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TWENTY-THIRD ANNUAL REPORT OF COMMITTEE ON ATOMIC WEIGHTS. DETERMINATIONS PUBLISHED DURING 1915.

BY GREGORY PAUL BAXTER.

Received January 26, 1916.

The number of new researches upon the atomic weights published during the past year is as large as could be expected under prevailing conditions.

For the first time since 1912 the International Committee on Atomic Weights[1] recommends changes in the accepted values for a few ele ents. These changes are as follows:

	1912.	1916.
Carbon	12.00	12.005
Sulfur	32.07	32.06
Helium	3.99	4.00
Tin	119.0	118.7
Lead	207.10	207.20
Radium	226.4	226.0
Uranium	238.5	238.2
Ytterbium	172.0	173.5
Praseodymium	140.6	140.9
Yttrium	89.0	88.7
Lutecium	174.0	175.0

Oxygen.—Germann[2] discusses critically determinations of the density

[1] THIS JOURNAL, **37**, 2449 (1915).

[2] *J. Phys. Chem.*, **19**, 437 (1915).

of oxygen and describes in detail his own experiments in this field.[1] His final conclusion is that the weight of the normal liter is 1.42905 g.

Carbon.—By analysis of the calcium and ammonium salts of salicylic acid and the ammonium salts of *m*- and *p*-oxybenzoic acids Oechsner de Coninck[2] found the molecular weight of these acids to be 137.99. If H = 1.008, carbon is 11.99. As only four experiments were performed and the quantities used were very small, this result has little significance.

Copper.—Shrimpton[3] compared the weights of simultaneous silver and copper deposits. The silver cells were of the Guthe-Richards porous pot type. Corrections were made for inclusions in the silver and for cathodic solution of the copper. Vacuum weights are given.

Weight Ag.	Weight Cu.	At. wt. Cu.	Weight Ag.	Weight Cu.	At. wt. Cu.
2.21697 2.21636	0.65306 0.65309 0.65305	63.567	2.29785 2.29783	0.67673 0.67724 0.67701 0.67718	63.572
4.32294 4.32294	1.27358 1.27341 1.27351 1.27346	63.561	3.54120 3.54370	1.04372 1.04339 1.04367 1.04327	(63.558)
2.18669 2.18601	0.64406 0.64406 0.64416 0.64407 0.64415	63.563	3.91789 3.91852	1.15430 1.15434 1.15362 1.15486	63.562
2.14755 2.14747	0.63264 0.63262 0.63255 0.63266	63.559	4.83364 4.82973	1.42323 1.42331 1.42331 1.42320	(63.556)
3.24431 (3.24523)	0.95570 0.95580 0.95581 0.95564	63.561	2.43820 2.43837	0.71818 0.71844 0.71828 0.71835	63.562
				Average,	63.563

Molybdenum.—Müller[4] has determined the atomic weight of this element by oxidizing weighed amounts of the metal in a current of air and weighing the resulting oxide. The metal was prepared by reduction in hydrogen from oxide which had been fractionally sublimed as hydroxychloride in a current of hydrochloric acid. Quartz apparatus was utilized. Weights are corrected to vacuum.

[1] *Comp. rend.*, **157**, 926 (1913); see also 21st Annual Report, THIS JOURNAL, **36**, 457 (1914).

[2] *Compt. rend.*, **160**, 67 (1915).

[3] *Proc. Phys. Soc. London*, **26**, 292 (1914).

[4] THIS JOURNAL, **37**, 2046 (1915).

Fraction.	Weight Mo.	Weight MoO_3.	At. Wt. Mo.
I	0.52591	0.78879	96.027
I	0.56327	0.84487	96.012
I	1.12757	1.69117	96.031
II	0.53014	0.79517	96.014
II	1.10754	1.66130	96.002
II	1.62166	2.43181	96.080
II	1.45530	2.18259	96.047
III	0.94968	1.42428	96.048
III	0.65659	0.9870	96.054
		Mean,	96.035
		Mean, omitting the 6th analysis,	96.029

Cadmium.—Oechsner de Coninck and Gerard[1] ignited weighed amounts of cadmium carbonate and then reduced the resulting oxide to metal in a current of hydrogen. It is worth noting that an error of 0.1 mg. in the weight of the metal would alter the atomic weight by nearly one-tenth of a unit.

Weight $CdCO_3$.	Weight Cd.	At. wt. Cd.
0.5500	0.3585	112.32
0.6050	0.3943	112.28
0.6600	0.4302	112.32
0.6171	0.4023	112.37
0.5445	0.3549	112.31
	Average,	112.32

Cadmium.—Hulett and Quinn[2] have published a paper in support of their earlier work.

Tin.—Briscoe[3] purified stannic chloride by fractional distillation, the portions analyzed being collected in weighed bulbs. After being re-weighed the bulbs were broken under a solution of oxalic and nitric acids and the chloride was compared with weighed amounts of pure silver. Vaccuum weights are given.

Cl = 35.460.

Weight $SnCl_4$.	Weight Ag.	At. wt. Sn.	Weight $SnCl_4$.	Weight Ag.	At. wt. Sn.
9.02435	14.9475	118.685	7.55785	12.5183	118.688
9.39855	15.5666	118.696	9.11535	15.0983	118.683
10.32760	17.1058	118.689	9.22875	15.2866	118.675
9.17005	15.1880	118.699	9.21890	15.2696	118.686
6.68995	11.0808	118.686	11.29055	18.7017	118.675
9.33130	15.4570	118.666	9.89635	16.3912	118.694
7.77450	12.8764	118.702	9.43385	15.6250	118.696
9.22730	15.2840	118.678			
				Average,	118.686

[1] *Compt. rend.*, **161**, 676 (1915).
[2] This Journal, **37**, 1997 (1915).
[3] *J. Chem. Soc.*, **107**, 63 (1915).

Praseodymium.—Baxter and Stewart[1] purified praseodymium material by fractional crystallization of the double ammonium nitrate. Each fraction was converted to chloride, which, after fusion in an atmosphere of hydrochloric acid gas, was compared with silver and silver chloride in the usual way. Weights are corrected to vacuum.

Cl = 35.457.

Fraction.	Weight of $PrCl_3$.	Weight of AgCl.	At. wt. Pr.	Weight of Ag.	At. wt. Pr.
3474	4.12848	7.17915	140.913	....	...
3474	6.91605	12.02533	140.939	....	...
3474	7.66554	13.32931	140.923	10.03129	140.943
3474	5.01155	8.71379	140.941	6.55898	140.914
3474	8.78959	....	...	11.50311	140.924
4383	6.04235	10.50744	140.909	7.90820	140.910
4383	6.14745	10.69050	140.902	8.04563	140.914
4381	6.32550	10.99855	140.937	8.27886	140.908
4381	5.12982	....	...	6.71359	140.920
4381	4.59463	7.98940	140.925	6.01331	140.915
4381	4.77556	....	...	6.24994	140.921
4379	5.96661	10.37554	140.913	7.80908	140.910
4379	6.87536	11.95508	140.928	8.99824	140.915
4377	5.73602	....	...	7.50707	140.917
4377	4.64585	8.07758	140.951	6.08029	140.917
4374	6.85492	11.91774	140.965	8.97148	140.916
4374	8.01711	13.93953	140.943	10.49250	140.916
4374	6.17045	10.72833	140.952	8.07425	140.959
4374	6.90040	11.99946	140.911	9.03064	140.926
4374	7.08498	12.32019	140.916	9.27274	140.911
4374	5.81310	....	...	7.60811	140.911
4371	6.20845	10.79552	140.926	8.12541	140.915
4371	7.07590	12.30401	140.924	9.26045	140.922
4368	5.77646	10.04403	140.935	7.56000	140.916
4368	5.72002	9.94651	140.919	7.48596	140.922
		Average,	140.932		140.919

A very small proportion of cerium in Fractions 4368 and 4371 was quantitatively determined. When a correction is applied for this impurity, the average result of all the experiments is 140.924.

Tantalum.—Sears and Balke[2] have investigated the ratio $TaCl_5 : 5Ag$. The chloride was prepared from the oxide by distillation in a current of sulfur monochloride and the product was fractionally distilled. In Series I the chloride was hydrolyzed in a current of moist air, and the hydrochloric acid was absorbed and compared with silver. In Series II the chloride was transferred to a stoppered platinum weighing bottle without exposure to moisture, and after being weighed it was dissolved

[1] *Proc. Nat. Acad.*, **1**, 77 (1915); *Proc. Am. Acad.*, **50**, 171 (1915); THIS JOURNAL, **37**, 516 (1915); *Z. anorg. Chem.*, **92**, 171 (1915).

[2] THIS JOURNAL, **37**, 833 (1915).

in a large platinum flask in hydrofluoric acid solution concentrated enough to prevent the precipitation of silver tantalate. The chloride was next compared with silver. In Series III the same method of analysis was used, but the number of distillations to which the chloride was subjected varied. Vacuum weights are given in the following tables:

SERIES I.

Weight of $TaCl_5$.	Weight of Ag.	At. wt. Ta.
11.66795	17.51344	182.06
7.61398	11.42585	182.14
4.09519	6.15647	181.50
8.09039	12.16628	181.40

SERIES II.

Weight of $TaCl_5$.	Weight of Ag.	At. wt. Ta.
3.53605	5.31834	181.34
2.99083	4.49851	181.32
6.21118	9.34345	181.27

SERIES III.

Weight of $TaCl_5$.	Weight of Ag.	At. wt. Ta.
4.03892	6.07417	181.36
3.32164	5.00133	180.96
2.68304	4.04002	180.93
3.01453	4.53953	180.90
3.95846	5.95931	181.00

The research is avowedly preliminary. The authors believe the composition of the chloride to vary with the conditions of distillation and are at present investigating this matter.

Lead.—Nonradioactive lead has been investigated by Baxter and Thorvaldson[1] and Baxter and Grover.[2] The first named compared lead bromide, which had been fused in an atmosphere containing hydrobromic acid, with silver and silver bromide. Br = 79.916. Weights are corrected to vacuum.

Weight of $PbBr_2$.	Weight of Ag.	At. wt. Pb.	Weight of AgBr.	At. wt. Pb.
6.55858	3.85610	207.14	6.71241	207.15
4.83285	2.84126	207.17	...	....
5.67758	3.33787	207.17	...	....
6.73361	3.95874	207.16	6.89124	207.17
5.93130	3.48660	207.21	...	....
5.01729	2.94968	207.17	5.13400	207.22
5.89902	3.46730	207.25	...	....
7.71526	4.53498	207.24	7.89526	207.20
7.40244	4.35157	207.20	...	....
7.01144	4.12154	207.21	7.17470	207.21
6.91460	4.06484	207.19	7.07672	207.16
8.12623	4.77679	207.22		
				Average, 207.19
		Average, 207.19		

In a similar series of experiments Baxter and Grover corrected for a trace of insoluble material in the fused lead bromide, which is neglected in the above series. The outcome of the two series is essentially the same.

[1] THIS JOURNAL, 37, 1020 (1915).

[2] *Proc. Nat. Acad.*, 1, 71 (1915); THIS JOURNAL, 37, 1027 (1915).

Weight of $PbBr_2$.	Weight of Ag.	At. wt. Pb.	Weight of AgBr.	At. wt. Pb.
5.27845	3.10271	207.23	...	....
2.65094	1.55822	207.23	...	....
4.08449	2.40104	207.17	...	....
4.97508	2.92473	207.15	...	....
4.05573	2.38398	207.20	4.15017	207.18
3.44158	2.02288	207.23	3.52224	207.14
5.17416	3.04158	207.19	5.29498	207.17
3.84522	2.26022	207.21	3.93446	207.22
4.30542	2.53086	207.19	4.40616	207.15
4.53467	2.66549	207.21	4.64048	207.18
5.78467	3.40044	207.19	5.91976	207.17
4.87104	2.86337	207.19	4.98467	207.18
6.28465	3.69447	207.19	6.43124	207.19
4.74644	2.79011	207.21	4.85708	207.20
6.82444	4.01148	207.21	6.98380	207.18
6.53721	3.84274	207.20	...	....
4.10128	2.41088	207.18	4.19791	(207.09)
2.64271	1.55352	207.18	...	....
6.30717	3.70718	207.23	...	....
	Average,	207.20	Average,	207.18

In order to determine whether common lead always possesses the same atomic weight Baxter and Grover also analyzed lead chloride which had been prepared from minerals from known widely different geographical sources. None of the material was radioactive.

Cl = 35.457.

Mineral.	Source.	Weight of $PbCl_2$.	Weight of Ag.	At. wt. Pb.	Weight of AgCl.	At. wt. Pb.
		5.63567	4.37200	207.21	...	....
	Commercial	5.58730	4.33427	207.22	...	....
	nitrate	6.86319	5.32402	207.22	...	....
Galena	Joplin, Mo.,	4.70770	3.65223	207.20	...	....
	U. S. A.	4.20222	3.25968	207.23	...	....
Cerussite	Wallace, Id.,	7.04688	5.46691	207.20	...	....
	U. S. A.	5.88935	4.56868	207.22	...	....
		6.96370	....	....	7.17754	207.22
		6.89046	....	....	7.10231	207.21
Vanadinite and	Tucson, Ariz.,	4.90083	3.80171	207.22	...	....
wulfenite	U. S. A.	5.79300	4.49404	207.21	...	....
Galena	Metalline Falls,	5.43965	4.21992	207.21	...	....
	Wash., U. S. A.	5.74504	4.45674	207.22	...	....
Galena	Nassau, Germany	6.57216	5.09849	207.21	...	....
		5.66330	4.39340	207.21	...	....
Cerussite	Eifel Mts., Ger-	5.73434	4.44857	207.21	...	....
	many	4.17445	3.23862	207.19	...	....
Cerussite	New South Wales	6.25884	4.85584	207.19	...	....
		5.25882	4.07933	207.23	...	....
		7.33227	...	....	7.55732	207.22
		6.51699	...	....	6.71690	207.23
			Average,	207.21		207.22

The average of all the different series of results is 207.20. This value is perceptibly higher than that obtained some years ago by Baxter and Wilson.

Radioactive Lead.—Hönigschmid and Mme. St. Horovitz[1] have continued their investigation upon radioactive lead by analysis of lead chloride prepared from carefully selected minerals.

Source.	Weight of $PbCl_2$.	Weight of Ag.	At. wt. Pb.	Weight of AgCl.	At. wt. Pb.
St. Joachimsthal, Pitchblende	2.91224	...	...	3.01042	206.410
	2.47886	...	...	2.56256	206.396
	2.76797	...	...	2.86126	206.413
				Average,	206.405
Crystallized uranium oxide, Morogoro, German East Africa	3.24177	2.52563	206.024	3.35537	206.054
	3.94867	3.07636	206.025	4.08686	206.066
	3.78263	2.94693	206.033	3.91519	206.053
	3.68899	2.87400	206.030	3.81830	206.052
	4.49731	3.50343	206.054	4.65464	206.070
		Average,	206.033	Average,	206.059
Bröggerit, Moos, Norway	4.50069	...	...	4.65794	206.082
	4.49363	...	...	4.65060	206.084
				Average,	206.083
Bröggerit, Moos, Norway, distilled $PbCl_2$	4.83605	3.76724	206.060	5.00512	206.076
	3.97826	3.09903	206.060	4.11741	206.072
	4.91204	3.82647	206.057	5.08425	206.050
		Average,	206.059	Average,	206.066
Common lead, distilled $PbCl_2$	6.17861	4.79374	207.177	6.36895	207.193
	4.75170	3.68659	207.182	4.89837	207.176
	4.83397	3.75047	207.178	4.98328	207.170
		Average,	207.179	Average,	207.180

The leads from Morogoro and Moos possess a lower atomic weight than any other specimen of radioactive lead which has been examined.

Guye and Germann[2] have calculated the effect on various atomic weights of the gaseous impurities which they have found in silver.[3] Inasmuch as their investigations were not carried out with silver prepared with the care necessary for atomic weight experiments, it is premature to rely upon the corrections which they compute.

[1] *Sitzb. k. Akad., Wien, Abt. IIA,* **123,** 1 (1914); *Monatsh.,* **36,** 355 (1915).
[2] *Compt. rend.,* **159,** 992 (1914).
[3] See Twenty-second Annual Report; also *Compt. rend.,* **159,** 225 (1914).

The idiosyncrasies of the silver coulometer have been further investigated by Richards and Anderegg,[1] and Hulett and Vinal.[2]

CAMBRIDGE, MASS.

[CONTRIBUTION FROM THE NATIONAL BUREAU OF STANDARDS, PUBLISHED BY PERMISSION OF THE DIRECTOR.]

INCLUSIONS IN THE SILVER VOLTAMETER DEPOSITS.

BY G. W. VINAL AND WM. M. BOVARD.

Received December 31, 1915.

TABLE OF CONTENTS.

1. Introduction.

In a previous paper[3] on the voltameter a brief discussion of the question of inclusions of foreign materials in the silver voltameter deposits was given, together with a short résumé of other papers on this subject and a few experiments which had been made at the Bureau of Standards. It was pointed out that, in so far as the international ampere is concerned, the value assigned to the electrochemical equivalent of silver by the London Conference has been generally accepted by the various National laboratories as applying to the silver as we find it deposited in the voltameter, without reference to any inclusions that it may contain. This is not a serious matter because the uniformity of the results obtained by the National laboratories working together, indicated that the inclusions must be very small or very constant in amount and the International committee was enabled to fix the voltage for the Weston normal cell with sufficient accuracy for present purposes. But it was also stated in the reference mentioned above that it is important, if possible, to eliminate any error due to the inclusions, in order that we may know what deviation there is, if any, from the value assigned to the electrochemical equivalent of silver (1.11800 mg. per coulomb).

The earliest experiments of the Bureau on the inclusions in the silver were few in number and were not considered conclusive. Only one deposit was heated to incandescence and that was from an electrolyte in

[1] THIS JOURNAL, **37**, 675 (1915).

[2] *J. Phys. Chem.*, **19**, 173 (1915).

[3] "The Silver Voltameter," Part IV, by Rosa, Vinal, and McDaniel, *Bull. Bur. Standards*, **10**, 516, reprint No. 220.