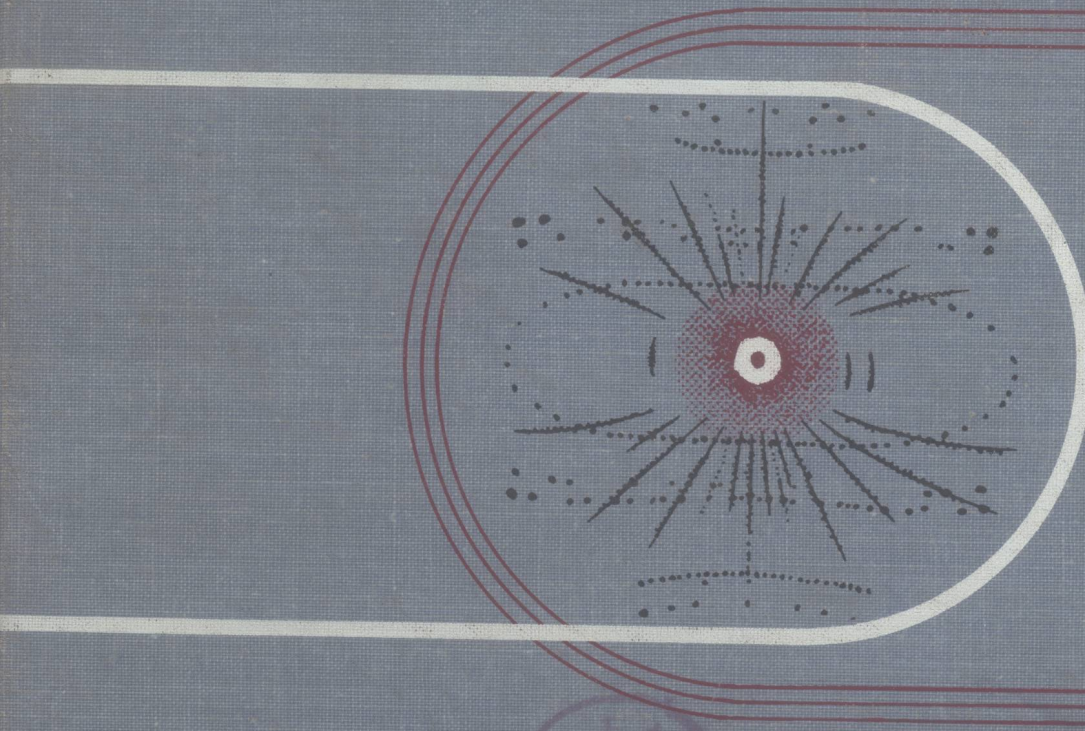

CHEMISTRY

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An Introduction to Matter and Energy

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An Introduction to Matter and Energy

To my Mother and Father

Preface

In his "Love of Two Chemists" Max Shulman has Dobie Gillis enrolled —apparently only temporarily—in a freshman chemistry course. Mr. Fitzhugh introduces the subject in the following manner.

"This course is dedicated to the idiotic proposition that you can be taught the fundamentals of organic chemistry, inorganic chemistry, qualitative analysis, quantitative analysis, physical chemistry, and biochemistry all in one semester. The odds against any of you passing this course would be staggering to contemplate if there were any time for contemplation. However, there is not. Get out your notebooks."[1] Gillis subsequently describes the lecture.

"For the next hour Mr. Fitzhugh, speaking a little faster than Clem McCarthy when he is announcing the Kentucky Derby, delivered a lecture about matter, elements, mixtures, compounds, reagents, the periodic table, atomic weights, ionization, valence, and other improbable topics. At the end of the hour I had nineteen pages of notes, all illegible."[2]

To those students who use this text I would point out that Mr. Shulman is a writer of fiction, not history. To their teachers I submit that were the picture drawn here completely unrelated to fact, it would be the more humorous.

The first course in chemistry cannot be all things for all people. We shall have to continue offering courses in organic chemistry, physical chemistry, and biochemistry to convey the ideas fostered by these disciplines. The ideas regarded as the properties of these disciplines will continue to be more easily perceived when they are laid upon a foundation of those "more noble" ideals which pervade the whole of chemistry.

Accordingly I have followed the precept of Bagehot that "to illustrate a principle you must exaggerate much and you must omit much. . ." To pay more attention to that most pervasive of all "chemical" ideas—atomic-molecular theory—some of what is ordinarily found in beginning texts has been omitted. Since the atomic-molecular theory as we know it today has evolved so slowly, it is presented historically. Those of us who have devoted our lives to acquiring some sophistication in thinking about atoms and molecules become impatient when our students do not perceive that which we would have them understand. We err here, of course, for they require time to arrive at this understanding. Because atomic-molecular theory accounts for the phenomena of heat, electricity, and light, as well as for the particulars of chemical change, rather more attention has been devoted to the former topics than is ordinarily the case in beginning texts. Hopefully, this will assist the prospective chemist in seeing chemistry and physics in

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[1] From *The Many Loves of Dobie Gillis;* copyright 1945, 1946, 1948, 1950, 1951, by Max Shulman. Reprinted by permission of the Harold Matson Company and Doubleday and Company, Inc.

[2] Ibid., pp. 105-106.

one light rather than two. If this is achieved, then surely the synthesis he or she later encounters in physical chemistry will be grasped more easily. At the present the physicists place the heavier claim on the study of the nucleus. That many chemists would have it no other way we may deduce from the circumstance that textbooks of organic chemistry frequently ignore the nucleus altogether. Nonetheless, the atomic-molecular theory of yesterday is in fact atomic-molecular-nuclear theory today. Hence the chemistry and physics of the nucleus is considered here at some length.

I hope that neither the exaggerations nor the omissions will be regarded as being too severe.

One cannot hope to acknowledge fully one's debt in affairs of learning. Nevertheless, I wish to convey my appreciation to certain of my teachers, colleagues, and collaborators in this endeavor. To my teachers Dr. H. C. Brown, Dr. C. D. Kochakian, Dr. Grace Jencke, and Mrs. Charles Goodwin I owe a considerable debt. My colleagues the Mssrs. G. E. Castleberry, Al Ossinger, Ed Neparko, E. A. Reynolds, and G. L. Cunningham (now at Eastern Illinois University) have helped me with many suggestions. However, my wife Jean, Dr. H. F. Timmons, the consulting editor Dr. Therald Moeller of the University of Illinois, and Truman Hall of Appleton-Century-Crofts have suffered the most; I can but hope that they find their influence on this work some reward.

Many authors and publishers have permitted the inclusion of their material herein. I should like to express my appreciation to them as well.

D. H.

THE CHEMICAL ELEMENTS

Element	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	[227]
Aluminum	Al	13	26.9815
Americium	Am	95	[243]
Antimony	Sb	51	121.75
Argon	Ar	18	39.948
Arsenic	As	33	74.9216
Astatine	At	85	[210]
Barium	Ba	56	137.34
Berkelium	Bk	97	[249]
Beryllium	Be	4	9.0122
Bismuth	Bi	83	208.980
Boron	B	5	10.811
Bromine	Br	35	79.909
Cadmium	Cd	48	112.40
Calcium	Ca	20	40.08
Californium	Cf	98	[251]
Carbon	C	6	12.01115
Cerium	Ce	58	140.12
Cesium	Cs	55	132.905
Chlorine	Cl	17	35.453
Chromium	Cr	24	51.996
Cobalt	Co	27	58.9332
Copper	Cu	29	63.54
Curium	Cm	96	[247]
Dysprosium	Dy	66	162.50
Einsteinium	Es	99	[254]
Erbium	Er	68	167.26
Europium	Eu	63	151.96
Fermium	Fm	100	[253]
Fluorine	F	9	18.9984
Francium	Fr	87	[223]
Gadolinium	Gd	64	157.25
Gallium	Ga	31	69.72
Germanium	Ge	32	72.59
Gold	Au	79	196.967
Hafnium	Hf	72	178.49
Helium	He	2	4.0026
Holmium	Ho	67	164.930
Hydrogen	H	1	1.00797
Indium	In	49	114.82
Iodine	I	53	126.9044
Iridium	Ir	77	192.2
Iron	Fe	26	55.847
Krypton	Kr	36	83.80
Lanthanum	La	57	138.91
Lawrencium	Lw	103	[257]
Lead	Pb	82	207.19
Lithium	Li	3	6.939
Lutetium	Lu	71	174.97
Magnesium	Mg	12	24.312
Manganese	Mn	25	54.9380
Mendelevium	Md	101	[256]

Element	Symbol	Atomic Number	Atomic Weight
Mercury	Hg	80	200.59
Molybdenum	Mo	42	95.94
Neodymium	Nd	60	144.24
Neon	Ne	10	20.183
Neptunium	Np	93	[237]
Nickel	Ni	28	58.71
Niobium	Nb	41	92.906
Nitrogen	N	7	14.0067
Nobelium	No	102	[254]
Osmium	Os	76	190.2
Oxygen	O	8	15.9994
Palladium	Pd	46	106.4
Phosphorus	P	15	30.9738
Platinum	Pt	78	195.09
Plutonium	Pu	94	[242]
Polonium	Po	84	[210]
Potassium	K	19	39.102
Praseodymium	Pr	59	140.907
Promethium	Pm	61	[147]
Protactinium	Pa	91	[231]
Radium	Ra	88	[226]
Radon	Rn	86	[222]
Rhenium	Re	75	186.2
Rhodium	Rh	45	102.905
Rubidium	Rb	37	85.47
Ruthenium	Ru	44	101.07
Samarium	Sm	62	150.35
Scandium	Sc	21	44.956
Selenium	Se	34	78.96
Silicon	Si	14	28.086
Silver	Ag	47	107.870
Sodium	Na	11	22.9898
Strontium	Sr	38	87.62
Sulfur	S	16	32.064
Tantalum	Ta	73	180.948
Technetium	Tc	43	[99]
Tellurium	Te	52	127.60
Terbium	Tb	65	158.924
Thallium	Tl	81	204.37
Thorium	Th	90	232.038
Thulium	Tm	69	168.934
Tin	Sn	50	118.69
Titanium	Ti	22	47.90
Tungsten	W	74	183.85
Uranium	U	92	238.03
Vanadium	V	23	50.942
Xenon	Xe	54	131.30
Ytterbium	Yb	70	173.04
Yttrium	Y	39	88.905
Zinc	Zn	30	65.37
Zirconium	Zr	40	91.22

Atomic weight values are based on carbon-12. Values listed in brackets denote mass numbers; these values are given for either the longest-lived or the best-known isotope.

PERIODIC TABLE OF THE ELEMENTS

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 H 1.00797															2 He 4.0026
2	3 Li 6.939	4 Be 9.0122									5 B 10.811	6 C 12.01115	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
3	11 Na 22.9898	12 Mg 24.312									13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
4	19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9044	54 Xe 131.30
6	55 Cs 132.905	56 Ba 137.34	57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac (227)															

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (249)	98 Cf (251)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lw (257)

Atomic weight values listed in parentheses are approximate.

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