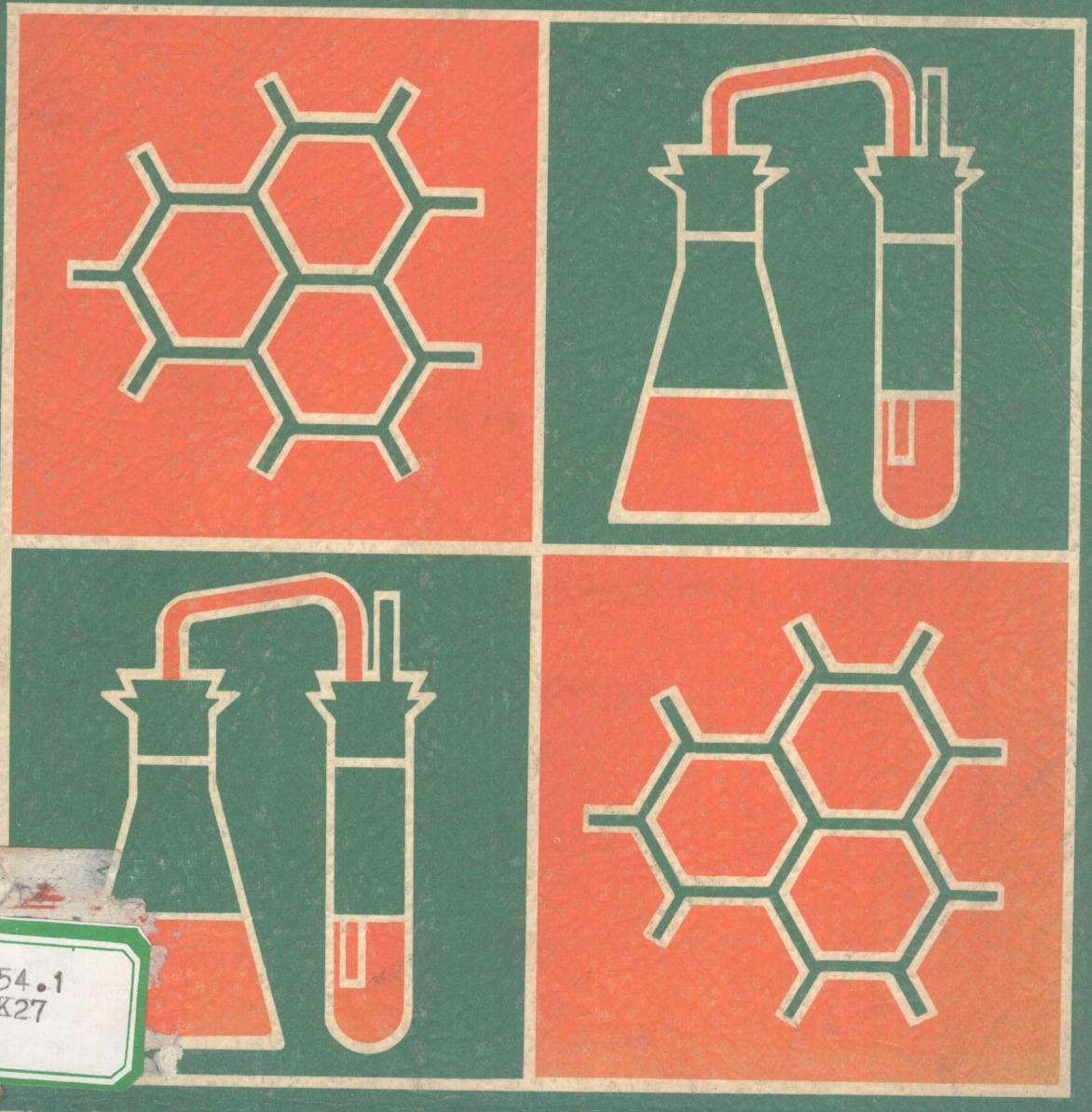
Programmed basic chemistry for allied health students

Danile Keily



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PREFACE

Many allied health students, for one reason or another, are afraid of and have come to dislike chemistry. One reason for this may be that they have been taught chemistry as if they were going to be chemistry majors or at least research chemists. The dislike they have developed may be an innate cry for freedom. In my teaching experience I have found that students dislike any subject that seems to be master of them. As soon as they begin to understand a subject and realize they can be in charge, they begin to like it. Seeing one's progress is the best motivator for furthering one's progress.

This programmed basic chemistry text covers those aspects of chemistry that I see as essential knowledge for the allied health student. The material covered in it has been gleaned from my many years of experience in the clinical laboratory and in teaching allied health students. My objective is to present the essentials of chemistry in such a way that the student will not only become master of the material presented but also will come to like chemistry. I welcome comments and suggestions from instructors and students.

Over the years I have used many different chemistry books to increase my knowledge of chemistry. My best teachers, however, have been my students, who have challenged me and taught me how to teach. To all of you, my former students, wherever you are, I am grateful and humbly dedicate this book to you.

Danile Keily

CONTENTS

UNIT I Elements and their symbols, 1

II Atomic structure, 12

III Energy, matter, compounds, 26

IV Mole, molecular weight, equivalent weight, 52

V Acids, bases, salts, buffers, pH, 68

VI Solutions, 98

VII Organic chemistry, 134

VIII Basic mathematics, 168

UNIT I

ELEMENTS AND THEIR SYMBOLS

BEHAVIORAL OBJECTIVES

When you have completed the study of this unit you will be able to do the following either orally or in writing:

- Write the element's name, with correct spelling, if it is dictated to you.
- If given the name of an element, be able to write its symbol.
- If given the symbol of an element, be able to write its name.
- Be able to define the following:
  1. Atom
  2. Chemistry
  3. Matter
- Be able to tell what all material substances are composed of.
- Be able to differentiate between natural and man-made elements and give the atomic numbers identifying each group.
- Be able to tell what is studied in the following branches of chemistry:
  1. Inorganic chemistry
  2. Biochemistry
  3. Physiological chemistry
  4. Organic chemistry
  5. Clinical chemistry
- Using the table of elements be able to give the atomic number and the atomic weight of any of the elements.

Chemistry is defined as the study of *matter* and the *changes* it undergoes.

Matter is anything that *has mass* and *occupies space.*

matter; changes

1 Chemistry is the study of _____ and the _____ it undergoes.

mass; occupies space

2 Matter is anything that has _____ and _____.

We can look at matter from several different angles. If we study "nonliving" matter we are studying *inorganic chemistry.* The study of carbon and its compounds is the science of *organic chemistry.* The study of chemistry within the living system is called *biochemistry.* Sometimes biochemistry is called *physiological chemistry.* When we do examinations on body fluids such as blood, urine, or spinal fluid, we are doing *clinical chemistry.* A

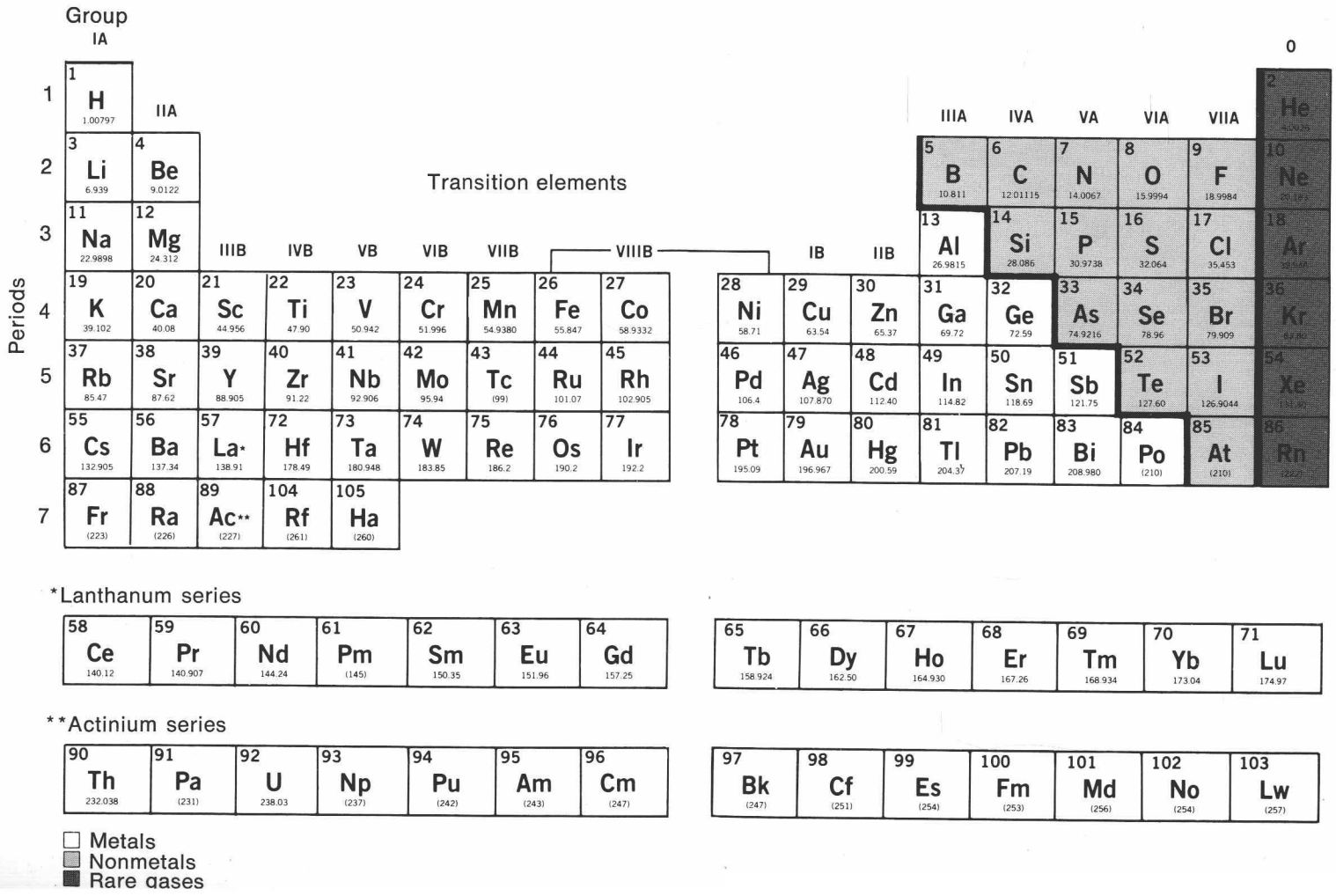
Group
IA
IIA
IIIB
IVB
VB
VIB
VIIB
VIIIB
IB
IIB
IIIA
IVA
VA
VIA
VIIA
0
Periods
Transition elements
1 H 1.00797
2 He
3 Li 6.939
4 Be 9.0122
5 B 10.811
6 C 12.01115
7 N 14.0067
8 O 15.9994
9 F 18.9984
10 Ne
11 Na 22.9898
12 Mg 24.312
13 Al 26.9815
14 Si 28.086
15 P 30.9738
16 S 32.064
17 Cl 35.453
18 Ar
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
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
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
87 Fr (223)
88 Ra (226)
89 Ac** (227)
104 Rf (261)
105 Ha (260)
*Lanthanum series
58 Ce 140.12
59 Pr 140.907
60 Nd 144.24
61 Pm (145)
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
**Actinium series
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 (247)
98 Cf (251)
99 Es (254)
100 Fm (253)
101 Md (256)
102 No (254)
103 Lw (257)
Metals
Nonmetals
Rare gases

Table 1. Table of elements

Element	Symbol	Atomic number	Atomic weight	Element	Symbol	Atomic number	Atomic weight
Actinium	Ac	89	227	Mercury ✓	Hg	80	200.59
Aluminum ✓	Al	13	26.9815	Molybdenum ✓	Mo	42	95.94
Americium	Am	95	[243]*	Neodymium	Nd	60	144.24
Antimony ✓	Sb	51	121.75	Neon ✓	Ne	10	20.183
Argon ✓	Ar	18	39.948	Neptunium	Np	93	[237]
Arsenic ✓	As	33	74.9216	Nickel ✓	Ni	28	58.71
Astatine	At	85	[210]	Niobium	Nb	41	92.906
Barium ✓	Ba	56	137.34	Nitrogen ✓	N	7	14.0067
Berkelium	Bk	97	[249]	Nobelium	No	102	[253]
Beryllium ✓	Be	4	9.0122	Osmium ✓	Os	76	190.2
Bismuth ✓	Bi	83	208.980	Oxygen ✓	O	8	15.9994
Boron ✓	B	5	10.811	Palladium	Pd	46	106.4
Bromine ✓	Br	35	79.909	Phosphorus ✓	P	15	30.9738
Cadmium ✓	Cd	48	112.40	Platinum ✓	Pt	78	195.09
Calcium ✓	Ca	20	40.08	Plutonium	Pu	94	[242]
Californium	Cf	98	[251]	Polonium	Po	84	210
Carbon ✓	C	6	12.01115	Potassium ✓	K	19	39.102
Cerium	Ce	58	140.12	Praseodymium	Pr	59	140.907
Cesium ✓	Cs	55	132.905	Promethium	Pm	61	[145]
Chlorine ✓	Cl	17	35.453	Protactinium	Pa	91	231
Chromium ✓	Cr	24	51.996	Radium ✓	Ra	88	226.05
Cobalt ✓	Co	27	58.9332	Radon	Rn	86	222
Copper ✓	Cu	29	63.54	Rhenium	Re	75	186.2
Curium	Cm	96	[247]	Rhodium	Rh	45	102.905
Dysprosium	Dy	66	162.50	Rubidium	Rb	37	85.47
Einsteinium	Es	99	[254]	Ruthenium	Ru	44	101.07
Erbium	Er	68	167.26	Samarium	Sm	62	150.35
Europium	Eu	63	151.96	Scandium	Sc	21	44.956
Fermium	Fm	100	[253]	Selenium ✓	Se	34	78.96
Fluorine ✓	F	9	18.9984	Silicon ✓	Si	14	28.086
Francium	Fr	87	[223]	Silver	Ag	47	107.870
Gadolinium	Gd	64	157.25	Sodium ✓	Na	11	22.9898
Gallium	Ga	31	69.72	Strontium ✓	Sr	38	87.62
Germanium	Ge	32	72.59	Sulfur ✓	S	16	32.064
Gold ✓	Au	79	196.967	Tantalum	Ta	73	180.948
Hafnium	Hf	72	178.49	Technetium	Tc	43	[99]
Helium ✓	He	2	4.0026	Tellurium	Te	52	127.60
Holmium	Ho	67	164.930	Terbium	Tb	65	158.924
Hydrogen ✓	H	1	1.00797	Thallium	Tl	81	204.37
Indium	In	49	114.82	Thorium	Th	90	232.038
Iodine ✓	I	53	126.9044	Thulium	Tm	69	168.934
Iridium	Ir	77	192.2	Tin ✓	Sn	50	118.69
Iron ✓	Fe	26	55.847	Titanium	Ti	22	47.90
Krypton ✓	Kr	36	83.80	Tungsten ✓	W	74	183.85
Lanthanum	La	57	138.91	Uranium ✓	U	92	238.03
Lawrencium	Lw	103	[257]	Vanadium	V	23	50.942
Lead ✓	Pb	82	207.19	Xenon	Xe	54	131.30
Lithium ✓	Li	3	6.939	Ytterdium	Yb	70	173.04
Lutetium	Lu	71	174.97	Yttrium	Y	39	88.905
Magnesium ✓	Mg	12	24.312	Zinc ✓	Zn	30	65.37
Manganese ✓	Mn	25	54.9380	Zirconium	Zr	40	91.22
Mendelevium	Md	101	[256]				

*A value given in brackets denotes the mass number of the longest-lived or best-known isotope. Atomic weights based on carbon 12.

clinical setting is a hospital, doctor's office, or any place where patients are being examined, diagnosed, and treated.

biochemistry (physiological chemistry)
clinical chemistry

3 When you study the function of chemicals within a living system you are studying _____, and if tests are done on body fluids you are in _____.

inorganic

4 The study of "nonliving" chemicals is _____ chemistry.

inorganic

organic
biochemistry

clinical

5 We will begin by studying "nonliving" or _____ chemistry, then learn a little bit about carbon and its compounds when we study _____ chemistry. Later on we will study some _____ and learn about chemical substances in the human body, and last we will study _____ chemistry, in which we do tests on body fluids for different chemical substances.

Look around you. What do you see? A desk? A chair? People? Buildings? Trees? Grass? Soil? Whatever material object you see is composed of some combination of the *elements*. Therefore, matter is composed of some combination of the elements.

103

6 Look at the table of the elements (Table 1). How many elements are there? _____

Ninety-two of these elements are natural elements; the other eleven are man-made elements. Man-made elements have been made from the natural elements by fission or fusion.

elements

7 All material substances are composed of some combination of the _____.

For example, table salt is composed of a combination of two elements, sodium and chlorine. When one part of sodium and one part of chlorine are combined, we have a new substance that chemically is named sodium chloride and is commonly called table salt.

Baking soda is composed of one part of sodium, one part of hydrogen, one part of carbon, and three parts of oxygen. The chemical name for baking soda is sodium bicarbonate.

The smallest particle of an element is an atom of that element.

92

8 How many kinds of natural atoms are there? _____

11

9 How many different kinds of atoms have been made by humans? _____

elements
atom

10 All material objects are made of some combination of the _____, and the smallest piece of an element is the _____.

103

11 How many different kinds of atoms are there? _____

Look at the table of the elements again. Notice that each element has a *name,* an *atomic number*, a *symbol,* and an *atomic mass* (also called *atomic weight*). We need to know the names of the elements, but instead of writing out the name of the element we symbolize the element with a chemical symbol.

In beginning the study of chemistry it is necessary to learn to know the names of the elements, to spell them correctly, and to know their symbols.

name; atomic number
symbol; atomic mass

12 Every element has a _____, an _____, a _____, and an _____.

weight

13 Another name for atomic mass is atomic _____.

H

14 The symbol for hydrogen is _____.

elements

15 Hydrogen is one of the _____.

Al

16 The symbol for aluminum is _____.

elements

17 Aluminum is one of the _____.

atom

18 The smallest piece of hydrogen we can have is a(n) _____ of hydrogen.

atom

19 The smallest piece of aluminum we can have is a(n) _____ of aluminum.

Notice that the symbol for an element is either one letter, a capital letter, or two letters, a capital letter and a lower case letter. If two or more elements begin with the same letter, one will have a symbol with one letter and the others will have a second letter in their symbol.

C

20 The symbol for carbon is _____.

Ce

21 The symbol for cerium is _____.

Cs

22 The symbol for cesium is _____.

Cl

23 The symbol for chlorine is _____.

Cr

24 The symbol for chromium is _____.

Co

25 The symbol for cobalt is _____.

Cu

26 The symbol for copper is _____.

Cm

27 The symbol for curium is _____.

carbon
2

28 One element has the symbol C; this is the element _____. All other elements beginning with C will have _____ letters in their symbol.

yes
copper

29 Look at the elements beginning with C. Did any of them have a letter in it that was not in the element's name? _____ If yes, which one(s)? _____

30 Look at the table of elements again. Draw a line under the name of the element and its symbol if the symbol has letters in it that are not in the name of the element. How many are there? _____

11

The names of these elements are taken from another language. The foreign word they are taken from is given below.

Name of element	Foreign name	Symbol
Antimony	Strobelium	Sb
Copper	Cuprum	Cu
Gold	Aurum	Au
Iron	Ferrum	Fe
Lead	Plumbum	Pb
Mercury	Hydrargyrum	Hg
Potassium	Kalium	K
Silver	Argentium	Ag
Sodium	Natrium	Na
Tin	Stannum	Sn
Tungsten	Wolfram	W

31 Write the element with the following symbols:

antimony; potassium
copper; silver
gold; sodium
iron; tin
lead; tungsten
mercury

Sb _____ K _____
Cu _____ Ag _____
Au _____ Na _____
Fe _____ Sn _____
Pb _____ W _____
Hg _____

32 Give the symbol for the following elements:

Na; K
Au; Ag
Sn; W
Fe; Pb
Hg; Cu
Sb

Sodium _____ Potassium _____
Gold _____ Silver _____
Tin _____ Tungsten _____
Iron _____ Lead _____
Mercury _____ Copper _____
Antimony _____

Learn these eleven elements and their symbols first (say them, write them, look at them until you know them), then it will be easy to learn the names and symbols of the other elements.

Ag
Na

33 The symbol for silver is _____ and the symbol for sodium is _____.

Sn
W

34 The symbol for tin is _____ and the symbol for tungsten is _____.

Sb; K; Cu; Au; Fe
Pb

35 Antimony, potassium, copper, gold, iron, and lead have the symbols _____, _____, _____, _____, _____, and _____, respectively.

Respectively means the symbols must be named in the same order as the names of the elements.

A; Au
Ag
no

36 Notice that the symbol for gold and silver both begin with a capital _____. The symbol for gold is _____ and the symbol for silver is _____. Does gold have a "g" in its symbol? _____

F
Fe

37 The symbol for iron begins with a capital _____. The symbol for iron is _____.

iron
Fe

38 When you see a compound with ferric or ferrous in its name, you know it contains the element _____, because you know that the symbol for iron is _____.

tin
tin

39 If you see the name stannous chloride, you know the substance contains _____ because you know the symbol for _____ is Sn.

K
P

40 The symbol for potassium is _____; the symbol for phosphorus is _____.

P
K

41 Notice that phosphorus has two "p's" in its name. The element with the two "p's" in its name has the symbol _____. Potassium has the symbol _____.

sodium; potassium; calcium

42 You receive an order in the clinical laboratory to do a serum Na, K, and Ca. The doctor wants to know how much _____, _____, and _____, respectively, are present in the patient's serum.

Look at the table of the elements again. Notice that some of them have a checkmark (✓) after the name. These are the elements encountered most frequently in the clinical laboratory. Memorize their names and their symbols. Write them until you know the spelling of the element and its symbol. You will be tested on your knowledge of these.

12
boron; oxygen
carbon; phosphorus
fluorine; potassium
hydrogen; sulfur
iodine; tungsten
nitrogen; uranium

43 How many of the elements have a symbol with only one letter? _____ Name them.

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

44 Give the symbols for the following elements:

Boron ___	Hydrogen ___	Oxygen ___	Sulfur ___
Carbon ___	Iodine ___	Phosphorus ___	Tungsten ___
Fluorine ___	Nitrogen ___	Potassium ___	Uranium ___

B; H; O; S
C; I; P; W
F; N; K; U

45 Look at the table of elements again. Notice the column, *atomic number*. How many elements have an atomic number of greater than 92? _____ Put a checkmark in front of them. These are the so-called man-made elements.

11

46 The man-made elements' atomic numbers are greater than _____. They vary from _____ to _____.

92; 93 to 103

47 The natural elements have atomic numbers of less than _____. They vary from _____ to _____.

93
1 to 92

48 All material substances are made up of some combination of the _____.

elements

49 The smallest piece of an element is an _____ of the element.

atom

50 There are _____ natural elements and _____ man-made elements.

92; 11

51 Instead of writing the whole name of an element we write its _____.

symbol

52 The _____ for oxygen is O.

symbol

53 The atomic number of hydrogen is _____.

1

54 The atomic weight of hydrogen is _____.

1

55 The symbol for sulfur is _____.

S

56 F is the _____ for _____. It has an atomic number of _____ and an atomic mass of _____.

symbol; fluorine
9
18.99

57 One of the elements has a symbol of C. It is _____. All the other elements beginning with a C have _____ letters in their symbol.

carbon
2

58 The only element with the symbol of F is _____. All the other elements with F will have _____ letters in their symbol.

fluorine
2

59 There are eleven symbols that are taken from a foreign language. Write the name of the element and its symbol.

Element	Symbol
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

antimony; Sb
copper; Cu
gold; Au
iron; Fe
lead; Pb

mercury; Hg
potassium; K
silver; Ag
sodium; Na
tin; Sn
tungsten; W

Element	Symbol
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

60 There are twelve elements that have a symbol of one letter. Write the element and its symbol.

boron; B
carbon; C
fluorine; F
hydrogen; H
iodine; I
nitrogen; N
oxygen; O
phosphorus; P
potassium; K
sulfur; S
tungsten; W
uranium; U

Element	Symbol
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

61 Give the symbol or element in the following:

Ca
manganese
Ni
Si
barium
Cr
lithium
selenium
Mg
bromine
Pt
Al
bismuth
He
osmium
strontium

Element	Symbol
Calcium	_____
_____	Mn
Nickel	_____
Silicon	_____
_____	Ba
Chromium	_____
_____	Li
_____	Se
Magnesium	_____
_____	Br
Platinum	_____
Aluminum	_____
_____	Bi
Helium	_____
_____	Os
_____	Sr

62 Anything that occupies space and has weight is defined as _____.

matter

63 The study of "nonliving" matter is called _____ chemistry.

inorganic

64 The study of carbon and its compounds is called _____ chemistry.

organic

clinical

65 When working in _____ chemistry one does examinations on body fluids such as blood.

biochemistry (physiological chemistry)

66 Chemical changes within a living system is called _____ _____.

atom

67 The smallest piece of an element is the _____.

103

68 There are _____ different kinds of atoms.

You may notice in some periodic charts that there are 105 elements given, 104 being Ku and 105 Ha. These two man-made elements have not been officially accepted. The element with an atomic number of 104 has been named Kurchatovium by the Russians and symbolized Ku. The Americans have called it Rutherfordium and symbolized it Ru. The element with the atomic number of 105 has been called Nielsbohrium by the Russians and Hahnium by the Americans. On your periodic chart of the elements it is symbolized Ha.

officially

69 Elements with atomic numbers of 104 and 105 have not been _____ accepted by the chemistry community.

Continue to study the elements and their symbols until you are sure you know them. The use of flash cards is very good for this. Remember, correct spelling is very important. When you are ready take the self test.

Self test

1 Which of the following is not a natural element? _____

a. Plutonium b. Sodium
c. Chlorine d. Phosphorus

a

its atomic number is greater than 92

2 How do you know that it is not a natural element? _____ _____

3 Which of the following is not a man-made element? _____

a. Sodium b. Nobelium
c. Neptunium d. Einsteinium

a

its atomic number is 11 (less than 93)

4 How do you know that it is not a man-made element? _____ _____

b

103 (105 is also correct)

5 The atomic number of calcium is: a. 40.08 b. 20 c. 80 d. 40

atom

6 How many different kinds of atoms are there? _____

elements

7 The smallest piece of an element is an _____.

1; 92
93; 105 (or 103)

8 All material things are made of some combination of the _____.

9 The atomic numbers of the natural elements vary from _____ to _____ and of the man-made elements vary from _____ to _____.

iron; iron
Fe

sodium; potassium

92

F; Au
Br; Ag
U; Li
W; Zn
Pb; Hg

calcium; sulfur
potassium; aluminum
phosphorus; tungsten
barium; magnesium
bismuth; manganese
sodium; chlorine
hydrogen; oxygen
nitrogen; tin

10 A substance has a name beginning with ferric. You know this substance contains the element _____, because _____ has the symbol _____.

11 Natrium is to _____ as kalium is to _____.

12 There are _____ natural elements.

13 Give the correct symbol for the following:

Fluorine	_____	Gold	_____
Bromine	_____	Silver	_____
Uranium	_____	Lithium	_____
Tungsten	_____	Zinc	_____
Lead	_____	Mercury	_____

14 Write the correct name (spelled correctly) for the following symbols:

Ca	_____	S	_____
K	_____	Al	_____
P	_____	W	_____
Ba	_____	Mg	_____
Bi	_____	Mn	_____
Na	_____	Cl	_____
H	_____	O	_____
N	_____	Sn	_____

GIVE YOURSELF:

1 point for every correct answer to questions 1 to 12
1 point for every correct answer in question 13
2 points for every correct answer in question 14 (1 point for the correct element and 1 point for the correct spelling)

TOTAL POINTS POSSIBLE: 60

YOUR POINT SCORE: _____ YOUR SCORE: _____ %

To obtain your grade in percent divide your score by 60. For example, your score is 50.

$$
\begin{array}{r}
.83 \\
60\overline{)50.00} \\
\underline{48} \\
20 \\
\underline{18} \\
20
\end{array}
$$

To change the decimal to percent move the decimal point two places to the right. This becomes 83%. Moving the decimal two places to the right is the same as multiplying by 100.

UNIT II

ATOMIC STRUCTURE

BEHAVIORAL OBJECTIVES

When you have completed the study of this unit you will be able to do the following either orally or in writing:

- Define the following:
  1. Subatomic particle
  2. Electron
  3. Proton
  4. Neutron
  5. Valence shell
  6. Isotope
  7. Nuclear chemistry
  8. Valence
- If given the name or symbol of an element, be able to use the periodic chart and tell how many protons, electrons, or neutrons it contains.
- Using the periodic chart, be able to give the atomic number and the atomic weight of any element.
- Be able to differentiate between groups and periods as used in the periodic chart and be able to tell what information is given by groups and periods.
- If given the name or symbol of an element, be able (using the periodic chart) to give the structure of the element.
- Be able to tell where the following are found in an element:
  1. Protons
  2. Neutrons
  3. Electrons
- Be able to differentiate between the following:
  1. Atomic weight and atomic number
  2. Reactive elements and inert elements
  3. Protons, electrons, and neutrons
- Be able to explain why every atom has no charge.
- Be able to tell what makes an element radioactive.
- Be able to tell where the following are located on the periodic chart:
  1. Noble gases
  2. Inert elements
  3. Alkali metals
  4. Alkaline earth metals
  5. Nonmetals
  6. Halogens
  7. Transition elements

Look at the periodic table of the elements (Fig. 1). Notice that the symbol of an element is given in each square.