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INTERNATIONAL ATOMIC WEIGHTS

1925

Second Report of the International Committee on Chemical Elements

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Explanation of the Table

In this table, the primary standard is, as usual, O = 16.000. We have retained the old value for the secondary standard, Ag = 107.880 although we are of the opinion that this value is slightly higher than the true one. If a more probable value (between 107.870 and 107.876) had been adopted for this secondary standard, many atomic weights dependent upon it (about 42 in number) would be lowered in the same proportion. Since the difference is of slight importance for most purposes, we believe it advisable to avoid the inconvenience of a change until more certain evidence has been obtained. The new table differs in several points from the table published by the former Committee.

First: The third column contains the atomic (or Moseley) numbers of the elements.

Second: The atomic weights are given with one uncertain decimal place (except in the case of hydrogen; see below). This is in accord with usual scientific practise. Those persons who prefer fewer decimal places may easily round off the values to suit their needs. For analytical commercial purposes the use of the complete values given in the table is recommended in order to avoid conflicting reports from different analysts.

In accordance with the application of this principle the Atomic Weights of the following twenty-three elements have been slightly changed by being expressed with one more decimal place than in the previous table. The values of these fundamental atomic weights given in the table have been used in computing the others: A, Ag, Br, Cl, Cr, Dy, F, Gd, Hg, I, K, Li, Na, Nd, O, P, Pr, Pt, Ra, Rh, S, U, V.

On the other hand, the second decimal has been omitted in the case of krypton; and all decimal places have been omitted in the case of zirconium (for the zirconium material examined up to the present time has undoubtedly been a mixture of two elements) to which the round number 91 is given.

Third: In divers new investigations the atomic weights of twenty-four elements have been revised. The changes which seem to us desirable in the light of the new work are included in the table. The following elements are those affected: Al, B, Be, Ga, Ge, La, Sb, Sc, Si, Sm, Sn, Tl.

A brief summary of the results of these recent investigations is appended so that those who wish to verify the conclusions may easily consult the original records.

Furthermore, since one more decimal place has been added in the case of most of the fundamental atomic weights, more detailed evidence upon which these changes are based is cited, in conformity with the procedure adopted regarding the other changes made in the old International Table.

Aluminum.—Richards and Krepelka [This Journal, 42, 2221 (1920)] find Al = 26.96 from the ratio $AlBr_3$: 3Ag.

Recently (in a paper communicated to the *Bohemian Academy* and to This Journal) Krepelka finds from the ratio $AlCl_3$: 3Ag, as a mean of eleven very concordant experiments, Al = 26.972, a value slightly higher (by 0.009) than that obtained from the bromide.

Antimony.—Sb = 121.77. Willard and McAlpine [This Journal, **43,** 797 (1921)] have determined the ratios $SbBr_3$: 3Ag and $SbBr_3$: 3AgBr.

Beryllium.—Hönigschmid and Birckenbach [*Ber.*, **55B**, 4 (1922)] find from the ratios $BeCl_2$: 2Ag and $BeCl_2$: 2AgCl the value Be = 9.018.

Boron.—Baxter and Scott [*Science*, N. S., **54,** 524 (1921)] reported the preliminary value B = 10.83. Hönigschmid and Birckenbach [*Anales soc. españ. fís. quím.*, **20,** 167 (1922)] find from the ratio BCl_3 : 3Ag, B = 10.817 – 10.838, and from the ratio BCl_3 : 3AgCl, B = 10.818 – 10.842. The authors prefer B = 10.82. Recently Baxter and Scott [*Proc. Am. Acad.*, **59,** 21 (1923)] find from the ratio BCl_3 : 3Ag, B = 10.820 as a mean of twenty-two experiments; from the ratio BCl_3 : 3AgCl (seven experiments) B = 10.824; from the ratio BBr_3 : 3Ag (fourteen experiments) B = 10.822; from the ratio BBr_3 : 3AgBr (two experiments), B = 10.812. The mean of all analyses is B = 10.820.

Bismuth.—Hönigschmid and Birckenbach [*Ber.*, **54B,** 1873 (1921)] find Bi = 209.00 from the ratios $BiCl_3$: 3Ag and $BiBr_3$: 3Ag.

Bromine.—Br = 79.916. Ag : AgBr = 0.574453; AgBr : AgCl = 1.310171. Baxter [*Proc. Am. Acad.*, 42, 202 (1906)]. Br : Ag = 0.740786; Br : AgBr = 0.425547. Hönigschmid and Zintl [*Ann.*, **433,** 201 (1923)].

Carbon.—C = 12.000. CO_2 : C = 2.6660 [Clarke. "A Recalculation of the Atomic Weights." 4th Ed. Memoir of the Nat. Acad. Science, vol. XVI, No. 3].

Chlorine.—Cl = 35.457. AgCl : Ag = 1.32867. Richards and Wells [*Car-*

negie Inst. Pub., No. 28 (1905)]. AgBr : AgCl = 1.310171. BAXTER [*Proc. Am. Acad.*, **42,** 202 (1906)].

Chromium.—BAXTER, MUELLER and HINES [THIS JOURNAL, **31,** 329 (1909)] from the ratio Ag_2CrO_4 : 2Ag, and BAXTER and JESSE [*ibid.*, **31,** 541 (1909)] from the ratio $Ag_2Cr_2O_7$: 2Ag find Cr = 52.01.

Cobalt.—Co = 58.94. BAXTER and DORCAS [*ibid.*, **46,** 357 (1924)] find from the analysis of the chloride that both terrestrial and meteoric cobalt possess the atomic weight 58.94.

Fluorine.—SMITH and VAN HAAGEN [*Carnegie Inst. Pub.*, No. 267 (1918)] find F = 19.00.

Gallium.—RICHARDS with W. M. CRAIG [*Bull. soc. chim.*, **31,** 929 (1922)] from the ratio $GaCl_3$: 3Ag find Ga = 69.716; see also THIS JOURNAL, **45,** 1155 (1923).

Germanium.—Ge = 72.60. BAXTER and COOPER [*Proc. Am. Acad. Arts Sci.*, **59,** 235 (1924)] find from the ratio $GeCl_4$: 4Ag the atomic weight Ge = 72.60. They have confirmed the result by the analysis of the bromide (not yet published).

Holmium.—Ho = 163.4. HOLMBERG [*Z. anorg. Chem.*, **71,** 226 (1911)].

Hydrogen.—The best gravimetric and gasometric determinations give for the atomic weight of this element values lying between 1.0075 and 1.0078. The rounded value 1.008 suffices for all practical purposes.

Iodine.—I = 126.932. Ag : I = 0.849906. BAXTER [THIS JOURNAL, **32,** 1591 (1910)].

Lanthanum.—La = 138.90. BAXTER, TANI and CHAPIN [*ibid.*, **43,** 1080 (1921)] find La = 138.91. HOPKINS and DRIGGS [*ibid.*, **44,** 1927 (1922)] find La = 138.89.

Lithium.—Li = 6.940. LiCl : AgCl = 0.29579; LiCl : Ag = 0.39299. RICHARDS and WILLARD [*Carnegie Inst. Pub.*, No. 25, 1 (1910)].

Mercury.—Hg = 200.61. EASLEY, then BAKER and WATSON [See Clarke's "Recalculation of the Atomic Weights." 4th ed., pp. 200–205 (1920)]. HÖNIGSCHMID, BIRCKENBACH and STEINHEIL [*Ber.*, **56,** 1212 (1923)].

Neodymium.—Nd = 144.27. BAXTER and CHAPIN [THIS JOURNAL, **33,** 1 (1911)]; BAXTER, WHITCOMB and STEWART [*ibid.*, **38,** 302 (1916)].

Phosphorus.—P = 31.027. 3AgBr : Ag_3PO_4 = 1.34562; BAXTER and JONES [*Proc. Am. Acad.*, **45,** 137 (1910)]. PBr_3 : 3Ag = 0.836647; PBr_3 : 3AgBr = 0.480623; BAXTER, MOORE and BOYLSTON [*ibid.*, **47,** 585 (1912)]. PCl_3 : 3AgCl = 0.319509; PCl_3 : 3Ag = 0.424507; BAXTER and MOORE [THIS JOURNAL, **34,** 1644 (1912)].

Platinum.—Pt = 195.23. ARCHIBALD [*Proc. Roy. Soc. Edinburgh*, **29,** 721 (1909)].

Potassium.—K = 39.096. KCl : AgCl = 0.52012; KCl : Ag = 0.69107. RICHARDS and MUELLER [*Carnegie Inst. Pub.*, No. 69, 27 (1907)].

Praseodymium.—Pr = 140.92. BAXTER and STEWART [THIS JOURNAL, **37,** 516 (1915)].

Radium.—Ra = 225.95. HÖNIGSCHMID [*Monatsh.*, **33,** 253 (1911); *Wien. Akad.*, **121,** Nov. (1912)].

Radon.—Formerly *Niton*. The round number Rn = 222 appears the most probable from radioactive evidence.

Samarium.—Sm = 150.43. STEWART and JAMES [THIS JOURNAL, **39,** 2605 (1917)]. OWENS, BALKE and KREMERS [*ibid.*, **42,** 515 (1920)].

Scandium.—Sc = 45.10. HÖNIGSCHMID [*Z. Elektrochem.*, **25,** 93 (1919)].

Silicon.—Si = 28.06. BAXTER, WEATHERILL and SCRIPTURE [*Proc. Am. Acad.*, **58,** 245 (1923)] find from the ratio $SiCl_4$: 4Ag, Si = 28.063; from $SiBr_4$: 4Ag, Si = 28.059. Mean of the best series: Si = 28.061.

Sulfur.—S = 32.064. 2AgCl : Ag_2SO_4 = 0.91933; RICHARDS and JONES [*Carnegie Inst. Pub.*, No. 69, 69 (1907)]. Na_2SO_4 : Na_2CO_3 = 1.34016; Na_2CO_3 : 2Ag = 0.491265. RICHARDS and HOOVER [THIS JOURNAL, **37,** 95 (1915)].

INTERNATIONAL TABLE OF ATOMIC WEIGHTS OF THE CHEMICAL ELEMENTS[1]

1925

	Symbol	At. number	At. weight		Symbol	At. number	At. weight
Aluminum	Al	13	26.97	Molybdenum	Mo	42	96.0
Antimony	Sb	51	121.77	Neodymium	Nd	60	144.27
Argon	A	18	39.91	Neon	Ne	10	20.2
Arsenic	As	33	74.96	Nickel	Ni	28	58.69
Barium	Ba	56	137.37	Nitrogen	N	7	14.008
Beryllium	Be	4	9.02	Osmium	Os	76	190.8
Bismuth	Bi	83	209.00	Oxygen	O	8	16.000
Boron	B	5	10.82	Palladium	Pd	46	106.7
Bromine	Br	35	79.916	Phosphorus	P	15	31.027
Cadmium	Cd	48	112.41	Platinum	Pt	78	195.23
Calcium	Ca	20	40.07	Potassium	K	19	39.096
Carbon	C	6	12.000	Praseodymium	Pr	59	140.92
Cerium	Ce	58	140.25	Radium	Ra	88	225.95
Cesium	Cs	55	132.81	Radon	Rn	86	222.
Chlorine	Cl	17	35.457	Rhodium	Rh	45	102.91
Chromium	Cr	24	52.01	Rubidium	Rb	37	85.44
Cobalt	Co	27	58.94	Ruthenium	Ru	44	101.7
Columbium	Cb	41	93.1	Samarium	Sm	62	150.43
Copper	Cu	29	63.57	Scandium	Sc	21	45.10
Dysprosium	Dy	66	162.52	Selenium	Se	34	79.2
Erbium	Er	68	167.7	Silicon	Si	14	28.06
Europium	Eu	63	152.0	Silver	Ag	47	107.880
Fluorine	F	9	19.00	Sodium	Na	11	22.997
Gadolinium	Gd	64	157.26	Strontium	Sr	38	87.63
Gallium	Ga	31	69.72	Sulfur	S	16	32.064
Germanium	Ge	32	72.60	Tantalum	Ta	73	181.5
Gold	Au	79	197.2	Tellurium	Te	52	127.5
Helium	He	2	4.00	Terbium	Tb	65	159.2
Holmium	Ho	67	163.4	Thallium	Tl	81	204.39
Hydrogen	H	1	1.008	Thorium	Th	90	232.15
Indium	In	49	114.8	Thulium	Tm	69	169.4
Iodine	I	53	126.932	Tin	Sn	50	118.70
Iridium	Ir	77	193.1	Titanium	Ti	22	48.1
Iron	Fe	26	55.84	Tungsten	W	74	184.0
Krypton	Kr	36	82.9	Uranium	U	92	238.17
Lanthanum	La	57	138.90	Vanadium	V	23	50.96
Lead	Pb	82	207.20	Xenon	Xe	54	130.2
Lithium	Li	3	6.940	Ytterbium	Yb	70	173.6
Lutecium	Lu	71	175.0	Yttrium	Y	39	88.9
Magnesium	Mg	12	24.32	Zinc	Zn	30	65.38
Manganese	Mn	25	54.93	Zirconium	Zr	40	91.
Mercury	Hg	80	200.61				

[1] NOTE BY THE EDITOR.—The Table of Atomic Weights as issued by the International Committee lists the elements alphabetically according to their symbols. We have rearranged it alphabetically according to the names of the elements, and have brought the spelling into conformity with the usages of the JOURNAL. The Table does not include element No. 72, Hafnium or Celtium, atomic weight 180.8. For information

Thallium.—Tl = 204.39. Hönigschmid, Birckenbach and Kothe [*Sitzber. Bayer. Akad. Wiss.*, **1922**, 179] find from the ratio TlCl : Ag, Tl = 204.39; and from the ratio TlCl : AgCl, Tl = 204.39.

Thulium.—Tm = 169.4. James and Stewart [This Journal, **42**, 2022 (1920)] find Tm = 169.39.

Titanium.—Baxter and Fertig [*ibid.*, **45**, 1228 (1923)] find by analysis of the tetrachloride, Ti = 47.85. Since this result is preliminary no change is recommended.

Yttrium.—Y = 88.9. Mean of the best determinations.

Zinc.—Zn = 65.38. Richards and Rogers find Zn = 65.376 [*Proc. Am. Acad.*, **31**, 158 (1895)]. Baxter and Grose find Zn = 65.389 [This Journal, **38**, 868 (1916)]. Baxter and Hodges find Zn = 65.381 [*ibid.*, **43**, 1242 (1921)].

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THIRTY-FIRST ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS. DETERMINATIONS PUBLISHED DURING 1924

By Gregory Paul Baxter

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A Report of the German Committee on Atomic Weights has been published.[1]

Carbon.—Batuecas[2] has determined the weight of the normal liter of methyl oxide.

	Globe I, 773.4 cc.			Globe II, 220.3 cc.	
Globe I	2.1100	2.1105	2.1105	2.1104	2.1098
Globe II	2.1097	2.1105	2.1107	2.1084	2.1102
Av.	2.1099	2.1105	2.1106	2.1094	2.1100
Globe I	2.1099	2.1085	2.1093	2.1101	2.1086
Globe II	2.1091	2.1090	2.1098	2.1094	2.1084
Av.	2.1095	2.1087	2.1096	2.1097	2.1085
				Av.	2.1097

Experimental values of the compressibility and deviation from Boyle's Law extrapolated from data at 1 and 2/3 atmospheres gave $(PV)_0/(PV)_1$ as 1.0270 and C = 11.999.

regarding this atomic weight, and also for more recent information regarding the other atomic weights, see the following article entitled "Report of the Committee on Atomic Weights," by G. P. Baxter.—A. B. L.

[1] *Ber.*, **57B**, I (1924).

[2] Batuecas, *Compt. rend.*, **179**, 440, 565 (1924); *Anal. soc. españ. fís. quím.*, **22**, 409 (1924).