SEVENTH ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS. RESULTS PUBLISHED IN 1899.

BY F. W. CLARKE.

Received January 15, 1899.

THE year 1899 has not been remarkably prolific in determinations of atomic weight; and comparatively few investigations have been published. The data are given in the following pages, plus an account of two memoirs which appeared in 1898, but which reached this country only after the report for that year had been printed. These memoirs, by Vandenberghe on molybdenum, and by Kölle on cerium, were issued outside of the usual channels for chemical publication, and so seem to have escaped general notice hitherto.

BORON.

An elaborate memoir upon the atomic weight of boron has been published by Gautier,[1] who worked upon four different compounds. All weights were reduced to a vacuum, and all calculations were made with the atomic weights recommended a year ago by the committee of the German Chemical Society.

First, sulphide of boron was decomposed by a dilute solution of caustic soda; the solution produced was then oxidized by means of bromine water, and the sulphur was precipitated and weighed as barium sulphate. The results obtained were as follows:

Weight B_2S_3.	Weight $BaSO_4$.	Atomic weight.
0.2754	1.6312	11.032
0.3380	2.0004	11.081
0.3088	1.8300	11.000
0.2637	1.5614	11.050
	Mean,	11.041

The second compound studied was the carbide, B_6C. This was heated in chlorine gas to eliminate boron; the residual carbon was then weighed directly, and afterwards burned in oxygen to reweigh as CO_2. The atomic weights given below were calculated from the weight of the carbon dioxide.

Weight B_6C.	Weight C.	Weight CO_2.	Atomic weight.
0.2686	0.0429	0.1515	11.001
0.3268	0.0512	0.1844	10.994
		Mean,	10.997

---

[1] *Ann. chim. phys.* (7), 18, 352, November, 1899.

With the third compound, boron tribromide, two series of experiments were made, representing two preparations. The bromide was in each analysis decomposed by water, special precautions being taken to avoid explosive reactions; and the bromine was finally precipitated and weighed as silver bromide. The data are subjoined:

FIRST SERIES.

Weight BBr_3.	Weight AgBr.	Atomic weight.
3.1130	6.994	11.009
3.3334	7.490	10.981
3.7456	8.414	11.043
3.2780	7.364	11.032
4.2074	9.452	11.026
	Mean,	11.018

SECOND SERIES.

Weight BBr_3.	Weight AgBr.	Atomic weight.
3.3956	7.628	11.037
4.0295	9.052	11.032
3.7886	8.512	11.003
3.1711	7.124	11.026
	Mean,	11.025

With boron trichloride the analyses were conducted precisely as in the case of the bromide, silver chloride being the final product weighed.

Weight BCl_3.	Weight AgCl.	Atomic weight.
2.6412	9.682	10.987
2.7920	10.234	11.000
2.4634	9.026	11.043
3.4489	12.640	11.013
2.2015	8.070	10.992
2.6957	9.878	11.030
	Mean,	11.011

The mean of the values obtained from the bromide and chloride series, 11.016, is the value which Gautier proposes to adopt.

NITROGEN.

Dean[1] has continued the investigation which was reported in 1898, relative to the atomic weight of nitrogen. The ratio studied is that between potassium bromide and silver cyanide, and the value finally found is N = 14.031. Only an abstract of the paper has yet appeared.

---

[1] *Chem. News*, 80, 279.

CALCIUM.

A paper upon the atomic weight of calcium, by T. W. Richards, was read at the meeting of the American Association for the Advancement of Science in August, but has not, at the date of this report, been fully published. Five analyses of carefully purified calcium chloride were made to determine the ratio $CaCl_2 : 2AgCl$. Calculated with $O = 16$ and $Cl = 35.455$, the values found for Ca range from 40.121 to 40.130, the mean of all being 40.126.

NICKEL.

The work of Richards and Cushman upon the atomic weight of nickel, noticed in the report of 1897, has been continued.[1] The sublimed bromide was reduced in hydrogen, giving the ratio between bromine and the metal. The weights corrected for known impurities, and the values found, are as follows :

Weight $NiBr_2$.	Weight Ni.	Atomic weight.
2.83325	0.76081	58.705
3.21625	0.86358	58.696
2.31241	0.62094	58.703
2.87953	0.77330	58.710
2.29650	0.61679	58.719
2.98893	0.80272	58.714
5.51291	1.48056	58.716
2.24969	0.60415	58.710
	Mean,	58.709

All weights represent reductions to vacuum, and the antecedent values used in calculation are $O = 16$, and $Br = 79.955$. The complete agreement with the former determinations is almost startling. A full discussion of earlier determinations is given at the close of the paper, and it is shown that the work of Winkler and of Zimmermann is in accord with the new data.

COBALT.

Just as in the case of nickel, Richards and Baxter have extended their observations upon cobalt,[2] and now give three series of new determinations dependent upon the reduction of bromide to metal. In the first series, which is preliminary, a slight impurity is stated as "residue;" in the other series corrected weights are

---

[1] *Proc. Amer. Acad.*, **34**, 327, February, 1899.

[2] *Ibid.*, **34**, 351, February, 1899.

given. The nature of the impurity, however, is fully discussed in the paper.

FIRST SERIES.

Weight $CoBr_2$.	Weight Co.	Residue.	Atomic weight.
5.59216	1.50873	0.00193	59.007
4.61944	1.24807	0.00426	58.996
3.75291	1.01713	0.00793	58.989
3.00645	0.81409	0.00510	59.007
		Mean,	59.000

SECOND SERIES.

Weight $CoBr_2$.	Weight Co.	Atomic weight.
5.32194	1.43428	58.996
7.50786	2.02321	58.989
2.32630	0.62677	58.973
7.44694	2.00736	59.011
	Mean,	58.992

THIRD SERIES.

Weight $CoBr_2$.	Weight Co.	Atomic weight.
5.10891	1.37721	59.016
6.41339	1.72850	58.999
6.59805	1.77876	59.021
3.02854	0.81606	58.982
	Mean,	59.004

The mean of the second and third series is 58.998, when O = 16 and Br = 79.955. Vacuum weights are given throughout.

In a still later paper[1] Richards and Baxter check their determinations of the atomic weight of cobalt by experiments upon the chloride and oxide. The chloride was reduced in hydrogen to metal, and the data obtained, after corrections for known impurities and reduction to a vacuum, were as follows:

Weight $CoCl_2$.	Weight Co.	Atomic weight Co.
4.16483	1.89243	59.053
2.30512	1.04723	59.035
	Mean,	59.044

The reduction of cobalt monoxide in hydrogen was similarly effected, but with varying results depending upon differences in the conditions of the experiments.

First, three determinations, with vacuum weights, gave as follows:

---

[1] *Proc. Amer. Acad.*, **35**, 61, August, 1899.

Weight CoO.	Weight Co.	Atomic weight Co.
7.04053	5.53779	58.962
6.69104	5.26312	58.974
7.83211	6.15963	58.927
	Mean,	58.954

These data, which are not sufficiently concordant among themselves or with the bromide determinations, probably indicate that the cobalt oxide contained some excess of oxygen. In a fourth experiment precautions were taken to avoid this difficulty, and 7.74242 grams of oxide gave 6.09219 of cobalt, whence Co = 59.068. In a fifth experiment, resembling the fourth, but with differences in detail, 10.58678 grams of CoO gave 8.32611 of metal, corresponding to an atomic weight of Co = 58.929.

The authors give elaborate particulars as to the circumstances under which each determination was made, and conclude that cobalt monoxide varies too widely in its composition to be suitable for exact measurements of atomic weight. The true value for cobalt undoubtedly lies between 58.93 and 59.07, the figure 58.995. obtained from the bromide, being the most probable.

MOLYBDENUM.

In 1897 the Belgian Academy of Sciences awarded a special Stas prize to M. Ad. Vandenberghe for his determination of the atomic weight of molybdenum. The memoir has recently been published,[1] and the data are now available.

Vandenberghe starts out with molybdenum dibromide, scrupulously purified. From this he obtains metallic molybdenum, by careful reduction in hydrogen at a white heat. The atomic weight determinations are made by the oxidation of Mo to MoO_3, by means of pure nitric acid. The product was finally dried at a temperature of from 350° to 400°, and cooled in a current of oxygen. The data obtained are as follows:

Weight Mo.	Weight MoO_3	Atomic weight.
0.7143	1.0711	95.851
0.3453	0.5177	95.899
0.9693	1.4533	95.889
0.5089	0.7631	95.854
1.7219	2.5820	95.855
4.2597	6.3872	95.869

---

[1] *Acad. Roy. des Sciences*, Mémoires Couronnés, 4to. series, Tome 56. 1898.

Reducing all weights to a vacuum, the final value becomes 95.829, when O = 15.96. If O = 16, Mo = 96.069. If O = 15.88, then Mo = 95.349. This value is very near that found by Smith and Maas, by an entirely different method, but rather higher than that given by Seubert and Pollard. For all practical purposes the value Mo = 96 may be assumed.

TUNGSTEN.

Two investigations relative to the atomic weight of tungsten have been published from the laboratory of the University of Pennsylvania. The first one by G. E. Thomas[1] contains a record of experiments upon WO_3 and $Na_2WO_4.2H_2O$. The reduction of oxide to metal, and the reverse process of oxidation, gave figures ranging from 183.51 to 184.22 for the atomic weight of tungsten, and work along this line was discontinued. With sodium tungstate three series of dehydration experiments were made, giving the ratio between water and the anhydrous salt as the measure from which to calculate. These results also were discordant, and Thomas discards the method as unsuited to accurate determinations. The object of the paper seems to be negative, and to show that neither method employed is adequate to its purpose.

The second paper, by Professor Smith, contains a section by W. L. Hardin,[2] of similar purport to that of Thomas. Experiments were made upon the oxide, the oxychloride, barium metatungstate, and the precipitation of silver by metallic tungsten, and each method was found to be defective. Discordant results were obtained in each set of trials. The mean of all experiments upon the reduction of WO_3, and the oxidation of tungsten give approximately the value W = 184. This value Hardin thinks it best to accept until more conclusive determinations shall have been made.

CERIUM.

Kölle's dissertation[3] upon this element deals partly with its atomic weight and partly with other matters. His material was obtained from cerite, and was purified with extreme care. Iodo-

---

[1] This Journal, 21, 373, April, 1899.

[2] *Ibid.*, 21, 1017, November, 1899.

[3] Beiträge zür Kenntniss des Cers. Doctoral Dissertation by Gotthold Kölle, Zurich, 1898.

metric determinations of cerium salts gave, invariably, results which were too high, and which led him to believe that the source of error was in the accepted atomic weight of cerium, an essential factor in his calculations.

Accordingly, new determinations of atomic weight were made by the standard method; namely, the ignition of cerium sulphate to cerium dioxide. Cerium chloride prepared from the oxide, was spectroscopically examined, and found to be free from other metals. The atomic weight data are as follows, computed with $O = 16$.

Weight $Ce_2(SO_4)_3$.	Weight CeO_2.	Per cent. CeO_2.	Atomic weight.
1.84760	1.11648	60.429	139.11
1.16074	0.70078	60.331	138.78
1.53599	0.92722	60.366	138.73
0.97196	0.58661	60.353	138.64
1.40374	0.84760	60.384	138.84
1.75492	1.05956	60.377	138.80
1.53784	0.92853	60.379	138.82
1.64233	0.99150	60.372	138.76
		Mean,	138.81

This value is lower than any of the later determinations, but agrees nearly with that of Wolf. Like Wolf, and like some other recent investigators, Kölle obtained a white ceric oxide, and he regards the colored preparations of former researches as evidently impure. Furthermore, iodometric estimations made on known quantities of ceric oxide gave good results when the new atomic weight was used in calculation, but excesses of 0.8 per cent. when Brauner's or Robinson's value was employed. So far as present evidence goes there is a presumption in favor of Kölle's determination.

PALLADIUM.

Hardin's research[1] upon the atomic weight of palladium is based upon the reduction of certain compounds in hydrogen. Neither of the salts studied had been previously applied to determinations of this character, and the results obtained are therefore of special value. They are, moreover, very concordant, and seem to be more nearly conclusive than any determinations previously made. All weights were reduced to a vacuum, and the

---

[1] This Journal, **21**, 943. November, 1899.

calculations are based upon atomic weights given in the table of your committee for 1898.

First, diphenyl-pallad-diammonium chloride was studied. After reduction, the metal was heated in air to burn off possible free carbon, then reheated in hydrogen, and cooled in air to prevent occlusion of the former gas.

Weight of salt.	Weight Pd.	Atomic weight.
0.98480	0.28953	107.06
1.10000	0.32310	106.92
1.02820	0.30210	106.96
1.19230	0.35040	107.00
1.40550	0.41300	106.98
1.26000	0.37040	107.04
2.25510	0.66310	107.08
		Mean, 107.006

The second series of determinations was made upon diphenyl-pallad-diammonium bromide, with the following results:

Weight of salt.	Weight Pd.	Atomic weight.
0.88567	0.20917	107.01
1.31280	0.31000	106.99
1.50465	0.35540	107.03
2.01635	0.47635	107.05
2.92300	0.69080	107.10
		Mean, 107.036

Finally, ammonium palladium bromide was studied, giving four more determinations.

Weight of salt.	Weight Pd.	Atomic weight.
0.77886	0.18006	107.03
1.53109	0.35381	106.96
2.75168	0.63614	107.03
1.88136	0.43478	106.98
		Mean, 107.00

The mean of all three series, when $O = 16$, is 107.014. 107 then, may be taken as the most probable value for the atomic weight of palladium.

RADIUM.

Madame Curie,[1] having prepared a large quantity of radiferous barium chloride, has determined the chlorine in several fractions

---

[1] *Chem. News*, 80, 793.

of the material, and so ascertained the atomic weight of the metal contained in it. Three determinations gave for this atomic weight:

140.0
140.9
145.8

Hence the atomic weight of radium is higher than that of barium, although its true value is still unknown.

THE ELECTROCHEMICAL EQUIVALENTS OF COPPER AND SILVER.

This subject has been reinvestigated somewhat elaborately by Richards, Collins, and Heimrod.[1] First, copper was precipitated in comparison of the silver and copper voltameters, under varying conditions as to temperature, character of solution, and size of plates, and the results are summarized as follows for the atomic weight of copper, when Ag = 107.93.

Large	plates,	cupric	solutions,	*t.* 20°,	Cu = 63.47
"	"	"	"	*t.* 0°,	63.525
Small	"	"	"	*t.* 0°,	63.547
Medium	"	cuprous	"	*t.* 0°,	63.573
"	"	"	"	*t.* 60°,	63.615
Corrected results from cupric solutions,					Cu = 63.563

a value 0.041 lower than that determined by chemical processes.

A study of the silver voltameter by itself showed that it gives results which are too high by about 0.081 per cent. Correcting the atomic weight of copper in accordance with this observation, the true value is found to lie between 63.598 and 63.615. The value previously established by Richards was 63.604, a confirmation of the present work, which is to be continued.

TABLE OF ATOMIC WEIGHTS.

In the following table of atomic weights your committee give first its own set of values, based upon both fundamental standards. Next is given Richards' table, revised for 1899, and finally that of the German Chemical Society. The values in the German table are rounded off to convenient approximations for practical use; those of Richards give the nearest significant figure, and the latter policy, which is wise, has also been adopted by your committee. There are, however, slight differences of

---

[1] *Proc. Amer. Acad.*, **35**, 123, December, 1899.

opinion in some cases as to where the nearest significant decimal place really is. Hardin's work on palladium and tungsten, and Kölle's research on cerium, have led to the only notable changes from last year.

	Clarke.			
	H = 1.	O = 16.	Richards.	German.
Aluminum	26.9	27.1	27.1	27.1
Antimony	119.5	120.4	120.0	120.
Argon	?	?	39.9?	40.
Arsenic	74.45	75.0	75.0	75.
Barium	136.4	137.40	137.43	137.4
Bismuth	206.5	208.1	208.0	208.5
Boron	10.9	11.0	10.95	11.
Bromine	79.34	79.95	79.955	79.96
Cadmium	111.55	112.4	112.3	112.
Caesium	131.9	132.9	132.9	133.
Calcium	39.8	40.1	40.1	40.
Carbon	11.9	12.0	12.001	12.00
Cerium	138.0	139.0	140.	140.
Chlorine	35.18	35.45	35.455	35.45
Chromium	51.7	52.1	52.14	52.1
Cobalt	58.55	59.00	59.00	59.
Columbium	93.0	93.7	94.	94.
Copper	63.1	63.6	63.60	63.6
Erbium	164.7	166.0	166.	166.
Fluorine	18.9	19.05	19.05	19.
Gadolinium	155.8	157.0	156. ?	....
Gallium	69.5	70.0	70.0	70.
Germanium	71.9	72.5	72.5	72.
Glucinum	9.0	9.1	9.1	9.1
Gold	195.7	197.2	197.3	197.2
Helium	?	?	4.0?	4.
Hydrogen	1.000	1.008	1.0075	1.01
Indium	113.1	114.0	114.	114.
Iodine	125.89	126.85	126.85	126.85
Iridium	191.7	193.1	193.0	193.
Iron	55.6	56.0	56.0	56.
Lanthanum	137.6	138.6	138.5	138.
Lead	205.36	206.92	206.92	206.9
Lithium	6.97	7.03	7.03	7.03
Magnesium	24.1	24.3	24.36	24.36
Manganese	54.6	55.0	55.02	55.
Mercury	198.50	200.0	200.0	200.3
Molybdenum	95.3	96.0	96.0	96.
Neodymium	142.5	143.6	143.6	144.
Nickel	58.25	58.70	58.70	58.7

	Clarke.			
	H = 1.	O = 16.	Richards.	German.
Nitrogen	13.93	14.04	14.045	14.04
Osmium	189.6	191.0	190.8	191.
Oxygen	15.88	16.000	16.0000	16.00
Palladium	106.2	107.0	106.5	106.
Phosphorus	30.75	31.0	31.0	31.
Platinum	193.4	194.9	195.2	194.8
Potassium	38.82	39.11	39.140	39.15
Praseodymium	139.4	140.5	140.5	140.
Rhodium	102.2	103.0	103.0	103.
Rubidium	84.75	85.4	85.44	85.4
Ruthenium	100.9	101.7	101.7	101.7
Samarium	149.2	150.3	150.0	150.
Scandium	43.8	44.1	44.	44.1
Selenium	78.6	79.2	79.2	79.1
Silicon	28.2	28.4	28.4	28.4
Silver	107.11	107.92	107.930	107.93
Sodium	22.88	23.05	23.050	23.05
Strontium	86.95	87.60	87.68	87.6
Sulphur	31.83	32.07	32.065	32.06
Tantalum	181.5	182.8	183.	183.
Tellurium	126.5	127.5?	127.5?	127.
Terbium	158.8	160.	160.	....
Thallium	202.61	204.15	204.15	204.1
Thorium	230.8	232.6	233.	232.
Thulium	169.4	170.7	170.?	....
Tin	118.1	119.0	119.0	118.5
Titanium	47.8	48.15	48.17	48.1
Tungsten	182.6	184.	184.4	184.
Uranium	237.8	239.6	240.	239.5
Vanadium	51.0	51.4	51.4	51.2
Ytterbium	171.9	173.2	173.	173.
Yttrium	88.3	89.0	89.0	89.
Zinc	64.9	65.4	65.40	65.4
Zirconium	89.7	90.4	90.5	90.6

PRELIMINARY COMMUNICATION ON THE CHEMISTRY OF MUCIN.[1]

By P. A. Levene.

Received December 23, 1899.

THE proteids may be divided into two main groups: First, simple proteids, second, combined proteids. Of the latter the most common are the nucleo-compounds and the mu-

---

[1] Read before the New York Section of the American Chemical Society, November 10, 1899.