. An asterisk indicates the reference material used for the best measurement. Additional information is given in Appendix B.

Column 9: Representative isotopic composition.

In this Column are listed the values for the isotopic composition of the elements which, in the opinion of SIAM, will include the chemicals and/or materials most commonly encountered in the laboratory. They may not, therefore correspond to the most abundant natural material. For example, in the case of hydrogen, the deuterium abundance quoted corresponds to that in fresh water in temperate climates rather than to ocean water. The uncertainties listed in parenthesis cover the range of probable variations of the materials as well as experimental errors. Uncertainties quoted are from one to nine in the last digit except for a few cases where rounded values would be outside of the observed range. In those cases uncertainties greater than nine have been used.

Warning

- 1) Representative isotopic composition should be used to evaluate average properties of material of unspecified natural terrestrial origin, though no actual sample having the exact composition listed may be available.
- 2) When precise work is undertaken, such as assessment of individual properties, samples with more precisely known isotopic abundances (such as those listed in Column 8) should be obtained or suitable measurements should be made.

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

Atomic Number 1	Element 2	Mass Number 3	Evaluated Limits of Published Values (Atom %) 4	Annotations 5	Best Measurement from a Single Natural Source (Atom %) 6	Reference (Appendix A) 7	Available Reference Materials (Appendix B) 8	Representative Isotopic Composition (Atom %) 9
1	H	1 2	99.9918 - 99.9816 0.0184 - 0.0082	r,g m	99.984426 (5) 2s C 0.015574 (5)	70HAG1	IAEA VSMOW* IAEA SLAP C.E.A.	99.985 (1) ^a 0.015 (1) (for water only)
2	He	3 4	0.0041 - 4.6x10 ⁻⁸ 100 - 99.9959	r,g	0.0001343 (13) 2s 99.9998657 (13)	88SAN1	Air*	0.000137 (3) 99.999863 (3) (for air only)
3	Li	6 7	7.68 - 7.30 92.70 - 92.32	r,g m	7.525 (29) 2s C 92.475 (29)	83MIC1	NIST-RS LSVEC CBNM-GEEL 016*	7.5 (2) ^b 92.5 (2)
4	Be	9	—		100	63LEI1		100
5	B	10 11	20.316 - 19.098 80.902 - 79.684	r,m g	19.82 (2) 2s C 80.18 (2)	69BIE1	CBNM-GEEL 011* NIST-SRM 951	19.9 (2) 80.1 (2)
6	C	12 13	98.99 - 98.86 1.15 - 1.01	r,g	98.889 (3) P 1.111 (3)	57CRA1	NIST-RS 20*	98.90 (3) 1.10 (3)
7	N	14 15	99.651 - 99.622 0.378 - 0.349	r,g	99.6337 (4) C 0.3663 (4)	58JUN1	Air NIST-RS NSVEC*	99.634 (9) 0.366 (9)
8	O	16 17 18	99.7771 - 99.7539 0.0407 - 0.035 0.2084 - 0.1879	r	99.7628 (5) 1s 0.0372 (4) 0.20004 (5)	76BAE1	NIST-RS 20 IAEA VSMOW*, IAEA SLAP	99.762 (15) 0.038 (3) ^c 0.200 (12)
9	F	19	—		100	20AST1		100
10	Ne	20 21 22	90.514 - 88.47 1.71 - 0.266 9.96 - 9.20	r,g m	90.484 (9) 1s C 0.270 (1) 9.246 (9)	84BOT1	Air*	90.48 (3) 0.27 (1) 9.25 (3) (for air only)
11	Na	23			100	56WHI1		100
12	Mg	24 25 26	—		78.992 (25) 2s C 10.003 (9) 11.005 (19)	66CAT1	NIST-SRM 980*	78.99 (3) 10.00 (1) 11.01 (2)
13	Al	27			100	56WHI1		100
14	Si	28 29 30	92.41 - 92.14 4.73 - 4.57 3.14 - 3.01	r	92.22933 (155) 2s C 4.66982 (124) 3.10085 (74)	75BAR1	NIST-SRM 990*	92.23 (1) 4.67 (1) 3.10 (1)
15	P	31			100	63LEI1		100
16	S	32 33 34 36	95.253 - 94.638 0.780 - 0.731 4.562 - 4.001 0.0199 - 0.0153	r,g	95.018 (4) P 0.750 (7) 4.215 (4) 0.017 (2)	50MAC1	IAEA C.E.A.	95.02 (9) 0.75 (4) 4.21 (8) 0.02 (1)
17	Cl	35 37	75.872 - 75.72 24.28 - 24.128	m	75.771 (45) 2s C 24.229 (45)	62SHI1	NIST-SRM 975*	75.77 (7) 24.23 (7)
18	Ar	36 38 40		g	0.3365 (6) P C 0.0632 (1) 99.6003 (6)	50NIE1	Air*	0.337 (3) 0.063 (1) 99.600 (3) (for air only)
19	K	39 40 41			93.25811 (292) 2s C 0.011672 (41) 6.73022 (292)	75GAR1	NIST-SRM 985*	93.2581 (44) 0.0117 (1) 6.7302 (44)

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20	Ca	40	96.98213- 96.88	r,g	96.941 (6) 2s	72MOO1	NIST-SRM 915*	96.941 (18)
		42	0.6562 - 0.640		0.647 (3)			0.647 (9)
		43	0.1457 - 0.1312		0.135 (2)			0.135 (6)
		44	2.13 - 2.05675		2.086 (4)			2.086 (12)
		46	0.0046 - 0.00313		0.004 (1)			0.004 (3)
		48	0.200 - 0.179		0.187 (1)			0.187 (4)
21	Sc	45	—		100	50LEL1		100
22	Ti	46	—		8.0124 (1) 2s	81NIE1		8.0 (1)
		47			7.3309 (3)		7.3 (1)	
		48			73.8145 (4)		73.8 (1)	
		49			5.4964 (3)		5.5 (1)	
		50			5.3458 (3)			5.4 (1)
23	V	50	—	g	0.2497 (6) se C	66FLE1		0.250 (2)
		51			99.7503 (6)		99.750 (2)	
24	Cr	50	—		4.3452 (85) 2s C	66SHI1	NIST-SRM 979*	4.345 (13)
		52			83.7895 (117)			83.789 (18)
		53			9.5006 (110)			9.501 (17)
		54			2.3647 (48)			2.365 (7)
25	Mn	55	—		100	63LEI1		100
26	Fe	54	6.04 - 5.77		5.81	47VAL1		5.8 (1)
		56	91.79 - 91.52		91.75		91.72 (30)	
		57	2.25 - 2.11		2.15		2.2 (1)	
		58	0.34 - 0.28		0.29		0.28 (1)	
27	Co	59	—		100	63LEI1		100
28	Ni	58	—		68.0769 (59) 2s C	89GRA1		68.077 (9)
		60			26.2231 (51)		26.223 (8)	
		61			1.1399 (4)		1.140 (1)	
		62			3.6345 (11)		3.634 (2)	
		64			0.9256 (6)		0.926 (1)	
29	Cu	63	69.24 - 68.98	r	69.174 (20) 2s C	64SHI1	NIST-SRM 976*	69.17 (3)
		65	31.02 - 30.76		30.826 (20)			30.83 (3)
30	Zn	64	48.9 - 48.6		48.63 (13) 2s C	72ROS1		48.6 (3)
		66	27.9 - 27.6		27.90 (8)		27.9 (2)	
		67	4.17 - 4.07		4.10 (3)		4.1 (1)	
		68	18.75 - 18.48		18.75 (16)		18.8 (4)	
		70	0.69 - 0.62		0.62 (1)		0.6 (1)	
31	Ga	69	60.5 - 59.988	m	60.1079 (62) 2s C	86MAC1	NIST-SRM 994*	60.108 (9)
		71	40.012 - 39.5		39.8921 (62)			39.892 (9)
32	Ge	70	21.23 - 19.92		21.234 (12) 2se	86GRE1		21.23 (4)
		72	27.67 - 27.26		27.662 (11)		27.66 (3)	
		73	7.88 - 7.51		7.717 (2)		7.73 (1)	
		74	37.41 - 35.95		35.943 (8)		35.94 (2)	
		76	7.97 - 7.44		7.444 (5)		7.44 (2)	
33	As	75	—		100	63LEI1		100
34	Se	74	0.908 - 0.889	r	0.889 (3) 1s	89WAC1		0.89 (2)
		76	9.366 - 8.982		9.366 (18)		9.36 (11)	
		77	7.635 - 7.590		7.635 (10)		7.63 (6)	
		78	23.772 - 23.487		23.772 (20)		23.78 (9)	
		80	49.718 - 49.607		49.607 (17)		49.61 (10)	
		82	9.209 - 8.731		8.731 (10)		8.73 (6)	

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35	Br	79 81	—		50.686 (47) 49.314 (47)	2s C 64CAT1	NIST-SRM 977*	50.69 (7) 49.31 (7)
36	Kr	78 80 82 83 84 86	0.36 - 0.341 2.29 - 2.223 11.59 - 11.49 11.55 - 11.44 57.14 - 56.90 17.44 - 17.24	g,m	0.360 (4) 2.277 (4) 11.58 (1) 11.52 (1) 56.96 (1) 17.30 (1)	P 73WAL1	Air*	0.35 (2) 2.25 (2) 11.6 (1) 11.5 (1) 57.0 (3) 17.3 (2)
37	Rb	85 87	72.24 - 72.14 27.86 - 27.76	g	72.1654 (132) 27.8346 (132)	2s C 69CAT1	NIST-SRM 98	72.165 (20) 27.835 (20)
38	Sr	84 86 87 88	0.58 - 0.55 9.99 - 9.75 7.14 - 6.94 82.75 - 82.29	r,g	0.5574 (16) 9.8566 (34) 7.0015 (26) 82.5845 (66)	2s C 82MOO1	NIST-SRM's 98 988, 607	0.56 (1) 9.86 (1) 7.00 (1) ^e 82.58 (1)
39	Y	89	—		100	57COL1		100
40	Zr	90 91 92 94 96	51.7 - 51.12 11.32 - 10.8 17.4 - 17.1 17.57 - 17.283 2.9 - 2.759	g	51.452 (9) 11.223 (12) 17.146 (7) 17.380 (12) 2.799 (5)	2s 83NOM1		51.45 (3) 11.22 (4) 17.15 (2) 17.38 (4) 2.80 (2)
41	Nb	93	—		100	56WHI1		100
42	Mo	92 94 95 96 97 98 100	15.05 - 14.74 9.35 - 9.11 15.93 - 15.78 16.71 - 16.56 9.6 - 9.48 24.42 - 24.00 9.63 - 9.60	g	14.8362 (148) 9.2466 (92) 15.9201 (159) 16.6756 (167) 9.5551 (96) 24.1329 (241) 9.6335 (96)	2s 74MOO1		14.84 (4) 9.25 (3) 15.92 (5) 16.68 (5) 9.55 (3) 24.13 (7) 9.63 (3)
43	Tc	—		—		—		—
44	Ru	96 98 99 100 101 102 104	5.57 - 5.47 1.91 - 1.84 12.77 - 12.7 12.69 - 12.56 17.1 - 17.01 31.7 - 31.52 18.67 - 18.5	g	5.52 (1) 1.86 (1) 12.74 (2) 12.60 (2) 17.05 (1) 31.57 (3) 18.66 (3)	1s 76DEV1		5.52 (6) 1.88 (6) 12.7 (1) 12.6 (1) 17.0 (1) 31.6 (2) 18.7 (2)
45	Rh	103	—		100	63LEI1		100
46	Pd	102 104 105 106 108 110	1.021 - 0.99 11.14 - 10.97 22.33 - 22.18 27.33 - 27.25 26.69 - 26.46 11.91 - 11.72	g,r	1.020 (8) 11.14 (5) 22.33 (5) 27.33 (2) 26.46 (6) 11.72 (6)	2s C 78SHI1		1.02 (1) 11.14 (8) 22.33 (8) 27.33 (3) 26.46 (9) 11.72 (9)
47	Ag	107 109		g	51.8392 (51) 48.1608 (51)	2s C 82POW1	NIST-SRM 978*	51.839 (7) 48.161 (7)
48	Cd	106 108 110 111 112 113 114 116	—	g	1.25 (2) 0.89 (1) 12.49 (6) 12.80 (4) 24.13 (7) 12.22 (4) 28.73 (14) 7.49 (6)	2s D 80ROS1		1.25 (4) 0.89 (2) 12.49 (12) 12.80 (8) 24.13 (14) 12.22 (8) 28.73 (28) 7.49 (12)

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49	In	113	4.33 - 4.16	g	4.33 (4)	56WHI1		4.3 (2)	
		115	95.84 - 95.67		95.67 (4)			95.7 (2)	
50	Sn	112	1.017 - 0.90	g	0.973 (3)	1s C	83DEV1	0.97 (1)	
		114	0.681 - 0.61		0.652 (3)			84ROS1	0.65 (1)
		115	0.38 - 0.33		0.339 (3) ^d		0.34 (1)		
		116	14.78 - 14.07		14.537 (36)		14.53 (1)		
		117	7.767 - 7.51		7.676 (23)		7.68 (7)		
		118	24.31 - 23.84		24.225 (36)		24.23 (11)		
		119	8.68 - 8.45		8.586 (13)		8.59 (4)		
		120	33.11 - 32.34		32.595 (33)		32.59 (10)		
		122	4.78 - 4.559		4.629 (9)		4.63 (3)		
		124	6.11 - 5.626		5.789 (18)		5.79 (5)		
51	Sb	121	—	g	57.362 (26)	2s	88LAE1	57.36 (8)	
		123			42.638 (26)			42.64 (8)	
52	Te	120	—	g	0.0960 (7)	2s	78SMI1	0.096 (2)	
		122			2.603 (1)			2.603 (4)	
		123			0.908 (1)	0.908 (2)			
		124			4.816 (2)	4.816 (6)			
		125			7.139 (2)	7.139 (6)			
		126			18.952 (4)	18.95 (1)			
		128			31.687 (4)	31.69 (1)			
		130			33.799 (3)	33.80 (1)			
53	I	127	—		100		49LEL1	100	
54	Xe	124	0.102 - 0.095	g,m	0.096 (1)	P	50NIE2	Air*	0.10 (1)
		126	0.09 - 0.088		0.090 (1)				0.09 (1)
		128	1.93 - 1.91		1.919 (4)	1.91 (3)			
		129	26.51 - 26.24		26.44 (8)	26.4 (6)			
		130	4.08 - 3.68		4.08 (1)	4.1 (1)			
		131	21.24 - 21.04		21.18 (5)	21.2 (4)			
		132	27.12 - 26.88		26.89 (7)	26.9 (5)			
		134	10.54 - 10.43		10.44 (2)	10.4 (2)			
		136	8.98 - 8.87		8.87 (1)	8.9 (1)			
55	Cs	133	—		100		56WHI1	100	
56	Ba	130	—	g	0.1058 (2)	3se C	69EUG1	0.106 (2)	
		132			0.1012 (2)			0.101 (2)	
		134			2.417 (3)	2.417 (27)			
		135			6.592 (2)	6.592 (18)			
		136			7.853 (4)	7.854 (36)			
		137			11.232 (4)	11.23 (4)			
		138			71.699 (7)	71.70 (7)			
57	La	138	0.089 - 0.09016	g	0.09016 (5)	2s	87MAK1	0.0902 (2)	
		139	99.911 - 99.90980		99.90980 (5)			99.9098 (2)	
58	Ce	136	0.195 - 0.190	g	0.1904 (3)	2s	62UME1	0.19 (1)	
		138	0.265 - 0.250		0.2536 (4)			0.25 (1)	
		140	88.48 - 88.449		88.475 (8)	88.48 (10)			
		142	11.098 - 11.07		11.081 (7)	11.08 (10)			
59	Pr	141	—				57COL1	100	
60	Nd	142	27.3 - 26.80	g	27.16 (4)	2s	81HOL1	27.13 (12)	
		143	12.32 - 12.12		12.18 (2)			12.18 (6)	
		144	23.97 - 23.795		23.83 (4)	23.80 (12)			
		145	8.35 - 8.23		8.30 (2)	8.30 (6)			
		146	17.35 - 17.06		17.17 (3)	17.19 (9)			
		148	5.78 - 5.66		5.74 (1)	5.76 (3)			
		150	5.69 - 5.53		5.62 (1)	5.64 (3)			
61	Pm		—		—			—	

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62	Sm	144	3.16 - 2.87	g	3.076 (1) 2s	75LUG1		3.1 (1)
		147	15.10 - 14.87		14.995 (1)			15.0 (2)
		148	11.35 - 11.22		11.242 (1)			11.3 (1)
		149	13.96 - 13.82		13.819 (1)			13.8 (1)
		150	7.47 - 7.36		7.380 (1)			7.4 (1)
		152	26.90 - 26.55		26.738 (2)			26.7 (2)
		154	22.88 - 22.43		22.750 (1)			22.7 (2)
63	Eu	151	47.86 - 47.75	g	47.77 (25)	48HES1		47.8 (15)
		153	52.25 - 52.14		52.23 (25)			52.2 (15)
64	Gd	152	0.205 - 0.20	g	0.2029 (5) 1s	70EUG1		0.20 (1)
		154	2.23 - 2.1		2.1809 (6)			2.18 (3)
		155	15.1 - 14.68		14.800 (3)			14.80 (5)
		156	20.67 - 20.36		20.466 (2)			20.47 (4)
		157	15.73 - 15.64		15.652 (2)			15.65 (3)
		158	24.96 - 24.5		24.835 (4)			24.84 (12)
		160	22.01 - 21.6		21.863 (2)			21.86 (4)
65	Tb	159	—		100	57COL1		100
66	Dy	156	0.064 - 0.0524	g	0.056 (1) 2s	81HOL1		0.06 (1)
		158	0.105 - 0.0902		0.096 (2)			0.10 (1)
		160	2.36 - 2.294		2.34 (2)			2.34 (6)
		161	19.0 - 18.73		18.91 (5)			18.9 (2)
		162	25.53 - 25.36		25.51 (7)			25.5 (2)
		163	24.97 - 24.9		24.90 (7)			24.9 (2)
		164	28.47 - 28.1		28.19 (8)			28.2 (2)
67	Ho	165	—		100	57COL1		100
68	Er	162	0.154 - 0.136	g	0.137 (1) 2s	81HOL1		0.14 (1)
		164	1.61 - 1.56		1.609 (5)			1.61 (2)
		166	33.61 - 33.36		33.61 (7)			33.6 (2)
		167	22.94 - 22.82		22.93 (5)			22.95 (15)
		168	27.07 - 26.79		26.79 (7)			26.8 (2)
		170	15.04 - 14.88		14.93 (5)			14.9 (2)
69	Tm	169	—		100	57COL1		100
70	Yb	168	—	g	0.127 (2) 2s	81HOL1		0.13 (1)
		170			3.04 (2)			3.05 (6)
		171			14.28 (8)			14.3 (2)
		172			21.83 (10)			21.9 (3)
		173			16.13 (7)			16.12 (21)
		174			31.83 (14)			31.8 (4)
		176			12.76 (5)			12.7 (2)
71	Lu	175	—	g	97.416 (5) 2s	83PAT1		97.41 (2)
		176			2.584 (5)			2.59 (2)
72	Hf	174	0.199 - 0.163		0.1621 (9) 2se	83PAT1		0.162 (3)
		176	5.23 - 5.15		5.2056 (17)			5.206 (5)
		177	18.61 - 18.39		18.6060 (13)			18.606 (4)
		178	27.30 - 27.08		27.2969 (13)			27.297 (4)
		179	13.78 - 13.62		13.6289 (19)			13.629 (6)
		180	35.44 - 35.07		35.1005 (22)			35.100 (7)
73	Ta	180	0.0123 - 0.0117		0.0123 (3)	56WHI1		0.012 (2)
		181	99.9883 - 99.9877		99.9877 (3)			99.988 (2)
74	W	180	0.16 - 0.126		0.126 (6)	48WHI1		0.13 (4)
		182	26.41 - 26.09		26.31 (3)			26.3 (2)
		183	14.43 - 14.24		14.28 (1)			14.3 (1)
		184	30.68 - 30.63		30.64 (3)			30.67 (15)
		186	28.85 - 28.38		28.64 (3)			28.6 (2)

Atomic Number 1	Element 2	Mass Number 3	Evaluated Limits of Published Values (Atom %) 4	Annotations 5	Best Measurement from a Single Natural Source (Atom %) 6	Reference (Appendix A) 7	Available Reference Materials (Appendix B) 8	Representative Isotopic Composition (Atom %) 9
75	Re	185 187	—		37.398 (16) 2s C 62.602 (16)	73GRA1	NIST-SRM 989*	37.40 (2) 62.60 (2)
76	Os	184 186 187 188 189 190 192	0.02 - 0.018 1.67 - 1.59 1.67 - 1.60 13.27 - 13.15 16.21 - 16.08 26.42 - 26.15 41.21 - 40.96	g	0.018 (2) P 1.59 (5) 1.64 (5) 13.27 (12) 16.14 (14) 26.38 (20) 40.96 (14)	37NIE1		0.02 (1) 1.58 (30) 1.6 (3) 13.3 (7) 16.1 (8) 26.4 (12) 41.0 (8)
77	Ir	191 193			37.3 62.7	54BAL1		37.3 (5) 62.7 (5)
78	Pt	190 192 194 195 196 198	0.0127 - 0.012 0.78 - 0.78 32.9 - 32.8 33.8 - 33.7 25.4 - 25.2 7.23 - 7.19		0.0127 (5) 0.78 (1) 32.9 (1) 33.8 (1) 25.2 (1) 7.19 (4)	56WHI1		0.01 (1) 0.79 (6) 32.9 (6) 33.8 (6) 25.3 (6) 7.2 (2)
79	Au	197	—		100	63LEI1		100
80	Hg	196 198 199 200 201 202 204	0.16 - 0.147 10.12 - 9.968 17.01 - 16.83 23.21 - 23.07 13.27 - 13.12 29.863 - 29.64 6.865 - 6.69		0.15344 (19) 1s 9.968 (13) 16.873 (17) 23.096 (26) 13.181 (13) 29.863 (33) 6.865 (7)	89ZAD1		0.15 (1) 9.97 (8) 16.87 (10) 23.10 (16) 13.18 (8) 29.86 (20) 6.87 (4)
81	Tl	203 205	—		29.524 (9) 2s C 70.476 (9)	80DUN1	NIST-SRM 997*	29.524 (14) 70.476 (14)
82	Pb	204 206 207 208	1.65 - 1.04 27.48 - 20.84 23.65 - 17.62 56.21 - 51.28	r,g	1.4245 (12) 2s C 24.1447 (57) 22.0827 (27) 52.3481 (86)	68CAT1	NIST-SRM 981*	1.4 (1)e 24.1 (1) 22.1 (1) 52.4 (1)
83	Bi	209	—		100	63LEI1		100
84	Po	—	—					—
85	At	—	—					—
86	Rn	—	—					—
87	Fr	—	—					—
88	Ra	—	—					—
89	Ac	—	—					—
90	Th	232	—	r,g	100	36DEM1		100
91	Pa	231	—	100		77BRO1		100
92	U	234 235 238	0.0059 - 0.0050 0.7202 - 0.7198 99.2752 - 99.2739	r,g,m	0.00548 (2)f 1s 0.7200 (1) 99.2745 (10)	69SMI1 76COW1	NBL-SRM's U0002-U970* C.E.A.	0.0055 (5) 0.7200 (12) 99.2745 (60)

^aAvailable hydrogen gases vary from 0.0032% to 0.0184% D.

^bEnriched ⁷Li is a commercial source of lithium.

^cThe reference reported a calibrated ¹⁶O/¹⁸O ratio on VSMOW, the ¹⁷O was derived from a measurement on air.

^dDue to ¹¹⁵In contamination the ¹¹⁵Sn abundance reported by 83DEV1 was adjusted using data from 84ROS1.

^eRepresentative isotopic composition is for most but not all commercial samples.

^fThe ²³⁴U abundance is from 69SMI1, ²³⁵U and ²³⁸U are from 76COW1.

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APPENDIX B: SOURCES OF REFERENCES MATERIALS

I.A.E.A.

Samples such as VSMOW, SLAP, and GISP may be obtained from:

International Atomic Energy Agency
Section of Isotope Hydrology
P.O. Box 100 1400 Vienna, Austria
or
Dr. Robert D. Vocke, Jr.
National Institute of Standards and Technology (NIST)
A23 Physics Building Gaithersburg, MD 20899 U.S.A.

NIST-SRM's

NIST Standard Reference Materials may be purchased through:
Office of Standard Reference Materials
National Institute of Standards and Technology
B-311, Chemistry Building Gaithersburg, MD 20899 U.S.A.

CBNM-GEEL

Reference Materials may be obtained through:
Dr. Paul De Bièvre
Central Bureau for Nuclear Measurements
Commission of the European Communities B-2440 Geel, Belgium

NBS-RS (Reference Samples)

Samples may be obtained through:
Dr. Robert D. Vocke, Jr. (Address above)
NOTE: Samples of N and Li previously
available from Professor H.J. Svec have
been sent to NIST for distribution.

C.E.A.

Standards may be obtained through:
Dr. J. Césario
Centre D'Etudes Nucleaires de Saclay
B.P. no 2 - 91190 Gif-sur-Yvette France

NBL

Standards may be obtained through:
U.S. Department of Energy
New Brunswick Laboratory
9800 S. Cass Ave.
Argonne IL 60439

ERRATA

Report entitled 'Atomic Weights of the Elements 1989' published in Vol. 63, No. 7 (1991), pp. 975-990

p.980 (Table 2)	Atomic Weight of Sulfur	:	<u>for</u>	35.066(6)	<u>read</u>	32.066(6)
p.989	Reference 24	:	<u>for</u>	Vol.69	<u>read</u>	Vol. 62
p.990	Reference 67	:	<u>for</u>	Howkins	<u>read</u>	Hawkins

Report entitled 'Isotopic Composition of the Elements 1989' published in Vol. 63, No. 7 (1991), pp. 991-1002

p.995	Atomic no. 22, Ti-49	:	<u>Transfer</u>	5.5(1)	<u>from</u>	under column 7	<u>to</u>	under column 9
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Paper entitled 'Thermodynamic Properties of gas phase species of importance to ozone depletion' by S. Abramowitz and M.W. Chase Jr., published in Vol. 63, No. 10(1991), pp. 1449-1454

Please insert the missing page 1450A supplied herewith on page 1829 between pp. 1450 and 1451