now. Enough has been said to show that such an application of the atomic theory is legitimate and is most highly important as a step towards the clearing up of the problems springing from the conception of valence and from the periodic system.

*Note.*—Since certain points in this paper require treatment at greater length than was practicable in an address, it will be followed by a second paper elaborating such portions.

UNIVERSITY OF NORTH CAROLINA, December 29, 1898.

# SIXTH ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS. RESULTS PUBLISHED IN 1898.

BY F. W. CLARKE.

Received January 10, 1898.

DURING the year 1898, there has been an increased activity in the determination of atomic weights, and a considerable number of investigations have been published. The importance of the subject is also indicated by the fact that the German Chemical Society has appointed a strong committee to report annually upon atomic weights; and its action for the current year is stated farther on. The new data are as follows:

## OXYGEN.

Keiser[1] has effected the complete synthesis of water, by a new method, in which the hydrogen held by palladium, the oxygen, and the water produced are all determined by successive weighings in one and the same apparatus. For details of construction, etc., the original memoir must be consulted. The data for four experiments are as follows:

| Weight H. | Weight O. | Sum H + O. | Weight $H_2O$. |
|---|---|---|---|
| 0.27549 | 2.18249 | 2.45798 | 2.45975 |
| 0.27936 | 2.21896 | 2.49832 | 2.49923 |
| 0.27091 | 2.15077 | 2.42168 | 2.42355 |
| 0.26845 | 2.13270 | 2.40115 | 2.40269 |

From columns first and second, the ratio H : O can be computed, while the first and fourth give the ratio $H : H_2O$.

| | Ratio H : O. | | Ratio $H : H_2O$. |
|---|---|---|---|
| | 7.922 | | 8.929 |
| | 7.943 | | 8.946 |
| | 7.939 | | 8.946 |
| | 7.944 | | 8.950 |
| Mean, | 7.937 | Mean, | 8.943 |

From ratio H : O, $O = 15.874$
" " $H : H_2O$, $O = 15.886$

Mean, 15.880

[1] *Am. Chem. J.*, 20, 733, November, *1898*.

This value is very near that obtained by Morley, 15.879; and has corroborative value. Its great merit is in the directness of the determination, and in the avoidance of complicated or troublesome corrections.

### NITROGEN.

The equivalent of cyanogen has been determined by Dean;[1] but as yet only an abstract of his work has appeared. Silver cyanide was dissolved in nitric acid, and titrated by Stas' method with potassium bromide. The data give $CN = 26.065$; whence, if $C = 12.01$, $N = 14.055$.

### BORON.

Armitage[2] has redetermined the atomic weight of boron by two methods. First, by determination of the percentage of water in borax, which had been washed with alcohol and ether successively, and then dried for six hours in a vacuum. The mean of six experiments gave

$$B = 10.959.$$

Secondly, by the method of Rimbach. Fused borax was dissolved in water and titrated with dilute sulphuric acid. The mean of two experiments gave

$$B = 10.928.$$

The abstract published gives no details of individual determinations, and neglects to state what values were assigned to the other atomic weights involved in the calculations, except that $O = 16$. The communication was discussed, in the main unfavorably, by Veley, Groves, Scott, and Dewar.

Armitage's paper called forth also a brief note from Leonard,[3] who refers to experiments of his own upon the dehydration of borax. He states that soda and boric acid are both volatilized when borax is intensely ignited, and that the composition of the residue is not constant. From this he concludes that the use of borax for determinations of atomic weight is liable to be attended by serious errors.

1 *Chem. News*, 78, 261, November 25, *1898*.
2 *Ibid.*, 77, 78. A paper read before the Chemical Society. Not yet printed in full.
3 *Ibid.*, 77, 104.

## ZINC.

In the atomic weight determinations made some years ago by Morse and Burton, metallic zinc was converted into oxide, and in that way the ratio between metal and oxygen was measured. Later, Richards and Rogers showed that zinc oxide, prepared as Morse and Burton had prepared it, namely, by conversion of the metal into nitrate and subsequent ignition, always retained occluded gases, and in distinctly weighable quantities.

The research is now completed by the labors of Morse and Arbuckle,[1] who have repeated the determinations made by Morse and Burton, with measurements of the occluded gases, and correction for them. In each experiment the gas, which consisted of oxygen and nitrogen, was analyzed; and the corrections applied assume the liter weights to be, under standard conditions at latitude 45° and sea-level, 1.42923 grams for oxygen, and 1.25461 for nitrogen. The volumes are given in cubic centimeters.

| Weight Zn. | Weight ZnO. | Volume gas. | Per cent. O. | Atomic weight Zn. |
|---|---|---|---|---|
| 1.19573 | 1.48860 | 0.468 | 26.28 | 65.459 |
| 1.03381 | 1.28707 | 0.402 | 18.14 | 65.445 |
| 1.06519 | 1.32599 | 0.342 | 18.42 | 65.459 |
| 1.05802 | 1.31711 | 0.312 | 18.58 | 65.440 |
| 1.26618 | 1.57619 | 0.521 | 13.82 | 65.489 |
| 1.03783 | 1.29198 | 0.408 | 35.28 | 65.475 |
| 1.08655 | 1.35276 | 0.412 | 19.55 | 65.437 |
| 1.11364 | 1.38647 | 0.456 | 18.62 | 65.447 |
| | | | Mean, | 65.457 |

O = 16. Vacuum weights are given. Without correction for occluded gases, Zn = 65.328, as against the earlier determination of Zn = 65.27. The new determinations agree closely with those of Richards and Rogers, who found Zn = 65.459, and of Richards alone, who found Zn = 65.404. The value assigned to zinc in the table of your committee is 65.41, as published a year ago.

## CADMIUM.

In the case of cadmium the same uncertainty existed as in the case of zinc. Morse and Jones had determined the atomic weight by conversion of the metal into the oxide, in that way

[1] *Am. Chem. J.*, 20, 195, March, *1898*.

finding Cd = 112.06. Morse and Arbuckle[1] have repeated the investigation, this time with search for occluded gases in the oxide, and now give a new series of data, with corrections applied. In all essential features the research is parallel to that upon zinc, which had just been noted; and the results obtained are given in the subjoined table. The weights are reduced to a vacuum, and O = 16.

| Weight Cd. | Weight CdO. | Volume of gas. | Per cent. O. | Atomic weight Cd. |
|---|---|---|---|---|
| 1.93188 | 2.20764 | 0.574 | 21.25 | 112.392 |
| 1.67935 | 1.91910 | 0.480 | 25.16 | 112.365 |
| 1.48430 | 1.69620 | 0.441 | 19.95 | 112.376 |
| 1.36486 | 1.55972 | 0.402 | 18.33 | 112.368 |
| 1.50295 | 1.71744 | 0.419 | 21.95 | 112.394 |
| 1.43804 | 1.64330 | 0.431 | 18.56 | 112.395 |
| 1.44041 | 1.64604 | 0.406 | 20.93 | 112.365 |
| 1.45938 | 1.66771 | 0.421 | 21.85 | 112.375 |
| 1.40379 | 1.60420 | 0.390 | 19.50 | 112.359 |
| | | | Mean, | 112.377 |

The uncorrected weighings give Cd = 112.084. Bucher, working with cadmium chloride and cadmium bromide, found the mean values 112.39 and 112.38, and the analysis of cadmium sulphate gave 112.36. These results accord fairly well with the determinations made by Dumas and by Huntington, but not with those of Hardin. The weight of evidence, however, now seems to be with the higher value, which may, with much probability, be adopted.

### COBALT AND NICKEL.

The paper by Winkler[2] upon these metals is merely a criticism of the determinations by Richards and Baxter, and Richards and Cushman, which were noticed in the committee report for 1897. No new determinations are offered. Winkler suggests that the bromides prepared by Richards and his associates, which were sublimed in porcelain tubes, might have acted upon the glaze of the latter, and so have acquired impurities. He also suggests that perhaps the bromide might have retained an excess of hydrobromic acid, and he points out possible danger in the use of the Gooch crucible, in which the silver bromide was collected.

1 *Am. Chem. J.*, 20, 536, July, *1898*.
2 *Ztschr. anorg. Chem.*, 17, 236, June 25, *1898*.

## SELENIUM.

The atomic weight of selenium has been redetermined by Lenher,[1] in the laboratory of the University of Pennsylvania. First, silver selenite was heated in a stream of gaseous hydrochloric acid, giving silver chloride, the latter being quite free from selenium. Three experiments gave as follows :

| Weight $Ag_2SeO_3$. | Weight AgCl. | Atomic weight Se. |
|---|---|---|
| 0.98992 | 0.82715 | 79.326 |
| 1.59912 | 1.33600 | 79.373 |
| 2.70573 | 2.26087 | 79.320 |
| | Mean, | 79.339 |

In a second series of eight experiments the silver chloride, after weighing, was reduced to metal in a stream of hydrogen. Thus the ratio between silver selenite and silver was measured. The weighings were as follows :

| Weight $Ag_2SeO_3$. | Weight AgCl. | Weight Ag. |
|---|---|---|
| 0.26204 | 0.21897 | 0.16480 |
| 0.58078 | 0.48522 | 0.36534 |
| 0.70614 | 0.58999 | 0.44417 |
| 0.80811 | 0.67532 | 0.50821 |
| 0.98396 | 0.82232 | 0.61882 |
| 1.29685 | 1.08350 | 0.81562 |
| 1.63103 | 1.36288 | 1.02588 |
| 2.00162 | 1.67234 | 1.25884 |

Hence, for the atomic weight of selenium we have :

| $Ag_2SeO_3$ : AgCl. | $As_2SeO_3$ : Ag. |
|---|---|
| 79.299 | 79.356 |
| 79.371 | 79.280 |
| 79.350 | 79.301 |
| 79.282 | 79.369 |
| 79.263 | 79.358 |
| 79.361 | 79.277 |
| 79.316 | 79.320 |
| 79.358 | 79.357 |
| Mean, 79.325 | Mean, 79.329 |

Still another set of determinations was based upon analyses of ammonium bromoselenate, $Am_2SeBr_6$. This salt was reduced by hydroxylamine hydrochloride, and the precipitated selenium was weighed in a Gooch crucible. The results are subjoined :

[1] This Journal, 20, 555, August, *1898*.

| Weight $Am_2SeBr_6$. | Weight Se. | Atomic weight Se. |
|---|---|---|
| 1.00059 | 0.13324 | 79.243 |
| 1.50153 | 0.20022 | 79.367 |
| 2.00059 | 0.26649 | 79.273 |
| 2.00126 | 0.26657 | 79.269 |
| 3.00125 | 0.39958 | 79.226 |
| 4.00216 | 0.53346 | 79.333 |
| 5.00218 | 0.66656 | 79.306 |
| 5.03001 | 0.66998 | 79.267 |
| | Mean, | 79.285 |

General mean of all twenty-seven determinations,

$$Se = 79.314.$$

The antecedent values are O = 16, H = 1.008, N = 14.04, Ag = 107.92, Br = 79.95, Cl = 35.45. All weights were reduced to a vacuum.

The result obtained is near that found by Dumas, but considerably higher than that given by Ekman and Pettersson. The reason for this disaccordance is yet to be found. In the table at the end of this paper the value assigned to selenium is the mean of Lenher's determination, and the value given in the report of last year; namely, when O = 16,

$$Se = 79.17.$$

Neither the new nor the old determinations can be yet adopted to the exclusion of the other, and the mean value is the safest for present use.

## TELLURIUM.

Metzner[1] has employed two methods for determining the atomic weight of this element. First, by synthesis of the sulphate, $Te_2SO_7$, which is perfectly stable at 440°. The tellurium which served as the starting-point was prepared by dissociation of hydrogen telluride, and was crystallized in beautiful needles. By solution in sulphuric acid, evaporation to dryness, and calcination at temperatures not over 440°, the sulphate was produced. The weights given are probably milligrams.

| Weight Te. | Weight sulphate. | Atomic weight Te. |
|---|---|---|
| 790.2 | 1235.0 | 127.9 |
| 414.3 | 647.5 | 128.0 |
| 1098.3 | 1717.0 | 127.8 |

[1] *Ann. chim. phys.* [7], 15, 272, October, *1898*.

Metzner's second method consisted in reducing tellurium dioxide by carbon monoxide, in presence of metallic silver. The latter prevents the volatilization of tellurium.

| Weight $TeO_2$ | Loss of weight. | Atomic weight Te. |
|---|---|---|
| 743.2 | 118.8 | 127.8 |
| 1106.7 | 221.3 | 128.0 |
| 988.5 | 197.0 | 128.24 |
| 1312.5 | 263.0 | 127.75 |

Metzner adopts 127.9 as the final result of his investigation. Apparently his weights were not reduced to a vacuum, and he neglects to state what value he assumed for the atomic weight of sulphur. $O = 16$ was evidently the basis of his calculations.

The work of Metzner called forth two theoretical papers by Wilde,[1] who holds that the experiments show that the true value for tellurium is 128. In his second paper he discusses the positions of tellurium and iodine in the periodic system. As both communications are purely critical in character, and contain no new data, they need no further notice here.

Still another set of determinations relative to tellurium is due to Heberlein.[2] First, telluric acid was dissolved in hydrochloric acid, and the liberated chlorine was distilled off into a dilute solution of potassium iodide. In the latter, iodine was set free, and was titrated with a decinormal solution of sodium thiosulphate. The values found for Te, with $O = 16$ and $H = 1.008$ are

| | |
|---|---|
| | 127.16 |
| | 127.28 |
| | 127.32 |
| | 127.35 |
| | 127.09 |
| Mean, | 127.24 |

Secondly, telluric acid was transformed into tellurium dioxide, by heating with proper precautions to avoid loss.

| Weight $H_2TeO_4.2H_2O$. | Loss of weight. | Atomic weight Te. |
|---|---|---|
| 1.35236 | 0.41431 | 126.60 |
| 1.76859 | 0.54122 | 126.84 |
| | Mean, | 126.72 |

1 *Compt. rend.*, **127**, 613, 616.

2 Beitrage zur Kenntnis des Tellur's.—Doctoral Dissertation : Strassburg, 1898.

Thirdly, tellurium dioxide was reduced to tellurium by means of hydrogen, in presence of metallic silver.

| Weight $TeO_2$. | Loss of weight. | Atomic weight Te. |
|---|---|---|
| 1.35908 | 0.37353 | 126.99 |
| 1.94038 | 0.39050 | 127.00 |
| | Mean, | 126.995 |

The mean of all three series is Te = 126.985.

It will be seen that some of these values range below, and others above, the atomic weight of iodine. Heberlein regards the higher figures as too high, and the lower as probably too low, the mean of all being most nearly correct. The main question, the position of tellurium in the periodic system, he considers experimentally unsettled, but favors the opinion that more critical determinations will place it below iodine and in the sulphur-selenium group. The value which he has actually found is only a trifle higher than that of iodine, and better determinations may well reduce it to the necessary amount.

## ZIRCONIUM.

Venable[1], in order to determine the atomic weight of this element, has availed himself of the oxychloride, $ZrOCl_2.3H_2O$. This compound can be crystallized from strong hydrochloric acid, and dried in a current of gaseous hydrochloric acid at 100°–125° without loss of its water. When dissolved in water in a platinum crucible, evaporated to dryness, and strongly ignited, pure zirconia, free from chlorine, remains. The ratio $ZrOCl_2.3H_2O : ZrO_2$ is thus determined, and from it the atomic weight of the metal is calculable. The results of ten experiments are given by Venable, as follows :

| Weight $ZrOCl_2.3H_2O$. | Weight $ZrO_2$. | Ratio. |
|---|---|---|
| 5.25762 | 2.78450 | 52.961 |
| 3.53994 | 1.87550 | 52.981 |
| 3.25036 | 1.72435 | 53.051 |
| 1.52245 | 0.80708 | 53.012 |
| 1.98802 | 1.58274 | 52.969 |
| 2.11371 | 1.11920 | 52.949 |
| 2.38139 | 1.26161 | 52.978 |
| 1.90285 | 1.00958 | 53.055 |
| 2.61847 | 1.38658 | 52.954 |
| 1.07347 | 0.56840 | 52.951 |
| 26.64828 | 14.11953 | 52.986 |

[1] This Journal, 20, 119, February, *1898*.

Hence, if $O = 16$, $H = 1.008$, and $Cl = 35.45$, the atomic weight of zirconium becomes

90.78 in mean,
91.12 maximum,
90.61 minimum.

As further results are promised, this investigation is to be regarded as a preliminary research, rather than as a final determination.

## THORIUM.

Brauner's work upon the atomic weight of thorium[1] has as yet appeared only in abstract. The determinations were made with the normal oxalate, in which thorium dioxide was estimated by heating, and the $C_2O_3$ was measured by titration with potassium permanganate. The values found for thorium with $O = 16$, were

| | |
|---|---|
| 232.50 | 232.33 |
| 232.46 | 232.50 |
| 232.45 | 232.44 |
| 232.31 | 232.35 |

In mean, Th = 232.42.

## CERIUM.

Brauner's paper upon the compound nature of cerium,[2] has also only appeared in abstract. By a series of fractionations oxides were obtained giving atomic weights ranging from 140.25 down to 130.70. As the atomic weight decreases, the color of the oxide changes from white to reddish-brown orange. Brauner infers that cerium is accompanied by another metal of atomic weight about 110. Yttrium was looked for in the lower fractions, but not found, nor were there any lines in the spark spectra, other than those of cerium. The supposed new element, like gadolinium, may have no characteristic spectrum.

## THE DIDYMIUMS.

Jones[3] has determined the atomic weights of neodymium and praseodymium by means of the synthesis of the sulphates from the oxides. The material for the investigation was furnished by Wal-

1 *Chem. News*, 77, 160, April 7, *1898*.
2 *Ibid.*, 77, 160, April 7, *1898*.
3 *Am. Chem. J.*, 20, 345, May, *1898*.

dron Shapleigh, and was very nearly pure. It was further purified by repeated fractional crystallizations of the double ammonium nitrates. From these salts the oxalates were prepared, and, from the latter, the oxides. The superoxide of praseodymium, $Pr_4O_7$, was reduced to $Pr_2O_3$ by ignition in hydrogen.

For praseodymium the results obtained were as follows, when $O = 16$ and $S = 32.07$:

| Weight $Pr_2O_3$. | Weight $Pr_2(SO_4)_3$. | Atomic weight Pr. |
|---|---|---|
| 0.5250 | 0.9085 | 140.42 |
| 0.6436 | 1.1135 | 140.50 |
| 0.7967 | 1.3788 | 140.38 |
| 0.7522 | 1.3018 | 140.38 |
| 0.7788 | 1.3473 | 140.53 |
| 0.6458 | 1.1172 | 140.54 |
| 0.6972 | 1.2062 | 140.51 |
| 0.7204 | 1.2464 | 140.49 |
| 0.8665 | 1.4990 | 140.54 |
| 0.6717 | 1.1624 | 140.40 |
| 0.7439 | 1.2873 | 140.42 |
| 0.6487 | 1.1224 | 140.47 |
| 8.4905 | 14.6908 | 140.46 |

With $O = 15.88$, $Pr = 139.41$.

For neodymium the data are as follows:

| Weight $Nd_2O_3$. | Weight $Nd_2(SO_4)_3$. | Atomic weight Nd. |
|---|---|---|
| 0.8910 | 1.5296 | 143.58 |
| 0.7880 | 1.3530 | 143.51 |
| 0.9034 | 1.5509 | 143.57 |
| 0.7668 | 1.3166 | 143.51 |
| 0.8908 | 1.5296 | 143.49 |
| 0.8848 | 1.5194 | 143.46 |
| 0.8681 | 1.4903 | 143.57 |
| 0.8216 | 1.4103 | 143.62 |
| 0.8531 | 1.4646 | 143.56 |
| 0.8711 | 1.4957 | 143.50 |
| 0.8932 | 1.5332 | 143.62 |
| 0.8893 | 1.5268 | 143.55 |
| 10.3212 | 17.7200 | 143.55 |

This value for neodymium must be corrected for the presence of a little praseodymium, which was estimated by the intensity of its lines in the spectrum. Corrected it becomes 143.6, or 142.52 when $O = 15.88$.

It is noteworthy that the values found by Jones almost absolutely reverse those given by von Welsbach, who puts praseodymium at 143.6 and neodymium at 140.8. Possibly the error in the latter figures may be only typographical.

Another determination of the atomic weight of praseodymium is due to C. von Schele,[1] who worked up 100 kilos of monazite to obtain his material for investigation. Two methods of determination were tried: one by synthesis of sulphate from oxide, the other based upon the oxalate. The oxide itself was prepared from the oxalate, and reduced from $Pr_4O_7$, or as v. Schele gives it, $PrO_2$, to $Pr_2O_3$, by ignition in hydrogen. Disregarding a preliminary series of experiments, made with impure material, and also the oxalate series, which gave unsatisfactory results, the final data are as follows:

| Weight $Pr_2O_3$. | Weight $Pr_2(SO_4)_3$. | Atomic weight Pr. |
|---|---|---|
| 0.6872 | 1.1890 | 140.30 |
| 0.7834 | 1.3550 | 140.46 |
| 0.6510 | 1.1260 | 140.45 |
| 0.7640 | 1.3216 | 140.42 |
| 0.5183 | 0.8967 | 140.32 |
| | Mean, | 140.40 |

This value, computed with O = 16, and S = 32, is sensibly identical with that found by Jones.

In the case of neodymium a single determination of atomic weight has been published by Boudouard.[2] 2.758 grams of sulphate gave 1.605 of oxide, or 58.194 per cent. Hence, with O = 16 and S = 32, Nd = 143.045.

In this connection the spectroscopic work of Demarçay,[3] may also be properly noted. This chemist has studied the spectrum of neodymium obtained from diverse sources, and finds it to be definite and uniform. He therefore concludes that the metal is a distinct element, and not, as some chemists have thought, a mixture.

A preliminary notice, by Brauner,[4] of determinations of atomic weight upon the two metals in question, has also appeared. The material studied was obtained from Dr. Shapleigh, the

1 *Ztschr. anorg. Chem.*, 17, 319.
2 *Compt. rend.*, 126, 900.
3 *Ibid.*, 126, 1039.
4 *Chem. News*, 77, 161, April 7, *1898*.

determinations being made by the sulphate and oxalate methods. For praseodymium he obtained values ranging from 140.84 to 141.19, the average of thirteen determinations being Pr = 140.95.

Neodymium gave values from 143.4 to 143.63, but the material used still contained two and nine-tenths per cent. praseodymium. Here again Welsbach's figures are reversed.

MISCELLANEOUS NOTES.

In a series of papers Daniel Berthelot[1] shows that the true molecular weights of gases can be computed from their normal densities with the help of their coefficients of compressibility. By suitable mathematical formulas, from existing data, he computes the following values, taking O = 16 as his standard of comparison.

| | | |
|---|---|---|
| H = | 1.0074. | |
| N = | 14.005. | From N and $N_2O$. |
| C = | 12.005. | From CO, $CO_2$, and $C_2H_2$. |
| A = | 39.882. | |
| Cl = | 35.479. | From HCl. |
| S = | 32.046. | From $SO_2$. |

From the density of nitrogen he finds N = 14.000; and from nitrous oxide, N = 14.007. These values he regards as superior to those determined by Stas, which are much higher; but Vèzes,[2] in a critical note, expresses the contrary opinion. After all, a mathematical discussion of data depends for its ultimate value upon the accuracy of the data, and an exact theory applied to inexact material may yield inferior results. It may well be asked, therefore, whether the experimental data discussed by Berthelot are superior to those furnished by the researches of Stas, and this is the real point at issue. So far, the work of Stas does not seem to be overthrown.

The paper by Dulk,[3] "Atomgewicht oder Atomgravitation," is essentially an abstract or summary of a book. Starting with H = 1, by a system of geometric configurations, the author computes a series of values for atomic weights, which are sometimes curiously near the experimental determinations. The following atomic weights are computed :

1 *Compt. rend.*, **126**, 954, 1030, 1415, and 1501.

2 *Ibid.*, **126**, 1714.

3 *Ber. d. chem. Ges.*, **31**, 1865, July 25, *1898*.

| | | | | | |
|---|---|---|---|---|---|
| Li, | 7.0 | I, | 126.23 | Cu, | 63.339 |
| Na, | 23.06 | N, | 14.0 | Ag, | 107.717 |
| K, | 39.111 | O, | 16.0 | Au, | 195.77 |
| Rb, | 84.96 | F, | 18.928 | Hg, | 198.45 |
| Cs, | 131.1 | B | 11.041 | Zn, | 65.385 |
| Cl, | 35.464 | C, | 11.9497 | Cd, | 112.0 |
| Br, | 79.666 | Si, | 28.0 | Tl, | 204.298 |

NEW TABLES.

Two new tables of atomic weights have appeared during the year; one by Richards,[1] the other by a committee of the German Chemical Society, consisting of Professors Landolt, Ostwald, and Seubert.[2] Both tables coincide in the main with that of your committee, but in some instances there are differences which can be eliminated only by new investigations.

Richards' table is preceded by a careful discussion of some points at issue, especially as regards the atomic weights of antimony, cadmium, calcium, magnesium, platinum, tungsten and uranium. For antimony, Richards prefers the value 119.92, or in round numbers 120, which depends on Cooke's analyses of the bromide, and involves the rejection of other data which seem entitled to some weight. For cadmium he accepts the higher value 112.3, rather than 112. Morse and Arbuckle's recent work lead me to adopt the value 112.38 for the present, bringing the committee table into harmony with that of Richards. In the case of calcium Richards regards the value 40.07 as too high, and adopts the round number 40. For magnesium, two values are in controversy, and here again Richards accepts the higher. In this case more evidence is needed. The same thing is true of platinum, tungsten, and uranium. The atomic weights of all three are uncertain to some tenths of a unit at least, and where Richards has selected data, I have preferred to use least square averages. New and better determinations are necessary in all three cases.

The committee of the German Chemical Society present their table without discussion of the data, so that it represents their careful judgment as to the best values for analytical use, unencumbered by argument. All three of the members, however, argue at length in favor of O = 16, as the basis of the scale, and give the well-known reasons in support of that view. Apart

1 *Am. Chem. J.*, 20, 543, July, *1898*.

2 *Ber. d. chem. Ges.*, 31, 2761, November 28, *1898*.

from theory, the oxygen scale certainly has the merit of greater convenience. The committee also suggest the desirability of an international commission upon atomic weights, and in that all chemists are likely to agree.

In the following table of atomic weight your committee give first its own sets of values, based upon both standards, H = 1, and O = 16. These values are only rounded off to the second decimal place, and represent, so far, the actual results of recalculation from the original data. Next is given Richards' table, and finally the table of the German Chemical Society, both sets of constants being more or less rounded off by the authors for convenience in practical use. It will be seen at once that the values adopted are in most cases sensibly identical. The new elements coronium, polonium, radium, monium, etherion, krypton, neon, xenon, and metargon are omitted, for lack of sufficiently precise data.

| | Clarke. | | | |
|---|---|---|---|---|
| | H = 1. | O = 16. | Richards. | German. |
| Aluminum | 26.91 | 27.11 | 27.1 | 27.1 |
| Antimony | 119.52 | 120.43 | 120.0 | 120. |
| Argon | ? | ? | 39.9 | 40. |
| Arsenic | 74.44 | 75.01 | 75.0 | 75. |
| Barium | 136.39 | 137.43 | 137.43 | 137.4 |
| Bismuth | 206.54 | 208.11 | 208.0 | 208.5 |
| Boron | 10.86 | 10.95 | 10.95 | 11. |
| Bromine | 79.34 | 79.95 | 79.955 | 79.96 |
| Cadmium | 111.54 | 112.38 | 112.3 | 112. |
| Caesium | 131.89 | 132.89 | 132.9 | 133. |
| Calcium | 39.76 | 40.07 | 40.0 | 40. |
| Carbon | 11.91 | 12.00 | 12.001 | 12.00 |
| Cerium | 138.30 | 139.35 | 140.0 | 140. |
| Chlorine | 35.18 | 35.45 | 35.455 | 35.45 |
| Chromium | 51.74 | 52.14 | 52.14 | 52.1 |
| Cobalt | 58.55 | 58.99 | 59.00 | 59. |
| Columbium | 93.02 | 93.73 | 94.0 | 94. |
| Copper | 63.12 | 63.60 | 63.60 | 63.6 |
| Erbium | 165.06 | 166.32 | 166.0 | 166. |
| Fluorine | 18.91 | 19.06 | 19.05 | 19. |
| Gadolinium | 155.57 | 156.76 | 156.0 | .... |
| Gallium | 69.38 | 69.91 | 70.0 | 70. |
| Germanium | 71.93 | 72.48 | 72.5 | 72. |
| Glucinum | 9.01 | 9.08 | 9.1 | 9.1 |
| Gold | 195.74 | 197.23 | 197.3 | 197.2 |
| Helium | ? | ? | 4.0 | 4. |
| Hydrogen | 1.000 | 1.008 | 1.0075 | 1.01 |

| | Clarke. R = 1. | Clarke. O = 16. | Richards. | German. |
|---|---|---|---|---|
| Indium | 112.99 | 113.85 | 114.0 | 114. |
| Iodine | 125.89 | 126.85 | 126.85 | 126.85 |
| Iridium | 191.66 | 193.12 | 193.0 | 193. |
| Iron | 55.60 | 56.02 | 56.0 | 56. |
| Lanthanum | 137.59 | 138.64 | 138.5 | 138. |
| Lead | 205.36 | 206.92 | 206.92 | 206.9 |
| Lithium | 6.97 | 7.03 | 7.03 | 7.03 |
| Magnesium | 24.10 | 24.28 | 24.36 | 24.36 |
| Manganese | 54.57 | 54.99 | 55.02 | 55. |
| Mercury | 198.49 | 200.00 | 200.0 | 200.3 |
| Molybdenum | 95.26 | 95.99 | 96.0 | 96. |
| Neodymium | 142.52 | 143.60 | 143.6 | 144. |
| Nickel | 58.24 | 58.69 | 58.70 | 58.7 |
| Nitrogen | 13.93 | 14.04 | 14.045 | 14.04 |
| Osmium | 189.55 | 190.99 | 190.8 | 191. |
| Oxygen | 15.88 | 16.00 | 16.000 | 16.00 |
| Palladium | 105.56 | 106.36 | 106.5 | 106. |
| Phosphorus | 30.79 | 31.02 | 31.0 | 31. |
| Platinum | 193.41 | 194.89 | 195.2 | 194.8 |
| Potassium | 38.82 | 39.11 | 39.140 | 39.15 |
| Praseodymium | 139.41 | 140.46 | 140.5 | 140. |
| Rhodium | 102.23 | 103.01 | 103.0 | 103.0 |
| Rubidium | 84.78 | 85.43 | 85.44 | 85.4 |
| Ruthenium | 100.91 | 101.68 | 101.7 | 101.7 |
| Samarium | 149.13 | 150.26 | 150.0 | 150. |
| Scandium | 43.78 | 44.12 | 44.0 | 44.1 |
| Selenium | 78.58 | 79.17 | 79.0 | 79.1 |
| Silicon | 28.18 | 28.40 | 28.4 | 28.4 |
| Silver | 107.11 | 107.92 | 107.93 | 107.93 |
| Sodium | 22.88 | 23.05 | 23.050 | 23.05 |
| Strontium | 86.95 | 87.61 | 87.68 | 87.6 |
| Sulphur | 31.83 | 32.07 | 32.065 | 32.06 |
| Tantalum | 181.45 | 182.84 | 183.0 | 183. |
| Tellurium | 126.52 | 127.49 | 127.5 | 127. |
| Terbium | 158.80 | 160.00 | 160.0 | .... |
| Thallium | 202.61 | 204.15 | 204.15 | 204.1 |
| Thorium | 230.87 | 232.63 | 233.0 | 232. |
| Thulium | 169.40 | 170.70 | 170.0 | .... |
| Tin | 118.15 | 119.05 | 119.0 | 118.5 |
| Titanium | 47.79 | 48.15 | 48.16 | 48.1 |
| Tungsten | 183.43 | 184.83 | 184.4 | 184. |
| Uranium | 237.77 | 239.59 | 240.0 | 239.5 |
| Vanadium | 50.99 | 51.38 | 51.4 | 51.2 |
| Ytterbium | 171.88 | 173.19 | 173.0 | 173. |
| Yttrium | 88.35 | 89.02 | 89.0 | 89. |
| Zinc | 64.91 | 65.41 | 65.40 | 65.4 |
| Zirconium | 89.72 | 90.40 | 90.5 | 90.6 |