The Journal of the American Chemical Society

VOL. 53 | MAY, 1931 | No. 5

FIRST REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS OF THE INTERNATIONAL UNION OF CHEMISTRY

By G. P. Baxter (*Chairman*), Mme. M. Curie, O. Hönigschmid, P. Le Beau and R. J. Meyer

Received April 3, 1931 Published May 6, 1931

In September, 1930, at the meeting of the International Union of Chemistry at Liege, the Committee on Elements which has functioned since 1923 was replaced by three committees, on Atomic Weights, Atoms, including isotopy and atomic structure, and Radioactive Constants. Hereafter the function of the first of these committees will be to prepare annually a table of atomic weights on the basis of the most recent evidence. National Committees on Atomic Weights are requested by the International Union to refrain from publishing tables of their own.

While it was impossible for the new committee to issue a report earlier this year, it is the intention of the committee normally to issue its report so far as possible in the first (January) number of current chemical and physical periodicals. These reports will cover the twelve months from October to September preceding.

Authors of papers bearing on the subject are requested to send copies to each of the five members of this committee at the earliest possible moment.[1]

Since the reports of the German and American committees[2] adequately cover the ground of progress during 1929, only investigations published since January 1, 1930, are reviewed in this report.

Batuecas, Schlatter and Maverick[3] have published new determinations

	I	II
N_2	1.0040	
NH_3	1.01543	1.01515
HCl	1.00787	1.00737
CO	1.00048	
H_2S	1.01031	1.01035

[1] Prof. G. P. Baxter, Coolidge Laboratory, Harvard University, Cambridge, Mass., U. S. A.; Mme. M. Curie, Institut du Radium, 1 Rue Pierre Curie, Paris 5, France; Prof. O. Hönigschmid, Arcisstrasse 1, Munich, Germany; Prof. P. Le Beau, École Superieure de Pharmacie, 4 Avenue de l'Observatoire, Paris 5, France; Prof. R. J. Meyer, Meinekestrasse 8, Berlin W. 15, Germany.

[2] *Ber.*, **63B**, 1 (1930); This Journal, **52**, 857 (1930).

[3] Batuecas, Schlatter and Maverick, *J. chim. phys.*, **27**, 36, 45 (1930).

of $(PV)_0/(PV)_1$ by the expansion method. In Column I the assumption is made that the quantity varies lineally with the pressure; in Column II an equation of the second degree is used.

Nitrogen.—Moles and Batuecas[4] have redetermined the density of ammonia at various pressures. The gas was prepared (1) from ammonium oxalate and potassium hydroxide, (2) by synthesis (technical) from the elements, (3) by hydrolysis of magnesium nitride. After chemical purification the gas was fractionally distilled and in most cases was dried finally with phosphorus pentoxide. Correction for adsorption on the walls of the

Method of preparation	Globe N-3 773 ml.	Globe N-2 647 ml. Preliminary	Globe G, 1007 ml.	Average
		1 Atmosphere		
1	0.77167	0.77196		0.7718
	.77234	.77184		.7721
	.77226	.77207		.7722
	.77137	.77219		.7718
Average	.77191	.77202		.7720
	.77174	.77130		.77152
	.77168	.77190		.77179
	.77113	.77158		.77136
	.77160	.77168		.77164
		.77166		.77166
	.77170	.77149		.77160
	.77184	.77212		.77198
Average	.77162	.77168		.77165
2	.77118	.77185		.77152
	.77153	.77207		.77180
	.77180	.77119		.77149
	.77144	.77188		.77166
	.77161	.77193		.77177
Average	.77151	.77178		.77165
3			0.77169	.77169
			.77165	.77165
	.77195		.77193	.77194
	.77168		.77170	.77169
	.77187		.77206	.77197
Average	.77183		.77181	.77179
Average of all	.77163	.77172	.77181	.77169
Method of preparation	**Globe N_3**	**Globe N_2**	**Globe G**	**Average**
		$^2/_3$ Atmosphere		
1	0.76758		0.76763	0.76761
	.76734		.76773	.76754
	.76839		.76842	.76841
	.76803		.76844	.76824
Average	.76784		.76806	.76795

[4] Moles and Batuecas. *Anales soc. españ. fís. quím.*, **28**, 871 (1930).

Method of preparation	Globe N_3	Globe N_2	Globe G	Average
2	0.76754	0.76770		0.76762
	.76770			.76770
	.76752	.76769		.76761
Average	.76759	.76770		.76764
3	.76743		.76729	.76736
	.76737		.76758	.76748
Average	.76740		.76744	.76742
Average of all	.76766	.76770	.76785	.76773
		$^1/_2$ Atmosphere		
1	0.76511		0.76624	0.76568
	.76623		.76597	.76610
	.76586		.76557	.76572
Average	.76573		.76593	.76583
2	.76592		.76606	.76599
	.76582		.76592	.76587
Average	.76587		.76599	.76593
3		0.76539		.76539
	.76641			.76641
	.76577	.76561		.76569
	.76610	.76593		.76602
	.76605	.76541		.76573
Average	.76608	.76559		.76585
Average of all	.76592	.76559	.76595	.76585
		$^1/_3$ Atmosphere		
1	0.76328		0.76321	0.76325
	.76378		.76341	.76360
	.76395		.76434	.76415
Average	.76367		.76365	.76366
2	.76424		.76314	.76369
			.76348	.76348
	.76400		.76403	.76402
	.76416		(.76260)	.76416
	.76444		.76387	.76416
	.76387		.76360	.76374
Average	.76418		.76362	.76390
3	.76391			
	.76438			
	.76342			
	.76350			
	.76405		.76426	.76416
Average	.76385		.76426	.76392
Average of all	.76392		.76370	.76383

globes was made. The results are expressed in the weight of the liter at 0° and 760 mm.

From the densities at various pressures the limiting density of ammonia is calculated by the method of differences to be 0.75990. The corresponding molecular weight of ammonia is then 17.032, and the atomic weight of nitrogen 14.009.

Phosphorus.—Ritchie[5] has determined the density of phosphine at different pressures. The gas was prepared from phosphonium iodide by means of potassium hydroxide and was fractionated.

P, atmospheres	Globe I, 336 ml.	Globe II, 341 ml.	Average
1	(1.5311)	1.5308	1.5308
	1.5308	1.5307	1.5308
	1.5307	1.5305	1.5306
	1.5307	1.5307	1.5307
	1.5308	1.5308	1.5308
	1.5306		1.5306
	Average 1.5307	1.5307	1.5307
0.75	1.5274	1.5272	1.5273
		1.5273	1.5273
	1.5271	1.5272	1.5272
	Average 1.5273	1.5272	1.5272
0.50	1.5241	1.5237	1.5239
	1.5242		1.5242
	1.5237	1.5236	1.5237
	1.5233	1.5238	1.5236
	1.5238	1.5238	1.5238
	Average 1.5238	1.5237	1.5238
0.25	1.5204	1.5202	1.5203
	1.5202	1.5203	1.5203
		1.5201	1.5201
	1.5205	1.5205	1.5205
	Average 1.5204	1.5203	1.5203

Assuming a linear relation between PV and pressure, $(PV)_0/(PV)_1$ is calculated to be 1.0091.

If the normal liter of oxygen weighs 1.4290 g. and the coefficient of deviation from Boyle's Law per atmosphere is -0.00096, then $PH_3 = 34.000$ and $P = 30.977$. This value for phosphorus is appreciably lower than the chemical value.

Sulfur.—Hönigschmid and Sachtleben[6] have completed a synthesis of silver sulfide from its elements. The compound was found to be stable up to 300° but to lose sulfur by decomposition above this temperature. When reheated in sulfur vapor, partially decomposed sulfide takes up quantitatively the deficiency in sulfur. Excess sulfur is given up at 300°. To carry out a synthesis weighed quantities of the purest silver were heated in sulfur vapor until the reaction was complete and then the excess of sulfur was eliminated in a current of pure nitrogen at 280°. Constancy in weight of the sulfide was readily attained. The sulfur was prepared by precipita-

[5] Ritchie, *Proc. Roy. Soc.* (London), **A128**, 551 (1930).

[6] Hönigschmid and Sachtleben, *Z. anorg. Chem.*, **195**, 207 (1931).

tion from thiosulfate and double distillation in vacuum. Weights are corrected to vacuum. In the twelfth analysis the materials of the eleventh were reweighed in exhausted receptacles.

THE ATOMIC WEIGHT OF SULFUR

Wt. of Ag, g.	Wt. of Ag_2S, g.	Ratio $Ag_2S:2Ag$	Atomic weight of sulfur
7.90291	9.07742	1.148617	32.066
9.42181	10.82209	1.148621	32.066
9.74522	11.19355	1.148620	32.066
9.59836	11.02489	1.148622	32.067
9.20378	10.57166	1.148622	32.067
10.75224	12.35021	1.148617	32.066
8.28317	9.51424	1.148623	32.067
9.86327	11.32913	1.148618	32.066
10.43748	11.98871	1.148621	32.066
7.21091	8.28265	1.148627	32.068
9.84440	11.30749	1.148621	32.067
9.84439	11.30748	1.148622	32.067
	Average	1.148621	32.066

Since all recent determinations of the atomic weight of sulfur have yielded a value not far from 32.06, this value has been adopted for the table.

Chlorine.—Scott and Johnson,[7] call attention to an error in the solubility of silver chloride at 0° assumed by Hönigschmid and Chan[8] in their syntheses of silver chloride, which amounts to 0.002% in the weight of silver chloride.

Calcium.—Hönigschmid and Kempter[9] purified calcium nitrate from marble by ten recrystallizations, and converted the product to chloride by precipitation of the carbonate and solution of the latter in hydrochloric acid (Sample I). Sample II was prepared from commercial nitrate by fifteen crystallizations. After recrystallization of the chloride it was prepared for weighing by dehydration and fusion in hydrogen chloride, and allowed

ATOMIC WEIGHT OF CALCIUM

Sample	Wt. of $CaCl_2$, g.	Wt. of Ag, g.	Ratio $CaCl_2:2Ag$	Atomic weight of calcium
I	1.84526	3.58692	0.514441	40.082
I	1.62314	3.15509	.514451	40.084
I	1.42216	2.76444	.514447	40.083
I	2.21933	4.31400	.514448	40.083
I	1.03950	2.02064	.514441	40.082
I	1.45783	2.83364	.514472	40.088
II	2.93786	5.71052	.514464	40.086
II	2.45368	4.76952	.514451	40.084
II	2.11276	4.10689	.514441	40.082
		Average	.514451	40.084

[7] Scott and Johnson, THIS JOURNAL, **52**, 3586 (1930).

[8] Hönigschmid and Chan, *Z. anorg. Chem.*, **163**, 315 (1927).

[9] Hönigschmid and Kempter, *ibid.*, **195**, 1 (1931).

Atomic Weight of Calcium (*Concluded*)

Sample	Wt. of $CaCl_2$, g.	Wt. of AgCl, g.	Ratio $CaCl_2$:2AgCl	Atomic weight of calcium
I	1.97942	5.11225	0.387191	40.083
I	2.35393	6.07937	.387199	40.086
I	1.67385	4.32284	.387210	40.089
I	1.62314	4.19217	.387183	40.082
I	1.42216	3.67297	.387196	40.085
I	2.21933	5.73153	.387214	40.090
II	1.03950	2.68467	.387198	40.086
II	1.45783	3.76499	.387206	40.088
		Average	.387200	40.086

to solidify in nitrogen. The solutions of the weighed chloride were corrected for deviations from the neutral point by titration with $N/100$ solutions of acid and base and then were compared with silver in the usual way, and the silver chloride was collected and weighed. Weights are corrected to vacuum.

The average of both series, 40.085, is slightly higher than that found earlier by Richards and Hönigschmid, 40.071. For the present 40.08 is recommended.

A. V. and O. Frost[10] claim to have discovered a concentration of Ca^{41} by beta-ray emission from K^{41} in a potassium feldspar containing 0.042% of calcium oxide. Only 0.15 g. of calcium oxide was available. From the ratio $CaCl_2$:$CaBr_2$ the atomic weight of calcium was found in two experiments to be 40.23. Similar experiments with ordinary calcium which had been purified in the same way gave 40.10.

Hönigschmid and Kempter[11] attacked the same problem with calcium extracted from sylvin by von Hevesy. After preliminary purification the average atomic weight through the chloride was found to be 40.22. Spectroscopic investigation, however, revealed the presence of strontium. After removal of this impurity by fractional precipitation of the oxalate, the observed atomic weight was lowered to 40.093. The material still contained 0.015 atom per cent. of strontium so that the value to be expected is 40.091. Since the sylvin is a geologically younger mineral than the feldspar, a smaller concentration of Ca^{41} is to be expected, so that the question as to appreciable variation of Ca^{41} in nature is still an open one.

Vanadium.—Scott and Johnson,[12] have analyzed vanadyl trichloride. This was made by heating purified vanadium trioxide in a current of chlorine, and the product was purified by vacuum distillation, after removal of excess chlorine with mercury and sodium. Portions for analysis were removed in sealed glass bulbs in the later stages of the distillation. After being weighed the bulbs were broken under either nitric acid or ammonia.

[10] Frost and Frost, *Nature*, **125**, 48 (1930).

[11] Hönigschmid and Kempter, *Z. anorg. Chem.*, **195**, 9 (1931).

[12] Scott and Johnson. This Journal, **52**, 2638 (1930).

In the former case the glass was washed with nitric acid and collected on a filter. In the latter, after the supernatant liquid had been filtered, the precipitate was dissolved in nitric acid and the glass was washed and collected. The solutions were then compared with silver in the usual way, and in some cases the silver chloride was collected. The analyses are arranged in the order of decreasing volatility of the chloride samples. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF VANADIUM

Wt. of $VOCl_3$, g.	Wt. of Ag, g.	Ratio $VOCl_3$:3Ag	Atomic wt. of vanadium	Wt. of AgCl, g.	Ratio $VOCl_3$:3AgCl	At. wt. of vanadium
		Acid Hydrolysis				
8.15697	15.23143	0.535535	50.950	20.23483	0.403115	50.973
8.29538	15.48986	.535536	50.950	20.57872	.403105	50.969
7.60527	14.20111	.535541	50.951	18.86755	.403087	50.961
7.01143	13.09218	.535543	50.952			
	Average	.535539	50.951		.403102	50.968
		Alkaline Hydrolysis				
7.75120	14.47384	0.535532	50.949			
7.88453	14.72386	.535493	50.936	19.56218	.403050	50.945
9.19783	17.17614	.535500	50.938	22.81924	.403073	50.955
6.69572	12.50344	.535510	50.941			
8.04970	15.03136	.535527	50.947	19.96976	.403094	50.964
7.62984	14.24666	.535553	50.955			
	Average	.535519	50.945		.403072	50.955

Experimental evidence was found that the nephelometric end-point was slightly affected by the presence of vanadic acid, but the effect on the atomic weight of vanadium is less than 0.005. The average of the comparisons with silver, 50.948, agrees almost exactly with the recent results obtained by McAdam, and by Briscoe and Little.

Chromium.—Gonzales[13] has applied to chromyl chloride the recently developed method of preparing volatile inorganic compounds by fractional distillation in vacuum. The compound was prepared by the action of concentrated sulfuric acid on a mixture of sodium chloride and potassium bichromate and after fractional distillation under low pressure was collected in sealed glass bulbs. The bulbs were broken under water and the halogen was determined by comparison with silver in the usual way. Ultimately the silver chloride was determined. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF CHROMIUM

Wt. of CrO_2Cl_2, g.	Wt. of Ag, g.	Ratio CrO_2Cl_2:2Ag	Atomic wt. of chromium	Wt. of AgCl, g.	Ratio CrO_2Cl_2:2AgCl	At. wt. of chromium
9.56543	13.32143	0.718049	52.012	17.69786	0.540485	52.029
9.54415	13.29120	.718080	52.019	17.65929	.540460	52.022
	Average	.718065	52.016		.540473	52.026

[13] Gonzales, *Anales soc. españ. fís. quím.*, **28**, 579 (1930).

The average result 52.02 is only 0.01 unit higher than the current one and no change is recommended for the present.

Arsenic.—Krepelka[14] has published details of the analysis of arsenic trichloride noted earlier.[15] Recrystallized arsenic trioxide was reduced with sugar charcoal and the metal resublimed. Conversion of the metal to chloride was followed by repeated vacuum distillation of the latter. Samples were collected for weighing in sealed evacuated bulbs. Hydrolysis with ice water was followed by comparison with silver in the usual way. In two cases the silver chloride was collected and weighed. Vacuum weights are given.

THE ATOMIC WEIGHT OF ARSENIC

Wt. of $AsCl_3$, g.	Wt. of Ag, g.	Ratio $AsCl_3:3Ag$	At. wt. of arsenic[a]	Wt. of AgCl, g.	Ratio $AsCl_3:3AgCl$	At. wt. of arsenic[a]
3.98710	7.11681	0.560237	74.944			
4.81766	8.59961	.560218	74.938			
6.27437	11.20020	.560201	74.933			
2.42721	4.33242	.560244	74.946	5.75672	0.421631	74.934
3.86442	6.89796	.560227	74.941			
5.09819	9.10041	.560215	74.937			
5.46890	9.76222	.560211	74.936			
5.10039	9.10415	.560227	74.941			
5.71146	10.19540	.560200	74.932			
3.05992	5.46180	.560240	74.945			
1.49994	2.67755	.560191	74.929	3.55734	.421646	74.941
	Average	.560219	74.938		.421638	74.938

[a] Calculated with Cl = 35.457. The figures given by the authors are calculated with Cl = 35.458.

This value is slightly lower than the value which has been in use for some time, and slightly higher than that found by Aston with the mass spectrograph after correction for the presence of O^{18}, 74.927. The value 74.93 is adopted in the table of atomic weights.

Tantalum.—Krishnaswami[16] has analyzed the chloride and bromide of tantalum. Metallic tantalum was first obtained by reducing purified potassium tantalum fluoride with sodium in an atmosphere of argon. When examined spectroscopically the metal appeared to be free from impurities, although it contained a small percentage of oxide. The metal was converted to halides by the action of pure dry halogens and the halides were twice distilled in vacuum and collected in sealed glass bulbs. After being weighed the bulbs were broken under ammonia and the solutions filtered to remove glass and tantalic acid. To find the weight of the glass the tantalic acid was dissolved in oxalic acid and the glass was collected on a weighed crucible. The solutions were then compared with silver, and

[14] Krepelka, *Collect. trav. chim. Tchecoslovaquie*, **2**, 255 (1930).

[15] Krepelka, *Nature*, **123**, 944 (1929).

[16] Krishnaswami, *J. Chem. Soc.*, 1277 (1930).

the silver halides were collected and weighed. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF TANTALUM

Wt. of $TaBr_5$, g.	Wt. of Ag, g.	Ratio $TaBr_5$:5Ag	Atomic wt. of tantalum	Wt. of AgBr, g.	Ratio $TaBr_5$:5AgBr	At. wt. of tantalum
3.07127				4.96415	0.61869	181.36
3.72095				6.01413	.61870	181.37
3.81890	3.54594	1.07698	181.34	6.17267	.61868	181.35
3.59654	3.33939	1.07700	181.36	5.81303	.61870	181.37
2.69071	2.49831	1.07701	181.37	4.34926	.61866	181.33
2.61163	2.42488	1.07702	181.37	4.22133	.61868	181.35
3.92094	3.64064	1.07699	181.35	6.33750	.61869	181.36
2.04583	1.89956	1.07700	181.36	3.30681	.61867	181.34
	Average	1.07700	181.36		.61868	181.35

Wt. of $TaCl_5$, g.	Wt. of Ag, g.	Ratio $TaCl_5$:5Ag	Atomic wt. of tantalum	Wt. of AgCl, g.	Ratio $TaCl_5$:5AgCl	At. wt. of tantalum
3.15350	4.74301	0.66488	181.35	6.30152	0.50044	181.37
2.96215	4.45549	.66483	181.33	5.91874	.50047	181.40
4.08061	6.13756	.66486	181.34	8.15438	.50042	181.36
3.21073	4.82972	.66479	181.30	6.41613	.50042	181.36
3.49922	5.26278	.66490	181.36	6.99201	.50046	181.39
	Average	.66485	181.34		.50044	181.37

The average value, 181.36, is lower than that found by Balke in 1910, 181.50. Balke's method, in which the ratio $TaCl_5$:Ta_2O_5 was determined, has been found to be unreliable because of the uncertain composition of most oxides. The new value therefore has been adopted.

Rhenium.—Hönigschmid and Sachtleben[17] have taken advantage of the increased quantities of rhenium now available by analyzing silver perrhenate. Three specimens of material were prepared. (I) Potassium perrhenate was recrystallized and the silver salt precipitated. Retained potassium was removed by reprecipitation and crystallization. (II) Metallic rhenium was burned to heptoxide in oxygen, and after solution of the oxide in water, silver perrhenate was precipitated with silver nitrate. (III) The third sample was prepared by dissolving silver oxide in perrhenic acid.

THE ATOMIC WEIGHT OF RHENIUM

Sample	Wt. of $AgReO_4$, g.	Wt. of AgBr, g.	Ratio $AgReO_4$:AgBr	Atomic weight of rhenium
I	5.36365	2.81186	1.90751	186.34
II	7.83577	4.10795	1.90747	186.33
II	8.55829	4.48684	1.90742	186.33
II	6.34973	3.32894	1.90743	186.33
III	8.90918	4.67111	1.90729	186.30
III	6.95494	3.64684	1.90712	186.27
III	7.85704	4.11955	1.90726	186.30
		Average	1.90735	186.31

[17] Hönigschmid and Sachtleben, *Z. anorg. Chem.*, **191**, 309 (1930).

The silver salt was prepared for weighing by fusion in air of a mixture of the perrhenate with an excess of acid. Weighed amounts of salt were dissolved in water and the silver was precipitated as silver bromide. Weights are corrected to vacuum.

This result is 2.4 units lower than the preliminary value found by W. and I. Noddack by analysis of the disulfide, but in view of the inferiority of the latter method and the small quantities weighed, the new value 186.31 is adopted for the table.

Thallium.—Hönigschmid and Striebel[18] prepared thallous bromide by precipitation from a solution of the purified sulfate. After distillation in nitrogen the salt was weighed in a quartz tube. Solution in hot water was followed by hot precipitation with a nearly equivalent amount of silver. The end-point was found with a nephelometer in the usual way. Weights are corrected to vacuum.

THE ATOMIC WEIGHT OF THALLIUM

Wt. of TlBr, g.	Wt. of Ag, g.	Ratio TlBr:Ag	Atomic weight of thallium
	Preliminary Series		
3.86281	1.46582	2.63526	204.38
3.78429	1.43583	2.63561	204.41
3.96949	1.50639	2.63510	204.36
3.94471	1.49669	2.63562	204.42
	Average	2.63540	204.39
	Final Series		
4.01222	1.52251	2.63527	204.377
3.97142	1.50692	2.63546	204.397
3.90498	1.48170	2.63547	204.399
4.07193	1.54509	2.63540	204.391
3.68886	1.39974	2.63539	204.390
4.04739	1.53580	2.63536	204.387
	Average	2.63539	204.390

This value agrees exactly with that found earlier by Hönigschmid, Berckenbach and Kothe through the analysis of thallous chloride.

Lead.—Baxter and Bliss[19] have determined the atomic weight of two specimens of RaG. The first was extracted from Swedish kolm, the second from uraninite from Wilberforce, Ontario, Canada. Purification was effected by precipitation as chromate and sulfate and crystallization as nitrate and chloride. After resublimation the chloride was fused preparatory to weighing. Comparison with silver was carried out as usual. Weights are corrected to vacuum.

The kolm lead has a lower atomic weight than any other specimen yet examined and seems to consist almost entirely of the isotope Pb^{206}.

[18] Hönigschmid and Striebel, *Z. anorg. allgem. Chem.*, 194, 293 (1930).

[19] Baxter and Bliss, THIS JOURNAL, **52**, 4848, 4851 (1930).

International Atomic Weights

1931

	Symbol	Atomic Number	Atomic Weight
Aluminum	Al	13	26.97
Antimony	Sb	51	121.76
Argon	A	18	39.944
Arsenic	As	33	74.93
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	40.08
Carbon	C	6	12.00
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	93.3
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	157.3
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	271	175.0
Magnesium	Mg	1	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	186.31
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	181.4
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	50.95
Xenon	Xe	54	130.2
Ytterbium	Yb	70	173.5
Yttrium	Y	39	88.92
Zinc	Zn	30	65.38
Zirconium	Zr	40	91.22

The Atomic Weight of Lead

Sample	Wt. of $PbCl_2$, g.	Wt. of Ag, g.	Ratio $PbCl_2$:2Ag	Atomic weight of lead
Common	2.74332	2.12809	1.28910	207.222
	3.60741	2.79852	1.28904	207.209
	3.07537	2.38565	1.28911	207.224
	2.81471	2.18351	1.28908	207.218
			1.28909	207.218
Kolm	1.61294	1.25678	1.28339	205.990
	1.60407	1.24983	1.28343	205.999
	2.56499	1.99842	1.28351	206.016
	1.83748	1.43167	1.28345	206.003
	3.32075	2.58729	1.28349	206.011
	3.07451	2.39530	1.28356	206.027
			1.28347	206.008
Uraninite	3.74779	2.91808	1.28433	206.194
	5.63102	4.38436	1.28434	206.196
			1.28434	206.195

Aston[20] has extended the usefulness of the mass spectrograph to the determination of the chemical atomic weight of complex elements by microphotometric measurements of the intensities of the isotopic lines in a mass spectrogram. The following table gives the percentages of the components, as well as the packing fractions and the atomic weights calculated on the basis of chemical oxygen.

	Isotopic weights and percentages											Packing fraction	Atomic wt. O = 16.0000
Chromium	50	52	53	54									
	4.9	81.6	10.4	3.1								-10×10^{-4}	52.011
Zinc	64	65	66	67	68	69	70						
	48.0	2.5	25.9	5.3	17.1	0.85	0.38					-9.9×10^{-4}	65.380
Molybdenum	92	94	95	96	97	98	100						
	14.2	10.0	15.5	17.8	9.6	23.0	9.8					-5.5×10^{-4}	95.97
Krypton	78	80	82	83	84	86							
	0.42	2.45	11.79	11.79	56.86	16.70						-8.8×10^{-4}	83.77
Tin	112	114	115	116	117	118	119	120	121	122	124		
	1.07	0.74	0.44	14.19	9.81	21.48	11.02	27.04	2.96	5.03	6.19		
												-7.3×10^{-4}	118.72
Xenon	124	126	128	129	130	131	132	134	136				
	0.08	0.08	2.30	27.13	4.18	20.67	26.45	10.31	8.79				
												-5.3×10^{-4}	131.27
Mercury	196	198	199	200	201	202	204						
	0.10	9.89	16.45	23.77	13.67	29.27	6.85					$+0.8 \times 10^{-4}$	200.62

The close agreement of the calculated atomic weights with those found by chemical means in the case of chromium, zinc, molybdenum, tin and mercury, indicates that the method is capable of giving results of a high

[20] Aston, *Proc. Roy. Soc.* (London), **A126**, 511 (1930); **A130**, 302 (1931); *Nature*, **126**, 200, 348 (1930).

degree of accuracy. In the cases of krypton and xenon the calculated and experimental (density) values are discrepant and, as pointed out by Aston, new determinations of the densities and compressibilities of these gases should be made.

[Contribution from the Department of Botany at Los Angeles and the Division of Plant Nutrition at Berkeley, University of California]

THE CRYSTAL STRUCTURE OF SOME FORMS OF GLUCOSE. A PRELIMINARY PAPER

By O. L. Sponsler and W. H. Dore

Received June 18, 1930 Published May 6, 1931

In anticipation of throwing more light upon the atomic arrangement of the cellulose unit, several crystalline forms of glucose have been under investigation. The structural relationship between cellulose and the beta modification of the amylene oxidic ring form of glucose has been pointed out by the authors.[1] In order to gain a clearer conception of cellulose it has seemed desirable to determine the structure of the crystals of the beta form and also of other forms of glucose. The present report deals with some preliminary results on the alpha and the beta forms of *d*-glucose ($C_6H_{12}O_6$) and on the alpha glucose monohydrate ($C_6H_{12}O_6 \cdot H_2O$).

The first two forms were prepared[2] by the method of Hudson and Dale[3] and the monohydrate by that of Hudson and Yanovsky.[4] The fine crystals so obtained were examined by the powder method of x-ray crystal analysis. Radiation from a molybdenum target Coolidge tube was employed for obtaining the diffraction patterns. The existence of crystallographic data for the two alpha forms made it possible to determine the lattice dimensions and to assign space groups to these forms. The absence of similar data for beta glucose precluded those deductions regarding its structure, but the diffraction patterns made it evident that the alpha and beta forms have different crystal structures.

After this paper was written Hengstenberg and Mark[5] reported a lattice for "*d*-glucose" without stating whether the alpha or beta form was used. They employed a single crystal rotation method. The agreement of their data with those appearing in this paper, together with the method they used for preparing their material, makes it clear that they were working with alpha *d*-glucose.

[1] Sponsler and Dore, "Fourth Colloid Symposium Monograph," The Chemical Catalog Co., New York, **1926**, pp. 174–202; Meyer and Mark, *Ber.*, **61**, 593–614 (1928).

[2] The thanks of the authors are due to Mr. T. C. Broyer, of the Plant Nutrition Laboratory, for preparing these two forms.

[3] Hudson and Dale, This Journal, **39**, 320 (1917).

[4] Hudson and Yanovsky, *ibid.*, **39**, 1013 (1917).

[5] Hengstenberg and Mark, *Z. Krist.*, **72**, 301 (1929).