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McGRAW-HILL
PUBLICATIONS IN PHARMACY

PHARMACEUTICAL MATHEMATICS

BY

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PREFACE TO THE SECOND EDITION

The general plan of the first edition has been followed in this one.

The chapters upon Manufacturing in Quantity and Percentage Solutions have been rewritten.

The chapter on profit and loss has been improved by a contribution made by Dr. L. H. Baldinger of the University of Notre Dame.

Many additional problems have been added throughout the book.

E. S.

WESTERN RESERVE UNIVERSITY,
February, 1938.

PREFACE TO THE FIRST EDITION

This book is intended as a textbook to be used in teaching the mathematics of pharmacy to pharmacy and nursing students. No explanatory statements, either historical or scientific, which are unnecessary in presenting methods of calculations will be found in its pages.

One printed and several mimeographed editions of this book have been used by the author in class work. The present edition is the result of many years' experience in teaching this subject, the author having had in view the one object of impressing upon the student's mind the necessity of thinking, rather than of memorizing a few specific problems in mathematics.

The plan of instruction has been to assign a chapter or part of a chapter and to give such explanation of it as is necessary. At the next class period, 10 minutes is consumed in working two problems on paper and the remainder of the period in blackboard exercises. A list of from five to ten problems on this same assignment is handed out to be solved and returned at the next class period. Monthly and final examinations in addition to the daily assignments give one a fair estimate of the student's ability to work the applied mathematics of pharmacy.

As extreme accuracy and ability to follow directions are two desirable qualities in pharmacists and nurses, the author has found it advisable to give directions for the manner of reporting problems. All problems are to be in ink on plain white paper, size $8\frac{1}{2}$ by

11 inches, and words are to be lettered (printed, not written). The paper is then to be folded upon its long axis and labeled in the following order:

Name..........................	F. P. Rose.
Course number..................	Pharmacy 106.
Date reported..................	2/13/30.
List number....................	1.

Problems have been appended to each chapter. Answers have been omitted because (1) this text is applied mathematics and contains no mathematics that a high-school graduate has not previously had, and (2) the pharmacist and nurse must know without verification if his or her answers are correct.

The author would suggest to teachers of the Drugs and Solutions course to nurses that they lay particular emphasis upon Chaps. I, II, III, IV, V, XI, XII, XIII, and XIV, stressing such problems as experience proves are of most importance to nurses. It is not necessary to attempt to make pharmacists of nurses, and such is not the intention of this text.

If time permits, the teacher of nurses may cover the subject of specific gravity or such parts of it as are deemed necessary, as found in Chaps. VI, VII, and VIII, and may find Chaps. XXII and XXIII helpful in reviewing two phases of chemical problems; but the remaining chapters, in the opinion of the author, are unnecessary for nurses. It would seem preferable to select a few topics and teach them thoroughly than to select a large number and teach them superficially.

Other texts have been freely consulted, especially Remington's "Practice of Pharmacy," Oldberg's "Pharmaceutical and Chemical Problems," Stevens'

"Arithmetic of Pharmacy," and Sturmer's "Pharmaceutical Arithmetic," and the author wishes to acknowledge anything of methods and ideas that may have been taken from them. He also wishes to acknowledge the many helpful suggestions that he has received from colleagues, associates, students, and friends.

E. S.

WESTERN RESERVE UNIVERSITY,
January, 1930.

CONTENTS

PAGE

Preface to the Second Edition vii

Preface to the First Edition ix

CHAPTER I

Tables and Prescription Forms—Apothecaries', Troy, and Avoirdupois 1

CHAPTER II

Tables and Prescription Forms—Metric Tables 8

CHAPTER III

Tables of Equivalents and Miscellaneous Tables . . . 12

CHAPTER IV

Percentage 20

CHAPTER V

Dosage 24

CHAPTER VI

Specific Gravity of Solids 29

CHAPTER VII

Specific Gravity of Liquids 36

CHAPTER VIII

Miscellaneous Problems in Specific Gravity 40

CHAPTER IX

Compounding and Dispensing 46

CHAPTER X

Manufacturing in Quantity 51

CHAPTER XI

Percentage Solutions 59

PAGE

CHAPTER XII

Solution by Parts 65

CHAPTER XIII

Saturated Solutions 69

CHAPTER XIV

Temperature 80

CHAPTER XV

On the Use of Tables 87

CHAPTER XVI

Proof Degrees 94

CHAPTER XVII

Dilution of Solids 96

CHAPTER XVIII

Dilution of Liquids 104

CHAPTER XIX

Dilution of Liquids (*Continued*) 111

CHAPTER XX

Dilution of Liquids (*Continued*) 116

CHAPTER XXI

Alligation 121

CHAPTER XXII

Percentage Composition of Chemicals 126

CHAPTER XXIII

Chemical-reaction Calculations 128

CHAPTER XXIV

Commercial Discounts 135

CHAPTER XXV

Profit and Loss 138

Index 147

PHARMACEUTICAL MATHEMATICS

CHAPTER I

TABLES AND PRESCRIPTION FORMS

APOTHECARIES', TROY, AVOIRDUPOIS

The physician, pharmacist, chemist, nurse, and laboratory technician should be familiar with all tables of weight and measure which they are using and should have handy reference to those which they may need occasionally.

All such tables and prescription forms will be found in the first three chapters with exercises in the form of problems upon some of them.

In order to facilitate the solving of problems found in this book, the student will find it advisable to take a short review of some of the simple processes of mathematics.

Problems should be worked showing the application of addition, subtraction, multiplication, and division to (1) common numbers, (2) fractions, common and decimal, (3) mixed numbers, and (4) algebraic calculations.

It may not be a waste of time to review the subject of proportion, which was known to older mathematicians as "the rule of three" but is now defined as "a statement of the equality of two ratios." The ratio of one number to another is the quotient obtained by dividing the one by the other; that is, the ratio of a to b is $\frac{a}{b}$; or, of 1 to 4 is $\frac{1}{4}$.

Proportions may be stated thus:

$$\frac{a}{b} = \frac{c}{d} \text{ or } a:b::c:d, \text{ or}$$

$$\frac{1}{4} = \frac{3}{12} \text{ or } 1:4::3:12$$

The terms "weighable denominations" and "measurable denominations" are used in this chapter and throughout the text. Wherever they appear and, indeed, whenever answers to problems are submitted, they should be in such denominations that they may be weighed upon a balance or scales with the usual weights or measured with the usual apparatus without further calculation.

TABLES

Apothecaries' Weight

20 grains (gr.)	=	1 scruple (℈)
3 scruples	=	1 drachm (ʒ)
8 drachms	=	1 ounce (℥)
12 ounces	=	1 pound

Observe that 480 grains = 1 ounce. Also, that 5,760 grains = 1 Apothecaries' pound. The grain is the same in all systems.

Troy Weight

24 grains	=	1 pennyweight (pwt.)
20 pennyweights	=	1 ounce
12 ounces	=	1 pound

The Troy system is used in weighing precious stones and metals. The ounce in the Troy and Apothecaries' systems is the same.

Avoirdupois Weight

$27\frac{11}{32}$	grains	= 1 dram (dr.)
16	drams	= 1 ounce (oz.)
16	ounces	= 1 pound (lb.)
100	pounds	= 1 hundredweight (cwt.)
20	hundredweights	= 1 ton (T.)

Observe that 7,000 grains = 1 pound Avoirdupois; also, that 437.5 grains = 1 ounce. The symbol # for pound is used occasionally in marking packages.

The Avoirdupois dram is obsolete and is seldom, if ever, used.

Apothecaries' Measure

60 minims (♏)	= 1 fluidrachm (f ʒ)
8 fluidrachms	= 1 fluidounce (f ℥)
16 fluidounces	= 1 pint (O.)
8 pints	= 1 gallon (C.)

The minim is sometimes considered as equivalent to a drop. This is not actually so, as the minim is a definite volume, and the drop varies with the liquid under consideration. Gutta, -ae, drop, is abbreviated gtt. The abbreviation O. for pint stands for the Latin word *octarius*. Sometimes *octavus* is given, meaning one-eighth, or the eighth part of a gallon. Similarly, C. stands for the Latin word *congius*, which means gallon. It is also abbreviated Cong.

U. S. Liquid Measure

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon

Imperial Measure

60 minims	= 1 fluidrachm
8 fluidrachms	= 1 fluidounce
20 fluidounces	= 1 pint
8 pints	= 1 gallon

The Imperial fluidounce of water weighs 437.5 grains, and, therefore, all denominations in this system differ from Apothecaries' and U. S. Measure.

PRESCRIPTION FORM

In writing prescriptions in the Apothecaries' system it is customary to follow the abbreviations or symbols with the amounts. The amounts are expressed with Roman numerals, except when fractions of grains are used.

Example

a. Ammonii Chloridi.................. gr. xx
b. Syrupi Picis Pini.................... fʒ vi
c. Atropinæ Sulfatis.................... gr. 1/120
d. Extracti Rhei........................ ʒ iiiss
e. Opii Pulverati....................... gr. ss
f. Glycerini............................ f℥ viii

Prescription (a)

℞

Potassii Iodidi.......................... ʒ iiss
Tincturæ Gentianæ Compositæ............ f℥ iss
Aquæ Destillatæ quantum sufficit ad....... f℥ iii
Misce ut fiat solutio.
Sig. One teaspoonful in water three (3) times daily after meals.

Prescription (b)

℞

Calcii Carbonatis........................ gr. v
Sodii Bicarbonatis....................... gr. v
Misce ut fiat capsula.
Mitte tales triginta.
Sig. One (1) capsule disintegrated in water three times daily (3 × d) after meals.

PRACTICE WITH SYMBOLS

Classroom or laboratory practice of the following type will be found to be an aid in developing familiarity with symbols and tables.

Solving of problems similar to the following, without the aid of pencil and paper, insofar as one is able to do so, is excellent practice.

Example (a)

Add	℥ i	ʒ iiss	℈ i	gr. x	=	gr. 660
	℥ ii	ʒ iv	℈ iiss	gr. xiv	=	gr. 1,264
				Sum	=	gr. 1,924

converted to highest denominations:

℥ iv ʒ 0 ℈ 0 gr. iv

Example (b)

Add	℥ ii	ʒ ii	℈ ii	gr. ii
	℥ ss	ʒ iss	℈ i	gr. xix
Sum =	℥ iiss	ʒ iiiss	℈ iii	gr. xxi

Converted to highest denominations:

℥ iii ʒ ss ℈ i gr. i

Example (c)

Subtract	℥ iiss	ʒ iii	℈ ii	gr. xix	=	gr. 1,439
	℥ i	ʒ v	℈ iv	gr. xxiv	=	gr. 884
				Difference	=	gr. 555

Converted to highest denominations:

℥ i ʒ i ℈ ss gr. v

Example (d)

Subtract	℥ iv	ʒ iiiss	℈ iiss	gr. xviii
	℥ i	ʒ iii	℈ iv	gr. xix
Difference =	℥ iiss	ʒ iiiss	℈ i	gr. ix

Example (e)

Multiply ℥ ii	ʒ iii	℈ i	gr. iss	=	gr.	1,161½
			× ix	=		× 9
			Product	=	gr.	10,453½

converted to highest denominations:

Apoth. lb. iss ℥ iiiss ʒ ii ℈ ss gr. iiiss

Example (f)

Multiply (*a*)	℥ ii	ʒ i	℈ iss	gr. ix
				× 3
Product =	℥ vi	ʒ iii	℈ ivss	gr. xxvii

converted to highest denominations:

	℥ viss	ʒ 0	℈ iiss	gr. vii
(*b*)	℥ i	ʒ ss	℈ i	gr. ix
				× 5
	℥ vss	ʒ ss	℈ i	gr. v

Example (g)

Divide $\dfrac{\text{℥ viii} \quad \text{ʒ iiss} \quad \text{℈ i} \quad \text{gr. x}}{3} = \dfrac{\text{gr. } 4{,}020}{3} = \text{gr. } 1{,}340$

converted to highest denominations:

℥ iiss ʒ ii ℈ i gr. 0

Problems

1. Add $\frac{1}{6}$, $\frac{2}{5}$, and $\frac{5}{9}$; add $\frac{1}{20}$, $\frac{5}{7}$, and $\frac{1}{64}$.
2. Subtract $\frac{2}{5}$ from $\frac{7}{9}$; subtract $\frac{1}{5}$ from $1\frac{2}{7}$.
3. Multiply $\frac{4}{9}$ by $\frac{3}{22}$; multiply $\frac{2}{3}$ by $\frac{1}{3}$.
4. Divide $\frac{3}{14}$ by $\frac{1}{5}$; divide $1\frac{2}{5}$ by $\frac{5}{9}$.
5. Write twenty-four grains; two scruples; one drachm; one-half ounce, Apothecaries'; one twenty-fifth grain; two and one-half drachms; one-half grain.
6. Write one fluidounce; two and one-half fluidrachms; fifteen minims; twenty drops; one pint; one-half gallon.

7. Convert one fluidrachm into minims; one-half fluidounce into fluidrachms; one pint into fluidrachms; one gallon into half-pints; one hundred minims into measurable denominations.

8. Convert two and one-half scruples into grains; two hundred grains into weighable denominations; one ounce, Apothecaries', into scruples; one-half scruple into grains; one-eighth ounce, Avoirdupois, into grains; one pound, Avoirdupois, into drachms.

9. Add ℥ ii, ℈ i, gr. ss to ℥ iss, ℈ iv, gr. iii and convert to highest denominations.

10. Add ℥ iss, ℈ iiss, gr. iss to ℥ ii, ℈ ii, gr. xi and convert to highest denominations.

11. Subtract ℥ i, ʒ ss, ℈ ii, gr. iv from ℥ vi, ʒ ii, ℈ i, gr. ii and convert to highest denominations.

12. Subtract ℥ i, ℈ ii, gr. xix, from ℥ iv, ʒ i, gr. vii and convert to highest denomination.

13. Multiply ℥ ii, ʒ iss, ℈ i, gr. xvii by 7 and convert to highest denominations.

14. Multiply f℥ iv, fʒ vii, ♏ xx by 9 and convert to highest denominations.

15. Divide ℥ vi, ʒ v, ℈ iiss, gr. xxi by 3 and convert to highest denominations.

16. Divide C. i, O. iss, f℥ vi, ♏ xx by 6 and convert to highest denominations.

17. Calculate the minims in an Imperial pint.

18. Calculate the minims in a U. S. pint.

19. Express the relationship between an Apothecaries' fluidounce and an Imperial fluidounce by means of a simple fraction; also by means of a decimal.

20. How does the size of an Imperial pint compare with a U. S. pint?

CHAPTER II

TABLES AND PRESCRIPTION FORMS

METRIC TABLES

Metric Linear Measure

10 millimeters (mm.)	= 1 centimeter (cm.)
10 centimeters	= 1 decimeter (dm.)
10 decimeters	= 1 Meter (M.)
10 Meters	= 1 Dekameter (Dm.)
10 Dekameters	= 1 Hectometer (Hm.)
10 Hectometers	= 1 Kilometer (Km.)
10 Kilometers	= 1 Myriameter (Mm.)

Observe that 1,000 millimeters = 1 meter. Fractions of meters are usually expressed as decimal fractions of the meter; and in writing 1 decimeter, 2 centimeters, and 5 millimeters, one would write 0.125 meter, which would be read nought, decimal, one, two, five meter. The kilometer (1,000 M.) is the only multiple of the meter in common use.

The square meter or Centare, the square dekameter or Are, and the square hectometer or Hectare are used in measuring areas. The cubic meter is called a Stere.

Metric Measure of Capacity

10 milliliters (ml.)	= 1 centiliter (cl.)
10 centiliters	= 1 deciliter (dl.)
10 deciliters	= 1 Liter (L.)
10 Liters	= 1 Dekaliter (Dl.)
10 Dekaliters	= 1 Hectoliter (Hl.)
10 Hectoliters	= 1 Kiloliter (Kl.)

The milliliter and the liter are the only measures in common use. The abbreviation for milliliter is ml.

and for liter L. One pharmacopœia used mil for milliliter. Scientists usually use cubic centimeter (cc.) in place of milliliter (ml). The cubic centimeter used in this text is intended to correspond to the one-thousandth part of a liter.

METRIC WEIGHT

10 milligrams (mg.)	= 1 centigram (cg.)
10 centigrams	= 1 decigram (dg.)
10 decigrams	= 1 Gram (Gm.)
10 Grams	= 1 Dekagram (Dg.)
10 Dekagrams	= 1 Hectogram (Hg.)
10 Hectograms	= 1 Kilogram (Kg.)
10 Kilograms	= 1 Myriagram (Mg.)

Multiples of the gram, with the exception of the kilogram, are seldom used. The milligram is the division of the gram that is most often used. The weights are recorded and read as decimal fractions of the gram, as illustrated under Linear Measure.

PRESCRIPTION FORM

In writing prescriptions in the Metric system, it was formerly customary to follow the abbreviations by the amounts just as in the Apothecaries', but custom has changed and now the amounts are written first. The amounts are always expressed in Arabic numerals.

Example

a. Ammonii Chloridi.............	2.0	Gm.
b. Syrupi Picis Pini..............	24.0	cc.
c. Atropinæ Sulfatis..............	0.0005	Gm.
d. Extracti Rhei..................	15.0	Gm.
e. Opii Pulverati.................	0.030	Gm.
f. Glycerini......................	240.0	cc.

Sometimes a metric prescription blank is printed substituting a perpendicular line for the decimal point. Solids are read in grams and liquids in cubic centimeters.

Example

	Gm. or cc.	
a. Ammonii Chloridi..................	2	
b. Syrupi Picis Pini..................	24	
c. Atropinæ Sulfatis..................		0005
d. Extracti Rhei......................	15	
e. Opii Pulverati.....................		030
f. Glycerini..........................	240	

Prescription (*a*)

℞

	Gm. or cc.	
Picis Juniperi..........................	6	
Hydrargyri Ammoniati....................	3	
Acidi Salicylici........................	1	2
Petrolati...............................		
Adipis Lanæ Hydrosi āā q.s. ad..........	60	

Misce ut fiat unguentum.
Sig. Apply locally.

Prescription (*b*)

℞

	Gm. or cc.	
Tincturæ Belladonnæ.....................	6	8
Fluidextracti Ergotæ....................	13	5
Sodii Bromidi...........................	20	
Aquæ Cinnamoni ad.......................	90	

Misce.
Sig. 10 cc. three times daily after meals. Shake well.

Problems

1. Write ten grams; four decigrams; one and one-half kilograms; two decigrams and one centigram; sixty centigrams; two-fifths milligram; two hundred and ten milligrams; five and one-half grams.

2. Read in as many ways as possible: 1.6725 Gm.; 0.002 Gm.; 0.205 Gm.

3. Write twenty liters; write three hundred and twenty cubic centimeters.

4. Convert seventy centigrams into milligrams; two and five-tenths grams into decigrams; forty milligrams into grams.

5. Write, using the decimal line, 20 Gm., 16 mg., 5 cg., 120 dg., 2 dg., 15 cc., and 480 cc.

6. Add 14 Gm., 3 dg., 7 cg., and 9 mg., to 11 Gm., 5 dg., 4 cg., and 7 mg., and express sum in grams.

7. Subtract 3 Gm., 2 dg., 5 cg., and 7 mg., from 5 Gm., 1 dg., and 9 mg., and express difference in grams.

8. Multiply 380 Gm. and 9 mg. by 9 and express product in grams.

9. Multiply 2 L. and 25 cc., by 7 and express product in cubic centimeters.

10. Divide 120 Gm., 1 dg., 2 cg., and 8 mg. by 4 and express quotient in grams.

CHAPTER III

TABLES OF EQUIVALENTS AND MISCELLANEOUS TABLES

EQUIVALENTS

1 meter = 39.37 inches.

1 micromillimeter (micron, μ) = the one-thousandth part of a millimeter = about $\frac{1}{25,000}$ inch.

1 inch = 25.4 millimeters.

1 fluidounce of water at 25°C. weighs 454.6 grains.

1 fluidounce of water at 15.6°C. weighs 455.7 grains.

1 fluidounce of water at 4°C. weighs 456.3 grains.

1 fluidounce = 29.57 cc.

The Imperial pint contains 20 fluidounces.

1 cubic inch of water weighs 252 grains at 25°C. ($2.54^3 \times 0.996039 \times 15.432 = 251.88$.)

1 gallon contains 231 cubic inches.

1 gallon of water at 25°C. weighs 8.31 Avoirdupois pounds.

1 gallon of water at 0°C. weighs 8.344 Avoirdupois pounds.

1 gallon = 3.785 liters. (29.57 cc. × 128 f℥ = 3,784.96 cc.)

1 pint = 473 cc.

1 liter = 2.11 pints or 33 fluidounces, 6½ fluidrachms.

1 cubic centimeter of water at 4°C. (maximum density) weighs 1 gram.

1 pound, Avoirdupois = 453.592 grams.

1 kilogram = 2.2 pounds, Avoirdupois.

1 ounce, Avoirdupois = 28.35 grams.

1 ounce, Apothecaries' = 31.1 grams.

1 gram = 15.432 grains.

1 grain = 64.8 milligrams.

1 minim = the one-sixtieth part of a fluidrachm, often erroneously called one drop.

1 minim of water at 4°C. = 0.95 grain.
4 inches = 1 hand.
6 feet = 1 fathom.
31 gallons = 1 barrel (often different sizes).
63 gallons = 1 hogshead.
2,240 pounds = 1 long ton (used in U. S. Custom House).
112 pounds = 1 long hundredweight (used in U. S. Custom House).
1 carat = 3.168 Troy grains = 4 carat grains. (Carat is used to express fineness of gold and means one twenty-fourth part. Gold that is 18 carats fine is $^{18}/_{24}$ gold.)

The equivalents in this table are accurate for all practical purposes, but in some instances they are calculated only to the nearest whole number and the student must learn that slight errors may be increased by continued multiplication or division, and when extreme accuracy is desirable he must return to the original source.[1]

Domestic or Approximate Measure

A tumblerful	= f℥ viii	= 240 cc.
A teacupful	= f℥ iv	= 120 cc.
A wineglassful	= f℥ ii	= 60 cc.
A tablespoonful	= fʒ iv	= 16 cc.
A dessertspoonful	= fʒ ii	= 8 cc.
A teaspoonful	= fʒ i	= 4 cc.

These measures are approximations only, and we now measure medicines in the home with the medicine glass.

PRESCRIPTION BOTTLES

Prescription bottles are usually graduated, though these graduations will not serve for extreme accuracy.

[1] For definitions of the fundamental units, Meter, Liter, and Kilogram, and the derivation of all weights and measures, see Bureau of Standards *Circular* 47.

Both Metric and Apothecaries' systems are used and below is a table of the common prescription bottles showing the number of cubic centimeters they will hold.

1 fluidrachm	(f ʒ i)	holds	4 cc.
2 fluidrachms	(f ʒ ii)	hold	8 cc.
4 fluidrachms	(f ʒ iv)	hold	16 cc.
1 fluidounce	(f ℥ i)	holds	30 cc.
2 fluidounces	(f ℥ ii)	hold	60 cc.
3 fluidounces	(f ℥ iii)	hold	90 cc.
4 fluidounces	(f ℥ iv)	hold	120 cc.
6 fluidounces	(f ℥ vi)	hold	180 cc.
8 fluidounces	(f ℥ viii)	hold	250 cc.
16 fluidounces	(f ℥ xvi)	hold	500 cc.
32 fluidounces	(f ℥ xxxii)	hold	1,000 cc.

Observe that, while the above table is correct, 1 fluidounce is not equivalent to 30 cubic centimeters, nor are any of the above quantities exact equivalents of one another. Laboratory and prescription practice will show that a liter bottle will always hold 2 pints but that the reverse is seldom, if ever, true.

MISCELLANEOUS TABLES

Stationer's Table

24 sheets	= 1 quire
20 quires	= 1 ream
2 reams	= 1 bundle
5 bundles	= 1 bale

Linear Measure

12 inches (in.; ″)	= 1 foot (ft.; ′)
3 feet	= 1 yard (yd.)
5½ yards 16½ feet	= 1 rod (rd.)
320 rods	= 1 mile
5,280 feet	= 1 statute mile
3 miles	= 1 league

Cubic Measure

1,728	cubic inches	=	1 cubic foot
27	cubic feet	=	1 cubic yard
24¾	cubic feet	=	1 perch

Dry Measure

2 pints	=	1 quart
8 quarts	=	1 peck
4 pecks	=	1 bushel

Board Measure

16 cubic feet	=	1 cord foot
8 cord feet 128 cubic feet	=	1 cord
1 cord of wood	=	8 by 4 by 4 feet

Square Measure

144	square inches	=	1 square foot
9	square feet	=	1 square yard
30¼	square yards	=	1 square rod
160	square rods	=	1 acre
640	acres	=	1 square mile

Mariner's Measure

6	feet	=	1 fathom
120	fathoms	=	1 cable length
7½	cable lengths	=	1 mile
6,085	feet	=	1 nautical or geographical mile

CONVERSIONS

In order quickly to convert the sizes of tablet medication from Apothecaries' to Metric system and *vice versa*, one must practice this conversion.

$$1 \text{ Gram} = 15.432 \text{ grains}$$

$$1 \text{ grain} = \frac{1}{15.432} = 0.0648 \text{ Gram}$$

With this starting point the multiplication and division come easily as is illustrated in Prob. 21 at the end of this chapter.

Practice also facilitates all conversions, and each class should be given a number of prescriptions for practice in conversions.

Convert to the Metric system:

(*a*)

℞
Phenolis.............................. gr. x
Ceræ Flavæ.......................... gr. xxiv
Petrolati q.s. ad...................... ℥ i
Misce ut fiat unguentum.

(*b*)

℞
Acidi Tannici.............................. gr. v
Olei Theobromatis q.s. ad................. ʒ ss
Misce ut fiat suppositorium.
Mitte tales duodecim.

(*c*)

℞
Ferri Sulfatis.......................... ℥ ss
Potassii Carbonatis.................... ʒ ii
Sucrosi................................. ℥ i
Tragacanthæ............................ gr. xv
Althææ................................. gr. xv
Glycerini
Aquæ Destillatæ āā quantum sufficiat
Misce ut fiat massa in
pilulas in numero centum dividenda.

(*d*)

℞
Phenobarbitali.......................... gr. x
Pulveris Aromaticæ..................... gr. v
Sucrosi q.s. ad......................... ʒ ss
Misce ut fiat pulvis.
Divide in chartulas in numero decem.

Convert to the Apothecaries' system:

(*a*)

℞	Gm. or cc.	
Calaminæ Præparatæ	7	2
Zinci Oxidi	7	2
Olei Olivæ	45	
Liquoris Calcii Hydroxidi ad	90	

Misce.
Sig. Apply locally. SHAKE.

(*b*)

℞	Gm. or cc.	
Acidi Salicylici	1	8
Alcohol	65	
Aquæ Destillatæ ad	90	

Misce ut fiat lotio.
Sig. Apply. . . .

(*c*)

℞	Gm. or cc.	
Calcii Oxidi	14	85
Sulfuris	22	50
Aquæ Destillatæ ad	90	

Misce.
Sig. Apply locally.

(*d*)

℞	Gm. or cc.	
Mentholis		3
Unguenti Aquæ Rosæ ad	60	

Misce.
Sig. Apply. . . .

Problems

1. Convert 1 gr. into grams; 1 Gm. into grains.
2. Convert 437.5 gr. into grams; 480 gr. into grams.

3. Convert 473.12 cc. into pints; 1 pt. into cubic centimeters.

4. Convert 1 mile into meters; convert 1 inch into centimeters.

5. Convert 1 L. into pints; 2.11 pt. into measurable denominations.

6. Convert $\frac{1}{25}$ in. into microns; convert 1 micron into millimeters.

7. Convert 1 lb., Avoirdupois, into grams; one scruple into centigrams.

8. One liter of water at 4°C. will weigh how many grams?

9. One pint of water at 25°C. will weigh how many grains?

10. A 5-pt. bottle will hold how many cubic centimeters?

11. A 20-L. demijohn will hold how many gallons?

12. A 250-lb. drum of Glycerin will weigh how many kilograms?

13. One liter of water will contain how many cubic centimeters?

14. An Avoirdupois pound of water at 25°C. will contain how many fluidounces?

15. A 300-lb. barrel of Petrolatum will fill how many tubes holding 25 Gm. each?

16. One milligram is what common fraction of a grain?

17. What will be the cubic-inch capacity of a 5-gal. can?

18. One hundred kilograms of White Wax will weigh how many Avoirdupois pounds?

19. Calculate the weight in pounds, Avoirdupois, of 1 gal. of water at 4°C.; at 15.6°C.; at 25°C.

20. Calculate the weight in grains of 1 minim of water at 4°C.; at 15.6°C.; at 25°C.

21. Complete the following tablet sizes:

Grains	Exact metric equivalent	Practical metric equivalent
1	0.0648	0.06
2	0.1296	0.13

3, 4, 5, $7\frac{1}{2}$, and 10 gr., and $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{6}$, $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{12}$, $\frac{1}{20}$, $\frac{1}{30}$, $\frac{1}{40}$, $\frac{1}{50}$, $\frac{1}{60}$, $\frac{1}{80}$, $\frac{1}{100}$, $\frac{1}{120}$, $\frac{1}{150}$, $\frac{1}{200}$, and $\frac{1}{300}$ gr.

22. A square plot of ground containing 1 acre will measure how many feet on each side? How many meters?

23. A work shelf 30 in. wide is 36 in. from the floor. What will be the dimensions of a tank holding 70 gal. of water that will fit under it, allowing 4 in. for castors and 2 in. for top clearance?

CHAPTER IV

PERCENTAGE

The term percentage is derived from the Latin words *per centum* which mean "by the hundred." It is another way of saying hundredths. Three per cent (3%) of anything would mean three hundredths of it. Percentage may likewise be stated to mean parts per 100. If a drug is said to be 90 per cent pure, then in every 100 parts of that drug 90 parts are pure substance.

In pharmaceutical operations, percentage by weight and percentage by volume are often required. In the first, parts by weight in 100 parts by weight is meant, and in the second, parts by volume in 100 parts by volume is meant. It is essential, particularly in the case of liquid preparations, that when asking for percentage one should state whether percentage by weight or percentage by volume is wanted.

Example (a)

What is 3 per cent of $1?

Divide $1 into 100 parts or into 100 cts. and take 3 of these parts or 3 cts.

Example (b)

What is 3 per cent of 12 lb.?

Divide 12 lb. into 100 parts and take 3 of them; thus, 12 lb. $\div$ 100 = 0.12 lb.; 0.12 lb. $\times$ 3 = 0.36 lb., or, 12 lb. $\times$ 0.03 = 0.36 lb.

$$100 \text{ per cent} = 12 \text{ lb.}$$

$$1 \text{ per cent} = \frac{12}{100} \text{ lb.}$$

$$3 \text{ per cent} = \frac{36}{100} \text{ lb.}$$

This result, 0.36 lb., may be reduced to ounces and grains so that it is weighable.

Example (c)

Converse: 0.36 lb. is 3 per cent of what number of pounds?

$$0.36 \div 3 = 0.12 \text{ lb., or 1 per cent.}$$
$$100 \text{ per cent} = 100 \times 0.12 \text{ lb.} = 12 \text{ lb.}$$

Example (d)

What percentage of 12 is 3?

$$12 = 100 \text{ per cent.}$$
$$1 = \frac{100}{12}.$$
$$3 = 3 \times \frac{100}{12} \text{ or 25 per cent.}$$

or

$$3 \div 12 = 0.25 \text{ or 25 per cent.}$$

It is necessary to observe that 0.25 and 25 per cent are identical but that the identical decimal for 0.25 per cent is 0.0025.

Problems

1. If 3.6 Gm. of a drug be incinerated and the ash remaining weighs 0.3600 Gm., what is the percentage of ash?

2. If U.S.P. Potassium Hydroxide is 85 per cent pure, how much pure potassium hydroxide (KOH) is there in 90 Gm. of U.S.P. Potassium Hydroxide?

3. If 500 Gm. of a dusting powder is to contain one-half of 1 per cent of phenol and U.S.P. Phenol is 98 per cent pure, how much U.S.P. Phenol must be used?

4. If U.S.P. Powdered Opium contains 10 per cent of morphine, how many grains of morphine are there in a ⅛-oz. package of the opium?

5. How many grains of a 10 per cent substance are needed to make 60 gr. of a 5 per cent substance?

6. One-fifth is what percentage of one-third?

7. If Paregoric contains 4 Gm. of 10 per cent opium (10 per cent morphine) in 1,000 cc., what would be its approximate percentage strength in terms of morphine?

8. If Compound Chalk Powder contains Prepared Chalk 30 Gm., Acacia 20 Gm., and Sugar 50 Gm., calculate its percentage composition.

9. How large a savings account drawing 4 per cent interest must one have in order to have an annual income of $3,000?

10. If one has deposited in savings $5,000 at 2 per cent interest, compounded semiannually, and draws all above the principal each year on January 1, how much does one draw?

11. How large a savings account must one have at 2 per cent interest compounded, semiannually, in order to draw $1,200 on January 1 of each year?

12. If one buys a $1,000 bond at "82" whose interest rate is 5 per cent, paid semiannually, how much does one receive in each payment and what is the real interest rate?

13. If one buys a $1,000 bond at "105" whose interest rate is 5.5 per cent, what would the annual income be? What is the real interest rate?

14. If one purchases 1 lb. of KOH labeled "85 per cent total alkali of which 3.5 per cent is K_2CO_3," how much pure KOH is in the pound? How much K_2CO_3? How much total alkali?

15. A sample of 10.5246 Gm., of vegetable drug was dried (see U.S.P. XI, p. 473, X). The dried drug weighed 10.2088 Gm., the first time, and after one hour of further drying it weighed 10.2085 Gm. Was this final drying sufficient? Was the drying carried to "constant weight" (see U.S.P. XI, p. 3)? What percentage of moisture was present in the original sample?

16. "When Activated Charcoal is dried to constant weight at 120°C., the loss does not exceed 15 per cent." How many milligrams may a sample of 5.3341 Gm. lose in weight when so dried?

17. A sample of vegetable drug was dried (see U.S.P. XI, p. 473, X). The sample before drying weighed 6.2230 Gm. After 5 hours of drying it weighed 6.0986 Gm. After another drying of 1 hour it weighed 6.0376 Gm. After still another hour of drying it weighed 6.0237 Gm. Was it dried to "constant weight?" What percentage of weight did it lose upon each drying?

18. If upon drying a drug should not lose "more than 0.25 per cent" to be dried to "constant weight," how many milligrams may a sample of 4.9334 Gm. lose if it came within this limit before heating?

19. If a chemical contains 4.3 per cent of moisture, and no amount is specified in the monograph, how many milligrams will a sample of 4.2618 Gm., lose? Does this conform to U.S.P. XI, page 3?

20. A sample of a chemical weighs 5.2663 Gm. Upon drying to "constant weight" it loses 0.0005 Gm. What percentage is this loss? What does U.S.P. XI, page 3, call this amount?

CHAPTER V

DOSAGE

It is necessary for a druggist and a nurse to be able to calculate the amount of medicine to be administered at a given time, and especially is it often necessary to be able to calculate the dose for a child when the average adult dose is given. In the U.S.P. the average adult dose of official medicines is given, and the pharmacist and nurse should be able to calculate the dosage for children.

There are two rules for calculating approximate dosage—Dr. Young's and Dr. Crowling's, the former being the more popular.

Dr. Young's Rule.

Divide the age of the child, *stated in years*, by that age plus 12, and take that fraction of the average adult dose.

Example (*a*)

If the dose of Bismuth Subnitrate is given as gr. xv, what will it be for a child five years old?

$$\frac{5}{5 + 12} = \frac{5}{17}. \qquad \frac{5}{17} \text{ of } 15 \text{ gr.} = 4.4 \text{ gr.}$$

If the child is less than one year old, it will be observed that if one takes the fraction, $\frac{\text{months}}{150} \times$ average adult dose, it will approximate the same result as applying the above rule.

Dr. Cowling's Rule.

Add 1 to the age of the child, *stated in years*, and divide that sum by 24; multiply the average adult dose by the quotient thus found.

Example (b)

If the dose of Bismuth Subnitrate is gr. xv, what will it be for a child three years old?

$$\frac{3+1}{24} = \frac{1}{6}. \quad \frac{1}{6} \times 15 \text{ gr.} = 2\tfrac{1}{2} \text{ gr.}$$

These rules, of course, do not apply to narcotics, tonics, and mild cathartics and are, at best, only approximations. In the case of powerful narcotics, reduce the dose, as found by the above rules, one-half before administering. The hypodermic dose is usually one-half of, and the rectal dose one-fourth more than, the dose *per os*.

It sometimes becomes necessary for the nurse on the ward and even the pharmacist to prepare doses from tablets of a size other than that to be given or to prepare doses from stock solutions of given strengths.

It may be well to note that hypodermic tablets are always soluble in water, and, of course, many other tablets are, also. When a dose is to be given in water, the dilution may be made with water. If it is given in powder form, milk sugar is usually used as the diluent.

Care should be used to prepare enough of any dilution for dosage so that one will not be forced to weigh or measure any minute quantities. The larger the amount weighed or measured, within reason, the smaller is the error involved in manipulation. Waste of material used is usually to be preferred to loss in accuracy.

The nurse must remember that tablets are labeled as to strength and not by gross weight. A tablet containing only 1/60 grain of Strychnine Sulfate may weigh 1 or 2 grains.

Example (c)

How would you prepare a 1/4-gr. dose from 1/10-gr. tablets?

1. Dose is to be given in powder form. Ten tablets 1/10 gr. in strength furnish 1 gr. of the medicine. Powder 10 tablets and take one-fourth the quantity for the desired dose.

2. Dose is to be given in 2 cc. of liquid. Dissolve 10 1/10-gr. tablets in 8 cc. of liquid and take 2 cc. of the solution for the desired dose.

Example (d)

Prepare a 1-cc. dose containing 1/120 gr. from 1/40-gr. tablets.

40 tablets furnish gr. i of the medicine. Dissolve 40 tablets in water to make 120 cc. and take 1 cc. as the dose; or
20 tablets in 60 cc. and take 1 cc., or
10 tablets in 30 cc. and take 1 cc., or
5 tablets in 15 cc. and take 1 cc.

Example (e)

A solution is labeled "♏ x contain gr. 1/8." How should a 2-cc. dose of gr. 1/30 be prepared?

♏ lxxx furnish gr. i of the medicine. Assuming 1 cc. = ♏ xvi, dilute ♏ lxxx or 5 cc. of the stock solution to 60 cc. and take 2 cc.

The above problems will make this type of procedure easy and safe, especially for one who does not habitually work with fractions. A tablet should never be divided.

Problems

1. If the average adult dose of a medicine is gr. x, what will be the dose for a child three years old, by Young's rule?

2. What will be the dose of the same medicine, by Cowling's rule?

3. If the average adult dose of Strychnine Sulfate is gr. $\frac{1}{40}$, what will it be for a child eight years old, by Young's rule?

4. If the average adult dose of a medicine is gr. $\frac{1}{4}$, what will it be for a child ten months old, by Young's rule?

5. If the average adult dose of Paregoric is ♏ lx, what will it be for a child four years old, by Young's rule?

6. A 4-fluidounce mixture taken in teaspoonful doses three times daily will last how long?

7. If the dose of Morphine Sulfate is 0.008 Gm., how many grains would this be? How many doses in 1 Gm.? How many in a $\frac{1}{8}$-oz. vial?

8. If the dose of Strychnine Sulfate is 0.0015 Gm., or gr. $\frac{1}{40}$, how many grams are needed to last 7 days if given four times daily? How many grains? If each dose is to be dissolved in 1 fluidrachm of water, how many fluidrachms should be used? What size bottle would you use?

9. If the dose of Atropine Sulfate is gr. $\frac{1}{120}$ (0.0005 Gm.), how much should be used to make 30 cc. of solution, each cubic centimeter containing one dose?

10. If there are 4 Gm. of Powdered Opium in 1,000 cc. of Paregoric, how many grains are there in the average dose of 4 cc.? How many grains in 1 fluidounce?

11. How many 5-gr. Barbital powders may be made from a 1-oz. package?

12. If a douche is to contain 1 fluidrachm of a solution to the pint, how many teaspoonfuls would this be?

13. If a 20-minim dose of a solution contains gr. $\frac{1}{30}$ of Strychnine Sulfate, how many doses in 1 fluidounce? How many grains? How many milligrams?

14. If Mercurial Ointment is 50 per cent Mercury and 1 Gm. is rubbed in as a dose, how many grains of Mercury does the patient get? Why should the nurse use rubber gloves?

15. Dissolve a 1-gr. tablet in sufficient water so that 2 cc. will contain gr. $\frac{1}{10}$.

16. How many $\frac{1}{40}$-gr. Strychnine Sulfate tablets should be dissolved and in how much water, so that 1 teaspoonful (f ʒ i) will contain gr. $\frac{1}{30}$?

17. How many $\frac{1}{10}$-gr. tablets should be used to make four doses each containing gr. $\frac{1}{20}$; each containing gr. $\frac{1}{30}$; each containing gr. $\frac{1}{60}$?

18. How many $\frac{1}{60}$-gr. tablets would you use and how much water, so that 2 cc. would contain gr. $\frac{1}{150}$ of Strychnine Sulfate?

19. How would you prepare a $\frac{1}{12}$-gr. dose from a $\frac{1}{10}$-gr. tablet?

20. A solution is labeled "♏ x contain gr. $\frac{1}{8}$." How should you give gr. $\frac{1}{40}$? How give gr. $\frac{1}{50}$? gr. $\frac{1}{60}$? gr. $\frac{1}{120}$?

21. A solution is labeled "f℥ i contains gr. i." How should you give gr. $\frac{1}{40}$?

22. Seidlitz Powder is made up of Sodium Bicarbonate 30 Gm., Rochelle Salts 90 Gm., and Tartaric Acid 26 Gm. This amount makes 12 pairs of powders, a dose being 1 pair. If you had the Sodium Bicarbonate and Rochelle Salts properly mixed in one bottle and the Tartaric Acid in another, how many grains of each would you use for one dose?

23. What size bottle should be used for two 1-tablespoonful doses of Castor Oil?

24. A $7\frac{1}{2}$-gr. tablet dissolved in a pint of water will contain how much in 30 minims?

25. How do you prepare a dose of $\frac{1}{10}$-gr. Calomel from a $\frac{1}{4}$-gr. tablet?

26. Express tablets labeled gr. $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{50}$, $\frac{1}{60}$, $\frac{1}{10}$, $\frac{1}{2}$, and $\frac{1}{30}$, respectively, in the Metric system, using the nearest simple decimal.

27. Calculate the dose of each ingredient in the following prescription, expressing results in both grams and grains:

℞

Calomel	0.065 Gm.
Salol	1.000 Gm.
Sulfonethylmethane	1.200 Gm.

Misce ut fiant Caps. No. XII.
Sig. One (1) capsule every two (2) hours.

28. Sixty grams of Calomel are used to make 1,000 Compound Cathartic Pills. How many grains are in the average dose of two pills?

CHAPTER VI

SPECIFIC GRAVITY OF SOLIDS

This subject is one of utmost importance to the pharmacist as well as to the physician and nurse. As an explanation of the subject is usually given in a course in practical pharmacy that either accompanies or precedes this course, it will not be necessary to enter into a general discussion of the subject in this book. Those who feel the need of a review on the general principles of the subject can refer to any good text on practical pharmacy or to any text on physics. The term "density," the weight of any unit volume of a substance, which becomes identical with its specific gravity when the Metric system only is employed, is purposely omitted from this text.

It will be necessary to take up the calculations involved in finding specific gravity of solids and liquids only, as the specific gravity of gases is not of so much importance to the pharmacist and nurse and is usually covered in courses in chemistry which are pursued in conjunction with this work.

The general rule for finding the specific gravity of solids is: Divide the weight of the body, weighed in air, by the weight of an equal bulk of water (loss of weight in water, or weight of water displaced by body on immersion). For the purpose of determining their specific gravities, solids may be classified into four classes, as follows:

1. Solids that are heavier than, but insoluble in, water.
2. Solids that are lighter than, but insoluble in, water.
3. Solids that are heavier than, but soluble in, water.
4. Solids that are lighter than, but soluble in, water.

1. Solids Heavier than, but Insoluble in, Water.

The specific gravity of a solid of this type may be taken in several different ways, depending largely upon the physical character of the solid:

a. By displacement or immersion.
b. By means of the pycnometer.
c. By means of a graduated specific-gravity tube.
d. By immersion in a liquid of the same density as the solid.
e. By means of the Jolly balance (modification of *a*).

Example (a)

Displacement Method.—The weight of a substance in air is 2.9 Gm., and immersed in water its weight is 1.7 Gm. Find its specific gravity.

2.9 Gm. − 1.7 Gm. = 1.2 Gm., loss of weight in water or weight of an equal bulk of water.

2.9 Gm. ÷ 1.2 Gm. = 2.41, specific gravity of the solid.

The above weighings may be made in any other system than the Metric, with the same results in specific gravity.

Example (b)

Pycnometer Method.—A pycnometer weighing 12 Gm. holds 50 Gm. of water. If 10 Gm. of lead chips be introduced into it and it be again filled with water and the combined weights of the pycnometer, lead, and water weigh 71.13 Gm., find the specific gravity of the lead.

Pycnometer weight....................	12 Gm.
Weight of water pycnometer will hold....	50 Gm.
Weight of sample of lead...............	10 Gm.
Total................................	72 Gm.

72 Gm. − 71.13 Gm. = 0.87 Gm., weight of water displaced.

10 Gm. ÷ 0.87 Gm. = 11.49, specific gravity of the lead.

It is not necessary in case of solids to determine the weight of the empty pycnometer.

Example (c)

Graduated-tube Method.—This is a tube graduated to hold a certain number of cubic centimeters of water. Say the tube holds 100 cc. and is graduated to tenths of a cubic centimeter. In the tube used expressly for this purpose the zero reading is usually elevated somewhat from the bottom of the tube, and the tube is filled with water to the zero reading before proceeding. Suppose a body weighs 5 Gm. in air; dropped into the graduated tube it displaces 4 cc. of water, as noted by the rise of the water in the tube. Now, 4 cc. of water at 4°C. weigh 4 Gm. To find the specific gravity of the body, divide the weight in air (5 Gm.) by the weight of the water displaced (4 Gm.), and the quotient (1.25) is the specific gravity sought.

Example (d)

Immersion in a Liquid of the Same Density as the Solid Method.—This method is not often used. It consists in immersing the body in a liquid in which it will float and adding water to the heavy liquid until the body neither sinks nor floats, which shows them to be of the same specific gravity, then taking the specific gravity of the liquid.

Example (e)

Jolly-balance Method.—This method is practically the same as (*a*), the displacement method. The Jolly balance is a spiral spring, firmly attached at the upper end, hanging in a vertical position. The lower end has a fixed point or pointer attached to it, that will move across a scale, also in a vertical position, and indicates divisions of stretch on the scale when an object is attached to the lower end of the spring. Suppose a small object attached to the lower end should cause the pointer to move down five divisions on the scale. With a beaker of water set under the object it moves down into the water only three divisions. Find the specific gravity.

$$5 - 3 = 2 \text{ divisions, loss of weight in water.}$$
$$5 \div 2 = 2.5, \text{ specific gravity of the body.}$$

In case one wished to carry out this experiment with actual weights, one could calibrate the balance by getting the number of divisions on the scale equal to 1 Gm. (or other weight), and then calculate from the value of one division the actual grams (or other weights) that the body weighs in air and in water, and proceed as before to find the specific gravity.

2. Solids Lighter than, but Insoluble in, Water.

Example (a)

Find the specific gravity of a piece of wood which weighs in air 177.4 gr. A piece of brass is used for a sinker. The weight of the brass in water is 68.4 gr. When the brass is attached to the wood and the two are weighed together in water, they are found to weigh 35.5 gr. Now, 68.4 gr. minus 35.5 gr. equals 32.9 gr., the weight required to immerse the wood. This weight (32.9 gr.) must be added to the weight of the wood in air to get the weight of an equal volume of water, or to make the wood weigh the same as an equal volume of water. Then, dividing 177.4 gr. by 210.3 gr., we find the specific gravity of the wood to be 0.843. This is dividing the weight of the wood in air by the weight of an equal volume of water.

Or,

177.4 gr., weight of the wood in air.
245.8 gr., weight of wood and brass, brass only submerged.
35.5 gr., weight of wood and brass, both submerged.

210.3 gr., loss of weight of wood upon immersion, or the weight of a volume of water equal in volume to the wood.

$$\frac{177.4 \text{ gr.}}{210.3 \text{ gr.}} = 0.843, \text{ specific gravity of the wood.}$$

3. Solids Heavier than, but Soluble in, Water.

Example (*a*)

A crystal weighs 4.5 Gm. in air and 2.22 Gm. when suspended in alcohol, specific gravity 0.816. Find the specific gravity of the crystal.

The following proportion serves as an easy means of solving the above problem:

$$\frac{\text{Specific gravity of water}}{\text{Specific gravity of alcohol}} = \frac{\text{loss of weight in water } (x)}{\text{loss of weight in alcohol}}.$$

$$\frac{\text{Weight of crystal in air}}{\text{Loss of weight in water}} = \text{specific gravity of crystal.}$$

Substituting values,

$$\frac{1}{0.816} = \frac{x}{2.28}.$$

$$x = 2.79 \text{ Gm., loss of weight in water.}$$

$$\frac{4.5}{2.79} = 1.61, \text{ specific gravity of the crystal.}$$

4. Solids Lighter than, but Soluble in, Water.

This is a combination of the last two named methods. The proper way to proceed is to weigh the substance in air, then weigh it in a liquid having a greater specific gravity than that of the substance and less than that of water. Calculate the loss of weight in the liquid and use the following proportion:

Specific gravity of water: specific gravity of light liquid:: loss of weight in water: loss of weight in light liquid. Then divide the loss of weight in water into the weight in air.

This last-named method is one not often met with, nor is it of much practical value, so we omit an example of this type.

Problems

1. If a piece of iron weighs 9.25 Gm. in air and 8 Gm. immersed in water, find its specific gravity.

2. If a body upon immersion in water loses 15 per cent of its weight, what is its specific gravity?

3. If a light insoluble body weighs 12 Gm. in air, and a sinker weighing 4.5 Gm. in water is used to submerge it and the combined weights of the body and sinker with both submerged are 2.3 Gm., what is the specific gravity of the body?

4. Find the specific gravity of a light insoluble body which weighs 6 Gm. in air. If a sinker be attached to the body and the two are weighed with the sinker only submerged, the weight is found to be 8.25 Gm. If the two be next weighed, both submerged in water, the weight is found to be 1.15 Gm.

5. If a body soluble in water but insoluble in alcohol weighs 5 Gm. in air and 3.36 Gm. in alcohol of the specific gravity of 0.8160, what is the specific gravity of the body?

6. If a glass pycnometer or specific-gravity bottle weighs 12 Gm. and will hold 25 Gm. of water and if when containing 14 Gm. of granulated zinc and filled with water the total combined weight is 49 Gm., what is the specific gravity of the zinc?

7. If a body soluble in water and weighing 5 Gm. has a specific gravity of 1.57 compared with alcohol of the specific gravity of 0.816, what would be its true specific gravity?

8. If a piece of metal has a specific gravity of 7, how much should 5 Gm. of it weigh when suspended in water?

9. A body loses 27 per cent of its weight upon immersion in glycerin of the specific gravity of 1.25. Find its specific gravity.

10. A body having a specific gravity of 3, weighing 12 Gm. in air and 8.736 Gm. in alcohol having a specific gravity of 0.816, should weigh how much suspended in water?

11. A body having an apparent specific gravity of 3.56 taken in chloroform of specific gravity 1.47 will have what true specific gravity?

12. The combined weights of a pycnometer containing 50 Gm. of water, and 5 Gm. of a body of specific gravity 0.714, are 67 Gm. The pycnometer containing the body and then filled with water weighs 60 Gm. Find the weight of the empty pycnometer.

13. A body weighing 4 Gm. in air and having a specific gravity of 3 should weigh what suspended in water?

14. An empty pycnometer weighs 15 Gm., and when filled with water 65 Gm. If 5 Gm. of a powder of specific gravity 1.25 be placed in the pycnometer and it then be filled with water, what will be its weight?

15. A body weighs 7 Gm. in air and 6.3 Gm. suspended in alcohol of specific gravity 0.816. What should be the loss of weight of the body when suspended in water?

CHAPTER VII

SPECIFIC GRAVITY OF LIQUIDS

The specific gravity of a liquid may be found in several ways:

1. By means of the pycnometer.
2. By means of the Sprengel tube.
3. By the sinker method (plummet).
4. By means of the hydrometer.
5. By means of Lovi's beads.
6. By means of the specific-gravity balance.

1. Pycnometer Method.

Divide the weight of liquid the pycnometer will hold by the weight of water the pycnometer will hold, both being under the same conditions of temperature and pressure.

Example (a)

A pycnometer weighs 8 Gm. Filled with water at the proper temperature and pressure, it weighs 18 Gm. Filled with alcohol under the same conditions, it weighs 16 Gm. Find the specific gravity of the alcohol.

18 Gm. − 8 Gm. = 10 Gm. of water in the pycnometer.
16 Gm. − 8 Gm. = 8 Gm. of alcohol in the pycnometer.
8 Gm. ÷ 10 Gm. = 0.8, the specific gravity of the alcohol.

This problem can be carried out with any system of weights and is not confined to the Metric system.

Caution.—Always subtract the weight of the pycnometer from the weighings, when finding specific gravity of liquids, before making final division. To illustrate this fact, suppose 16 Gm. are divided by 18 Gm. This would give 0.8888 as the specific gravity of the alcohol, instead of 0.8000. The specific gravity of the glass in the pycnometer would be included in this calculation.

2. Sprengel-tube Method.

This is a variation of the pycnometer method, and the weighings and calculations are made in the same manner.

3. Sinker Method.

Take the weight of the sinker in air. Immerse the sinker in water and take its weight there. Immerse the sinker in the unknown liquid and take its weight there. From these data calculate the loss of weight in water and the loss of weight in the unknown liquid. These weights, as has been proved before, are equal to the weights of equal volumes of water and the unknown liquid, respectively. The specific gravity of the unknown liquid is, then, the loss in weight in the unknown liquid divided by the loss in weight in water, which is equivalent to dividing the weight of a volume of the unknown liquid by the weight of an equal volume of water. The same result can be accomplished by the following proportion:

Specific gravity of water: specific gravity of unknown liquid::loss of weight in water:loss of weight in unknown liquid.

Example (*a*)

A body weighs 200 Gm. in air. In water it weighs 125 Gm. In an unknown liquid it weighs 105 Gm. Find the specific gravity of the liquid.

200 Gm. − 125 Gm. = 75 Gm., loss of weight in water.

200 Gm. − 105 Gm. = 95 Gm., loss of weight in the liquid.

95 Gm. ÷ 75 Gm. = 1.26+, specific gravity of the unknown liquid.

Or, the method by proportion:

$$1:x::75:95,$$

$75x = 95,$

$x = 1.26+$, specific gravity of the unknown liquid.

4. Hydrometer Method.

If taken by the direct-reading specific-gravity hydrometer, there is no calculation to be made unless it would be a calculation for temperature, and this is taken up later. If taken by means of a Baumé hydrometer, then it might be desirable, in some cases, to convert the Baumé reading into specific gravity. The factors now in use for making the above conversion are the following:

a. To convert degrees Baumé into specific gravity, for liquids heavier than water:

$$\frac{145}{145 - {}^\circ\text{Bé.}} = \text{specific gravity.}$$

b. To convert specific gravity into degrees Baumé, for liquids heavier than water:

$$145 - \frac{145}{\text{sp. gr.}} = \text{degrees Baumé.}$$

c. To convert degrees Baumé into specific gravity, for liquids lighter than water:

$$\frac{140}{130 + {}^\circ\text{Bé.}} = \text{specific gravity.}$$

d. To convert specific gravity into degrees Baumé, for liquids lighter than water:

$$\frac{140}{\text{sp. gr.}} - 130 = \text{degrees Baumé.}$$

It would be well to commit to memory factors *a* and *c* only.

5. Lovi's-beads Method.

Lovi's beads are little pear-shaped bodies, each one reading a certain specific gravity and used principally in liquids when it is wished to concentrate to a certain density. Each bead is marked with one specific gravity, a considerable number are placed in the liquid, and when the liquid is at the density corresponding to any one of the beads, this bead may be placed at any spot in the liquid and it will remain there, showing that the liquid is the same specific gravity as is the bead. The beads are, in fact, hydrometers that read only one specific gravity. As the specific gravity is read direct, there is no calculation to obtain it.

6. The specific-gravity balance (Mohr balance) is an instrument reading specific gravity direct and involves no calculations.

Problems

1. A pycnometer weighing 12 Gm. when empty weighs 37 Gm. when filled with water at 25°C. and weighs 43 Gm. when filled with glycerin at 25°C. Find the specific gravity of the glycerin.

2. A glass plummet weighs 10 Gm. in air, 7.52 Gm. in water, and 8.16 Gm. in an unknown liquid. Find the specific gravity of the unknown liquid.

3. If 10 per cent Ammonia Water has a specific gravity of 0.958 at 25°C., what should be its reading on a Baumé hydrometer for liquids lighter than water?

4. If Syrup has a specific gravity of 1.313, what should be the reading on a Baumé hydrometer for liquids heavier than water?

5. If Nitric Acid has a reading of 42°Bé. on the scale for liquids heavier than water, what should be its specific gravity?

6. Which would be the lighter and, hence, the better grade of gasoline, 56 or 80°Bé.? Find the specific gravity of each.

CHAPTER VIII

MISCELLANEOUS PROBLEMS IN SPECIFIC GRAVITY

After covering the subject of specific gravity under the various headings, it is well to work some miscellaneous problems that involve a combination of all the methods. If these problems be solved successfully, it is fair to assume that an understanding of the subject has been obtained.

As has been stated before, 1 cubic centimeter of water at 4°C. weighs 1 gram. For most practical purposes, this same value is used for all temperatures. In analytical work, where not the slightest error can be introduced, one must always consider the true weight of 1 cubic centimeter of water at the temperature at which the operation is carried out. In such calculations all weighings should be carried on at the same temperature and pressure. A table showing the weight of 1 liter of water at different temperatures may be found in the *Journal of Analytical and Applied Chemistry*, Vol. VI, p. 326. The U.S.P. contains a table which gives the weight of 100 cubic centimeters of distilled water at different temperatures.

If 1 cubic centimeter of water is taken to weigh 1 gram at all temperatures, calculation of specific gravity in the Metric system becomes very simple.

Example (a)

Find the specific gravity of Syrupus, when 1 cc. weighs 1.313 Gm.

If 1 cc. of water weighs 1 Gm. and 1 cc. of Syrupus weighs 1.313 times as much, the specific gravity of Syrupus is 1.313, because specific gravity is the comparison of the weights of equal volumes of substances, taking water as a standard.

When it comes to the calculation of specific gravity, using the Troy, Apothecaries', or Avoirdupois system of weights and measures, more calculation is involved, and one must secure the exact relation between the weights of equal volumes.

Example (*b*)

It is desired to know the weight of 1 fluidounce of sulfuric acid of the specific gravity of 1.84.

It is known by the definition of specific gravity that the acid weighs 1.84 times as much as an equal volume of water. One fluidounce of water weighs 454.6 gr.; therefore the acid will weigh 1.84 times as much.

454.6 gr. $\times$ 1.84 = 836.464 gr., weight of 1 fluidounce of the acid. The only error involved, and this is negligible for practical purposes, is the fact that the temperature of the water was at 25°C. and that of the acid may have been at some other temperature. It is easy to have them both at the same temperature if so desired.

If one should have the weight of 1 fluidounce of any liquid given, to find its specific gravity, divide the weight of the 1 fluidounce by the weight of 1 fluidounce of water at the same temperature; if at 25°C., the U.S.P. temperature, then by 454.6 gr.

Example (*c*)

A piece of metal weighing 24 Gm. has a specific gravity of 8 and loses 2.448 Gm. when immersed in a liquid. Find the specific gravity of the liquid.

24 Gm. $\div$ 8 Gm. = 3 Gm., loss of weight of the metal upon immersion in water (weight of an equal volume of water).

2.448 Gm. ÷ 3 Gm. = 0.816, specific gravity of the unknown liquid.

This is dividing the weight of a volume of the unknown liquid by the weight of an equal volume of water.

Example (d)

A piece of iron weighs 6.75 lb. and is 12 in. long, 2 in. wide, and 1 in. thick. Find its specific gravity.

12 × 2 × 1 = 24 cu. in., volume of the iron.

24 cu. in. × 252 gr. (weight of 1 cu. in. of water) = 6,048 gr., weight of an equal volume of water.

6.75 lb. × 7,000 = 47,250 gr., weight of the iron.

47,250 gr. ÷ 6,048 gr. = 7.8, specific gravity of the iron.

Example (e)

If iron has a specific gravity of 7.8 and a bar of it weighs 3,000 Gm. and is 4 cm. wide and 1 cm. thick, what is its length?

3,000 Gm. ÷ 7.8 = 384.6 Gm., weight of an equal volume of water.

Assuming 1 cc. of water to weigh 1 Gm., then 384.6 Gm. = 384.6 cc., volume the bar occupies.

4 cm. × 1 cm. = 4 sq. cm.

384.6 cc. ÷ 4 sq. cm. = 96.15 cm., length of the bar.

Example (f)

A bar of iron, specific gravity 7.8, and 100 cm. long, 5 cm. wide, and 2 cm. thick, will weigh how many grams?

100 cm. × 5 cm. × 2 cm. = 1,000 cc., volume of the bar.

1,000 cc. × 7.8 = 7,800 Gm., weight of the bar.

Example (g)

A bar of iron upon immersion in water loses 13 per cent of its weight. Find its specific gravity.

Assume any weight for the weight of the bar of iron, as the size or weight of the sample taken will not influence the specific gravity. For convenience, assume the bar of iron to weigh 100 Gm. If it loses 13 per cent of weight upon immersion in water, it loses 13 Gm. Then 100 Gm., its weight in air, divided by 13 Gm., its loss of weight in water, gives 7.69, its specific gravity.

Or, let x = the weight of the bar of iron. Then $0.13x$ = the loss of weight in water.

$$\frac{x \text{ (weight in air)}}{0.13x \text{ (loss of weight in water)}} = 7.69, \text{ specific gravity.}$$

Example (h)

A piece of iron weighs 24 Gm. in water and 24.644 Gm. in Alcohol of specific gravity 0.816. Find the specific gravity of the iron.

Let

x = the weight in grams of the iron.

Then

$x - 24$ Gm. = the loss of weight in water (weight of an equal volume of water).

and

$x - 24.644$ Gm. = the loss of weight in Alcohol (weight of an equal volume of Alcohol).

$$\frac{x - 24.644}{x - 24} = 0.816.$$

Solving,

$x = 27.5$ Gm., weight of the iron.

27.5 Gm. − 24 Gm. = 3.5 Gm., loss of weight in water.

$$\frac{27.5 \text{ Gm. (weight of the iron)}}{3.5 \text{ Gm. (loss of weight in water)}} = 7.8, \text{ specific gravity}$$

of the iron.

Example (i)

A bottle which will hold 1 fluidounce of water at 25°C. will hold what weight of Glycerin of specific gravity 1.25 at the same temperature?

454.6 gr. × 1.25 = 568.25 gr., weight of 1 fluidounce of Glycerin.

Example (j)

Ten pounds of Sulfuric Acid of the specific gravity of 1.84 will fill how many 4-fluidounce bottles?

10 lb. × 7,000 gr. = 70,000 gr.

70,000 gr. ÷ 1.84 = 38,043.4 gr., weight of water which will occupy the same volume as does the acid.

454.6 gr. × 4 = 1,818.4 gr., weight of 4 fluidounces of water.

38,043.4 gr. ÷ 1,818.4 gr. = 20.9 bottles.

Or,

454.6 gr. = the weight of 1 fluidounce of water at 25°C.

454.6 × 4 × 1.84 = the weight of 4 fluidounces of acid.

10 lb. × 7,000 gr. = 70,000 gr., weight of acid.

$$\frac{70{,}000 \text{ gr.}}{\text{Sp. gr. } 1.84 \times 454.6 \text{ gr.} \times 4} = 20.9 \text{ bottles.}$$

Example (k)

A bottle filled with water weighs 52 Gm., and filled with Glycerin of specific gravity 1.25 it weighs 59.5 Gm.

1. Find the weight of the bottle.
2. How many cubic centimeters will the bottle hold?

Let

x = the weight of the bottle in grams.

$52 - x$ = the weight of water the bottle will hold.

$59.5 - x$ = the weight of Glycerin the bottle will hold.

As Glycerin is 1.25 times as heavy as water,

$$(52 - x)1.25 = 59.5 - x.$$

x = 22 Gm., weight of the bottle (1).

52 Gm. − 22 Gm. = 30 Gm., or 30 cc. of water the bottle will hold (2).

Or,

59.5 Gm. − 52 Gm. = 7.5 Gm., the excess in weight of Glycerin over weight of water the bottle will hold.

1.25 Gm. − 1.00 Gm. = 0.25 Gm., the excess in weight of 1 cc. of Glycerin over 1 cc. of water.

7.5 ÷ 0.25 = 30 cc. the bottle will hold (2).

30 cc. of water will weigh 30 Gm.

52 Gm. − 30 Gm. = 22 Gm., weight of the bottle (1).

Problems

1. What will be the weight in grams of 25 cc. of Glycerin of the specific gravity of 1.25?

2. What will be the weight of 1 pt. of Chloroform if its specific gravity at 25°C. is 1.474? Express answer in weighable denominations.

3. How many fluidounces of Glycerin will be found to be in 1 lb. of Glycerin of specific gravity of 1.246 at 25°C.?

4. One fluidounce of Mercury of specific gravity of 13.5 should weigh how much?

5. Find the specific gravity of a liquid of which 1 pt. weighs 1 lb. Avoirdupois.

6. If a specific-gravity bottle or pycnometer when filled with water weighs 70 Gm., and when filled with Glycerin of specific gravity of 1.25 weighs 82.5 Gm., what will be the weight of the bottle?

7. If a bar of metal is 5 cm. long, 3 cm. wide, and 1 cm. thick and has a specific gravity of 6.5, what will be its weight in grams?

8. If a metal container is 9 in. high, 6 in. wide, and 12 in. long, how much Castor Oil of specific gravity 0.960 at 25C.° will it hold if a cubic inch of water is considered to weigh 252 gr.?

9. What is the weight in Avoirdupois pounds of 1 gal. of U.S.P. Syrupus, specific gravity 1.313? If it contains 850 Gm. of sugar in each liter, what is its percentage strength? How many Avoirdupois pounds of sugar is this per gallon?

10. How many fluidounces of ether, specific gravity 0.723 at 25°C., are in a can labeled "50 Gm.?"

CHAPTER IX

COMPOUNDING AND DISPENSING

Some of these problems cannot be solved solely by means of a knowledge of mathematics, as a knowledge of pharmacy and chemistry is also essential.

To illustrate the type of problem above referred to, several such problems will be appended and the teacher or student may draw from experience other such examples.

The answers to all such problems should be expressed in weighable or measurable denominations. By this is meant to express an answer so that the proper quantity can be weighed or measured without further calculation. For example, 112 grains cannot be weighed, but ʒ i, ℈ ii, gr. x, and gr. ii can be weighed.

It is obvious that in many such problems more than one answer can be expressed, and it would be good practice for students who have not had laboratory or drugstore experience to ascertain how many answers are possible for a given problem.

If the Metric system could be used exclusively, these calculations would immediately become quite simple. As the pharmacist receives requests and prescriptions in more than one system, it would seem rational to express answers in the same system as that in which the request is made.

Example (a)

Prepare 30 cc. of Chalk Mixture. The U.S.P. formula calls for Compound Chalk Powder 20 Gm., Cinnamon

Water 40 cc., Distilled Water to make 100 cc. For any required number of cubic centimeters, divide the quantities by 100 and multiply by the required number of cubic centimeters, thus:

20 Gm. ÷ 100 = 0.20 Gm. × 30 cc. = 6 Gm. of Compound Chalk Powder.

40 cc. ÷ 100 = 0.40 cc. × 30 cc. = 12 cc. of Cinnamon Water.

Distilled Water to make 30 cc.

Example (*b*)

Prepare 1 fluidounce of Chalk Mixture. It is obvious that it is easier to proceed as under Example (*a*); still it is possible to proceed with Apothecaries' weights and measures.

One fluidounce contains 29.57 cc.

20 Gm. ÷ 100 = 0.20 Gm. × 29.57 cc. = 5.9 Gm. × 15.432 gr. = 91 gr.

40 cc. ÷ 100 = 0.40 cc. × 29.57 cc. = 11.8 cc. × 16 minims = 189 minims.

Thus, ʒ iss, gr. i of Compound Chalk Powder and fʒ iii, ♏ ix of Cinnamon Water and Distilled Water to make f℥ i would be used.

Or, where the ingredients do not consist of extremely potent drugs, proceed by percentage.

20 per cent of 454.6 gr. = 91 gr. of Compound Chalk Powder.

40 per cent of 480 minims = 192 minims of Cinnamon Water.

Example (*c*)

Fill a prescription for ℥ i of Iodine Ointment. The U.S.P. formula calls for Iodine 4 Gm., Potassium Iodide 4 Gm., Glycerin 12 Gm., Wool Fat 5 Gm., Yellow Wax 5 Gm., and Petrolatum 70 Gm., to make 100 Gm.

A 1-oz. prescription weighs 480 gr.

$$
\begin{aligned}
480 \text{ gr.} &= 100 \text{ parts.} \\
480 \text{ gr.} \div 100 &= 4.8 \text{ gr. or 1 part.} \\
4 \text{ parts} \times 4.8 \text{ gr.} &= 19.2 \text{ gr. of Iodine.} \\
4 \text{ parts} \times 4.8 \text{ gr.} &= 19.2 \text{ gr. of Potassium Iodide.} \\
12 \text{ parts} \times 4.8 \text{ gr.} &= 57.6 \text{ gr. of Glycerin.} \\
5 \text{ parts} \times 4.8 \text{ gr.} &= 24 \text{ gr. of Wool Fat.} \\
5 \text{ parts} \times 4.8 \text{ gr.} &= 24 \text{ gr. of Yellow Wax.} \\
70 \text{ parts} \times 4.8 \text{ gr.} &= \underline{336} \text{ gr. of Petrolatum.} \\
\text{Total} &= 480.0 \text{ gr. of Iodine Ointment.}
\end{aligned}
$$

Or, by percentage:

$$
\begin{aligned}
480 \text{ gr.} &= 100 \text{ per cent of the amount prepared.} \\
4 \text{ per cent of } 480 &= 19.2 \text{ gr. of Iodine.} \\
4 \text{ per cent of } 480 &= 19.2 \text{ gr. of Potassium Iodide.} \\
12 \text{ per cent of } 480 &= 57.6 \text{ gr. of Glycerin.} \\
5 \text{ per cent of } 480 &= 24 \text{ gr. of Wool Fat.} \\
5 \text{ per cent of } 480 &= 24 \text{ gr. of Yellow Wax.} \\
70 \text{ per cent of } 480 &= \underline{336} \text{ gr. of Petrolatum.} \\
\text{Total} &= 480.0 \text{ gr. of Iodine Ointment.}
\end{aligned}
$$

Example (d)

If the same prescription had been called for with the proviso that it contain only 2 per cent of Iodine, how many grains of each ingredient are necessary?

Here one must know that the Potassium Iodide and the Glycerin must bear the same relation to the Iodine as they do in the U.S.P. ointment. This is a matter of pharmaceutical and not mathematical knowledge.

As 480 gr. of Ointment containing 2 per cent of Iodine are wanted, proceed thus:

$$2 \text{ per cent of } 480 \text{ gr.} = 9.6 \text{ gr. of Iodine.}$$

As there should be the same amount of Potassium Iodide present, 2 per cent of 480 gr. = 9.6 gr. of Potassium Iodide.

As there should be three times as much Glycerin as Iodine, 6 per cent of 480 gr. = 28.8 gr. of Glycerin.

To secure the amount of basis:

	9.6	gr. of Iodine.
	9.6	gr. of Potassium Iodide.
	28.8	gr. of Glycerin.
Sum =	48.0	gr. of ingredients.
	480	gr. of Ointment.
	48	gr. of ingredients.
Difference =	432	gr. of basis.

432 gr. ÷ 80 = 5.4 gr. = one part.
5 parts × 5.4 gr. = 27 gr. of Wool Fat.
5 parts × 5.4 gr. = 27 gr. of Yellow Wax.
70 parts × 5.4 gr. = 378 gr. of Petrolatum.
Total = 432 gr. of basis.

Some of the problems that follow are so obviously simple that it will be unnecessary to show examples of them.

Problems

1. How many grains of Strychnine Sulfate are needed to make 100 pills, each containing gr. $\frac{1}{60}$ of the Sulfate?

2. How would you weigh the Strychnine Sulfate to make the above pills?

3. If a physician wishes to prescribe 5 gr. of Sodium Iodide and 3 minims of Fowler's Solution in each teaspoonful dose, how much of each would you use in preparing a 2-fluidounce mixture?

4. If a stock solution of Strychnine Sulfate contains 1 gr. in each fluidrachm, how much of it is needed to make 25 pills, each pill containing gr. $\frac{1}{40}$ of Strychnine Sulfate?

5. How long will an 8-fluidounce mixture last if taken in teaspoonful doses three times daily?

6. How much Fluidextract of Henbane must be placed in a 3-fluidounce prescription, in order that a 2-teaspoonful dose will contain 3 minims?

7. If a stock solution of Strychnine Sulfate contains 1 gr. in each fluidrachm, how much should be used in a 4-fluidounce mixture so that one teaspoonful dose will contain gr. $\frac{1}{120}$?

8. How much of each ingredient should be used to make 1 oz., Apothecaries', of Ointment of Ammoniated Mercury?

9. How much of each ingredient should be used to fill a 1-oz. prescription with Ointment of Ammoniated Mercury, 15 per cent in strength?

10. How many Avoirdupois ounces of 5 per cent Phenolated Olive Oil can be made from 1 lb. of U.S.P. Phenol?

11. How much U.S.P. Ointment of Yellow Mercuric Oxide and how much Wool Fat, Yellow Wax, and Petrolatum should be used to fill a 2-drachm prescription with 0.5 per cent Ointment of Yellow Mercuric Oxide?

12. How many grains of each ingredient should be used to make 24 Compound Cathartic pills?

13. How much U.S.P. Ointment of Ammoniated Mercury and how much Wool Fat, White Wax and White Petrolatum would you use to dispense a prescription calling for 4 drachms of a 6 per cent ointment?

14. How much U.S.P. Strong Mercurial Ointment and how much White Wax and White Petrolatum should be used to dispense 2 drachms of a 20 per cent ointment?

15. If you had a stock mass for pills of Ferrous Carbonate, how much would you use to dispense 12 pills?

16. How many grains of U.S.P. Phenol should be used to dispense a 2-oz. prescription ointment containing 3 per cent of Phenol?

17. If Basham's Mixture uses 40 cc. of Tincture of Ferric Chloride to make 1,000 cc., how many cubic centimeters would you use for a prescription of 4 fluidounces?

18. How much of each ingredient should be used to prepare 30 cc. of Glycerite of Phenol N.F. VI? Would you dispense this when asked for Carbolized Glycerin?

19. How much of each ingredient should be used to prepare 24 Blaud's Pills? (See U.S.P. XI and note that each pill weighs about 5 gr. and contains 1 gr. of Ferrous Carbonate.)

20. How much of each ingredient should be used to prepare 50 Blaud's Pills, each pill weighing 1 gr.? 2 gr.? 3 gr.? 7 gr.?

CHAPTER X

MANUFACTURING IN QUANTITY

A little practice in the adaptation of formulas to quantity production and to the calculations involved in the preparation of larger amounts than are made at the prescription counter may be helpful.

The questions most often asked by a student in regard to these calculations are: How accurate must the results be? How many decimals must be used in a divisor? To how many decimals must a quotient be carried?

Here is where the student must begin to use judgment and learn to answer such questions.

The teacher should insist upon calculations being made with the utmost accuracy until the student can understand how to avoid increasing errors by multiplication or division. The student should learn to use the nearest whole number in a quotient, first, and then, later, it may be used in the factors that go to make up the final figures. Some practice in the calculation of errors would not be amiss.

It is obviously ridiculous to spend time to bring calculations to such a degree of mathematical accuracy that the fractions of quantities involved can neither be weighed nor measured by means of the apparatus at hand.

One might illustrate by observing what difference it would make if a mistake of any number, say, 5 or 10 grains, is made in the amount of an alkaloid that is to be added to 25 gallons of a preparation. Extreme accuracy may become ridiculous, but the difference between intelligent calculation of weights and measures and carelessness is very great.

Practice and experience are the only things that will give satisfactory answers to these questions.

For the sake of uniformity, it is customary in quantity manufacturing to express weights in pounds, ounces, and grains, and volumes in gallons, pints, fluidounces, and minims. Experience shows when the grains or minims may be disregarded. The Metric system is not used in this country in manufacturing because drugs and chemicals are all priced and purchased in the U. S. system of weights and measures.

One should not express an answer to any problem partly in the Metric and partly in the U. S. system of weights and measures.

The formulas one meets with in quantity manufacturing consist largely of those from the U.S.P. and N.F., from other formularies, certain special formulas, and even the expansion of prescriptions.

The U.S.P. XI on pages 634 to 636 gives tables for converting Metric quantities into the Avoirdupois and Apothecaries' systems and reference to them during the study of these calculations will demonstrate their usefulness.

Observation of formulas will reveal that they may be classified as follows:

1. Ingredients stated by weight to prepare a given weight.
2. Ingredients stated by volume to prepare a given volume.
3. Ingredients stated by weight and volume to prepare a given weight.
4. Ingredients stated by weight and volume to prepare a given volume.

In case one should find ingredients stated by weight to prepare a given volume or stated by volume to prepare a given weight, the methods shown under classes 3 and 4 will apply.

Class 1. *Example* (*a*)

How much of each ingredient should be used to make 25 lb. of U.S.P. Ammoniated Mercury Ointment?

Reference to the U.S.P. will show the formula to contain

Ammoniated Mercury..................	10 Gm.
Wool Fat............................	5 Gm.
White Wax...........................	5 Gm.
White Petrolatum....................	80 Gm.
To make............	100 Gm.

10 per cent of 25 lb. = 2.5 lb. of Ammoniated Mercury.
5 per cent of 25 lb. = 1.25 lb. of Wool Fat.
5 per cent of 25 lb. = 1.25 lb. of White Wax.
80 per cent of 25 lb. = 20.0 lb. of White Petrolatum.
25.0 lb. prepared.

Example (*b*)

How much of each ingredient should be used to make 1 lb., Avoirdupois, of U.S.P. Camphor Liniment? (Compare with table U.S.P. XI, p. 636.)

Reference to the U.S.P. will show the formula to contain

Camphor..........................	200 Gm.
Cottonseed Oil....................	800 Gm.
To make..........	1,000 Gm.

20 per cent of 16 oz. = 3.2 oz. =
3 oz., 87.5 gr. of Camphor.
80 per cent of 16 oz. = 12.8 =
12 oz., 350 gr. of Cottonseed Oil.
16 oz. of Camphor Liniment.

When a large quantity is called for, as, for example, 25 lb. of Camphor Liniment, it will save labor to calculate the whole amount at one time rather than to calculate a unit quantity and then multiply by the number of units desired.

Class 2. *Example* (*c*)

How much of each ingredient should be used to make 25 gal. of U.S.P. Syrup of Ipecac?

Reference to the U.S.P. will show the formula to contain

Fldext. Ipecac	70 cc.
Glycerin	100 cc.
Syrup, a sufficient quantity	
To make	1,000 cc.

7 per cent of 25 gal. = 1.75 gal. = 1 gal., 6 pt., of the Fldext. of Ipecac.

10 per cent of 25 gal. = 2.5 gal. = 2 gal., 4 pt., Glycerin.

Syrup, a sufficient quantity

To make.... 25 gal.

Class 3. *Example* (*d*)

How much of each ingredient should be used to make 25 lb. of U.S.P. Rose Water Ointment?

Reference to the U.S.P. will show the formula to contain

Spermaceti	125	Gm.
White Wax	120	Gm.
Expressed Almond Oil	560	Gm.
Sodium Borate	5	Gm.
Rose Water	50	cc.
Distilled Water	140	cc.
Oil of Rose	0.2	cc.
To make about	1,000	Gm.

For the weights:

12.5 per cent of 25 lb. = 3.125 lb. = 3 lb. 2 oz. of Spermaceti.

12 per cent of 25 lb. = 3 lb. of White Wax.

56 per cent of 25 lb. = 14 lb. of Expressed Almond Oil.

0.5 per cent of 25 lb. = 0.125 lb. = 2 oz. of Sodium Borate.

For the volumes:

25 lb. ÷ 8.334 lb. = 2.996 gal.
5 per cent of 2.996 gal. = 0.1498 gal. =
19 fl. oz., 83.7 ♏ of Rose Water.
14 per cent of 2.996 gal. = 0.4194 gal. =
3 pt., 5 fl. oz., 330. ♏ of Distilled Water.
0.02 per cent of 2.996 gal. = 0.0006 gal. =
36.8 ♏ of Oil of Rose.

The above method for calculating the volumes to be used may be checked by the U.S.P. tables. They also may be checked by the method given below:

For the Distilled Water:

Distilled Water 140 cc. to make about 1,000 Gm.

1,000 Gm. = 2.2 lb. Avoirdupois. ∴ 140 cc. to make 2.2 lb.

1 lb. requires 140 cc. ÷ 2.2 lb. = 63.6 cc.

25 lb. requires 25 × 63.6 cc. = 1,590 cc.

1,590 cc. ÷ 29.57 cc. = 53.7 fl. oz. = 3 pt., 5 fl. oz., and 336 ♏.

Class 4. *Example* (*e*)

How much of each ingredient should be used to make 1 gal. of U.S.P. Camphor and Soap Liniment.

Reference to the U.S.P. will show the formula to contain

Hard Soap........................	60 Gm.
Camphor..........................	45 Gm.
Oil of Rosemary..................	10 cc.
Alcohol..........................	700 cc.
Distilled Water, a sufficient quantity	
To make...........	1,000 cc.

6 per cent of 8.344 lb. = 0.50064 lb. = 8.01 oz. =
8 oz., 4 gr. of Hard Soap
4.5 per cent of 8.344 lb. = 0.37548 lb. = 6.007 oz. =
6 oz., 3 gr. of Camphor
1 per cent of 128 fl. oz. = 1.28 fl. oz. = 1 fl. oz., 134 ♏
of Oil of Rosemary

70 per cent of 8 pt. = 5.6 pt. = 5 pt., 9 fl. oz., 288 ♏ of Alcohol

Distilled Water, a sufficient quantity

To make.................... 1 gal.

The above method for calculating the weights to be used may be checked by the U.S.P. tables. The quantities also may be checked by the method given below.

1 gal. = 3.785 L.

60 Gm. × 3.785 L. = 227.1 Gm. ÷ 28.35 Gm. = 8.01 oz. = 8 oz., 4 gr. of Hard Soap

45 Gm. × 3.785 L. = 170.325 Gm. ÷ 28.35 Gm. = 6.007 oz. = 6 oz., 3 gr. of Camphor

10 cc. × 3.785 L. = 37.85 cc. ÷ 29.57 cc. = 1.28 fl. oz. = 1 fl. oz., 134 ♏ of Oil of Rosemary

700 cc. × 3.785 L. = 2649.5 cc. ÷ 473 cc. = 5.6 pt. = 5 pt., 9 fl. oz., 288 ♏ of Alcohol

Distilled Water, a sufficient quantity

To make.................... 1 gal.

EXPANSION OF PRESCRIPTIONS

In case the prescription be a Metric one, first convert to a 100-cc. or 100-Gm. basis and then proceed as shown in one of the above examples.

Example (f)

How much of each ingredient should be used to make 5 gal. of the following prescription:

℞

	Gm. or cc.	For 100 cc.
Codeine Sulfate..............	0|18...............	|2
Ammonium Chloride.........	6|0..............	6|66
Fldgly. of Glycyrrhiza.......	16|0..............	17|77
Syrup of Tolu, to make......	90|0	to make..100|

Proceed as in Class 4, Example (*e*).

Example (g)

How much of each ingredient should be used to make 25 lb. of the following prescription:

℞	Gm. or cc.	For 100 Gm.	
Crude Coal Tar......	2	6	6
Zinc Oxide...........	2	6	6
Petrolatum, to make..	30	to make...100	

Proceed as in Class 1, Example (*a*).

In case the prescription be in the Apothecaries' system, first obtain the factor to multiply by and then proceed.

Example (h)

How much of each ingredient should be used to make 5 gal. of the following prescription:

℞

Camphor..............................	ʒ iss
Chloral Hydrate......................	ʒ i
Glycerin.............................	f℥ ss
Alcohol, a sufficient quantity, to make.....	f℥ iv

5 gal. = 640 fl. oz. ÷ 4 fl. oz. = 160.

ʒ iss = 90 gr. × 160 = 14,400 gr. ÷ 7,000 gr. = 2.057 lb. = 2 lb., 399 gr. of Camphor.

ʒ i = 60 gr. × 160 = 9,600 gr. ÷ 7,000 gr. = 1.37 lb. = 1 lb., 5 oz., 403 gr. of Chloral.

f℥ ss = fʒ iv × 160 = 640 fl. dr. ÷ 128 fl. dr. = 5 pt. of Glycerin.

Alcohol, a sufficient quantity, to make 5 gal.

Problems

1. How much of each ingredient is necessary to make 5 gal. of Syrup of Tolu Balsam? (Express answer in U. S. system of weights and measures and in weighable and measurable denominations.)

2. How much of each ingredient is necessary to make 4 dozen bottles of Solution of Magnesium Citrate? How much to make 1 gal.?

3. How much of each ingredient is necessary for 50 lb. of Strong Mercurial Ointment?

4. How much of each ingredient is necessary for 30 gal. of Syrup? What should each gallon weigh in pounds, Avoirdupois?

5. How much of each ingredient is necessary to make 10 gal. of Aromatic Fluidextract of Cascara Sagrada?

6. How much of each ingredient is necessary to make 25 lb. of Yellow Mercuric Oxide Ointment?

7. How much of each ingredient is necessary to make 1 gal. of Syrup of Hydriodic Acid?

8. How much of each ingredient is necessary to make 5 gal. of Fowler's Solution?

9. How much of each ingredient is necessary for 1 gal. of Syrup of Ferrous Iodide?

10. How much of each ingredient is necessary for 50,000 tablets of Phenolphthalein, N.F. V?

11. How much of each ingredient is necessary for 5 lb. of Blaud's Pills? About how many pills would this be?

12. How much of each ingredient is necessary to make 25 lb. of Belladonna Ointment?

13. How much of each ingredient is necessary to make 25 gal. of Compound Syrup of Sarsaparilla?

14. How much of each ingredient is necessary to make 50 gal. of Elixir of Terpin Hydrate, N.F. VI?

15. How much of each ingredient is necessary to make 25 lb. of Dental Anodyne Paste, N.F. VI?

16. How much of each ingredient is necessary to make 10 lb. of Cantharides Cerate?

17. How much of each ingredient is necessary to make 10 gal. of Aromatic Elixir?

18. How much of each ingredient is necessary to make 5 gal. of Emulsion of Cod Liver Oil?

19. How much of each ingredient is necessary to make 500 Suppositories of Glycerin?

20. How much of each ingredient is necessary to make 5 gal. of Tincture of Vanilla, N.F. VI?

CHAPTER XI

PERCENTAGE SOLUTIONS

There always has been much confusion concerning the preparation of percentage solutions until now, when the U.S.P. XI has definitely clarified the subject.

The Pharmacopœia on page 4 reads as follows:

"**Percentages.**—Unless otherwise stated, percentage figures in this Pharmacopœia are understood to mean by weight."

"**Percentage Solutions.**—In connection with solutions, per cent or percentage has different meanings under different circumstances as follows:

Per cent or percentage, 'weight in weight' ($^w/_w$) expresses the number of grams of an active ingredient in 100 grams of the solution.

Per cent, or percentage, 'weight in volume' ($^w/_v$) expresses the number of grams of an active ingredient in 100 cubic centimeters of the solution.

Per cent or percentage, 'volume in volume' ($^v/_v$) expresses the number of cubic centimeters of an active ingredient in 100 cubic centimeters of the solution.

In the dispensing of prescriptions, slight changes in volume due to variations in room temperature and the trifling difference between the volumes of the cubic centimeter and the milliliter are negligible and may be disregarded. When the expression 'per cent' is used in prescriptions without qualification, it is to be interpreted to mean: for solutions of solids in liquids, per cent, weight in volume; for solutions of liquids in liquids, per cent, volume in volume; and for solutions of gases in liquids, per cent, weight in volume. For example, a 1 per cent solution is prepared by dissolving 1 gram of a solid or 1 cubic centimeter of a liquid in sufficient of the solvent to make 100 cubic centimeters of the solution. A solution of the same strength may be prepared by Apothecaries' weight and measure by dissolving 4.5 grains (more accurately 4.5457 grains, at 25°C.) of a solid or 4.8 minims of a liquid in sufficient of the solvent to make 1 fluidounce of the solution."

The above statements from U.S.P. XI are definite and clear. It is equally clear that the basis upon which any given percentage solution is to be made is seldom mentioned and this basis is rightly left to the judgment of the operator.

The Pharmacopœia does, however, state what is to be done when percentage solutions are called for upon prescription "without qualification."

In the problems which follow one should observe carefully which ones are prescriptions and which ones are not.

Example (a)

Prepare 100 Gm. of a 5 per cent solution of Silver Nitrate upon a $^w/_w$ basis.

5 per cent of 100 Gm. = 5 Gm.

Use 5 Gm. of Silver Nitrate and Distilled Water to make 100 Gm. of solution.

Example (b)

Prepare 100 cc. of a 5 per cent solution of Silver Nitrate upon a $^w/_v$ basis.

5 per cent of 100 = 5 Gm.

Use 5 Gm. of Silver Nitrate and Distilled Water to make 100 cc. of the solution.

Example (c)

Prepare 100 cc. of a 5 per cent solution of Liquefied Phenol in Alcohol upon a $^v/_v$ basis.

5 per cent of 100 cc. = 5 cc.

Use 5 cc. of Liquefied Phenol and Alcohol to make 100 cc. of the solution.

Example (*d*)

Fill a prescription for 30 cc. of a 5 per cent solution of Mild Protein Silver.

(*Observe this is a prescription and the basis is not mentioned.*)

5 per cent of 30 = 1.5 Gm.

Use 1.5 Gm. of Mild Protein Silver and Distilled Water to make 30 cc.

Example (*e*)

Fill a prescription for 60 cc. of a 5 per cent Solution of Liquefied Phenol in Glycerin.

5 per cent of 60 cc. = 3 cc.

Use 3 cc. of Liquefied Phenol and Glycerin to make 60 cc.

Example (*f*)

Fill a prescription for 1 fluidounce of a 5 per cent solution of Mild Protein Silver.

5 per cent of 454.6 gr. = 22.7 gr.

Use 22.7 gr. (23 gr.) of Mild Protein Silver and Distilled Water to make 1 fluidounce of solution.

Example (*g*)

Fill a prescription for 1 pt. of a 5 per cent solution of Saponated Solution of Cresol.

5 per cent of 7,680 minims = 384 minims.

Use 384 minims (f℥ vi, ♏ xxiv,) of the Saponated Solution of Cresol and Distilled Water to make 1 pt. of the solution.

The following problems are illustrative of the possible types of percentage solutions which one may prepare, but the judgment of the operator must be relied upon when the request does not specify whether the solution is to be prepared upon a $^{w}/_{w}$, $^{w}/_{v}$, or $^{v}/_{v}$ basis. The use to which the solution is to be put is often the governing factor in determining what is the basis for calculations.

Example (h)

1. Prepare 100 Gm. of a 5 per cent solution of Iodine in Alcohol upon a $^{w}/_{w}$ basis.

5 per cent of 100 Gm. = 5 Gm.

Use 5 Gm. of Iodine and Alcohol to make 100 Gm. of the solution. Its volume is unknown.

2. Prepare 100 cc. of a 5 per cent solution of Iodine in Alcohol upon a $^{w}/_{w}$ basis.

The specific gravity of Alcohol is 0.816.

100 cc. of Alcohol will weigh $100 \times 0.816 = 81.6$ Gm.
5 per cent of 81.6 Gm. = 4.08 Gm.

Use 4.08 Gm. of Iodine and Alcohol to make 81.6 Gm. of the solution. This will be a true 5 per cent solution upon a $^{w}/_{w}$ basis, but its volume is not exactly 100 cc.

3. Prepare 100 cc. of a 5 per cent solution of Iodine in Alcohol upon a $^{w}/_{v}$ basis.

5 per cent of 100 = 5 Gm.

Use 5 Gm. of Iodine and Alcohol to make 100 cc. of the solution.

Example (i)

1. Prepare 500 cc. of a 5 per cent solution of Boric Acid in Glycerin upon a $^{w}/_{v}$ basis.

5 per cent of 500 = 25 Gm.

Use 25 Gm. of Boric Acid and Glycerin to make 500 cc. of the solution.

2. Prepare 500 cc. of a 5 per cent solution of Boric Acid in Glycerin upon a $^{w}/_{w}$ basis.

The specific gravity of Glycerin is 1.249.

500 cc. of Glycerin will weigh 500 × 1.249 = 624.5 Gm.
5 per cent of 624.5 Gm. = 31.225 Gm.

Use 31.225 Gm. of Boric Acid and Glycerin to make 624.5 Gm. of the solution. This will be a true 5 per cent solution, but its volume is not exactly 500 cc.

Sometimes the percentage purity or percentage strength of a solute must be considered when making a solution of it. In most cases, however, of U.S.P. chemicals the purity rubric may be disregarded. One or two examples will serve to illustrate this principle.

Example (j)

Prepare 1,000 Gm. of a 4 per cent solution of Tannic Acid, using the Glycerite of Tannic Acid as a source of the Tannic Acid, upon a $^{w}/_{w}$ basis.

Glycerite of Tannic Acid contains 20 per cent of Tannic Acid.

4 per cent of 1,000 Gm. = 40 Gm. of Tannic Acid needed.
40 Gm. = 20 per cent of the Glycerite needed.
200 Gm. of Glycerite is needed.

Use 200 Gm. of Glycerite of Tannic Acid and Distilled Water to make 1,000 Gm. of the solution.

Example (k)

Prepare 500 Gm. of a solution of Potassium Hydroxide containing 10 per cent of total alkali, upon a $^{w}/_{w}$ basis.

U.S.P. Potassium Hydroxide contains 85 per cent of total alkali calculated as KOH.

10 per cent of 500 Gm. = 50 Gm. of KOH needed.
50 Gm. = 85 per cent of the amount of the U.S.P. chemical needed.
58.8 Gm. of the U.S.P. chemical needed.

Use 58.8 Gm. of U.S.P. Potassium Hydroxide and Distilled Water to make 500 Gm. of the solution.

Problems

1. How many grains of Cocaine Hydrochloride are needed to fill a prescription for 1 fluidounce of a 4 per cent solution?

2. How many grams of Cocaine Hydrochloride are needed to fill a prescription for 60 cc. of a 4 per cent solution?

3. How many cubic centimeters of Liquefied Phenol are needed to fill a prescription for 30 cc. of a 2 per cent solution in Glycerin?

4. Find the percentage strength of U.S.P. Syrup.

5. How many grams of Sodium Chloride are needed to make 25 L. of a 0.85 per cent solution upon a $^{w}/_{v}$ basis?

6. How many grams of Procaine Hydrochloride are needed to fill 3 dozen 30-cc. bottles with 5 per cent solution upon a $^{w}/_{v}$ basis?

7. How many grams of Dextrose are needed to make 25 flasks of 10 per cent solution upon a $^{w}/_{v}$ basis if each flask is to hold 300 cc.?

8. How many grams of Boric Acid are needed to make 1,000 Gm. of a 4 per cent solution upon a $^{w}/_{w}$ basis?

9. How many grains of Atropine Sulfate are needed to fill a prescription for 1 fluidounce of a 1 per cent solution?

10. How would you prepare 1,000 Gm. of a 5 per cent $^{w}/_{w}$ solution of Boric Acid in Glycerin? 500 cc. of a 5 per cent $^{w}/_{w}$ solution?

11. How much liquid soap is needed to fill 4 dozen half-gallon bottles with 10 per cent $^{v}/_{v}$ solution?

12. Is Camphor Liniment a true percentage solution, and if so, upon what basis?

13. How many grains of Zinc Sulfate are needed to fill a prescription for 1 fluidounce of a 1 per cent $^{w}/_{v}$ solution in Camphor Water?

14. What is the percentage $^{w}/_{v}$ of Iodine in Tincture of Iodine? How could its percentage $^{w}/_{w}$ be calculated?

15. How many grains of Mercury Bichloride are needed to make 1 pt. of a 1 per cent $^{w}/_{v}$ solution?

CHAPTER XII

SOLUTION BY PARTS

This type of solution is similar to the one just discussed and logically comes at this point. It is the solution often called 1 in 10, 1 in 500, or a 1 in 1,000 solution of a substance in a liquid. One should, of course, first know just what is meant by such a solution and then how to proceed to make it. The main point for a pharmacist or a nurse is to know what is meant in every case by such an expression. Such a statement as 1 in 10 does not mean a total of 11 parts but means in the ratio of 1:10. A 1 in 10 solution is a solution containing 1 part of solute and 9 parts of solvent and would, therefore, be one containing 10 parts in all. This would also be a 10 per cent solution. These solutions have their strengths indicated by means of ratios.

Speaking of solutions upon a ratio basis is merely another way of speaking of percentage solutions. All such ratios are easily converted into percentage, therefore it is rational to apply the rules for percentage solutions to them and make them upon a $^{w}/_{w}$, $^{w}/_{v}$ or $^{v}/_{v}$ basis, as the case may indicate.

Example (a)

If one wishes to make 1 pt. of a 1 in 1,000 solution, divide the weight of 1 pt. of water, 7,273.6 gr. at 25°C., into 1,000 parts and take one of these parts, which is 7 gr. of the salt.

Dissolve this in the proper manner and add water in sufficient quantity until the finished product equals 1,000 parts, or 7,273.6 gr. This would be upon a $^{w}/_{w}$ basis.

In practical work, one dissolves the 7 gr. of the salt in water sufficient to measure 1 pt. In other words, it is usually prepared upon a $^{w}/_{v}$ basis unless otherwise definitely specified. A common example of this will be found in the ordinary 7-gr. bichloride tablet. The label on the bottle reads: "Use one tablet in a pint of water in order to make a 1–1,000 solution."

In the case of ointments, it is best to weigh the solute, be it liquid or solid, before adding it to the ointment base, unless its volume can be calculated easily by means of specific gravity.

Example (b)

If the solute is a liquid, then proceed as in the following problem:

Prepare 1 pt. of a 1 in 1,000 solution of Saponated Solution of Cresol. One pint of water or 1,000 parts contain 7,680 minims. One part is 7,680 ÷ 1,000, which is 7.68 minims of the solution to use. Take 7.68 minims (8 minims) of the Solution of Cresol and add water sufficient to make 1 pt. This then becomes a solution upon a $^{v}/_{v}$ basis.

Example (c)

Prepare 1,000 Gm. of a 1 in 1,000 solution of a salt. Use 1 Gm. of the salt and water to make 1,000 Gm. This would be upon a $^{w}/_{w}$ basis. If the request be for 1,000 cc., then use 1 Gm. of the salt and water to make 1,000 cc. Proceed as in percentage solutions if, upon prescription, the meaning is clear; but if not, then proceed as good practice and judgment indicate.

Example (d)

Oftentimes, one wishes to make up a certain quantity of a 1 in 5,000 solution from a 1 in 1,000 solution, or from various dilutions. Should one wish to make the above, take

1 part of the 1 in 1,000 solution and add 4 parts of the diluent, which would give a solution of the strength of 1 in 5,000.

Example (e)

In case of diluting Solution of Epinephrine Hydrochloride or other similar solutions, there may be another principle involved. In the specific case mentioned, the diluent should be Physiological Salt Solution instead of pure water. If the U.S.P. 1 in 1,000 solution is at hand, add 4 parts of Physiological Salt Solution (8.5 Gm. of Sodium Chloride in Distilled Water up to 1 L.) to 1 part of the Epinephrine solution in order to have a solution of 1 in 5,000 in strength.

The same attention should be given to purity or strength of solute as is given in preparing percentage solutions. As an example, Liquefied Phenol is 88 per cent phenol and must not be treated as 100 per cent pure when one wishes to make a solution of phenol of a definite strength.

Problems

1. How many grams of Zinc Sulfate should be used to prepare 250 cc. of a 1 in 20 solution upon a $^{w}/_{v}$ basis?

2. How many grains of Novocaine are necessary to make 1 fluidounce of a 1 in 200 solution upon a $^{w}/_{v}$ basis?

3. How many grains of U.S.P. Phenol (98 per cent pure) are necessary to fill a 1-oz. prescription for an ointment using Petrolatum for the basis, if this ointment is to contain pure phenol, 1 part in 50, of the ointment? What percentage is this upon a $^{w}/_{w}$ basis?

4. How many grains of Novocaine are needed to prepare 1 fluidounce of a 1 in 4,000 solution in Physiological Salt Solution for infiltration anesthesia upon a $^{w}/_{v}$ basis? How many drops of Solution of Epinephrine Hydrochloride, 1 in 1,000 in strength, should be added if there must be one drop to each fluidrachm? How much Novocaine would be contained in a 2-cc. hypodermic syringe full of this solution?

5. How much U.S.P. Phenol should be used to prepare 1 pt. of a 1 in 5,000 solution of Phenol in Alcohol upon a $^{w}/_{v}$ basis?

6. If one wished to use Phenol Liquefactum in solving Prob. 5, how much of it should be used?

7. If one wished to prepare 1 L. of a 1 in 50 solution of Potassium Hydroxide in Alcohol upon a $^w/_v$ basis, how much of the U.S.P. salt should be used?

8. If a 1 in 1,000 solution of Epinephrine Hydrochloride is at hand, how much of it should be used to prepare 1 fluidounce of a 1 in 5,000 solution in Physiological Salt Solution upon a $^v/_v$ basis?

9. How much Lugol's Solution should be used to prepare 2 fluidounces of a solution of Iodine, 1 in 500 in strength upon a $^w/_v$ basis?

10. If Physiological Salt Solution contains 8.5 Gm. of Sodium Chloride in 1 L., what will be the proportion by parts to represent the strength of this solution if the salt represents one part?

11. Express in ratio solutions labeled, 1 Gm. in 1 cc.; 2 cg. in 1 cc.; gr. iii in f℥ i; gr. x in O. i; gr. xlii in O. ss; 1 per cent; 0.7 per cent; 5 per cent; 15 per cent; 0.5 per cent; ♏ v in O. i; 10 cc. in 120 cc.; f ʒ ix in f℥ iv; gr. x in ℥ ii.

12. How many $\frac{1}{10}$-gr. tablets should be used to make f℥ i of a 1 in 5,000 solution; $\frac{1}{4}$-gr. tablets; 1-gr. tablets?

13. Show how to prepare 1 pt. of a 1 in 1,000 solution using 3-gr. tablets; 5-gr. tablets; 10-gr. tablets.

14. How much of a 1 in 500 solution must be used to make f℥ i of a 1 in 5,000 solution?

15. How much of a 1 in 20 solution must be used to make 30 cc. of a 1 in 40 solution; to make 90 cc. of a 1 in 50 solution?

16. Is it possible to make 1 pt. of a 1 in 50 solution from a 1 in 100 solution, and if so, how much should be used?

17. A solution of a salt labeled 1 in 10 will have how many grams of salt per cubic centimeter? How many grains per fluidounce? Drachms per gallon?

18. A dilution of Liquor Cresolis Saponatus containing 1 fluidounce per gallon would be in what ratio?

19. How many minims of a 1 in 25 solution would you use to make 70 cc. of a 1 in 1,000 solution?

20. A doctor ordered a dose of Hyoscine Hydrochloride 0.00045 Gm. The dispensary has tablets marked $\frac{1}{100}$, $\frac{1}{150}$, $\frac{1}{200}$ gr. each. Which one would you use? How place it in a volume of 2 cc. of water? What ratio strength would this be?

CHAPTER XIII

SATURATED SOLUTIONS

A saturated solution is one in which the solvent in the presence of the solute has taken up all of the solute that it can hold at that temperature.

It may be otherwise stated to be a solution of one substance in another substance where the second substance has dissolved all of the first substance that it can without being cooled or heated below or above the temperature at the start of the operation.

These solutions may be made of solids, liquids, or gases.

It is perfectly obvious that one may dissolve ammonia gas in water in such quantity that the water will refuse to hold any more of the gas. This point is attained when the water has dissolved about 28 per cent of its own weight of NH_3 at slightly below average room temperature. If the temperature rises, some of the gas is liberated.

It is likewise obvious that sugar may be dissolved in water at room temperature until the water will hold no more. If the temperature is raised, more sugar will be dissolved. To keep this solution saturated over the variations in temperature that may occur in the room where the solution is, keep an excess of sugar in the solution so the water may dissolve it as the temperature rises and may lose it by crystallization as the temperature recedes. One may have to agitate this solution and excess sugar to insure complete saturation at any specified temperature.

This same phenomenon is true of chloroform in water and of many other liquids, solids, and gases in water and in other solvents.

Experience and knowledge of chemistry both show that when some substances go into solution, heat is produced. In such a case, one must add an excess of the solute and keep an excess of the solute in the presence of the solvent until the temperature has again receded to normal or to the desired temperature.

Some tables will say that the solubility of a salt in water is five, which will mean that 1 part by weight of the salt will dissolve in 5 parts by weight of the solvent, making 6 parts by weight of a saturated solution at the temperature of the table.

The solubility of any given solute at a given temperature in any given solvent may likewise be so stated.

Some tables will say that 1 gram of a salt will dissolve in 5 grams of a solvent to make a saturated solution. This method of expression will be the same as the one above given.

Other tables will say that 1 gram of a salt will dissolve in 5 cubic centimeters of a solvent to make a saturated solution. This type of table of solubility is obviously a harder one to apply unless some practical deviation from the common method of procedure is allowable. It is the one now found in the U.S.P., and it can be shown to be a practical table.

One point to be observed in regard to all tables is that the volume of the completed saturated solution or its specific gravity is seldom given.

The U.S.P., no doubt, assumes, for practical purposes, that 1 cubic centimeter of water weighs 1 gram, and it is true that for all ordinary practical purposes this deviation from exact truth is allowable. It may even be allowable with other solvents, in many instances. No rule can be given, and the operator must always be the judge.

It is likewise true that one may take any given volume or weight of a solvent and, by gradually adding a solute, finally make a saturated solution at any given desired temperature. One can then either measure or weigh the resultant saturated solution and file this information for future reference when such solution must be remade.

In the same manner, some substances cause a lowering of temperature while going into solution.

This topic of solution and heat of solution, its causes and effects, is a large one and not a subject for study in a book of this type. The point to be emphasized is, however, that one must always mention the temperature at which a saturated solution is to be made.

It will be well for the student to refer to a text upon practical pharmacy or to one upon physical chemistry and read somewhat of saturated and supersaturated solutions. It would even be well to observe a few specific examples of substances that raise or lower the temperature while undergoing solution, as well as to observe ones more readily soluble at a low temperature than at a high one, and *vice versa.* A suggestion in this regard would be to investigate and make solutions of Calcium Hydroxide, Sodium Chloride, Exsiccated Alum, Alcohol, and Sulfuric Acid.

One will likewise observe that some substances seem to be mutually soluble, so that it is difficult to say which is solute and which is solvent.

Some substances are said to be "miscible" or "entirely miscible" with others and, perhaps, cannot be called solutions.

This text will confine itself to the more common solutions used in a saturated form and made often in the laboratory or pharmacy.

The amount of any solute to use to make a known volume of saturated solution cannot be calculated unless one has the specific gravity of the saturated solution at hand. Preparation of such a table would entail an immense amount of labor, as the specific gravity of the saturated solution would be different for each different degree of temperature. One can, however, calculate the amount of solute to use to make a definite weight of a saturated solution at a definite temperature.

Tables of solubility usually express the amount of solvent necessary to dissolve a given amount of solute in terms of weight or in parts by weight. It will thus be seen that experience alone tells of the final volume or specific gravity of a saturated solution.

Experience, also, tells one that a quantity of a very insoluble solute to use for a given volume of saturated solution can be calculated with a greater degree of accuracy than can the quantity of a very soluble solute.

It will be the object of this text to point out merely a practical way for making saturated solutions of solutes, for the first time, and then leave it to the operator's experience to determine his future procedures.

Another point to be observed in using U.S.P. solubilities, when one is working with Apothecaries' weights and measures, is the relationship between the grain and the minim.

Suppose the U.S.P. should say that 1 gram of a given salt dissolves in 5 cubic centimeters of water. Some other table might say that the solubility of this salt in water is five. These statements must mean for all practical purposes that 1 gram of the salt dissolves in 5 grams (cubic centimeters) of water to make 6 grams of a saturated solution.

If one be using Apothecaries' weights and measures, one could use the same proportion and say that 1 grain of the salt dissolves in 5 grains of water to make 6 grains of saturated solution. If one should say, however, that 1 grain of the salt dissolves in 5 minims of water, one would not be entirely correct in this view, yet such a deviation is nearly always permissible for most purposes. It may be well to observe that the true weight of 1 minim of water at 25°C. is $454.6 \div 480 = 0.947$ grain, and, therefore, the judgment of the operator will tell him that this error may usually be disregarded.

When the solubility is expressed in liquids other than water, one must always observe if it be necessary to take into consideration the specific gravity of the liquid in question.

Example (a)

How much Boric Acid must be used to make 30 Gm. of a saturated solution of Boric Acid in water?

The U.S.P. says that 1 Gm. of Boric Acid dissolves in 18 cc. of water. This, of course, means at 25°C.

Assuming for practical purposes that 1 cc. of water weighs 1 Gm. at all temperatures, this becomes a comparatively easy problem. If one wishes to find the weight of 1 cc. of water at 25°C. or at other temperatures, reference to the tables in the U.S.P. giving the weight of 1 L. of water will be helpful.

To make a saturated solution of Boric Acid in water, one should take 1 Gm. of Boric Acid and 18 Gm. of water. The result is 19 Gm. of saturated solution. In order to make 30 Gm. of such solution, one should divide 30 Gm. by 19, thus: $30 \div 19 = 1.58$, the number of grams of Boric Acid to use. The water to be used would be 30 Gm. − 1.58 Gm. = 28.42 Gm. of water.

Example (b)

How much Boric Acid must be used to make 30 cc. of a saturated solution of Boric Acid in water?

As the solubility of this salt is so slight in water, one will observe that the dissolving of 1.58 Gm. of Boric Acid, either in 28.42 Gm. of water or in water sufficient to make 30 cc., will be accurate enough for all purposes, and the variance of the specific gravity of a saturated solution of Boric Acid from that of water (1.0000) is so slight as to be negligible. In all cases, one must use pharmaceutical and chemical judgment to know how to proceed.

Example (c)

How much Boric Acid must be used to make 30 Gm. of a saturated solution of Boric Acid in Glycerin?

The U.S.P. says that 1 Gm. will dissolve in 4 cc. of Glycerin at 25°C. It further says that the specific gravity of Glycerin must be not less than 1.249 at 25°C.

4 cc. of Glycerin would weigh $4 \times 1.249 = 4.996$ Gm.
1 Gm. + 4.996 Gm. = 5.996 Gm. of saturated solution.
30 Gm. ÷ 5.996 Gm. = 5.003 Gm., or about 5 Gm.

Therefore, one would use 5 Gm. of Boric Acid and 25 Gm. of Glycerin.

Example (d)

How much Boric Acid must be used to make 30 cc. of a saturated solution of Boric Acid in Glycerin?

The solubility of Boric Acid and the specific gravity of Glycerin are the same as in Example (*c*).

4 cc. of Glycerin will weigh 4.996 Gm.
30 cc. of Glycerin will weigh $30 \times 1.249 = 37.47$ Gm.

As in Example (*c*), 1 Gm. of Boric Acid plus 4.996 Gm. of Glycerin will weigh 5.996 Gm. and be a saturated solution.

37.47 Gm. $\div$ 5.996 = 6.249 Gm. of Boric Acid to use.
37.47 Gm. $-$ 6.249 Gm. = 31.221 Gm. of Glycerin to use.

One may at this point weigh the Glycerin and add it or divide the weight of the Glycerin by its specific gravity, thus·

$$31.221 \div 1.249 = 25 \text{ cc. of Glycerin to use.}$$

In practical work one would use 7 Gm. of Boric Acid and 25 cc. of Glycerin.

If one should observe, upon making this solution or any other, that after making the solution it did not measure up to 30 cc. or any other specified volume, one should conclude that the specific gravity of a saturated solution of Boric Acid in Glycerin differed materially from the specific gravity of pure Glycerin, or, in any other case, the solvent used, and then one must add more Boric Acid and Glycerin in the same proportion as before.

Example (*e*)

How much water is necessary to dissolve 100 Gm. of Boric Acid?

With the solubility as before, 1 Gm. will dissolve in 18 cc. of water. Then it will take as many cubic centimeters to dissolve 100 Gm. of Boric Acid as $100 \times 18 = 1{,}800$ cc. of water. The exact volume of the finished saturated solution and its specific gravity are both unknown.

Example (*f*)

How much Boric Acid will 1 L. of water dissolve?

If 18 cc. will dissolve 1 Gm., then 1,000 cc. will dissolve $1{,}000 \div 18 = 55.5$ Gm.

Again, the volume and specific gravity of the finished saturated solution are unknown.

Example (g)

How much water is necessary to dissolve 1 oz., Apothecaries', of Boric Acid?

Again, the solubility is stated, 1 Gm. dissolves in 18 cc. of water. Assuming 1 cc. of water to weigh 1 Gm., then it can be said that 1 gr. of Boric Acid will dissolve in 18 gr. of water. If this statement is true, then it will take as many grains of water to dissolve 480 gr. of Boric Acid as $480 \times 18 = 8{,}640$ gr. of water.

$$8{,}640 \div 454.6 = 19 \text{ fluidounces of water necessary.}$$

Example (h)

How much Boric Acid will 1 fluidounce of water at 25°C. dissolve?

Again, the solubility of Boric Acid in water is the same; 1 Gm. will dissolve in 18 cc. of water at 25°C.

One may likewise say that 1 gr. will dissolve in 18 gr. of water at 25°C.

Then 454.6 gr. of water will dissolve as many grains of Boric Acid as $454.6 \div 18 = 25.25$ gr. of Boric Acid.

Example (i)

How much Potassium Iodide is necessary to make 30 Gm. of a saturated solution of Potassium Iodide?

The U.S.P. gives the solubility of Potassium Iodide as: 1 Gm. dissolves in 0.7 cc. of water.

Observe that this is a very soluble salt and not at all so insoluble as Boric Acid.

One should use 1 Gm. of Potassium Iodide and 0.7 Gm. of water and the resulting solution is 1.7 Gm. of a saturated solution of Potassium Iodide.

To make 30 Gm. of such solution, divide 30 Gm. by 1.7 Gm., thus:

$$30 \div 1.7 = 17.6 \text{ Gm. of Potassium Iodide.}$$

$$30 \text{ Gm.} - 17.6 \text{ Gm.} = 12.4 \text{ Gm. or cc. of water.}$$

This will make 30 Gm. of a saturated solution, but its volume and specific gravity are unknown.

Example (j)

How much Potassium Iodide is necessary to make 30 cc. of a saturated solution of Potassium Iodide?

The solubility is the same as in Example (*i*).

One proceeds to solve the problem in the same manner as in Example (*i*) and gets the same results.

17.6 Gm. of Potassium Iodide are necessary.

12.4 Gm. or cc. of water are necessary.

When these are mixed, 30 Gm. is obtained but not 30 cc. One can then proceed only by mixing Potassium Iodide and water in the same proportion. If one observes the actual volume, then the problem becomes one of making up a solution, the volume of which is the difference between the observed volume and 30 cc., and the proportion is the same as employed to make up this observed volume.

Example (k)

How much Potassium Iodide is necessary to make 1 fluidounce of a saturated solution of Potassium Iodide?

With the solubility the same as given before, one can say 1 gr. of Potassium Iodide dissolves in 0.7 gr. of water to make a saturated solution.

454.6 gr., the weight of 1 fluidounce of water at 25°C., is divided by 1.7 gr., thus:

$$454.6 \div 1.7 = 267.4 \text{ gr. Potassium Iodide to use.}$$
$$454.6 - 267.4 = 187.2 \text{ gr. water to use.}$$

If one mixes these two quantities, one will have a saturated solution which will weigh 454.6 gr. but will not measure 1 fluidounce.

One must then add Potassium Iodide and water in the same proportion until 1 fluidounce is obtained, just as is outlined in Example (*j*).

This is the method to employ with a solute when one has never made a solution of it before. It is a general method.

Example (l)

How much Potassium Iodide is necessary to make 1 fluidounce of a saturated solution of Potassium Iodide?

As the general methods for all such solutions have been given and as this particular solution is frequently asked for in the drugstore, a special method applying to this problem will be given.

The special method following is based solely upon practical experience.

Pharmacists who have had experience with the making of saturated solutions of Potassium Iodide always use 1 oz., Apothecaries', or 480 gr. of Potassium Iodide to make 1 fluidounce of a saturated solution of it.

If water be added gradually to dissolve this amount of salt, it is known that the volume is just a trifle over 1 fluidounce, so that the cost of this solution can be based on the 1 oz., Apothecaries', of salt used. One will discard approximately 1 fluidrachm of solution at each operation. This is necessitated because the solution must be freshly prepared unless one uses a greater volume than 1 fluidounce within a short period.

As said before, this is a special case and the amount is based entirely upon experience. Such other special cases may be evolved by anyone needing them.

This case may be explained mathematically in the following manner:

1 gr. of Potassium Iodide dissolves in 0.7 gr. of water to make 1.7 gr. of a saturated solution.

If one lets 1 gr. or 1 part by weight of Potassium Iodide be represented by 480 gr., then, likewise, 0.7 gr. or 0.7 parts would be represented by 0.7 of 480 gr. or 336 gr. Thus, one could use 480 gr. of Potassium Iodide and 336 gr. of water, which will give a saturated solution and which has been observed to measure just over 1 fluidounce.

This amply illustrates how hard it is to calculate true amounts of a solute and of a solvent to use in preparing a given volume of a saturated solution of a salt that is very soluble in water.

Problems

1. How many grams of Boric Acid should be used to make 1 L. of a saturated solution at 25°C., in water?

2. Assuming the specific gravity of a saturated solution of Boric Acid in water to be 1.000, what would be the percentage strength of such saturated solution? What would be its strength in terms of "parts" or by ratio?

3. How much Magnesium Sulfate should be used to make 1 pt. of a saturated solution at 25°C., in water?

4. How many grams of Sodium Chloride should be used to make 1 L. of a saturated solution at 25°C., in water?

5. How much Sodium Iodide should be used to make 1 fluidounce of a saturated solution at 25°C., in water?

6. How much Chloroform will 1,000 cc. of water dissolve?

7. How much Iodine is necessary to make 500 cc. of a saturated solution at 25°C., in water?

8. How much Corrosive Sublimate is necessary to make 1 pt. of a saturated solution at 25°C., in water?

9. How much Boric Acid can be dissolved by 1 pt. of Glycerin? What would the percentage strength of this solution be?

10. How much Sodium Iodide should be used for 5 lb., Avoirdupois, of a saturated solution?

11. What is the percentage strength of a saturated aqueous solution of Morphine Sulfate? How much of this should be placed in a 1-fluidounce bottle and diluted so that 1 fluidrachm would contain one dose?

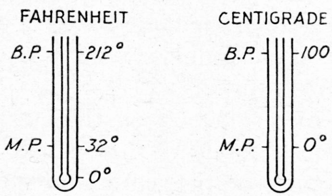
12. How much Zinc Sulfate should be used to make 100 cc. of a saturated solution?

CHAPTER XIV

TEMPERATURE

The instruments used for measuring intensity of heat—thermometers—are graduated in two systems or scales. It becomes our problem here to know how to convert observed readings in one system into readings in the other system.

These systems are those of Fahrenheit, and of Celsius (or Centigrade). The calculations are, of course, based upon the constant points in each system, those of boiling water and of melting ice. These points are usually called the "boiling point" (B.P.) and the "freezing or melting point" (M.P.).



The easiest manner of calculating the factors to convert readings in one system into readings in another system, so that definite rules need not be memorized, is to represent the systems or scales graphically. It is well to draw the scales for the systems under consideration in any given problem as a precaution against error.

First Method.

From the above drawings it will be seen that the following relationship holds true between the lengths of degrees on the scales: 180°F. = 100°C., between the constant points on each scale, the B.P. and the M.P. The fact that the Fahrenheit scale continues for 32° below the M.P. before it comes to its zero must always be taken into consideration when converting degrees Fahrenheit into Centigrade or in converting Centigrade into degrees Fahrenheit; otherwise, merely a direct relation exists.

Example (a)

Convert a reading of 60°F. into the corresponding reading on the Centigrade scale.

Subtract 32 from the degrees Fahrenheit, and divide this remainder by 1.8; the quotient is degrees Centigrade.

Expressed as a mathematical formula,

$$\frac{\text{F.} - 32}{1.8} = \text{C.}$$

Substituting the value for F.,

$$\frac{60 - 32}{1.8} = \text{C.}$$

Solving,

$$\text{C.} = 15.5^\circ.$$

The 32° is first subtracted in order to bring the calculation to the constant point on each scale, *i.e.*, the melting point.

Example (b)

Convert a reading of 25°C. into the corresponding reading on the Fahrenheit scale.

Expressed as a mathematical formula,

$$\text{F.} = (\text{C.} \times 1.8) + 32^\circ.$$

Substituting the value for C.,

$$\text{F.} = (25^\circ \times 1.8) + 32^\circ.$$

Solving,

$$\text{F.} = 77^\circ.$$

The 32° is added so that the final reading in Fahrenheit degrees will be from 0°F., instead of from the melting point, or 32°.

The Fahrenheit and the Centigrade scales are the only ones used, the Fahrenheit being used principally for weather temperatures and the Centigrade for chemical and pharmaceutical operations.

One other scale of temperature might be mentioned at this point, that of absolute temperature. This is the degree of temperature where there is supposed to be no molecular motion and is given as $-273°$ on the Centigrade scale. If a liquid had a temperature of 15.6°C., then its absolute temperature would be $273 + 15.6 = 288.6°$ of absolute temperature, read on the Centigrade scale.

Second Method.

From the drawings of the thermometers at the beginning of this chapter, it is seen that the lengths of the Centigrade degrees are to the lengths of the Fahrenheit degrees as:

$$100:180, \text{ or, more simply, as } 5:9.$$

This easily remembered proportion enables one to convert scale reading from one scale to any other. It is only necessary to know the relative lengths of the degrees on each scale and to remember the ratio 5:9.

One has, therefore, as a basis for converting temperature readings from one scale to another, the proportion:

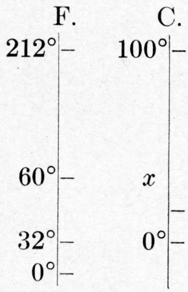
$$\text{C.}:\text{F.} = 5:9.$$

It must be noted that the above proportion is true for lengths of degrees only, and not for temperatures.

In converting temperature readings from Fahrenheit to Centigrade, therefore, or *vice versa*, the fact that the melting point on the Fahrenheit scale is 32° must be taken into consideration. Many errors will be avoided by drawing a diagram representing the thermometric scales under consideration in any given problem.

Example (*a*)

Convert a reading of 60° on the Fahrenheit scale to a corresponding reading on the Centigrade scale.



C.:F. = 5:9

60° − 32° = 28°, number degrees 60° is above M.P. on the Fahrenheit scale

Applying proportion,

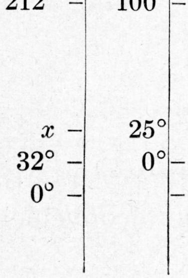
$$\frac{C.}{28} = \frac{5}{9}$$

$$9C. = 140$$

$$C. = 15\tfrac{5}{9}°$$

Example (*b*)

Convert a reading of 25° on the Centigrade scale to a corresponding reading on the Fahrenheit scale.



C.:F. = 5:9

Applying proportion,

$$\frac{25}{F.} = \frac{5}{9}$$

$$5F. = 225$$

$$F. = 45°,$$

number of degrees above the M.P. on Fahrenheit scale.

$$32° + 45° = 77°$$

Third Method.

Some prefer the following method for the conversion of Fahrenheit readings to Centigrade, and *vice versa.*

Example (a)

Convert a reading of 60°F. into the corresponding reading on the Centigrade scale.

Fahrenheit to Centigrade: Add 40, divide by 1.8, and subtract 40, or, expressed as a mathematical formula,

$$C. = \frac{F. + 40}{1.8} - 40.$$

Substituting the value for F.,

$$C. = \frac{60 + 40}{1.8} - 40.$$

Solving,

$$C. = 15.5°.$$

Example (b)

Convert a reading of 25°C. into the corresponding reading on the Fahrenheit scale.

Centigrade to Fahrenheit: Add 40, multiply by 1.8, and subtract 40.

Expressed as a mathematical formula,

$$F. = (C. + 40)1.8 - 40.$$

Substituting the value for C.,

$$F. = (25 + 40)1.8 - 40.$$

Solving,

$$F. = 77°.$$

GRAPHICAL PRESENTATION

Secure a sheet of cross-section paper, 10 by 10 to the inch and 40 in. long or any other size more convenient to the operator.

Draw two vertical lines, from ½ to 2 inches apart and properly spaced from both edges. These two lines represent the two scales of temperature, Centigrade and Fahrenheit.

On the left line, the Centigrade, begin at the top with the B.P. 100°C., and mark each interval of 5°, allowing one space (1/10 inch) to each degree, down to −270°C., and then locate the absolute zero at −273°C.

On the right line, the Fahrenheit, begin at the top with the B.P. 212°F., and mark each interval of 9°, allowing five spaces (½ inch) for each interval, (212°F., 203°F., 194°F., . . .) down to a horizontal line conforming to −273° on the Centigrade scale. Indicate with figures the absolute zero on the Fahrenheit scale.

Connect with dotted lines, horizontally, 100°C. and 212°F., 25°C. and 77°F., 15°C. and 59°F., 0°C. and 32°F., −40°C. and −40°F., and the two absolute zeros. By means of a square or triangle connect 0°F. with the proper point on the Centigrade scale. Do the same with 61°F. Likewise connect 37°C. and 4°C., with their equivalents on the Fahrenheit scale and indicate with figures the points so located.

It may be of value to so mark each of the connected points on the two scales to show of what interest they are to a pharmacist.

Problems

1. Convert a reading of 25° on the Centigrade scale to a corresponding reading on the Fahrenheit scale.

2. Convert a reading of 98.6° on the Fahrenheit scale to a corresponding reading on the Centigrade scale.

3. Convert a reading of 40° below the zero on the Fahrenheit scale (−40°F.) to a corresponding reading on the Centigrade scale.

4. The absolute zero is given as $-273°$ on the Centigrade scale. What is it on the Fahrenheit scale?

5. If the Weather Bureau states the temperature to be 68°F., what should it read on a Centigrade thermometer?

6. Convert a reading of 10° below zero on the Fahrenheit to a corresponding reading on the Centigrade scale.

7. Convert a reading at 2° below zero on the Centigrade scale to a corresponding reading on the Fahrenheit.

8. If a patient shows a temperature of 101.5°F. on a clinical thermometer, what would it be on the Centigrade scale?

9. The U.S.P. says, in preparing Glycerite of Starch, to keep the temperature "below 144°C." What would be the reading if the Fahrenheit thermometer were used?

10. If the maximum density of water is reached at 4°C., what would this point be upon a Fahrenheit thermometer?

CHAPTER XV

ON THE USE OF TABLES

The United States Pharmacopœia and other works used as references by pharmacists and chemists give tables showing the specific gravity and corresponding percentage strengths of alcohol, ammonia water, and acids. As these tables are constantly in use, it may be of value to explain, in some degree, the meaning of them and the calculations involved in using them.

The headings of the alcohol tables will be the only ones discussed in detail, but, after thoroughly understanding them, it will be easy to take up the acids and ammonia water without any explanation, as they are all based upon the same fundamental principle.

The headings of the alcohol tables, as found in the Pharmacopœia, reading from left to right, are as follows:

1. Per cent of C_2H_5OH by volume at 15.56°C.
2. Corresponding per cent of C_2H_5OH by weight.
3. Specific gravity in air at $\frac{25°C.}{25°C.}$
4. Specific gravity in air at $\frac{15.56°C.}{15.56°C.}$
5. Per cent of C_2H_5OH by weight.
6. Corresponding per cent of C_2H_5OH by volume at 15.56°C.
7. Specific gravity in air at $\frac{25°C.}{25°C.}$
8. Specific gravity in air at $\frac{15.56°C.}{15.56°C.}$

To Find Percentage When the Specific Gravity Is Given.

Example (a)

Suppose the specific gravity of an alcoholic liquid is taken at 15.56°C. and found to be 0.9810. If the corresponding percentage by volume is desired, reference is made to column 4, until the specific gravity 0.9810 is found; then, opposite in column 1, the percentage by volume is seen to be 15, which means that in every 100 parts by volume of this alcohol, 15 parts by volume are pure alcohol (C_2H_5OH). Reference to column 2 will show the percentage by weight to be 12.14.

To Find Specific Gravity When Percentage Is Given.

Example (b)

Suppose a bottle was labeled "Alcohol, 20 per cent by volume at 15.56°C." To find the corresponding specific gravity, first find 20 in column 1, and, directly opposite in column 4, the specific gravity of 0.9759 is found, which is the specific gravity of this alcohol, and one does not have to determine it in the laboratory.

Reference may also be made to column 3 at this point in the table, and the corresponding specific gravity of 0.9744 at 25° is found.

To Find Percentage When Specific Gravity Is Not Given in the Table.

In this case, another problem confronts one that is not quite so simple as the foregoing problems. Suppose the specific gravity of an alcohol as found in the laboratory is not found in the table. One should then proceed in the following manner:

Note between what two specific gravities this specific gravity *A* lies. Take the difference between these two specific gravities and call this difference *B*. This difference *B* is the difference in specific gravity corresponding to 1 per cent in the table at this point. Then take the difference between A and the specific gravity corresponding to the lower percentage strength. Use the last value, or C, as a numerator, and, with B as a denominator, take that fraction of 1 per cent and add it to the lower percentage strength.

Example (*c*)

Suppose the specific gravity found at 15.56°C. is 0.9784, to find the percentage by volume corresponding to it.

Reference to column 4 shows that 0.9784 (A) lies between 0.9789 and 0.9779. The difference (B) between 0.9789 and 0.9779 is 0.0010. The difference between 0.9784 (A) and the specific gravity corresponding to the lower percentage strength (0.9789 corresponding to 17 per cent) is 0.0005 (C).

$\frac{0.0005\ (C)}{0.0010\ (B)}$ of 1 per cent $=$ 0.5 per cent to be added to the lower percentage 17, giving a percentage of 17.5, which is the percentage corresponding to a specific gravity of 0.9784.

A specific gravity taken at 25°C. may be treated in the same manner only referring it to column 3 instead of column 4. To obtain the percentage by weight, refer the specific gravity to column 7 or 8 as the case may be.

Before calculating a percentage strength from a specific gravity found by experiment, one should always refer the observed specific gravity to columns 3 and 7, or 4 and 8, as two opportunities are given to find a specific gravity that actually coincides with the observed specific gravity.

Observe that, in alcohol and ammonia water tables, as the percentage increases the specific gravity decreases, and that in acid tables, as the percentage increases, the specific gravity increases, but if the above rule is carefully carried out, it will be found to serve for any of these tables.

To Find Specific Gravity When Percentage Is Not Given in the Tables.

Note between what two percentages in the U.S.P. table the observed percentage A lies. Look in columns 3 and 7 or in columns 4 and 8, as the case may be, for the corresponding specific gravities, depending upon whether the observed percentage is by volume or by weight. Take the difference between these two specific gravities and call this value B. This difference B is the difference in specific gravity corresponding to 1 per cent in the table at this point. Now, multiply B by the fraction of percentage not given in the table, and subtract this value from the specific gravity corresponding to the lower percentage strength. This is the specific gravity sought.

This rule will hold in all cases where the specific gravity *decreases* as the percentage increases.

Example (*d*)

Find the specific gravity of an alcohol known to contain 16.7 per cent by volume of pure alcohol (C_2H_5OH) at 15.56°C.

Reference to column 1 shows the percentage 16.7 to lie between 16 and 17. The corresponding specific gravities as found in column 4 are 0.9800 and 0.9789. The difference between them (B) is 0.0011. (B) multiplied by 0.7 = 1.00077, and 0.9800 minus 0.00077 = 0.97923, the specific gravity corresponding to 16.7 per cent by volume. This may also be applied to any case where the percentage by weight is given and the corresponding specific gravity is sought, except that reference must be made to columns giving percentage by weight.

When the specific gravity *increases* as the percentage strength increases, change the last sentence of the rule to read: "Add this value to the specific gravity corresponding to the lower percentage strength."

Example (e)

Find the specific gravity of a solution of nitric acid known to contain 16.7 per cent by weight of pure nitric acid (HNO_3) at 25°C. (Observe that in tables of acids only percentage by weight is given, and the corresponding specific gravities are given for two temperatures, 15° and 25°C.)

Reference to column 1 shows the percentage 16.7 to lie between 16 and 17. The corresponding specific gravities found in column 2 are 1.0910 and 1.0972. The difference between them (B) is 0.0062. 0.0062 (B) multiplied by 0.7 = 0.00434, and 1.0910 plus 0.00434 = 1.09534, the specific gravity corresponding to 16.7 per cent by weight of nitric acid.

Observe that in the acetic acid tables the percentage scale divides at 79 per cent and that from there on the specific gravity decreases as the percentage strength increases, but that up to this point the specific gravity increases as the percentage increases. There is more than one percentage that has the same specific gravity, and, of course, such a percentage can be determined analytically.

Specific Gravity When Working Temperature Is Other than That Found in the Tables.

The U.S.P. tables for acids and ammonia water have some columns not found in the alcohol tables. One of these has the heading "Correction of specific gravity for 1°C."

Reference to U.S.P. XI, page 607, shows a worked out example for a sample of Sulfuric Acid taken at 21°C. and corrected to 25°C. with the percentage determined.

The remainder of this page together with the footnotes under each of the succeeding tables will show the use of all the columns in the tables.

Other Tables.

The purpose of the other tables in the Pharmacopœia is apparent after a little study and the manner of using them is quite clear. The beginning student should be given some problems to solve involving the use of such tables as coincide with his work so that he may become familiar with them.

Problems

1. If the percentage strength of an alcohol is 76 by volume, what will be its specific gravity at 15.56°C.; at 25°C.?

2. If the specific gravity of an alcoholic distillate observed at 15.56°C. is 0.9697, find its percentage strength by volume; by weight.

3. If the percentage strength of Acetic Acid is 36, what is its specific gravity at 15°C.; at 25°C.?

4. If the percentage strength of a hydrochloric acid is 38.6, find its specific gravity at 25°C.; at 15°C.

5. If the specific gravity of Sulfuric Acid at 15°C. is 1.8400, what is its percentage strength?

6. Find the specific gravity of an alcohol whose percentage strength by volume is 94.9 at 15.56°C. Also one whose strength is 92.3 per cent by weight at 15.56°C. Secure the corresponding specific gravities at 25°C.

7. Calculate the specific gravities at 15.56°C. for alcohols of 48.4 and 49.5 per cent, respectively, by volume.

8. What is the percentage strength of a sulfuric acid which has a specific gravity of 1.0640 at 25°C.?

9. What is the percentage strength of a nitric acid which has a specific gravity of 1.4030 at 25°C.? What should this specific gravity be at 15°C.?

10. What is the percentage strength of a hydrochloric acid which has a specific gravity of 1.1750 at 25°C.? Ditto of one of 1.0460 at 25°C.?

11. An alcohol has a specific gravity of 0.9280 at 25°C. Find its percentage strength. Ditto of one that has a specific gravity of 0.9340 at 15.56°C.

12. An acetic acid has a specific gravity of 1.0091 at 15°C. Find its percentage strength.

13. An acetic acid has a percentage strength of 5.75 at 25°C. Find its specific gravity.

14. The specific gravity of an acetic acid determined at 25°C. is 1.0680. What is its percentage strength?

15. A hydrochloric acid has a percentage strength of 9.8 at 25°C. Find its specific gravity. What would be its specific gravity at 15°C.?

16. A nitric acid has a percentage strength of 19.6. What is its specific gravity at 25°C.?

17. A sulfuric acid has a percentage strength of 98.4 at 25°C. Find its specific gravity.

18. A sulfuric acid whose percentage strength at 25°C. is 97.5 has what specific gravity?

19. An ammonia water having a specific gravity of 0.95810 at 25°C. has what percentage strength?

20. An ammonia water, which has a percentage strength of 27.8, has what specific gravity at 15°C.?

21. An ammonia water having an apparent specific gravity of 0.92261 at 22°C. will have what specific gravity at 25°C.? What is its percentage strength at 25°C.?

22. A sulfuric acid having an apparent specific gravity of 1.1780 at 23°C. has what specific gravity at 25°C.?

23. A sulfuric acid having an apparent specific gravity of 1.1475 at 17°C. will have what specific gravity at 15°C.? What will be its percentage strength at 15°C.?

24. Find the Fahrenheit equivalent of 37°C. and the Centigrade equivalent of 100°F. in the tables found on pages 619 and 620, U.S.P. XI.

25. Can the weight of a liter of distilled water at 25°C. and at other temperatures be obtained from one of the U.S.P. tables?

CHAPTER XVI

PROOF DEGREES

The term "proof degree" is one applied to alcohol and alcoholic liquors as a basis upon which to calculate tax.

A proof gallon of alcohol is a wine gallon of alcohol, containing 50 per cent by volume of pure alcohol (C_2H_5OH), or an equivalent thereof in alcoholic strength. The tax on alcohol or alcoholic liquors is quoted at a definite figure per proof gallon, and the owner must pay a tax of this figure upon every proof gallon that the package contains or that is capable of being made from the contents of the package.

It is seen then that the value of one proof degree is that of 0.5 per cent of alcohol by volume and that 1 per cent of alcohol by volume constitutes two proof degrees.

"Proof spirit" is a term that is applied to alcohol that is exactly 50 per cent by volume in strength.

Wine gallon or United States gallon means a gallon by measure and does not refer to strength or other quality of the liquid. It is a quantitative term.

It will be observed that if one should have a gallon of alcohol that is 100 per cent alcohol by volume, its proof or its strength in terms of proof degrees would be 200.

Example (a)

The U.S.P. says that Alcohol must contain not less than 94.9 per cent by volume of C_2H_5OH. What would be its strength in proof degrees?

If 1 per cent by volume is the equivalent in strength of 2 proof degrees, then 94.9 per cent $\times$ 2 = 189.8 proof, the minimum proof for U.S.P. Alcohol.

Example (*b*)

If a steel drum contains 49 wine gallons of alcohol and is marked "190 proof," how much tax must be paid at the rate of $4.40 per proof gallon?

100 per cent by volume alcohol is 200 proof, and

50 per cent by volume alcohol is 100 proof, or, if a gallon by measure, is 1 proof gallon.

One gallon of 100 per cent by volume will, therefore, make 2 proof gallons.

Likewise, 1 gal. of 190 proof will make 1.90 proof gallons.

49 gal. of 190 proof will make 49 $\times$ 1.9 = 93.1 proof gallons or taxable gallons.

93.1 proof gallons $\times$ $4.40 = $409.64.

Problems

1. If U.S.P. Diluted Alcohol must be at least 48.4 per cent by volume C_2H_5OH, what must be its strength in terms of proof degrees?

2. If a 5-gal. can contains 4⅞ gal. of Alcohol and is marked "190 proof," how many proof gallons or taxable gallons does it contain?

3. If U.S.P. Alcohol Dehydratum must be at least 99 per cent by weight of C_2H_5OH, what would be its strength in terms of proof degrees?

4. If a barrel was labeled "Spirits, 188 proof," what would be its percentage strength by volume?

5. If the tax on alcohol is $3.30 per proof gallon and if the cost of the alcohol is $0.60 per wine gallon, what would be the cost to a druggist of 4⅞ gal. of alcohol, 190 proof, exclusive of the container? What would this cost him per wine gallon; per pint?

6. How many taxable gallons in 3,500 wine gallons of alcohol, 40 per cent by volume?

CHAPTER XVII

DILUTION OF SOLIDS

It is sometimes necessary to dilute or to fortify substances such as powders, extracts, and various solid and semisolid substances in order to reduce them in strength or to increase their strength, as it is likewise necessary to mix solids, powders, extracts, and the like, at times, for economic reasons, and to this end a few such problems are appended. The problems found below are all worked upon the basis of opium as a convenient body to use as an example, as it can be had in powdered form and is one commonly diluted.

Example (a)

A jobbing house purchases 100 lb. of powdered opium, and, after assaying, it is found to contain 16 per cent of morphine. How much diluent such as starch or sugar of milk should be added to reduce its percentage to 12.5 per cent?

(1) 100 lb. × 0.16 = 16 lb. of morphine in the 100 lb. of opium.

12.5 per cent = 16 lb. of morphine.

1 per cent = 1.28 lb. of morphine.

100 per cent = 128 lb., weight of opium after adding diluent.

128 lb. − 100 lb. = 28 lb. of diluent added.

(2) 16 per cent of 100 lb. = 16 lb. of morphine in the 100 lb. of opium. 12.5 per cent of 1 lb. = 0.125 lb. of morphine in 1 lb. of opium after dilution.

Then 16 lb. of morphine will make as many pounds of opium of 12.5 per cent strength as 0.125 lb. is contained times in 16 lb., which is $16 \div 0.125 = 128$ lb. after the opium has been diluted.

128 lb. − 100 lb. = 28 lb. of diluent.

(3) Let x = the pounds of diluent to be added.

Then $100 + x$ = the pounds of mixture after diluting.

$0.125\ (100 + x) = 16$ lb.

$12.5 + 0.125x = 16$ lb.

$0.125x = 3.5$ lb.

$x = 28$ lb. of diluent.

Example (b)

How much opium containing 20 per cent of morphine must be weighed and diluted in order to give 5 lb. of opium containing 12 per cent of morphine? How much diluent must be added?

(1) 5 lb. × 0.12 = 0.6 lb. of morphine in 5 lb. of the 12 per cent opium.

0.6 lb. = 20 per cent of the amount of 20 per cent opium necessary to take.

1 per cent = (0.6 lb. ÷ 20) or 0.03 lb.

100 per cent = 3 lb. of the 20 per cent opium necessary to take.

5 lb. − 3 lb. = 2 lb. of diluent to be added.

(2) Let

x = the pounds of 20 per cent opium to be weighed.

$0.20x$ = the pounds of morphine in x lb. of 20 per cent opium.

12 per cent of 5 lb. = 0.6 lb. of morphine in 5 lb. of 12 per cent opium.

$0.20x = 0.6$ lb.

$x = 3$ lb. necessary, of 20 per cent opium.

Example (c)

A jobber has 200 lb. of powdered opium containing 20 per cent of morphine and 300 lb. of opium containing 10 per cent of morphine. If he mixes these two, what will be the percentage strength of the mixture?

200 lb. × 0.20 = 40 lb. of morphine in the 200-lb. package of opium.

300 lb. × 0.10 = 30 lb. of morphine in the 300-lb. package of opium.

If the two are mixed, the mixture will weigh 300 lb. + 200 lb. = 500 lb. The morphine in the mixture will be 40 lb. + 30 lb. = 70 lb. Calculating the percentage, 70 lb. ÷ 500 lb. × 100 = 14 per cent of morphine.

Example (d)

If a jobber has 300 lb. of 20 per cent opium, how much 10 per cent opium must he add to it in order to make it 12.5 per cent in strength? (Application of algebra to this problem will simplify the solving of it.)

Let

x = the number of pounds of 10 per cent opium to be added.

Then

$300 + x$ = the number of pounds in the mixture.

$0.10x$ = the number of pounds of morphine in the 10 per cent opium.

$0.20\ (300\text{ lb.})$ = the number of pounds of morphine in the 20 per cent opium.

$0.125\ (300 + x)$ = the number of pounds of morphine in the mixture.

As the morphine in the 10 per cent opium plus the morphine in the 20 per cent opium is equal to the morphine in the mixture, the following equation is true:

$$\begin{aligned} 0.10x + 0.20\ (300\text{ lb.}) &= 0.125\ (300\text{ lb.} + x) \\ 0.10x + 60\text{ lb.} &= 37.5\text{ lb.} + 0.125\,x \\ 0.10x - 0.125x &= 37.5\text{ lb.} - 60\text{ lb.} \\ 0.025x &= 22.5\text{ lb.} \end{aligned}$$

and

x = 900 lb. of the 10 per cent opium to be added.

Example (e)

How much opium containing 20 per cent of morphine and how much opium containing 10 per cent of morphine must be mixed in order to have 500 lb. of opium containing 12.5 per cent of morphine?

(1) Let

x = the number of pounds of 20 per cent opium necessary

Then

$500 - x$ = the number of pounds of 10 per cent opium necessary.

$0.20x$ = the number of pounds of morphine in the 20 per cent opium.

$0.10\,(500 - x)$ = the number of pounds of morphine in the 10 per cent opium.

$0.125\,(500)$ = the number of pounds of morphine in the 500 lb. of 12.5 per cent opium.

As the pounds of morphine in the 20 per cent opium plus the pounds of morphine in the 10 per cent opium are equal to the pounds of morphine in 500 lb. of the mixture, the following equation is true:

$$0.20x + 0.10\,(500 - x) = 0.125\,(500).$$
$$0.20x + 50 \text{ lb.} - 0.10x = 62.5 \text{ lb.}$$
$$0.20x - 0.10x = 62.5 \text{ lb.} - 50 \text{ lb.}$$
$$0.10x = 12.5 \text{ lb.}$$
$$x = 125 \text{ lb. of 20 per cent opium necessary.}$$
$$500 - x = 375 \text{ lb. of 10 per cent opium necessary.}$$

(2) Let

x = the pounds of 20 per cent opium necessary,

and

y = the pounds of 10 per cent opium necessary.

Then

$x + y$ = 500 lb., or the weight of the mixture,

and

$0.20x + 0.10y = 0.125\,(500)$,

or

$$0.20x + 0.10y = 62.5 \text{ lb.},$$

or

$$2x + y = 625 \text{ lb.}$$

$$x + y = 500. \qquad (1)$$

$$2x + y = 625. \qquad (2)$$

Subtracting Eq. (1) from Eq. (2),

$$x = 125 \text{ lb. of 20 per cent opium.}$$

$$y = 500 - 125 = 375 \text{ lb. of 10 per cent opium.}$$

If the foregoing problem is worked upon the basis to make up 100 lb. of 12.5 per cent opium, then the quotients given will be the exact proportion in which these substances should be mixed in order to make any amount of the 12.5 per cent mixture.

Example (f)

If one had prepared 100 Gm. of deodorized opium and found it to assay 8.5 per cent anhydrous morphine, how much anhydrous morphine must be added to it to increase its assayed strength to 10 per cent?

(1) Let

x = the grams of anhydrous morphine to be added.

Then

$100 + x$ = the grams of the finished product after fortification.

$0.085\ (100)$ = the grams of morphine in 100 Gm. of 8.5 per cent opium.

$0.10\ (100 + x)$ = the grams of morphine in the finished product.

Therefore,

$$0.085\ (100) + x = 0.10(100 + x)$$

$$8.5 + x = 10 + 0.10x$$

$$x - 0.10x = 10 - 8.5.$$

$$0.9x = 1.5.$$

$$x = 1.67 \text{ Gm. of morphine to be added.}$$

(2) 8.5 per cent of 100 Gm. = 8.5 Gm. of anhydrous morphine.

100 Gm. − 8.5 Gm. = 91.5 Gm. of inert material.

100 per cent − 10 per cent = 90 per cent of inert material.

90 per cent = 91.5 Gm.

1 per cent = 1.0167 Gm.

100 per cent = 101.67 Gm. after fortification.

101.67 Gm. − 100 Gm. = 1.67 Gm. anhydrous morphine to be added.

RULES

In some texts, rules equivalent to the following ones are given for solving this type of problem. These rules have been applied to both liquid and solid substances. Where there is no specific gravity given, the rules will serve for the mixing of solutions on the basis of parts by weight to get weight. These rules are not advocated but are given merely because they are still in use.

Parts by volume may be mixed to get volume if the percentage strength is by volume, as in the case of alcohol, but parts by volume should never be mixed to get volume if the percentage is by weight, as in the case of ammonia water and acids.

The term "substance" will be used later on to mean either solids or liquids.

Example (g)

How much of a 28 per cent substance is needed in order to make 140 lb. of a 10 per cent substance?

Rule.—Parts by weight, expressed in the units of the specific problem corresponding to the lower percentage strength, diluted up to parts by weight corresponding to the higher percentage strength, will give a mixture corresponding in strength to the lower percentage strength.

(1) The proper proportion for mixing in this problem would be:

Take 10 lb. of the 28 per cent substance and dilute it to 28 lb., which will be 28 lb. of a 10 per cent substance.

According to this proportion, 1 lb. of a 28 per cent substance, will be $28 \div 10 = 2.8$ lb. of 10 per cent substance.

It will then take as many pounds of the 28 per cent substance to make 140 lb. of the 10 per cent substance as 2.8 lb. is contained times in 140 lb., which is 50 lb. of a 28 per cent substance.

Then 50 lb. is diluted up to 140 lb. in order that it may be 10 per cent in strength.

(2) Let

$x =$ the pounds of 28 per cent substance necessary.

Then

$$0.28x = 0.10\ (140)$$

or

$$0.28x = 14$$

$x = 50$ lb. of 28 per cent substance.

Example (h)

The converse of Example (*g*) may be worked by the same rule. If one has 25 lb. of a 28 per cent substance, how many pounds of a 10 per cent substance may be made from it?

If 1 lb. of a 28 per cent substance will make 2.8 lb. of a 10 per cent substance, then 25 lb. will make $25 \times 2.8 = 70$ lb. of 10 per cent substance.

Problems

1. If a 1-oz., Avoirdupois, package of powdered opium is at hand containing 12.5 per cent morphine, how many grains of diluent such as starch or sugar of milk must be added to reduce it to 10 per cent?

2. If an ointment containing 50 per cent of mercury is at hand and a prescription calls for 1 oz. of an ointment containing 30 per cent of mercury, how many grains of the former should be used?

3. If one mixes 100 Gm. of extract of opium containing 22 per cent of morphine with 150 Gm. containing 17 per cent of morphine, what will be the percentage strength of the mixture?

4. How many grams of 24 per cent extract of opium must be mixed with 125 Gm. of 19 per cent extract to bring the strength of the mixture exactly to 20 per cent?

5. How many grams of 12 per cent extract of nux vomica and how many grams of 5 per cent extract must be mixed to prepare 1,000 Gm. assaying 7.5 per cent?

6. If one has 500 Gm. of extract of colchicum which assays 0.95 per cent of colchicine, how many grams of colchicine must be added to it to make it assay 1.4 per cent?

7. How many grams of Ung. Hydrarg. Fort. assaying exactly 50 per cent of mercury must be added to 250 Gm. of Ung. Hydrarg. Mit., assaying 27 per cent of mercury, to make it assay 30 per cent?

8. How much strychnine must be added to 220 Gm. of extract of nux vomica assaying 6.9 per cent of strychnine to raise its assayed strength to 7.2 per cent?

9. A sample of yellow mercuric oxide ointment from a 50-lb. lot was assayed and found to contain 0.8 per cent of HgO. How much HgO must be added so that it will assay 1 per cent?

10. How many 2-oz. tubes can be filled from 10 lb. of U.S.P. Ammoniated Mercury Ointment if it is first diluted to 3 per cent in strength?

CHAPTER XVIII

DILUTION OF LIQUIDS

It is often necessary for the pharmacist to make dilutions of or to fortify acids, alcohol, and other liquids, or solutions, in order that he may secure solutions of a certain definite strength. To this end he must be able to calculate the amount of his stock solution to use and the amount of diluent to add. Again, he may wish at times to utilize alcohols of different strengths or acids of different strengths that he may have on hand, if he can ascertain the strength of them after they are mixed together. It is the purpose of this chapter to take up certain specific examples of this kind and, thus, show how these calculations may be made.

Solutions of alcohol and solutions of acids cannot be mixed or diluted in the same manner as can solids, because there is a "contraction in volume" taking place whenever alcohol of one strength is mixed with alcohol of another strength or with water, and when acid of one strength is mixed with acid of another strength or with water.

By "contraction in volume" is meant that one volume (as 100 cubic centimeters) of alcohol mixed with one volume (as 100 cubic centimeters) of water will not give two volumes (as 200 cubic centimeters) of the mixture. The reason for this is sometimes given that the alcohol dissolves in the water or the water dissolves in the alcohol, or that they are mutually soluble. It is sufficient for us to say, however, that the contraction does take place. This is likewise true of acids and of many other liquids.

It is true, however, that one part by weight of alcohol (as 100 grams) mixed with one part by weight (as 100 grams) of water will give two parts by weight (as 200 grams) of the mixture.

In order to make these dilutions correctly, one must either do it on the parts by weight basis, disregarding volumes, or calculate the volumes used from their respective weights.

It is sufficiently accurate for practical purposes to assume the weight of 1 cubic centimeter of water at all temperatures to be 1 gram.

Example (a)

(1) U.S.P. Alcohol is 92.3 per cent by weight and has a specific gravity of 0.816 at 15.56°C. How much of it is necessary to make 500 cc. of 40 per cent by weight alcohol, having a specific gravity of 0.939 at 15.56°C.?

(2) How much water must be used?

(3) What is the contraction in volume taking place?

(1) 1 cc. $\times$ 0.816 $\times$ 0.923 = 0.753168 Gm. of pure alcohol (C_2H_5OH) in 1 cc. of U.S.P. Alcohol.

500 cc. $\times$ 0.939 $\times$ 0.40 = 187.8 Gm. of pure alcohol (C_2H_5OH) in the 500 cc. of the finished solution.

187.8 Gm. $\div$ 0.753168 Gm. = 249.3 cc., amount of U.S.P. Alcohol necessary to make the 500 cc. required.

(2) 500 cc. $\times$ 0.939 = 469.5 Gm., weight of the 500 cc. of finished solution.

249 3 cc. $\times$ 0.816 = 203.4 Gm., weight of the 249.3 cc. of U.S.P. Alcohol used.

469.5 Gm. $-$ 203.4 Gm. = 266.1 Gm. of water to be added.

The 249.3 cc. of U.S.P. Alcohol may be placed in a measuring vessel and water added up to 500 cc. instead of calculating the weight of water to be added.

(3) 266.1 Gm. of water is equivalent to 266.1 cc. of water.

266.1 cc. of water + 249.3 cc. of alcohol = 515.4 cc., which were actually used to make the 500 cc. of finished solution. Therefore, the contraction in volume would be the difference between 515.4 and 500, which is 15.4 cc.

Or the following method may be employed for solving part 1 of this problem:

Let

x = the volume of U.S.P. Alcohol required.

Then

$0.923(0.816x)$ = the weight of pure alcohol (C_2H_5OH) in the finished solution,

and

$0.40(0.939 \times 500)$ = the weight of pure alcohol (C_2H_5OH) in the finished solution.

Therefore,

$$0.923(0.816x) = 0.40(0.939 \times 500).$$
$$0.753168x = 187.8.$$
$$x = 249.3 \text{ cc.}$$

The same methods as used for the above problem can also be used in calculations using any other system of weights and measures.

Example (b)

Aqua Ammoniæ Fortior is 28 per cent by weight in strength and has a specific gravity of 0.897 at 25°C. How much of it will be necessary to make 4 pt. of Aqua Ammoniæ which is 10 per cent by weight in strength and has a specific gravity of 0.958 at the same temperature?

1 fluidounce of water at 25°C. weighs 454.6 gr. (454.6125).

1 fluidounce of Aqua Ammoniæ Fortior weighs $454.6 \times 0.897 = 407.776$ gr.

1 fluidounce of Aqua Ammoniæ Fortior contains 407.776 gr. multiplied by 0.28 = 114.17 gr. of pure ammonia (NH_3).

1 fluidounce of Aqua Ammoniæ weighs 454.6 × 0.958 = 435.50 gr.

4 pt. contain 64 fluidounces; therefore 64 fluidounces of Aqua Ammoniæ weigh 64 × 435.50 = 27,872 gr.

64 fluidounces of Aqua Ammoniæ contain 27,872 × 0.10 = 2,787.2 gr. of pure ammonia (NH_3).

Thus, it will take as many fluidounces of Aqua Ammoniæ Fortior to make 64 fluidounces of Aqua Ammoniæ as 114.17 gr. is contained times into 2,787.2 gr., which is 24.41 times. One should use 24.41 fluidounces (f℥ xxiv, f℥ iii, and ♏ xvii) of Aqua Ammoniæ Fortior and water sufficient to make 4 pt.

In practical work it is not necessary to carry along all the decimals in calculating, but one should observe in each individual problem where this elimination should begin, as it varies, depending upon the purpose for which the solution is to be used.

The converse of the above problems can also be worked by the same method. The following problem will involve the use of alcohol of different strengths from that used in Example (*a*), to show that the method is applicable to any such calculation:

Example (*c*)

1,000 cc. of alcohol, 50 per cent by weight in strength and having a specific gravity of 0.9181 at 15.56°C., will make how much alcohol 10 per cent by weight in strength, having a specific gravity of 0.9838 at the same temperature?

1,000 cc. × 0.9181 = 918.10 Gm., weight of 1,000 cc.

918.10 Gm. × 0.50 = 459.05 Gm. of pure alcohol (C_2H_5OH) in 1,000 cc.

This problem can be completed in two ways:

(1) 1 cc. of 10 per cent alcohol will weigh 1 cc. × 0.9838 = 0.9838 Gm.

0.9838 Gm. $\times$ 0.10 = 0.09838 Gm. of pure alcohol (C_2H_5OH) in 1 cc. of 10 per cent alcohol.

459.05 Gm. $\div$ 0.09838 Gm. = 4,666.09 cc. of 10 per cent alcohol that can be made from 1,000 cc. of 50 per cent alcohol.

In preparing the above solution of 10 per cent strength, the 1,000 cc. of 50 per cent alcohol can be diluted until it measures 4,666.09 cc., or the amount of water to be added can be calculated in the following manner:

4,590.5 Gm. − 918.1 Gm. = 3,672.4 Gm. (or cc.) of water to be added.

(2) This example may be solved in the following manner: Let

x = the number of cubic centimeters of 10 per cent alcohol which can be made.

Then

$0.10\,(0.9838x)$ = the weight of pure alcohol (C_2H_5OH) in the finished solution,

and

$1{,}000 \times 0.9181 \times 0.50$ = the weight of pure alcohol (C_2H_5OH) in the finished solution.

Therefore

$$0.10\,(0.9838x) = 1{,}000 \times 0.9181 \times 0.50,$$

and

$$x = \frac{1{,}000 \times 0.9181 \times 0.50}{0.10(0.9838)} = 4{,}666.09$$

cc. of 10 per cent alcohol.

To explain a similar problem using another system of weights and measures, the following method would be pursued:

Example (d)

One pint of Aqua Ammoniæ Fortior, 28 per cent in strength, having a specific gravity of 0.897 at 25°C., will make how much Aqua Ammoniæ, 10 per cent in strength, having a specific gravity of 0.958 at the same temperature?

One fluidounce of water at 25°C. will weigh 454.6 gr.

One pint of water of 16 fluidounces will weigh $16 \times 454.6 = 7{,}273.6$ gr.

One pint of Aqua Ammoniæ Fortior will weigh 7,273.6 gr. $\times$ 0.897 = 6,524.4192 gr.

One pint of Aqua Ammoniæ Fortior will contain $6{,}524.4192 \times 0.28 = 1{,}826.837376$ gr. of pure ammonia (NH_3). This problem may be worked in two ways from this point:

(1) One fluidounce of Aqua Ammoniæ will weigh $454.6 \times 0.958 = 435.5068$ gr.

$435.5068 \times 0.10 = 43.55068$ gr. of pure ammonia (NH_3) in 1 fluidounce of Aqua Ammoniæ.

1,826.83 gr. of pure ammonia (NH_3) will make as many fluidounces of Aqua Ammoniæ as the number of times that 43.55 gr. is contained in it, which is $1{,}826.83 \div 43.55 = 41.9$ fluidounces of Aqua Ammoniæ which can be made from 1 pt. of Aqua Ammoniæ Fortior.

(2) 1,826.83 gr. of pure ammonia (NH_3) will be 10 per cent of the weight of the Aqua Ammoniæ that can be made. Its total weight, or 100 per cent, will be $10 \times 1{,}826.83 = 18{,}268.3$ gr.

$18{,}268.3 \div 0.958 = 19{,}069.2$ gr., the weight of an equal bulk of water.

19,069.2 gr. $\div$ 454.6 gr. = 41.9 fluidounces of Aqua Ammoniæ which can be made from 1 pt. of Aqua Ammoniæ Fortior.

This problem may also be solved in the following manner Let

x = the number of fluidounces of 10 per cent Aqua Ammoniæ that can be made.

$(454.6x)0.958 \times 0.10$ = the weight of pure ammonia (NH_3) in the finished solution.

And

$454.6 \times 16 \times 0.897 \times 0.28$ = the weight of pure ammonia (NH_3) in the finished solution.

Therefore,

$$(454.6x)0.958 \times 0.10 = 454.6 \times 16 \times 0.897 \times 0.28.$$

$$x = \frac{454.6 \times 16 \times 0.897 \times 0.28}{454.6 \times 0.958 \times 0.10} = 41.9 \text{ fluidounces of Aqua}$$

Ammoniæ.

Problems

1. If an alcohol is 90 per cent by weight and has a specific gravity of 0.8224 at 15.56°C., how much of it is needed to make 1,000 cc. of alcohol 10 per cent by weight having a specific gravity of 0.9839 at the same temperature? How much water must be used? What contraction in volume takes place?

2. If Acetic Acid is 36 per cent by weight and has a specific gravity of 1.0445 at 25°C., how much of it is necessary to make 1 pt. of Diluted Acetic Acid which is 6 per cent by weight, specific gravity 1.0083 at 25°C.?

3. If Acetic Acid is 36 per cent by weight, specific gravity 1.0445 at 25°C., 500 cc. will make how many cubic centimeters of Diluted Acetic Acid which is 6 per cent by weight, specific gravity 1.0083 at the same temperature?

4. One pound, Avoirdupois, of Sulfuric Acid 94 per cent by weight, specific gravity 1.8322 at 25°C., will make how many fluidounces of 10 per cent by weight Sulfuric Acid having a specific gravity of 1.0672 at the same temperature?

5. How many cubic centimeters of Alcohol 92.3 per cent by weight at 15.56°C., specific gravity 0.816, are needed to make 1,000 cc. of diluted alcohol 41 per cent by weight at 15.56°C., specific gravity 0.935?

6. One pound of U.S.P. Sulfuric Acid should make how many fluidounces of Diluted Sulfuric Acid?

7. Nine pounds of U.S.P. Sulfuric Acid should make how many pounds of Diluted Sulfuric Acid?

8. Prove the U.S.P. formula for making Diluted Hydrochloric Acid to be correct.

9. Prove the U.S.P. formula for making Diluted Phosphoric Acid to be correct.

10. Prove the U.S.P. formula for making Diluted Alcohol to be correct.

CHAPTER XIX

DILUTION OF LIQUIDS (*Continued*)

In the previous chapter, alcohol was considered only under the heading of "percentage strength by weight." It is more often spoken of under the heading of "percentage strength by volume." From the above, it is seen that whenever percentage strength of alcohol is mentioned, it is essential to add whether it is meant by volume or by weight. When proof degrees are given, one should know that 2 degrees proof are the equivalent of 1 per cent by volume of alcohol and that proof spirit is 100 proof degrees. In the case of acids and of ammonia water, percentage strength by weight is always meant.

When it is desired to make a certain amount of a weaker alcohol, acid, or ammonia water from a stronger, or to find how much of a weaker may be made from a definite amount of a stronger, it may be done by the methods outlined in the previous chapters or by the following methods. The following method of diluting alcohol on a volume basis is of particular importance to nurses, as they are often called upon to prepare 70 and 50 per cent by volume alcohol.

Dilution of Alcohol by Volume; Metric System.

To make dilutions of alcohol on the percentage strength by volume basis, let the volume percentage of the stronger alcohol be represented by V, and that of the weaker alcohol by v. Then mix v volumes of the stronger alcohol with distilled water to make V volumes of the finished product.

Example (a)

How many cubic centimeters of U.S.P. Alcohol 94.9 per cent by volume are necessary to make 500 cc. of 10 per cent by volume alcohol?

10 volumes of the stronger alcohol must be diluted to 94.9 volumes; 1 volume of the stronger alcohol must be diluted to $94.9 \div 10 = 9.49$ volumes, or 1 cc. of the stronger alcohol would make 9.49 cc. of the weaker alcohol. Then, to make 500 cc. of the 10 per cent alcohol, it will take as many cubic centimeters of 94.9 per cent alcohol as the number of times that 9.49 cc. are contained in 500 cc., which is $500 \div 9.49 = 52.68$ cc., which would then be diluted with distilled water up to 500 cc. In practical work one should use 52.7 or 53 cc. of the stronger alcohol.

Example (b)

1,000 cc. of U.S.P. Alcohol 94.9 per cent by volume will make how many cubic centimeters of 50 per cent by volume alcohol?

If 50 volumes of the stronger alcohol will make 94.9 volumes of the weaker alcohol, then 1 volume of the stronger will make $94.9 \div 50 = 1.898$ volumes of the weaker. Using 1,000 cc. of the stronger as 1 volume, then as many cubic centimeters of the weaker can be made as $1.898 \times 1{,}000 = 1{,}898$ cc. One should then dilute the 1,000 cc. of the U.S.P. Alcohol with distilled water until it measures 1,898 cc. in order that the finished product may be 50 per cent by volume.

Dilution of Alcohol by Weight; Metric System.

To make dilutions of alcohol on the percentage-by-weight basis, let the percentage strength by weight of the stronger alcohol be represented by W, and that of the weaker alcohol by w. Then mix w parts by weight of the stronger alcohol with distilled water to make W parts by weight of the finished product.

Example (*c*)

How much U.S.P. Alcohol 92.3 per cent by weight must be used in order to make 500 Gm. of alcohol 20 per cent by weight?

20 parts by weight of the stronger alcohol must be diluted with distilled water to weigh 92.3 parts by weight; 1 part by weight will then make $92.3 \div 20 = 4.615$ parts by weight.

To make 500 Gm., one must take as many parts of the stronger alcohol as the number of times that 4.615 is contained in 500, which is $500 \div 4.615 = 108.34$ Gm. This amount must be diluted with water to weigh 500 Gm.

NOTE 1.—If one wishes to measure rather than to weigh these amounts, one may divide the grams of the stronger alcohol, 108.34, by its specific gravity, 0.816, and this will give the number of cubic centimeters to take.

Further, one may divide the grams of finished product, 500, by its specific gravity, 0.97137, and the number of cubic centimeters to be made will thus be obtained. This result, of course, may be obtained more easily by working on the volume basis, as in Example (*a*).

Example (*d*)

1,000 Gm. of U.S.P. Alcohol 92.3 per cent by weight will make how many grams of 25 per cent by weight alcohol?

25 parts by weight of the stronger alcohol will make 92.3 parts by weight of the weaker alcohol; 1 part by weight of the stronger will make $92.3 \div 25 = 3.692$ parts by weight of the weaker alcohol. Using 1,000 Gm. of the stronger alcohol as 1 part by weight, it will make one thousand times $3.692 = 3,692$ Gm. of the weaker alcohol. Therefore, 1,000 Gm. of the stronger should be diluted with water until it weighs 3,692 Gm.

NOTE 2.—The same principle as outlined in Note 1, Example (*c*), may also be applied to the above problem.

Dilution of Acids and Solutions of Ammonia; Metric System.

The same methods of procedure as outlined in Examples (*c*) and (*d*) may be applied to these substances. If it is desired to measure these substances, apply the principle outlined in Note 1, Example (*c*).

Dilution of Alcohol by Volume; Apothecaries' System.

Example (*e*)

How many fluidounces of U.S.P. Alcohol, 94.9 per cent by volume, must be used in order to make 1 pt. of 10 per cent by volume alcohol?

10 volumes of the stronger alcohol will make 94.9 volumes of the weaker alcohol; 1 volume of the stronger will make $94.9 \div 10 = 9.49$ volumes of the weaker. To make 16 fluidounces of the weaker will require as many fluidounces of the stronger as the number of times that 9.49 is contained in 16, which is $16 \div 9.49 = 1.68$ fluidounces.

1.68 fluidounces (f℥ i, fʒ v, and ♏ xxiv) of the stronger alcohol should be diluted with distilled water to 1 pt., which gives 1 pt. of 10 per cent by volume.

Example (*f*)

One pint of U.S.P. Alcohol, 94.9 per cent by volume, will make how many fluidounces of 5 per cent by volume alcohol?

5 volumes of the stronger alcohol will make 94.9 volumes of the weaker alcohol; 1 volume of the stronger will make $94.9 \div 5 = 18.98$ volumes of the weaker. Using 16 fluidounces as 1 part by volume, it will make as many fluidounces of the weaker as $18.98 \times 16 = 303.68$ fluidounces (O. xviii, f℥ xv, and fʒ vi) which can be made from 1 pt. of the stronger alcohol.

Dilution of Alcohol, Acids, and Solutions of Ammonia, by Weight; Apothecaries' System.

In order to dilute alcohol on the percentage-by-weight basis, and, likewise, acids, and solutions of ammonia, which are always diluted on the parts-by-weight basis, one can adopt the methods used in these problems. Care should always be exercised to use the same units, be they pounds, ounces, or grains, throughout the whole calculation.

Problems

1. How many cubic centimeters of U.S.P. Alcohol 94.9 per cent by volume are necessary to make 1,000 cc. of alcohol 70 per cent by volume?

2. How much sulfuric acid 94 per cent by weight is necessary to make 500 Gm. of sulfuric acid 10 per cent by weight? How many cubic centimeters would this be?

3. One liter of Alcohol 94.9 per cent by volume will make how many cubic centimeters of 70 per cent alcohol?

4. One pound, Avoirdupois, of sulfuric acid 94 per cent by weight will make how many ounces, Avoirdupois, of 10 per cent by weight acid? How many fluidounces would this be?

5. Five pints of Aqua Ammoniæ Fortior 28 per cent by weight will make how many pints of Aqua Ammoniæ 10 per cent by weight?

6. 50 gal. of Alcohol 94.9 per cent by volume will make how many gallons of 70 per cent by volume alcohol? How many ½-gal. bottles can be filled?

7. A wall work counter is 36 in. high and 30 in. deep. What should be the dimensions of a cylindrical tank that will fit under it in which 50 gal. of Alcohol 94.9 per cent by volume may be diluted to 70 per cent by volume? Allow 4 in. underneath for castors, 2 in. above for clearance, and 3 in. above the liquid for mixing.

8. Read the labels upon the original bottles (about 5 pt. in size) in which c.p. acids and ammonia are delivered to the laboratory. Record the percentage strengths, the specific gravity, and at what temperature, and the capacity of the bottles in pounds, if so labeled. Determine how much, both in pounds and in cubic centimeters, of U.S.P. acids and Ammonia Waters may be made from one bottle of each?

CHAPTER XX

DILUTION OF LIQUIDS (*Continued*)

MISCELLANEOUS

The following types of problems are found only occasionally, but in order that our study of these problems may be complete, it is deemed wise to consider a few of the ways in which dilutions or mixtures of solutions can be made. The solving of these problems is largely for practice, because the mental training obtained by solving them enables one to understand the use of specific gravity wherever it is needed to facilitate solving of practical problems.

Example (a)

(1) If 150 cc. of nitric acid 10 per cent in strength, specific gravity 1.0555, and 300 cc. of nitric acid 18 per cent in strength, specific gravity 1.1034, are mixed, what will be the percentage strength of the mixture?

(2) What is its volume?

(1) 1.0555×150 cc. $= 158.325$ Gm., weight of the 150 cc. of acid.

$158.325 \times 0.10 = 15.8325$ Gm. of pure nitric acid (HNO_3) in the 150 cc.

1.1034×300 cc. $= 331.02$ Gm., weight of the 300 cc. of acid.

331.02 Gm. $\times 0.18 = 59.5836$ Gm. of pure nitric acid (HNO_3) in the 300 cc.

$158.325 + 331.02 = 489.345$ Gm., weight of the mixture.

$15.8325 + 59.5836 = 75.4161$ Gm. of pure nitric acid (HNO_3) in the mixture.

$75.4161 \div 489.345 = 0.1541$, and

$0.1541 \times 100 = 15.41$ per cent, strength of the mixture.

(2) Refer the 15.41 per cent to the U.S.P. tables to find the corresponding specific gravity. This specific gravity is found to lie between the specific gravities corresponding to 15 per cent and 16 per cent. Interpolate for the specific gravity corresponding to 0.41 per cent in the following manner:

15 per cent = 1.0850
16 per cent = 1.0910

Difference = 0.0060. This difference multiplied by 0.41 = 0.00246.

1.0850 + 0.00246 = 1.08746, specific gravity of the mixture.

489.345 Gm. ÷ 1.08746 = 449.98 cc. of the mixture.

Example (b)

How many cubic centimeters of sulfuric acid, 20 per cent in strength, specific gravity 1.1400, and how many cubic centimeters of sulfuric acid, 60 per cent in strength, specific gravity 1.4989, must be taken to make 500 cc. of sulfuric acid, 30 per cent in strength, specific gravity 1.2188?

1.2188 × 500 cc. = 609.40 Gm., weight of 500 cc. of finished product.

Let

x = the number of grams of 20 per cent acid needed.

Then

609.40 − x = the number of grams of 60 per cent acid needed.

The weight of pure sulfuric acid (H_2SO_4) in the 20 per cent acid taken, plus the weight of pure sulfuric acid (H_2SO_4) in the 60 per cent acid taken, is equal to the weight of pure sulfuric acid (H_2SO_4) in the finished product, from which the following equation is deduced:

$$0.20x + 0.60(609.40 - x) = 0.30(609.40).$$

x = 457.05 Gm. of 20 per cent acid.

609.40 − x = 152.35 Gm. of 60 per cent acid.

457.05 ÷ 1.1400 = 400.9 cc. of 20 per cent acid.

152.35 ÷ 1.4989 = 101.64 cc. of 60 per cent acid.

Example (c)

(1) How much 10 per cent sulfuric acid, specific gravity 1.0672, must be added to 500 cc. of 60 per cent sulfuric acid, specific gravity 1.4989, in order that it may be reduced in strength to 15 per cent, specific gravity 1.1027?

(2) What will be the volume of the finished product?

(1) $500 \times 1.4989 = 749.45$ Gm., weight of 500 cc. of 60 per cent acid.

Let $x =$ the number of grams of 10 per cent acid needed.

749.45 Gm. $+ x =$ the weight of the finished product, in grams.

The grams of pure sulfuric acid (H_2SO_4) in the 10 per cent acid used, plus the grams of pure sulfuric acid (H_2SO_4) in the 60 per cent acid used, is equal to the number of grams of pure sulfuric acid (H_2SO_4) in the finished product, from which the following equation is deduced:

$$0.10x + 0.60(749.45) = 0.15(749.45 + x)$$

$x = 6{,}745.05$ Gm. of 10 per cent acid.

$6{,}745.05 \div 1.0672 = 6{,}320$ cc. of 10 per cent acid.

(2) 6,745.05 Gm. + 749.45 Gm. = 7,494.5 Gm. of finished product.

7,494.5 Gm. $\div$ 1.1027 = 6,796 cc. of mixture.

Example (d)

Some U.S.P. Syrup has been accidentally diluted with water. The specific gravity of the mixture is found to be 1.20.

(1) How much water has been added?

(2) How much sugar must be added in order to restore it to the density of U.S.P. Syrup, 1.313, which contains in every liter 850 Gm. of sugar?

(1) 100 cc. of the mixture is used as a basis for calculation.

100 cc. $\times$ 1.20 = 120 Gm., weight of 100 cc. of the mixture.

Let $x =$ the grams of water added in each 100 cc.

$120 - x =$ the grams of U.S.P. Syrup in each 100 cc. of the mixture.

$\frac{x}{1}$ = cubic centimeters of water added.

Then $\frac{120 - x}{1.313}$ = cubic centimeters of U.S.P. Syrup in the mixture

$$\frac{x}{1} + \frac{120 - x}{1.313} = 100 \text{ cc.}$$

x = 36.1 Gm. (or cc.) of water added.

(2) 1.313 Gm. is the weight of 1 cc. of U.S.P. Syrup. If there are 850 Gm. of sugar per liter in U.S.P. Syrup, then in 1 cc. there is 0.85 Gm. of sugar.

1.313 − 0.85 = 0.463 Gm. of water in every cubic centimeter of U.S.P. Syrup.

Then 36.1 Gm. of water will make as many cubic centimeters of U.S.P. Syrup as 0.463 is contained times in 36.1, which is 36.1 Gm. ÷ 0.463 = 77.96 cc. Syrup.

77.96 × 0.85 Gm. = 66.27 Gm. of sugar necessary to be added to every 100 cc. of the mixture.

Problems

1. If 500 cc. of hydrochloric acid 37 per cent in strength, specific gravity 1.1848 at 15°C., be mixed with 500 cc. of acid 10 per cent in strength, specific gravity 1.0493 at the same temperature, what will be the percentage strength of the mixture and its volume?

2. How many cubic centimeters of nitric acid 25 per cent in strength, specific gravity 1.1473 at 25°C., and how many cubic centimeters of 10 per cent in strength, specific gravity 1.0555 at the same temperature, must be mixed in order to make 500 cc. of an acid 15 per cent in strength, specific gravity 1.0850?

3. How much acetic acid 6 per cent in strength, specific gravity 1.0083 at 25°C., must be added to 500 cc. of acetic acid, 40 per cent in strength, specific gravity 1.0483 at 25°C., in order to reduce it to 36 per cent in strength, specific gravity 1.0445?

4. 500 cc. of acetic acid 5 per cent, specific gravity 1.0070 at 25°C., and 1,500 cc., 8 per cent, specific gravity 1.0111 at 25°C., and 4,000 cc., 11 per cent, specific gravity 1.0151 at 25°C., were mixed. Find the percentage strength of the mixture and its volume at 25°C.

5. How much water must be added to the mixture of acids from Prob. 4 to reduce it in strength to 6 per cent, specific gravity 1.0083 at 25°C.?

6. How much Alcohol Dehydratum must be added to 500 cc. of alcohol 92 per cent by weight, specific gravity 0.8104 at 25°C., so that its percentage strength will be exactly 92.3 at 25°C.?

7. 500 Gm. of hydrochloric acid 10 per cent, specific gravity 1.0485 at 25°C., were mixed with 500 Gm. of 20 per cent, specific gravity 1.0960 at 25°C. Will adding the two specific gravities and dividing by 2, give the specific gravity of the mixture? Will adding the percentage strengths and dividing by 2 give the percentage strength of the mixture?

8. Duplicate Prob. 7 using 500 cc. each instead of 500 Gm.

9. Try mixing three equal weights of acids such as, 10, 20, and 30 per cent, and see the effect of dividing by 3. Try three equal volumes.

10. Find the reading Baumé of the two acids in Prob. 7, and see if dividing their sum will give the Baumé reading of the mixture. Try more than two acids and divide by 3.

CHAPTER XXI

ALLIGATION

A chapter upon this subject is included in this work because it is found in nearly all texts in pharmaceutical arithmetic and because employment of this process by state boards makes it imperative.

This process is a means by which quantities of drugs of various percentages of strength may be mixed to obtain a mixture of any definite strength. Alligation may also be applied to liquids, provided there is no contraction in volume upon mixing. Where the weights of liquids are known or can be determined in advance and used, the process of alligation can still be employed.

The percentages of the different ingredients are written in a horizontal row with the percentage of the desired mixture placed above them. Each percentage in the row which is less than that of the mixture is joined with a line to one that is greater, or *vice versa*. Then, starting at the left, the difference between each percentage and that of the mixture sought is placed under the number to which the line leads. The figures thus determined will give the proportionate parts by weight of each ingredient to be used.

Example (a)

In what proportion must a 7 and a 12 per cent substance be mixed in order to make a 10 per cent substance?

	10	
7		12
2		3

2 parts of 7 per cent and 3 parts of 12 per cent would be used.

Example (*b*)

In what proportion would three samples of opium, respectively 9, 12, and 15 per cent in morphine content, be mixed in order to have the mixture contain 10 per cent morphine?

	10	
9	12	15
2	1	1
5		
7	1	1

7 parts of 9 per cent, 1 part of 12 per cent, and 1 part of 15 per cent would be necessary.

Example (*c*)

1. An analytical pharmacist has four samples of a fluidextract, respectively 7, 9, 18, and 20 per cent in strength. How much of each would he need to make the product represent 10 per cent of active ingredient?

		10	
7	9	18	20
8	10	3	1

He would use 8 parts of 7 per cent, 10 parts of 9 per cent, 3 parts of 18 per cent, and 1 part of 20 per cent. These parts should be weighed or their weights be divided by their respective specific gravities to obtain their volumes.

2. In another manner, Example (*c*) may be worked as follows.

$$
\begin{array}{cccc}
 & & 10 & \\
7 & 9 & 18 & 20 \\
10 & 8 & 1 & 3
\end{array}
$$

Both phases may be proved to be correct.
In the first case:

$$
\begin{aligned}
8 \times 7 &= 56 \\
10 \times 9 &= 90 \\
3 \times 18 &= 54 \\
1 \times 20 &= \underline{20} \\
& 220
\end{aligned}
$$

$$\frac{220}{22} = 10$$

Therefore, the mixture is 10 per cent. The second part may be proved in a similar manner.

Example (*d*)

10, 12, and 15 per cent samples of a drug would be mixed in what proportions to make it a 9 per cent product? (Since no percentage is smaller than that of the mixture, we must employ an inert diluent here with the value of zero.)

$$
\begin{array}{cccc}
 & & 9 & \\
0 & 10 & 12 & 15 \\
1 & 9 & 9 & 9 \\
3 & & & \\
\underline{6} & & & \\
10 & \overline{9} & \overline{9} & \overline{9}
\end{array}
$$

10 parts of the diluent, 9 parts of 10 per cent, 9 parts of 12 per cent, and 9 parts of 15 per cent are used, making altogether 37 parts of 9 per cent.

Example (e)

How much of an 8 and of an 11 per cent substance must be used to make 600 Gm. of a 10 per cent substance?

$$\begin{array}{ccc} & 10 & \\ 8 & & 11 \\ 1 & & 2 \end{array}$$

1 part of the 8 per cent substance plus 2 parts of the 11 per cent substance will make 3 parts of the 10 per cent mixture.

The following proportion may then be applied:

$$1:3::x:600, \text{ or } \frac{1}{3} = \frac{x}{600}$$

$$x = 200 \text{ Gm. of 8 per cent substance.}$$

$$600 - x = 400 \text{ Gm. of 11 per cent substance.}$$

SPECIFIC GRAVITIES

Alligation may also be employed when two liquids of different specific gravities are mixed, provided there is no contraction in volume. The procedure is the same as in the case of percentages, except that specific gravities are substituted in the place of percentages and the answers represent parts by measure.

Example (f)

What quantities of Glycerin (specific gravity 1.25) and Alcohol (specific gravity 0.816) must be mixed to have a specific gravity of 1.000?

$$\begin{array}{ccc} & 1.000 & \\ 1.250 & & 0.816 \\ 184 & & 250 \end{array}$$

250 volumes of Alcohol.
184 volumes of Glycerin.

Problems

1. In what proportion should 5 and 14 per cent substances be mixed to produce a 12 per cent substance? Solve by alligation and prove result.

2. In what proportion must 7, 9, 18, and 20 per cent sulfuric acids be mixed to make 500 cc. of 10 per cent sulfuric acid, specific gravity 1.0672 at 25°C.?

3. In what proportion should 9, 12, and 14 per cent opium be mixed and with how much inert diluent in order to make 500 Gm. of 10 per cent opium?

4. In what proportion should 3, 5, 7, and 15 per cent ointments be mixed to make a 10 per cent ointment?

5. In what proportion should 3, 5, 7, 12, 15, and 18 per cent ointments be mixed to make a 14 per cent ointment?

6. In what proportion should glycerin of specific gravity 1.249 be mixed with water to yield a mixture having a specific gravity of 1.1245? Can this be solved by alligation?

7. Show if alligation may be employed in making 1,000 cc. of 70 per cent by volume alcohol from official 94.9 per cent by volume alcohol.

8. See the percentage strengths by weight of the two alcohols in Prob. 7 and solve by alligation.

9. Show in what proportion you would mix 3, 5, and 12 per cent acetic acid to make 6 per cent acetic acid by means of alligation, and demonstrate if this method is the most practical one to use.

10. How much 36 per cent acetic acid must be added to 500 cc. of 5 per cent acetic acid to increase its strength to 6 per cent, specific gravity 1.0083 at 25°C.? May this problem be solved by alligation, and if so, is alligation the best method?

CHAPTER XXII

PERCENTAGE COMPOSITION OF CHEMICALS

As this course is always preceded or accompanied by a course in chemistry where equation writing is taught, no effort will be made in these pages to consider this subject. In most courses in chemistry the solving of the following type of problems is often pursued, and in such cases the following problems may be omitted or simply used as review.

For tables of atomic and molecular weights, see U.S.P. XI, pages 586 to 603.

Example (a)

Find the percentage composition of potassium bromide.

The atomic weight of potassium is..............	39.096
The atomic weight of bromine is................	79.916
The molecular weight of potassium bromide is....	119.01

The percentage of potassium in potassium bromide is

$$\frac{39.096 \times 100}{119.01} = 32.01 \text{ per cent}$$

The percentage of bromine in potassium bromide is

$$\frac{79.916 \times 100}{119.01} = 67.15 \text{ per cent}$$

Example (b)

Find the percentage of potassium in potassium chlorate.

The atomic weight of potassium is..............	39.096
The atomic weight of chlorine is................	35.457
The atomic weight of oxygen (three atoms) is......	48.00
The molecular weight of potassium chlorate is....	122.55

The percentage of potassium in potassium chlorate is

$$\frac{39.096 \times 100}{122.55} = 31.9 \text{ per cent}$$

Example (c)

Find the percentage of copper in U.S.P. Copper Sulfate ($CuSO_4.5H_2O$).

The atomic weight of copper is..................	63.57
The atomic weight of sulfur is....................	32.06
The atomic weight of oxygen (four atoms) is.......	64.00
The molecular weight of water (five molecules)....	90.08
The molecular weight of $CuSO_4.5H_2O$ is...........	249.71

The percentage of copper in U.S.P. Copper Sulfate is

$$\frac{63.57 \times 100}{249.71} = 25.45 \text{ per cent}$$

Problems

1. Calculate the percentage composition of potassium iodide.

2. What is the percentage of iodine in ferrous iodide?

3. What is the percentage of calcium in calcium hydroxide?

4. Find the percentage of iron in U.S.P. Ferri Sulfas ($FeSO_4$.-$7H_2O$).

5. Find the percentage of arsenic in arsenous acid.

6. Calculate the percentage of iron in ferrous carbonate. How many grams of iron in 0.06 Gm. of Ferrous Carbonate? How many grains?

7. Calculate the percentage of iron in Iron and Ammonium Citrates. See U.S.P. XI, page 162.

8. Calculate the percentage of iron in Anhydrous Ferrous Sulfate. Also in the Exsiccated. See U.S.P. XI, page 593.

9. Check the percentage of Iron in Saccharated Ferrous Carbonate, N.F. VI, page 146. What size dose would represent 1 Gm. of Iron? Also 1 gr. of Iron?

10. Calculate the amount of iron in 1 Gm. of mass of Ferrous Carbonate. Express results in grams, also in grains.

CHAPTER XXIII

CHEMICAL REACTION CALCULATIONS

Under this heading may be discussed the following calculations:

a. How much of a chemical must be taken to react completely with a definite weight of another chemical?

b. How much of one or more chemicals must be taken to form a definite weight of a third chemical?

c. How much of a chemical can be prepared from a definite weight of another chemical?

In problems of this type, one must know how to write the chemical equation, and to do this must know the constituents used and the products formed. These facts are obtained from a study of chemistry and by reference to suitable chemical literature.

The fact that it sometimes requires more than the theoretical amount of one chemical, reacting with a definite amount of another chemical, to cause the reaction actually to take place, will not be discussed here but will be left entirely to the domain of physical chemistry.

In order to explain these problems in detail, the chemicals themselves will have to be considered in two ways:

1. That they are 100 per cent pure.
2. That they are not 100 per cent pure, but that their percentage purity is known.

Most textbooks of chemistry perform these calculations upon the basis that the chemicals are 100 per cent pure, and so we shall consider this phase of calculations first. Reference to the U.S.P. will show that many chemicals—in fact, all of them—are not absolutely pure, and so proper allowance will have to be made, in some instances, for this fact. Some chemicals are so nearly pure that the error involved in not considering them pure is negligible (except in analytical operations), as, for instance, Potassium Bicarbonate, which the U.S.P. says should be 99 per cent pure. In the case of Potassium Hydroxide, which is only 85 per cent pure, the variation cannot be neglected in our calculations.

Calculations with Pure Chemicals.

In stating the proportions in the following problems, when an expression such as NaOH:HCL or the expression $2NaOH:H_2SO_4$ is used, the symbolic formulas will stand for the molecular weights of these substances. In addition, these symbolic formulas may also mean molecular weight in grams, ounces, pounds, grains, etc., depending upon the units of weight used in the specific problem under consideration, but observe that the same units must always be used throughout a proportion in order that the amounts be proportional to one another.

Example (*a*)

How many grams of sodium hydroxide (NaOH) are necessary to react completely with (neutralize) 100 Gm. of hydrochloric acid (HCl)?

$$NaOH + HCl = NaCl + H_2O.$$

From this equation it is seen that it requires one molecule of HCl to react completely with one molecule of NaOH.

$$NaOH:HCl::x:100$$
$$40.00:36.47::x:100$$
$$\frac{40.00 \times 100}{36.47} = 109.67$$
$$x = 109.67 \text{ Gm. of } NaOH.$$

Example (*b*)

How many grams of potassium hydroxide (KOH) are necessary to react with (neutralize) 50 Gm. of sulfuric acid (H_2SO_4)?

$$2KOH + H_2SO_4 = K_2SO_4 + 2H_2O.$$

From this equation it is seen that it requires two molecules of KOH to react completely with one molecule of H_2SO_4.

$$2KOH:H_2SO_4::x:50$$
$$112.20:98.08::x:50$$
$$\frac{112.20 \times 50}{98.08} = 57.19.$$
$$x = 57.19 \text{ Gm. of } KOH.$$

Example (*c*)

How many grams of sodium hydroxide (NaOH) must be used to make 216 Gm. of NaCl?

$$NaOH + HCl = NaCl + H_2O$$

From this equation it is seen that it requires one molecule of NaOH to form one molecule of NaCl.

$$NaOH:NaCl::x:216$$
$$40.00:58.45::x:216$$
$$\frac{40.00 \times 216}{58.45} = 147.81$$
$$x = 147.81 \text{ Gm. of } NaOH.$$

Example (*d*)

How many grams of barium dioxide (BaO_2) must be used to make 50 Gm. of hydrogen peroxide?

$$6BaO_2 + 6H_2O + 4H_3PO_4 = 6H_2O_2 + 2Ba_3(PO_4)_2 + 6H_2O.$$

From this equation it is seen that it requires one molecule of BaO_2 to make one molecule of H_2O_2.

$$BaO_2 : H_2O_2 : : x : 50$$
$$169.36 : 34.02 : : x : 50$$
$$\frac{169.36 \times 50}{34.02} = 248.91$$
$$x = 248.91 \text{ Gm. of barium dioxide.}$$

Example (e)

10 Gm. of pure iron wire will make how many grams of ferrous iodide (FeI_2)?

$$Fe + 2I = FeI_2$$

From this equation it is seen that every atom of iron requires two atoms of iodine to form FeI_2, or that one atom of iron is necessary to form one atom of ferrous iodide.

$$Fe : FeI_2 : : 10 : x$$
$$55.84 : 309.68 : : 10 : x$$
$$\frac{309.68 \times 10}{55.84} = 55.4$$
$$x = 55.4 \text{ Gm. } FeI_2$$

Example (f)

500 Gm. of ferrous sulfate ($FeSO_4$) will make how many grams of ferric sulfate ($Fe_2(SO_4)_3$)?

$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 = 3Fe_2(SO_4)_3 + 4H_2O + 2NO.$$

From this equation it is seen that it takes two molecules of $FeSO_4$ to make one molecule of $Fe_2(SO_4)_3$.

$$2FeSO_4 : Fe_2(SO_4)_3 : : 500 : x$$
$$303.80 : 399.86 : : 500 : x$$
$$\frac{399.86 \times 500}{303.80} = 658.09$$
$$x = 658.09 \text{ Gm. of ferric sulfate.}$$

Calculations with Chemicals Observing Purity.

Example (a)

How many grams of U.S.P. Sodium Hydroxide (95 per cent) are necessary to react completely with (neutralize) 100 Gm. of a sample of U.S.P. Hydrochloric Acid which is 36 per cent pure?

If this U.S.P. Hydrochloric Acid is 36 per cent pure, then 100 Gm. of it will contain 36 per cent of 100 Gm., which is 36 Gm. of pure hydrochloric acid (HCl).

$$NaOH + HCl = NaCl + H_2O$$
$$NaOH : HCl :: x : 36$$
$$40.00 : 36.47 :: x : 36$$
$$\frac{40.00 \times 36}{36.47} = 39.48$$
$$x = 39.48 \text{ Gm. of pure NaOH.}$$

If U.S.P. NaOH is 95 per cent pure, then 39.48 Gm. of pure NaOH will make

$$\frac{39.48 \times 100}{95} = 41.55 \text{ Gm. of U.S.P. Sodium Hydroxide}$$

Example (b)

How many grams of U.S.P. Sodium Hydroxide (95 per cent) must be used to make 200 Gm. of U.S.P. Sodium Chloride (99 5 per cent)?

If U.S.P. NaCl is 99.5 per cent pure, then 200 Gm. of U.S.P. NaCl will contain 99.5 per cent of 200 Gm., which is 199 Gm. of pure sodium chloride (NaCl).

$$NaOH + HCl = NaCl + H_2O$$
$$NaOH : NaCl :: x : 199$$
$$40.00 : 58.45 :: x : 199$$
$$\frac{40.00 \times 199}{58.45} = 136.18$$
$$x = 136.18 \text{ Gm. of pure sodium hydroxide (NaOH).}$$

If U.S.P. Sodium Hydroxide is 95 per cent pure, then 136.18 Gm. of pure sodium hydroxide (NaOH) will make

$$\frac{136.18 \times 100}{95} = 143.34 \text{ Gm. of U.S.P. Sodium Hydroxide.}$$

Example (*c*)

How many pounds of a 65 per cent pure sodium hydroxide are needed to react with 250 lb. of U.S.P. Epsom Salt in making Milk of Magnesia by the precipitation method?

U.S.P. Epsom Salt contains "not less than 45 per cent and not more than 52 per cent of water." An average percentage would be 48.5. 48.5 per cent of 250 lb. = 121 lb.

$$250 \text{ lb.} - 121 \text{ lb.} = 129 \text{ lb.}$$

$$MgSO_4 + 2NaOH = Mg(OH)_2 + Na_2SO_4.$$

$$MgSO_4 : 2NaOH :: 129 \text{ lb.} : x$$

$$120.38 : 80.00 :: 129 \text{ lb.} : x$$

$$\frac{80.00 \times 129 \text{ lb.}}{120.38} = 85.72$$

$x = 85.72$ lb. of pure sodium hydroxide (NaOH).

If the sodium hydroxide to be used is 65 per cent pure, then 85.72 lb. of pure sodium hydroxide (NaOH) will make $\frac{85.72 \text{ lb.} \times 100}{65} = 131.88$ lb. of the 65 per cent sodium hydroxide needed.

Problems

1. How many grams of hydrochloric acid (HCl) are necessary to react completely with (precipitate the silver chloride from) 100 Gm. of silver nitrate ($AgNO_3$)?

2. How many grams of ammonium hydroxide are necessary to react completely with (neutralize) 100 Gm. of sulfuric acid (H_2SO_4)? Also if one should use U.S.P. Aqua Ammoniæ Fortior and U.S.P. Acidum Sulfuricum?

3. How many grams of potassium hydroxide (KOH) must be used to make 454 Gm. of potassium iodide (KI)?

4. How many grams of calcium carbonate ($CaCO_3$) must be used to make 100 Gm. of calcium chloride ($CaCl_2$)?

5. How many grams of a solution of ammonium hydroxide 28 per cent pure are necessary to react completely with 500 Gm. of a solution of ferric chloride which contains 10 per cent of $FeCl_3$?

6. How many pounds of U.S.P. Sodium Hydroxide are needed to react with 125 lb. of U.S.P. Salicylic Acid?

7. How many pints of U.S.P. Stronger Ammonia Water should be used to react with 25 lb. of U.S.P. Mercuric Chloride? What should be the theoretical yield of Ammoniated Mercury?

8. How much U.S.P. Mercuric Chloride and how much U.S.P. Sodium Hydroxide should be used to prepare 25 lb. of U.S.P. Yellow Mercuric Oxide?

9. Check the U.S.P. formula for Magma of Ferric Hydroxide and point out which ingredient is in excess after the reaction is complete.

10. Check the quantities of Magnesium Carbonate and Citric Acid used in preparing the official solution of Magnesium Citrate. Note the pharmacopoeial requirement for quantity of MgO.

CHAPTER XXIV

COMMERCIAL DISCOUNTS

As there is always need for commercial calculations in the retail drugstore, a few problems of this nature are, therefore, appended.

Example (a)

If a certain medicinal preparation is listed at \$15 a dozen, 40 per cent off, what will be the cost to the druggist of one bottle?

40 per cent of \$15 = \$6.
\$15 – \$6 = \$9.

This preparation will cost \$9 per dozen, and \$9 divided by 12 will give \$0.75 as the cost of one bottle.

Example (b)

If a certain medicinal preparation is listed at \$19.50 a dozen, less 40 and 15, what will be the cost to the druggist of a single bottle?

40 per cent of \$19.50 = \$7.80.
\$19.50 – \$7.80 = \$11.70.
15 per cent of \$11.70 = \$1.75.
\$11.70 – \$1.75 = \$9.95.

This preparation will cost \$9.95 per dozen, and \$9.95 divided by 12 will give \$0.83 as the cost of one bottle. Or,

60 per cent of \$19.50 = \$11.70.
85 per cent of \$11.70 = \$9.95.
\$9.95 ÷ 12 = \$0.83 as the cost of one bottle.

Example (c)

If a certain medicinal preparation is listed at \$24 per dozen, less 40 and 10, with 2 per cent off for cash in 30 days, what will one gross cost the druggist who discounts his bills?

40 per cent of \$24 = \$9.60.
\$24 − \$9.60 = \$14.40.
10 per cent of \$14.40 = \$1.44.
\$14.40 − \$1.44 = \$12.96.
2 per cent of \$12.96 = \$0.26.
\$12.96 − \$0.26 = \$12.70.
One gross will cost 12 × \$12.70 = \$152.40.

or,

60 per cent of \$24.00 = \$14.40.
90 per cent of \$14.40 = \$12.96.
98 per cent of \$12.96 = \$12.70.
One gross will cost 12 × \$12.70 = \$152.40.

Problems

1. If a medicinal preparation is listed at \$28 per dozen packages, with a discount of 40 per cent offered, what will one package cost?

2. If a chemical is listed at \$6.50 per pound, less 25 and 10, what will 1 lb. cost?

3. If a medicinal preparation is listed at \$2.25 per pound bottle, with discounts of 25 and 10 and an additional 1 per cent for cash offered, what will two bottles cost with all discounts taken?

4. If glycerin be quoted at \$0.41 per pound with a discount of 5 per cent offered, what will 50 lb. cost?

5. If a case of three gross of bottles be offered at \$18 with a discount of 5 per cent and with an additional 1 per cent for cash, what will one bottle cost?

6. A druggist bought 1,000 cigars for \$37.50. He received a rebate check for \$2 and was given discounts of 5 and 2 per cent. What was the net cost of one cigar?

7. If the wholesale price of one bottle of 100 tablet triturates of codeine sulfate, strength gr. ¼, is \$1.80, less discounts of

30 and 5 per cent, what percentage of saving would there be to the pharmacist if he should make his own tablet triturates, the price of codeine sulfate being $8.75 per ounce? (Disregard filler and overhead.)

8. A certain article costs, in small quantities, $4.75 per dozen. If six dozen are purchased, an extra dozen is sent free and discounts of 10 and 10 per cent are allowed. What is the net cost of a single article when bought this way?

9. A box containing 20 panes of window glass is listed at $83 less discount of 85, 10, and 5 per cent. The freight is $0.85. What is the cost of a single pane?

10. A druggist buys four dozen articles for $19.20 with one-fourth dozen free goods, and two dozen articles for $19.20 with one-sixth dozen free goods. The freight on the package is $1.63 and is deductible from the bill. The discounts are 10, 5, and 2 per cent. Calculate net cost of a single article of each kind.

11. A druggist receives a bill of goods priced at $625 marked 2 per cent in 10 days and net in 30 days. Would he save or lose by borrowing money for one month at 6 per cent per annum to discount this bill and how much?

12. If the terms in Prob. 11, read 3 per cent in 10 days and 1 per cent 15 days and net in 30 days, what would the druggist save by borrowing money at 6 per cent per annum for one month on the eighth day as compared with the thirteenth day?

13. A firm offers a druggist merchandise with the option of credit for 90 days or 3 per cent for cash on delivery. What is the highest interest rate he can pay on borrowed money in order to pay cash?

14. Calculate a single discount equivalent to each series of discounts listed. (*a*) 20, 10, and 5. (*b*) 25, 10, 10, and 2. (*c*) 20, 10, 5, and 5. (*d*) 60, 5, 5, and 1. (*e*) 10, 10, 3, and 2.

15. A proprietary lists at $4.60 per dozen in gross lots and one dozen free on such an order if paid for upon delivery. This would be equivalent to what discount and how much would be saved on each item?

CHAPTER XXV

PROFIT AND LOSS

The question of profit upon any item sold is a thing that every business man should thoroughly understand. It is suggested here that the important point for a retail dealer to know is the amount of profit made upon an article in actual dollars and cents, because percentage profit may be twisted about to suit the ideas of each individual.

The salesman is often schooled to talk percentage of profit to the retailer and to forget about the item of overhead expense. If one desires to calculate profit in terms of percentage, one should say to the salesman that the cost of doing business in the store in question is a certain amount or percentage of the gross sales each year, and then proceed with the calculation of percentage profit on the goods offered for sale.

For a clear understanding of this subject, the student should secure from some store in which he is interested the actual figures of the expenses for one year and calculate the cost of doing business, known, usually, as "overhead expense," which must be met in all cases before a cent of profit can be made. In the retail store a basis of 52 weeks per year is probably the easiest method from which to derive a fair estimate of this. Secure the gross sales of this store for one year. Then secure the data on the following items: salaries, including proprietor's salary; interest upon the investment at the legal rate; taxes, insurance; heat and light; rent or equivalent upon owned property; cartage, expressage, and freight; losses in stock and apparatus; uncollected accounts; telephone; supplies, such as ice, upon which no resale is made; depreciation upon fixtures; advertising; donations to charity; and any other specific or incidental expenses. There may be some objections by some to a few of the items entered above, but, where they constitute about the same figures from year to year, they must be observed.

One attempt at such calculations will prove to the student whether he should enter into business for himself at once upon graduation, or whether he should clerk long enough to learn how to keep down expenses. It is not the volume of business done, but profit earned, that spells success.

The word "profit" as used thus far in this chapter means *net profit*, which is determined by subtracting all forms of expense or cost from the gross receipts.

Overhead consists of all expenses with the exception of the cost of the goods, that is, total business expense.

Gross profit is determined by subtracting the cost of the goods from the selling price. This is also known as *markup* or *margin*.

Inventory is a list of stock with value attached. This is usually based upon cost figures, though it can be upon selling price.

Average stock is the average amount invested in stock for a given period. This is found by adding the inventory at the beginning of the period to the inventory at the close of the period and dividing by 2. This is also known as *average inventory*.

Turnover is the number of times stock may be sold and replaced within any given space of time.

Markup per cent is markup divided by selling price.

Gross profit per cent is the same as markup per cent.

Overhead expense per cent is total business expense divided by total sales.

Markdown is the difference between a previous and the present selling price.

Markdown per cent is the markdown divided by the previous selling price.

If one keeps clearly in mind that selling price is made up of three items, *cost of the article*, *overhead*, and *net profit*, few mistakes will be made. The main differences of opinion and misunderstandings occur when these three items or various combinations or derivatives of them have been converted into percentage figures. Percentage figures are capable of many interpretations.

Example (a)

If the cost of a single article is \$1.25, and if the cost of doing business is 30 per cent of the gross sales, for how much must this article be sold in order to realize a profit of 10 per cent?

10 per cent of the selling price is profit for the store.
30 per cent of the selling price is the cost of doing business.
60 per cent, remaining, must cover the cost of the article.
100 per cent is the selling price of the article.

60 per cent = \$1.25.
1 per cent = \$0.0208.
100 per cent = \$2.08.

Or, by means of a formula:

100 per cent = selling price.
(a) per cent = net profit.
(b) per cent = overhead.
$100 - a - b$ = the total cost in per cent.

$$\text{Selling price} = 100 \times \frac{\text{cost}}{100 - a - b}.$$

$$\text{Selling price} = 100 \times \frac{\$1.25}{100 - 10 - 30}.$$

$$\text{Selling price} = \$2.08.$$

Example (b)

If the selling price of an article is $0.89, the cost of doing business is 25 per cent, and the profit is 5 per cent, what is the cost price?

5 per cent of the selling price is the profit for the store.
25 per cent of the selling price is the cost of doing business.
70 per cent, remaining, must be the cost of the article.
100 per cent is the selling price of the article.
100 per cent = $0.89.
1 per cent = $0.0089.
70 per cent = $0.62.

If one desires to calculate the profit upon the cost price alone, then the following problem will serve as an example:

Example (c)

If an article costs $0.66, and one wishes to make a profit of 10 per cent when the cost of doing business is 30 per cent, for how much must the article sell?

10 per cent of $0.66 = $0.066. $0.66 + $0.066 = $0.726.
30 per cent of the selling price is the cost of doing business.
70 per cent, remaining, includes profit and purchase price.
100 per cent is the selling price.
70 per cent = $0.726.
1 per cent = $0.01037.
100 per cent = $1.04.

If one wishes a quick method to calculate a selling price from the cost of the article alone the following formula may be used:

$$\frac{S}{100 - S} \times 100 = C.$$

100 per cent = the selling price.
S = the percentage of gross profit desired on the selling price.
$100 - S$ = cost of the article expressed as percentage of selling price.
C = percentage of profit based on cost.

Example (*d*)

A medicine cost \$0.69. What should it sell for to make a gross profit of 50 per cent?

$$\frac{50}{100 - 50} \times 100 = C$$

C = 100 per cent to be added to cost.

\$0.69 + \$0.69 = \$1.38

Example (*e*)

A medicine costs \$0.23. What should it sell for to make a gross profit of 35 per cent?

$$\frac{35}{100 - 35} \times 100 = C.$$

C = 53.8 per cent (54 per cent)

54 per cent of \$0.23 = \$0.12

\$0.23 + \$0.12 = \$0.35, the selling price

Or suppose

30 per cent = the overhead
5 per cent = the net profit.
65 per cent = the cost.

100 per cent = the selling price.
65 per cent = \$0.23
1 per cent = \$0.0035
100 per cent = \$0.35, the selling price.

As has been stated before, it is immaterial what system one uses, but one should never neglect the fact of overhead expense, and one should always know exactly what profit is being made in a store in order to avert disaster.

Problems

1. If the cost of a hair brush is \$0.78 and if overhead is 24 per cent, for how much must this brush sell to realize a profit of 10 per cent?

2. If the selling price of an article is \$1, the profit made is 10 per cent, and the cost of doing business is 25 per cent, what did the article cost?

3. If an article cost \$0.58 and sells for \$1 and the cost of doing business is 25 per cent, what is the percentage of profit?

4. If an article costs \$8 per dozen, the retail price per article is \$0.85, and the cost of doing business is 25 per cent, is a profit earned or a loss sustained?

5. If an article cost \$0.67 and sells for \$1 and the cost of doing business is 27 per cent, does one make a profit or sustain a loss to sell two such articles at one time for \$1.01?

6. If Sulfuric Acid, specific gravity 1.84, costs \$0.10 per pound, at what price per pint must it be sold to give a gross profit of 50 per cent upon the selling price?

7. A pharmacy has yearly sales of \$30,000. The cost of conducting the business is 24 per cent of the gross receipts. State the percentage of gross profit that must be made on the year's sales to produce a net profit of \$4,500.

8. If the cost of doing business is 25 per cent of the gross sales, what should the merchant pay for an article retailing at \$1.50 in order to make a net profit of 15 per cent?

9. A bottle of phenacetin tablets is listed at \$3 with discounts of 30, 5, and 2 per cent. At what price must it be sold to yield a gross profit of 40 per cent upon the retail selling price?

10. A pharmacist bought a gross of talcum listed at \$45 per gross. The maker advanced the list price $33\frac{1}{3}$ per cent but allowed discounts of 10, 8, and 4 per cent. He also added one and one-half dozen as free goods. At what price must a single can be sold to make a profit of 75 per cent based upon cost?

11. A pharmacist insures his store, stock and fixtures for three-fourths of their value. His premium was \$270 for 3 years based upon a rate of 1.5 per cent per \$1,000. What is the value of his store?

12. A druggist's sales are $48,000 per year and his total overhead is $14,000. If he marks an article to sell for $0.75 which cost $6 per dozen, what will be his percentage of net profit?

13. The report of the business for one year in a drugstore is as follows:

Inventory, Jan. 1....................	$ 6,020.20
Inventory, Dec. 31....................	6,743.24
Purchases for the year...............	37,134.50
Salaries (partners, clerks, other help)..	7,400.00
Freight and express.................	70.00
Rent.............................	2,400.00
Repairs...........................	785.10
Taxes.............................	330.80
Supplies..........................	196.44
Other expenses (interest, depreciation, etc.)...........................	1,556.28
Sales.............................	50,756.72

Calculate percentage increase in inventory. Turnover. Percentage of overhead. Gross profit, amount and percentage. Net profit, amount and percentage. Percentage of merchandising cost.

14. A druggist bought a gross of toothpaste listed at $2.40 per dozen. The manufacturers advanced the list price 25 per cent but allowed discounts of 10, 8, and 2 per cent. They also added 1 dozen as free goods. At what price must a single tube be sold in order to make a profit of 50 per cent on the selling price?

15. Complete the following table by computing the percentage markup on cost necessary to make the percentage on sales listed:

% net profit on sales	5	10	15	16⅔	20	25	30	33⅓	50
% markup on cost									

16. A druggist buys 500 aspirin tablets for $1.25. He sells them for 10 cts. per dozen. The cost of doing business is 20 per cent. What is his net profit? What is the percentage of net profit? What is the percentage of gross profit?

17. If chloroform, specific gravity 1.47, costs 25 cts. per pound, for what price per pint should it be sold to give a gross profit of 50 per cent on the selling price?

18. A soda fountain costs $500, is of service for ten years, and has a scrap value of $50. Calculate the depreciation per year. Show by graph the accumulated depreciation and the value of the fountain at the end of each year.

19. Assuming that 0.5 per cent of the total soda sales are allotted to depreciation, how much must be taken in at the soda fountain per month to cover the depreciation on the fountain in Prob. 18?

20. By selling a dozen bottles of medicine at $1.25 each, a druggist would have made 66⅔ per cent net profit, but he let one bottle fall and break. What was his percentage profit, the eleven selling at full price?

21. If rent is $75 per month, salaries $250, other expenses $25, the gross profit on goods sold 33⅓ per cent, what must be the amount of goods sold so that the proprietor will come out even at the end of the month?

22. It costs 2⅓ cts. to dispense a glass of soda water, exclusive of clerk hire. How many glasses a day at 5 cts. per glass would a $10-per-week clerk have to dispense in a week of six days to make a profit to the proprietor of three times the clerk's salary?

23. If the proper amount of syrup for a popular beverage cost ¾ ct. and the soda dispenser puts in 15 per cent more than is necessary, what is the loss on 200 glasses?

INDEX

A

Absolute temperature, 82
Acids, dilution of, 104, 114, 116
Acre, 15
Alcohol, acid, etc., use of tables, 87
  dilution of, 104, 105, 107, 111
Alligation, 121
  observing specific gravity, 124
Ammonia, dilution of, 106, 108, 114
Answers, when apothecaries', 52
  when metric, 52
Apothecaries' measure, 3
Apothecaries' prescription form, 4
Apothecaries' symbols, 2, 3
Apothecaries' weight, 2
Approximate measure, 13
Are, 8
Avoirdupois weight, 3

B

Bale, 14
Barrel, 13
Baumé hydrometers, 38
Board measure, 15
Bottles, prescription, size of, 14
Bundle, 14
Bushel, 15

C

Carat, 13
Centare, 8
Centigrade, 80
Centigram, 9
Centiliter, 8
Centimeter, 8
Chemicals, percentage composition, 126
  reaction calculations, 128
Combining weights, of chemicals, 128
Commercial discounts, 135
Compounding, calculations, 46
Contraction in volume, 104
Cord, 15
Cowling's rule of dosage, 25
Cubic centimeter, 9
  abbreviation for, 9
  weight of, 12, 40
Cubic inch, of water, weight of, 12
Cubic measure, 15

D

Decigram, 9
Deciliter, 8
Decimeter, 8
Degrees, proof, 94
Degrees, temperature, 80
Dekagram, 9
Dekaliter, 8
Dekameter, 8
Density, 29
Dessertspoonful, 13
Dilution, acids, 104, 114
  alcohol, 104, 105, 107, 112
  ammonia, 104, 106, 108, 114
  liquids, 104, 116
  miscellaneous problems, 116
  rules, 101
  solids, 96
Discounts, commercial, 135
Dispensing, calculations, 46
Displacement method, specific gravity, 30

Domestic measure, 13
Dosage, 24
  Cowling's rule, 25
  dilution of, 25
  hypodermic, 25
  narcotics, 25
  rectal, 25
  tablets, calculated from, 26
  Young's rule, 24
Drachm, 2
Drop, 3
Dry measure, 15

E

Equivalents, 12
Expanding U. S. P. formulas, 46–58

F

Fahrenheit, 80
Fathom, 13, 15
Feet, 14
Fluidounce, 3
  cubic centimeters in, 12
  grains in, at 4°C., 12
    at 15.6°C., 12
    at 25°C., 12
  imperial, 3

G

Gallon, 3
  abbreviation for, 3
  cubic inches in, 12
  liters in, 12
  weight in pounds, 12
Gill, 3
Graduated tube, specific gravity, 31
Grain, 2
  abbreviation for, 2
  milligrams in, 12
Gram, 9
  abbreviation for, 9
  grains in, 12

H

Hand, 13
Hectare, 8
Hectogram, 9
Hectoliter, 8
Hectometer, 8
Hogshead, 13
Hundredweight, 13
Hydrometer, Baumé, factors, 38
  specific gravity, 38

I

Imperial measure, 3
Inch, 14
  millimeters in, 12

J

Jolly balance, 31

K

Kilogram, 9
  pounds, avoirdupois, in, 12
Kiloliter, 8
Kilometer, 8

L

League, 14
Linear measure, 14
Liquids, dilution of, 104, 111, 116
  fortification of, 104, 111, 116
  specific gravity of, 36
Liter, 8
  abbreviation for, 9
  pints in, 12
Loss, and profit, 138
Lovi's beads, 39

M

Manufacturing in quantity, 51
Mariner's measure, 15
Measurable denominations, 2

Measure, approximate, 13
 board, 15
 cubic, 15
 domestic, 13
 dry, 15
 linear, 14
 mariner's, 15
 square, 15
Meter, 8
 inches in, 12
Metric, capacity, 8
Metric linear measure, 8
Metric prescription form, 9
Metric weight, 9
Micron, 12
 symbol for, 12
Mil, 8
Mile, geographical, 14
 nautical, 15
 statute, 14
Milligram, 9
Milliliter, 8
Millimeter, 8
Minim, 3, 12, 73
Mohr balance, 39
Myriagram, 9
Myriameter, 8

O

Ounce, apothecaries', 2
  grains in, 2
  grams in, 12
 avoirdupois, 3
  grains in, 3
  grams in, 12
 imperial, 3
 troy, 2
  grains in, 2

P

Peck, 15
Pennyweight, 2
Percentage, 20
 of chemicals, 126
 solutions, 59
Percentage, weight-volume, 59
Perch, 15
Pint, 3
 abbreviation for, 3
 cubic centimeters in, 12
 imperial, 12
Pound, apothecaries', 2
 avoirdupois, 3
  grains in, 3
  grams in, 12
 troy, 2
  grains in, 2
Prescription, apothecaries', 4
 bottles, size of, 14
 decimal line, 10
 metric, 9
Profit and loss, 138
Proof degrees, 94
 gallon, 94
 spirit, 94
Proportion, 1
Pycnometer, specific gravity, liquids, 36
  solids, 30

Q

Quart, 3
Quire, 14

R

Ratio, 1
 solutions, 65
Ream, 14
Rod, 14
Rule, dilution, of liquids, 101
  of solids, 101
 specific gravity, 29

S

Saturated solutions, 69
  of Potassium Iodide, 76, 77
Scruple, 2
Sinker method, specific gravity of liquids, 37

Solids, dilution of, 96
  fortification of, 96
  heavier than but insoluble in water, 30
  heavier than but soluble in water, 33
  lighter than but insoluble in water, 32
  lighter than but soluble in water, 33
Solutions, parts, basis, 65
  percentage, 59
  ratio basis, 65
  saturated, 69
  specific gravity, 36–39
    displacement method, 30
    graduated tube method, 31
    jolly balance method, 31
Sprengel tube, 37
Square measure, 15
Stationer's table, 14
Stere, 8
Symbols, apothecaries', 2, 3

T

Tables, acids, use of, 87
  alcohol, use of, 87
  ammonia water, use of, 87
  apothecaries' measure, 3
  apothecaries' weight, 2
  avoirdupois weight, 3
  board measure, 15
  cubic measure, 15
  domestic or approximate measure, 13
  dry measure, 15
  equivalents, 12
  imperial measure, 3
  mariner's measure, 15
Tables, metric linear measure, 8
  metric measure of capacity, 8
  metric weight, 9
  miscellaneous, 14, 15
  square measure, 15
  stationer's, 14
  troy weight, 2
  U. S. linear measure, 14
  U. S. liquid measure, 3
Tablespoonful, 13
Tablets, dosage, 18
Teacupful, 13
Teaspoonful, 13
Temperature, 80
  absolute, 82
Ton, 3
  long, 13
Troy weight, 2
Tumblerful, 13

U

U. S. liquid measure, 3

V

Volume, contraction in, 104

W

Weighable denominations, 2, 46
Weight-volume, 59
Wine gallon, 94
Wineglassful, 13

Y

Yard, 14
Young's rule, of dosage, 24