VOL. XXXVI. MARCH, 1914. No. 3.

THE JOURNAL

OF THE

American Chemical Society

with which has been incorporated the

American Chemical Journal

(Founded by Ira Remsen)

TWENTY-FIRST ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS. DETERMINATIONS PUBLISHED DURING 1913.

BY GREGORY PAUL BAXTER.

Received February 6, 1914.

The following data have been obtained in the various investigations upon atomic weights published during 1913. Since in the past similar summaries have been essentially non-critical, the results are quoted without comment in the present report.

Oxygen.—Germann[1] has redetermined the weight of the normal liter of oxygen, and has obtained a value essentially identical with the one commonly accepted.

Globe 1. 872.33 cc.	Globe 2. 455.72 cc.	Globe 3. 410.27 cc.	Globe 4. 252.004 cc.
1.42889	1.42906	1.42941	1.42941
1.42901	1.42936	1.42940	1.42906
1.42877	1.42815	1.42896	1.42837
1.42847	1.42956	1.42896	1.42915
			General mean, 1.42900

Helium.—Heuse,[2] in seven experiments with a 547 cc. globe, finds the weight of the normal liter of helium to be as follows:

[1] *Compt. rend.*, **157**, 926 (1913).

[2] *Verh. deutsch. phys. Gesell.*, **15**, 518 (1913).

	0.17845
	0.17851
	0.17868
	0.17862
	0.17825
	0.17890
	0.17853
Mean,	0.17856

By the method of limiting densities he then calculates the molecular and atomic weight of helium to be 4.002.

Chlorine and Fluorine.—Jaquerod and Tourpaian[1] have determined the densities of chlorine and silicon tetrafluoride both by displacement of the gases with a vessel of known volume, and by the use of an ordinary density globe. Measurements were made at 15–20° and about 725 mm.

	Weight of one liter of chlorine at 0° and 725 mm.
By displacement.........	3.0630 at 15°
By displacement.........	3.0632 at 15°
By density globe.........	3.0624 at 15°
By density globe.........	3.0629 at 0°
Mean,	3.0629

Corrected for the deviation from Boyle's law, the weight of the normal liter is 3.2137 grams.

	Weight of one liter of silicon tetrafluoride at 0° and 725 mm.	
By displacement...........	4.4750	3 experiments at 20°
By density globe...........	4.4757	3 experiments at 20°
By density globe...........	4.4760	3 experiments at 0°
Mean,	4.4756	

The weight of the normal liter is then calculated to be 4.6929 grams. By the methods of "corresponding densities" and "critical constants" the atomic weight of chlorine is computed to be 35.28 and 35.27, respectively, and that of fluorine 19.10 and 19.09, the atomic weight of silicon being assumed to be 28.3.

Silver, Sulfur and Chlorine.—Scheuer[2] dissolved weighed amounts of pure silver in concentrated sulfuric acid. The sulfur dioxide evolved was liquefied and weighed. The silver sulfate, after it had been fused and weighed, was changed to silver chloride in a current of hydrochloric acid gas, and the silver chloride was weighed.

[1] *J. chim. phys.*, **11**, 3, 269 (1913).

[2] *Arch. sci. phys. nat.*, [4] 36, 381 (1913).

Wt. Ag.	Wt. SO_2.	Wt. Ag_2SO_4.	Wt. AgCl.	At. wt. Ag.	At. wt. S.	At. wt. Cl.
8.63592	2.56427	12.48100	11.47436	107.881	32.066	35.458
5.99316	1.77946	8.66142	7.96296	107.888	32.067	35.460
10.21124	3.03204	14.75768	13.56757	107.884	32.069	35.460
8.96085	2.66050	12.95023	11.90590	107.891	32.066	35.459
9.70232	2.88105	14.02239	12.89159	107.877	32.067	35.460
			Mean,	107.884	32.067	35.460

Silver.—Richards and Cox[1] have shown it to be improbable that lithium perchlorate, as prepared by Richards and Willard in their work upon the atomic weights of silver and lithium, contains any residual water. The value for the atomic weight of silver obtained by the latter, 107.871, therefore needs no correction.

Calcium.—The atomic weight of calcium has been determined by Oechsner de Coninck[2] by the conversion of weighed amounts of calcium carbonate into calcium sulfate, with the following results:

Weight $CaCO_3$.	Weight $CaSO_4$.	At. wt. Ca.
0.3300	0.4486	40.16
0.2640	0.3590	40.04
0.3630	0.4935	40.13
0.2541	0.3454	40.19
0.1524	0.2072	40.11
	Mean,	40.13

Barium.—Oechsner de Coninck[3] has also determined the atomic weight of barium through the carbonate by weighing the carbon dioxide evolved with nitric acid. The value 137.36 was obtained.

Radium.—Hönigschmid[4] has published additional data upon the analysis of radium bromide, and for sake of completeness all his results with the above salt are quoted below. In some analyses silver bromide was precipitated and weighed, in others the radium bromide was compared with silver. Ag = 107.880. Br = 79.916.

Weight $RaBr_2$.	Weight AgBr.	At. wt. Ra.
1.17016	1.13940	225.90
0.99658	0.97022	225.97
0.90111	0.87733	225.94
0.75504	0.73502	225.98
0.72731	0.70810	225.95
0.60329	0.58734	225.96
1.08458	1.05588	225.97
	Mean, omitting the first,	225.96

[1] *Com. Eighth Internat. Cong. Appl. Chem.*, **25**, 157 (1913).

[2] *Bull. belg. acad.*, **1913**, 222.

[3] *Rev. gén. chim.*, **16**, 245 (1913).

[4] *Sitzungsb. kais. Akad. Wien.*, **121**, Abt. II*a* 1973 (1912); *Monatsh. Chem.*, **34**, 283 (1913).

Weight $RaBr_2$.	Weight Ag.	At. wt. Ra.
0.68496	0.38306	225.97
0.60329	0.33739	225.97
		Mean, 225.97

For sake of comparison with Gray and Ramsay's method, Hönigschmid in two experiments converted radium bromide into radium chloride by heating in a current of hydrochloric acid gas. Cl = 35.457.

Weight $RaBr_2$.	Weight $RaCl_2$.	At. wt. Ra.
0.12885	0.09915	225.93
0.93192	0.71712	225.94

Hönigschmid also points out that Gray and Ramsay added the vacuum corrections to the weights of their salts instead of subtracting them, as was necessary since their weights were of quartz. Gray and Ramsay's results, when corrected for this error, are widely discrepant and deviate less from Hönigschmid's than the uncorrected.

Weight $RaBr_2$. Mg.	Weight $RaCl_2$. Mg.	At. wt. Ra.
2.85238	2.19536	226.20
2.76046	2.12422	225.95
2.61007	2.00922	226.42
2.43259	1.87213	226.11
2.35986	1.81687	226.61
		Mean, 226.26

The mean of Hönigschmid's results from analyses of the chloride and bromide is 225.96. To this value, however, must be added 0.01 as a correction for the temperature of the radium preparations, so that the final outcome of Hönigschmid's researches is the value 225.97 for the atomic weight of radium.

Cadmium.—Laird and Hulett[1] simultaneously electrolyzed cadmium and silver solutions. The cadmium was deposited in mercury in platinum vessels, and the silver on gold or platinum. The silver deposit was corrected for inclusions. Ag = 107.88. Vacuum weights are given.

Weight Cd.	Weight Ag.	At. wt. Cd.
2.2721	4.3638	112.340
2.2733		112.400
2.3549	4.5225	112.352
2.3534		112.276
2.6637	5.1186	112.280
2.6656		112.358
1.9937	3.8312	112.280
1.9938		112.288

[1] *Trans. Amer. Elect. Soc.*, **22**, 385 (1912).

Weight Cd.	Weight Ag.	At. wt. Cd.
2.2979	4.4148	112.302
2.2972		112.268
2.4265	4.6605	112.336
2.4261		112.318
2.1496	4.1297	112.308
2.1501		112.334
2.6679	5.1256	112.304
2.6675		112.288
		Mean, 112.313

This low result for the atomic weight of cadmium is in accord with the value 112.30 previously obtained by Perdue and Hulett and has been confirmed by Quinn and Hulett,[1] who determined electrolytically the cadmium content of fused cadmium chloride and bromide. After the salts were weighed they were converted into sulfate, and the cadmium was deposited in mercury in a platinum vessel. Weights are corrected to vacuum. Cl = 35.458. Br = 79.92.

Weight $CdCl_2$.	Weight Cd.	At. wt. Cd.
4.10119	2.51427	112.36
4.47151	2.74084	112.31
5.66452	3.47180	112.28
5.99291	3.67211	112.20
6.52910	4.00219	112.32
4.87415	2.98785	112.33
4.88423	2.99384	112.31
		Mean, 112.32

Weight $CdBr_2$.	Weight Cd.	At. wt. Cd.
4.95538	2.04468	112.28
4.15801	1.71573	112.29
5.31272	2.19183	112.26
4.31525	1.78013	112.24
4.55544	1.87940	112.26
5.69646	2.34983	112.23
4.47748	1.84754	112.29
5.36276	2.21228	112.24
		Mean, 112.26

Mercury.—Taylor and Hulett[2] synthesized mercuric oxide by heating mercury in oxygen. Weighed amounts were then decomposed at a high temperature with metallic iron, and the mercury was weighed.

[1] *J. Physic. Chem.*, **17**, 780 (1913).

[2] *Ibid.*, **17**, 755 (1913).

Weight HgO.	Weight Hg.	At. wt. Hg.
2.98464	2.76390	200.33
3.61841	3.35066	200.25
3.82184	3.53923	200.39
3.40356	3.15185	200.36
3.80726	3.52567	200.39
4.56858	4.23065	200.30
5.42945	5.02819	200.48
2.38313	2.20681	200.28
3.76766	3.48933	200.57
		Mean, 200.37

Scandium.—Lukens[1] extracted scandium material from Colorado wolframite. The purified salt showed no evidence of radioactivity, and its spark spectrum contained only scandium lines. Weighed amounts of anhydrous sulfate were calcined to oxide.

Weight $Sc_2(SO_4)_3$.	Weight Sc_2O_3.	At. wt. Sc.
0.30636	0.11134	44.59
1.14140	0.41553	44.77
		Mean, 44.68

Yttrium.—Three researches upon the atomic weight of yttrium have appeared during the past year. Egan and Balke[2] purified yttrium material by crystallization of the bromate and by fractional precipitation of the chromate, but spectroscopic examination showed a small proportion of erbium still to be present. After comparison of different methods, that of converting weighed amounts of yttrium oxide into anhydrous chloride was adopted. Cl = 35.46.

Weight Y_2O_3.	Weight YCl_3.	At. wt. Y.
0.72180	1.24092	90.54
0.80392	1.38437	90.10
0.70050	1.20610	90.14
0.73030	1.25755	90.11
		Mean, 90.22

R. J. Meyer and Wuorinen[3] freed yttrium material from other rare earths by fractional precipitation of the impurities with potassium iodate. Five syntheses of yttrium sulfate from the oxide yielded the following results, no correction being made for the retention of acid by the anhydrous sulfate. S = 32.0.

[1] THIS JOURNAL, **35**, 1470 (1913).
[2] *Ibid.*, **35**, 365 (1913).
[3] *Z. anorg. Chem.*, **80**, 7 (1913).

Weight Y_2O_3.	Weight $Y_2(SO_4)_3$.	At. wt. Y.
0.5096	1.0534	88.46
0.5126	1.0592	88.54
0.5491	1.1347	88.52
0.5071	1.0479	88.52
0.7234	1.4950	88.50
		Mean, 88.51

In two additional analyses the sulfuric acid retained by the sulfate was determined, and the necessary correction applied.

Weight Y_2O_3.	Weight $Y_2(SO_4)_3$.	At. wt. Y.
0.5544	1.1452	88.60
0.9003	1.8595	88.64
		Mean, 88.62

The purified material contained spectroscopic traces of several rare earths.

In a subsequent paper, R. J. Meyer and Weinheber[1] correct the results of Meyer and Wuorinen by recalculating them on the basis S = 32.07, and give the results of three experiments with new material purified as by the latter.

Weight Y_2O_3.	Weight $Y_2(SO_4)_3$.	At. wt. Y.
0.5544	1.1452	88.71
0.9003	1.8595	88.73
0.4954	1.0231	88.76
0.4972	1.0266	88.80
0.4980	1.0286	88.73
		Mean, 88.75

In another series of experiments Meyer and Weinheber calcined weighed amounts of anhydrous sulfate to oxide.

Weight $Y_2(SO_4)_3$.	Weight Y_2O_3.	At. wt. Y.
1.0248	0.4962	88.74
0.8585	0.4157	88.75
1.4060	0.6808	88.75
0.8944	0.4330	88.71
0.9795	0.4743	88.76
0.5686	0.2753	88.73
		Mean, 88.74

The above weights are not corrected to the vacuum standard. When this correction is made, the atomic weight of yttrium becomes 88.70.

Ytterbium.—Auer von Welsbach[2] has continued the fractionation of aldebaranium and cassiopeium material and has determined the atomic

[1] *Ber.*, **46**, 2672 (1913).

[2] *Monatsh. Chem.*, **34**, 1713 (1913).

weights of both by precipitating the oxalate from weighed amounts of the hydrated sulfate, and igniting the oxalate to oxide.

Weight $Cp_2(SO_4)_3.8H_2O$.	Weight Cp_2O_3.	At. wt. Cp.
2.0428	1.0394	175.06
2.0197	1.0274	174.96
2.4044	1.2232	175.00
	Mean,	175.00

Weight $Ad_2(SO_4)_3.8H_2O$.	Weight Ad_2O_3.	At. wt. Ad.
2.0530	1.0392	172.98
2.0891	1.0575	172.99
2.1155	1.0710	173.04
	Mean,	173.00

Selenium.—Bruylants and Bytebier[1] prepared selenium hydride by the action of water upon aluminum selenide and after the purification of the gas determined the weight of the liter at 0° and 760 mm., uncorrected for the force of gravity at Louvain, to be as follows:

	Globe 1. 410 cc.	Globe 2. 503 cc.	Globe 3. 603 cc.	Globe 4. 1006 cc.
	3.67108	3.67101	3.67215	3.67120
	3.67128	3.67101	3.67074	3.67243
	3.67141	3.67132	3.67163	3.67106
	3.67096	3.67110	3.67142	3.67216
	.....	.....	3.67246	3.67240
Mean,	3.67118	3.67111	3.67168	3.67185
			General mean,	3.6715

For purposes of comparison, Bruylants and Bytebier also determined the weight of a liter of oxygen under the same conditions.

Globe 1.	Globe 2.	Globe 3.	Globe 4.
1.42941	1.42977	1.42933	1.42942
1.42969	1.42932	1.42926	1.42980
.....	1.42921	.....	1.42966
		General mean,	1.4295

By the method of limiting densities the molecular weight of selenium hydride is computed to be 81.196, and the atomic weight of selenium, therefore, to be 79.18. (H = 1.008.)

Jannek and J. Meyer[2] have determined directly the ratio of selenium to oxygen by oxidizing weighed amounts of the element to the dioxide. The selenium was heated in a quartz vessel in a current of dry oxygen and nitrogen peroxide. To show that no material was lost by vaporization

[1] *Bull. Belg. Acad.*, **1912**, 856.

[2] *Z. Electroch.*, **19**, 833 (1913); *Z. anorg. Chem.*, **83**, 51 (1913).

during the process, in three experiments the dioxide was dissolved, the selenium precipitated by dilute hydrazine, collected upon a Neubauer crucible and weighed. The maximum difference between the selenium used and that recovered was 0.00003 gram. The following weights are reduced to the vacuum standard:

Weight Se.	Weight SeO_2.	At. wt. Se.
2.32307	3.26249	79.132
2.00162	2.81083	79.151
2.14178	3.00789	79.132
3.29634	4.62932	79.135
2.10447	2.95522	79.152
4.82540	6.77635	79.148
5.91515	8.30670	79.146
2.43479	3.41935	79.135
2.95206	4.14583	79.133
3.27487	4.59907	79.140
	Mean,	79.140

Tellurium.—Dudley and Bowers[1] reject as unsatisfactory the basic nitrate method of determining the atomic weight of tellurium and find the synthesis of the tetrabromide from the metal far more satisfactory. Five preliminary experiments with the same specimen of material give the following results (vacuum weights). Br = 79.92.

Weight Te.	Weight $TeBr_4$.	At. wt. Te.
0.479816	1.682387	127.550
0.296341	1.037049	127.897
0.433241	1.516746	127.819
0.457782	1.605684	127.487
0.321522	1.126939	127.612
	Mean,	127.673

Six final determinations were made with three different fractions.

Weight Te.	Weight $TeBr_4$.	At. wt. Te.
0.300558	1.054251	127.481
0.199807	0.700947	127.456
0.22032	0.773048	127.425
0.158161	0.554717	127.500
0.436907	1.532360	127.500
0.29811	1.045485	127.512
	Mean,	127.479

Copper.—The atomic weight of copper has been found by Oechsner de Coninck and Ducelliez[2] by dissolving weighed amounts of metal in nitric acid and igniting the residue after evaporation. Four results, which vary from 63.523 to 63.605, give an average value of 63.549.

[1] THIS JOURNAL, **35**, 875 (1913).

[2] *Rev. gén. chim.*, **16**, 122 (1913).

Iridium.—The atomic weight of iridium has been determined by Holzmann[1] by reduction of ammonium chloroiridiate in a current of hydrogen. The following weights are reduced to the vacuum standard. H = 1.008. N = 14.01. Cl = 35.46.

Weight $(NH_4)_2IrCl_6$.	Weight Ir.	At. wt. Ir.
1.09292	0.47809	193.50
1.15060	0.50299	193.27
0.80293	0.35126	193.52
0.78021	0.34119	193.39
		Mean, 193.42

Guye[2] compares critically the various methods employed in atomic weight investigations, and pleads for a more systematic attack on the problem from many quarters. Guareschi[3] calls attention to the universal presence of bromine in compounds of chlorine and iodine. Several articles have appeared dealing with the relations between the different atomic weights.[4]

THE ACCELERATION OF ELECTRICAL CONDUCTORS.

By Richard C. Tolman, Earl W. Osgerby and T. Dale Stewart.

Received December 26, 1913.

CONTENTS.

PART I. ACCELERATED ELECTROLYTES.

(Experimental Work Performed in the Chemical Laboratory of the University of Cincinnati by R. C. Tolman and E. W. Osgerby.)

1. Introduction.

The force of gravity has been found to produce a difference in electrical potential between the two ends of a vertical tube of salt solu-

[1] *Sitzungsb., Phys.-med. Soz. Erlangen*, **44**, 84 (1912).

[2] *J. chim. phys.*, **11**, 275 (1913).

[3] *Atti accad. sci. Torino*, **48**, 128 (1913).

[4] Bilecki, *Z. physik. Chem.*, **82**, 249; Borodovskii, *Chem. Ztg.*, **36**, 198; Büry, *Z. physik. Chem.*, **80**, 381; Dambier, *J. chim. phys.*, **11**, 260; Guye, *Ibid.*, 267; Feilmann, *Chem. News*, **107**, 15; Katayama, *Sci. Rep'ts Tohoku Imp. Univ. Sendai*, **1**, 171; Loring, *Chem. News*, **107**, 193; **108**, 95; Moir, *J. Chem. Met. Soc. S. Africa*, **13**, 544; Wilde, *Chem. News*, **108**, 52.