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THIRTY-FIFTH ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS. DETERMINATIONS PUBLISHED DURING 1928

By Gregory Paul Baxter

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The German Committee on Atomic Weights has issued its Annual Report.[1] During the past year the following investigations were published.

Addingley and Whytlaw-Gray,[2] by a differential method, have found the ratio of the deviations from Boyle's Law for oxygen and hydrogen to be 1.00148 for the pressure range 0–1 atmosphere.

Potassium.—Hönigschmid and Goubeau[3] have confirmed by analysis of potassium bromide the value recently found by them by analysis of the chloride. Potassium oxalate was recrystallized five times with rejection of mother liquors and small head fractions in each case. Conversion to bromide with an excess of the purest bromine was followed by double crystallization of the bromide. The salt was dried in a current of pure nitrogen at gradually increasing temperatures and finally was fused in this atmosphere. Comparison with silver was followed by the determination of the silver bromide formed. Weights in air are corrected to vacuum.

Table I

The Atomic Weight of Potassium

Wt. of KBr	Wt. of Ag	Ratio KBr:Ag	At. wt. K	Wt. of AgBr	Ratio KBr:AgBr	At. wt. K
6.43476	5.83244	1.103271	39.103	10.15286	0.633788	39.107
7.37102	6.68104	1.103274	39.105	11.63067	.633757	39.101
4.70287	4.26274	1.103250	39.103	7.42057	.633767	39.102
5.72267	5.18704	1.103263	39.104	9.02972	.633759	39.102
5.05508	4.58197	1.103250	39.103			
4.96244	4.49799	1.103257	39.103	7.83013	.633762	39.102
5.60505	5.08032	1.103287	39.107	8.84400	.633769	39.103
4.68275	4.24433	1.103295	39.108	7.38862	.633779	39.105
6.37343	5.77696	1.103250	39.103	10.05611	.633787	39.107
6.60947	5.99069	1.103290	39.107	10.42840	.633795	39.108
	Average	1.103270	39.105		.633774	39.104

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[1] *Ber.*, **61B,** 1 (1928).

[2] Addingley and Whytlaw-Gray, *Trans. Faraday Soc.*, **24,** 378 (1928).

[3] Hönigschmid and Goubeau, *Z. anorg. allgem. Chem.*, **177,** 102 (1928).

Hevesy and Lögstrup[4] through ideal distillation have effected a slight concentration of the heavier isotope of potassium. The atomic weight of the residual material has been determined by Hönigschmid and Goubeau to be 39.109 instead of the normal value found by them, 39.105.

Titanium.—Baxter and Butler[5] by the analysis of titanium tetrabromide have confirmed the result obtained by them through the analysis of the tetrachloride (see report for 1927). The tetrabromide was prepared by the action of bromine carried by helium on (1) titanium, and (2) a mixture of titanium dioxide and carbon. The product was fractionally distilled eighteen times in an exhausted glass apparatus, without exposure to air after the ninth distillation. In each distillation a head and a tail fraction were removed in sealed glass bulbs. Certain head and tail fractions obtained after the tenth distillation were analyzed by comparison with silver. Weights are corrected to vacuum. The numbers of the fractions increase with decreasing volatility.

Table II

The Atomic Weight of Titanium

Fraction	Wt. of $TiBr_4$	Wt. of Ag	Ratio $TiBr_4$:4Ag	At. wt. Ti
Head 11	10.02147	11.76512	0.851796	47.903
13	9.20373	10.80493	.851808	47.908
14	9.59208	11.26116	.851784	47.898
17	5.29301	6.21411	.851773	47.893
18	6.14520	7.21447	.851788	47.900
Tail 20	4.72253	5.54427	.851786	47.899
22	6.53582	7.67324	.851768	47.891
24	5.09864	5.98582	.851786	47.899
25	4.33488	5.08901	.851812	47.910
27	8.22722	9.65886	.851780	47.896
		Average	.851788	47.900

Copper.—Ruer[6] finds that copper which has been ignited in hydrogen at 750° to constant weight takes up not more than 0.001% of air (oxygen). The experimental values for the atomic weights of copper found by Ruer and Bode (see report for 1924) are lowered by only 0.002 if corrections for air adsorbed by copper oxide and copper are made.

Cesium.—Richards and Françon[7] extracted cesium salt from pollucite (Maine, U. S. A.) and purified cesium alum by several recrystallizations. Sulfate was removed by means of barium chloride and the cesium precipitated as perchlorate, which was recrystallized several times. Cesium chloride was obtained by thermal decomposition of the perchlorate and twice recrystallized. Drying by fusion in nitrogen containing a small

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[4] Hevesy and Lögstrup, *Z. anorg. allgem. Chem.*, **171**, 1 (1928).

[5] Baxter and Butler, This Journal, **50**, 408 (1928).

[6] Ruer, *Z. anorg. allgem. Chem.*, **169**, 251 (1928).

[7] Richards and Françon, This Journal, **50**, 2162 (1928).

proportion of hydrochloric acid in a bottling apparatus was followed by weighing and comparison with silver in the usual way. Weights are corrected to vacuum.

TABLE III

THE ATOMIC WEIGHT OF CESIUM

Wt. of CsCl	Wt. of Ag.	Ratio $CsCl:Ag$	At. wt. Cs
4.42344	2.83610	1.55969	132.802
5.01421	3.21416	1.56004	132.840[a]
4.14983	2.66099	1.55951	132.783
4.48842	2.87747	1.55985	132.820
	Average	1.55977	132.811

[a] Corrected for error in calculation.

Barium and Silver.—Hönigschmid and Sachtleben[8] dried barium perchlorate at 260° and converted it to chloride with hydrogen chloride at 550°. Both substances were weighed in exhausted vessels to avoid air adsorption. The barium chloride was then compared with silver in the usual way and the silver chloride was weighed in a few experiments.

TABLE IV

THE ATOMIC WEIGHTS OF SILVER AND BARIUM

Wt. of $Ba(ClO_4)_2$	Wt. of $BaCl_2$	Wt. of O_4	Wt. of Ag	Ratio $Ag:O_4$	At. wt. Ag
7.14254	4.42378	2.71876	4.58277	1.68561	107.879
12.02482	7.44756	4.57726	7.71567	1.68565	107.882
10.32340	6.39382	3.92958	6.62360	1.68558	107.877
10.64966	6.59588	4.05378	6.83327	1.68563	107.882
11.69950	7.24609	4.45341	7.50692	1.68566	107.882
			Average	1.68564	107.880

	Ratio $Ba(ClO_4)_2:BaCl_2$	Ratio $Ba(ClO_4)_2:2Ag$	Ratio $BaCl_2:2Ag$	Wt. of AgCl	Ratio $Ba(ClO_4)_2:2AgCl$	Ratio $BaCl_2:2Ag$
	1.61458	1.55856	0.96531			
	1.61460	1.55849	.96525			
	1.61459	1.55858	.96531	8.80070	1.17302	0.72651
	1.61459	1.55850	.96526	9.07900	1.17300	.72650
	1.61459	1.55850	.96525	9.97378	1.17303	.72651
Average	1.61459	1.55853	.96528		1.17302	.72650
At. wt. Ba	137.355	137.354	137.355		137.360	137.357

The average result for barium, 137.36, is about 0.01 unit lower than that found by Richards thirty-five years ago.

Cerium.—Hönigschmid and Holch,[9] using cerium material which had been freed from lanthanum and neodymium by fractional crystallization of the double magnesium nitrates, have analyzed cerous chloride. The

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[8] Hönigschmid and Sachtleben, *Z. anorg. allgem. Chem.*, **178**, 1 (1929).

[9] Hönigschmid and Holch, *ibid.*, **177**, 91 (1928).

recrystallized chloride was dehydrated at gradually increasing temperatures, first in a current of nitrogen and hydrogen chloride, then in pure hydrogen chloride, and ultimately was fused. Comparison with silver was followed by the determination of the silver chloride. Weights in air are corrected to vacuum.

TABLE V

THE ATOMIC WEIGHT OF CERIUM

Wt. of $CeCl_3$	Wt. of Ag	Ratio $CeCl_3$:3Ag	At. wt. Ce	Wt. of AgCl	Ratio $CeCl_3$:3AgCl	At. wt. Ce
3.43507	4.51018	0.76163	140.122	5.99272	0.57321	140.114
2.39181	3.14058	.76158	140.107	4.17266	.57321	140.116
3.05998	4.01767	.76163	140.123	5.33803	.57324	140.130
4.17583	5.48247	.76167	140.136	7.28454	.57325	140.131
1.34828	1.77015	.76168	140.138	2.35210	.57322	140.122
2.04994	2.69147	.76164	140.127	3.57628	.57320	140.113
2.38287	3.12846	.76168	140.138	4.15673	.57326	140.135
2.57235	3.37733	.76165	140.130	4.48755	.57322	140.120
2.16635	2.84432	.76164	140.127	3.77918	.57323	140.126
		.76164	140.127		.57323	140.123

This result is lower than that obtained by Brauner, 140.25, which has been in use for some time.

Erbium.—Boss and Hopkins[10] further fractionated material already limited in content to erbium and yttrium by (a) nitrate decomposition and (b) nitrite precipitation. Head fractions were converted to chloride and portions which had been dehydrated by gradual heating to the fusion point were weighed and compared with silver. Weights in air are corrected to vacuum.

TABLE VI

THE ATOMIC WEIGHT OF ERBIUM

Method of purif.	Wt. of $ErCl_3$	Wt. of Ag		Ratio $ErCl_3$:3Ag	At. wt. Er
a	2.25485	2.66270		0.84683	167.69
a	0.30165	0.35630		.84663	167.63
a	1.02242	1.20761		.84665	167.64
b	0.38998	0.46068		.84654	167.60
b	.38219	.45144		.84662	167.63
b	.17445	.20604		.84668	167.65
			Av.	.84666	167.64

The result is very slightly lower than the current one.

Rhenium.—W. and I. Noddack[11] have determined the atomic weight of rhenium by several methods, of which they consider the reduction of the disulfide the most reliable.

[10] Boss and Hopkins, THIS JOURNAL, **50,** 298 (1928).

[11] Noddack and Noddack, *Z. Elektrochem.*, **34,** 627, 630 (1928).

TABLE VII

THE ATOMIC WEIGHT OF RHENIUM

	Ratio Re:S_2	At. wt. Re
	2.9432	188.7
	2.9405	188.6
	2.9458	188.9
	2.9395	188.5
Av.	2.9423	188.7

Lead.—Lotze[12] on the basis of determinations of the uranium and thorium content and of the atomic weight of the lead contained in uranium minerals computes the atomic weight of actinium lead to be 207.

Uranium.—Hönigschmid and Schilz[13] have continued the work of Hönigschmid (see report for 1914) on uranium by the preparation and analysis of uranous chloride. Two preparations were employed: A, used in the earlier investigation, was obtained from commercial nitrate; B was obtained from Norwegian euxemite and samarskite. Both specimens were subjected to the same elaborate purification and ultimately converted to oxide. To prepare the uranous chloride the oxide was mixed with pure sugar charcoal and heated in a current of chlorine in a quartz sublimation apparatus. The first product was then sublimed into a quartz weighing tube and fused in an atmosphere containing varying proportions of nitrogen and chlorine as follows.

In Series I the chloride was resublimed and fused in pure nitrogen. In Series II resublimation in pure chlorine was followed by fusion in pure nitrogen or very dilute chlorine and the salt was solidified in pure nitrogen. In Series III, after resublimation in a mixture of nitrogen and chlorine, the chloride was twice melted and cooled in pure nitrogen.

To analyze the product, the solution, after acidification with nitric acid and oxidation with hydrogen peroxide, was compared with silver

TABLE VIII

THE ATOMIC WEIGHT OF URANIUM

Series I

Preparation	Wt. of UCl_4	Wt. of Ag	Ratio UCl_4:4Ag	At. wt. U	Wt. of AgCl	Ratio UCl_4:4AgCl	At. wt. U
A	1.86485	2.11805	0.880456	238.11	2.81388	0.662733	238.14
A	2.49763	2.83641	.880560	238.15	3.76866	.662737	238.16
A	4.75974	5.40512	.880598	238.17	7.18174	.662756	238.16
A	4.97877	5.65443	.880508	238.13	7.51270	.662714	238.14
A	4.90253	5.56780	.880515	238.13	7.39765	.662715	238.14
B	3.09615	3.51621	.880536	238.14	4.67190	.662718	238.14
B	2.61129	2.96561	.880524	238.14			
B	3.28471	3.73029	.880551	238.15	4.95638	.662724	238.14
		Av.	.880535	238.14		.662728	238.15

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[12] Lotze, *Z. anorg. allgem. Chem.*, **170,** 213 (1928).

[13] Hönigschmid and Schilz, *ibid.*, **170,** 145 (1928).

TABLE VIII (*Concluded*)

Preparation	Wt. of UCl_4	Wt. of Ag	Ratio $UCl_4:4Ag$	At. wt. U	Wt. of AgCl	Ratio $UCl_4:4AgCl$	At. wt. U
Series II							
A	3.36146	3.81768	0.880498	238.12	5.07211	0.662734	238.15
A	3.48180	3.95413	.880548	238.15	5.25351	.662757	238.16
A	3.05228	3.46649	.880510	238.13	4.60579	.662705	238.13
A	2.23307	2.53616	.880493	238.12	3.36983	.662666	238.11
A	2.87576	3.26616	.880471	238.11	4.33961	.662677	238.12
B	5.17799	5.88081	.880489	238.12	7.81333	.662712	238.14
B	6.06599	6.88877	.880562	238.15	9.15306	.662728	238.15
B	5.35148	6.07749	.880541	238.14	8.07478	.662740	238.15
		Av.	.880514	238.13		.662720	238.14
Series III							
B	4.59686	5.22090	0.880473	238.11	6.93657	0.662699	238.13
B	3.94272	4.47757	.880549	238.15	5.94951	.662697	238.13
B	3.68049	4.17994	.880513	238.13	5.55357	.662725	238.14
		Av.	.880507	238.13		.662707	238.13

and the silver chloride was collected and weighed. Weights in air are corrected to vacuum.

The final average, 238.14, is slightly lower than the earlier one.

Ruer and Kuschman[14] have investigated the adsorption of air on inorganic solids. One of the important findings is that fused powdered potassium chloride and precipitated dried lead chloride adsorb less than 0.5 mg. of air per 100 g. of solid.

Hogness and Kvalnes[15] confirm Aston's suspicion of the existence of an isotope of neon of mass 21 and estimate the proportions of the three isotopes as Ne^{20}, 88%, Ne^{21}, 2%, Ne^{22}, 10%.

Aston[16] has discovered additional isotopes of zinc and germanium which are listed below in the order of abundance, together with those already known.

Zn	64,	66,	68,	67,	65,	70,	69	
Ge	74,	72,	70,	73,	75,	76,	71,	77

In the table of atomic weights on p. 653 changes from the 1928 table are made in the cases of hydrogen, phosphorus, sulfur, barium, cerium, erbium, potassium, radium, thorium and uranium. The value for hydrogen depends largely upon the evidence of the mass spectrograph. In the cases of phosphorus and sulfur, the uncertainty of existing data makes the third decimal place of dubious value. The value for potassium is given to two decimal places only, since the cause of the discrepancy between that found by Richards, Staehler and Mueller, 39.095, and the recent one by Hönigschmid and Goubeau, 39.105, is not evident. The atomic weight of

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[14] Ruer and Kuschman, *Z. anorg. allgem. Chem.*. **166,** 257 (1927).

[15] Hogness and Kvalnes, *Nature,* **122,** 441 (1928).

[16] Aston, *ibid.,* **122,** 167, 345 (1928).

AMERICAN CHEMICAL SOCIETY
ATOMIC WEIGHTS
1929

	Symbol	At. number	At. weight
Aluminum	Al	13	26.97
Antimony	Sb	51	121.77
Argon	A	18	39.94
Arsenic	As	33	74.96
Barium	Ba	56	137.36
Beryllium	Be	4	9.02
Bismuth	Bi	83	209.00
Boron	B	5	10.82
Bromine	Br	35	79.916
Cadmium	Cd	48	112.41
Calcium	Ca	20	40.07
Carbon	C	6	12.000
Cerium	Ce	58	140.13
Cesium	Cs	55	132.81
Chlorine	Cl	17	35.457
Chromium	Cr	24	52.01
Cobalt	Co	27	58.94
Columbium	Cb	41	93.1
Copper	Cu	29	63.57
Dysprosium	Dy	66	162.46
Erbium	Er	68	167.64
Europium	Eu	63	152.0
Fluorine	F	9	19.00
Gadolinium	Gd	64	157.26
Gallium	Ga	31	69.72
Germanium	Ge	32	72.60
Gold	Au	79	197.2
Hafnium	Hf	72	178.6
Helium	He	2	4.002
Holmium	Ho	67	163.5
Hydrogen	H	1	1.0078
Indium	In	49	114.8
Iodine	I	53	126.932
Iridium	Ir	77	193.1
Iron	Fe	26	55.84
Krypton	Kr	36	82.9
Lanthanum	La	57	138.90
Lead	Pb	82	207.22
Lithium	Li	3	6.940
Lutecium	Lu	71	175.0
Magnesium	Mg	12	24.32
Manganese	Mn	25	54.93
Mercury	Hg	80	200.61
Molybdenum	Mo	42	96.0
Neodymium	Nd	60	144.27
Neon	Ne	10	20.183
Nickel	Ni	28	58.69
Nitrogen	N	7	14.008
Osmium	Os	76	190.8
Oxygen	O	8	16.0000
Palladium	Pd	46	106.7
Phosphorus	P	15	31.02
Platinum	Pt	78	195.23
Potassium	K	19	39.10
Praseodymium	Pr	59	140.92
Radium	Ra	88	225.97
Radon	Rn	86	222
Rhenium	Re	75	188.7
Rhodium	Rh	45	102.91
Rubidium	Rb	37	85.44
Ruthenium	Ru	44	101.7
Samarium	Sm	62	150.43
Scandium	Sc	21	45.10
Selenium	Se	34	79.2
Silicon	Si	14	28.06
Silver	Ag	47	107.880
Sodium	Na	11	22.997
Strontium	Sr	38	87.63
Sulfur	S	16	32.06
Tantalum	Ta	73	181.5
Tellurium	Te	52	127.5
Terbium	Tb	65	159.2
Thallium	Tl	81	204.39
Thorium	Th	90	232.12
Thulium	Tm	69	169.4
Tin	Sn	50	118.70
Titanium	Ti	22	47.90
Tungsten	W	74	184.0
Uranium	U	92	238.14
Vanadium	V	23	50.96
Xenon	Xe	54	130.2
Ytterbium	Yb	70	173.6
Yttrium	Y	39	88.92
Zinc	Zn	30	65.38
Zirconium	Zr	40	91.22

radium includes the correction determined by Hönigschmid for the temperature of the radium salt. This was overlooked in the earlier tables. The value for thorium is that obtained by Hönigschmid in his most reliable series.[17]

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ACTIVE NITROGEN. II. THE INFLUENCE OF SURFACE ON THE AFTERGLOWS IN NITROGEN AND OXYGEN[1,2]

By Bernard Lewis[3]

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It has been contended by some workers[4] that pure nitrogen subjected to the action of an electric discharge shows no afterglow but that its restoration is effected by the addition of a trace of oxygen. Other investigators[5] have shown that pure nitrogen undoubtedly could give rise to an afterglow, which, however, is intensified by the addition of oxygen or certain other impurities. More recently Bonhoeffer and Kaminsky[6] have concluded that pure nitrogen is glowless but the introduction of certain optimum amounts of such impurities as oxygen, hydrogen sulfide and methane into the discharge mixture produces a glow of maximum intensity.

The action of the impurities has been thought to be due to the formation of a layer of gas on the surface of the vessel which inhibits the catalytic combination of nitrogen atoms thereon. The atoms must now combine in the gas phase with consequent emission of the α-bands. It was the purpose early in these experiments to ascertain whether the impurity, oxygen, entered into the mechanism of afterglow production. The possibility could not be entirely excluded that oxygen was necessary in some physical action to induce the afterglow in the gas phase, notwithstanding results by Bonhoeffer and Kaminsky, namely, that different impurities are without effect on the character of the afterglow.

[17] Hönigschmid *Sitz. Kaiser. Akad. Wien,* [IIa] **125,** 1 (1916).

[1] Read before the Midwest Regional Meeting of the American Chemical Society at Minneapolis, June 8, 1928.

[2] Bernard Lewis, Part I, This Journal, **50,** 27 (1928).

[3] National Research Fellow in Chemistry.

[4] Compte, *Physik. Z.,* **14,** 74 (1913); Tiede, *Ber.,* **46,** 340 (1913); Tiede and Domcke, *ibid.,* **46,** 4095 (1913); **47,** 420 (1914).

[5] Von Mosengeil, *Ann. Physik,* **20,** 833 (1906); Strutt, *Proc. Roy. Soc.,* **85,** 219 (1912); *Physik. Z.,* **14,** 215 (1913); König and Elöd, *ibid.,* **14,** 165 (1913); *Ber.,* **47,** 523 (1913); König, *Z. Elektrochem.,* **21,** 278 (1915); Baker and Strutt, *Ber.,* **47,** 801, 1049 (1914); Baker, Tiede, Strutt and Domcke, *Nature,* **93,** 478 (1914); Strutt, *Proc. Roy. Soc.,* **91,** 303 (1915).

[6] Bonhoeffer and Kaminsky, *Z. physik. Chem.,* **127,** 385 (1927).