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THIRTY-SIXTH ANNUAL REPORT OF THE COMMITTEE ON ATOMIC WEIGHTS. DETERMINATIONS PUBLISHED DURING 1929

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In the report of the German Committee on Atomic Weights for 1928,[1] the table of atomic weights is essentially identical with the American report.[2] The report of the new English committee[3] is based on the following principles. For 36 elements for which no data have been published since 1919, the values given are taken from Clarke's Recalculation of the Atomic Weights. For certain other elements Clarke's values are modified in view of recent work. For nine "simple" elements, H, He, C, N, F, Na, P, As and I, Aston's results with the mass spectrograph are given. The result is a table differing noticeably from recent German and American tables.

On the basis of modern physico-chemical data Moles[4] recalculates eight of the "fundamental" atomic weights.

Boron.—Cousens and Turner[5] find that differences in the density of fused boric oxide with method of preparation are due to internal strain and thus explain those supposed by Briscoe, Robinson and Stephenson to be due to differences in isotopic composition.

Carbon.—Pire and Moles[6] have redetermined the normal density of

THE DENSITY OF CARBON MONOXIDE

	Globe N_3 608.81 ml.	Globe 3 580.49 ml.
	1.25031	
	1.25003	
	1.24998	
	1.25014	1.24995
	1.25009	1.25027
Average	1.25011	1.25011

[1] *Ber.*, **62B**, 1 (1929).

[2] THIS JOURNAL, **51**, 647 (1929).

[3] *J. Chem. Soc.*, 216 (1929).

[4] Moles, *Rec. trav. chim.*, **48**, 864 (1929).

[5] Cousens and Turner, *J. Chem. Soc.*, 2654 (1928).

[6] Pire and Moles, *Anales soc. españ. fís. quím.*, **27**, 267 (1929).

carbon monoxide, made by decomposition of formic acid with concentrated sulfuric acid.

With $(PV)_0/(PV)_1$, 1.00050, and molal volume, 22.414 liters, the atomic weight of carbon is 12.006.

Phosphorus.—Richie[7] gives preliminary values of the density of phosphine at one and at one-half atmosphere as 1.5317 and 0.7622, respectively. Then $(PV)_0/(PV)_1$ is 1.0097 and the atomic weight of phosphorus 30.98.

Chlorine.—Scott and Johnson[7a] prepared nitrosyl chloride by the action of hydrogen chloride on nitrosyl sulfuric acid and purified the product by prolonged fractional distillation in exhausted vessels, with protection from photochemical decomposition. The final product, representing 19 ml. out of an initial 150 ml. was separated by fractionation into seven portions, which yielded percentages of chlorine between 54.235 and 54.079. The three middle fractions were identical in composition and are considered by the authors to represent pure material. Analysis was carried out by comparison with silver. Weights are corrected to vacuum. N = 14.008.

THE ATOMIC WEIGHT OF CHLORINE

Wt. of NOCl	Wt. of Ag	Ratio NOCl: Ag	At. wt. Cl
3.92308	6.46486	0.606832	35.457
4.16219	6.85896	.606825	35.456
4.17839	6.88567	.606824	35.456
	Average	.606827	35.457

Argon.—Baxter and Starkweather[8] have found traces of hydrogen in argon used in a previous density determination. (See report for 1928.) After removal of this hydrogen the purified gas was identical with a new sample which had been freed from hydrogen and purified by fractional adsorption on chilled chabazite.

THE DENSITY OF ARGON

0°		P = 760 mm.	g = 980.616	
Number of adsorptions	Globe IV 2110.95 ml.	Globe VIII 3265.23 ml.	Globe IX 3210.26 ml.	Average
6		1.78395	1.78381	1.78388
6		1.78399	1.78401	1.78400
7		1.78406	1.78411	1.78408
7		1.78397	1.78402	1.78399
8	1.78391	1.78389		1.78390
8	1.78392	1.78387		1.78389
9	1.78402	1.78404		1.78403
9	1.78396	1.78394		1.78395
Old gas		1.78397		1.78397

[7] Richie, *Nature*, **123**, 838 (1929).

[7a] Scott and Johnson, *J. Phys. Chem.*, **33**, 1975 (1929).

[8] Baxter and Starkweather, *Proc. Nat. Acad.*, **15**, 441 (1929).

THE DENSITY OF ARGON (*Concluded*)

Number of adsorptions	Globe IV 2110.95 ml.	Globe VIII 3265.23 ml.	Globe IX 3210.26 ml.	Average
Old gas		1.78390		1.78390
Old gas		1.78389		1.78389
Old gas		1.78393		1.78393
10		(1.78350)	(1.78374)	
10		1.78395	1.78401	1.78398
11		1.78378	1.78382	1.78380
11		1.78387	1.78391	1.78389
12		1.78390	1.78392	1.78391
14		1.78400	1.78396	1.78398
19	1.78384	1.78389		1.78387
6		1.78401	1.78393	1.78397
Average	1.78393	1.78394	1.78395	1.78394
		P = 506.667 mm.		
	2110.83 ml.	3265.07 ml.	3210.11 ml.	
12		1.18889	1.18884	1.18887
13		1.18889	1.18892	1.18891
15		1.18872	1.18868	1.18870
15		1.18886	1.18884	1.18885
16		1.18880	1.18877	1.18878
17		1.18892	1.18880	1.18886
17		1.18895	1.18890	1.18893
18		1.18874	1.18870	1.18872
20	1.18882	1.18894		1.18888
21	1.18887	1.18896		1.18892
Average	1.18884	1.18887	1.18881	1.18884
		P = 253.333 mm.		
	2110.71 ml.	3264.91 ml.	3209.95 ml.	
13		0.59431	0.59429	0.59430
14		.59426		.59426
16		.59426	0.59427	.59427
19	0.59432	.59428		.59430
20	.59412	.59422		.59417
21	.59419	.59420		.59419
Average	.59421	.59426	0.59428	.59425

From the average densities, weighted inversely as the "average" errors and directly as the pressures, the best straight line to represent change in PV/w with changing pressure is

$$PV/w = 0.560556\ (1 + 0.001068\ (1 - P))$$

From this expression the limiting density of argon is 1.78204 and the atomic weight 39.944 if gram molecular volume is 22.4146 liters. The limiting density is the same as that previously found, but the coefficient of deviation from Boyle's Law is higher, −0.00107 instead of −0.00090.

Nickel.—Baxter and Ishimaru[9] have again compared meteoric with terrestrial nickel, this time by analysis of nickelous bromide. The source

[9] Baxter and Ishimaru, THIS JOURNAL, **51**, 1729 (1929).

of meteoric nickel was an iron meteorite suspected to be a fragment from the Cañon Diablo, Colorado, U. S. A., fall. Most of the iron and cobalt had already been removed in an earlier investigation. This material (M) and also common nickel salt (T) were carefully purified and converted into nickelous bromide, and the latter was several times sublimed in a current of hydrogen bromide. The sublimed product was compared with silver in the usual way and the silver bromide determined in most cases. Weights are in vacuum. Br = 79.916.

THE ATOMIC WEIGHT OF NICKEL

	Wt. of $NiBr_2$	Wt. of Ag	Ratio $NiBr_2$:Ag	At. wt. Ni	Wt. of AgBr	Ratio $NiBr_2$:2AgBr	At. wt. Ni
T	4.97931	4.91621	1.012835	58.697	8.55787	0.581840	58.702
T	5.33870	5.27101	1.012842	58.699			
T	7.91596	7.81580	1.012815	58.693	13.60533	.581828	58.698
T	4.63096	4.57242	1.012803	58.690	7.95995	.581783	58.681
T	5.35138	5.28348	1.012851	58.701			
		Average	1.012829	58.696		.581817	58.694
M	6.31054	6.23068	1.012817	58.693	10.84628	.581816	58.693
M	5.66561	5.59419	1.012767	58.683	9.73797	.581806	58.690
M	6.08659	6.00948	1.012831	58.696	10.46106	.581833	58.700
		Average	1.012805	58.691		.581818	58.694
		Average of all		58.694			58.694

The result confirms the evidence obtained with the Sonora, Mexico, meteorite that there is no difference between terrestrial and meteoric material greater than the experimental error.

Copper.—Richards and Phillips[10] have determined the atomic weight of copper from the Calumet and Hecla mines, Lake Superior, U. S. A., and from Chuquicamata, Chili. Both specimens were purified by repeated crystallization of cupric chloride. Attempts to prepare the anhydrous chloride failed. Instead, therefore, both the copper and the chlorine content of solutions of the neutral salt were found. These solutions deposited atacamite, $CuCl_2 \cdot 3CuO \cdot 4H_2O$, on standing, owing to a small cuprous content of the original cupric chloride. The analysis of solutions from which this deposition had taken place was employed in some instances. In others the deposition was prevented by adding nitric acid, and a correction was applied based on the weight of atacamite deposited from neutral solutions of similar salt.

THE ATOMIC WEIGHT OF COPPER

		Copper, %	Chlorine, %	At. wt. Cu
Lake Superior	Neutral	1.18507	4.02299	63.557
	Acid (corrected)	1.26191	4.28389	63.557
Chuquicamata	Acid (corrected)	1.25088	4.24639	63.557
	Neutral	1.26349	4.28921	63.557
			Average	63.557

[10] Richards and Phillips, THIS JOURNAL, **51**, 400 (1929).

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Atomic Weights

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	Symbol	Atomic Number	Atomic Weight		Symbol	Atomic Number	Atomic Weight
Aluminum	Al	13	26.97	Molybdenum	Mo	42	96.0
Antimony	Sb	51	121.77	Neodymium	Nd	60	144.27
Argon	A	18	39.94	Neon	Ne	10	20.183
Arsenic	As	33	74.93	Nickel	Ni	28	58.69
Barium	Ba	56	137.36	Nitrogen	N	7	14.008
Beryllium	Be	4	9.02	Osmium	Os	76	190.8
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	40.07	Potassium	K	19	39.10
Carbon	C	6	12.00	Praseodymium	Pr	59	140.92
Cerium	Ce	58	140.13	Radium	Ra	88	225.97
Cesium	Cs	55	132.81	Radon	Rn	86	222
Chlorine	Cl	17	35.457	Rhenium	Re	75	188.7
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	162.46	Scandium	Sc	21	45.10
Erbium	Er	68	167.64	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	32.06
Gold	Au	79	197.2	Tantalum	Ta	73	181.5
Hafnium	Hf	72	178.6	Tellurium	Te	52	127.5
Helium	He	2	4.002	Terbium	Tb	65	159.2
Holmium	Ho	67	163.5	Thallium	Tl	81	204.39
Hydrogen	H	1	1.0078	Thorium	Th	90	232.12
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	238.14
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	88.92
Magnesium	Mg	12	24.32	Zinc	Zn	30	65.38
Manganese	Mn	25	54.93	Zirconium	Zr	40	91.22
Mercury	Hg	80	200.61				

Arsenic.—Krepelka[11] reports the analysis of arsenic trichloride, with the result for the atomic weight of arsenic 74.937. This is slightly lower than the value in general use, 74.96, and is in close agreement with the evidence of the mass spectrograph.

Antimony.—McAlpine[12] has compared samples of antimony from Hungary and Bolivia, by determination of the density of the metal and by titration with potassium bromate, without finding significant differences. This confirms Krishnaswami's work and indicates Muzaffar's conclusion that antimony from different sources varies in isotopic composition to be incorrect. (See reports for 1923 and 1927.)

King and Birge[13] and Birge[14] have obtained spectroscopic evidence of the existence of a small proportion of C^{13} with C^{12}.

Giauque and Johnston[15] find in atmospheric absorption spectra evidence of the occurrence of O^{17} and O^{18} in maximum proportions of 1/10,000 and 1/1250, respectively. If these isotopes are present in ordinary oxygen to the above extent, atomic weights determined with the mass spectrograph by reference to O^{16} may be expected to be about 1/10,000 higher than those found by chemical methods.

Aston[16] from the mass spectrum of lead from Norwegian bröggerite has determined its isotopic composition to be as follows:

Pb^{206}	86.8 per cent.
Pb^{207}	9.3 per cent.
Pb^{208}	3.9 per cent.

Since in ordinary lead Pb^{208} is more abundant than Pb^{207}, at least a portion of the latter in the bröggerite lead must be the product of radioactive disintegration, and may be the end product of actinium.

The only change in the following table of atomic weights from that published a year ago is the lowering of that of arsenic.

CAMBRIDGE, MASSACHUSETTS

[11] Krepelka, *Nature*, **123**, 944 (1929).
[12] McAlpine, THIS JOURNAL, **51**, 1745 (1929).
[13] King and Birge, *Nature*, **124**, 127 (1929).
[14] Birge, *ibid.*, **124**, 182 (1929).
[15] Giauque and Johnston, THIS JOURNAL, **51**, 3528 (1929); *Nature*, **123**, 831 (1929).
[16] Aston, *ibid.*, **123**, 313 (1929).