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Seventh Report of the Committee on Atomic Weights of the International Union of Chemistry

BY G. P. BAXTER (*Chairman*), O. HÖNIGSCHMID AND P. LEBEAU

The following report of the Committee covers the twelve-month period, September 30, 1935, to September 30, 1936.[1]

The following changes in the table of atomic weights have been made:

Carbon, from 12.00 to 12.01
Rubidium, from 85.44 to 85.48
Gadolinium, from 157.3 to 156.9
Lead, from 207.22 to 207.21
Uranium, from 238.14 to 238.07

Oxygen.—Dole[2] reports a difference in isotopic composition between the oxygen of the air and that of the water of Lake Michigan, U. S., corresponding to 0.00008 atomic weight unit, and advocates some single isotope such as protium as atomic weight standard. Since analytical accuracy under the most favorable conditions does not surpass 0.001% and since the determination of atomic weights by chemical methods, no matter what standard is used, must in most cases involve reference to oxygen more or less directly, the Committee sees no reason to change the position taken in its Second Report,[3] that no advantage is to be gained by any change of standard at the present time.

Hydrogen.—Although no change in the atomic weight of hydrogen is made in this year's table, it seems increasingly probable from mass spectrographic measurements[4] that the atomic weight of hydrogen is 0.0002–0.0003 higher than the current value. As pointed out by Moles,[5] chemical determinations have ordinarily been made with electrolytic hydrogen which, owing to isotopic separation, has a less than normal proportion of deuterium.

Carbon.—Toral and Moles[6] have determined the density of carbon dioxide, made by pyrolysis of sodium bicarbonate, with the following average results. Individual results are not given.

1 atmosphere	1.97701
$^1/_2$ atmosphere	1.97014

Limiting density is then 1.96327 and the atomic weight of carbon 12.006 if gram molecular volume is taken as 22.4146. Using their own value for the limiting density of oxygen Toral and Moles obtain the value 12.007 for carbon.

Carbon.—Baxter and Hale[7] have determined the atomic weight of carbon by combustion of hydrocarbons. A weighed amount of hydrocarbon was burned in pure oxygen and both the carbon dioxide and the water formed were collected and weighed. From the weight of water the weight of hydrogen was calculated and subtracted from the weight of hydrocarbon to find

(1) Authors of papers bearing on the subject are requested to send copies to each of the three members of the Committee at the earliest possible moment: Prof. G. P. Baxter, Coolidge Laboratory, Harvard University, Cambridge, Mass., U. S. A.; Prof. O. Hönigschmid, Sofienstrasse 9/2, Munich, Germany; Prof. P. LeBeau, Faculté de Pharmacie, 4 Avenue de l'Observatoire, Paris VI^e, France.

(2) Dole, THIS JOURNAL, **57**, 2731 (1935); *J. Chem. Phys.*, **4**, 268 (1936).

(3) *Ibid.*, **54**, 1269 (1932).

(4) Aston, *Nature*, **135**, 541 (1935); **137**, 357 (1936).

(5) Moles, *Anales soc. españ. fís. quím.*, **33**, 721 (1935).

(6) Toral and Moles, *Bol. acad. cienc. exactas. fís. y nat., Madrid*, **2**, No. 4, 4 (1936).

(7) Baxter and Hale, THIS JOURNAL, **58**, 510 (1936).

THE ATOMIC WEIGHT OF CARBON

Sample	H_2O	H	C	CO_2	O	C:O_2	At. wt. C
			Weights in grams				
			Chrysene				
2.78044	1.31209	0.14680	2.63364	9.65247	7.01883	0.375225	12.007(2)
2.69258	1.27609	.14277	2.54981	9.34368	6.79387	.375310	12.009(9)
2.97782	1.41063	.15782	2.82000	10.33447	7.51447	.375276	12.008(8)
2.99649	1.41913	.15877	2.83772	10.39870	7.56098	.375311	12.010(0)
						Average .375281	12.009(0)
			Triphenylbenzene				
3.00012	1.59012	0.17790	2.82222	10.34136	7.51914	0.375338	12.010(8)
2.99773	1.58730	.17759	2.82014	10.33463	7.51449	.375294	12.009(4)
2.99639	1.58592	.17743	2.81896	10.33026	7.51130	.375296	12.009(5)
						Average .375309	12.009(9)
			Anthracene				
2.99484	1.51453	0.16945	2.82539	10.35398	7.52859	0.375288	12.009(2)
2.04930	1.03682	.11600	1.93330	7.08554	5.15224	.375235	12.007(5)
						Average .375262	12.008(4)
						Average of all	12.009(1)

the weight of carbon, from which, with the weight of carbon dioxide formed, the ratio of carbon to oxygen may be calculated.

Hydrocarbons were purified by chemical treatment, by crystallization from hydrocarbon solvents and by distillation or sublimation.

Combustion was effected by slowly evaporating weighed amounts of hydrocarbon into a stream of an excess of oxygen which passed over platinum catalysts in a quartz tube, first at 650°, but eventually at 800°. A short section of copper oxide provided for a possible deficiency of oxygen. Water was collected largely by condensation but partly by phosphorus pentoxide. Carbon dioxide was collected in ascarite (sodium hydroxide) and escape of water from the carbon dioxide absorber was prevented by phosphorus pentoxide. Vacuum corrections are applied.

Results with pyrene were inconsistent and differed from those with other hydrocarbons.

This result is in accord with recent gas density and mass spectrographic evidence that the atomic weight of carbon is not far from 12.01. Accordingly the International value has been altered to this figure.

Batuecas[8] recalculates his data on the densities of several gases and finds values for carbon from 11.999 to 12.007, and for nitrogen 14.011 and 14.009.

Neon.—Jungbluth-Ficht and Hoeppener[9] starting with neon containing 18% of helium, fractionated this gas by adsorption on active charcoal at low temperature. The products of the last three fractionations gave the following densities (volume of globe = 300 ml., g = 980.616)

A	0.8988
B	0.89949
C	0.89990

The density of the purest fraction (C) corresponds to the atomic weight of neon in current use.

Potassium.—Brewer[10] has measured the abundance ratio K^{39}/K^{41} in potassium from various sources. With minerals the ratio varied from 14.11 to 14.32 (except for one sample which gave 14.6). With plant ash a larger variation was found, from 12.63 (kelp) to 14.6 (potato sprouts). In sea water from different localities the ratio was constant at 14.20. The abundance ratio 14.20, with the packing fraction -7.0×10^{-4} and the conversion factor 1.00027, give 39.094 for the atomic weight of potassium. With the average abundance ratio from minerals, 14.25, the atomic weight is 39.093. The abundance ratio corresponding to the atomic weight 39.096 is 13.93.

Gallium.—Lundell and Hoffman[11] have determined the ratio of gallium to gallium oxide. Gallium of 99.999% purity was prepared by a combination of wet methods, electrolysis and fractional crystallization of the metal.[12] By chemical and optical examination the crystals were found to be free from oxide film. In one set of experiments weighed crystals were dissolved in a mixture of nitric, hydrochloric and

(8) Batuecas, *Bol. Univ. Santiago*, Oct.-Dec., 1935.

(9) Jungbluth-Ficht and Hoeppener, *Ber.*, **68**, 2389 (1935).

(10) Brewer, THIS JOURNAL, **58**, 365, 370 (1936).

(11) Lundell and Hoffman, *Bur. Standards J. Research*, **15**, 409 (1935).

(12) Hoffman, *ibid.*, **13**, 665 (1934).

THE ATOMIC WEIGHT OF GERMANIUM

Fraction	$GeBr_4$, g.	Ag, g.	GeBr:4Ag	At. wt. Ge	AgBr, g.	$GeBr_4$:4AgBr	At. wt. Ge
2	3.57997	3.93852	0.908963	72.572	6.85620	0.522151	72.567
4	7.58115	8.33982	.909030	72.601	14.51750	.522208	72.610
6	4.90761	5.39888	.909005	72.590	9.39827	.522182	72.591
7	6.13136	6.74501	.909022	72.597	11.74160	.522191	72.598
9	4.57465	5.03256	.909011	72.592	8.76096	.522163	72.577
11	8.62179	9.48497	.908995	72.586	16.51123	.522177	72.587
12	6.31559	6.94772	.909016	72.595	12.09440	.522191	72.598
13	6.80706	7.48879	.908967	72.573	13.03664	.522148	72.565
14	5.46488	6.01211	.908979	72.579	10.46570	.522171	72.582
15	6.03550	6.63970	.908996	72.586	11.55892	.522151	72.567
Total	60.01956	66.02812	.909000	72.588	114.94142	.522175	72.586

THE ATOMIC WEIGHT OF GERMANIUM

Fraction	$GeCl_4$, g.	Ag, g.	$GeCl_4$:4Ag	At. wt. Ge	AgCl, g.	$GeCl_4$:4AgCl	At. wt. Ge
1	3.10145	6.24157	0.496902	72.595			
2	2.21830	4.46415	.496914	72.600			
4	3.04473	6.12798	.496857	72.576	8.14193	0.373957	72.579
6	3.45885	6.96104	.496887	72.589			
7	3.06428	6.16679	.496900	72.594			
8	3.47933	7.00214	.496895	72.592			
10	2.75854	5.55169	.496883	72.587	7.37629	.373974	72.589
5	4.26094	8.57525	.496888	72.589			
3	2.95678	5.95028	.496914	72.601	7.90580	.374001	72.605
Total	8.76005				23.42402	.373977	72.591
Total	28.34320	57.04089	.496893	72.591			

sulfuric acids and after removal of nitric and hydrochloric acids gallium hydroxide was precipitated with ammonia. The hydroxide was collected and ignited at 1200–1300° to constant weight (I). In another the gallium sulfate was evaporated to dryness and ignited at 1200–1300° (II). In a third, after solution in mixed nitric and hydrochloric acids, the hydrochloric acid was eliminated by evaporation with nitric acid, the solution of gallium nitrate was evaporated to dryness and the residue ignited at 1200–1300° (III). Oxide samples prepared by the three methods were found to be free from occluded gases. Weights are corrected to the vacuum standard.

THE ATOMIC WEIGHT OF GALLIUM

Method	Ga, g.	Ga_2O_3, g.	2Ga: Ga_2O_3	At. wt. Ga
I	0.86526	1.16307	0.74394	69.730
	1.25888	1.69205	.74400	69.750
	1.23368	1.65815	.74401	69.753
	3.45532	4.64464	.74394	69.727
	2.97452	3.99838	.74393	69.725
		Average	.74396	69.737
II	1.15767	1.55604	.74398	69.745
	1.53230	2.05967	.74395	69.733
	2.48716	3.34320	.74395	69.730
	3.09080	4.15443	.74398	69.741
		Average	.74397	69.737
III	0.78420	1.05411	.74395	69.730
	.80495	1.08196	.74397	69.740
		Average	.74396	69.735
		Average of all	.74396	69.737

The difference between the average value for gallium and that found earlier by Richards and Craig, though the analysis of $GaCl_3$, 69.72, warrants further investigation.

Germanium.—Hönigschmid, Wintersberger and Wittner[13] have determined the ratio of germanium tetrabromide to silver and silver bromide. The tetrabromide was synthesized from spectroscopically pure germanium and pure bromine and was fractionally distilled in exhausted glass systems. Glass bulbs were partially filled with material at various stages of the fractionation. After being weighed the bulbs were broken under sodium hydroxide and the glass was collected for weighing. The solution was then acidified and compared with silver in the usual way. Finally the silver bromide was collected. Weights are corrected to vacuum. Fractions are numbered in the order of decreasing volatility.

Hönigschmid and Wintersberger[14] have determined the ratio of germanium tetrachloride to silver and silver chloride. Germanium was recovered from the tetrabromide analyses by precipitation as hydroxide or sulfide and after conversion to oxide was reduced in hydrogen. The tetrachloride, which was synthesized from the

(13) Hönigschmid, Wintersberger and Wittner, *Z. anorg. allgem. Chem.*, **225**, 81 (1935).

(14) Hönigschmid and Wintersberger, *Z. anorg. allgem. Chem.*, **227**, 17 (1936).

THE ATOMIC WEIGHT OF RUBIDIUM

Sample	RbBr, g.	Ag, g.	RbBr:Ag	At. wt. Rb	AgBr, g.	RbBr:AgBr	At. wt. Rb
I	3.67283	2.39554	1.53320	85.485			
I	3.27067	2.13320	1.53322	85.488			
II	4.04039	2.63537	1.53314	85.479			
II	3.20309	2.08916	1.53320	85.485			
II	4.00547	2.61245	1.53322	85.488			
II	6.66951	4.35022	1.53314	85.480	7.57272	0.880728	85.481
II	4.69377	3.06150	1.53316	85.481	5.32945	.880723	85.480
II	3.33389	2.17458	1.53312	85.477			
III	3.62456	2.36409	1.53317	85.483	4.11561	.880686	85.473
		Average	1.53315	85.483		.880712	85.478

metal and chlorine prepared from pyrolusite and hydrochloric acid, was fractionally distilled in exhausted systems and collected in sealed glass bulbs. These were analyzed as described above. Weights are corrected to vacuum.

The average result, 72.59, is 0.01 unit lower than the International value, which depends upon the work of Baxter and Cooper.

Rubidium.—Archibald, Hooley and Phillips[15] have redetermined the ratio RbCl:Ag. Rubidium dichloroiodide was fractionally crystallized ten times from dilute hydrochloric acid. Conversion through the sulfate to the hydroxide by means of barium hydroxide was followed by neutralization with tartaric acid and five recrystallizations of the acid tartrate. After conversion of the tartrate to carbonate by ignition, the chloride was formed and recrystallized three times. Spectrographic analysis yielded no evidence of the presence of other alkalies.

Rubidium chloride was prepared for weighing by fusion in nitrogen, and was compared with pure silver by the "standard solution" method of Johnson. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF RUBIDIUM

RbCl, g.	Ag, g.	RbCl:Ag	At. wt. Rb
2.41226	2.15167	1.12111	85.488
2.77942	2.47848	1.12142	85.519
2.90458	2.59105	1.12100	85.476
2.51028	2.23897	1.12118	85.495
3.04508	2.71636	1.12101	85.478
2.25778	2.01411	1.12098	85.474
2.44580	2.18166	1.12107	85.484
2.59528	2.31509	1.12103	85.479
Average of last six analyses		1.12104	85.481

Archibald and Hooley[16] have continued the foregoing investigation by the determination of the ratio RbBr:Ag:AgBr. Rubidium nitrate resulting from the rubidium chloride analyses was freed from silver and converted to acid tartrate which was four times crystallized. Conversion to bromide followed. The first fraction of crystals formed Sample I. The remainder was converted to tribromide and twice recrystallized. The crystals after conversion to bromide formed Sample II, the mother liquors Sample III. Comparison of weighed amounts of rubidium bromide with silver was followed by gravimetric determination of the silver bromide formed. Weights are corrected to vacuum.

The average value from the three ratios, 85.48, is 0.04 unit higher than that found by Archibald over thirty years ago and has been adopted for the table.

Silver.—Hönigschmid and Schlee[17] have determined the ratio of silver nitrate to silver chloride in the dry way. Silver nitrate which had been prepared from the purest silver was crystallized from nitric acid and after being dried in pure air at 150° was fused at 220°. Conversion of the weighed nitrate to chloride was effected, first at 150° in hydrogen chloride diluted with nitrogen, later at higher temperatures in more concentrated hydrogen chloride, until finally the fusion temperature was passed. No loss of silver salt occurred during the conversion. Weights are corrected to vacuum.

THE RATIO OF SILVER NITRATE TO SILVER CHLORIDE

	$AgNO_3$, g.	AgCl, g.	$AgNO_3$: AgCl
	6.60708	5.57445	1.185244
	6.25586	5.27812	1.185244
	6.53756	5.51582	1.185238
	6.42000	5.41662	1.185241
	6.19269	5.22483	1.185242
	7.48847	6.31810	1.185241
	6.58954	5.55968	1.185237
	6.76512	5.70780	1.185241
Total	52.85632	44.59542	1.185241

This experimental value affords close confirmation of International atomic weights which give, as the value to be expected, 1.185235.

(15) Archibald, Hooley and Phillips, THIS JOURNAL, 58, 70 (1936).

(16) Archibald and Hooley, THIS JOURNAL, 58, 618 (1936).

(17) Hönigschmid and Schlee, *Z. angew. Chem.*, 49, 464 (1936).

THE ATOMIC WEIGHT OF CADMIUM

Sample	$CdCl_2$, g.	Ag, g.	$CdCl_2:2Ag$	At. wt. Cd
I	3.57277	4.20504	0.849640	112.404
I	4.04302	4.75840	.849659	112.408
I	3.77238	4.43989	.849656	112.407
I	4.07495	4.79598	.849659	112.409
		Average	.849654	112.407
II	4.23323	4.98215	0.849679	112.413
II	4.42435	5.20722	.849657	112.408
II	4.87970	5.74305	.849670	112.411
II	3.43664	4.04470	.849665	112.410
		Average	.849668	112.411
		Average of all	.849661	112.409

$CdBr_2$, g.	Ag, g.	$CdBr_2:2Ag$	At. wt. Cd	AgBr, g.	$CdBr_2:2AgBr$	At. wt. Cd
4.13490	3.27717	1.26173	112.399	5.70479	0.724812	112.402
4.07813	3.23214	1.26174	112.402	5.62629	.724835	112.410
4.09476	3.24530	1.26175	112.403	5.64920	.724839	112.411
5.28536	4.18885	1.26177	112.407			
6.12808	4.85675	1.26177	112.407	8.45436	.724842	112.413
	Average	1.26175	112.404		.724832	112.409

Cadmium.—Hönigschmid and Schlee[18] have analyzed cadmium chloride and bromide. Cadmium metal was fractionally distilled in vacuum until spectroscopic examination (Gerlach) showed no impurities. Cadmium chloride was prepared by solution of the metal in nitric acid and displacement of the nitric acid by hydrochloric acid. After crystallization the salt was dehydrated and twice sublimed in hydrogen chloride (Sample I). A second sample was made by heating the metal in dry hydrogen chloride, and twice subliming the product (Sample II). Preparatory to weighing the chloride was fused in nitrogen in a quartz system, since chlorine and hydrogen chloride are retained if the operation is conducted in these gases.

Cadmium bromide was synthesized by heating the metal in a current of nitrogen and bromide in a quartz apparatus and was twice resublimed in nitrogen and bromide before the final fusion in nitrogen. Analysis by comparison with silver followed the conventional lines. Weights are corrected to vacuum.

The average of all the individual values, 112.41, is identical with the present International value and is 0.2 unit higher than Aston's most recent mass spectroscopic determination, 112.2.

Gadolinium.—Naeser and Hopkins[19] have determined the ratio of gadolinium chloride to silver. Samarium–europium–gadolinium material was fractionally crystallized as double magnesium nitrates with and without bismuth as "separating element," and then as simple nitrates with bismuth nitrate as separator. Bismuth was eventually removed as sulfide and the gadolinium was five times alternately precipitated as hydroxide and oxalate. Of the eight final fractions, 7–14, the first six showed only gadolinium in their arc spectra.

Gadolinium chloride was prepared for weighing by evaporating to dryness a solution of the salt in a weighed quartz flask and cautious expulsion of the crystal water wholly by efflorescence, all in a current of hydrogen chloride. Fusion in hydrogen chloride followed. Comparison with silver followed conventional lines, by the equal opalescence method. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF GADOLINIUM

Fraction	$GdCl_3$, g.	Ag, g.	$GdCl_3:3Ag$	At. wt. Gd
7	0.38265	0.47047	0.81333	156.86
7	.82483	1.01416	.81331	156.85
8	1.56656	1.92608	.81334	156.86
8	0.63482	0.78060	.81325	156.82
9	.68899	.84716	.81330	156.85
9	2.27153	2.79249	.81344	156.89
10	1.89197	2.32637	.81329	156.84
10	1.41902	1.74486	.81326	156.83
11	1.23485	1.51829	.81332	156.85
11	1.61684	1.98796	.81332	156.85
12	1.72986	2.12689	.81333	156.86
12	2.48952	3.06091	.81333	156.85
			.81332	156.85

Since this result is in accord with Aston's recent finding, the value 156.9 has been adopted for the International table.

(18) Hönigschmid and Schlee, *Z. anorg. allgem. Chem.*, **227**, 184 (1936).

(19) Naeser and Hopkins, THIS JOURNAL, **57**, 2183 (1935).

Erbium.—Hönigschmid[20] has redetermined, by analysis of the chloride, the atomic weight of an erbium preparation containing 0.37 atomic per cent. of yttrium and 0.42% of thulium. The value found was 166.96, which, when corrected for yttrium and thulium becomes 167.24. The material used earlier by Hönigschmid and Kapfenberger, which gave the value 165.2, was found to contain 2.9 atomic per cent. of yttrium, 2.9% of holmium, 2.9% of thulium and 2.7% of ytterbium. Correction for these impurities raises the observed value to 167.35. The discrepancy between the results of Hönigschmid and Kapfenberger, and that of Aston, 167.15, is thus largely removed. However, the Committee feel that it is advisable to defer any change in the value for erbium in the table until the details of Hönigschmid's work are available.

Tantalum.—Hönigschmid and Schlee[21] have continued their work on the atomic weight of tantalum by analysis of tantalum pentachloride. The purification of tantalum material consisted in recrystallization of the double potassium fluoride, conversion to tantalic acid by evaporation with sulfuric acid, extraction of potassium salt with hot water and ignition at 1000°. At this stage, columbium, thorium and zirconium had been eliminated but a trace of iron remained. This was removed by fusion with sodium hydroxide and precipitation of iron as sulfide. Precipitation of tantalic acid with sulfurous acid and ignition followed.

The pentachloride was prepared by first converting the oxide to sulfide by heating in a current of hydrogen sulfide and carbon disulfide and then heating the sulfide in chlorine. Removal of sulfur chloride was effected by distillation in a current of chlorine and by heating in a high vacuum. The product was distilled into small glass bulbs for weighing.

The weighed bulbs were broken under alcohol, and after dilution with water the glass was collected and weighed. Precipitation of tantalic acid with ammonia followed and after addition of a slight excess of nitric acid the solution was compared with weighed quantities of pure silver. Weights are corrected to vacuum.

The average result agrees exactly with that previously found by the authors from the analysis of the pentabromide.

(20) Hönigschmid, *Naturwissenschaften*, **24**, 619 (1936).

(21) Hönigschmid and Schlee, *Z. anorg. allgem. Chem.*, **225**, 64 (1935).

THE ATOMIC WEIGHT OF TANTALUM

$TaCl_5$, g.	Ag, g.	$TaCl_5$:5Ag	At. wt. Ta
2.59060	3.90135	0.664026	180.891
2.86797	4.31891	.664049	180.903
2.43804	3.67183	.663985	180.869
1.58970	2.39423	.663971	180.861
3.13325	4.71853	.664030	180.893
4.25695	6.41098	.664009	180.883
16.87651	25.41583	.664016	180.885

Lead.—Hecht and Kroupa[22] have determined the atomic weights of several radiogenic leads. Lead chloride from each specimen was purified by crystallization as nitrate, conversion to sulfate and to carbonate, recrystallization as nitrate and as chloride and distillation of the chloride in hydrogen chloride. The ratios of lead chloride to silver and silver chloride were found in the conventional way. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF LEAD

$PbCl_2$, g.	Ag, g.	$PbCl_2$: 2Ag	At. wt. Pb	AgCl, g.	$PbCl_2$: 2AgCl	At. wt. Pb
Pitchblende, Great Bear Lake, N. W. T., Canada						
4.10802	3.19996	1.28377	206.073			
3.10366	2.34736	1.28386	206.090			
3.94641	3.07404	1.28379	206.076	4.08412	0.96628	206.094
3.00540	2.34110	1.28376	206.069	3.11048	.96622	206.075
3.99564	3.11230	1.28382	206.084	4.13520	.96625	206.085
5.21141	4.05947	1.28377	206.071	5.39355	.96623	206.079
Average		1.28379	206.077		.96625	206.083
Uraninite, Wilberforce, Ontario, Canada						
3.05552	2.37910	1.28432	206.190	3.16127	.96655	206.170
3.02424	2.35477	1.28430	206.187			
5.01384	3.90390	1.28432	206.190			
2.57832	2.00763	1.28426	206.178			
Average		1.28430	206.186			
Pitchblende, Katanga, Africa. Black Insoluble						
2.90173	2.26061	1.28360	206.037			
2.77498	2.16174	1.28368	206.053			
Average		1.28364	206.045			
Galena, Tetüche						
3.83794	2.97731	1.28907	207.214	3.95559	0.97026	207.234
4.33839	3.36557	1.28905	207.211	4.47171	.97019	207.213
3.41397	2.64831	1.28912	207.224	3.51904	.97014	207.201
Average		1.28908	207.216		.97020	207.216

The value for Great Bear Lake material is slightly higher than that found by Marble and by Baxter and Alter with a different sample. This difference is undoubtedly due to varying amounts of common lead which the mineral is known to contain. With a different specimen of Wilberforce uraninite Baxter and Bliss found 206.195, although the Th/U ratio of this specimen was lower. It is far from certain, however, that Wilberforce uraninite is free from common lead. The lead in the black insoluble portion of Katanga pitchblende appears to have a slightly higher atomic weight than that in the hydro-

(22) Hecht and Kroupa, *Z. anorg. allgem. Chem.*, **226**, 248 (1936).

INTERNATIONAL ATOMIC WEIGHTS

1937

	Symbol	Atomic Number	Atomic Weight		Symbol	Atomic Number	Atomic Weight
Aluminum	Al	13	26.97	Molybdenum	Mo	42	96.0
Antimony	Sb	51	121.76	Neodymium	Nd	60	144.27
Argon	A	18	39.944	Neon	Ne	10	20.183
Arsenic	As	33	74.91	Nickel	Ni	28	58.69
Barium	Ba	56	137.36	Nitrogen	N	7	14.008
Beryllium	Be	4	9.02	Osmium	Os	76	191.5
Bismuth	Bi	83	209.00	Oxygen	O	8	16.0000
Boron	B	5	10.82	Palladium	Pd	46	106.7
Bromine	Br	35	79.916	Phosphorus	P	15	31.02
Cadmium	Cd	48	112.41	Platinum	Pt	78	195.23
Calcium	Ca	20	40.08	Potassium	K	19	39.096
Carbon	C	6	12.01	Praseodymium	Pr	59	140.92
Cerium	Ce	58	140.13	Protactinium	Pa	91	231
Cesium	Cs	55	132.91	Radium	Ra	88	226.05
Chlorine	Cl	17	35.457	Radon	Rn	86	222
Chromium	Cr	24	52.01	Rhenium	Re	75	186.31
Cobalt	Co	27	58.94	Rhodium	Rh	45	102.91
Columbium	Cb	41	92.91	Rubidium	Rb	37	85.48
Copper	Cu	29	63.57	Ruthenium	Ru	44	101.7
Dysprosium	Dy	66	162.46	Samarium	Sm	62	150.43
Erbium	Er	68	167.64	Scandium	Sc	21	45.10
Europium	Eu	63	152.0	Selenium	Se	34	78.96
Fluorine	F	9	19.00	Silicon	Si	14	28.06
Gadolinium	Gd	64	156.9	Silver	Ag	47	107.880
Gallium	Ga	31	69.72	Sodium	Na	11	22.997
Germanium	Ge	32	72.60	Strontium	Sr	38	87.63
Gold	Au	79	197.2	Sulfur	S	16	32.06
Hafnium	Hf	72	178.6	Tantalum	Ta	73	180.88
Helium	He	2	4.002	Tellurium	Te	52	127.61
Holmium	Ho	67	163.5	Terbium	Tb	65	159.2
Hydrogen	H	1	1.0078	Thallium	Tl	81	204.39
Indium	In	49	114.76	Thorium	Th	90	232.12
Iodine	I	53	126.92	Thulium	Tm	69	169.4
Iridium	Ir	77	193.1	Tin	Sn	50	118.70
Iron	Fe	26	55.84	Titanium	Ti	22	47.90
Krypton	Kr	36	83.7	Tungsten	W	74	184.0
Lanthanum	La	57	138.92	Uranium	U	92	238.07
Lead	Pb	82	207.21	Vanadium	V	23	50.95
Lithium	Li	3	6.940	Xenon	Xe	54	131.3
Lutecium	Lu	71	175.0	Ytterbium	Yb	70	173.04
Magnesium	Mg	12	24.32	Yttrium	Y	39	88.92
Manganese	Mn	25	54.93	Zinc	Zn	30	65.38
Mercury	Hg	80	200.61	Zirconium	Zr	40	91.22

chloric acid-soluble portion of the same specimen as determined by Hönigschmid, Sachtleben and Baudrexler, 206.03.

In the light of recent evidence (see preceding reports) the atomic weight of common lead appears to be nearer 207.21 than 207.22 and this change has been made in the table.

Uranium.—Hönigschmid and Wittner[23] have investigated the ratios UCl_4:4Ag:4AgCl and UBr_4:4Ag:4AgBr. Samples of uranium material from different mineral sources were purified by essentially similar methods, including removal of heavy metals with hydrogen sulfide, precipitation of uranyl carbonate and solution in excess ammonium carbonate, crystallization of uranyl nitrate, precipitation of uranyl oxalate and ignition, first to U_3O_8 and then to UO_2 in hydrogen.

The halides were obtained by heating the oxide mixed with sugar charcoal in an atmosphere of nitrogen and chlorine or bromine and the first sublimate obtained was resublimed into a weighed quartz tube, all in a quartz bottling system. In

(23) Hönigschmid and Wittner, *Z. anorg. allgem. Chem.*, **226**, 289 (1936).

many of the experiments the sublimed halide was fused in an atmosphere of the corresponding halogen before being weighed. Analysis followed by dissolving the salt, oxidizing with hydrogen peroxide in acid solution and comparison with silver. Afterward, in some cases the silver halides were collected. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF URANIUM

UCl_4, g.	Ag, g.	UCl_4: 4Ag	At. wt. U	AgCl, g.	UCl_4: 4AgCl	At. wt. U
Morogoro uraninite						
Sublimed in chlorine and fused in chlorine						
3.08216	3.50091	0.88039	238.077	4.65181	0.66257	238.057
2.17001	2.46488	.88037	238.070			
3.43045	3.89642	.88041	238.087			
Average		.88039	238.078			
Sublimed in chlorine, not fused						
3.43612	3.90301	0.88038	238.072			
4.37836	4.97304	.88042	238.091			
2.90330	3.29784	.88037	238.067			
5.49584	6.24257	.88038	238.074			
4.90768	5.57455	.88037	238.070			
4.99286	5.67158	.88033	238.052			
3.75336	4.26323	.88040	238.084			
4.77701	5.42582	.88042	238.092			
4.47977	5.08841	.88039	238.077			
Average		.88038	238.075			
Katanga curite						
4.63617	5.26634	0.88034	238.056	6.99683	0.66261	238.078
4.36107	4.95357	.88039	238.078	6.58181	.66260	238.069
4.47121	5.07874	.88038	238.073	6.74810	.66259	238.065
Average		.88037	238.069		.66260	238.071
Norwegian euxenite and samarskite						
3.18342	3.61604	0.88036	238.065	4.80457	0.66258	238.062
4.46996	5.07739	.88037	238.068	6.74596	.66261	238.080
4.70546	5.34497	.88035	238.062	7.10206	.66255	238.043
Average		.88036	238.065		.66258	238.062
Sublimed in bromine and fused in bromine						
UBr_4, g.	Ag, g.	UBr_4: 4Ag	At. wt. U	AgBr, g.	UBr_4: 4Ag	At. wt. U.
Morogoro uraninite						
2.42503	1.87618	1.29254	238.091	3.26598	0.74251	238.099
6.09031	4.71214	1.29247	238.064			
5.02670	3.88920	1.29248	238.066	6.77004	.74249	238.084
4.72075	3.65242	1.29250	238.075			
4.69691	3.63391	1.29252	238.085	6.32562	.74252	238.106
4.32567	3.34676	1.29250	238.073	5.82595	.74248	238.078
Average		1.29250	238.075		.74250	238.092
Joaquimstahl pitchblende						
4.78298	3.70053	1.29251	238.081	6.44193	0.74248	238.072
3.49630	2.70491	1.29258	238.108	4.70845	.74356	238.134
2.93547	2.27122	1.29246	238.060			
4.37485	3.38489	1.29246	238.060	5.89220	.74248	238.076
3.02257	2.33852	1.29252	238.082	4.07087	.74249	238.081
3.45769	2.67520	1.29250	238.075	4.65671	.74252	238.104
3.42225	2.64779	1.29249	238.073	4.60899	.74252	238.102
Average		1.29250	238.077		.74251	238.095
Katanga curite						
4.00032	3.09498	1.29252	238.084	5.38767	0.74250	238.087
4.86883	3.76705	1.29248	238.066	6.55730	.74251	238.094
4.35228	3.36732	1.29251	238.078	5.86169	.74250	238.087
4.42009	3.41976	1.29252	238.082	5.95328	.74246	238.062
Average		1.29251	238.078		.74249	238.083
Norwegian euxenite and samarskite						
2.72360	2.10715	1.29255	238.098	3.66815	0.74250	238.090
2.60119	2.01259	1.29246	238.058	3.50361	.74243	238.039
4.20791	3.25555	1.29254	238.098	5.66706	.74252	238.106
Average		1.29252	238.082		.74248	238.078

Within the experimental error there seem to be no differences in the isotopic composition of the samples of uranium, although the original minerals differ considerably in geologic age.

The authors believe the comparisons of the halides with silver to be more accurate than those with silver halides, and point out that, since material fused after sublimation seems to yield slightly higher and less consistent results than when final fusion is omitted, dissociation and loss of halogen may occur during fusion. Therefore they prefer the final value 238.07, which results from analyses of unfused chloride, to the average of all the determinations.

This result is materially lower than the value in use for some time, which depends on the work of Hönigschmid and of Hönigschmid and Schilz. The authors believe the difference to be due to the fact that in the earlier work the halides were finally sublimed and fused in nitrogen before weighing. Since there seems to be no doubt that this is the case, and since the value 238.07 best represents the evidence of the foregoing work, this new value has been adopted for the International table.

Molybdenum and Tungsten.—Hönigschmid and Wittmann[24] and Hönigschmid and Menn[25] have redetermined the atomic weights of molybdenum and tungsten by analysis of the pentachloride and hexachloride, respectively.[26] Their results, Mo = 95.95 and W = 183.92, agree closely with Aston's recent determinations, and are only slightly lower than the International values.

New measurements of doublets by Aston[27] with a perfected mass spectrograph include the following values for certain light isotopes.

O^{16} = 16.0000	(Factor = 1.00025) O = 16.0000
H = 1.00812	H = 1.0079
D = 2.01471	D = 2.0142
He = 4.00391	He = 4.0029
C^{12} = 12.0035	C^{12} = 12.0005
N^{14} = 14.0073	N^{14} = 14.0038

The value for C^{12} is slightly lower than that reported by Aston in 1935, and with an abundance ratio of 1/100 for C^{13} leads to an atomic weight of 12.010.

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(24) Hönigschmid and Wittmann, *Z. anorg. allgem. Chem.*, **229**, 65 (1936).

(25) Hönigschmid and Menn, *ibid.*, **229**, 49 (1936).

(26) Published after Sept. 30, 1936.

(27) Aston, *Nature*, **137**, 357, 613 (1936).