VOL. 44. MARCH, 1922. NO. 3.

THE JOURNAL

OF THE

American Chemical Society

with which has been incorporated the

American Chemical Journal
(Founded by Ira Remsen)

TWENTY-EIGHTH ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS

DETERMINATIONS PUBLISHED DURING 1921

BY GREGORY PAUL BAXTER

Received January 27, 1922

The International Committee on Atomic Weights recommends[1] the following changes in its table.

Aluminum	27.0	Thulium	169.9
Bismuth	209.0	Silicon	28.1

At the Second International Conference of Pure and Applied Chemistry[2] at Brussels, in June, 1921, it was decided that the old International Committee on Atomic Weights should be enlarged and renamed the Committee on Chemical Elements, and that in addition to atomic weights, it should cover the fields of isotopes and radioactive elements.

Brauner[3] recommends to the New International Commission on Chemical Elements that the term "atomic weights" be confined to the values obtained by chemical methods and that the term "atomic masses" be used for the values of the individual isotopes of any given element. He also suggests that the proposed subcommittee of the International Commission be called a "Subcommittee for Atomic Weights."

[1] THIS JOURNAL, **43**, 1751 (1921).
[2] *J. Ind. Eng. Chem.*, **13**, 737 (1921).
[3] Brauner, *Chem. News*, **123**, 230 (1921).

A new (fourth) edition of Clarke's Recalculation of the Atomic Weights has been published as a Memoir of the National Academy of Sciences.[4]

Oddo[5] advocates a return to the hydrogen basis for the atomic weight system on the ground that the ratio between oxygen and hydrogen is now known with sufficient accuracy. The suggestion is also made that revisions of the atomic weight table be less frequent.

Moles[6] discusses critically determinations published in 1918–19.

Determinations published during 1921, besides some published during 1920, but not included in the last report are given below.

Boron.—Baxter and Scott[7] in a brief note announce that the analysis of both boron trichloride and boron tribromide has yielded the value 10.83 for the atomic weight of boron. This result is apparently in better accord with the isotopic ratio estimated by Aston than the recent result of Smith and Van Haagen (10.90).

Oxygen.—Moles and Gonzalez[8] have redetermined the density of oxygen prepared in different ways.

Series	Number of globes	Source of oxygen	Density
2	3	$KMnO_4$	1.42882
4	3	$KClO_3$	1.42849
5	3	$KMnO_4$	1.42910
6	2	HgO	1.42929
7	3	$KClO_3$	1.42875
8	3	HgO	1.42905
10	3	Ag_2O	1.42869
11	2	$KMnO_4$	1.42913
13	3	$KMnO_4$	1.42872
14	3	$KMnO_4$	1.42888
15	2	$KMnO_4$	1.42890
16	3	Ag_2O	1.42891
17	3	Ag_2O	1.42884
18	3	$KMnO_4$	1.42855
19	3	Electrolysis	1.42885
20	3	Electrolysis	1.42908
		Mean	1.42889

Source of oxygen	Number of determinations	Density
$KMnO_4$	19	1.42886
$KClO_3$	6	1.42862
HgO	5	1.42915
Ag_2O	9	1.42891
Electrolysis	6	1.42897

[4] Vol. XVI. Third Memoir, "The Constants of Nature." Part V. A Recalculation of the Atomic Weights. By F. W. Clarke. 1920.

[5] Oddo, *Gazz. chim. ital.*, **51**, 161 (1921).

[6] Moles, *J. chim. phys.*, **18**, 414 (1920).

[7] Baxter and Scott, *Science, N. S.*, **44**, 524 (1921).

[8] Moles and Gonzalez, *Compt. rend.*, **173**, 355 (1921).

This result is more than 0.01% lower than the value usually assumed and, if used, will raise in this proportion the molecular weights of gases referred to oxygen.

Fluorine.—Moles and Batuecas[9] have corrected and recalculated their results upon the density of methyl fluoride.[10] After new corrections for the force of gravity at Madrid, for the barometric scale, and for the contraction of the globes when exhausted have been applied, the following densities are computed from the determinations at different pressures: 1 atm., 1.54507 ± 0.00046; $^2/_3$ atm., 1.53576; $^1/_3$ atm., 1.52642. From these results $\frac{(pv)_0}{(pv)_1} = 1 + \lambda$ is computed by Guye's "secondary difference" and "algebraic" methods to be 1.01803. In a following paper[11] these methods are shown to be mathematically identical.

New determinations of the density of oxygen prepared from potassium permanganate are presented.

	Globe I	Globe I′	Globe II	Globe III
	1.42870	.....	1.42946	1.42886
	1.42939	.....	1.42949	1.42857
	.....	.....	1.42903	1.42843
	1.42872	1.42851	.....	1.42777
	1.42892	1.42858	.....	1.42907
Av.	1.42893	1.42855	1.42933	1.42854
			General mean	1.42882

The molecular weight of methyl fluoride is calculated, with the use of this value for the density of oxygen and the value 1.00097 for $1 + \lambda$, to be 34.025 and the atomic weight of fluorine to be 19.002 (C = 12.00; 3H = 3.023).

If the density of oxygen is taken as 1.4290, fluorine becomes 18.999.

Chlorine.—Mlle. Irene Curie[12] has compared the chlorine in certain geologically ancient minerals with ordinary chlorine. The minerals examined were sodalite from Bancroft, Canada, chlorapatite from Bamle, Norway, and an alkali chloride, probably formed by the weathering of Archaean granite, found in Dar Ouara, Central Africa. In every case barium chloride was prepared and used to precipitate known weights of silver nitrate, a comparison experiment with the same weight of silver nitrate and ordinary chloride being carried out at the same time.

The chlorine from sodalite and apatite is like ordinary chlorine within 0.02 unit of atomic weight, a quantity less than the experimental error. The material from Dar Ouara yielded slightly more silver halide than it

[9] Moles and Batuecas, *J. chim. phys.*, **18,** 353 (1920).

[10] *Ibid.*, **17,** 537 (1919).

[11] Page 599.

[12] Curie, *Compt. rend.*, **172,** 1025 (1921).

Wt. of $AgNO_3$ G.	Source	Wt. of AgCl G.
0.3200	sodalite	0.2690
0.3200	ordinary	0.2689
3.8000	sodalite	3.2056
3.8000	ordinary	3.2060
1.4500	apatite	1.22295
1.4500	ordinary	1.22275
4.50000	alkali chloride	3.7963
1.7001	alkali chloride	1.4343
1.7001	ordinary	1.4330

should, indicating an atomic weight as high as 35.60. Iodine and bromine were shown to be absent in appreciable quantities. Further, more exact experiments are promised.

Nickel.—Baxter and Parsons[13] have compared terrestrial and meteoric nickel by reduction of the oxide. The meteoric nickel was obtained from a meteorite found near Cumpas, Sonora, Mexico, in 1903. Iron from this meteorite has already been shown to be identical with terrestrial iron.[14] Both specimens of nickel were carefully freed from iron and cobalt, and the oxide was produced by ignition of the nitrate. Besides reduction of the oxide in hydrogen, occluded gases were determined in each sample of oxide. The following weights are corrected for gas content of the oxide and to the vacuum standard.

	Wt. of NiO G.	Wt. of Ni G.	Ratio Ni:O	At. wt. Ni
Terrestrial	6.10962	4.80103	3.66886	58.702
	6.41296	5.03963	3.66964	58.714
	6.91037	5.43008	3.66825	58.692
	4.60083	3.61530	3.66838	58.694
	5.57105	4.37793	3.66931	58.709
	5.59224	4.39444	3.66876	58.700
		Av.	3.66887	58.702
Meteoric	6.65669	5.23021	3.66650	58.664
	4.45619	3.50201	3.67018	58.723
	4.64808	3.65209	3.66680	58.669
		Av.	3.66783	58.685

The difference between the two series is within the experimental error.

Zinc.—Baxter and Hodges[15] determined the zinc in zinc chloride by electrolytic deposition in a mercury cathode. The problem of preparing anhydrous neutral zinc chloride was solved by heating zinc bromide in a current of dry chlorine. Since, when weighed quantities of zinc were electrolytically transported through an aqueous electrolyte into a weighed mercury cathode, a fairly constant excess in weight of the factors

[13] Baxter and Parsons, THIS JOURNAL, **43**, 507 (1921).

[14] Baxter and Thorvaldson, *ibid.*, **33**, 337 (1911). Baxter and Hoover, *ibid.*, **34**, 1657 (1912).

[15] Baxter and Hodges, *ibid.*, **43**, 1242 (1921).

over the products of 0.23 mg. was found, this weight is subtracted in each experiment from the weight of zinc found in zinc chloride. Weights are corrected to vacuum. Cl = 35.457.

Wt. of $ZnCl_2$ G.	Wt. of Zn G.	Ratio Zn:Cl_2	At. wt. Zn
5.86823	2.81536	0.92220	65.397
5.24761	2.51698	0.92176	65.365
6.34043	3.04120	0.92179	65.368
2.43157	1.16657	0.92219	65.396
4.73689	2.27161	0.92144	65.343
5.98605	2.87068	0.92147	65.345
5.94448	2.85136	0.92184	65.371
5.80579	2.78416	0.92141	65.341
5.87593	2.81862	0.92193	65.378
4.00115	1.91975	0.92234	65.407
3.51882	1.68795	0.92194	65.378
	Av.	0.92185	65.372

When Expts. 5, 6, 8 and 10, which are considered less trustworthy, are rejected the result becomes 65.379. This analysis of zinc chloride thus confirms the result obtained by analysis of zinc bromide, upon which the value in current use, 65.38, depends.

Germanium.—Müller[16] purified germanium material by processes which included (1) distillation of the chloride from hydrochloric acid solution in a stream of chlorine, (2) fractional crystallization of the hydrated oxide from aqueous solution. The fluogermanate of potassium was then synthesized from the purified germanium oxide, potassium carbonate and hydrofluoric acid. After repeated crystallization, the fluogermanate was prepared for an experiment by being heated to constant weight at 400–450°. Conversion to potassium chloride took place in a platinum bulb in a current of hydrogen chloride at temperatures ultimately high enough to melt the product. Weights are corrected to vacuum. K = 39.10, Cl = 35.46, F = 19.00.

Wt. of K_2GeF_6 G.	Wt. of KCl G.	At. wt. Ge
1.94831	1.09814	72.37
3.09380	1.74350	72.41
2.10784	1.18774	72.44
2.36113	1.33044	72.44
4.38070	2.46863	72.42
1.52575	0.85970	72.45
4.00100	2.25483	72.40
	Mean	72.418

Cadmium.—Baxter and Wilson[17] determined the cadmium in anhydrous cadmium sulfate by electrolytic deposition in a weighed mercury

[16] Müller, THIS JOURNAL, **43**, 1085 (1921).

[17] Baxter and Wilson, *ibid.*, **43**, 1230 (1921).

cathode. Blank experiments in which weighed buttons of pure cadmium were electrolytically transported through an aqueous electrolyte showed an average gain of 0.18 mg. A negative correction of this magnitude is applied to the weight of cadmium obtained in each analysis of cadmium sulfate. The cadmium sulfate was heated to constant weight in a current of air and sulfur trioxide at 700°. Weights are corrected to vacuum. S = 32.060.

Wt. of $CdSO_4$ G.	Wt. of Cd G.	Ratio $Cd:SO_4$	At. wt. Cd
3.65533	1.97033	1.16934	112.324
4.59450	2.47718	1.16996	112.386
4.12057	2.22166	1.16997	112.387
5.34263	2.88076	1.17015	112.405
6.19309	3.33940	1.17020	112.410
6.55765	3.53574	1.17004	112.394
6.04137	3.25735	1.17002	112.392
7.52884	4.06010	1.17048	112.437
6.58281	3.54949	1.17016	112.406
6.70646	3.61650	1.17040	112.429
6.56059	3.53730	1.17002	112.392
	Av.	1.17007	112.397
Av. of last 7 analyses.....		1.17019	112.409

This evidence supports the higher of the two conflicting values for this constant.

Antimony.—Willard and McAlpine[18] synthesized antimony tribromide from carefully purified antimony and bromine in an atmosphere of nitrogen in an all-glass apparatus. The product was fractionally distilled under a low pressure of nitrogen and was collected in sealed glass bulbs. After being weighed in an exhausted weighing bottle, the bulbs were broken under tartaric acid solution. The glass was collected and weighed and the solutions were precipitated with weighed equivalent amounts of silver. After the silver equivalent had been found, the silver bromide was collected. Material analyzed in the preliminary series was prepared from Kahlbaum's antimony. In Series B and D, metal reduced from the oxide by hydrogen was employed. In Series C the metal was reduced by sodium cyanide. Weights are corrected to vacuum. Br = 79.916.

Preliminary Series

Wt. of $SbBr_3$ G.	Wt. of Ag G.	Ratio $SbBr_3:3Ag$	At. wt. Sb
2.54052	2.27493	1.11675	121.675
3.86859	3.46507	1.11645	121.577
4.07278	3.64722	1.11668	121.651
3.80772	3.40997	1.11664	121.638
4.72332	4.23070	1.11644	121.574
	Av.	1.11663	121.623

[18] Willard and McAlpine, THIS JOURNAL, **43**, 797 (1921).

Final Series B

Wt. of $SbBr_3$ G.	Wt. of Ag G.	Ratio $SbBr_3$:3Ag	At. Wt. Sb	Wt. of AgBr G.	Ratio $SbBr_3$:3AgBr	At. wt. Sb
4.17410	3.73672	1.11705	121.771	6.50517	0.641659	121.774
4.97693	4.45524	1.11710	121.787	7.75589	0.641697	121.775
5.97344	5.34702	1.11715	121.803	9.30873	0.641703	121.759
5.65589	5.06310	1.11708	121.781	8.81443	0.641663	121.756
	Av.	1.11710	121.786	Av.	0.641680	121.766
			Final Series C			
3.64686	3.26462	1.11709	121.784	5.68301	0.641713	121.784
3.64435	3.26258	1.11701	121.758	5.67970	0.641645	121.746
3.35749	3.00574	1.11703	121.765	5.23284	0.641619	121.731
2.92082	2.61469	1.11712	121.794	4.55149	0.641728	121.793
	Av.	1.11706	121.777	Av.	0.641679	121.764
			Final Series D			
3.39050	3.03541	1.11699	121.752	5.28506	0.641525	121.678
4.32024	3.86739	1.11709	121.784	6.73334	0.641619	121.731
4.70518	4.21221	1.11703	121.765	7.33279	0.641663	121.756
	Av.	1.11704	121.767	Av.	0.641602	121.722

The average value, 121.77, is more than a per cent. higher than the value recommended by the International Committee on Atomic Weights.

Lanthanum.—Baxter, Tani and Chapin[19] fractionated two specimens of lanthanum ammonium nitrate until the least soluble fractions were apparently free from cerium. Lanthanum chloride was prepared through the oxide and after being dried was compared with silver and silver chloride. No systematic differences could be detected between the different fractions examined. Vacuum weights are given. Ag = 107.880, Cl = 35.457.

Fraction of $LaCl_3$	Wt. of $LaCl_3$ G.	Wt. of Ag G.	Ratio $LaCl_3$:3Ag	At. wt. La
C 27	3.45559	4.55950	0.757888	138.912
C 3 + 4	5.75303	7.59134	0.757841	138.897
C 3 + 4	8.18782	10.80361	0.757878	138.909
T 1	6.80122	8.97359	0.757915	138.921
T 1	6.73670	8.88829	0.757930	138.925
T 5	5.43254	7.16772	0.757917	138.921
		Av.	0.757895	138.914
		Wt. of AgCl	Ratio $LaCl_3$:3AgCl	
C 27	3.67748	6.44558	0.570543	138.969
C 3 + 4	5.33464	9.35255	0.570394	138.905
C 3 + 4	5.75303	10.08611	0.570391	138.904
C 3 + 4	8.18782	14.35625	0.570331	138.878
T 1	6.80122	11.92332	0.570413	138.913
T 1	6.73670	11.80952	0.570447	138.927
T 5	5.43254	9.52463	0.570368	138.893
		Av.	0.570413	138.913

[19] Baxter, Tani and Chapin, THIS JOURNAL, **43**, 1080 (1921); a later note corrects errors in the tables (*ibid.*, **44**, 328 (1922)). These corrections have been made in the above tables.

This value is nearly 0.1 unit lower than the one in common use.

Bismuth.—Classen and Ney[20] prepared bismuth triphenyl by the action of purified bismuth bromide on phenyl magnesium bromide, and purified the product by crystallization from alcohol and by distillation. After being dried in a high vacuum over phosphorus pentoxide, weighed amounts were heated with oxalic acid and a small amount of alcohol, at gradually increasing temperatures up to 750°. Constant weight of the resulting bismuth oxide was secured. Vacuum weights are given in the following table. H = 1.008, C = 12.005.

Wt. of $Bi(C_6H_5)_3$ G.	Wt. of Bi_2O_3 G.	Ratio $2Bi(C_6H_5)_3 : Bi_2O_3$	At. wt. Bi
5.45873	2.89068	1.88954	208.941
6.80350	3.60267	1.88962	208.920
3.51096	1.85942	1.88936	208.987
4.56421	2.41757	1.88909	209.059
5.17839	2.74216	1.88960	208.925
3.41677	1.80968	1.88921	209.027
2.34627	1.24281	1.88904	209.072
4.49340	2.38032	1.88933	208.996
4.55905	2.41489	1.88905	209.069
3.64677	1.93129	1.88942	208.971
	Av.	1.88933	208.997

The average result agrees very well with the following value found by Hönigschmid and Birckenbach, but the latter point out that if C = 12.001 and H = 1.0077 the above value becomes 208.91.

Bismuth.—Hönigschmid and Birckenbach[21] have published a more extended account of the analysis of bismuth chloride,[22] which was summarized in the last report, and have in addition analyzed bismuth bromide. Both salts were prepared by synthesis from several specimens of purified metal and the corresponding halogen, and after sublimation in a current of dry nitrogen were transferred to a weighing bottle without exposure to moisture. After the salt had been dissolved in 3 *N* nitric acid, to avoid hydrolysis, it was compared with silver and finally the silver halide was collected. Experiments with potassium halides showed that the nitric acid caused no loss of halogen. Series I was included in the last report, but since a small correction has been subsequently applied for silver contained in the distilled water, owing to the use of a silver condenser, and since a few additional experiments are included, the results of this series are given again. Weights are in a vacuum. Cl = 35.457, Br = 79.916, Ag = 107.880.

[20] Classen and Ney, *Ber.*, **53B**, 2267 (1920); *Z. anorg. allgem. Chem.*, **115**, 253 (1921).

[21] Hönigschmid and Birckenbach, *Ber.*, **54B**, 1873 (1921).

[22] Hönigschmid, *Z. Elektrochem.*, **26**, 403 (1920).

SERIES I

Sample	Wt. of $BiCl_3$	Wt. of Ag	Ratio $BiCl_3 : 3Ag$	At. wt. Bi	Wt. of AgCl	Ratio $BiCl_3 : 3AgCl$	At.wt.Bi
1	3.29894	3.38572	0.974369	208.97	4.49789	0.733442	209.02
1	3.54331	3.63644	0.974390	208.98	4.83067	0.733503	209.04
1	4.74125	4.86573	0.974417	208.99	6.46455	0.733423	209.01
1	2.64020	2.70984	0.974301	208.95	3.59956	0.733479	209.03
1	4.49476	4.61253	0.974467	209.01	6.12841	0.733430	209.01
1	5.19912	5.33556	0.974428	208.99	7.08896	0.733411	209.00
1	4.36220	.....	.....	....	5.94742	0.733461	209.03
1	4.42249	.....	.....	....	6.02960	0.733463	209.03
3	4.82566	.....	.....	....	6.57976	0.733408	209.00
2	4.99471	5.12592	0.974402	208.99	6.80969	0.733471	209.03
2	5.29284	5.43179	0.974419	208.99	7.21652	0.733434	209.01
2	4.62983	4.75126	0.974442	209.00	6.31252	0.733436	209.02
2	5.67213	5.82103	0.974420	208.99	7.73383	0.733418	209.01
5	5.69460	5.84417	0.974407	208.99	7.76479	0.733388	208.99
5	5.96312	6.11973	0.974409	208.99	8.13087	0.733393	209.00
4	5.57877	.....	.....	....	7.60652	0.733419	209.01
4b	6.24054	6.40429	0.974431	208.99	8.50911	0.733395	209.00
2	6.30709	6.47269	0.974416	208.99	8.60003	0.733380	208.99
6	5.88272	.....	.....	....	8.02168	0.733352	208.98
6	4.46068	4.57809	0.974354	208.97	6.08213	0.733407	209.00
	Weighted Mean		0.974406	208.99		0.733426	209.01

SERIES II

Wt. of $BiBr_3$	Wt. of Ag	Ratio $BiBr_3 : 3Ag$	At. wt. Bi	Wt. of AgBr	Ratio $BiBr_3 : AgBr$	At.wt. Bi
7.29339	.....	.....	....	9.15727	0.796458	208.97
5.39630	.....	.....	....	6.77528	0.796468	208.97
3.70766	.....	.....	....	4.65512	0.796469	208.97
5.60993	4.04608	1.38651	208.98	7.04331	0.796490	208.99
4.31679	3.11345	1.38650	208.98	5.41993	0.796466	208.97
6.08198	4.38645	1.38654	208.99	7.63592	0.796496	208.99
5.79839	4.18189	1.38655	208.99	7.27982	0.796501	208.99
5.57802	4.02293	1.38656	209.00	.....	.....	....
6.12608	4.41819	1.38656	209.00	.....	.....	....
5.49745	.....	.....	....	6.90203	0.796498	208.99
5.94212	4.28542	1.38659	209.01	7.46066	0.796460	208.97
5.36148	3.86663	1.38660	209.01	6.73168	0.796454	208.97
5.44985	3.93049	1.38656	209.00	.....	.....	....
5.02784	3.62606	1.38658	209.01	6.31276	0.796457	208.97
5.05097	3.64271	1.38660	209.01	.....	.....	....
3.91823	2.82605	1.38647	208.97	4.91968	0.796440	208.96
4.90320	.....	.....	....	6.15616	0.796470	208.97
6.40360	4.61829	1.38657	209.00	8.03956	0.796511	209.00
Weighted Mean		1.38655	209.00		0.796474	208.98

SERIES III

Wt. of $BiCl_3$	Wt. of Ag	Ratio $BiCl_3 : 3Ag$	At. wt. Bi	Wt. of AgCl	Ratio $BiCl_3 : 3AgCl$	At. wt. Bi
5.92659	6.08198	0.974451	209.00	8.08075	0.733429	209.01
5.67415	5.82301	0.974436	209.00	7.73633	0.733442	209.02
5.67569	5.82448	0.974454	209.00	7.73886	0.733401	209.00
6.01087	6.16839	0.974467	209.00	8.19606	0.733385	208.99
3.99300	4.09773	0.974441	209.00	5.44469	0.733375	208.99
6.69026	6.86567	0.974451	209.00	9.12219	0.733405	209.00
6.06332	6.22248	0.974421	208.99	8.26735	0.733405	209.00
6.26505	6.42952	0.974419	208.99	8.54321	0.733337	208.97
4.82012	4.94648	0.974454	209.00	6.57250	0.733376	208.99
6.44339	6.61235	0.974448	209.00	.....	.....	....
6.04882	6.20743	0.974448	209.00	8.24779	0.733387	208.99
1.77359	1.82015	0.974419	208.99	2.41846	0.733355	208.98
6.42838	.....	.....	....	8.76453	0.733454	209.02
3.58931	.....	.....	....	4.89385	0.733432	209.01
4.91588	.....	.....	....	6.70282	0.733404	209.00
5.70608	.....	.....	...	7.78038	0.733393	209.00
Weighted Mean		0.974442	209.00		0.733399	209.00

SERIES IV

Wt. of $BiBr_3$	Wt. of Ag	Ratio $BiBr_3 : 3Ag$	At. wt. Bi	Wt. of AgBr	Ratio $BiBr_3 : 3AgBr$	At. wt. Bi
7.64984	5.51723	1.38654	208.99	.....	.....	....
5.73427	4.13564	1.38655	209.00	.....	.....	....
6.74400	4.86378	1.38658	209.00	8.46713	0.796491	208.99
5.69756	4.10915	1.38655	209.00	7.15302	0.796525	209.01
3.11177	2.24420	1.38655	208.99	3.90698	0.796464	208.97
5.91488	4.26588	1.38656	209.00	.....	.....	....
7.07209	5.10050	1.38652	208.99	....	.....	....
3.91069	2.82047	1.38654	208.99	.....	.....	....
4.59461	3.31368	1.38656	209.00	.....	.....	....
7.07280	5.10087	1.38659	209.00	.....	.....	....
5.35474	.....	.....	....	6.72284	0.796500	208.99
Weighted Mean		1.38655	209.00		0.796495	208.99

The general mean of all the series is 209.00.

During recent years the application of positive ray analysis by Thompson, Aston and Dempster has furnished experimental evidence that many at any rate of the elements are mixtures of isotopes having atomic weights which are very nearly integers referred to oxygen as 16, the "chemical" atomic weight being the statistical average of the components in the mixture. A list of the isotopes of the existence of which there is experimental evidence is given below.[23] Radioactive disintegration products are omitted.

[23] Aston, *Phil. Mag.*, **42**, 143 (1921); **42**, 440 (1921); *Nature*, **107**, 520 (1921). Dempster, *Science N. S.*, **52**, 559 (1920); *Phys. Rev.*, **17**, 427 (1921).

Element	Atomic number	Atomic weight	Minimum number of isotopes	Mass of isotopes in the order of intensity
H	1	1.008	1	1.008
He	2	3.99	1	4
Li	3	6.94	2	7, 6
B	5	10.9	2	10, 11
C	6	12.00	1	12
N	7	14.01	1	14
O	8	16.00	1	16
F	9	19.00	1	19
Ne	10	20.2	2	20, 22 (21)
Na	11	23.00	1	23
Mg	12	24.36	3	24, 25, 26
Si	14	28.1	2	28, 29 (30)
P	15	31.04	1	31
S	16	32.06	1	32
Cl	17	35.46	2	35, 37 (39)
A	18	39.88	2	40, 36
K	19	39.10	2	39, 41
Ni	28	58.68	2	58, 60
As	33	74.96	1	75
Br	35	79.92	2	79, 81
Kr	36	82.92	6	84, 86, 82, 83, 80, 78
Rb	37	85.45	2	85, 87
I	53	126.92	1	127
X	54	130.2	5 (7)	129, 132, 131, 134, 136, (128), (130?)
Cs	55	132.81	1	133
Hg	80	200.6	(6)	(197-200), 202, 204

It is to be noted, however, that radium-lead of atomic weight as low as 206.06 has been isolated,[24] and thorium-lead as high as 207.9.[25] The relation of these to ordinary lead remains to be determined. Thorium containing ionium has been found to have a lower average atomic weight than thorium.[26]

Experimental evidence of the partial separation of the isotopes of neon has been obtained by Aston and Lindemann,[27] of chlorine by Harkins[28] and by Brönsted and von Hevesy,[29] and of mercury by Brönsted and von Hevesy[30] and by Harkins.[31]

T. JEFFERSON COOLIDGE, JR., CHEMICAL LABORATORY,
HARVARD UNIVERSITY,
CAMBRIDGE 38, MASSACHUSETTS

[24] Hönigschmid and Mme. St. Horovitz, *Sitzb. k. Akad. Wien., Abt.* IIA, **123,** 1 (1914); *Monatsh.*, **36,** 355 (1915). Richards and Wadsworth, THIS JOURNAL, **38,** 2613 (1916).

[25] *Z. Elektrochem.*, **25,** 91 (1919).

[26] Hönigschmid, *ibid.*, **22,** 18 (1916).

[27] Aston, *Report Brit. Ass. Adv. Sci.*, **1913,** 403. Aston and Lindemann, *Phil. Mag.*, **39,** 450 (1920).

[28] Harkins, *Phys. Rev.*, **15,** 74 (1920); *Science, N. S.*, **51,** 289 (1920); *Nature*, **105,** 230 (1920). Harkins and Hayes, THIS JOURNAL, **43,** 1803 (1921).

[29] Brönsted and von Hevesy, *Nature*, July, **1921.**

[30] Brönsted and von Hevesy, *ibid.*, Sept., **1920;** *Z. physik. Chem.*, **99,** 189 (1921); *Phil. Mag.*, **43,** 31 (1922).

[31] Harkins, THIS JOURNAL, **44,** 37 (1922).