The Journal of the American Chemical Society

with which has been incorporated
The American Chemical Journal
(Founded by Ira Remsen)

VOL. 49 MARCH, 1927 No. 3

THIRTY-THIRD ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS. DETERMINATIONS PUBLISHED DURING 1926

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RECEIVED FEBRUARY 5, 1927 PUBLISHED MARCH 9, 1927

The Sixth Report of the German Committee on Atomic Weights[1] has been criticized by Moles.[2]

Boron.—Briscoe, Robinson and Stephenson[3] have determined the density of boric oxide glass prepared from material of different mineralogical origin. Small differences, which they impute to differences in isotopic composition, correspond to differences found earlier in specimens of boron trichloride from the same sources. Boric oxide prepared from the head and tail fractions of a prolonged fractional crystallization of boric acid showed no differences in density within the accuracy of the experiments.[4]

Nitrogen.—Baxter and Starkweather[5] have determined the density of nitrogen at 0° and various pressures, using 2-liter globes. Nitrogen was prepared by decomposition of ammonium nitrite and by combustion of ammonia with copper oxide, and was fractionally distilled. Results are referred to sea level; latitude, 45°.

From the densities the deviation from Boyle's law per atmosphere, $(PV)_0/(PV)_1$ is calculated to be 1.00039 on the assumption that the deviation is inversely proportional to the pressure, and 1.00051 by the algebraic method involving two powers of p. These values, combined with similar data found for oxygen and given below, indicate that the atomic weight of nitrogen is between 14.008 and 14.006.

[1] *Ber.*, 59A, I (1926).

[2] Moles, *Ber.*, **59B**, 740 (1926).

[3] Briscoe, Robinson and Stephenson, *J. Chem. Soc.*, **1926**, 70.

[4] Ref. 3, p. 954.

[5] Baxter and Starkweather, *Proc. Nat. Acad. Sci.*, **12**, 703 (1926).

THE DENSITY OF NITROGEN

Series	Preparation of nitrogen	Globe IV 2110.95 ml.	Globe VII 2117.77 ml.	Av.
		760 mm.		
1	NH_4NO_2 I	1.25045	1.25049	1.25047
2	NH_4NO_2 I	1.25037	1.25043	1.25040
5	NH_4NO_2 II	1.25037	1.25031	1.25034
7	NH_4NO_2 II	1.25035	1.25038	1.25037
9	NH_4NO_2 II	1.25038	1.25036	1.25037
11	NH_4NO_2 III	1.25031	1.25036	1.25034
13	NH_4NO_2 III	1.25039	1.25031	1.25035
21	NH_3 I	1.25023	1.25028	1.25026
23	NH_3 I	1.25036	1.25036	1.25036
		Av. 1.25036	1.25036	1.25036
		506.67 mm.		
3	NH_4NO_2 I	0.83353	0.83351	0.83352
6	NH_4NO_2 II	.83354	.83355	.83354
12	NH_4NO_2 III	.83344	.83347	.83346
14	NH_4NO_2 III	.83345	.83346	.83346
15	NH_4NO_2 IV	.83347	.83346	.83347
17	NH_4NO_2 IV	.83346	.83347	.83347
19	NH_4NO_2 IV	.83344	.83349	.83347
22	NH_3 I	.83351	.83350	.83351
24	NH_3 I	.83345	.83347	.83346
		Av. 0.83348	0.83349	0.83348
		253.33 mm.		
8	NH_4NO_2 II	0.41664	0.41671	0.41668
10	NH_4NO_2 II	.41667	.41671	.41669
16	NH_4NO_2 IV	.41662	.41664	.41663
18	NH_4NO_2 IV	.41663	.41666	.41665
20	NH_4NO_2 IV	.41663	.41667	.41665
25	NH_3 I	.41667	.41670	.41669
26	NH_3 I	.41667	.41670	.41669
		Av. 0.41665	0.41669	0.41667

Oxygen.—Baxter and Starkweather[6] have published new determinations of the density of oxygen at 0° and at various pressures, using 2-liter globes. Fractionated electrolytic oxygen was employed. Results are referred to sea level; latitude, 45°.

THE DENSITY OF OXYGEN

Series	Preparation	Globe IV 2110.95 ml.	Globe V 2117.64 ml.	Globe VI 2117.61 ml.	Globe VII 2117.77 ml.	Av.
			760 mm.			
23	I	1.42895	1.42896	.....	.....	1.42896
24	II	1.42898	1.42897	.....	.....	1.42898
25	III	1.42896	1.42895	.....	.....	1.42896
	Av.	1.42896	1.42896			1.42896

[6] Ref. 5, p. 699.

THE DENSITY OF OXYGEN (*Concluded*)

Series	Preparation	Globe IV 2110.95 ml.	Globe V 2117.64 ml.	Globe VI 2117.61 ml.	Globe VII 2117.77 ml.	Av.
			570 mm.			
26	IV	1.07145	1.07148	.....	.....	1.07147
27	V	1.07139	1.07144	.....	.....	1.07142
28	VI	1.07148	1.07148	.....	.....	1.07148
29	VII	1.07148	1.07148	.....	.....	1.07148
38	X	1.07156	.....	.....	1.07157	1.07157
42	XI	1.07161	.....	.....	1.07161	1.07161
43	XI	1.07143	.....	.....	1.07135	1.07139
44	XII	1.07148	.....	.....	1.07148	1.07148
45	XII	1.07148	.....	.....	1.07148	1.07148
46	XII	1.07150	.....	.....	1.07147	1.07149
	Av.	1.07149	1.07147		1.07149	1.07149
			380 mm.			
30	VIII	0.71407	.....	0.71418	.....	0.71413
31	VIII	.71419	.....	.71414	.....	.71417
32	IX	.71416	.....	.71417	.....	.71417
33	X	.71407	.....	.....	0.71414	.71411
34	X	.71416	.....	.....	.71422	.71419
35	X	.71419	.....	.....	.71416	.71418
	Av.	0.71414		0.71416	0.71417	0.71415
			190 mm.			
36	X	0.35697	.....	.....	0.35701	0.35699
37	X	.35699	.....	.....	.35703	.35701
39	XI	.35693	.....	.....	.35697	.35695
40	XI	.35696	.....	.....	.35699	.35698
41	XI	.35699	.....	.....	.35701	.35700
	Av.	0.35697			0.35700	0.35699

The average of the above densities at one atmosphere and the corrected value found earlier,[7] 1.42898, is 1.42897. From the densities at different pressures, the deviation from Boyle's law per atmosphere is calculated to be 1.00092, and the limiting value of molal volume is 22.4144 liters.

Silicon.—Robinson and Smith[8] have determined the densities of specimens of silicon tetrachloride prepared from silicon of different geological origin. The extreme difference in density found, 0.00005, corresponds to a difference of 0.005 in atomic weight.

Chlorine.—Batuecas[9] prepared methyl chloride (1) by decomposition of tetramethylammonium chloride and (2) by chemical and physical purification of a commercial sample, and determined the normal density.

[7] Baxter and Starkweather, *Proc. Nat. Acad. Sci.*, 10, 479 (1924); **12**, 20 (1926).

[8] Robinson and Smith, *J. Chem. Soc.*, **1926**, 1262.

[9] Batuecas, *Anal. soc. españ. fís. quím.*, **24**, 528 (1926).

THE DENSITY OF METHYL CHLORIDE

Method of purification	Globe N-3	Globe III	Av.
	1 atmosphere		
1	2.3067	2.3071	
1	2.3066	2.3068	
1	2.3071	2.3074	
1	2.3075	2.3083	
Av.	2.3070	2.3074	2.3072
2	2.3075	....	
2	....	2.3070	
2	2.3072	2.3085	
2	2.3069	2.3083	
2	2.3072	2.3082	
Av.	2.3072	2.3080	2.3076
Av. of all	2.3071	2.3077	2.3074

The average value is considerably lower than that found earlier with material made by the action of phosphorus trichloride on methyl alcohol.

The following results were obtained at pressures below one atmosphere and are corrected to one atmosphere by the law of a perfect gas.

	Globe N-3	Globe III	Globe N-3	Globe III
	2/3 atmosphere		1/3 atmosphere	
	2.2896	....	2.2715	....
	2.2893	....	2.2721	....
	2.2900	....	2.2713	2.2713
	2.2890	....	2.2715	2.2722
	2.2895	2.2904	2.2693	2.2717
	2.2885	2.2901	....	....
Av.	2.2893	2.2903	2.2711	2.2717
		Av. of all 2.2895		Av. of all 2.2714

	Globe N-3	Globe III	Globe N-3	Globe III
	1/2 atmosphere		1/4 atmosphere	
	2.2806	2.2786	2.2648	2.2674
	2.2815	2.2806	2.2669	2.2677
	2.2800	2.2797	2.2652	....
Av.	2.2807	2.2797	2.2656	2.2676
		Av. of all 2.2802		Av. of all 2.2664

From these results the limiting density is calculated to be 2.2527 and the molecular weight of methyl chloride to be 50.488, whence the atomic weight of chlorine is 35.465.

Titanium.—Baxter and Butler[10] have continued the analysis of fractionated titanium tetrachloride prepared by Baxter and Fertig.[11] In the following table the fractions are numbered in the order of decreasing volatility. Weights are in vacuum; Cl = 35.458.

[10] Baxter and Butler, THIS JOURNAL, **48**, 3117 (1926).

[11] Baxter and Fertig, *ibid.*, **45**, 1228 (1923).

Atomic Weight of Titanium

Fraction of $TiCl_4$	Wt. of $TiCl_4$	Wt. of Ag	Ratio $TiCl_4$:4Ag	At. wt. of Ti
		Preliminary Series		
2	4.65029	10.57700	0.439660	47.890
24	4.84172	11.01281	.439644	47.883
22	4.56353	10.37794	.439734	47.922
20	5.96411	13.56460	.439682	47.900
19	5.52182	12.55878	.439678	47.898
5	4.36899	9.93570	.439726	47.919
7	4.81128	10.94135	.439734	47.922
8	4.22304	9.60393	.439720	47.916
9	4.94516	11.24595	.439728	47.919
			Av. 0.439701	47.908
		Final Series		
10	4.29334	9.76432	0.439697	47.906
12	5.25291	11.94723	.439676	47.897
14	5.64352	12.83589	.439667	47.893
16	5.02562	11.43011	.439683	47.900
18	3.66098	8.32645	.439680	47.899
11	4.22599	9.61148	.439682	47.900
13	4.86075	11.05516	.439682	47.900
15	4.86836	11.07274	.439671	47.895
			Av. 0.439680	47.900
		Av. of all determinations	0.439691	47.903

Copper.—Ruer and Bode[12] continue to defend their work on copper oxide against criticisms by the German Committee on Atomic Weights.

Silver.—Riley and Baker[13] prepared silver oxide by precipitation with silver nitrate and barium hydroxide in an atmosphere free from carbon dioxide. After thorough washing, the precipitate was dried over potassium hydroxide for several weeks. Weighed quantities of oxide were then decomposed in a current of dry air at about 400°. The water and traces of carbon dioxide were collected in a weighed tube containing fused potassium hydroxide and phosphorus pentoxide, and the residual silver, after fusion in hydrogen, was weighed.

Atomic Weight of Silver

Wt. of Ag_2O in air	Wt. of H_2O	Wt. of Ag_2O in a vacuum	Wt. of Ag in a vacuum	At. wt. of Ag
20.20674	0.06607	20.14133	18.75067	107.866
19.43588	.04469	19.39186	18.05298	107.869
21.82606	.06330	21.76351	20.26076	107.861
20.03207	.07361	19.95910	18.58107	107.870
19.47189	.05963	19.41287	18.07242	107.859
21.31387	.05989	21.25468	19.78708	107.861
				Av. 107.864

[12] Ruer and Bode, *Ber.*, **59B**, 1698 (1926).

[13] Riley and Baker, *J. Chem. Soc.*, **1926**, 2510.

Iodine.—Moles and Miravelles[14] have found the weight of the normal liter of hydrogen iodide to be 5.7888. At $^2/_3$ and $^1/_3$ atmosphere the corresponding figures are 3.8402 and 1.9105, whence the deviation from Boyle's law between 0 and 1 atmosphere is 1.0149 or 1.0151, according to whether the PV values are assumed to lie on a straight line or curve, and the corresponding values of the atomic weight of iodine are 126.84 and 126.81. The authors consider their experiments only preliminary.

Lead.—Richards and Hall[15] have determined the atomic weight of radio-active lead extracted from a very pure specimen of uraninite found in the Black Hills, South Dakota. After very careful purification the chloride was analyzed by comparison with silver in the usual way. Weights are in vacuum; Cl = 35.458.

Atomic Weight of Lead

Wt. of $PbCl_2$	Wt. of Ag	At. wt. of Pb
4.37550	3.40841	206.063
4.83808	3.76860	206.074
4.88040	3.80155	206.075
5.31437	4.13960	206.074
		Av. 206.071

The age of this mineral computed from the percentages of uranium, thorium and lead (66.9% of uranium, 2.0% of thorium, 15.2% of lead) is 1,500,000,000 years. If allowance is made for thorium present the atomic weight of uranium lead must be as low as 206.02

Richards, King and Hall[16] have attempted to effect isotopic separation of ordinary lead, and a mixture of ordinary with uranium lead (1) by irreversible evaporation of the metal in a vacuum and (2) by means of the Grignard reaction. The products were compared by preparing pure lead chloride and determining the ratio of this substance to silver. Weights are in vacuum; Cl = 35.458.

Atomic Weight of Lead

	Wt. of $PbCl_2$	Wt. of Ag	At. wt. of Pb
	Common Lead		
Preliminary	5.80433	4.50278	207.210
	5.88331	4.56400	207.214
	6.15400	4.77405	207.210
	6.63841	5.14990	207.207
			Av. 207.210
Residue	6.34617	4.92305	207.214
	5.94908	4.61505	207.212

[14] Moles and Miravelles, *Anal. soc. españ. fís. quím.*, **24**, 356 (1926).

[15] Richards and Hall, This Journal, **48**, 704 (1926).

[16] Richards, King and Hall, *ibid.*, **48**, 1530 (1926).

ATOMIC WEIGHT OF LEAD (*Concluded*)

	Wt. of $PbCl_2$	Wt. of Ag	At. wt. of Pb
	6.06445	4.70447	207.216
	5.43000	4.21211	207.229
	5.35480	4.15388	207.222
	5.62478	4.36351	207.209
			Av. 207.217
Volatile fraction	5.60375	4.34708	207.217
	5.53665	4.29505	207.215
	5.62345	4.36242	207.213
	4.34037	3.36694	207.223
			Av. 207.217
	Uranium + Common Lead		
Residue	4.68864	3.64742	206.436
	5.40318	4.20337	206.431
			Av. 206.434
Middle fraction	3.75115	2.91811	206.438
	4.16937	3.24344	206.439
			Av. 206.438
Volatile fraction	4.85385	3.77601	206.431
	4.70148	3.65750	206.430
			Av. 206.431
	Grignard Fractionation of Common Lead		
Lead fraction	5.98464	4.64259	207.215
	4.60637	3.57327	207.224
	7.55415	5.86020	207.212
	4.57721	3.55077	207.215
			Av. 207.217
Tetraphenyl fraction	4.39785	3.41161	207.217
	6.61651	5.13269	207.218
	4.35602	3.37909	207.222
	3.85162	2.98786	207.218
			Av. 207.219

The results give no certain evidence of isotopic separation. The average atomic weight of common lead is 207.217.

Recent work by Aston on mercury[17] indicates the following isotopes in proportions corresponding to the members in parentheses: 198(4), 199(5), 200(7), 201(3), 202(10), 204(2). The numbers are in accord with the atomic weight 200.6. Sulfur[18] has been found to contain approximately 3% of the isotopes S^{33} and S^{34} in the ratio 1 to 3.

The following table of atomic weights seems to the author of this report to represent the situation at the present time. Changes from the International Table for 1925 involve the following elements: hafnium, helium, holmium, lead, titanium, yttrium and zirconium.

[17] Aston, *Nature*, **116**, 208 (1926).

[18] Aston, *ibid.*, **117**, 893 (1926).

AMERICAN CHEMICAL SOCIETY
ATOMIC WEIGHTS
1927

	Symbol	At. number	At. weight		Symbol	At. number	At. weight
Aluminum	Al	13	26.97	Mercury	Hg	80	200.61
Antimony	Sb	51	121.77	Molybdenum	Mo	42	96.0
Argon	A	18	39.91	Neodymium	Nd	60	144.27
Arsenic	As	33	74.96	Neon	Ne	10	20.2
Barium	Ba	56	137.37	Nickel	Ni	28	58.69
Beryllium	Be	4	9.02	Nitrogen	N	7	14.008
Bismuth	Bi	83	209.00	Osmium	Os	76	190.8
Boron	B	5	10.82	Oxygen	O	8	16.000
Bromine	Br	35	79.916	Palladium	Pd	46	106.7
Cadmium	Cd	48	112.41	Phosphorus	P	15	31.027
Calcium	Ca	20	40.07	Platinum	Pt	78	195.23
Carbon	C	6	12.000	Potassium	K	19	39.096
Cerium	Ce	58	140.25	Praseodymium	Pr	59	140.92
Cesium	Cs	55	132.81	Radium	Ra	88	225.95
Chlorine	Cl	17	35.457	Radon	Rn	86	222
Chromium	Cr	24	52.01	Rhodium	Rh	45	102.91
Cobalt	Co	27	58.94	Rubidium	Rb	37	85.44
Columbium	Cb	41	93.1	Ruthenium	Ru	44	101.7
Copper	Cu	29	63.57	Samarium	Sm	62	150.43
Dysprosium	Dy	66	162.52	Scandium	Sc	21	45.10
Erbium	Er	68	167.7	Selenium	Se	34	79.2
Europium	Eu	63	152.0	Silicon	Si	14	28.06
Fluorine	F	9	19.00	Silver	Ag	47	107.880
Gadolinium	Gd	64	157.26	Sodium	Na	11	22.997
Gallium	Ga	31	69.72	Strontium	Sr	38	87.63
Germanium	Ge	32	72.60	Sulfur	S	16	32.064
Gold	Au	79	197.2	Tantalum	Ta	73	181.5
Hafnium	Hf	72	178.6	Tellurium	Te	52	127.5
Helium	He	2	4.000	Terbium	Tb	65	159.2
Holmium	Ho	67	163.5	Thallium	Tl	81	204.39
Hydrogen	H	1	1.008	Thorium	Th	90	232.15
Indium	In	49	114.8	Thulium	Tm	69	169.4
Iodine	I	53	126.932	Tin	Sn	50	118.70
Iridium	Ir	77	193.1	Titanium	Ti	22	47.90
Iron	Fe	26	55.84	Tungsten	W	74	184.0
Krypton	Kr	36	82.9	Uranium	U	92	238.17
Lanthanum	La	57	138.90	Vanadium	V	23	50.96
Lead	Pb	82	207.22	Xenon	Xe	54	130.2
Lithium	Li	3	6.940	Ytterbium	Yb	70	173.6
Lutecium	Lu	71	175.0	Yttrium	Y	39	89.0
Magnesium	Mg	12	24.32	Zinc	Zn	30	65.38
Manganese	Mn	25	54.93	Zirconium	Zr	40	91.22

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