Specific Gravity at			Percentage by weight.	Specific Gravity at			Percentage by weight.
$\frac{4^\circ}{4^\circ}$ C.	$\frac{15^\circ}{15^\circ}$ C.	$\frac{25^\circ}{25^\circ}$ C.		$\frac{4^\circ}{4^\circ}$ C.	$\frac{15^\circ}{15^\circ}$ C.	$\frac{25^\circ}{25^\circ}$ C.	
0.8923	0.8836	0.8756	68	0.9469	0.9392	0.9332	43
0.8946	0.8858	0.8779	67	0.9489	0.9412	0.9353	42
0.8969	0.8881	0.8803	66	0.9508	0.9433	0.9375	41
0.8992	0.8904	0.8826	65	0.9527	0.9454	0.9397	40
0.9014	0.8927	0.8850	64	0.9541	0.9469	0.9413	39
0.9037	0.8950	0.8874	63	0.9554	0.9484	0.9430	38
0.9060	0.8973	0.8897	62	0.9567	0.9499	0.9446	37
0.9083	0.8996	0.8921	61	0.9580	0.9514	0.9462	36
0.9106	0.9019	0.8944	60	0.9594	0.9529	0.9479	35
0.9129	0.9041	0.8968	59	0.9607	0.9544	0.9495	34
0.9151	0.9064	0.8991	58	0.9620	0.9559	0.9512	33
0.9174	0.9087	0.9015	57	0.9634	0.9574	0.9528	32
0.9197	0.9110	0.9038	56	0.9647	0.9589	0.9545	31
0.9220	0.9133	0.9062	55	0.9660	0.9604	0.9561	30
0.9243	0.9156	0.9086	54	0.9674	0.9619	0.9578	29
0.9266	0.9179	0.9109	53	0.9687	0.9635	0.9594	28
0.9289	0.9202	0.9133	52	0.9700	0.9650	0.9611	27
0.9311	0.9224	0.9156	51	0.9714	0.9665	0.9627	26
0.9334	0.9247	0.9180	50	0.9727	0.9680	0.9644	25
0.9354	0.9268	0.9202	49	0.9740	0.9795	0.9660	24
0.9373	0.9289	0.9223	48	0.9754	0.9710	0.9677	23
0.9392	0.9309	0.9245	47	0.9767	0.9725	0.9693	22
0.9411	0.9330	0.9267	46	0.9780	0.9740	0.9709	21
0.9431	0.9351	0.9288	45	0.9794	0.9755	0.9726	20
0.9450	0.9371	0.9310	44				

REPORT OF COMMITTEE ON ATOMIC WEIGHTS, PUBLISHED DURING 1894.[1]

By F. W. Clarke.

Received January 2, 1895.

To the Members of the American Chemical Society:

YOUR committee upon atomic weights respectfully submits the following report, which summarizes the work done in this department of chemistry during 1894. Although the volume of completed determinations is not large, it is known that several important investigations are in progress, from which valuable results may be expected in the near future. It is in this country that the greatest activity exists, and that the greatest progress is being made at present; and the preparation of these reports is therefore a peculiarly appropriate function of the Society. The data for 1894 are as follows:

The H: O ratio.—An interesting attempt at the indirect measurement of this ratio, which is the base line upon which our sys-

[1] Read at the Boston Meeting, December 28, 1894.

tem of atomic weights depends, has been made by Julius Thomsen.[1] His determinations are really determinations of the ratio $NH_3:HCl$, and were conducted thus: First, pure, dry, gaseous hydrochloric acid was passed into a weighed absorption apparatus containing pure distilled water. After noting the increase in weight, gaseous ammonia was passed through to slight excess, and the apparatus was weighed again. The excess of ammonia was then measured by titration with standard hydrochloric acid. In weighing, the apparatus was tared by another as nearly like it as possible, containing the same amount of water. Three sets of weighings were made, with apparatus of different size, and these Thomsen considers separately, giving the greatest weight to the experiments involving the largest masses of material. The data are as follows, with the ratio $\frac{HCl}{NH_3}$ in the third column:

FIRST SERIES.

Wt. HCl.	Wt. NH_3.	Ratio
5.1624	2.4120	2.1403
3.9425	1.8409	2.1416
4.6544	2.1739	2.1411
3.9840	1.8609	2.1409
5.3295	2.4898	2.1406
4.2517	1.9863	2.1405
4.8287	2.2550	2.1414
6.4377	3.0068	2.1411
4.1804	1.9528	2.1407
5.0363	2.3523	2.1410
4.6408	2.1685	2.1411

SECOND SERIES.

Wt. HCl.	Wt. NH_3.	Ratio.
11.8418	5.5302	2.14130
14.3018	6.6808	2.14073
12.1502	5.6759	2.14067
11.5443	5.3927	2.14073
12.3617	5.7733	2.14118

THIRD SERIES.

Wt. HCl.	Wt. NH_3.	Ratio.
19.3455	9.0360	2.14094
19.4578	9.0890	2.14081

[1] *Ztschr. phys. Chem.*, 13, 398.

From the sums of the weights Thomsen finds the ratio to be 2.14087, or 2.13934 in vacuo. From this, using Ostwald's reduction of Stas' data for the atomic weights of nitrogen and chlorine, he gets the ratio O : H : : 16 : 0.99946, or almost exactly 16 : 1. In a later paper[1] Thomsen himself recalculates Stas' data, with O = 16 as the basis of computation, and derives from them the subjoined values for the elements which Stas studied:

Ag	107.9299
Cl	35.4494
Br	79.9510
I	126.8556
S	32.0606
Pb	206.9042
K	39.1507
Na	23.0543
Li	7.0307
N	14.0396

Combining these values for chlorine and nitrogen with his ratio $HCl:NH_3$ he gets O : H : : 16 : 0.9992. This, however, is only an apparent support of Prout's hypothesis, for it depends upon the anti-Proutian determinations of Stas. If we calculate from Thomsen's new ratio with N = 14 and Cl = 35.5, it gives H = 1.0242; which is most unsatisfactory. In short, the method followed by Thomsen is too indirect and subject to too many possibilities of error to entitle it to much weight in fixing so important a constant as the atomic weight of oxygen. The direct processes, followed by several recent investigators, and giving O = 15.87 to 15.89 are much more trustworthy. Meyer and Seubert[2], in their criticism of Thomsen's work, have pointed out some of its uncertainties.

In this connection it may be noted that Scott's research upon the composition of water by volume, cited by abstract in the report of last year, has been published in full in the Philosophical Transactions.[3]

Strontium.—The atomic weight of strontium has been redetermined by Richards[4] from analyses of the bromide. The first ratio measured, after a careful preliminary study of materials

[1] *Ztschr. phys. Chem.*, 13, 726.
[2] *Ber d. chem. Ges.*, 27, 2770. See also abstract by Ostwald in *Ztschr. phys. Chem.*, 15, 705.
[3] 184, 543, *1893*.
[4] *Proc. Amer. Acad.* *1894*, 369.

and methods, was that between silver and strontium bromide. Of this ratio, three sets of determinations were made, all volumetric, but with differences of detail in the process. The weights are as follows, with the ratio $Ag_2 : SrBr_2 :: 100 : x$ in the third column:

FIRST SERIES.

Wt. Ag.	Wt. $SrBr_2$.	Ratio.
1.30755	1.49962	114.689
2.10351	2.41225	114.677
2.23357	2.56153	114.683
5.36840	6.15663	114.683
Sum, 11.01303	12.63003	114.683

SECOND SERIES.

Wt. Ag.	Wt. $SrBr_2$.	Ratio.
1.30762	1.49962	114.683
2.10322	2.41225	114.693
4.57502	5.24727	114.694
5.36800	6.15663	114.691
Sum, 13.35386	15.31577	114.692

THIRD SERIES.

Wt. Ag.	Wt. $SrBr_2$.	Ratio.
2.5434	2.9172	114.697
3.3957	3.8946	114.692
3.9607	4.5426	114.692
4.5750	5.2473	114.695
Sum, 14.4748	16.6017	114.694

From these data we have, if $Ag = 107.93$, and $Br = 79.955$, $(O = 16)$, the following results:

From first series............	$Sr = 87.644$
" second series.........	87.663
" third series..........	87.668

In two additional series, partly identical with the foregoing, the silver bromide thrown down was collected and weighed. I subjoin the weighings with the ratio $2AgBr : SrBr_2$ in the last column.

FIRST SERIES.

2AgBr.	$SrBr_2$.	Ratio.
2.4415	1.6086	65.886
2.8561	1.8817	65.884
6.9337	4.5681	65.883
Sum, 12.2313	8.0584	65.8834

SECOND SERIES.

2AgBr.	$SrBr_2$.	Ratio.
2.27625	1.49962	65.881
3.66140	2.41225	65.883
3.88776	2.56153	65.887
9.34497	6.15663	65.882
Sum, 19.17038	12.63003	65.883

From the first series........ Sr = 87.660
" " second series..... 87.659

The average of all five series is Sr = 87.659.

Barium.—Richards has corroborated his earlier determinations of the atomic weight of barium, which were made with the bromide, by means of additional series of experiments upon the chloride.[1] The work was carried out in the most elaborate and thorough manner, and for details the original paper must be consulted. First, barium chloride was titrated with standard solutions of silver, and the several series represent different methods of ascertaining accurately the end point. The data are as follows, with the ratio $Ag_2 : BaCl_2 :: 100 : x$ in the third column.

FIRST SERIES.

Wt. Ag.	Wt. $BaCl_2$.	Ratio.
6.1872	5.9717	96.517
5.6580	5.4597	96.495
3.5988	3.4728	96.499
9.4010	9.0726	96.507
0.7199	0.6950	96.541
		Mean, 96.512

SECOND SERIES.

Wt. Ag.	Wt. $BaCl_2$.	Ratio.
6.59993	6.36974	96.512
5.55229	5.36010	96.539
4.06380	3.92244	96.522
		Mean, 96.524

THIRD SERIES.

Wt. Ag.	Wt. $BaCl_2$.	Ratio.
4.4355	4.2815	96.528
2.7440	2.6488	96.531
6.1865	5.9712	96.520
3.4023	3.2841	96.526
		Mean, 96.526

[1] *Proc. Amer. Acad.*, **29**, 55.

FOURTH SERIES.

Wt. Ag.	Wt. $BaCl_2$.	Ratio.
6.7342	6.50022	96.525
10.6023	10.23365	96.523
		Mean, 96.524

All the weights represent vacuum standards. From the four series the atomic weight of barium is deduced as follows; when $O = 16$.

First series	Ba =	137.419
Second "	"	137.445
Third "	"	137.449
Fourth "	"	137.445

In three more series of experiments Richards determined the ratio between $2AgCl$ and $BaCl_2$. The data are subjoined, with the ratio $2AgCl : BaCl_2 :: 100 : x$ appended.

FIRST SERIES.

Wt. AgCl.	Wt. $BaCl_2$.	Ratio.
8.7673	6.3697	72.653
5.1979	3.7765	72.654
4.9342	3.5846	72.648
2.0765	1.5085	72.646
4.4271	3.2163	72.650
		Mean, 72.649

SECOND SERIES.

Wt. AgCl.	Wt. $BaCl_2$.	Ratio.
2.09750	1.52384	72.650
7.37610	5.36010	72.669
5.39906	3.92244	72.650
		Mean, 72.6563

THIRD SERIES.

Wt. AgCl.	Wt. $BaCl_2$.	Ratio.
8.2189	5.97123	72.6524
4.5199	3.28410	72.6587
		Mean, 72.6555

Hence we have for Ba,

First series	Ba	= 137.428
Second "	"	= 137.446
Third "	"	= 137.444

The mean of all is 137.440, as against 137.434 found in the work on the bromide. By combining the two chloride ratios,

$Ag_2 : BaCl_2$ and $2AgCl : BaCl_2$, the ratio $Ag : Cl$ can be computed. This gives $Ag = 107.930$, a value identical with that of Stas.

Cobalt and Nickel.—The atomic weights of these two metals have been redetermined by Winkler,[1] who adopts a radically new method, using the pure electrolytic elements as a starting-point. In each case, the weighed metal, deposited upon platinum, is treated with a weighed excess of iodine dissolved in potassium iodide. The metals are thus converted into iodides, and the excess of iodine is then measured by titration with thiosulphate solution. Thus the direct ratios, Co : I, Ni : I, are determined. Two series of estimations are given for each metal, with results as follows. The atomic weights used in calculation are $H = 1$, $I = 126.53$.

FIRST SERIES—COBALT.

Wt. Co.	Wt. I.	At. Wt. Co.
0.4999	2.128837	59.4242
0.5084	2.166750	59.3772
0.5290	2.254335	59.3828
0.6822	2.908399	59.3582
0.6715	2.861617	59.3824
	Mean,	59.3849

SECOND SERIES—COBALT.

0.5185	2.209694	59.3798
0.5267	2.246037	59.3430
0.5319	2.268736	59.3294
	Mean,	59.3507

Mean of all, $Co = 59.3678$.

FIRST SERIES—NICKEL.

Wt. Ni.	Wt. I.	At. Wt. Ni.
0.5144	2.217494	58.6702
0.4983	2.148502	58.6918
0.5265	2.268742	58.7268
0.6889	2.970709	58.6828
0.6876	2.965918	58.6678
	Mean,	58.6878

SECOND SERIES—NICKEL.

0.5120	2.205627	58.7436
0.5200	2.204107	58.7432
0.5246	2.259925	58.7432
	Mean,	58.7433

[1] *Ztschr. anorg. Chem.*, 8, 1.

Mean of all, Ni = 58.7155.

For O = 16, these become

Co = 59.517

Ni = 58.863.

Palladium—In 1889 Keiser published his determinations of the atomic weight of palladium, for which, since then, other investigators have found somewhat different values. He has now, jointly with Mary B. Breed, given a new set of determinations, which confirm his former series.[1] As before, palladiammonium chloride was reduced in hydrogen, the salt being prepared by two methods and carefully examined as to purity. Two series of experiments are given, with the following weights of material :

FIRST SERIES.

$Pd(NH_3Cl)_2$.	Pd.	At. Wt. Pd.
1.60842	0.80997	106.271
2.08295	1.04920	106.325
2.02440	1.01975	106.334
2.54810	1.28360	106.342
1.75505	0.88410	106.341
	From sum of weights,	106.325
	Reduced to vacuum,	106.246

SECOND SERIES.

$Pd(NH_3Cl)_2$.	Pd.	At. Wt. Pd.
1.50275	0.75685	106.297
1.23672	0.62286	106.296
1.34470	0.67739	106.343
1.49059	0.75095	106.353
	From sum of weights,	106.322
	Reduced to vacuum,	106.245

The atomic weight was computed with H = 1, N = 14.01, and Cl = 35.37. If O = 16 this becomes Pd = 106.51. This is only 0.02 less than the value obtained in the earlier investigation.

Tungsten.—A new determination of the atomic weight of tungsten, by Pennington and Smith,[2] leads to a much higher value than that commonly accepted. The older work seems very probably to have been done upon material contaminated

[1] *Am. Chem. J.*, 16, 20.

[2] Read before the Amer. Philos. Soc., Nov. 2, 1894.

with molybdenum, an impurity which was eliminated in this investigation by Debray's method,—that is, by volatilization by means of gaseous hydrochloric acid. The metal, carefully purified, was oxidized in porcelain crucibles, with all necessary precautions, and the following data are given:

Wt. W.	Wt. O_3.	At. Wt. W.
0.862871	0.223952	184.942
0.650700	0.168900	184.923
0.597654	0.155143	184.909
0.666820	0.173103	184.902
0.428228	0.111168	184.900
0.671920	0.174406	184.925
0.590220	0.153193	184.933
0.568654	0.147588	184.943
1.080973	0.280600	184.913
	Mean,	184.921

All weights are reduced to a vacuum, and $O = 16$ is taken as the standard of reference.

Another paper, by Smith and Desi, was read at the same meeting with that just cited. In this research, the tungstic oxide was purified in the same way, and reduced by heating in a stream of pure hydrogen. The water formed was weighed, and all weights reduced to a vacuum. Computed with $O = 16$ and $H = 1.008$, the results are as follows:

Wt. WO_3.	Wt. H_2O.	At. Wt. W.
0.983024	0.22834	184.683
0.998424	0.23189	184.709
1.008074	0.23409	184.749
0.911974	0.21184	184.678
0.997974	0.23179	184.704
1.007024	0.23389	184.706
	Mean,	184.704

Why this result should be lower than that previously found by Pennington and Smith remains to be explained.

Thallium.—Two determinations of atomic weight were made by Wells and Penfield to ascertain the constancy of the element as such.[1] The nitrate was fractionally crystallized until about one-twentieth remained in the mother-liquor, while another

[1] *Am. J. Sci.*, [3], 47, 466.

twentieth had been subjected to repeated recrystallization. Both fractions were converted into thallium chloride, which was dried at 100°, and in both the chlorine was estimated by weighing as silver chloride on a Gooch filter. The results were as follows:

	TlCl.	AgCl.	At. Wt. Tl.
Crystals.............	3.9146	2.3393	204.47
Mother-liquor........	3.3415	1.9968	204.47

Calculated with $Ag = 107.92$ and $Cl = 35.45$.

In the report for 1893 Lepierre's work on thallium was given, and the last value cited was $Tl = 203.00$, varying widely from the rest of the series, and affecting the mean. The mean stated by Lepierre was 203.62, and as found by me was 203.57. Lepierre[1] now calls attention to the fact that his value 203.00 was a misprint for 203.60, and that his mean was therefore correctly given. He also gives additional details relative to his work.

Bismuth.—The long-standing controversy between Schneider and Classen over the atomic weight of bismuth, has led to a new set of determinations on the part of Schneider.[2] The old method was still used; namely, of converting the metal into the trioxide by means of nitric acid and subsequent ignition of the nitrate; but the metal itself was carefully purified. Results as follows:

Wt. Bi.	Wt. Bi_2O_3.	Per cent. Bi in Bi_2O_3.
5.0092	5.5868	89.661
3.6770	4.1016	89.648
7.2493	8.0854	89.659
9.2479	10.3142	89.662
6.0945	6.7979	89.653
12.1588	13.5610	89.660
		Mean, 89.657

If $O = 16$, Bi ranges from 207.94 to 208.15, or in mean 208.05, confirming the earlier determinations.

Tin.—Incidentally to his paper on the white tin sulphide Schmidt gives one determination of the atomic weight of the metal.[3]

0.5243 gram Sn gave 0.6659 SnO_2. Hence $Sn = 118.48$.

[1] *Bull. Soc. Chim.*, [3], 11, 423.

[2] *J. prakt. Chem.*, [2], 50, 461.

[3] *Ber d. chem. Ges.*, 27, 2743.

Anomalous Nitrogen.—An important discovery has been made by Lord Rayleigh, who finds that nitrogen obtained by purely chemical methods is perceptibly lighter than that from atmospheric air.[1] Equal volumes of the gas, variously prepared, weighed as follows:

By passing NO over hot iron	2.30008
" " N_2O " " "	2.29904
" " $AmNO_2$ " " "	2.29869

For nitrogen from air he found:

From air passed over hot iron	2.31003
" " " through moist FeO_2H_2	2.31020
" " " over hot copper	2.31026

Investigating the cause of this anomaly, with the co-operation of Ramsay, Rayleigh came to the astonishing results communicated a few months later to the British Association. It was found, in short, that atmospheric air contains a gas heavier than nitrogen, and hitherto unknown. Its density, in a sample as pure as could be obtained, was 19.09, and it was characterized by extraordinary inertness. Whether it is a new element, or allotropic nitrogen, N_3, remains to be determined. The work is cited here because it shows that the density of nitrogen as hitherto determined, can give no trustworthy value for the atomic weight of the element.

Miscellaneous Notes.—Some data bearing upon the atomic weight of tellurium are given by Gooch and Howland.[2] As the homogeneity of tellurium is still uncertain, I omit their details.

Wanklyn's attempt to show that the atomic weight of carbon is not 12, but 6, was noted last year. He has since published more on the subject in a paper on Russian Kerosene,[3] and the matter was also discussed at the Oxford meeting of the British Association.[4]

In a communication upon the Stasian determinations,[5] Hinrichs discusses the availability of silver as a secondary standard in the scale of atomic weights. He makes silver, chlorine, bromine, iodine, and sulphur all Proutian in value. Hinrichs also

1 *Chem. News*, **69**, 231, May 18, *1894*.
2 *Am. J. Sci.*, [3], **48**, 375.
3 *Phil. Mag.*, [5], **37**, 495.
4 *Chem. News*, **70**, 87, Aug. 24, *1894*.
5 *Compt. rend.*, **118**, 528.

has published his views upon atomic weights *in extenso* in book form.[1]

In conclusion I submit a table of atomic weights revised to January 1, 1894. O = 16 is still retained as the base of the system; but I hope that in another year it will be practicable to return to H = 1.

Name.	Atomic Weight.	Name.	Atomic Weight.
Aluminum	27.	Neodymium	140.5
Antimony	120.	Nickel	58.7
Arsenic	75.	Nitrogen	14.03
Barium	137.43	Osmium	190.8
Bismuth	208.	Oxygen	16.
Boron	11.	Palladium	106.5
Bromine	79.95	Phosphorus	31.
Cadmium	112.	Platinum	195.
Caesium	132.9	Potassium	39.11
Calcium	40.	Praseodymium	143.5
Carbon	12.	Rhodium	103.
Cerium	140.2	Rubidium	85.5
Chlorine	35.45	Ruthenium	101.6
Chromium	52.1	Samarium	150.
Cobalt	59.5	Scandium	44.
Columbium	94.	Selenium	79.
Copper	63.6	Silicon	28.4
Erbium	166.3	Silver	107.92
Fluorine	19.	Sodium	23.05
Gadolinium	156.1	Strontium	87.66
Gallium	69.	Sulphur	32.06
Germanium	72.3	Tantalum	182.6
Glucinum	9.	Tellurium	125.
Gold	197.3	Terbium	160.
Hydrogen	1.008	Thallium	204.18
Indium	113.7	Thorium	232.6
Iodine	126.85	Thulium	170.7
Iridium	193.1	Tin	119.
Iron	56.	Titanium	48.
Lanthanum	138.2	Tungsten	184.9
Lead	206.95	Uranium	239.6
Lithium	7.02	Vanadium	51.4
Magnesium	24.3	Ytterbium	173.
Manganese	55.	Yttrium	89.1
Mercury	200.	Zinc	65.3
Molybdenum	96.	Zirconium	90.6

[1] The True Atomic Weight of the Chemical Elements, and the Unity of Matter. By Gustavus Detlef Hinrichs, St. Louis, 1894.