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REPORT OF THE INTERNATIONAL COMMITTEE ON ATOMIC WEIGHTS. 1909.

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Since the publication of our last report several important memoirs upon atomic weights have appeared, containing data of fundamental significance. They may be summarized as follows:

Hydrogen.—W. A. Noyes[1] has made complete syntheses of water in five series of determinations. The first series, however, was defective, and is therefore not published by the author. In mean, the four successful series give H = 1.00787, as compared with Morley's figure, 1.00762. The general mean of these values, combined with all other trustworthy determinations, is 1.00779. The rounded-off value, 1.008, is therefore retained in the table.

Chlorine.—Noyes and Weber[2] have effected the synthesis of hydrochloric acid, weighing the hydrogen in palladium, the chlorine in potassium chloroplatinate, and also the hydrochloric acid produced by the union of the two elements. From the ratio H : Cl, Cl = 35.458, when H = 1.00779. From the ratio H : HCl, Cl = 35.457.

The same ratios have also been measured by Edgar,[3] but by a different method. The hydrogen, as in former determinations, was weighed in palladium, but the chlorine was prepared by the electrolysis of fused silver chloride, and weighed in the liquid form. The hydrogen chloride was weighed directly in three experiments, and in two others after absorption in water. From the ratio H:Cl, Cl = 35.468. From the ratio H : HCl, Cl = 35.467. With Morley's value for H, the results are nearer Cl = 35.46. Taking all the data together, the value Cl = 35.46

[1] This Journal, **29**, 1718.

[2] *Ibid.*, **30**, 13.

[3] *Proc. Roy. Soc.*, **81**A, 216.

seems to be as near the truth as can be positively asserted now. This includes the former work of Dixon and Edgar, and the density determinations by Guye and Gazarian.

Sulphur.[1]—From eighteen determinations of the density of hydrogen sulphide, Baumé and Perrot deduce the value S = 32.070. In an earlier investigation by Baumé,[2] who determined the density of sulphur dioxide, he found lower values for S. The figure 32.07, however, is in close agreement with the value obtained by Richards and Jones, when Ag = 107.88, and is doubtless very nearly true.

Lead.—Atomic weight determined by Baxter and Wilson,[3] from analyses of the chloride. With Ag = 107.93, Pb = 207.19. With Ag = 107.88, Pb = 207.10. This value is still much higher than that previously accepted.

Cadmium.—Blum[4] has attempted to determine the atomic weight of cadmium by conversion of the oxide into the sulphide. The values obtained range from 112.50 to 112.88, and are admittedly of slight significance.

Tellurium.—In an elaborate memoir upon the atomic weight of tellurium, Baker and Bennett[5] give determinations by two new methods. By heating tellurium dioxide with sulphur in such a way that only sulphur dioxide could escape, the ratio TeO_2 to SO_2 was determined. From the mean of twenty-five determinations, Te = 127.609. By direct conversion of tellurium into the tetrabromide, the mean of eighteen determinations was Te = 127.601, when Br = 79.96. Referred to Br = 79.92 this becomes 127.54. Several analyses of tellurium tetrachloride, for which the details are not published, gave values for Te between 127.58 and 127.64. On the basis of the modern values for Ag, Cl, and Br, and with due regard to the earlier work of Pellini, Gutbier, Koethner, Norris, Scott, Staudenmaier, and others, the rounded-off figure Te = 127.5 seems to be fairly acceptable.

Marckwald,[6] however, by careful dehydration of telluric acid, found values for Te ranging from 126.65 to 126.94. Six experiments were made, the mean of five, rejecting the lowest of all, being Te = 126.85. This falls below the atomic weight of iodine, and is therefore in harmony with the periodic classification. In view of the general agreement between other investigators in favor of a higher figure, Marckwald's work cannot

[1] *J. Chim. Phys.*, **6**, 610.

[2] *J. Chim. Phys.*, **6**, 1. Baumé also determined the densities of methyl oxide and methyl chloride.

[3] *Proc. Amer. Acad.*, **43**, 365.

[4] Thesis, University of Pennsylvania, 1908.

[5] *J. Chem. Soc.*, **91**, 1849.

[6] *Ber.*, **40**, 4730 (1907). For a criticism of Marckwald see Baker, *Chem. News*, **97**, 209 (1908).

be accepted without confirmation. The controversy over tellurium is evidently not ended.

Rhodium.—Hüttlinger,[1] working in Gutbier's laboratory, made three reductions in hydrogen of rhodium pentamine chloride. His results, which seem to be preliminary in character, are practically identical with those obtained by Seubert and Kobbe, whose value for rhodium has been accepted since 1890. No change in this atomic weight is needed.

Palladium.—Woernle[2] made seven analyses of palladosamine chloride; two by reductions in hydrogen, five electrolytically. The mean value obtained was Pd = 106.708, presumably computed with the old figures for N and Cl.

Haas,[3] from similar reductions of palladosamine bromide, found Pd = 106.75, calculated with N = 14.037 and Br = 79.953. These determinations, like those of Krell, were made under the direction of Professor Gutbier. The results obtained by Krell, Woernle and Haas agree well together, and also with Amberg's determinations, and are probably quite accurate. Recomputed, with modern values for N and Cl, Pd = 106.7 very nearly, with an uncertainty of not over 0.05.

Lower values were found by Kemmerer.[4] By reduction in hydrogen, palladosamine chloride gave Pd = 106.399 and 100.442, as the means of two series of observations. From palladosamine cyanide the value Pd = 106.458 was obtained. The mean of fifteen determinations, taken as one series, gave Pd = 106.434. The more concordant values cited above, seem to be more trustworthy, at least so far as present evidence permits us to judge. Kemmerer's computations were made with N = 14.01 and Cl = 15.473.

Europium.—From analyses of the octohydrated sulphate Jantsch[5] finds Eu = 152.03, when S = 32.06 and H = 1.008. The round number 152 is retained in the table. This is probably the nearest significant figure.

Erbium.—By repeated fractionation of erbium compounds, Hofmann and Burger[6] have isolated an oxide of slightly higher molecular weight than that of the old erbia. To the new metal thus indicated they assign the name "neo-erbium," and by synthesis of the sulphate they find its probable atomic weight to be 167.43. The rounded-off figure 167.4 is given provisionally in the table, to stand until more complete data have been obtained.

[1] Inaugural Dissertation, Erlangen, 1907.
[2] *Sitzungsb. phys. med. Soz. Erlangen*, **38**, 296.
[3] Inaugural Dissertation, Erlangen, 1908.
[4] Thesis, University of Pennsylvania, 1908. This Journal, **30**, 1701.
[5] *Compt. rend.*, **146**, 473.
[6] *Ber.*, **41**, 308.

Ytterbium.—That the old ytterbium is a mixture of two elements has been proved by Urbain[1] in Paris and Auer von Welsbach[2] in Vienna, working almost simultaneously and independently. In his earlier paper, Urbain names the two components "neoytterbium" and "lutecium," with approximate atomic weights of 170 and 174 respectively. In his second memoir, Urbain gives atomic weights for a series of ytterbium fractionations, ranging from 170.6 to 174.02. Welsbach, whose work appeared later than Urbain's, names the two elements "aldebaranium," atomic weight 172.90, and "cassiopeium," atomic weight 174.23. Since Urbain has clear priority, his nomenclature should be preferred, but the atomic weights need to be more sharply determined. Incidentally, Urbain notes that the atomic weight of thulium is lower than 168.5.

Columbium.—A concordant series of determinations, made by Balke and Smith,[3] give columbium an atomic weight of 93.5. This is lower than the value hitherto accepted.

Radium.—Thorpe[4] has redetermined the atomic weight of radium by analyses of the chloride. In mean his determinations, calculated with Ag = 107.88 and Cl = 35.46, give Ra = 226.64. Thorpe, however, gives preference to the determinations by Mme. Curie, who worked with larger quantities of material, regarding his own work as confirmatory. The recalculated value is 226.4

In their report for 1908 this committee recognized the fact that a general revision of the atomic weight table was desirable, and such a revision has now been made. Modern investigations have shown that the fundamental values required modification, and through them many other atomic weights are affected, although the changes thus brought about are less important than they were generally supposed to be. Many atomic weights remain practically unaltered, and in few instances are the changes large, as a comparison of the new table with its predecessors will show. A careful scrutiny of all the evidence was, however, none the less necessary, and the table now offered gives the results thus obtained.

The fundamental atomic weights, the standards of reference employed in the calculations, are as follows, when O = 16.

H	1.008	Ag	107.880
C	12.000	K	39.095
N	14.007	S	32.070
Cl	35.460		
Br	79.916		

[1] *Compt. rend.*, **145**, 759 (Nov. 4, 1907). See also *Ibid.*, **146**, 406, and *Chem. Z.* **32**, 730.

[2] *Monatsh. Chem.*, **29**, 181 (1908). Read before the Vienna Academy, Dec. 19, 1907.

[3] This Journal, **30**, 1646.

[4] *Proc. Roy. Soc.*, **80**A, 298.

The value for silver is possibly a trifle too low, by from three to five units in the third decimal place. A combination of the best measurements gives Ag = 107.883. In this case, and in others as well, the second place of decimals is given in the table, the third place being uncertain. Thus we have K 39.10, N 14.01, Br 79.92, etc. Only with hydrogen is the third place retained.

International Atomic Weights, 1909.

	Symbol.	Atomic weight.		Symbol.	Atomic weight.
Aluminum	Al	27 1	Molybdenum	Mo	96.0
Antimony	Sb	120 2	Neodymium	Nd	144.3
Argon	A	39.9	Neon	Ne	20.0
Arsenic	As	75.0	Nickel	Ni	58.68
Barium	Ba	137.37	Nitrogen	N	14.01
Bismuth	Bi	208.0	Osmium	Os	190.9
Boron	B	11.0	Oxygen	O	16.00
Bromine	Br	79.92	Palladium	Pd	106.7
Cadmium	Cd	112.40	Phosphorus	P	31.0
Caesium	Cs	132.81	Platinum	Pt	195.0
Calcium	Ca	40.09	Potassium	K	39.10
Carbon	C	12.00	Praseodymium	Pr	140.6
Cerium	Ce	140.25	Radium	Ra	226.4
Chlorine	Cl	35.46	Rhodium	Rh	102.9
Chromium	Cr	52.1	Rubidium	Rb	85.45
Cobalt	Co	58.97	Ruthenium	Ru	101.7
Columbium	Cb	93.5	Samarium	Sa	150.4
Copper	Cu	63.57	Scandium	Sc	44.1
Dysprosium	Dy	162.5	Selenium	Se	79.2
Erbium	Er	167.4	Silicon	Si	28.3
Europium	Eu	152.0	Silver	Ag	107.88
Fluorine	F	19.0	Sodium	Na	23.00
Gadolinium	Gd	157.3	Strontium	Sr	87.62
Gallium	Ga	69.9	Sulphur	S	32.07
Germanium	Ge	72.5	Tantalum	Ta	181.0
Glucinum	Gl	9.1	Tellurium	Te	127.5
Gold	Au	197.2	Terbium	Tb	159.2
Helium	He	4.0	Thallium	Tl	204.0
Hydrogen	H	1.008	Thorium	Th	232.42
Indium	In	114.8	Thulium	Tm	168.5
Iodine	I	126.92	Tin	Sn	119.0
Iridium	Ir	193.1	Titanium	Ti	48.1
Iron	Fe	55.85	Tungsten	W	184.0
Krypton	Kr	81.8	Uranium	U	238.5
Lanthanum	La	139.0	Vanadium	V	51.2
Lead	Pb	207.10	Xenon	Xe	128.0
Lithium	Li	7.00	Ytterbium		
Lutecium	Lu	174.0	(Neoytterbium)	Yb	172.0
Magnesium	Mg	24.32	Yttrium	Y	89.0
Manganese	Mn	54 93	Zinc	Zn	65.7
Mercury	Hg	200.0	Zirconium	Zr	90.6

In adjusting the other atomic weights the determinations by Richards[1] and his colleagues have generally been given preference. They are certainly entitled to the highest weight, but probably not to exclusive consideration. The work of Guye and his associates at Geneva, and the recent direct measurements of the chlorine-hydrogen ratio are also of very great importance. It is to work of this order that we must look for ultimate precision. Important investigations upon atomic weights are now being carried on in several laboratories, and our knowledge of these constants will doubtless become much more exact within the near future.

(Signed) F. W. CLARKE,
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T. E. THORPE,
G. URBAIN.

FURTHER INVESTIGATION OF THE ATOMIC WEIGHTS OF NITROGEN AND SILVER.

BY THEODORE WILLIAM RICHARDS, PAUL KÖTHNER AND ERICH TIEDE.

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The Analysis of Ammonium Chloride.

The subject of atomic weights has acquired new interest recently, because of the striking demonstration by Landolt that the law of the conservation of weight holds true to a great degree of precision in common chemical reactions.[2] The fact that the sum of the reacting weights remains perfectly constant, within the limit of error of the most exact experimentation, strengthens the conviction that each of these reacting weights possesses fundamental significance. Evidently no error is committed in calculating one atomic weight by subtracting another from the molecular weight of a substance containing two elements, and the whole structure of the table of atomic weights is seen to rest on a satisfactory basis.

These assurances are timely in view of the extraordinary discoveries concerning radioactivity in recent years. Not a few radical thinkers have supposed that these discoveries lessen the importance of exact atomic weight determinations, because of the doubt cast on the permanence of the supposed atom, but Landolt's admirable work assures us that under ordinary circumstances the chemical combining proportions are wonderfully permanent, and therefore as full of meaning as they have ever been supposed to be. The new discoveries concerning radioactivity extend the bounds of knowledge, but in no wise lessen the significance of that which went before.

[1] An excellent summary of the Harvard work is given by Richards in *J. Chim. Phys.*, **6**, 92.

[2] Landolt, *Sitzunber. kgl. preuss. Akad.*, **15**, **16**, 354 (1908).