Tenth Report of the Committee on Atomic Weights of the International Union of Chemistry.

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THE following report of the Committee covers the twelve-month period September 30th, 1938, to September 30th, 1939.* Three changes in the table of atomic weights have been adopted:

Hydrogen, from 1·0081 to 1·0080
Iron, from 55·84 to 55·85
Lutecium, from 175·0 to 174·99

HYDROGEN.—Several investigations of the $_1H/_2H$ ratio in certain natural waters during the last four years have given values higher than that used in computing the atomic weight of hydrogen for the Table, 5000 (see Eighth Report of the Committee).

Johnston, *J. Amer. Chem. Soc.*, 1935, **57**, 484	5900
Tronstad, Nordhagen, and Brun, *Nature*, 1935, **136**, 515	5840
Hall and Jones, *J. Amer. Chem. Soc.*, 1936, **58**, 1915	6550
Gabbard and Dole, *ibid.*, 1937, **59**, 181	7020
Morita and Titani, *Bull. Chem. Soc. Japan*, 1938, **13**, 419	6320
Tronstad and Brun, *Trans. Faraday Soc.*, 1938, **34**, 766	5400
Voskuyl, Thesis, Harvard University (1938)	6700
Swartout and Dole, *J. Amer. Chem. Soc.*, 1939, **61**, 2025	{6970, 6880

Since with $_1H = 1{\cdot}00785$ (chemical scale) and even with $_1H/_2H = 6000$ the atomic weight of hydrogen in natural waters becomes 1·0080, this value is adopted for the Table, although the nature of the hydrogen in any compound is bound to be subject to a slight uncertainty.

CHLORINE.—Hönigschmid and Hirschbold-Wittner (*Z. anorg. Chem.*, 1939, **242**, 222) have determined the atomic weight of chlorine in hydrogen chloride samples subjected to isotopic separation by the thermal diffusion method by Clausius and Dickel. Weighed amounts of silver were precipitated with excess of acid and the silver chloride was collected and weighed. Vacuum weights are given:

Wt. of Ag.	Wt. of AgCl.	AgCl : Ag.	At. wt. Cl.
	Heavy Fractions		
0·59164	0·78666	1·32963	35·560
0·48005	0·64450	1·34257	36·956
	Light Fractions		
0·73019	0·96925	1·32739	35·310
0·61237	0·81188	1·32580	35·147
0·58001	0·76830	1·32463	35·021
0·57969	0·76765	1·32428	34·979

If the isotopic weights of the two chief isotopes of chlorine are 36·968 and 34·971 on the chemical scale, the separation seems to have been nearly complete.

IRON.—Hönigschmid and Liang (*Z. anorg. Chem.*, 1939, **241**, 361) have compared ferrous bromide with silver and silver bromide. A solution of Mohr's salt was freed from

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heavy metals with hydrogen sulphide. After oxidation ferric hydroxide was three times precipitated from acid solution, and the third precipitate was dissolved in sulphuric acid and electrolytically reduced to ferrous sulphate, which was recovered by crystallisation. Electrolytic precipitation of metallic iron from ammonium oxalate solution followed, and the metallic deposit was dissolved in nitric acid. Carbon was removed by filtration, and the ferric nitrate solution evaporated to crystallisation. Thermal decomposition to oxide and reduction in hydrogen yielded sample I. Spectroscopic examination by Gerlach revealed no impurities. The remainder of the ferric nitrate was twice more recrystallised from nitric acid and converted into metal (sample II).

Synthesis of the bromide was effected by heating the pure metal in a current of dry nitrogen and bromine. The sublimed product was resublimed in pure nitrogen and fused in nitrogen in a quartz weighing tube which could be bottled in dry air. After being weighed, the salt was dissolved in very dilute sulphuric acid. The solution was clear and free from ferric salt. After careful oxidation with slightly less than the theoretical quantity of dichromate the solution was compared with silver in the conventional way with the help of a nephelometer. In many of the experiments the silver bromide was collected and weighed. Vacuum weights are given :

THE ATOMIC WEIGHT OF IRON.

Sample.	Wt. of $FeBr_2$.	Wt. of Ag.	$FeBr_2 : 2Ag$.	At. wt. Fe.	Wt. of AgBr.	$FeBr_2 : 2AgBr$.	At. wt, Fe.
I	1·85170	1·85236	0·999644	55·851			
I	3·30576	3·30690	0·999655	55·854			
II	2·07499	2·07574	0·999639	55·850			
II	3·28783	3·28900	0·999644	55·851	5·72554	0·574239	55·848
I	2·92032	2·92137	0·999641	55·850	5·08551	0·574243	55·849
I	3·30851	3·30966	0·999653	55·853	5·76158	0·574237	55·847
I	2·32787	2·32870	0·999644	55·851	4·05371	0·574257	55·854
I	2·83665	2·83765	0·999648	55·852	4·93977	0·574247	55·851
II	2·80087	2·80188	0·999640	55·850	4·87744	0·574250	55·852
II	2·61260	2·61354	0·999640	55·850	4·54968	0·574238	55·847
II	2·85977	2·86078	0·999647	55·852	4·98006	0·574244	55·849
	Average		0·999645	55·851		0·574244	55·850

The average of all the experiments, 55·850, is slightly higher than that found by analysis of ferrous bromide by Baxter, Thorvaldson, and Cobb (*J. Amer. Chem. Soc.*, 1911, **33**, 319), 55·838, presumably because the material employed by the latter contained traces of carbon, silica and possibly ferric salt. By reduction of ferric oxide Baxter and Hoover (*J. Amer. Chem. Soc.*, 1912, **34**, 1857) found 55·847, and Hönigschmid, Birckenbach, and Zeiss (*Ber.*, 1923, **56**, 1473) by analysis of ferric chloride obtained the value 55·853.

Recent determinations of abundance ratios with the mass spectrograph, when converted to the chemical scale with the packing fraction -7×10^{-4} (Dempster, *Physical Rev.*, 1938, **53**, 869) and the conversion factor 1·000275, give the following values :

Isotope	54.	56.	57.	58.	Mean mass number.	At. wt.
de Gier and Zeeman *	6·5	90·2	2·8	0·5	55·908	55·853
Nier †	6·04	91·57	2·11	0·28	55·906	55·851

* *Proc. Roy. Soc. Amsterdam*, 1935, **38**, 959.
† *Physical Rev.*, 1939, **55**, 1143.

In view of the evidence the value 55·85 for iron seems more probable than the older one 55·84, and has been adopted for the Table, although the value 55·847 obtained by the most direct method, the reduction of the oxide, might well be looked upon as a maximum owing to the possibility of incomplete reduction.

MOLYBDENUM.—Mattauch and Lichtblau (*Z. physikal. Chem.*, 1939, *B*, **42**, 288) have redetermined the relative abundances of the molybdenum isotopes. In the following table their percentages are compared with those found earlier by Aston. The atomic weight is calculated with the packing fraction $-6{\cdot}0 \times 10^{-4}$ (Dempster) and the conversion factor 1·000275.

Isotope	92.	94.	95.	96.	97.	98.	100.	Mean mass number.	At. wt. Mo.
Aston	14·2	10·0	15·5	17·8	9·6	23·0	9·8	95·94 *	95·86
Mattauch and Lichtblau	15·5	8·7	16·3	16·8	8·7	25·4	8·6	95·98	95·90

* Incorrectly calculated by Aston to be 96·03 (*Proc. Roy. Soc.*, 1931, *A*, **130**, 309).

Both these values are considerably lower than that obtained by Hönigschmid and Wittner by analysis of molybdenum pentachloride, 95·949, which was adopted for the Table two years ago (see Eighth Report of this Committee).

EUROPIUM.—Lichtblau (*Naturwiss.*, 1939, **27**, 260) has determined the abundance ratio of the europium isotopes, ${}_{151}Eu/{}_{153}Eu$, to be $0{\cdot}963 \pm 0{\cdot}012$. With the packing fraction -2×10^{-4} (Dempster) and the conversion factor 1·000275 the atomic weight of europium is $151{\cdot}95 \pm 0{\cdot}01$. This value agrees far better with that recently found by Baxter and Tuemmler by analysis of europous chloride, 151·96, than with Kapfenberger's recent value, 151·90 (see Ninth Report of this Committee).

LUTECIUM.—Hönigschmid and Wittner (*Z. anorg. Chem.*, 1939, **240**, 284) have published details of their analyses of lutecium trichloride, already reported (*Naturwiss.*, 1937, **25**, 748; see Eighth Report of this Committee). The starting material had been purified by von Welsbach and was identical with that used by him in his determination of the atomic weight. From examination of the *X*-ray spectrum Noddack estimates a content of 1·18% of ytterbium but no more than 0·04% of any other rare earth. Purification consisted in double precipitation of the hydroxide with solution in hydrochloric acid, double precipitation of the oxalate with subsequent ignition in each case, and double crystallisation of the chloride from concentrated hydrochloric acid. The chloride was dehydrated in a stream of dry hydrogen chloride at gradually increasing temperatures, finally at 450°, and after being weighed was compared with silver in the conventional way. The silver chloride was determined in some cases. Vacuum weights are given.

THE ATOMIC WEIGHT OF LUTECIUM.

Wt. of $LuCl_3$.	Wt. of Ag.	$LuCl_3$: 3Ag.	At. wt. Lu.	Wt. of AgCl.	$LuCl_3$: 3AgCl.	At. wt. Lu.
2·10076	2·41662	0·86930	174·968	3·21098	0·65424	174·961
2·94416	3·38688	0·86928	174·964	4·50009	0·65424	174·962
2·20514	2·53662	0·86932	174·977			
2·63280	3·02874	0·86927	174·960	4·02420	0·65424	174·960
2·70083	3·10697	0·86928	174·963			
Average		0·86929	174·966		0·65424	174·961

The authors prefer the result of the former method of analysis, 174·966. Corrected for the ytterbium content, this becomes 174·986.

Mattauch and Lichtblau (*Z. Physik*, 1939, **111**, 514), with the mass spectrograph, find a new isotope of lutecium of mass number 176, to the extent of 2·52%. With the packing fraction $+1 \times 10^{-4}$ (Dempster) and the conversion factor 1·000275 the atomic weight of lutecium is 174·994, in close agreement with that found by Hönigschmid and Wittner.

The value 174·99 is adopted for the Table in place of the older value 175·0, which depends on von Welsbach's analysis of the sulphate.

LEAD.—Nier (*Physical Rev.*, 1939, **55**, 153) has determined the abundance ratios of the lead isotopes in twenty-one specimens of radiogenic lead, and has computed the atomic weights of these specimens, using the packing fraction $+1{\cdot}55 \times 10^{-4}$ and the conversion factor 1·000275. While in most cases the agreement between the atomic weights found in this way and those which had been determined chemically is fair, in some cases considerable discrepancies appear. If Dempster's packing fraction for lead, $+2{\cdot}3 \times 10^{-4}$, is used, the agreement is far less satisfactory. The latter is also true for the results obtained by Nier with common lead (see Ninth Report of this Committee).

INTERNATIONAL ATOMIC WEIGHTS.

1940.

	Symbol.	Atomic Number.	Atomic Weight.
Aluminum	Al	13	26·97
Antimony	Sb	51	121·76
Argon	A	18	39·944
Arsenic	As	33	74·91
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
Cæsium	Cs	55	132·91
Calcium	Ca	20	40·08
Carbon	C	6	12·010
Cerium	Ce	58	140·13
Chlorine	Cl	17	35·457
Chromium	Cr	24	52·01
Cobalt	Co	27	58·94
Copper	Cu	29	63·57
Dysprosium ...	Dy	66	162·46
Erbium	Er	68	167·2
Europium	Eu	63	152·0
Fluorine	F	9	19·00
Gadolinium	Gd	64	156·9
Gallium	Ga	31	69·72
Germanium ...	Ge	32	72·60
Gold	Au	79	197·2
Hafnium	Hf	72	178·6
Helium	He	2	4·003
Holmium	Ho	67	163·5
Hydrogen	H	1	1·0080
Indium	In	49	114·76
Iodine	I	53	126·92
Iridium	Ir	77	193·1
Iron	Fe	26	55·85
Krypton	Kr	36	83·7
Lanthanum ...	La	57	138·92
Lead	Pb	82	207·21
Lithium	Li	3	6·940
Lutecium	Lu	71	174·99
Magnesium	Mg	12	24·32
Manganese	Mn	25	54·93
Mercury	Hg	80	200·61
Molybdenum ...	Mo	42	95·95
Neodymium ...	Nd	60	144·27
Neon	Ne	10	20·183
Nickel	Ni	28	58·69
Niobium (Columbium)	Nb (Cb)	41	92·91
Nitrogen	N	7	14·008
Osmium	Os	76	190·2
Oxygen	O	8	16·0000
Palladium	Pd	46	106·7
Phosphorus ...	P	15	30·98
Platinum	Pt	78	195·23
Potassium	K	19	39·096
Praseodymium	Pr	59	140·92
Protoactinium	Pa	91	231
Radium	Ra	88	226·05
Radon	Rn	86	222
Rhenium.........	Re	75	186·31
Rhodium	Rh	45	102·91
Rubidium	Rb	37	85·48
Ruthenium ...	Ru	44	101·7
Samarium	Sm	62	150·43
Scandium	Sc	21	45·10
Selenium	Se	34	78·96
Silicon	Si	14	28·06
Silver	Ag	47	107·880
Sodium	Na	11	22·997
Strontium	Sr	38	87·63
Sulphur	S	16	32·06
Tantalum	Ta	73	180·88
Tellurium	Te	52	127·61
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	183·92
Uranium	U	92	238·07
Vanadium	V	23	50·95
Xenon	Xe	54	131·3
Ytterbium	Yb	70	173·04
Yttrium	Y	39	88·92
Zinc	Zn	30	65·38
Zirconium	Zr	40	91·22