Pharmacy Calculations for Pharmacy Technicians

Solving Pharmacy Calculation Problems
Without All the Silly Formulas

FIRST EDITION

PDF Version

Learn a few simple concepts to be able to quickly set up and solve pharmacy calculation problems without resorting to notes or formulas.

Bradley J. Wojcik, PharmD
brad.wojcik@gmail.com

Pharmacy Calculations for Pharmacy Technicians

Pharmacy Calculations for Pharmacy Technicians

Solving Pharmacy Calculation Problems
Without All the Silly Formulas

First Edition

Learn a few simple concepts to be able to quickly set up and solve pharmacy calculation problems without resorting to notes or formulas.

Bradley J. Wojcik, PharmD

For permissions contact: Bradley J. Wojcik, PharmD at brad.wojcik@gmail.com

First Printing: 2018

ISBN 978-1-948477-00-0 (PDF Format)

Dedicated to my former students.

Foreword

By Mary B. Hibbert

Registered Nurse, MPH

Pharmacy Calculations for Pharmacy Technicians is designed to be a fundamental, comprehensive, creatively written and thoroughly practical reference for anyone working with mathematics in a healthcare setting. While in the position of Program Director at Heald College's ASHP Accredited Pharmacy Technician Program, I found that pharmacy math was one of the most challenging subjects for our students. Student success in the introductory pharmacy math course was in need of improvement.

Fortunately, our students soon received outstanding instruction from Dr. Brad, who joined our teaching staff as the pharmacy technician program's senior lead professor. Dr. Brad brought our program thirty-five years experience as a pharmacist, which encompassed various settings, including retail, clinic, long-term care, and hospital. Dr. Brad's expertise as a pharmacist, combined with his enthusiasm for pharmacy math and creative approach to teaching, resulted in the significant improvement of student completion rates of the introductory pharmacy course.

An integral component to our students' success was Dr. Brad's classroom handouts, which served as the precursor to *Pharmacy Calculations for Pharmacy Technicians.* This outstanding text is a long overdue addition to pharmacy math education. Looking back at my early years as a registered nursing student, it would have been much more flexible and easier to use *Pharmacy Calculations for Pharmacy Technicians* rather than the abstract and formula laden math textbooks.

Table of Contents

Introduction

Imagine that you just moved to a new city and needed to know how to get around. Would you rather be handed a long list of detailed instructions on how to drive between all the different points in the city, or be handed a map? This book takes the approach that it is easier to learn to read a map once than to memorize a myriad of different instructions. After learning a few simple concepts, you will be able to quickly set up and solve pharmacy calculation problems without resorting to notes or formulas. The book is divided into three chapters.

Auxiliary Subjects: Chapter I consists of topics which are important in forming a well-rounded knowledge of pharmacy calculations. Topics covered are:

- Rounding Numbers
- Roman Numerals
- The Metric System
- Scientific Notation
- Significant Figures
- Percent Error
- The Apothecary/Avoirdupois/Household Systems

Dimensional Analysis and Ratio Proportion: Chapter II is the most important chapter as it covers about 80% of the calculations encountered in pharmacy. **All problems in this chapter can be solved using one easy method.** Topics covered are:

- Dimensional Analysis vs. Ratio Proportion
- Unit Conversions
- Dosage Calculations
- IV Flow Rate Calculations
- Percent/Percent Strength/Ratio Strength Calculations
- Milliequivalent Calculations

Concentrations and Dilutions: Chapter III will teach you how to solve these problems easily and understand the basics of the problem. Topics covered are:

- The Alligation Method
- Preparing a Solution Using Two Different Strength Solutions
- Preparing a Solution from a Stock Solution and a Diluent
- Calculating the Percent Strength of a Mixture
- Powder Volume Calculations
- Serial Dilution

General Terminology Used in this Book:

- **Number: Includes integers, decimal numbers, and fractions.**
  - Integer: All positive and negative whole numbers and zero.
    - ✓ Examples: -4, -3, 0, 2, 25
  - Decimal Number: A number which includes a decimal point.
    - ✓ Examples: 25.3, 0.05
  - Fraction: A number represented as a/b where a and b are both integers, with the exception that b cannot be 0.
    - ✓ Examples: 1/2, 3/4, 7/8, -1/2
- **Unit: Unit of measurement.**
  - Examples: mg, mL, kg, L.

A Few Important Notes:

- Always include all units of measurement (mg, g, L, mL, etc.) in the calculations.
  - The units are the most important part of the calculation. The numbers only go along for the ride.
- Set the calculations up mathematically correct.
  - 0.25 X 100% = 25% **not** 0.25 X 100 = 25%
- Use a space between the number and the unit.
  - 5 mL not 5mL
- Always use leading zeros on decimal numbers which are less than 1.
  - 0.5 mg not .5 mg.
- Always avoid trailing zeros after whole numbers.
  - 5 mg not 5.0 mg
- Use mcg for microgram, not µg, as µg can be mistaken for mg.
- Definitions of terms in this book are limited in scope to the practice of pharmacy. You won't get a detailed technical definition of electrolytes, only that they are ions important to the function of the body.

Most of these topics are covered in my YouTube videos.
YouTube.com/c/BradWojcikPharmD

Feel free to email me at brad.wojcik@gmail.com with questions or comments.

Chapter I
Auxiliary Subjects

This chapter covers the following seven topics, some of which may prove to be very important in your practice, and some which may not. Additionally, some topics may go into more detail than necessary, so feel free to cover as much or as little of the subject matter as you feel is necessary.

- **Rounding Numbers**
    - This skill is important.
    - Hopefully this is only a refresher and you will get through this quickly.
- **Roman Numerals**
    - Study this topic in detail if you wish to impress people with the fact that you know that MCMLI is the year *A Streetcar Named Desire* came out.
    - Make sure you know the basics: 1-10, 15, 20, 25, 30, 40, 50, 60, 100.
- **The Metric System**
    - You absolutely must know at least the first two tables in this section.
- **Scientific Notation**
    - This is an easier method of writing very large and very small numbers. You may never be required to convert a number into scientific notation, but it is important to know the meaning of a number written in scientific notation.
- **Significant Figures**
    - Chances are that you will not use this material much in your practice, but it is important to know the basics of this topic.
- **Percent Error**
    - This section may or may not be important to your practice. It is important to know the basics.
- **Apothecary/Avoirdupois/Household Systems**
    - This is a short topic with only the top eight units covered. It is important to know everything presented here.

Rounding Numbers

Many times, calculated answers will have more decimal places than needed or desired and rounding will be required. To round a number:

- Identify the digit occupying the place to be rounded to. For example, if asked to round to the nearest tenth, you would look at the 8 in the following example.

3	5	6	.	8	1	9
Hundreds	**Tens**	**Ones**	**Decimal Point**	**Tenths**	**Hundredths**	**Thousandths**

- Look at the digit following the digit being rounding. In the above example, this is the 1.
- If the following digit is 0,1,2,3, or 4, all digits following the digit being rounded are dropped and you are finished. In the above example, the 1 and 9 are dropped, leaving 356.8 as the rounded number.
- If the following digit is 5,6,7,8, or 9, all digits following the digit being rounded are dropped, and the digit is increase by 1. In rounding the number 156.879 to the nearest tenth, the 7 and 9 are dropped and the 8 is increased to 9, leaving 156.9 as the rounded number.

IMPORTANT: When rounding numbers, look ONLY at the first digit after the digit being rounded. All other digits are irrelevant.

Example: Round to the nearest tenth.

- 6.759 rounded is 6.8 (Look only at the 5; the 9 is irrelevant.)
- 10.248 rounded is 10.2 (Look only at the 4; the 8 is irrelevant.)
- 0.38999 rounded is 0.4 (Look only at the 8; the 9's are irrelevant.)

Example: Round to the nearest hundredth.

- 89.523 rounded is 89.52
- 0.59788 rounded is 0.60
- 7.2395 rounded is 7.24

Rounding Exercise					
	Round to the Nearest Tenth	**Rounded Number**		**Round to the Nearest Hundredth**	**Rounded Number**
1	6.88	6.9	26	89.568	89.57
2	7.54		27	45.789	
3	2.22		28	1.005	
4	3.98		28	2.895	
5	78.53		30	3.997	
6	99.23		31	7.894	
7	101.16		32	3.433	
8	5.44		33	2.222	
9	99.99		34	1.111	
10	53.247		35	8.895	
11	9.355		36	3.578	
12	100.01		37	2.2256	
13	56.3756		38	90.3895	
14	9.56		39	78.451	
15	22.56		40	3.215	
16	78.59		41	9.782	
17	77.459		42	10.554	
18	3.57		43	3.987	
19	9.78		44	1.9954	
20	23.598		45	2.493	
21	78.3		46	8.523	
22	78.303		47	9.672	
23	798.32		48	4.956	
24	8.06		49	2.225	
25	9.11		50	3.987	

Answers on page 74

Roman Numerals

- **The decimal number system, also called the Arabic number system, is a positional number system in which the position of the digit determines its value. The 2 in 521 represents 20, but the 2 in 245 represents 200.**
- **The Roman numeral system is an additive and subtractive system in which the value of a numeral remains constant. The C in CXX represents a value of 100, just as the C in CLXV represents 100**.

Roman Numerals and Their Values

Roman Numeral	Value	Memory Hints
SS	1/2	Short stack of pancakes, which is about half a regular stack.
I	1	Easy to remember because it looks like a 1.
V	5	Your hand with your fingers together and thumb apart forms a V.
X	10	Think of it as two V's, one on top of the other.
L	50	Think of **L**asso. It has 5 letters and ends in O (50).
C	100	Think of **C**entury or **C**-note.
D	500	Imagine 500 **D**ogs in your house, all barking and running around.
M	1000	Think of **M**illennium.

Rules for Forming Roman Numerals

1) Start from the left with the largest numeral and work down to the smallest on the right.

2) No more than three of the same numeral in a row. 40 cannot be written XXXX.

3) If a smaller numeral is placed before a larger numeral, the smaller numeral is subtracted from the larger numeral. For example, IV is 4; the I is subtracted from V (5-1).

4) Only I, X, and C may be subtracted from a larger numeral. The "five" numerals (V, L, D) may not be subtracted from a larger numeral. 45 is written XLV, not VL.

5) When a smaller numeral is subtracted from a larger numeral, the smaller numeral can be no less than one tenth of the larger numeral. IX is 9, but IL is not permitted for 49, nor IC for 99. 49 is written XLIX and 99 is written XCIX. Only one numeral at a time may be subtracted and only from one other numeral. IIX is not permitted for 8, nor IXX for 19.

6) Always use the largest numerals possible. 15 is written XV, not VVV, even though writing three V's does not break rule #2.

These rules may seem complicated, but with a little practice Roman numeral are easy if you learn the following tips.

- A smaller numeral must be subtracted from a larger numeral only if the number contains a 4 or 9. 246 is written CCXLVI with the X being subtracted from the L. 2386 is written MMCCCLXXXVI, with no subtraction involved.
- When one numeral is subtracted from another, think of them as a unit. Think of IV as 4, not 5-1, XL as 40, not 50-10, etc.
- Learn the following table to be able to quickly form any Roman numeral.

1000	**M**	100	**C**	10	**X**	1	**I**
2000	**MM**	200	**CC**	20	**XX**	2	**II**
3000	**MMM**	300	**CCC**	30	**XXX**	3	**III**
		400	**CD**	40	**XL**	4	**IV**
		500	**D**	50	**L**	5	**V**
		600	**DC**	60	**LX**	6	**VI**
		700	**DCC**	70	**LXX**	7	**VII**
		800	**DCCC**	80	**LXXX**	8	**VIII**
		900	**CM**	90	**XC**	9	**IX**
						1/2	**SS**

Example: Convert 2648 to a Roman numeral.

- **Separate out the 1000's, 100's, 10's, and 1's and place the corresponding Roman numeral next to them.**

2000	MM
600	DC
40	XL
8	VIII

- **Line up the Roman numerals in order starting with the largest.**
  - **MMDCXLVIII**

Example: Convert MCMXXXIV to a number.

- **Separate out the 1000's, 100's, 10's, and 1's and place the corresponding number next to them.**

M	1000
CM	900
XXX	30
IV	4

- **Total the numbers.**
  - **1934**

Roman Numeral Exercise

1) You must know the eight basic Roman numerals and their number counterparts: SS, I, V, X, L, C, D, M. Fill in the blanks in the following tables.

Roman Numeral	Number
SS	
I	
V	
X	
L	
C	
D	
M	

Number	Roman Numeral
1/2 (0.5)	
1	
5	
10	
50	
100	
500	
1000	

2) Fill in the blanks with the corresponding Roman numerals or numbers.

50		C	
100		5	
1/2		10	
X		L	
M		I	
5		X	
V		D	
500		M	
L		X	
SS		V	
1000		L	
1		C	
D		5	
L		50	
M		1000	
10		100	

3) Fill in the blanks with the corresponding Roman numerals and try not to look at the table on page 7 until you are ready to check your answers.

1000		100		10		1	
2000		200		20		2	
3000		300		30		3	
		400		40		4	
		500		50		5	
		600		60		6	
		700		70		7	
		800		80		8	
		900		90		9	
						1/2	

4) Fill in the blanks with the corresponding number or Roman numeral.

10		LXX	
30		20	
400		CCC	
DC		CD	
2000		CM	
8		700	
XC		50	
40		20	
60		LXXX	
200		DCC	
900		600	
IV		CC	
III		9	
SS		4	

5) Write the corresponding Roman numerals or numbers:

Example: Write 2782 as a Roman numeral.

2000	MM
700	DCC
80	LXXX
2	II

- **Line up the Roman numerals in order starting with the largest.**
    - **MMDCCLXXXII**

Example: Write MMDCLXXVI as a number.

MM	2000
DC	600
LXX	70
VI	6

- **Total the numbers.**
    - **2676**

352 **752**

3564 **1437**

1369 **3421**

MMDCLXVII **MCMLI**

CCCXLV **DCLXII**

Answers on page 75

The Metric System

- **The metric system is the predominant system of measurement used in pharmacy.**
- **The primary base units used in pharmacy are gram, liter, and meter.**
- **Each of the base units can be multiplied or divided by powers of 10 to form larger or smaller units.**
- Prefixes are placed before the base units to denote the larger and smaller units.
- The first table below lists the most important metric units used in pharmacy.

The Metric System Basics for Pharmacy Technicians

Prefix	Symbol	Multiple of base	Weight	Volume	Length
micro	mc	1/1,000,000	**mcg**		
mili	m	1/1000	**mg**	**mL**	**mm**
centi	c	1/100			**cm**
		Base Unit	**g (gram)**	**L (liter)**	**m (meter)**
kilo	k	1000	**kg**		**km**

Approximate Equivalents to Selected Metric Units

Weight Unit	Approximate Equivalent	Volume Unit	Approximate Equivalent	Length Unit	Approximate Equivalent
mcg	1 ant leg?	**mL**	20 drops	**mm**	1/25 inch
mg	6 grains of salt	**L**	1 quart	**cm**	4/10 inch
g	1 paperclip			**m**	1 yard
kg	2.2 lb			**km**	6/10 mile

Metric Prefixes Between 10^{18} and 10^{-18}

Prefix	Symbol	Multiplication Factor	Exponent
exa	E	1000000000000000000	10^{18}
peta	P	1000000000000000	10^{15}
tera	T	1000000000000	10^{12}
giga	G	1000000000	10^{9}
mega	M	1000000	10^{6}
kilo	k	1000	10^{3}
hecto	h	100	10^{2}
deca	da	10	10^{1}
	Base Unit	1	10^{0}
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	mc	0.000001	10^{-6}
nano	n	0.000000001	10^{-9}
pico	p	0.000000000001	10^{-12}
femto	f	0.000000000000001	10^{-15}
atto	a	0.000000000000000001	10^{-18}

Scientific Notation

- **Scientific notation is an easier way to write very large and very small numbers.**
- Example: 602,200,000,000,000,000,000,000 becomes 6.022×10^{23} in scientific notation.
- Example: 0.0000000000000000019942 becomes 1.9942×10^{-18} in scientific notation.

Terminology:

- **Exponent:** The small number written just above and to the right of a base number. It is the 23 in 6.022×10^{23} and denotes the number of times 10 is used in a multiplication.
  - 10^2 denotes 10 X 10. 10^3 denotes 10 X 10 X 10.
  - A negative exponent denotes 1 divided by the 10's, which results in a number less than 1. For example, 10^{-2} is $1/10^2$, or 1/100, which is 0.01.
- **Coefficient:** The number which is multiplied by 10 raised to the exponent. It is the 6.022 in 6.022×10^{23}. It is always at least 1 and less than 10.

Steps to Write a Number in Scientific Notation

Examples using 6,154,000,000 and 0.000816:

Step 1) Separate out the digits which are either before or after all the zeros and place a decimal point after the first digit, forming the coefficient.

- **6,154,000,000: 6.154**
- **0.000816: 8.16**

Step 2) Look at the original number and count the number of places to move the decimal point either to the end or back to the original decimal point from the decimal point in the coefficient.

- **6,154,000,000: 9 places from between the 6 & 1 to the end.**
- **0.000816: 4 places back from between the 8 & 1 to the original decimal point.**

Step 3) Write the coefficient and multiply it by 10 raised to the number of places the decimal point was moved. If the decimal point was moved to the right, the exponent is positive; if the decimal point was moved to the left, the exponent is negative.

- **6.154×10^9**
- **8.16×10^{-4}**

Examples:

Number	Scientific Notation
5,015,000	5.015×10^6
3,000	3×10^3
645,000,000	6.45×10^8
0.00056	5.6×10^{-4}
0.00000734	7.34×10^{-6}
0.00003005	3.005×10^{-5}

Scientific Notation Exercise

1) Convert the following numbers to scientific notation.

Number	Coefficient	# of Places from New Decimal Point to end of Original Number	Coefficient X 10 Raised to the Number of Places the Decimal Point was Moved
67,000	6.7	4	**6.7 X 10^4**
2,387,000	2.387	6	**2.387 X 10^6**
7,000,000			
98,000			
432,000,000			
900,000,000			
58,000,000,000			
2,478,000,000			
92,000,000			
60,230,000,000			
105,000			

2) Convert the following decimal numbers to scientific notation.

Decimal Number	Coefficient	# of Places from New Decimal Point to Original Decimal Point	Coefficient X 10 Raised to the Negative Number of Places the Decimal Point was Moved
0.056	5.6	2	**5.6 X 10^{-2}**
0.000380	3.80	4	**3.80 X 10^{-4}**
0.00007			
0.00002039			
0.0005078			
0.00001832			
0.000650			
0.0000000012			
0.000054			
0.000783			
0.00034			

3) Convert the following numbers from scientific notation to numbers.

Scientific Notation	Coefficient	Exponent	# of Places to Move the Decimal Point to the Right	Number
5.62×10^{6}	5.62	6	6	**5,620,000**
7.8×10^{7}	7.8	7	7	**78,000,000**
9×10^{5}				
6.02×10^{7}				
1.05×10^{4}				
9.78×10^{9}				
6.99×10^{3}				
3.78×10^{8}				
4.0×10^{8}				
7.66×10^{5}				

4) Convert the following decimal numbers from scientific notation to decimal numbers.

Scientific Notation	Coefficient	Exponent	# of Places to Move the Decimal Point to the Left	Decimal Number
6.05×10^{-4}	6.05	-4	4	**0.000605**
2.3×10^{-7}	2.3	-7	7	**0.00000023**
7.80×10^{-4}				
3.5×10^{-6}				
8.995×10^{-5}				
1.023×10^{-9}				
5.00×10^{-4}				
8.43×10^{-6}				
2.22×10^{-3}				
1.6×10^{-7}				

Answers on page 77

Significant Figures

- **There are two types of numbers in the world: exact and inexact.**
- **Exact: 5 x 7 is exactly 35. 1 divided by 4 is exactly 0.25.**
- **Inexact: All measurements are inexact. (Note: counting is not measuring.)**

When a measurement is made, the results are reported using a number which conveys the accuracy of the measurement. The digits which convey the accuracy of the measurement are said to be significant.

For example, a line measured using a ruler which is marked off in centimeters might be reported as 3.5 cm because the line was clearly past the 3 cm mark and about half way to the 4 cm mark. This measurement has two significant figures. If the same line is measured with a ruler which is marked off in mm and it is seen that the line is about half way between the 6 mm and 7 mm mark of the fourth cm, the measurement would be reported as 3.65 cm. This measurement has three significant figures.

- Think of significant figures as a communication, from the person who made the measurement to the people reading the measurement, conveying the accuracy of the measurement. For example, a measurement of 1.015 kg conveys a very accurate measurement, while a measurement of 1 kg does not.
- Measurements contain all the digits which are known exactly plus one digit which is an estimate.

Significant Figure Rules

1) All nonzero figures are significant. 1,2,3,4,5,6,7,8,9 are always significant. **67825.98** has seven significant figures.

2) All zeros between two nonzero figures are significant. **57801** has five significant figures.

3) Leading zeros are not significant. Leading zeros (the zeros in front) are found in small decimal numbers, such as 0.000512. The zero before the decimal and the three zeros following the decimal are not significant as their only purpose is to hold the places. 0.000**512** has 3 significant figures.

4) Trailing zeros are significant if there is a decimal point in the number. **856.00** has five significant figures as the two zeros at the end were added only to convey the fact that the measurement was accurate to the hundredth place.

5) Trailing zeros without a decimal point in the number are generally not significant. **25**,000 has two significant figures. Conveying 25,000 as accurate to the ones place is best accomplished by writing it in scientific notation as **2.5000** x 10^4, which now has five significant figures.

The Easy Way to Sum up the Rules

Does the number have a decimal point?

If **YES**, all figures are significant except the zeros in front of the first nonzero digit.

0.00**579000 (6 significant figures)**

If **NO**, then all figures are significant except the zeros behind the last nonzero digit.

5,578,000 **(4 significant figures)**

Examples

Number	# of Significant Figures
506	**3**
450	**2**
5645	**4**
0.000**51**	**2**
5.1070	**5**
0.**25**	**2**
5600	**2**
5600.0	**5**
980005	**6**
980000	**2**
0.000**50**	**2**
6.7500 X 10^4	**5**

Rules for Adding and Subtracting Significant Figures

- **When adding or subtracting two or more measurements containing significant figures, the sum or difference may only have as many decimal places as the measurement with the least number of decimal places, assuming the units are the same.**

Example: 14.151 mg + 3.2 mg = 17.351 mg.

- 3.2 mg contains the least number of decimal places: one.
    - **The answer must be rounded to one decimal place: 17.4 mg.**

Rules for Multiplying and Dividing Significant Figures

- **When multiplying or dividing two measurements with significant figures, the result can have no more significant figures than the measurement with the least number of significant figures.**

Example: (1.5 m)(2587.6 m) = 3,881.4 m^2.

- 1.5 m has the least number of significant figures: two.
    - **The result must be rounded to two significant figures: 3,900 m^2.**

Significant Figures Exercise

1) Determine the number of significant figures in the following measurements.

Measurement	Decimal Point? Yes or No	Yes: All Digits are Significant Except the Leading Zeros	No: All Digits are Significant Except Trailing Zeros	Number of Significant Figures
605.30 cm	**Yes**	**605.30** cm		**5**
0.0050 cm	**Yes**	0.00**50** cm		**2**
905,000 mi	**No**		**905**,000 mi	**3**
1,000,000 ft	**No**		**1**,000,000 ft	**1**
0.00001 mi				
1,000,006 ft				
500 ft				
367 ft				
0.0051 g				
0.040 g				
92,000,000				
92,000,000.0				
807.01 cm				
100 ft				
9071.0000 in				
183 ft				
601 qt				

2) Determine the sums or differences for the following measurements using the rules for adding and subtracting significant figures.

Measurements	Sum or Difference Before Rounding	Least Accurate Measurement(s)	Answer Rounded to Correct Place
7.12 mg + 6.1 mg + 7.06 mg	20.28 mg	6.1 mg	**20.3 mg**
100.5 mg + 110 mg	210.5 mg	110 mg	**210 mg**
6 cm + 8.3 cm			
103 g + 1.1 g			
5 ft + 52 ft			
6.3 cm - 3 cm			
101 mg + 25 mg			
98.1 mg + 10 mg			
65.5551 g + 2 g			
1000 mi + 10 mi			

3) Determine the products of the following measurements using the rules for multiplying and dividing significant figures.

Measurements	Product before Rounding	Measurement with Least # of Sig Figures	Rounded Answer
31 cm X 9 cm	279 sq cm	9 cm (1 sig fig)	**300 sq cm**
100 cm x 892 cm	89,200 sq cm	100 cm (1 sig fig)	**90,000 sq cm**
61 ft X 561 ft			
78 cm X 1000 cm			
56 cm X 21 cm			
34 in x 605 in			

Answers on page 79

Percent Error

A 5 g error in a weight measurement may denote either an accurate or an inaccurate measurement. A 5 g error in weighing a bag of potatoes denotes a very accurate measurement, with a small percent error, while a 5 g error weighing out 16 g of active ingredient for a prescription denotes an inaccurate measurement, with a large percent error. It is important to understand, and know how to calculate, percent error.

Terminology:

- **Desired quantity:** Quantity which is trying to be measured. Think of it as the target.
- **Actual quantity:** Quantity which was actually measured.
- **Error quantity:** Absolute value of difference between desired and actual quantity. (Always a positive number.)
- **Percent error:** Error quantity expressed as a percentage of desired quantity.

Calculating Percent Error

Example: You tried to weigh a quantity of 100 g, but later found that you actually weighed a quantity of 95 g.

- Desired quantity is 100 g.
- Actual quantity is 95 g.
- Error quantity is 5 g.
- Percent error: $\left(\frac{5\text{ g}}{100\text{ g}}\right)100\% = 5\%$
- **Important: Always use desired quantity when calculating percent error.**

Example: The desired weight is 525 g, but you weighed out 501 g.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error
525 g	501 g	24 g	$\left(\frac{24\cancel{\text{ g}}}{525\cancel{\text{ g}}}\right)100\% = 4.6\%$

Percent Error Exercise

1) The desired volume is 46 mL, but you actually measured out 48 mL.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error

2) The desired weight is 350 mg, but the actual weight is 376 mg.

Desired Quantity (Target)	Actual Quantity	Amount of Error	Percent Error

3) The desired volume is 2.3 L, but the actual volume is 2.2 L.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error

4) The desired weight is 2.5 kg, but the actual weight is 1.7 kg.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error

5) The desired weight is 7.4 g, but the actual weight is 6.8 g.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error

Answers on page 80

Apothecary/Avoirdupois/Household Systems

- **These systems are rarely used in pharmacy today, but there are few units and key points which should be learned.**
- **Weight Units:**
  - **Grain (gr): Technically 64.8 mg, but usually rounded to 65 mg.**
  - **Ounce (oz): Technically 28.3 g, but usually rounded to 30 g.**
  - **Pound (lb): Contains 16 oz. Usually rounded to 454 g.**
- **Volume Units:**
  - **Fluidram/fluid dram: Technically 3.7 mL, but usually rounded to 5 mL.**
  - **Fluid ounce: Technically 29.6 mL, but usually rounded to 30 mL**
  - **Pint: 16 fluid ounces. Technically 473 mL, but usually rounded to 480 mL.**
  - **Teaspoonful: 5 mL**
  - **Tablespoonful: 15 mL**

Important Units with Rounded Metric Equivalents

Apothecary Volume	**Household Volume**	**Metric Volume**
1 fluidram /fluid dram	1 teaspoonful (tsp)	5 mL
1 fluid ounce	2 tablespoonfuls (tbs)	30 mL
16 fluid ounces	1 pint (pt)	480 mL (473 mL)
	1 tablespoonful	15 mL
Apothecary Weight		**Metric Weight**
1 grain (gr)		65 mg
Avoirdupois Weight	**Household Weight**	**Metric Weight**
1 ounce (oz)	1 ounce (oz)	30 g
1 pound (lb)	1 pound (lb)	454 g

Note: While these systems are not widely used today, the history of these systems is interesting and can be researched online.

Chapter II
Dimensional Analysis and Ratio Proportion

Terminology:

- **Dimensional Analysis (DA):** A powerful method of solving problems in pharmacy, chemistry, physics, and engineering in which a given is multiplied by one or more ratios to obtain the answer.
- **Ratio Proportion (RP):** A method widely used by the medical community to solve problems by comparing two ratios.

It is extremely important to fully understand everything in this chapter.

Most of the calculations encountered in pharmacy involve nothing more than changing the units from what is given to the units desired. These include:

- Unit Conversions
- Dosage Calculations
- IV Flow Rate Calculations
- Percent, Percent Strength, and Ratio Strength Calculations
- Milliequivalent Calculations

These calculations can all be solved using DA or RP.

Think of these not as five different types of calculations, but as a single type of calculation involving five different types of units.

These problems all have the same three parts:

- **The Units of the Answer:** Think of it as the destination.
- **A Given:** This is what is given to start the problem and what is changed into the answer.
- **One or More Ratios:** These are the tools used to change the units of the given into the units of the answer.

Example 1 using DA: Convert 4.5 g into mg.

- The units of the answer are mg. This is the destination.
- The given is 4.5 g. This is the starting point.
- The ratio is 1000 mg/g. This is the tool to change g to mg.
- Start by listing the starting point and destination. This will help when placing the ratio(s).

$$\mathbf{4.5\ g \quad = \quad mg}$$

- Place the ratio with the units of the answer on top and the units to be canceled on the bottom. Multiply the given by the ratio. The grams cancel out, leaving mg in the answer.

$$\mathbf{4.5\ g\left(\frac{1000\ mg}{g}\right) = 4500\ mg}$$

Example 2 using DA: A patient is prescribed 400 mg. The drug is available in a strength of 200 mg/mL. How many mL will the patient take?

- The units of the answer are mL.
- The given is 400 mg.
- The ratio is 200 mg/mL.
- Start by listing the starting point and destination.

400 mg = mL

- Place the ratio with the units of the answer on top and the units to be canceled on the bottom. Multiply the given by the ratio. The mg cancel out leaving, leaving mL.

$$\mathbf{400\ \cancel{mg}\left(\frac{1\ mL}{200\ \cancel{mg}}\right) = 2\ mL}$$

- In this case, the ratio was flipped upside down placing mL on top and mg on the bottom.

Key Points about the Ratios

- **The ratios always equal 1**. Since 1000 mg = 1 g, $\frac{1000\ \text{mg}}{1\ \text{g}} = 1$ (In this book, this type of ratio is called an "off the shelf" ratio because it is always true. There are always 1000 mg in a g.)
  In example 2, it is stated the drug's strength is 200 mg/mL. For this problem, it can be stated that 1 mL = 200 mg. $\frac{1\ \text{mL}}{200\ \text{mg}} = 1$ and $\frac{200\ \text{mg}}{1\ \text{mL}} = 1$. (In this book, this type of ratio is called a "custom ratio" because it only holds true for the problem at hand. There are not always 200 mg/mL, only if the problem states it.)
- **The ratios can be flipped upside down if needed.** $\mathbf{\frac{1000\ mg}{1\ g} = \frac{1\ g}{1000\ mg} = 1}$

The above two examples were solved using the dimensional analysis method. An explanation of the ratio proportion method follows.

The Ratio Proportion Method

The ratio proportion method is the other method used to solve the problems in this chapter. Using the ratio proportion method, also called the ratio and proportion method, two ratios are set up that are proportional (equal) to each other and the unknown is solved for. Using the above examples:

Example 1 using RP: Convert 4.5 g into mg.

- The RP method uses two ratios: one ratio containing the unknown and the given, the other ratio serving as a reference ratio.

$$\frac{\mathbf{x\ mg}}{\mathbf{4.5\ g}} = \frac{\mathbf{1000\ mg}}{\mathbf{1\ g}}$$

- The easiest way to solve for x mg is to cross multiply (4.5 g)(1000 mg) then divide by 1 g, resulting in the answer of **4500 mg**.

Example 2 using RP: A patient is prescribed 400 mg. The drug is available in a strength of 200 mg/mL. How many mL will the patient take?

$$\frac{\mathbf{x\ mL}}{\mathbf{400\ mg}} = \frac{\mathbf{1\ mL}}{\mathbf{200\ mg}}$$

- **Solving for x mL: (400 mg)(1 mL)/200 mg = 2 mL**

When using the ratio proportion method, both numerators must have the same units and both denominators must have the same units.

For simple one step problems, there is not a lot of difference between DA and RP as far as ease of use or safety. Now consider the following problem, which involves several ratios, solved using both DA and RP.

Example 3 using DA: A 186 lb patient has been prescribed a dosage of 20 mg/kg. The drug is available in 10 mL vials each containing 2.5 g of drug. How many mL should be administered?

- The units of the answer are mL.
- The given is 186 lb.
- The ratios are 20 mg/kg, 2.5 g/10 mL, 2.2 lb/kg, 1000 mg/g.

$$\mathbf{186\ \cancel{lb}}\left(\frac{\mathbf{1\ \cancel{kg}}}{\mathbf{2.2\ \cancel{lb}}}\right)\left(\frac{\mathbf{20\ \cancel{mg}}}{\mathbf{\cancel{kg}}}\right)\left(\frac{\mathbf{1\ \cancel{g}}}{\mathbf{1000\ \cancel{mg}}}\right)\left(\frac{\mathbf{10\ mL}}{\mathbf{2.5\ \cancel{g}}}\right) = \mathbf{6.8\ mL}$$

Example 3 using RP: A 186 lb patient has been prescribed a dosage of 20 mg/kg. The drug is available in 10 mL vials each containing 2.5 g of drug. How many mL should be administered?

- Step 1) Convert 186 lb to kg.

$$\frac{\mathbf{x\ kg}}{\mathbf{186\ lb}} = \frac{\mathbf{1\ kg}}{\mathbf{2.2\ lb}}$$

  - Solving for x kg yields 84.5 kg.
- Step 2) Calculate the dose of drug in mg needed for an 84.5 kg patient.

$$\frac{\mathbf{x\ mg}}{\mathbf{84.5\ kg}} = \frac{\mathbf{20\ mg}}{\mathbf{kg}}$$

  - Solving for x mg yields 1690 mg
- Step 3) Convert 1690 mg to g.

$$\frac{\mathbf{x\ g}}{\mathbf{1690\ mg}} = \frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}$$

  - Solving for x g yields 1.69 g.
- Step 4) Calculate the dose in mL needed to deliver 1.69 g of drug.

$$\frac{\mathbf{x\ mL}}{\mathbf{1.69\ g}} = \frac{\mathbf{10\ mL}}{\mathbf{2.5\ g}}$$

  - **Solving for x mL yields the answer: 6.8 mL.**

It is the author's belief that the dimensional analysis method is superior to the ratio proportion method for problems involving more than one step.

- Using dimensional analysis, the problem can be set up in one step and checked for accuracy by canceling out the units before any calculations are performed.
- Using the ratio proportion method, several problems must be set up, complicating the problem and introducing sources of error.
- A small pile of gravel can be moved with an "RP shovel", but climb into a "DA bulldozer" to move a large pile.

Going forward, both the DA and RP method will be shown for the simple unit conversion problems, but only DA will be shown for the other problems.

Unit Conversions

Terminology:

- **Unit:** Unit of measurement. The mg, g, mL, L, kg, etc., that are used in pharmacy calculations.
- **Unit Conversions:** Converting from one unit to another without changing the value.

Included in this section is the "Tool Shed", so called because it contains the tools which are used to convert the given units into the desired units.

Using the Tools in the DA Method

- Write down the quantity to be converted on the left side of the equation, say 8.67 g, and the units of the answer on the right side of the equation, say mg.

8.67 g = mg

- Look in the tool shed for the tool (conversion factor) which has mg on top and g on the bottom. Under Metric Weight you will find $\left(\frac{1000\text{ mg}}{\text{g}}\right)$.
- Place the tool to be used next to the quantity to be converted, cancel out the units, and multiply.

$$\mathbf{8.67g\left(\frac{1000\ mg}{\cancel{g}}\right) = 8670\ mg}$$

- More than one tool may be needed to complete the conversion. For example: How many inches are there in 3.5 m?

$$\mathbf{3.5\ \cancel{m}\left(\frac{100\ \cancel{cm}}{\cancel{m}}\right)\left(\frac{1\ in}{2.54\ \cancel{cm}}\right) = 137.8\ in}$$

Using the Tools in the RP Method

- Write a ratio with x followed by the units of the answer on top and the given on the bottom. Using the 8.67 g to mg example above:

$$\mathbf{\frac{x\ mg}{8.67\ g}}$$

- Find a ratio in the tool shed with mg on top and g on the bottom. This is the reference ratio which will be compared the ratio containing the unknow. Place an equal sign between them.

$$\mathbf{\frac{x\ mg}{8.67\ g} = \frac{1000\ mg}{1\ g}}$$

- **Solve for x mg. (8.67 g)(1000 mg) then divide by 1 g. x mg = 8670 mg**
- If more than one tool is needed, set up another problem with the first answer as your given, or preferably, use the DA method.

Tool Shed (Conversion Factors)

These conversion factors equal 1 and can be flipped upside down, if needed.

Metric Weight: $\left(\frac{1\text{ g}}{1000\text{ mg}}\right)\left(\frac{1000\text{ mg}}{1\text{ g}}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right)\left(\frac{1000\text{ g}}{1\text{ kg}}\right)\left(\frac{1\text{ mg}}{1000\text{ mcg}}\right)\left(\frac{1000\text{ mcg}}{1\text{ mg}}\right)$

Metric Volume: $\left(\frac{1\text{ L}}{1000\text{ ml}}\right)\left(\frac{1000\text{ ml}}{1\text{ L}}\right)$

Metric - U.S Weight: $\left(\frac{30\text{ g}}{1\text{ oz}}\right)\left(\frac{1\text{ oz}}{30\text{ g}}\right)\left(\frac{2.2\text{ lb}}{1\text{ kg}}\right)\left(\frac{1\text{ kg}}{2.2\text{ lb}}\right)\left(\frac{1\text{ lb}}{454\text{ g}}\right)\left(\frac{454\text{ g}}{1\text{ lb}}\right)$

Metric - U.S. Volume: $\left(\frac{1\text{ tsp}}{5\text{ ml}}\right)\left(\frac{5\text{ ml}}{1\text{ tsp}}\right)\left(\frac{1\text{ oz}}{30\text{ ml}}\right)\left(\frac{30\text{ ml}}{1\text{ oz}}\right)\left(\frac{1\text{ pt}}{480\text{ ml}}\right)\left(\frac{480\text{ ml}}{1\text{ pt}}\right)\left(\frac{1\text{ tbs}}{15\text{ ml}}\right)\left(\frac{15\text{ ml}}{1\text{ tbs}}\right)$

U.S. Volume: $\left(\frac{1\text{ tbs}}{3\text{ tsp}}\right)\left(\frac{3\text{ tsp}}{1\text{ tbs}}\right)\left(\frac{16\text{ oz}}{1\text{ pt}}\right)\left(\frac{1\text{ pt}}{16\text{ oz}}\right)\left(\frac{1\text{ qt}}{2\text{ pt}}\right)\left(\frac{8\text{ oz}}{1\text{ cup}}\right)\left(\frac{1\text{ cup}}{8\text{ oz}}\right)\left(\frac{1\text{ gal}}{4\text{ qt}}\right)\left(\frac{4\text{ qt}}{1\text{ gal}}\right)$

Metric Length: $\left(\frac{1\text{ m}}{100\text{ cm}}\right)\left(\frac{100\text{ cm}}{1\text{ m}}\right)\left(\frac{1\text{ cm}}{10\text{ mm}}\right)\left(\frac{10\text{ mm}}{1\text{ cm}}\right)$

Metric - U.S. Length: $\left(\frac{1\text{ in}}{2.54\text{ cm}}\right)\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)$

Apothecary - Metric Volume: $\left(\frac{1\text{ fl dram}}{5\text{ mL}}\right)\left(\frac{5\text{ mL}}{1\text{ fl dram}}\right)\left(\frac{1\text{ fl oz}}{30\text{ mL}}\right)\left(\frac{30\text{ mL}}{1\text{ fl oz}}\right)$

Apothecary - Metric Weight: $\left(\frac{65\text{ mg}}{1\text{gr}}\right)\left(\frac{1\text{ gr}}{65\text{ mg}}\right)$

Percent: $\left(\frac{1}{100\%}\right)\left(\frac{100\%}{1}\right)(100\%)$

Time: $\left(\frac{60\text{ sec}}{\text{min}}\right)\left(\frac{1\text{ min}}{60\text{ sec}}\right)\left(\frac{60\text{ min}}{\text{h}}\right)\left(\frac{1\text{ h}}{60\text{ min}}\right)\left(\frac{24\text{ h}}{\text{d}}\right)\left(\frac{1\text{ d}}{24\text{ h}}\right)$

Temperature: ˚F = (1.8 ˚C) + 32˚

Unit Conversion Exercise using Dimensional Analysis

Given to be Converted	Conversion Factor (Tool)	Units of the Answer	Answer: (Given)(Tool)
3.5 g	1000 mg/g	mg	**3500 mg**
3400 g	1 kg/1000 g	kg	**3.4 kg**
25 mg		g	
8.1 kg		lb	
320 mg		g	
3 tbs		tsp	
245 cm		m	
2.2 kg		lb	
967 mcg		mg	
45 mg		mcg	
188 lb		kg	
2.5 L		mL	
502 g		kg	
89 mm		cm	
400 mL		L	
923 g		kg	
8 kg		g	
3.2 m		cm	
389 mL		L	

Given to be Converted	Conversion Factor (Tool)	Units of the Answer	Answer: (Given)(Tool)
25 mm		cm	
9.5 in		cm	
50 g		mg	
0.25 L		mL	
45 cm		in	
679 cm		m	
90 g		kg	
245 lb		kg	

Answers on page 81

Unit Conversion Exercise using Ratio Proportion

Given	Units of the Answer	Set up Equation	Answer (Solve for x)
3.5 g	mg	$\frac{\text{x mg}}{\text{3.5 g}} = \frac{\text{1000 mg}}{\text{1 g}}$	**3500 mg**
3400 g	kg	$\frac{\text{x kg}}{\text{3400 g}} = \frac{\text{1 kg}}{\text{1000 g}}$	**3.4 kg**
25 mg	g		
8.1 kg	lb		
320 mg	g		
3 tbs	tsp		
245 cm	m		
2.2 kg	lb		
967 mcg	mg		

Given	Units of the Answer	Set up Equation	Answer (Solve for x)
45 mg	mcg		
188 lb	kg		
2.5 L	mL		
502 g	kg		
89 mm	cm		
400 mL	L		
923 g	kg		
8 kg	g		
3.2 m	cm		
389 mL	L		
25 mm	cm		
9.5 in	cm		
50 g	mg		
0.25 L	mL		
45 cm	in		
679 cm	m		
90 g	kg		
245 lb	kg		

Answers on page 82

Custom Ratio Workshop

There are two types of ratios used in pharmacy calculations: ratios which always hold true and ratios which are only true for the problem at hand.

- **Ratios which always hold true.**
  - There will always be 1000 mg/g, 1000 mL/L, 100 cm/m.
  - In this book, these ratios are referred to as "off the shelf" ratios.

- **Ratios which only hold true for the problem at hand.**
  - There are not always 250 mg/5 mL, 0.9 g/100 mL, 500 mg/tablet.
  - In this book, these ratios are referred to as "custom" ratios.

Many times, the ratios are written out in words and must be constructed for the calculation.

- **Look for the words per, every, in, times, etc. Examples:**
  - 25 mg per mL becomes 25 mg/mL or 1 mL/25 mg.
  - 1 capsule every 12 hours becomes 1 capsule/12 hours or 12 hours/capsule.
  - 50 mg in 500 mL becomes 50 mg/500 mL or 500 mL/50 mg.

Both types of ratios are treated the same in the calculations.

- Both types of ratios always equal 1.
- Both types of ratios can be flipped upside down if needed.

Example: A patient is prescribed 200 mg. The drug is available in 10 mL vials in a strength of 50 mg per mL. How many mL are administered?

- The "custom" ratios are 10 mL/vial and 50 mg/mL.
- $200\ \cancel{\text{mg}}\left(\frac{1\ \text{mL}}{50\ \cancel{\text{mg}}}\right) = 4\ \text{mL}$
  - The ratio had to be flipped. 1 mL = 50 mg, so either quantity can be on top.
  - The ratio 10 mL/vial was not needed in this calculation. Seeing extra ratios in pharmacy calculation problems is very common, especially on exams.

Dosage Calculations

Terminology:

- **Dose:** The quantity of drug administered at a single time.
- **Dosage:** The dose information along with other pertinent information relating to the frequency, duration, route of administration, etc. of the dose.
  - Example: A patient is prescribed 500 mg orally three times daily for 10 days. The dose is 500 mg; the dosage is 500 mg orally three times daily for 10 days.
- **mg/kg/day:** Amount of drug in mg administered per kg of body weight each day.
  - **mg/kg·day** is mathematically equivalent and easier to use in calculations.

Step 1) Read the problem thoroughly looking for these three components:

- **The Units of the Answer:** The problem may say something like: How many mL, tablets, mg, teaspoonfuls, etc. will the patient take? Or it may say something less specific, like: What is the weight of, the volume of, how much suspension will be needed?
- **The Given of the Problem:** The problem may say something like, "A prescription is written for 10 mg, 20 mL, 1 g, etc.." or it may say, "A patient is to receive 250 mg, 5 mL, etc."
- **One or More Ratios:** All problems (other than simple unit conversions) will have a ratio somewhere in the problem; you just must learn to recognize it. It may be something like: 250 mg per 5 mL, a 50 mg tablet, 400 mcg per mL, 3 g in 100 mL. "Off the shelf" ratios may be required to complete the calculation.

Step 2) All the following problems can be solved using DA with the following equation:

- **(Given)(Ratio 1)(Ratios 2, 3,…if needed) = Answer**

Once the three components have been identified, the problem can be set up and solved.

Example: A patient is to receive a dose of 500 mg of amoxicillin. The pharmacy has a bottle of amoxicillin 250 mg per 5mL suspension. How many mL of the suspension will the patient receive each dose?

- Units of the answer: mL
- The given: 500mg
- The ratio: $\left(\frac{250 \text{ mg}}{5 \text{ mL}}\right)$

Step 3) The problem can now be set up:

- Write down the given and the units of the answer with an equal sign in between.

$$\mathbf{500\ mg \qquad = \qquad mL}$$

- The ratio is the tool which will be used to change the units of the given (mg) into the units of the answer (mL). Remember, the ratios always equal 1 and can be flipped upside down if needed. The ratio must be placed so the units of the given are canceled out, leaving only the units of the answer. In this case, the ratio must be flipped putting mL on top and mg on the bottom.

$$\mathbf{500\ \cancel{mg}\left(\frac{5\ mL}{250\ \cancel{mg}}\right) = \ 10\ mL}$$

Dosage Exercise Set 1

1) A patient has a prescription order for a medication that is available as 500 mg/5 mL. She is to take 400 mg. How many milliliters will she take?

2) The doctor has ordered a dose of 800 mg. The medication is available as 200 mg/10 mL. How many milliliters will need to be drawn up to fill the order?

3) A patient has an order for 1500 mcg. The pharmacy has 500 mcg tablets. How many tablets will be needed to fill the order?

4) The pharmacy has a 480 mL bottle of KCl 20%. A patient has a prescription to take 15 mL every day. How many doses can be given from this bottle?

5) A patient has an order for 14,000 units of heparin. It is available as 10,000 units/mL in a 10 mL vial. How many milliliters are needed?

6) The doctor has ordered a dose of 65 mg. The medication is available as 100 mg/10 mL. How many milliliters will need to be drawn up to fill the order?

7) How many mcg of levothyroxine are contained in 2 tablets of levothyroxine 0.125 mg?

8) A patient has an order for 1.6 mg. The pharmacy has 0.4 mg tablets. How many tablets will be needed to fill the order?

9) A patient will be taking 5 mL of a drug which has a strength of 25 mg/mL. How many mg will the patient be taking?

10) A prescriber has ordered 375 mg of a drug which comes in a strength of 75 mg/mL. How many mL will the patient take?

Answers on page 83

Dosage Exercise Set 2

1) A patient is to receive 150 mg of a drug per day divided into 3 equal doses. The drug is available in 10 mL vials of 10 mg/mL. How many mL will be administered for each dose?

2) A patient who weighs 185 lb is to receive a dosage of 2 mg/kg/day for 4 days. The drug is available in 10 mL vials of 50 mg/mL. How many total mL will be administered over the 4 days.

3) A patient is ordered 600 mg/day in 4 equal doses. The drug is available in 10 mL vials of 50 mg/mL. How many mL will the patient receive in 1 dose?

4) A patient is prescribed 250 mg 3 times daily for 10 days. The drug is available in 125 mg capsules. How many capsules will be dispensed for the 10 days.

5) An 80 kg patient is prescribed 3 mg/kg/day for 7 days. The drug is available in 5 mL vials of 50 mg/mL. How many vials will be needed for the 7 days? Tip: Convert 3 mg/kg/day to 3 mg/kg*day.

6) A patient is to receive 5 mL of a drug 3 times daily for 10 days. The drug is available in a strength of 25 mg/mL in a bottle of 240 mL. How many mg will the patient receive in each dose?

7) A patient weights 205 lbs and is prescribed a dosage of 600 mg IV given over 2 hours. The drug is available in 10 mL vials of 100 mg/ mL. How many mL will be administered?

8) A patient is to receive a dosage of 34 mg/kg/day each day for 60 days. The patient weighs 196 lb. The drug is available in 20 mL vials of 200 mg/mL. How many vials will be required for the 60 day course of therapy?

9) A patient is prescribed 250 mg 4 times daily for 10 days. The drug is available in 250 mg capsules in bottles of 100. How many capsules will be dispensed for the 10 day course of therapy?

10) A patient is prescribed a dosage of 1 drop in each eye twice daily for 30 days. The eye drops are available in 5 mL bottles with 20 drops/mL. How many bottles will be required for the 30 days?

Answers on page 86

IV Flow Rate Calculations

These problems seem to cause some anxiety, but there is no new math, only new units, ratios, and terminology.

Terminology:

- **IV:** Abbreviation for intravenous, meaning administered into a vein.
- **drop factor**: The number of drops (gtts) per mL. Macrodrip tubing comes 10, 15, 20 gtts/mL while microdrip tubing is 60 gtt/mL.
- **flow rate/infusion rate/drip rate:** The volume of solution or weight of drug delivered over time. The units are usually gtts/min, mL/hour or mg/hour.

These problems are solved in the same manner as unit conversion and dosage problems. There is a given, units of the answer, and one or more ratios which will be used to convert the units of the given into the units of the answer. The main difference is that the given will usually be a rate, so there will be two units in the given and two units in the answer.

Example: An IV is running at a rate of 50 mL/h with a drop factor of 15 (15 gtts/mL). What is the rate in gtts/min?

- The given is $\frac{50\text{ mL}}{\text{h}}$ and must converted to $\frac{\text{gtts}}{\text{min}}$.
- mL must be converted to gtts.
  - The ratio used to convert mL to gtts is the drop factor of $\frac{15\text{ drops}}{\text{mL}}$
- Hours must be converted to minutes.
  - The ratio used to convert hours to minutes is $\frac{60\text{ min}}{\text{h}}$.
- It is easiest to write down the given and the units of the answer first, then fill in the ratios, which may need to be flipped

$$\frac{\mathbf{50\ mL}}{\mathbf{h}} = \quad \frac{\mathbf{gtts}}{\mathbf{min}}$$

- Inserting the drop factor first to change mL to gtts:

$$\frac{\mathbf{50}\ \cancel{\mathbf{mL}}}{\mathbf{h}}\left(\frac{\mathbf{15\ gtts}}{\cancel{\mathbf{mL}}}\right) \quad = \frac{\mathbf{gtts}}{\mathbf{min}}$$

- Inserting the next ratio to convert h to min:

$$\frac{\mathbf{50\ mL}}{\cancel{\mathbf{h}}}\left(\frac{\mathbf{15\ gtts}}{\cancel{\mathbf{mL}}}\right)\left(\frac{\cancel{\mathbf{1\ h}}}{\mathbf{60\ min}}\right) = \frac{\mathbf{12.5\ gtts}}{\mathbf{min}}\ \mathbf{rounded\ to}\ \frac{\mathbf{13\ gtt}}{\mathbf{min}}$$

IV Flow Rate Exercise

Calculate the flow rate in mL/h.

1) 1000 mL infused over 5 h.

2) 250 mL infused over 2 h.

Calculate the flow rate in gtts/min. Round to the nearest drop.

3) 1000 mL infused over 4 hours using an infusion set with a drop factor of 10 (10 gtts/mL).

4) 250 mL infused over 2 hours using an infusion set with a drop factor of 15.

5) 2 L infused over 24 hours using an infusion set with a drop factor of 20.

6) 100 mL infused over 1 hour using an infusion set with a drop factor of 10.

7) 1000 mL infused over 5 hours using an infusion set with a drop factor of 20.

Calculate the length of time required to infuse the following volumes.

8) A 1000 mL bag infused at the rate of 45 mL/h.

9) A 1000 mL bag infused at the rate of 45 mL/h using an infusion set with a drop factor of 20.

10) A 1000 mL bag infused at the rate of 45 mL/h using an infusion set with a drop factor of 10.

11) A 1 L bag infused at the rate of 50 gtts/min using an infusion set with a drop factor of 15.

12) A 500 mL bag infused at the rate of 25 gtts/min using an infusion set with a drop factor of 20.

Answer the following:

13) A patient has an order for regular insulin at the rate of 18 units/hour. The solution is 100 mL with 100 units of regular insulin. An infusion set with a drop factor of 20 is being used. What will be the flow rate in gtts/min?

14) A patient has an order for a drug to be infused at the rate of 5 mcg/kg/min. A 500 mL bag contains 250 mg of the drug and the patient weighs 185 pounds. An infusion set with a drop factor of 20 is being used. What is the flow rate in gtts/min?

15) A patient has an order for a drug to be infused at the rate of 25 mg/kg/h. A 1 L bag contains 10 g of the drug and the patient weighs 80 kg. An infusion set with a drop factor of 15 is being used. What is the flow rate in gtts/min?

Answers on page 87

Percent, Percent Strength, Ratio Strength

Percent

The three key concepts in understanding percent are:

- **Percent means per 100.** 50% is 50 parts per 100, or $\frac{50}{100}$.

- **100% equals 1.** Since 100% = 1, the corresponding conversion factors are $\left(\frac{100\%}{1}\right)$ and $\left(\frac{1}{100\%}\right)$, which is the same as multiplying or dividing by 100%.

- **The percent sign (%) will cancel itself out just as the units of measurement cancel themselves out.** $\frac{\mathbf{12}\cancel{\%}}{\mathbf{100}\cancel{\%}} = \frac{\mathbf{12}}{\mathbf{100}}$

Converting a Number to a Percent

- **Convert a number to a percent by multiplying by 100%.**
- **Example: Convert 0.30 to a percent. 0.30 (100%) = 30%.**
  - 100% = 1, so the value of 0.30 has not changed, only the appearance.

Converting a Percent to a Number

- **Convert a percent to a number by dividing by 100%. If you wish, you can multiply by $\left(\frac{1}{100\%}\right)$, which is the same thing.**
- **Example: Convert 35% to a number.**

$$\left(\frac{\mathbf{35}\cancel{\%}}{\mathbf{100}\cancel{\%}}\right) = \mathbf{0.35}.$$

Converting a Fraction to a Percent

- **Convert a fraction to a percent by multiplying the fraction by 100%.**
- **Example: Convert 1/4 to a percent. 1/4 (100%)= 25%**

Summing up: To add the % sign, multiply by 100%. To remove the % sign, divide by 100%. (Yes, you multiply or divide by 100%, NOT 100.)

More Examples

Convert the following numbers to percent.

Number	Percent
0.87	**0.87 (100%) = 87%**
1.67	**1.67 (100%) = 167%**
0.0056	**0.0056 (100%) = 0.56%**
0.36	**0.36 (100%) = 36%**
3	**3 (100%) = 300%**
1.1	**1.1 (100%) = 110%**
0.9944	**0.9944 (100%) = 99.44%**

Convert the following percents to numbers.

Percent	Number
89%	**89%/100% = 0.89**
0.25%	**0.25%/100% = 0.0025**
157%	**157%/100% = 1.57**
99.44%	**99.44%/100% = 0.9944**
56.1%	**56.1%/100% = 0.561**
25%	**25%/100% = 0.25**
34%	**34%/100% = 0.34**

Convert the following fractions to percents.

Fraction	Percent
5/6	**5/6 (100%) = 83.3%**
9/10	**9/10 (100%) = 90%**
2/20	**2/20 (100%) = 10%**
1/4	**1/4 (100%) = 25%**
34/50	**34/50 (100%) = 68%**
2/8	**2/8 (100%) = 25%**
13/99	**13/99 (100%) = 13.1%**

Percent Exercise

1) Convert the following numbers to percents using the format in the examples below.

0.35	(0.35)(100%)=35%
15/17	(15/17)(100%)=88.24%
0.98	
1.78	
3.99	
0.05	
0.003	
1.25	
6/9	
5.45	
9.95	
0.005	

2) Convert the following percents to numbers using the format in the example below.

56%	$\frac{56\cancel{\%}}{100\cancel{\%}}$=0.56
3.5%	
99%	
101%	
34.5%	
85.67%	
3.35%	
3%	

Answers on page 89

Percent Strength

The only difference between percent strength and percent is that percent strength includes units of weight and volume.

- **Weight, in a percent strength, is always expressed in units of gram (g).**
- **Volume, in a percent strength, is always expressed in units of milliliter (mL).**

The Four Types of Mixtures, also Called Solutions

Weight in Weight $\left(\frac{w}{w}\right)$: An example is 1 g of hydrocortisone (the solute) in 100 g of final cream (the solution). This is a 1% hydrocortisone cream.

Weight in Volume $\left(\frac{w}{v}\right)$: An example is 1 g of NaCl (the solute) in 100 mL of NaCl solution (the solution). This is a 1% NaCl solution.

Volume in Volume $\left(\frac{v}{v}\right)$: An example is 1 mL of ethanol (the solute) in 100 mL of final product (the solution) (1 mL ethanol mixed with 99 mL of water). This is a 1% ethanol solution.

Volume in weight $\left(\frac{v}{w}\right)$: This type of solution is not very common. An example is 10 mL of glycerin in 100 g glycerin ointment. This is a 10% glycerin ointment.

A 1% NaCl solution is 1% $\frac{w}{v}$ NaCl solution. Sometimes the units $\frac{w}{w}, \frac{w}{v}, \frac{v}{v}, \frac{v}{w}$ are not included in the problem and must be added. If it is weighed, it is w, if the volume is measured, it is v. Note that occasionally liquids are expressed in weight.

The Key to Solving these Problems

- **Substitute g for w and mL for v in the ratios and units of the answer.**
- **Preform the calculations.**
- **Substitute w and v back in the final answer, if required.**

Example: How many grams of NaCl are in 45 mL of $2\%\frac{w}{v}$ NaCl solution?

- This problem can be completed in one step. Substitute g for w and mL for v, multiply by 45 mL and divide by 100%.

$$45\,\cancel{\mathbf{mL}}\left(\frac{2\cancel{\%}\,\mathbf{g}}{100\cancel{\%}\,\cancel{\mathbf{mL}}}\right) = \mathbf{0.9\ g}$$

See how nicely mL and % cancel out? If the problem asked for the number of mg, add the conversion factor $\left(\frac{1000\ \text{mg}}{\text{g}}\right)$.

$$\mathbf{45\ \cancel{mL}\left(\frac{2\cancel{\%}\ g}{100\cancel{\%}\ \cancel{mL}}\right)\left(\frac{1000\ mg}{\cancel{g}}\right) = 900\ mg}$$

Calculate the Percent Strength from Weight and Volume

Calculate the percent strength of a solution by setting up the problem with the given and the units of the answer. The final units of the answer will be % w/v, % w/w, % v/v, or % v/w, but substitute g and mL for w and v.

Example: What is the percent strength of a solution if there are 985 mg of NaCl in 2.5 L?

- Write down the given and the units of the answer:

$$\mathbf{\frac{985\ mg}{2.5\ L}} = \qquad \%\ \mathbf{\frac{g}{mL}}$$

It is now easy to see that mg must be converted to g, L converted to mL, and the % must be added.

- Convert mg to g by multiplying by $\left(\frac{1\ \text{g}}{1000\ \text{mg}}\right)$.
- Convert L to mL by multiplying by $\left(\frac{1\ \text{L}}{1000\ \text{mL}}\right)$.
- Add the % sign by multiplying by 100%.

$$\mathbf{\frac{985\ \cancel{mg}}{2.5\ \cancel{L}}\left(\frac{1\ g}{1000\ \cancel{mg}}\right)\left(\frac{1\ \cancel{L}}{1000\ mL}\right)\ 100\% = \ 0.0394\%\ \frac{g}{mL}}$$

- Substitute w for g and v for mL in the final answer: $\mathbf{0.0394\%\ \frac{w}{v}}$

Percent Strength Exercise

Express the following as percent strength solution, and include the type of solution (w/w, w/v, v/v, v/w).

1) 7 g KCl in 200 mL

2) 3.5 g NaCl in 1000 mL

3) 7.9 mg $NaHCO_3$ in 100 mL

4) 5 mcg NaCl in 0.25 mL

5) 45 g NaCl in 3 L

6) 3 g HC in 200 g HC ointment

7) 5 g coal tar in 300 g coal tar ointment

8) 5 mg betamethasone in 10 g betamethasone ointment

9) 20 g urea in 40 g urea ointment

10) 18 g salicylic acid in 300 g salicylic acid cream

11) 900 mL IPA in 1000 mL IPA solution

12) 40 mL ETOH in 100 mL ETOH solution

Answer the following:

13) How many mg of NaCl are in 10 mL of 0.9% NaCl (normal saline)?

14) How many g of NaCl are in 2 L of NS (normal saline)?

15) How many g of KCl are in 473 mL of 20% KCl?

16) How many mg of bupivacaine are in 30 mL of 0.5% bupivacaine solution?

17) How many mg of lidocaine are in 100 mL of 1% lidocaine?

18) How many mcg of NaCl are in 1 drop of 0.9% NaCl if there are 20 drops/mL?

19) How many mL of ETOH are in 60 mL of 80 proof (40% ETOH) tequila?

20) How many g of HC are in 500 g of 2.5% HC ointment?

Answers on page 90

Ratio Strength

- **Very occasionally, drug strengths are expressed as ratio strengths.**
- **These calculations have similarities to percent strength calculations.**
  - The units are always g and mL.
  - Solutions may be w/w, w/v, v/v, or v/w.
- **The conventional format is 1:another number, where the other number is the amount of final product. Examples: 1:100, 1:500, 1:10,000.**
  - A 1:100 w/w preparation is 1 g active ingredient in 100 g of final product. **It is not 1 g of active ingredient mixed with 100 g of inactive ingredient.**
  - A 1:100 w/v solution is 1 g active ingredient in 100 mL solution.
  - A 1:100 v/v solution is 1 mL of active ingredient in 100 mL solution.
  - A 1:100 v/w solution is 1 mL of active ingredient in 100 g of product.
- **Keys to preforming calculations involving ratio strengths.**
  - Determine the type of solution (w/w, w/v,v/v, v/w).
  - Assign the units of g to w and mL to v.
  - Convert from the colon format into the fraction format with the units attached. **Example: 1:1000 w/v becomes 1 g/1000 mL.**
  - Proceed with calculations using DA or RP.

Example: How many mg of epinephrine are in 45 mL of a 1:10,000 solution of epinephrine?

- This is a **w** (mg) of epinephrine in **v** (45 mL) solution.
- 1:10,000 w/v is 1 g:10,000 mL
- 1 g:10,000 mL converted to fraction format is $\left(\frac{1\text{ g}}{10{,}000\text{ mL}}\right)$.
- Proceed with calculations using DA.

$$45\ \cancel{\text{mL}}\left(\frac{1\ \cancel{\text{g}}}{10{,}000\ \cancel{\text{mL}}}\right)\left(\frac{1000\text{ mg}}{\cancel{\text{g}}}\right) = 4.5\text{ mg}$$

Important: Many fatalities have resulted from incorrect calculations involving ratio strength, with epinephrine being one of the most common drugs involved. Be very careful when preforming ratio strength calculations. Most drugs labeled with ratio strength will include the strength listed in mg/mL, which is safer to use.

Ratio Strength Exercise

1) How many grams of active ingredient are in 500 mL of a 1:10,000 solution?

2) How many grams of active ingredient are in 40 mL of a 1:200 solution?

3) How many grams of active ingredient are in 600 g of a 1:25 w/w preparation?

4) How many mg of active ingredient are in 800 mL of a 1:10,000 solution?

5) How many mcg are in 10 mL of a 1:100,000 solution?

6) You have a 10 mL vial which is labeled 1:10,000 and are asked to draw up 0.4 mg of drug. How many mL would you draw?

7) You are asked to make 200 g of a 1:100 HC ointment preparation. How many grams of HC powder and how many grams of ointment base would you use?

8) You have a solution which is 1:10,000 w/v. What is the percentage strength?

9) What is the percentage strength of a 1:100 w/v solution?

10) You have a 100 mL vial which is labeled 1:1000. How many mg are in 25 mL of the solution?

Answers on page 92

Milliequivalent Calculations

Terminology:

- **Electrolytes:** Ions which are important to the function of the body. (Na^+, K^+, Cl^-, etc.)
- **Ion**: An atom or group of atoms that has either lost or gained electrons, and carries either a positive or negative charge.
- **Cation:** A positively charged ion (pronounced cat-ion).
- **Anion**: A negatively charged ion.
- **Valence:** The simple definition is the number of charges on the ion.
- **Atomic Mass/Atomic Weight**: For purposed of this book, these terms are used interchangeably. They are relative weights of the elements. For example, hydrogen has an atomic mass of 1 while carbon has an atomic mass of 12. An atom of carbon is twelve times as heavy as an atom of hydrogen. There are no units on atomic masses.

Key Concepts to Understanding Milliequivalent Calculations

- **mEq calculations involve quantities of ions and charges, not weights. Think dozens of eggs, not pounds of coffee beans.**
- **A millimole (mmole) is 1/1000 of a mole (mol) or 6.022 X 10^{20} of anything.**
- **A mEq is a mmol of charges.**
  Examples:
- 1 mmol of NaCl = 1 mmol of Na^+ and 1 mmol of Cl^-.
- Na^+ and Cl^- each have one charge.
- 1 mmol of NaCl = 1 mEq of Na^+ and 1 mEq Cl^-.
- 1 mmol of $MgSO_4$ = 1 mmol of Mg^{+2} and 1 mmol of SO_4^{-2}.
- Mg^{+2} and SO_4^{-2} each have two charges.
- 1 mmol of $MgSO_4$ = 2 mEq of Mg^{+2} and 2 mEq of SO_4^{-2}.

Converting Between mg and mEq

- The weight of a mmol of the electrolyte and the valence must be known.
- Determine the weight of a mmol of the electrolyte by looking up the atomic mass and adding mg to the end to give you the mg/mmol. For example, the atomic mass of potassium (K) is 39.1, which equates to 39.1 mg/mmol.
- Determine the valence by looking it up. The common electrolytes and their valences are listed in the milliequivalent exercise.

Example: How many mEq of KCl are in 300 mg of KCl?

- The formula mass (mass of K^+ + Cl^-) is 74.6, meaning 74.6 mg = 1 mmol. There is one charge on each ion, so 1 mmol = 1 mEq.

$$\mathbf{300\ \cancel{mg}\left(\frac{1\ \cancel{mmol}}{74.6\ \cancel{mg}}\right)\left(\frac{1\ mEq}{\cancel{mmol}}\right) = 4\ mEq}$$

- It can also be stated that 4 mEq of KCl = 4 mEq of K^+ and 4 mEq of Cl^-.

Example: How many mEq of Mg^{+2} are in 300 mg of $MgSO_4$?

$$\mathbf{300\ \cancel{mg}\left(\frac{1\ \cancel{mmol}}{120.4\ \cancel{mg}}\right)\left(\frac{2\ mEq}{\cancel{mmol}}\right) = 5\ mEq}$$

Milliequivalent Exercise

1) Look up the atomic masses (atomic weights) of the following elements. The atomic masses can be found on the periodic table or Google it. If you can't find them on your own, they are listed in the answers. Round to the nearest tenth.

Name	Atomic Symbol	Atomic Mass	Ionic Form
Hydrogen	H		H^+ (Hydrogen Ion)
Carbon	C		
Oxygen	O		
Sodium	Na		Na^+ (Sodium Ion)
Magnesium	Mg		Mg^{++} (Magnesium Ion)
Chlorine	Cl		Cl^- (Chloride Ion)
Potassium	K		K^+ (Potassium Ion)
Calcium	Ca		Ca^{++} (Calcium Ion)
Sulfur	S		

2) Now that you know the atomic masses of each of the elements, fill in the formula masses of the listed polyatomic ions (ions with more than one atom). Add up all the individual masses. CH_3COO^- has two carbon atoms, three hydrogen atoms, and two oxygen atoms.

Name	Chemical Formula	Formula Mass	Ionic Form
Acetate	CH_3COO^-		CH_3COO^-
Bicarbonate	HCO_3^-		HCO_3^-
Sulfate	SO_4^{-2}		SO_4^{-2}

3) Now that you know the above atomic and formula masses, you are ready to list the formula masses of the following ionic compounds.

Name	Chemical Formula	Formula Mass	Ionic Form
Sodium Chloride	$NaCl$		Na^{+} Cl^{-}
Potassium Chloride	KCl		K^{+} Cl^{-}
Calcium Chloride	$CaCl_2$		Ca^{++} $2Cl^{-}$
Magnesium Chloride	$MgCl_2$		Mg^{++} $2Cl^{-}$
Sodium Acetate	CH_3COONa		Na^{+} CH_3COO^{-}
Potassium Acetate	CH_3COOK		K^{+} CH_3COO^{-}
Magnesium Sulfate	$MgSO_4$		Mg^{++} SO_4^{2-}
Sodium Bicarbonate	$NaHCO_3$		Na^{+} HCO_3^{-}

4) Fill in the table with the ratios of mg/mmol and mEq/mmol for each compound.

Name	Chemical Formula	mg/mmol (ratio)	mEq/mmol (ratio)
Sodium Chloride	$NaCl$		
Potassium Chloride	KCl		
Calcium Chloride	$CaCl_2$		
Magnesium Chloride	$MgCl_2$		
Sodium Acetate	CH_3COONa		
Potassium Acetate	CH_3COOK		
Magnesium Sulfate	$MgSO_4$		
Sodium Bicarbonate	$NaHCO_3$		

- **You now have all the ratios needed to convert between mg and mEq.**

Example: How many mEq are in 500 mg of $CaCl_2$?

- Calcium chloride has 111 mg per mmol and two mEq per mmol.
- These ratios can be written $\frac{111\ \text{mg}}{\text{mmol}}$ or $\frac{1\ \text{mmol}}{111\ \text{mg}}$ and $\frac{2\ \text{mEq}}{\text{mmol}}$ or $\frac{1\ \text{mol}}{2\ \text{mEq}}$.
- Set the problem up with the given and units of the answer.

500 mg = mEq

- Insert the ratios in the usual way leaving only the units of the answer.

$$\mathbf{500\ \cancel{mg}\left(\frac{1\ \cancel{mmol}}{111\ \cancel{mg}}\right)\left(\frac{2\ mEq}{\cancel{mmol}}\right) = 9.0\ mEq}$$

Answer the following.

5) How many mEq are contained in 746 mg of KCl?

6) How many mEq of calcium chloride are contained in 2 g of calcium chloride?

7) How many mEq of Ca^{++} are in 2 g of calcium chloride?

8) How many mg of magnesium sulfate are in 10 mEq of magnesium sulfate?

9) How many g of sodium acetate are in 12 mEq of sodium acetate?

10) How many mEq of NaCl are in 2 L of 0.9% NaCl?

11) How many mEq of KCl are in 30 mL of 10% KCl solution?

12) How many mEq of $MgSO_4$ are contained in 10 g of $MgSO_4$?

13) How many mg of Na^+ (just the sodium) are contained in 1.5 L of 10% NaCl?

14) Try this one if you wish. You have 2.5 L of 10% NaCl solution and your friend has 1.5 L of $MgSO_4$ solution. You have twice as many mEq of NaCl as your friend has of mEq of MgSO4. What is the percentage strength of your friend's $MgSO_4$?

Answers on page 93

Chapter III
Concentrations and Dilutions

This chapter covers calculations involving concentrations, dilution, and mixing. There are several different types of problems in this chapter, but they all have similar components.

Topics covered are:

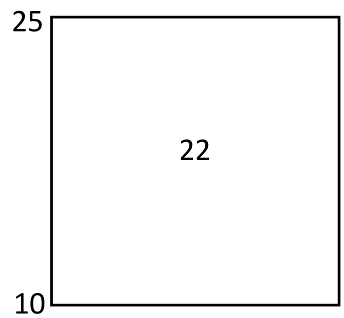
- **The Alligation Method**
  - A method used to calculate the volumes of two different strength solutions when preparing a third strength. It may also be used on some simpler problems.
- **Preparing a Solution Using Two Different Strength Solutions**
  - This topic is covered in the alligation method.
- **Preparing a Solution Using a Stock Solution and a Diluent**
  - This is the most common type of dilution calculation encountered in the pharmacy. Several different methods of solving these problems will be explained.
- **Calculating the Percent Strength of a Mixture**
  - These calculations seem complicated at first, but are very easy.
- **Powder Volume Calculations**
  - These calculations involve mixing a diluent with a dry powder containing the active ingredient. You may or may not encounter these calculations in your practice.
- **Serial Dilution**
  - The method for preparing a very dilute solution will be explained.

The Alligation Method

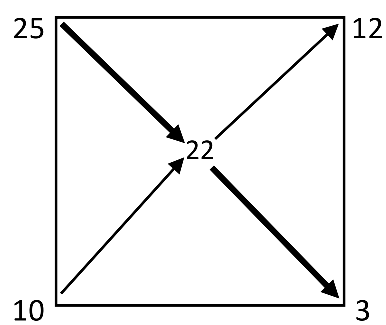
- **The alligation method is an easy way of solving problems which involve mixing two different strength solutions to form a third strength.**
- **Although not usually the easiest method of solving simple dilution problems, it can be used for these problems if desired.**
- **All strengths must be in percent strength.**

Example: **How much 10% solution must be mixed with a 25% solution to prepare 1000 mL of a 22% solution**

Step 1) Draw a box and place the percent of the lower strength solution on the lower left corner, the percent of the higher strength solution on the upper left corner, and the percent of the of the solution being preparing in the middle. In the above example, a 10 is placed in the lower left corner, a 25 in the upper left corner and a 22 in the middle.



Step 2) Take the difference between the lower left corner and the middle and write it in the upper right corner. Take the difference between the upper left corner and the middle and write it in the lower right corner. Note: The differences are always written as positive numbers.



Step 3) The 12 and the 3 represent the number of parts of the 25% solution and the 10% solution needed to make the 22% solution. The total number of parts of both solutions is 15 (12 + 3), so 12/15 of the final solution is the 25% solution and 3/15 of the final solution is the 10% solution. Multiply 1000 mL by 12/15 to determine the amount of 25% solution. Multiply 1000 mL by 3/15 to determine the amount of 10% solution to add.

$$\mathbf{1000\ mL}\ \left(\frac{\mathbf{12}}{\mathbf{15}}\right) = \mathbf{800\ mL\ of\ 25\%\ solution}$$

$$\mathbf{1000\ mL}\ \left(\frac{\mathbf{3}}{\mathbf{15}}\right) = \mathbf{200\ mL\ of\ 10\%\ solution}$$

This method can also be used when preparing a solution from a stock solution and a diluent if the stock solution and final product are expressed in percent strength. Use a 0 in the lower left corner and the percent strength of the stock solution in the upper left corner.

Preparing a Solution from a Stock Solution and a Diluent

This is probably the most common type of dilution problem encountered in the pharmacy. Three common methods of solving these problems are:

- **Calculate amount of active ingredient in the final product, then calculate amount of stock solution required to obtain the active ingredient.**
- **Use the formula V1C1=V2C2, where V1=Volume of first solution, C1=Concentration of first solution, V2=Volume of second solution, C2=Concentration of second Solution.**
- **Use the alligation method, which is not the easiest or quickest way.**

Consider the following example solved using each of the three methods.

An order calls for 600 mL of a 25 mg/mL solution. You have a 100 mg/mL stock solution on hand. How many mL of the stock solution and how many mL of the diluent are needed?

Before looking at the three methods, consider what Baker Bob did with a similar situation. Bob received a large order for 600 birthday cakes, each with 25 candles. Eager to order the supplies for the cakes, he thought to himself, "I am making 600 cakes and each cake will have 25 candles. 600 cakes x 25 candles/cake is 15,000 candles." Bob then gets on the phone to the candle wholesaler and asks him how many candles come in a box. He is told 100 candles per box. Bob thinks to himself, "I need 15,000 candles and they come 100 in a box." Bob then orders 150 boxes.

Bob didn't worry about what size box the candles came in until he calculated the total number of candles and he didn't need a "candle formula."

Method 1: Calculate the amount of active ingredient in the final product then calculate the volume of stock solution needed to obtain that amount of active ingredient.

$$\mathbf{600\,\cancel{mL}\left(\frac{25\ mg}{\cancel{mL}}\right) = 15,000\ mg}$$

15,000 mg of active ingredient is in the final product. The volume of stock solution required to obtain the 15,000 mg of active ingredient is now calculated.

$$\mathbf{15,000\,\cancel{mg}\left(\frac{1\ mL}{100\ \cancel{mg}}\right) = 150\ mL}$$

150 mL of the stock solution will be mixed with 450 mL (600 mL – 150 mL) of diluent to prepare the final solution.

Method 2: Use the formula V1C1=V2C2. In this case, V1=600 mL, C1=25 mg/mL, V2 is unknown stock solution volume and C2 is 100 mg/mL.

$$\mathbf{600\ mL}\left(\frac{\mathbf{25\ mg}}{\mathbf{mL}}\right) = \mathbf{V2}\left(\frac{\mathbf{100\ mg}}{\mathbf{mL}}\right)$$

To solve for V2, multiply both sides by 1 mL/100 mL.

$$\mathbf{V2} = \mathbf{600}\,\cancel{\mathbf{mL}}\left(\frac{\mathbf{25}\,\cancel{\mathbf{mg}}}{\cancel{\mathbf{mL}}}\right)\left(\frac{\mathbf{1\ mL}}{\mathbf{100}\,\cancel{\mathbf{mg}}}\right)$$

V2=150 mL

This method works because VC=AI (Active Ingredient). The AI is the same in both solutions.

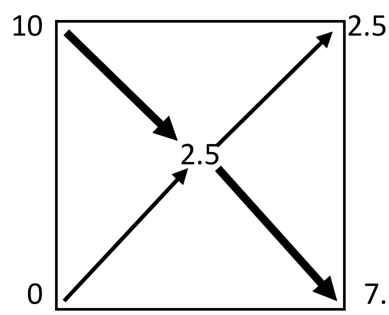
Method 3: Convert the stock solution and the final solution concentrations to percent strength, then use the alligation method.

The stock solution is 100 mg/mL.

$$\frac{\mathbf{100}\,\cancel{\mathbf{mg}}}{\mathbf{mL}}\left(\frac{\mathbf{1\ g}}{\mathbf{1000}\,\cancel{\mathbf{mg}}}\right)\mathbf{100\%} = \mathbf{10\%}\ \frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{10\%}\frac{\mathbf{w}}{\mathbf{v}}$$

The final preparation is 25 mg/mL, which works out to 2.5% w/v.

The diluent is 0%.



The total parts are 10, with 2.5/10 being the 10% solution and 7.5/10 being the 0% (diluent).

$$\mathbf{600\ mL}\ \left(\frac{\mathbf{2.5}}{\mathbf{10}}\right) = \mathbf{150\ mL\ of\ 10\%\ solution}$$

$$\mathbf{600\ mL}\ \left(\frac{\mathbf{7.5}}{\mathbf{10}}\right) = \mathbf{450\ mL\ of\ 0\%\ solution}$$

- **If all the solutions are stated in percent strength, you might consider using this method, otherwise it is easier to use one of the first two methods.**

Calculating the Percent Strength of a Mixture

To calculate the final concentration of a mixture of two or more solutions with different strengths, the amount of active ingredient and the volume of the final solution must be determined.

Example: 100 mL of a 40% w/v solution, 25 mL of a 90% w/v solution and 40 mL of a 75% w/v solution are mixed together. What is the percent strength of the final solution?

- Start by calculating the amount of active ingredient in each of the three solutions.

$$\mathbf{100\ \cancel{mL}\left(\frac{40\ g}{100\ \cancel{mL}}\right) = 40\ g}$$

$$\mathbf{25\ \cancel{mL}\left(\frac{90\ g}{100\ \cancel{mL}}\right) = 22.5\ g}$$

$$\mathbf{40\ \cancel{mL}\left(\frac{75\ g}{100\ \cancel{mL}}\right) = 30\ g}$$

- Total the volumes and active ingredients of the three solutions.
  - **100 mL + 25 mL+ 40 mL=165 mL**
  - **40 g + 22.5 g + 30 g = 92.5 g**
- Convert 92.5 g/165 mL into a percent strength.

$$\mathbf{\frac{92.5\ g}{165\ mL}(100\%) = 56.1\%\frac{g}{mL} = 56.1\%\frac{w}{v}}$$

Concentration and Dilution Exercise

1) An order calls for 600 mL of a 17% solution. You have a 43% solution on hand. How many mL of stock solution (43%) and how many mL of diluent are needed?

2) The pharmacy stocks a 35% solution. A doctor writes an order for 40 mL of 250 mg/mL solution. How many mL of the stock solution and how many mL of diluent are needed? Note: You can use V1C1=V2C2 even if the concentrations of the two solutions are not in the same units. Give it a try.

3) A prescription is written for 300 mL of a 16% solution. You have a 50% solution available in the pharmacy. How many mL of the stock solution and how many mL of diluent are needed?

4) A patient brings in a prescription for 60 mL of a 50 mg/mL solution. Your pharmacy stocks a 360 mg/2 mL solution. How many mL of the stock solution and how many mL of diluent are needed?

5) Your pharmacy has a 150 mL stock bottle of 1:1000 and a 200 mL stock bottle of 8% solution of the same drug. The pharmacist mixes both bottles together, for no reason other than to make your life difficult, and asks you to prepare 300 mL of a 30 mg/mL solution. How many mL of the mixed stock solution and how many mL of diluent are needed?

6) The pharmacy stocks a 15% and a 75% alcohol solution. You receive a prescription for 300 mL of a 40% alcohol solution. How many milliliters of the 15% and 75% solutions are needed?

7) An order is written for 700 mL of a 34% solution. Your pharmacy stocks a 10% and a 45% solution. How many milliliters of the 10% and 45% solutions are needed?

8) What is the percentage strength of a mixture containing 60 mL of a 10% solution and 180 mL of a 35% solution?

9) You are to prepare 200 mL of 19% dextrose solution from $D_{10}W$ and $D_{40}W$. How much of each is required? (Note: $D_{10}W$ = 10% dextrose in water and $D_{40}W$= 40% dextrose in water).

10) The same pharmacist in problem 5 mixes 100 mL of a 6% solution, 200 mL of a 100 mg/mL solution and 1 L of a 1:100 solution together, then he measures out 10 mL of that mixture and mixes it with 120 mL of diluent. What is the percent strength of the final solution?

Answers on page 95

Powder Volume Calculations

Powder volume calculations involve bottles or vials which contain a dry powder and are reconstituted with a diluent, usually water. You may be asked to solve for a variety of things, including the final volume, the final concentration, the weight of the active ingredient, the diluent volume or the powder volume. At first glance, these problems may seem complicated, but they are not if broken down into smaller parts.

These Problems all have Five Components in Common

- **Final Volume of the solution (FV):** The volume after the diluent and the powder have been mixed, and is usually expressed in mL.
- **Powder Volume (PV):** The volume of the dry powder, and is usually expressed in mL.
- **Diluent Volume (DV):** The volume of the diluent (usually water) that is added to the dry powder to make the final solution, and is usually expressed in mL.
- **Final Concentration (FC):** The concentration of the final solution after the powder and diluent have been mixed, and is usually expressed as $\frac{\mathrm{g}}{\mathrm{mL}}$ or $\frac{\mathrm{mg}}{\mathrm{mL}}$.
- **Weight of Active Ingredient (WT):** The weight of the active ingredient.

Summary:

Final Volume (FV)	Volume after Diluent and powder have been mixed.	If two out of these three items are known, the third can be calculated. **PV + DV = FV**
Powder Volume (PV)	Volume of the powder.	
Diluent Volume (DV)	Volume of the diluent (usually water).	
Final Concentration (FC)	Concentration of the solution.	If these two items are known, the FV can be calculated. **(WT)(FC with mL on top) = FV** **Also, WT/FV = FC**
Weight of Active Ingredient (WT)	Weight of the active ingredient.	

Note that some of the simpler problems will not require all five components. For example, if the problems states that the final volume is 10 ml and the power volume is 2 ml, and it asks for the diluent volume, you do not need to know the FC and WT. The diluent volume would just be 10 ml - 2 ml = 8 ml.

Solving Powder Volume Problems

Step 1) Make a list of the five components.

Final Volume (FV)	
Powder Volume (PV)	
Diluent Volume (DV)	
Final Concentration (FC)	
Weight of A.I. (WT)	

Step 2) Look at the problem and start filling in the blanks with the information in the problem.

Step 3) Calculate the remaining quantities from the given information.

Example 1: To make an injectable solution with a final concentration of 375 mg/mL you will be adding 3.3 mL to a vial that contains 1.5 g of active ingredient. What is the powder volume?

Final Volume (FV)	
Powder Volume (PV)	
Diluent Volume (DV)	3.3 mL
Final Concentration (FC)	375 mg/mL
Weight of A.I. (WT)	1.5 g

- After filling in the table with the information given in the problem, calculate the final volume from the final concentration and weight of active ingredient.

$$\mathbf{1.5\ \cancel{g}}\left(\frac{\mathbf{1\ mL}}{\mathbf{375\ \cancel{mg}}}\right)\left(\frac{\mathbf{1000\ \cancel{mg}}}{\mathbf{\cancel{g}}}\right)=\mathbf{4\ mL}$$

- Fill in the Final Volume.

Final Volume (FV)	4 mL
Powder Volume (PV)	
Diluent Volume (DV)	3.3 mL
Final Concentration (FC)	375 mg/mL
Weight of A.I. (WT)	1.5 g

- The final volume is 4 mL and the diluent volume is 3.3 mL, so the powder volume is the difference: 0.7 mL.

Final Volume (FV)	4 mL
Powder Volume (PV)	0.7 mL
Diluent Volume (DV)	3.3 mL
Final Concentration (FC)	375 mg/mL
Weight of A.I. (WT)	1.5 g

Solving Problems Involving Two Different Concentrations

Example 2: The label of a 10 g vial says that if you add 13.5 mL of diluent to the vial's contents you will get a concentration of $\left(\frac{\mathbf{1\ g}}{\mathbf{2.5\ mL}}\right)$. What concentration do you get if you add 9.5 mL?

Step 1) Fill in the known values that are given in the first part of the problem.

Final Volume (FV)	
Powder Volume (PV)	
Diluent Volume (DV)	13.5 mL
Final Concentration (FC)	1 g/2.5 mL
Weight of A.I. (WT)	10 g

Step 2) Calculate the Final Volume.

$$10\ \text{g}\left(\frac{2.5\ \text{mL}}{1\ \text{g}}\right) = 25\ \text{mL}$$

Step 3) Calculate the Powder Volume by subtracting the DV from the FV.

25 mL - 13.5 mL = 11.5 mL

Step 4) Fill in the final two components.

Final Volume (FV)	25 mL
Powder Volume (PV)	11.5 mL
Diluent Volume (DV)	13.5 mL
Final Concentration (FC)	1 g/2.5 mL
Weight of A.I. (WT)	10 g

The problem now asks for the final concentration if 8.5 mL, rather than 13.5 mL, of diluent is added. The weight of the active ingredient and the power volume will not change if a different volume of diluent is added.

Step 5) Set up a second column for the second scenario and fill in the known information.

	If 13.5 mL is added.	**If 8.5 mL is added.**
Final Volume	25 mL	
Powder Volume	11.5 mL	11.5 mL
Diluent Volume	13.5 mL	8.5 mL
Final Concentration	1 g/2.5 mL	
Weight of Active Ingredient	10 g	10 g

The final volume in the second scenario is calculated by adding the powder volume and the diluent volume (11.5 mL + 8.5 mL = 20 mL).

Step 6) Add the 20 mL calculation to the list in the second column.

Step 7) Calculate the concentration of the second solution from the weight of the active ingredient (10 g) and final volume (20 mL). $\frac{\mathbf{10\ g}}{\mathbf{20\ mL}}$ **is then simplified to** $\frac{\mathbf{1\ g}}{\mathbf{2\ mL}}$

	If 13.5 mL is added.	**If 8.5 mL is added.**
Final Volume	25 mL	20 mL
Powder Volume	11.5 mL	11.5 mL
Diluent Volume	13.5 mL	8.5 mL
Final Concentration	1 g/2.5 mL	1 g/2 mL
Weight of Active Ingredient	10 g	10 g

Powder Volume Exercise

Final Volume (FV)	Volume after Diluent and powder have been mixed.	If two out of these three items are known, the third can be calculated. **PV + DV = FV**
Powder Volume (PV)	Volume of the powder.	
Diluent Volume (DV)	Volume of the diluent (usually water).	
Final Concentration (FC)	Concentration of the solution.	If these two items are known, the FV can be calculated. **(WT)(FC with mL on top) = FV** **Also, WT/FV = FC**
Weight of Active Ingredient (WT)	Weight of the active ingredient.	

Use this space to draw a bottle showing the powder in the bottom and the diluent on top of the powder. Draw a bracket which includes the powder and the diluent and label it final volume. Now put some dots in the powder which represents the actual drug. (The powder usually has fillers, etc. which are not the actual drug.) The dots will represent the weight of the actual drug.

1) The label of a vial states that it contains 3 g. It also says that to make the solution 100 mg/mL, you must add 15.3 mL. What is the powder volume?

Final Volume (FV)	
Powder Volume (PV)	
Diluent Volume (DV)	
Final Concentration (FC)	
Weight of A.I. (WT)	

2) An oral suspension once reconstituted will have a concentration of 250 mg/5 mL. The A.I. is 5 g with a powder volume of 14.9 mL. How much water must be added?

Final Volume (FV)	
Powder Volume (PV)	
Diluent Volume (DV)	
Final Concentration (FC)	
Weight of A.I. (WT)	

3) A bottle of amoxicillin says to add 187 mL to the bottle to get a suspension of 125 mg/5 mL. The bottle contains 5 g of amoxicillin. What is the powder volume?

Final Volume (FV)	
Powder Volume (PV)	
Diluent Volume (DV)	
Final Concentration (FC)	
Weight of A.I. (WT)	

4) A 30 g bulk vial label states that if you add 142 mL of a diluent, the concentration will be 1 g/5 mL. How much diluent would you add to get a concentration of 1 g/3 mL?

This problem consists of two different scenarios. In the first scenario you end up with a concentration of 1 g/ 5mL, while in the second scenario you end up with a concentration of 1 g/3 mL. The important thing to understand is that in both cases you will start with a 30 g vial, you will just be adding different amounts of diluent. Look at the five components and ask yourself which ones will remain the same for both scenarios and which ones will change.

Will the FV change? Y N

Will the PV change? Y N

Will the DV change? Y N

Will the FC change? Y N

Will the WT change? Y N

Now that you have correctly answered the above questions, you can start filling in the blanks in column one (First Scenario).

First Scenario		**Second Scenario**	
Final Volume (FV)		Final Volume (FV)	
Powder Volume (PV)		Powder Volume (PV)	
Diluent Volume (DV)		Diluent Volume (DV)	
Final Concentration (FC)		Final Concentration (FC)	
Weight of A.I. (WT)		Weight of A.I. (WT)	

Now calculate the FV in the first scenario, then the PV in the first scenario. Now you can start filling in the second column with the information you know from the first column and the information given in the problem. Look at your list of items that will not change in the second scenario.

Answers on page 98

Serial Dilution

Occasionally, it is necessary to create a solution which is much less concentrated than the stock solution you must work with. For example, you may be required to prepare 10 mL of a 1 mcg/mL solution using a stock solution of 100 mg/mL. Using one of the usual methods, the amount of active ingredient needed in the final solution is first calculated.

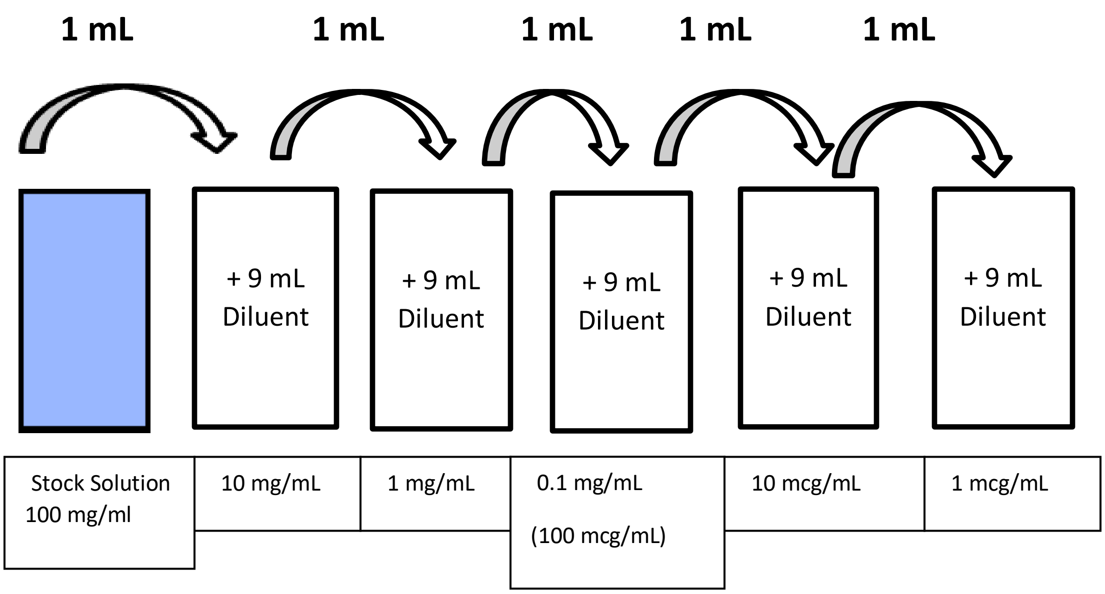
$$10\ \cancel{\text{ml}}\left(\frac{1\ \text{mcg}}{\cancel{\text{ml}}}\right) = 10\ \text{mcg}$$

The amount of stock solution required for the 10 mcg is then calculated.

$$10\ \cancel{\text{mcg}}\left(\frac{1\ \cancel{\text{ml}}}{100\ \cancel{\text{mg}}}\right)\left(\frac{1\ \cancel{\text{mg}}}{1000\ \cancel{\text{mcg}}}\right)\left(\frac{1000\ \text{mcL}}{1\ \cancel{\text{ml}}}\right) = 0.1\ \text{mcL}$$

One tenth of a microliter (1/10,000 of a mL) of stock solution would be mixed with 9.9999 mL of diluent to prepare 10 mL of a 1 mcg/mL solution. These volumes are very difficult, if not impossible, to measure, but an easier method is available called serial dilution.

- Serial dilution is the process of mixing a small amount of stock solution with a large quantity of diluent, then taking a small amount of the resulting solution and diluting again.
- The above procedure is repeated until the desired concentration is achieved.
- Many types of serial dilution exist. This section will cover ten-fold serial dilution.
- 1 mL of stock solution is mixed with 9 mL of diluent to produce a solution which is one tenth the concentration of the stock solution.



- 1 mL of the stock solution contains 100 mg of active ingredient which, when added to the 9 mL of diluent in the second container, yields a concentration of 100 mg/10 mL, or 10 mg/mL.
- 1 mL of the solution from the second container contains 10 mg of active ingredient which, when added to the 9 mL of diluent in the third container, yields a concentration of 10 mg/10 mL, or 1 mg/mL.
- The procedure is continued three more times, resulting in a concentration of 1 mcg/mL.

Calculating the Number of Dilutions Needed

- Make sure that the concentration of the stock solution and the concentration of the final solution are expressed in the same units. In the above case, mcg/mL will be used as the common units of measurement.
- The stock solution is 100 mg/mL which equals 100,000 mcg/mL. The final solution is 1 mcg/mL. Divide the concentration of the stock solution by the concentration of the final solution.

$$\frac{100{,}000 \text{ mcg/ml}}{1 \text{ mcg/ml}} = 100{,}000$$

- **The number of zeros is equal to the number of dilutions required.**

Serial Dilution Exercise

Describe how you would prepare 10 mL of a 1 mcg/mL solution starting with a stock solution of 10 g/100 mL?

Answer on page 99

Self-Assessment Exercise

1) Round 3.545 to the nearest tenth.

2) Round 78.9315 to the nearest thousandth.

3) Express 0.000502 in scientific notation.

4) Express 6.430 X 10^4 as a number.

5) How many significant figures are in 5.01 cm?

6) How many significant figures are in 650 cm?

7) You attempted to measure 120 mL, but later found out that you actually measured 125 mL. What is the percent error of the measurement?

8) You attempted to weigh 35 g, but the actual weight was 37 g. What is the percent error of the measurement?

9) How many mL in a teaspoonful?

10) What is the Roman numeral for 125?

11) What is the number for XXXI?

12) Convert 5.12 g to mg.

13) Convert 0.3 kg to g.

14) Convert 3 kg to mcg. State the answer in scientific notation.

15) A patient is prescribed 500 mg of a drug which is available in a strength of 250 mg/2 mL. How many mL should be administered?

16) A 194 lb patient is prescribed 10 mg/kg of a drug which is available in a strength of 100 mg/mL. How many mL should be administered?

17) A 201 lb patient is prescribed 15 mg/kg/day for 10 days. The drug is available in 10 mL vials of 80 mg/mL. How many vials will be need for the 10 days of therapy?

18) A patient is prescribed 250 mg three times daily for 10 days. The dug is available in 125 mg capsules. How many capsules will be dispensed?

19) A patient has been prescribed 25 mg t.i.d. (3 times daily) for 10 days. The tablets are available in scored 50 mg tablets. How many tablets will be dispensed?

20) An IV is running at 50 mL/h with a drop factor of 20. How many gtt/min is that?

21) A 500 mL IV bag with a drop factor of 10 contains 5 g of drug. How many mg are in each drop?

22) How many g of NaCl are in 1000 mL of 5% NaCl?

23) Change 0.205 to a percent.

24) You have 2 mmol of $MgSO_4$. How many mEq of Mg^{+2} do you have?

25) Does 1 mEq of Na^+ weigh the same as 1 mEq of K^+?

26) A prescription is written for 400 mL of a 15% solution. You have a 60% stock solution available. How many mL of the stock solution and how many mL of diluent will be used?

27) You are asked to prepare 1000 mL of a 5% solution from a 2% solution and a 40% solution. How many mL of each solution will be used?

28) You mix 60 mL of a 40% solution with 2000 mL of a 1:1000 solution. What will be the percent strength of the final solution?

29) You mix 30 mL of a 2 mg/mL solution with 90 mL of a 10 mg/mL solution. What is the final strength in mg/mL?

30) How many mg of active ingredient are in 1000 mL of a 1:10,000 solution?

31) The label of a vial states that it contains 4 g and says to make a solution of 100 mg/mL you must add 13.5 mL. What is the powder volume?

32) A 40 g bulk vial label states that if you add 130 mL of a diluent, the concentration will be 1 g/5 mL. How much diluent would you add to get a concentration of 1 g/4 mL?

33) How many mg of active ingredient are in each g of a 0.5% oint?

34) What does 5000 mg/5 g equal?

35) You have weighed out 3.2 mg, 5.09 mg, and 17.2 mg of a drug. What is the total weight of the three quantities expressed to the correct number of significant figures?

36) A plot of land measures 16.42 m x 21 m. What is the area expressed in the correct number of significant figures?

37) An IV with a drop factor of 20 has been running at a drip rate of 40 gtts/min for 1 hour. How many mL have been administered?

38) Round 3.9999 to the nearest tenth.

39) A patient is prescribed 5 mL of a drug, with a strength of 50 mg/mL, 4 times daily for 10 days. How many g of the drug will the patient receive over the 10 days?

40) What is the flow rate in gtts/min of a 1 L bag with a drop factor of 20 infused over 12 hours?

41) What is the Roman numeral for 2155?

42) If you are in a pharmacy tech math class and the instructor tells you to convert a number to a percent by multiplying by 100. What do you say to the instructor?

43) How many mcg of a drug are in 1000 mL of a 1 mg/mL solution?

44) What is the percent strength of a 1000 mL solution which contains 90 mL of a 40% ethanol solution? (90 mL of the 40% solution was added to 910 mL of water).

45) How many square cm are in an area which measures 20.00 cm x 20.00 cm? Round to the appropriate number of significant figures.

46) A 154 lb patient has been prescribed a dosage of 2 mg/kg/day in 4 equally divided doses. The drug is available in 10 mL vials of 10 mg/mL. How many mL will be administered for 1 dose?

47) Rank the following solutions from strongest to weakest. 100 mg/mL, 1%, 1:1000.

48) How many significant figures are in the measurement 29,000 ft? How about 29,002 ft?

49) How many mmol are in a mol?

50) 5 mL of a 50% solution are mixed with 25 mL of a 4% solution. What is the resulting percent strength?

Answers on page 99

Pharmacy Calculation Puzzles

You will never encounter problems like the following "puzzles", but they are a great challenge! **Give them a try.**

1) You place 6 g of NaCl and 4 g of KCl in a large glass container and let an IV of 0.9% NaCl, with a drop factor of 20, drip into the container at the rate of 3 gtt/min for 2 weeks. After exactly two weeks, you stop the drip and remove 1000 mL from the container and add 500 mL of 200 mEq/L KCl solution to the 1000 mL. What is the concentration of Cl^- in mg/mL in the final solution?

Assume:

- No evaporation from the container.
- No change in volume when adding NaCl and KCl crystals to water.

Use these values in the calculation:

Na^+	22.99 g/mol
Cl^-	35.45 g/mol
NaCl	58.44 g/mol
K^+	39.10 g/mol
KCl	74.55 g/mol

Good luck!

2) A new miracle drug has just hit the market which will reverse aging by 20 years, restore hair loss, and reduce body weight to ideal body weight. The dosage is 0.8 mg/kg/day for 30 days. The drug is quite expensive at $850/10 mL vial which is labeled 10 mg/mL. A patient comes into your pharmacy when you are very busy and asks about the drug. He states that he is 67 years old, bald, and weighs 245 lb. He shares information about his dismal love life, which you try to ignore. He states that he works down the street at the Dairy O clearing $10/h and asks you how long he will have to work to pay for a course of therapy in years, weeks, days and hours.

Assume:

- Patient works 8 hours/day and 52 weeks/year. No vacation.
- Patient must pay for full vial price for any partial vial used.
- Exactly 52 weeks/year.

If you enjoyed these puzzles, make one of your own and email it to brad.wojcik@gmail.com for possible inclusion in a future edition.

Answers on page 104

Answers to Exercises

Rounding Exercise Answers					
	Round to the Nearest Tenth	**Rounded Number**		**Round to the Nearest Hundredth**	**Rounded Number**
1	6.88	**6.9**	26	89.568	**89.57**
2	7.54	**7.5**	27	45.789	**45.79**
3	2.22	**2.2**	28	1.005	**1.01**
4	3.98	**4.0**	28	2.895	**2.90**
5	78.53	**78.5**	30	3.997	**4.00**
6	99.23	**99.2**	31	7.894	**7.89**
7	101.16	**101.2**	32	3.433	**3.43**
8	5.44	**5.4**	33	2.222	**2.22**
9	99.99	**100.0**	34	1.111	**1.11**
10	53.247	**53.2**	35	8.895	**8.90**
11	9.355	**9.4**	36	3.578	**3.58**
12	100.01	**100.0**	37	2.2256	**2.23**
13	56.3756	**56.4**	38	90.3895	**90.39**
14	9.56	**9.6**	39	78.451	**78.45**
15	22.56	**22.6**	40	3.215	**3.22**
16	78.59	**78.6**	41	9.782	**9.78**
17	77.459	**77.5**	42	10.554	**10.55**
18	3.57	**3.6**	43	3.987	**3.99**
19	9.78	**9.8**	44	1.9954	**2.00**
20	23.598	**23.6**	45	2.493	**2.49**
21	78.3	**78.3**	46	8.523	**8.52**
22	78.303	**73.3**	47	9.672	**9.67**
23	798.32	**798.3**	48	4.956	**4.96**
24	8.06	**8.1**	49	2.225	**2.23**
25	9.11	**9.1**	50	3.987	**3.99**

Roman Numerals Exercise Answers

1) You must know the eight basic Roman numerals and their number counterparts: SS, I, V, X, L, C, D, M. Fill in the blanks on the following tables.

Roman Numeral	Number
SS	**1/2**
I	**1**
V	**5**
X	**10**
L	**50**
C	**100**
D	**500**
M	**1000**

Number	Roman Numeral
1/2	**SS**
1	**I**
5	**V**
10	**X**
50	**L**
100	**C**
500	**D**
1000	**M**

2) Fill in the blanks with the corresponding Roman numerals or numbers.

50	**L**	C	**100**
100	**C**	5	**V**
1/2	**SS**	10	**X**
X	**10**	L	**50**
M	**1000**	I	**1**
5	**V**	X	**10**
V	**5**	D	**500**
500	**D**	M	**1000**
L	**50**	X	**10**
SS	**1/2**	V	**5**
1000	**M**	L	**50**
1	**I**	C	**100**
D	**500**	5	**V**
L	**50**	50	**L**
M	**1000**	1000	**M**
10	**X**	100	**C**

3) See page 7.

4) Fill in the blanks with the appropriate number or Roman numeral.

10	**X**	LXX	**70**
30	**XXX**	20	**XX**
400	**CD**	CCC	**300**
DC	**600**	CD	**400**
2000	**MM**	CM	**900**
8	**VIII**	700	**DCC**
XC	**90**	50	**L**
40	**XL**	20	**XX**
60	**LX**	LXXX	**80**
200	**CC**	DCC	**700**
900	**CM**	600	**DC**
IV	**4**	CC	**200**
III	**3**	9	**IX**
SS	**½ (0.5)**	4	**IV**

5) Write the corresponding Roman numerals or numbers:

352 **752**

300	**CCC**	700	**DCC**
50	**L**	50	**L**
2	**II**	2	**II**

CCCLII **DCCLII**

3564 **1437**

3000	**MMM**	1000	**M**
500	**D**	400	**CD**
60	**LX**	30	**XXX**
4	**IV**	7	**VII**

MMMDLXIV **MCDXXXVII**

1369 **3421**

1000	**M**	3000	**MMM**
300	**CCC**	400	**CD**
60	**LX**	20	**XX**
9	**IX**	1	**I**

MCCCLXIX **MMMCDXXI**

MMDCLXVII **MCMLI**

MM	**2000**	M	**1000**
DC	**600**	CM	**900**
LX	**60**	L	**50**
VII	**7**	I	**1**

2667 **1951**

CCCXLV **DCLXII**

CCC	**300**	DC	**600**
XL	**40**	LX	**60**
V	**5**	II	**2**
	345		**662**

Scientific Notation Exercise Answers

1) Convert the following numbers to scientific notation.

Number	Coefficient	# of Places from New Decimal Point to end of Original Number	Coefficient X 10 Raised to the Number of Places the Decimal Point was Moved
67,000	6.7	4	**6.7 X 10^{4}**
2,387,000	2.387	6	**2.387 X 10^{6}**
7,000,000	7	6	**7 X 10^{6}**
98,000	9.8	4	**9.8 X 10^{4}**
432,000,000	4.32	8	**4.32 X 10^{8}**
900,000,000	9	8	**9 X 10^{8}**
58,000,000,000	5.8	10	**5.8 X 10^{10}**
2,478,000,000	2.478	9	**2.478 X 10^{9}**
92,000,000	9.2	7	**9.2 X 10^{7}**
60,230,000,000	6.023	10	**6.023 X 10^{10}**
105,000	1.05	5	**1.05 X 10^{5}**

2) Convert the following decimal numbers to scientific notation.

Decimal Number	Coefficient	# of Places from New Decimal Point to Original Decimal Point	Coefficient X 10 Raised to the Negative Number of Places the Decimal Point was Moved
0.056	5.6	2	**5.6 X 10^{-2}**
0.000380	3.80	4	**3.80 X 10^{-4}**
0.00007	7	5	**7 X 10^{-5}**
0.00002039	2.039	5	**2.039 X 10^{-5}**
0.0005078	5.078	4	**5.078 X 10^{-4}**
0.00001832	1.832	5	**1.832 X 10^{-5}**
0.000650	6.50	4	**6.50 X 10^{-4}**
0.0000000012	1.2	9	**1.2 X 10^{-9}**
0.000054	5.4	5	**5.4 X 10^{-5}**
0.000783	7.83	4	**7.83 X 10^{-4}**
0.00034	3.4	4	**3.4 X 10^{-4}**

3) Convert the following numbers from scientific notation to numbers.

Scientific Notation	Coefficient	Exponent	# of Places to Move the Decimal Point to the Right	Number
5.62×10^6	5.62	6	6	**5,620,000**
7.8×10^7	7.8	7	7	**78,000,000**
9×10^5	9	5	5	**900,000**
6.02×10^7	6.02	7	7	**60,200,000**
1.05×10^4	1.05	4	4	**10,500**
9.78×10^9	9.78	9	9	**9,780,000,000**
6.99×10^3	6.99	3	3	**6,990**
3.78×10^8	3.78	8	8	**378,000,000**
4.0×10^8	4.0	8	8	**400,000,000**
7.66×10^5	7.66	5	5	**766,000**

4) Convert the following decimal numbers from scientific notation to decimal numbers.

Scientific Notation	Coefficient	Exponent	# of Places to Move the Decimal Point to the Left	Decimal Number
6.05×10^{-4}	6.05	-4	4	**0.000605**
2.3×10^{-7}	2.3	-7	7	**0.00000023**
7.80×10^{-4}	7.80	-4	4	**0.000780**
3.5×10^{-6}	3.5	-6	6	**0.0000035**
8.995×10^{-5}	8.995	-5	5	**0.00008995**
1.023×10^{-9}	1.023	-9	9	**0.000000001023**
5.00×10^{-4}	5.00	-4	4	**0.000500**
8.43×10^{-6}	8.43	-6	6	**0.00000843**
2.22×10^{-3}	2.22	-3	3	**0.00222**
1.6×10^{-7}	1.6	-7	7	**0.00000016**

Significant Figures Exercise Answers

1) Determine the number of significant figures in the following measurements.

Measurement	Decimal Point? Yes or No	Yes: All Digits are Significant Except the Leading Zeros	No: All Digits are Significant Except Trailing Zeros	Number of Significant Figures
605.30 cm	Yes	**605.30** cm		**5**
0.0050 cm	Yes	0.00**50** cm		**2**
905,000 mi	No		**905**,000 mi	**3**
1,000,000 ft	No		**1**,000,000 ft	**1**
0.00001 mi	Yes	0.0000**1** mi		**1**
1,000,006 ft	No		**1,000,006** ft	**7**
500 ft	No		**5**00 ft	**1**
367 ft	No		**367 ft**	**3**
0.0051 g	Yes	0.00**51 g**		**2**
0.040 g	Yes	0.0**40** g		**2**
92,000,000 mi	No		**92**,000,000 mi	**2**
92,000,000.0 mi	Yes	**92,000,000.0** mi		**9**
807.01 cm	Yes	**807.01** cm		**5**
100 ft	No		**1**00 ft	**1**
9,071.0000 in	Yes	**9,071.0000** in		**8**
183 ft	No		**183 ft**	**3**
601 qt	No		**601 qt**	**3**

2) Determine the sums or differences for the following using the rules for adding and subtracting significant figures.

Measurements	**Sum or Difference Before Rounding**	**Least Accurate Measurement(s)**	**Answer Rounded to Correct Place**
7.12 mg + 6.1 mg + 7.06 mg	20.28 mg	6.1 mg	**20.3 mg**
100.5 mg + 110 mg	210.5 mg	110 mg	**210 mg**
6 cm + 8.3 cm	14.3 cm	6 cm	**14 cm**
103 g + 1.1 g	104.1 g	103 g	**104 g**
5 ft + 52 ft	57 ft	Either	**57 ft**
6.3 cm - 3 cm	3.3 cm	3 cm	**3 cm**
101 mg + 25 mg	126 mg	Either	**126 mg**
98.1 mg + 10 mg	108.1 mg	10 mg	**110 mg**
65.5551 g + 2 g	67.5551 g	2 g	**68 g**
1000 mi + 10 mi	1010 mi	1000 mi	**1000 mi**

3) Determine the products of the following measurements using the rules for multiplying and dividing significant figures.

Measurements to Multiply	**Product before Rounding**	**Measurement with Least # of Significant Figures**	**Rounded Answer**
31 cm X 9 cm	279 sq cm	9 cm	**300 sq cm**
100 cm x 892 cm	89,200 sq cm	100 cm (1 sig fig)	**90,000 sq cm**
61 ft X 561 ft	34,221 sq ft	61 ft (2 sig fig)	**34,000 sq ft**
78 cm X 1000 cm	78,000 sq cm	1000 cm (1 sig fig)	**80,000 sq cm**
56 cm X 21 cm	1176 sq cm	Either (2 sig fig)	**1200 sq cm**
34 in x 605 in	20,570 sq in	34 in (2 sig fig)	**21,000 sq in**

Percent Error Exercise Answers

1) The desired volume is 46 mL, but you actually measured out 48 mL.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error
46 mL	48 mL	2 mL	$\left(\frac{\mathbf{2}\ \cancel{\mathbf{mL}}}{\mathbf{46}\ \cancel{\mathbf{mL}}}\right)\mathbf{100\%}=\mathbf{4.3\%}$

2) The desired weight is 350 mg, but the actual weight is 376 mg.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error
350 mg	376 mg	26 mg	$\left(\frac{\mathbf{26}\ \cancel{\mathbf{mg}}}{\mathbf{350}\ \cancel{\mathbf{mg}}}\right)\mathbf{100\%}=\mathbf{7.4\%}$

3) The desired volume is 2.3 L, but the actual volume is 2.2 L.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error
2.3 L	2.2 L	0.1 L	$\left(\frac{\mathbf{0.1}\ \cancel{\mathbf{L}}}{\mathbf{2.3}\ \cancel{\mathbf{L}}}\right)\mathbf{100\%}=\mathbf{4.3\%}$

4) The desired weight is 2.5 kg, but the actual weight is 1.7 kg.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error
2.5 kg	1.7 kg	0.8 kg	$\left(\frac{\mathbf{0.8}\ \cancel{\mathbf{kg}}}{\mathbf{2.5}\ \cancel{\mathbf{kg}}}\right)\mathbf{100\%}=\mathbf{32\%}$

5) The desired weight is 7.4 g, but the actual weight is 6.8 g.

Desired Quantity (Target)	Actual Quantity	Error Quantity	Percent Error
7.4 g	6.8 g	0.6 g	$\left(\frac{\mathbf{0.6}\ \cancel{\mathbf{g}}}{\mathbf{7.4}\ \cancel{\mathbf{g}}}\right)\mathbf{100\%}=\mathbf{8.1\%}$

Unit Conversion Exercise using Dimensional Analysis Answers

Given to be Converted	Conversion Factor (Tool)	Units of the Answer	Answer: (Given)(Tool)
3.5 g	1000 mg/g	mg	**3500 mg**
3400 g	1 kg/1000 g	kg	**3.4 kg**
25 mg	1 g/1000 mg	g	**0.025 g**
8.1 kg	2.2 lb/kg	lb	**17.8 lb**
320 mg	1 g/1000 mg	g	**0.320 g**
3 tbs	3 tsp/tbs	tsp	**9 tsp**
245 cm	1 m/100 cm	m	**2.45 m**
2.2 kg	2.2 lb/kg	lb	**4.8 lb**
967 mcg	1 mg/1000 mcg	mg	**0.967 mg**
45 mg	1000 mcg/mg	mcg	**45,000 mcg**
188 lb	1 kg/2.2 lb	kg	**85.5 kg**
2.5 L	1000 mL/L	mL	**2500 mL**
502 g	1 kg/1000 g	kg	**0.502 kg**
89 mm	1 cm/10 mm	cm	**8.9 cm**
400 mL	1 L/1000 mL	L	**0.400 L**
923 g	1 kg/1000 g	kg	**0.923 kg**
8 kg	1000 g/kg	g	**8000 g**
3.2 m	100 cm/m	cm	**320 cm**
389 mL	1 L/1000 mL	L	**0.389 L**
25 mm	1 cm/10 mm	cm	**2.5 cm**
9.5 in	2.54 cm/in	cm	**24.1 cm**
50 g	1000 mg/g	mg	**50,000 mg**
0.25 L	1000 mL/L	mL	**250 mL**
45 cm	1 in/2.54 cm	in	**17.7 in**
679 cm	1 m/100 cm	m	**6.79 m**
90 g	1 kg/1000 g	kg	**0.09 kg**
245 lb	1 kg/2.2 lb	kg	**111.4 kg**

Unit Conversion Exercise using Ratio Proportion Answers

Given to be Converted	Units of the Answer	Set up Equation	Answer:Solve for x
3.5 g	mg	$\frac{\text{x mg}}{\text{3.5 g}} = \frac{\text{1000 mg}}{\text{1 g}}$	**3500 mg**
3400 g	kg	$\frac{\text{x kg}}{\text{3400 g}} = \frac{\text{1 kg}}{\text{1000 g}}$	**3.4 kg**
25 mg	g	$\frac{\text{x g}}{\text{25 mg}} = \frac{\text{1 g}}{\text{1000 mg}}$	**0.025 g**
8.1 kg	lb	$\frac{\text{x lb}}{\text{8.1 kg}} = \frac{\text{2.2 lb}}{\text{1 kg}}$	**17.8 lb**
320 mg	g	$\frac{\text{xg}}{\text{320 mg}} = \frac{\text{1 g}}{\text{1000 mg}}$	**0.320 g**
3 tbs	tsp	$\frac{\text{x tsp}}{\text{3 tbs}} = \frac{\text{3 tsp}}{\text{1 tbs}}$	**9 tsp**
245 cm	m	$\frac{\text{x m}}{\text{245 cm}} = \frac{\text{1 m}}{\text{100 cm}}$	**2.45 m**
2.2 kg	lb	$\frac{\text{x lb}}{\text{2.2 kg}} = \frac{\text{2.2 lb}}{\text{1 kg}}$	**4.8 lb**
967 mcg	mg	$\frac{\text{x mg}}{\text{967 mcg}} = \frac{\text{1 mg}}{\text{1000 mcg}}$	**0.967 mg**
45 mg	mcg	$\frac{\text{x mcg}}{\text{45 mg}} = \frac{\text{1000 mcg}}{\text{1 mg}}$	**45,000 mcg**
188 lb	kg	$\frac{\text{x kg}}{\text{188 lb}} = \frac{\text{1 kg}}{\text{2.2 lb}}$	**85.5 kg**
2.5 L	mL	$\frac{\text{x mL}}{\text{2.5 L}} = \frac{\text{1000 mL}}{\text{1 L}}$	**2500 mL**
502 g	kg	$\frac{\text{x kg}}{\text{502 g}} = \frac{\text{1 kg}}{\text{1000 g}}$	**0.502 kg**
89 mm	cm	$\frac{\text{x cm}}{\text{89 mm}} = \frac{\text{1 cm}}{\text{10 mm}}$	**8.9 cm**
400 mL	L	$\frac{\text{x L}}{\text{400 mL}} = \frac{\text{1 L}}{\text{1000 mL}}$	**0.400 L**
923 g	kg	$\frac{\text{x kg}}{\text{923 g}} = \frac{\text{1 kg}}{\text{1000 g}}$	**0.923 kg**
8 kg	g	$\frac{\text{x g}}{\text{8 kg}} = \frac{\text{1000 g}}{\text{1 kg}}$	**8000 g**

Given to be Converted	Units of the Answer	Set up Equation	Answer:Solve for x
389 mL	L	$\frac{\text{x L}}{\text{389 mL}} = \frac{\text{1 L}}{\text{1000 mL}}$	**0.389 L**
25 mm	cm	$\frac{\text{x cm}}{\text{25 mm}} = \frac{\text{1 cm}}{\text{10 mm}}$	**2.5 cm**
9.5 in	cm	$\frac{\text{x cm}}{\text{9.5 in}} = \frac{\text{2.54 cm}}{\text{1 in}}$	**24.1 cm**
50 g	mg	$\frac{\text{x mg}}{\text{50 g}} = \frac{\text{1000 mg}}{\text{1 g}}$	**50,000 mg**
0.25 L	mL	$\frac{\text{x mL}}{\text{0.25 L}} = \frac{\text{1000 mL}}{\text{1 L}}$	**250 mL**
45 cm	in	$\frac{\text{x in}}{\text{45 cm}} = \frac{\text{1 in}}{\text{2.54 cm}}$	**17.7 in**
679 cm	m	$\frac{\text{x m}}{\text{679 cm}} = \frac{\text{1 m}}{\text{100 cm}}$	**6.79 m**
90 g	kg	$\frac{\text{x kg}}{\text{90 g}} = \frac{\text{1 kg}}{\text{1000 g}}$	**0.09 kg**
245 lb	kg	$\frac{\text{x kg}}{\text{245 lb}} = \frac{\text{1 kg}}{\text{2.2 lb}}$	**111.4 kg**

Dosage Exercise Set 1 Answers

1) A patient has a prescription order for a medication that is available as 500 mg/5 mL. She is to take 400 mg. How many milliliters will she take?

Units of the answer	mL
Given	400 mg
Ratio(s) as stated	500 mg/5 ml
Ratios(s) as used	5 mL/500 mg

$$\mathbf{400\ \cancel{mg}\left(\frac{5\ mL}{500\ \cancel{mg}}\right) = 4\ mL}$$

2) The doctor has ordered a dose of 800 mg. The medication is available as 200 mg/10 mL. How many milliliters will need to be drawn up to fill the order?

Units of the answer	mL
Given	800 mg
Ratio(s) as stated	200 mg/10 mL
Ratios(s) as used	10 mL/200 mg

$$\mathbf{800\ \cancel{mg}\left(\frac{10\ mL}{200\ \cancel{mg}}\right) = 40\ mL}$$

3) A patient has an order for 1500 mcg. The pharmacy has 500 mcg tablets. How many tablets will be needed to fill the order?

Units of the answer	tablets
Given	1500 mcg
Ratio(s) as stated	500 mcg/tablet
Ratios(s) as used	1 tablet/500 mcg

$$\mathbf{1500\ \cancel{mcg}\left(\frac{1\ tablet}{500\ \cancel{mcg}}\right) = 3\ tablets}$$

4) The pharmacy has a 480 mL bottle of KCl 20%. A patient has a prescription to take 15 mL every day. How many doses can be given from this bottle?

Units of the answer	doses
Given	480 mL
Ratio(s) as stated	15 mL/dose
Ratios(s) as used	1 dose/15 mL

$$\mathbf{480\ \cancel{mL}\left(\frac{1\ dose}{15\ \cancel{mL}}\right) = 32\ doses}$$

5) A patient has an order for 14,000 units of heparin. It is available as 10,000 units/mL in a 10 mL vial. How many milliliters are needed?

Units of the answer	mL
Given	14,000 units
Ratio(s) as stated	10,000 units/mL 10 mL/vial
Ratios(s) as used	1 mL/10,000 units

$$\mathbf{14,000\ \cancel{units}\left(\frac{1\ mL}{10,000\ \cancel{units}}\right) = 1.4\ mL}$$

6) The doctor has ordered a dose of 65 mg. The medication is available as 100 mg/10 mL. How many milliliters will need to be drawn up to fill the order?

Units of the answer	mL
Given	65 mg
Ratio(s) as stated	100 mg/10 mL
Ratios(s) as used	10 mL/100 mg

$$\mathbf{65\ \cancel{mg}\left(\frac{10\ mL}{100\ \cancel{mg}}\right) = 6.5\ mL}$$

7) How many mcg of levothyroxine are contained in 2 tablets of levothyroxine 0.125 mg?

Units of the answer	mcg
Given	2 tablets
Ratio(s) as stated	0.125 mg/tab
Ratios(s) used	0.125 mg/tab 1000 mcg/mg

$$\mathbf{2\ \cancel{tablets}\left(\frac{0.125\ \cancel{mg}}{\cancel{tablet}}\right)\left(\frac{1000\ mcg}{\cancel{mg}}\right) = 250\ mcg}$$

8) A patient has an order for 1.6 mg. The pharmacy has 0.4 mg tablets. How many tablets will be needed to fill the order?

Units of the answer	tablets
Given	1.6 mg
Ratio(s) as stated	0.4 mg/tablet
Ratios(s) as used	1 tablet/0.4 mg

$$\mathbf{1.6\ \cancel{mg}\left(\frac{1\ tablet}{0.4\ \cancel{mg}}\right) = 4\ tablets}$$

9) A patient will be taking 5 mL of a drug which has a strength of 25 mg/mL. How many mg will the patient be taking?

Units of the answer	mg
Given	5 mL
Ratio(s) as stated	25 mg/mL
Ratios(s) as used	25 mg/mL

$$\mathbf{5\ \cancel{mL}\left(\frac{25\ mg}{\cancel{mL}}\right) = 125\ mg}$$

10) A prescriber has ordered 375 mg of a drug which comes in a strength of 75 mg/mL. How many mL will the patient take?

Units of the answer	mL
Given	375 mg
Ratio(s) as stated	75 mg/mL
Ratios(s) as used	1 mL/75 mg

$$375\ \cancel{\text{mg}}\left(\frac{1\ \text{mL}}{75\ \cancel{\text{mg}}}\right) = 5\ \text{mL}$$

Dosage Exercise Set 2 Answers

1) A patient is to receive 150 mg of a drug per day divided into 3 equal doses. The drug is available in 10 mL vials of 10 mg/mL. How many mL will be administered for each dose?

$$\left(\frac{150\ \cancel{\text{mg}}}{\cancel{\text{day}}}\right)\left(\frac{1\ \cancel{\text{day}}}{3\ \text{doses}}\right)\left(\frac{1\ \text{mL}}{10\ \cancel{\text{mg}}}\right) = \frac{5\ \text{mL}}{\text{dose}}$$

2) A patient who weighs 185 lb is to receive a dosage of 2 mg/kg/day for 4 days. The drug is available in 10 mL vials of 50 mg/mL. How many total mL will be administered over the 4 days.

$$185\ \cancel{\text{lb}}\left(\frac{1\ \cancel{\text{kg}}}{2.2\ \cancel{\text{lb}}}\right)\left(\frac{2\ \cancel{\text{mg}}}{\cancel{\text{kg day}}}\right)\left(\frac{4\ \cancel{\text{days}}}{}\right)\left(\frac{1\ \text{mL}}{50\ \cancel{\text{mg}}}\right) = 13.5\ \text{mL}$$

Notes: This problem has two givens: 185 lb and 4 days. 2 mg/kg/day was converted to 2 mg/kg·day

3) A patient is ordered 600 mg/day in 4 equal doses. The drug is available in 10 mL vials of 50 mg/mL. How many mL will the patient receive in 1 dose?

$$\frac{600\ \cancel{\text{mg}}}{\cancel{\text{day}}}\left(\frac{1\ \cancel{\text{day}}}{4\ \text{doses}}\right)\left(\frac{1\ \text{mL}}{50\ \cancel{\text{mg}}}\right) = \frac{3\ \text{mL}}{\text{dose}}$$

4) A patient is prescribed 250 mg 3 times daily for 10 days. The drug is available in 125 mg capsules. How many capsules will be dispensed for the 10 days.

$$10\ \cancel{\text{days}}\left(\frac{3\ \cancel{\text{doses}}}{\cancel{\text{day}}}\right)\left(\frac{250\ \cancel{\text{mg}}}{\cancel{\text{dose}}}\right)\left(\frac{1\ \text{capsule}}{125\ \cancel{\text{mg}}}\right) = 60\ \text{capsules}$$

5) An 80 kg patient is prescribed 3 mg/kg/day for 7 days. The drug is available in 5 mL vials of 50 mg/mL. How many vials will be needed for the 7 days?

$$80\ \cancel{\text{kg}}\left(\frac{3\ \cancel{\text{mg}}}{\cancel{\text{kg day}}}\right)\left(\frac{1\ \cancel{\text{mL}}}{50\ \cancel{\text{mg}}}\right)\left(\frac{7\ \cancel{\text{days}}}{}\right)\left(\frac{1\ \text{vial}}{5\ \cancel{\text{mL}}}\right) = 6.7\ \text{vials rounded up to 7 vials}$$

Note: This problem has two givens: 80 kg and 7 days.

6) A patient is to receive 5 mL of a drug 3 times daily for 10 days. The drug is available in a strength of 25 mg/mL in a bottle of 240 mL. How many mg will the patient receive in each dose?

$$5\ \cancel{\text{mL}}\left(\frac{25\ \text{mg}}{\cancel{\text{mL}}}\right) = 125\ \text{mg}$$

7) A patient weights 205 lbs and is prescribed a dosage of 600 mg IV given over 2 hours. The drug is available in 10 mL vials of 100 mg/ mL. How many mL will be administered?

$$600\ \cancel{\mathrm{mg}}\left(\frac{1\ \mathrm{mL}}{100\ \cancel{\mathrm{mg}}}\right) = 6\ \mathrm{mL}$$

8) A patient is to receive a dosage of 34 mg/kg/day each day for 60 days. The patient weighs 196 lb. The drug is available in 20 mL vials of 200 mg/mL. How many vials will be required for the 60 day course of therapy?

$$196\ \cancel{\mathrm{lb}}\left(\frac{1\ \cancel{\mathrm{kg}}}{2.2\ \cancel{\mathrm{lb}}}\right)\left(\frac{34\ \cancel{\mathrm{mg}}}{\cancel{\mathrm{kg}}\ \mathrm{day}}\right)\left(\frac{60\ \cancel{\mathrm{days}}}{}\right)\left(\frac{1\ \cancel{\mathrm{mL}}}{200\ \cancel{\mathrm{mg}}}\right)\left(\frac{1\ \mathrm{vial}}{20\ \cancel{\mathrm{mL}}}\right) = 45.4\ \text{vials rounded to 46 vials}$$

9) A patient is prescribed 250 mg 4 times daily for 10 days. The drug is available in 250 mg capsules in bottles of 100. How many capsules will be dispensed for the 10 day course of therapy?

$$10\ \cancel{\mathrm{days}}\left(\frac{4\ \cancel{\mathrm{doses}}}{\cancel{\mathrm{day}}}\right)\left(\frac{250\ \cancel{\mathrm{mg}}}{\cancel{\mathrm{dose}}}\right)\left(\frac{1\ \mathrm{cap}}{250\ \cancel{\mathrm{mg}}}\right) = 40\ \mathrm{caps}$$

10) A patient is prescribed a dosage of 1 drop in each eye twice daily for 30 days. The eye drops are available in 5 mL bottles with 20 drops/mL. How many bottles will be required for the 30 days?

$$30\ \cancel{\mathrm{days}}\left(\frac{4\ \cancel{\mathrm{drops}}}{\cancel{\mathrm{day}}}\right)\left(\frac{1\ \cancel{\mathrm{mL}}}{20\ \cancel{\mathrm{drops}}}\right)\left(\frac{1\ \mathrm{bottle}}{5\ \cancel{\mathrm{mL}}}\right) = 1.2\ \text{bottle rounded to 2 bottles}$$

IV Flow Rate Exercise Answers

Calculate the flow rate in mL/h.

1) 1000 mL infused over 5 h.

$$\frac{1000\ \mathrm{mL}}{5\ \mathrm{h}} = \frac{200\ \mathrm{mL}}{\mathrm{h}}$$

2) 250 mL infused over 2 h.

$$\frac{250\ \mathrm{mL}}{2\ \mathrm{h}} = \frac{125\ \mathrm{mL}}{\mathrm{h}}$$

Calculate the flow rate in gtts/min. Round to the nearest drop.

3) 1000 mL infused over 4 hours using an infusion set with a drop factor of 10 (10 gtts/mL).

$$\frac{1000\ \cancel{\mathrm{mL}}}{4\ \cancel{\mathrm{h}}}\left(\frac{10\ \mathrm{gtts}}{\cancel{\mathrm{mL}}}\right)\left(\frac{1\ \cancel{\mathrm{h}}}{60\ \mathrm{min}}\right) = \frac{42\ \mathrm{gtts}}{\mathrm{min}}$$

4) 250 mL infused over 2 hours using an infusion set with a drop factor of 15.

$$\frac{250\ \cancel{\mathrm{mL}}}{2\ \cancel{\mathrm{h}}}\left(\frac{15\ \mathrm{gtts}}{\cancel{\mathrm{mL}}}\right)\left(\frac{1\ \cancel{\mathrm{h}}}{60\ \mathrm{min}}\right) = \frac{31\ \mathrm{gtts}}{\mathrm{min}}$$

5) 2 L infused over 24 hours using an infusion set with a drop factor of 20.

$$\frac{2\ \cancel{\mathrm{L}}}{24\ \cancel{\mathrm{h}}}\left(\frac{1000\ \cancel{\mathrm{mL}}}{\cancel{\mathrm{L}}}\right)\left(\frac{20\ \mathrm{gtts}}{\cancel{\mathrm{mL}}}\right)\left(\frac{1\ \cancel{\mathrm{h}}}{60\ \mathrm{min}}\right) = \frac{28\ \mathrm{gtts}}{\mathrm{min}}$$

6) 100 mL infused over 1 hour using an infusion set with a drop factor of 10.

$$\frac{100\ \cancel{\mathrm{mL}}}{1\ \cancel{\mathrm{h}}}\left(\frac{10\ \mathrm{gtts}}{\cancel{\mathrm{mL}}}\right)\left(\frac{1\ \cancel{\mathrm{h}}}{60\ \mathrm{min}}\right) = \frac{17\ \mathrm{gtts}}{\mathrm{min}}$$

7) 1000 mL infused over 5 hours using an infusion set with a drop factor of 20.

$$\frac{1000\ \cancel{\mathbf{mL}}}{5\ \cancel{\mathbf{h}}}\left(\frac{20\ \mathbf{gtts}}{\cancel{\mathbf{mL}}}\right)\left(\frac{1\ \cancel{\mathbf{h}}}{60\ \mathbf{min}}\right)=\frac{67\ \mathbf{gtts}}{\mathbf{min}}$$

Calculate the length of time required to infuse the following volumes.

8) A 1000 mL bag infused at the rate of 45 mL/h.

$$1000\ \cancel{\mathbf{mL}}\left(\frac{1\ \mathbf{h}}{45\ \cancel{\mathbf{mL}}}\right)=22.2\ \mathbf{h}$$

9) A 1000 mL bag infused at the rate of 45 mL/h using an infusion set with a drop factor of 20.

$$1000\ \cancel{\mathbf{mL}}\left(\frac{1\ \mathbf{h}}{45\ \cancel{\mathbf{mL}}}\right)=22.2\ \mathbf{h}$$

10) A 1000 mL bag infused at the rate of 45 mL/h using an infusion set with a drop factor of 10.

$$1000\ \cancel{\mathbf{mL}}\left(\frac{1\ \mathbf{h}}{45\ \cancel{\mathbf{mL}}}\right)=22.2\ \mathbf{h}$$

11) A 1 L bag infused at the rate of 50 gtts/min using an infusion set with a drop factor of 15.

$$1\ \mathbf{L}\left(\frac{1000\ \mathbf{mL}}{\mathbf{L}}\right)\left(\frac{15\ \mathbf{gtts}}{\mathbf{mL}}\right)\left(\frac{1\ \mathbf{min}}{50\ \mathbf{gtts}}\right)\left(\frac{1\ \mathbf{h}}{60\ \mathbf{min}}\right)=5\ \mathbf{h}$$

12) A 500 mL bag infused at the rate of 25 gtts/min using an infusion set with a drop factor of 20.

$$500\ \mathbf{mL}\left(\frac{20\ \mathbf{gtts}}{\mathbf{mL}}\right)\left(\frac{1\ \mathbf{min}}{25\ \mathbf{gtts}}\right)\left(\frac{1\ \mathbf{h}}{60\ \mathbf{min}}\right)=6.7\ \mathbf{h}$$

Answer the following:

13) A patient has an order for regular insulin at the rate of 18 units/hour. The solution is 100 mL with 100 units of regular insulin. An infusion set with a drop factor of 20 is being used. What will be the flow rate in gtts/min?

$$\frac{18\ \mathbf{units}}{\mathbf{h}}\left(\frac{100\ \mathbf{mL}}{100\ \mathbf{units}}\right)\left(\frac{20\ \mathbf{gtts}}{\mathbf{mL}}\right)\left(\frac{1\ \mathbf{h}}{60\ \mathbf{min}}\right)=\frac{6\ \mathbf{gtts}}{\mathbf{min}}$$

14) A patient has an order for a drug to be infused at the rate of 5 mcg/kg/min. A 500 mL bag contains 250 mg of the drug and the patient weighs 185 pounds. An infusion set with a drop factor of 20 is being used. What is the flow rate in gtts/min?

$$185\ \mathbf{lb}\left(\frac{1\ \mathbf{kg}}{2.2\ \mathbf{lb}}\right)\left(\frac{5\ \mathbf{mcg}}{\mathbf{kg\ min}}\right)\left(\frac{500\ \mathbf{mL}}{250\ \mathbf{mg}}\right)\left(\frac{1\ \mathbf{mg}}{1000\ \mathbf{mcg}}\right)\left(\frac{20\ \mathbf{gtts}}{\mathbf{mL}}\right)=\frac{17\ \mathbf{gtts}}{\mathbf{min}}$$

15) A patient has an order for a drug to be infused at the rate of 25 mg/kg/h. A 1 L bag contains 10 g of the drug and the patient weighs 80 kg. An infusion set with a drop factor of 15 is being used. What is the flow rate in gtts/min?

$$80\ \mathbf{kg}\left(\frac{25\ \mathbf{mg}}{\mathbf{kg\ h}}\right)\left(\frac{1\ \mathbf{h}}{60\ \mathbf{min}}\right)\left(\frac{1\ \mathbf{L}}{10\ \mathbf{g}}\right)\left(\frac{1000\ \mathbf{mL}}{\mathbf{L}}\right)\left(\frac{1\ \mathbf{g}}{1000\ \mathbf{mg}}\right)\left(\frac{15\ \mathbf{gtts}}{\mathbf{mL}}\right)=\frac{50\ \mathbf{gtts}}{\mathbf{min}}$$

In practice, you would probably change the 1 L bag to 1000 mL and the 10 g to 10,000 mg before you started the problem. This would simplify things a bit and result with the following calculation.

$$80\ \mathbf{kg}\left(\frac{25\ \mathbf{mg}}{\mathbf{kg\ h}}\right)\left(\frac{1\ \mathbf{h}}{60\ \mathbf{min}}\right)\left(\frac{1000\ \mathbf{mL}}{10{,}000\ \mathbf{mg}}\right)\left(\frac{15\ \mathbf{gtts}}{\mathbf{mL}}\right)=\frac{50\ \mathbf{gtts}}{\mathbf{min}}$$

Percent Exercise Answers

1)Convert the following numbers to percents using the format in the examples below.

0.35	**(0.35)(100%)=35%**
15/17	**(15/17)(100%)=88.24%**
0.98	**(0.98)(100%)=98%**
1.78	**(1.78)(100%)=178%**
3.99	**(3.99)(100%) = 399%**
0.05	**(0.05)(100%)=5%**
0.003	**(0.003)(100%)=0.3%**
1.25	**(1.25)(100%)=125%**
6/9	**(6/9)(100%)=66.7%**
5.45	**(5.45)(100%)=545%**
9.95	**(9.95)(100%)=995%**
0.005	**(0.005)(100%)=0.5%**

2) Convert the following percents to numbers using the format in the example below.

56%	$\frac{56\%}{100\%} = 0.56$
3.5%	$\frac{3.5\%}{100\%} = 0.035$
99%	$\frac{99\%}{100\%} = 0.99$
101%	$\frac{101\%}{100\%} = 1.01$
34.5%	$\frac{34.5\%}{100\%} = 0.345$
85.67%	$\frac{85.67\%}{100\%} = 0.8567$
3.35%	$\frac{3.35\%}{100\%} = 0.0335$
3%	$\frac{3\%}{100\%} = 0.03$

Percent Strength Exercise Answers

Express the following as percent strength solution, and include the type of solution (w/w, w/v, v/v).

1) 7 g KCl in 200 mL

$$\frac{\mathbf{7\ g}}{\mathbf{200\ mL}}(\mathbf{100\%}) = \mathbf{3.5\%}\frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{3.5\%}\frac{\mathbf{w}}{\mathbf{v}}$$

2) 3.5 g NaCl in 1000 mL

$$\frac{\mathbf{3.5\ g}}{\mathbf{1000\ mL}}(\mathbf{100\%}) = \mathbf{0.35\%}\frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{0.35\%}\frac{\mathbf{w}}{\mathbf{v}}$$

3) 7.9 mg $NaHCO_3$ in 100 mL

$$\frac{\mathbf{7.9}\ \cancel{\mathbf{mg}}}{\mathbf{100\ mL}}\left(\frac{\mathbf{1\ g}}{\mathbf{1000}\ \cancel{\mathbf{mg}}}\right)(\mathbf{100\%}) = \mathbf{0.0079\%}\frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{0.0079\%}\frac{\mathbf{w}}{\mathbf{v}}$$

4) 5 mcg NaCl in 0.25 mL

$$\frac{\mathbf{5}\ \cancel{\mathbf{mcg}}}{\mathbf{0.25\ mL}}\left(\frac{\mathbf{1}\ \cancel{\mathbf{mg}}}{\mathbf{1000}\ \cancel{\mathbf{mcg}}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000}\ \cancel{\mathbf{mg}}}\right)(\mathbf{100\%}) = \mathbf{0.002\%}\frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{0.002\%}\frac{\mathbf{w}}{\mathbf{v}}$$

5) 45 g NaCl in 3 L

$$\frac{\mathbf{45\ g}}{\mathbf{3}\ \cancel{\mathbf{L}}}\left(\frac{\mathbf{1}\ \cancel{\mathbf{L}}}{\mathbf{1000\ mL}}\right)(\mathbf{100\%}) = \mathbf{1.5\%}\frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{1.5\%}\frac{\mathbf{w}}{\mathbf{v}}$$

6) 3 g HC in 200 g HC ointment

$$\frac{\mathbf{3\ g}}{\mathbf{200\ g}}(\mathbf{100\%}) = \mathbf{1.5\%}\frac{\mathbf{g}}{\mathbf{g}} = \mathbf{1.5\%}\frac{\mathbf{w}}{\mathbf{w}}$$

7) 5 g coal tar in 300 g coal tar ointment

$$\frac{\mathbf{5\ g}}{\mathbf{300\ g}}(\mathbf{100\%}) = \mathbf{1.7\ \%}\ \frac{\mathbf{g}}{\mathbf{g}} = \mathbf{1.7\%}\frac{\mathbf{w}}{\mathbf{w}}$$

8) 5 mg betamethasone in 10 g betamethasone ointment

$$\frac{\mathbf{5\ mg}}{\mathbf{10\ g}}\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right)(\mathbf{100\%}) = \mathbf{0.05\%}\ \frac{\mathbf{g}}{\mathbf{g}} = \mathbf{0.05\%}\frac{\mathbf{w}}{\mathbf{w}}$$

9) 20 g urea in 40 g urea ointment

$$\frac{\mathbf{20\ g}}{\mathbf{40\ g}}(\mathbf{100\%}) = \mathbf{50\%}\frac{\mathbf{g}}{\mathbf{g}} = \mathbf{50\%}\frac{\mathbf{w}}{\mathbf{w}}$$

10) 18 g salicylic acid in 300 g salicylic acid cream

$$\frac{\mathbf{18\ g}}{\mathbf{300\ g}}(\mathbf{100\%}) = \mathbf{6\%}\frac{\mathbf{g}}{\mathbf{g}} = \mathbf{6\%}\frac{\mathbf{w}}{\mathbf{w}}$$

11) 900 mL IPA in 1000 mL IPA solution

$$\frac{\mathbf{900\ mL}}{\mathbf{1000\ mL}}(\mathbf{100\%}) = \mathbf{90\%}\frac{\mathbf{mL}}{\mathbf{mL}} = \mathbf{90\%}\frac{\mathbf{v}}{\mathbf{v}}$$

12) 40 mL ETOH in 100 mL ETOH solution

$$\frac{\mathbf{40\ mL}}{\mathbf{100\ mL}}(\mathbf{100\%}) = \mathbf{40\%}\ \frac{\mathbf{mL}}{\mathbf{mL}} = \mathbf{40\%}\frac{\mathbf{v}}{\mathbf{v}}$$

Answer the following:

13) How many mg of NaCl are in 10 mL of 0.9% NaCl (normal saline).

$$\mathbf{10\ mL}\left(\frac{\mathbf{0.9\%\ g}}{\mathbf{mL}}\right)\left(\frac{\mathbf{1}}{\mathbf{100\%}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right) = \mathbf{90\ mg}$$

Note: It is easier to just write 100% under the 0.9% g rather than multiply by $\left(\frac{1}{100\%}\right)$, so the following problems will be in that format.

14) How many g of NaCl are in 2 L of NS (Normal Saline)

$$\mathbf{2\ L}\left(\frac{\mathbf{0.9\%\ g}}{\mathbf{100\%\ mL}}\right)\left(\frac{\mathbf{1000\ mL}}{\mathbf{L}}\right) = \mathbf{18\ g}$$

15) How many g of KCl are in 473 mL of 20% KCl?

$$\mathbf{473\ mL}\left(\frac{\mathbf{20\%\ g}}{\mathbf{100\%\ mL}}\right) = \mathbf{94.6\ g}$$

16) How many mg of bupivacaine are in 30 mL of 0.5% bupivacaine solution?

$$\mathbf{30\ mL}\left(\frac{\mathbf{0.5\%\ g}}{\mathbf{100\%\ mL}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right) = \mathbf{150\ mg}$$

17) How many mg of lidocaine are in 100 mL of 1% lidocaine?

$$\mathbf{100\ mL}\left(\frac{\mathbf{1\%\ g}}{\mathbf{100\%\ mL}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right) = \mathbf{1000\ mg}$$

18) How many mcg of NaCl are in 1 drop of 0.9% NaCl if there are 20 drops/mL?

$$\mathbf{1\ drop}\left(\frac{\mathbf{1\ mL}}{\mathbf{20\ drops}}\right)\left(\frac{\mathbf{0.9\%\ g}}{\mathbf{100\%\ mL}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)\left(\frac{\mathbf{1000\ mcg}}{\mathbf{mg}}\right) = \mathbf{450\ mcg}$$

19) How many mL of ETOH are in 60 mL of 80 proof (40% ETOH) tequila?

$$\mathbf{60\ mL}\left(\frac{\mathbf{40\%\ mL}}{\mathbf{100\%\ mL}}\right) = \mathbf{24\ mL}$$

20) How many g of HC are in 500 g of 2.5% HC ointment?

$$\mathbf{500\ g}\left(\frac{\mathbf{2.5\%\ g}}{\mathbf{100\%\ g}}\right) = \mathbf{12.5}$$

Ratio Strength Exercise Answers

1) How many grams of active ingredient are in 500 mL of a 1:10,000 solution?

$$\mathbf{500\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{10,000\ mL}}\right)=\mathbf{0.05\ g}$$

2) How many grams of active ingredient are in 40 mL of a 1:200 solution?

$$\mathbf{40\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{200\ mL}}\right)=\mathbf{0.2\ g}$$

3) How many grams of active ingredient are in 600 g of a 1:25 w/w preparation?

$$\mathbf{600\ g\ prep}\left(\frac{\mathbf{1\ g\ AI}}{\mathbf{25\ g\ prep}}\right)=\mathbf{24\ g\ AI}$$

4) How many mg of active ingredient are in 800 mL of a 1:10,000 solution?

$$\mathbf{800\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{10,000\ mL}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)=\mathbf{80\ mg}$$

5) How many mcg are in 10 mL of a 1:100,000 solution?

$$\mathbf{10\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{100,000\ mL}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)\left(\frac{\mathbf{1000\ mcg}}{\mathbf{mg}}\right)=\mathbf{100\ mcg}$$

6) You have a 10 mL vial which is labeled 1:10,000 and you are asked to draw up 0.4 mg of drug. How many mL would you draw?

$$\mathbf{0.4\ mg}\left(\frac{\mathbf{10,000\ mL}}{\mathbf{1\ g}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right)=\mathbf{4\ mL}$$

7) You are asked to make 200 g of a 1:100 HC oint preparation. How many grams of HC powder and how many grams of ointment base would you use?

$$\mathbf{200\ g\ HC\ Oint}\left(\frac{\mathbf{1\ g\ HC\ powder}}{\mathbf{100\ g\ HC\ oint}}\right)=\mathbf{2\ g\ HC\ Powder}$$

Since you are making a total of 200 g of HC Ointment and the HC powder is 2 g, you would need **198 g** of ointment base.

8) You have a solution which is 1:10,000 w/v. What is the percentage strength?

$$\left(\frac{\mathbf{1\ g}}{\mathbf{10,000\ mL}}\right)\mathbf{100\%}=\mathbf{0.01\%}\frac{\mathbf{g}}{\mathbf{mL}}=\mathbf{0.01\%}\ \frac{\mathbf{w}}{\mathbf{v}}$$

9) What is the percentage strength of a 1:100 w/v solution?

$$\left(\frac{\mathbf{1\ g}}{\mathbf{100\ mL}}\right)\mathbf{100\%}=\mathbf{1\%}\frac{\mathbf{g}}{\mathbf{mL}}=\mathbf{1\%}\frac{\mathbf{w}}{\mathbf{v}}$$

10) You have a 100 mL vial which is labeled 1:1000. How many mg are in 25 mL of the solution?

$$\mathbf{25\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mL}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)=\mathbf{25\ mg}$$

Milliequivalent Exercise Answers

1) Look up the atomic masses (atomic weights) of the following elements.

Name	Atomic Symbol	Atomic Mass (rounded to nearest tenth)	Ionic Form
Hydrogen	H	**1.0**	H^+ (Hydrogen Ion)
Carbon	C	**12.0**	
Oxygen	O	**16.0**	
Sodium	Na	**23.0**	Na^+ (Sodium Ion)
Magnesium	Mg	**24.3**	Mg^{++} (Magnesium Ion)
Chlorine	Cl	**35.5**	Cl^- (Chloride Ion)
Potassium	K	**39.1**	K^+ (Potassium Ion)
Calcium	Ca	**40.1**	Ca^{++} (Calcium Ion)
Sulfur	S	**32.1**	

2) Now that you know the atomic masses of each of the elements, fill in the formula masses of the listed polyatomic ions (ions with more than one atom). Add up all the individual masses. CH_3COO^- has two carbons atoms, three hydrogen atoms, and two oxygen atoms.

Name	Chemical Formula	Formula Mass	Ionic Form
Acetate	CH_3COO^-	**59.0**	CH_3COO^-
Bicarbonate	HCO_{3-}	**61.0**	HCO_3^-
Sulfate	SO_4^{-2}	**96.1**	SO_4^{2-}

3) List the formula masses of the following ionic compounds.

Name	Chemical Formula	Formula Mass	Ionic Form
Sodium Chloride	NaCl	**58.5**	$Na^+ Cl^-$
Potassium Chloride	KCl	**74.6**	$K^+ Cl^-$
Calcium Chloride	$CaCl_2$	**111.1**	Ca^{++} $2Cl^-$
Magnesium Chloride	$MgCl_2$	**95.3**	Mg^{++} $2Cl^-$
Sodium Acetate	CH_3COONa	**82.0**	$Na^+ CH_3COO^-$
Potassium Acetate	CH_3COOK	**98.1**	$K^+ CH_3COO^-$
Magnesium Sulfate	$MgSO_4$	**120.4**	$Mg^{++} SO_4^{2-}$
Sodium Bicarbonate	$NaHCO_3$	**84.0**	$Na^+ HCO_3^-$

4) Fill in the table with the ratios of mg/mmol and mEq/mmol for each compound.

Name	Chemical Formula	mg/mmol (ratio)	mEq/mmol (ratio)
Sodium Chloride	NaCl	**58.5 mg/mmol**	**1 mEq/mmol**
Potassium Chloride	KCl	**74.6 mg/mmol**	**1 mEq/mmol**
Calcium Chloride	$CaCl_2$	**111.1 mg/mmol**	**2 mEq/mmol**
Magnesium Chloride	$MgCl_2$	**95.3 mg/mmol**	**2 mEq/mmol**
Sodium Acetate	CH_3COONa	**82.0 mg/mmol**	**1 mEq/mmol**
Potassium Acetate	CH_3COOK	**98.1 mg/mmol**	**1 mEq/mmol**
Magnesium Sulfate	$MgSO_4$	**120.4 mg/mmol**	**2 mEq/mmol**
Sodium Bicarbonate	$NaHCO_3$	**84.0 mg/mmol**	**1 mEq/mmol**

5) How many mEq are contained in 746 mg of KCl?

$$746\ \mathbf{mg}\left(\frac{\mathbf{1\ mmol}}{\mathbf{74.6\ mg}}\right)\left(\frac{\mathbf{1\ mEq}}{\mathbf{mmol}}\right)=\mathbf{10\ mEq}$$

Note: In this case where there is 1 mEq per mmol, you can skip the extra step of including the $\left(\frac{1\ \mathrm{mEq}}{\mathrm{mmol}}\right)$ conversion factor and just use $\left(\frac{1\ \mathrm{mEq}}{74.6\ \mathrm{mg}}\right)$.

6) How many mEq of calcium chloride are contained in 2 g of calcium chloride?

$$\mathbf{2\ g}\left(\frac{\mathbf{1\ mmol}}{\mathbf{111.1\ mg}}\right)\left(\frac{\mathbf{2\ mEq}}{\mathbf{mmol}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)=\mathbf{36\ mEq}$$

7) How many mEq of Ca^{++} are in 2 g of calcium chloride?

This is the same as problem #6. If there are 36 mEq of $CaCl_2$, there are 36 mEq of Ca^{++} and 36 mEq of Cl^-.

8) How many mg of magnesium sulfate are in 10 mEq of magnesium sulfate?

$$\mathbf{10\ mEq}\left(\frac{\mathbf{120.4\ mg}}{\mathbf{mmol}}\right)\left(\frac{\mathbf{1\ mmol}}{\mathbf{2\ mEq}}\right)=\mathbf{602\ mg}$$

9) How many g of sodium acetate are in 12 mEq of sodium acetate?

$$\mathbf{12\ mEq}\left(\frac{\mathbf{82.0\ mg}}{\mathbf{mEq}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right)=\mathbf{0.984\ g}$$

10) How many mEq of NaCl are in 2 L of 0.9% NaCl?

$$\mathbf{2\ L}\left(\frac{\mathbf{0.9\%\ g}}{\mathbf{ml}}\right)\left(\frac{\mathbf{1}}{\mathbf{100\%}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)\left(\frac{\mathbf{1000\ ml}}{\mathbf{L}}\right)\left(\frac{\mathbf{1\ mEq}}{\mathbf{58.5\ mg}}\right)=\mathbf{307.7\ \ mEq}$$

11) How many mEq of KCl are in 30 mL of 10% KCl solution?

$$\mathbf{30\ mL}\left(\frac{\mathbf{10\%\ g}}{\mathbf{mL}}\right)\left(\frac{\mathbf{1}}{\mathbf{100\%}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)\left(\frac{\mathbf{1\ mEq}}{\mathbf{74.6\ mg}}\right)=\mathbf{40.2\ \ mEq}$$

12) How many mEq of $MgSO_4$ are contained in 10 g of $MgSO_4$?

$$\mathbf{10\ g}\left(\frac{\mathbf{1\ mmol}}{\mathbf{120.4\ mg}}\right)\left(\frac{\mathbf{2\ mEq}}{\mathbf{mmol}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)=\mathbf{166.1\ mEq}$$

13) How many mg of Na^+ (just the sodium) are contained in 1.5 L of 10% NaCl?

$$\mathbf{1.5\ L}\left(\frac{\mathbf{10\%\ g}}{\mathbf{ml}}\right)\left(\frac{\mathbf{1}}{\mathbf{100\%}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)\left(\frac{\mathbf{1000\ ml}}{\mathbf{L}}\right)=\mathbf{150{,}000\ \ mg\ NaCl}$$

Since the ratio of the weight of sodium (Na^+) to the weight of sodium chloride (NaCl) is $\frac{23.0\ \mathrm{mg\ Na+}}{58.5\ \mathrm{mg\ NaCl}}$ (from the atomic masses):

$$\mathbf{150{,}000\ mg\ NaCl}\left(\frac{\mathbf{23.0\ mg\ Na^+}}{\mathbf{58.5\ mg\ NaCl}}\right)=\mathbf{58{,}974\ mg\ Na^+}$$

14) Try this one if you wish. You have 2.5 L of 10% NaCl solution and your friend has 1.5 L of $MgSO_4$ solution. You have twice as many mEq of NaCl as your friend has of mEq of $MgSO_4$. What is the percentage strength of your friend's $MgSO_4$?

Step 1) Figure out how many mEq of NaCl you have.

$$\mathbf{2.5\ L}\left(\frac{\mathbf{10\%\ g}}{\mathbf{ml}}\right)\left(\frac{\mathbf{1}}{\mathbf{100\%}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)\left(\frac{\mathbf{1000\ ml}}{\mathbf{L}}\right)\left(\frac{\mathbf{1\ mEq}}{\mathbf{58.5\ mg}}\right) = \mathbf{4,273.5\ \ mEq\ NaCl}$$

Step 2) You know that you have twice as many mEq of NaCl as your friend has mEq of $MgSO_4$, so your friend would have 2,136.8 mEq of $MgSO_4$. Now change the 2,136.8 mEq into g.

$$\mathbf{2,136.8\ mEq}\left(\frac{\mathbf{1\ mmol}}{\mathbf{2\ mEq}}\right)\left(\frac{\mathbf{120.4\ mg}}{\mathbf{mmol}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right) = \mathbf{128.6\ g\ MgSO_4}$$

Step 3) Now you know how many g of $MgSO_4$ and how many mL of solution your friend has, so you just have to convert that into a percent strength.

$$\frac{\mathbf{128.6\ g}}{\mathbf{1.5\ \cancel{L}}}(100\%)\left(\frac{\mathbf{1\cancel{L}}}{\mathbf{1000\ mL}}\right) = \mathbf{8.57\%}\ \frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{8.57\%}\frac{\mathbf{w}}{\mathbf{v}}$$

Concentration and Dilution Exercise Answers

1) An order calls for 600 mL of a 17% solution. You have a 43% solution on hand. How many mL of stock solution (43%) and how many mL of diluent are needed?

Using V1C1=V2C2 to calculate the volume of the stock solution:

$$\mathbf{600\ mL(17\%) = V2(43\%)}$$

$$\mathbf{V2} = \frac{\mathbf{600\ mL\ (17\%)}}{\mathbf{43\%}} = \mathbf{237.2\ mL}$$

You would use **237.2 mL of stock** and **362.8 mL** (600 mL – 237.2 mL) **of diluent.**

2) The pharmacy stocks a 35% solution. A doctor writes an order for 40 mL of 250 mg/mL solution. How many mL of the stock solution and how many mL of diluent are needed? Note: You can use V1C1=V2C2 even if the concentrations of the two solutions are not in the same units. Give it a try.

$$\mathbf{40\ mL}\left(\frac{\mathbf{250\ mg}}{\mathbf{mL}}\right) = \mathbf{V2}\left(\mathbf{35\%}\ \frac{\mathbf{g}}{\mathbf{mL}}\right)$$

$$\mathbf{V2 = 40\ mL}\frac{\mathbf{250\ mg}}{\mathbf{mL}}\left(\frac{\mathbf{mL}}{\mathbf{35\%\ g}}\right)\left(\frac{\mathbf{100\%}}{\mathbf{1}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right) = \mathbf{28.6\ mL}$$

You would use **28.6 mL of stock solution** and **11.4 mL of diluent**.

3) A prescription is written for 300 mL of a 16% solution. You have a 50% solution available in the pharmacy. How many mL of the stock solution and how many mL of diluent are needed?

Using the method of first calculating the amount of active ingredient needed in the final preparation, then calculating the volume of stock solution needed:

$$\mathbf{300\ mL}\left(\frac{\mathbf{16\ g}}{\mathbf{100\ mL}}\right) = \mathbf{48\ g}$$

$$\mathbf{48\ g}\left(\frac{\mathbf{100\ mL}}{\mathbf{50\ g}}\right) = \mathbf{96\ mL}$$

You would use **96 mL of the stock solution** and **204 mL of diluent**.

4) A patient brings in a prescription for 60 mL of a 50 mg/mL solution. Your pharmacy stocks a 360 mg/2 mL solution. How many mL of the stock solution and how many mL of diluent are needed?

$$\mathbf{60\ mL}\left(\frac{\mathbf{50\ mg}}{\mathbf{mL}}\right) = \mathbf{V2}\left(\frac{\mathbf{360\ mg}}{\mathbf{2\ mL}}\right)$$

$$\mathbf{V2} = \mathbf{60\ mL}\left(\frac{\mathbf{50\ mg}}{\mathbf{mL}}\right)\left(\frac{\mathbf{2\ mL}}{\mathbf{360\ mL}}\right) = \mathbf{16.7\ mL}$$

You would use **16.7 mL of stock solution** and **43.3 mL of diluent.**

5) Your pharmacy has a 150 mL stock bottle of 1:1000 and a 200 mL stock bottle of 8% solution of the same drug. The pharmacist mixes both bottles together, for no reason other than to make your life difficult, and asks you to prepare 300 mL of a 30 mg/mL solution. How many mL of the mixed stock solution and how many mL of diluent are needed?

Step 1) To find the concentration of the mixture of the two solutions, calculate the weight of the active ingredient in each solution, add them together, then divide by the total volume of the two solutions.

$$\mathbf{150\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mL}}\right) = \mathbf{0.15\ g}$$

$$\mathbf{200\ mL}\left(\frac{\mathbf{8\ g}}{\mathbf{100\ mL}}\right) = \mathbf{16\ g}$$

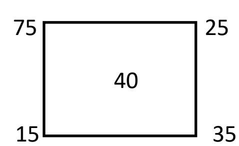
You now have 16.15 g of active ingredient in a total of 350 mL. You can use this ratio as it is to calculate the amount needed to prepare the solution.

$$\mathbf{300\ mL}\left(\frac{\mathbf{30\ mg}}{\mathbf{mL}}\right) = \mathbf{V2}\left(\frac{\mathbf{16.15\ g}}{\mathbf{350\ mL}}\right)$$

$$\mathbf{V2} = \mathbf{300\ mL}\left(\frac{\mathbf{30\ mg}}{\mathbf{mL}}\right)\left(\frac{\mathbf{350\ mL}}{\mathbf{16.15\ g}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right) = \mathbf{195\ mL}$$

You would use 195 mL of the mixture of the stock solutions and 105 mL of diluent.

6) The pharmacy stocks a 15% and a 75% alcohol solution. You receive a prescription for 300 mL of a 40% alcohol solution. How many milliliters of the 15% and 75% solutions are needed?

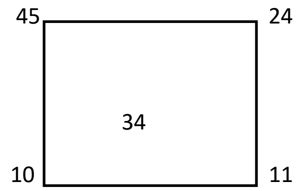


You have 60 total parts (25 +35). 25/60 will be the 75% and 35/60 will be the 15%. You are making a total of 300 mL, so you will multiply 300 mL by 25/60 to calculate the amount of 75% and multiply 300 mL by 35/60 to calculate the amount of 15%.

$$\mathbf{300\ mL}\left(\frac{\mathbf{25}}{\mathbf{60}}\right) = \mathbf{125\ ml\ (of\ 75\%)}$$

$$\mathbf{300\ mL}\left(\frac{\mathbf{35}}{\mathbf{60}}\right) = \mathbf{175\ mL\ (of\ 15\%)}$$

7) An order is written for 700 mL of a 34% solution. Your pharmacy stocks a 10% and a 45% solution. How many milliliters of the 10% and 45% solutions are needed?



$$\mathbf{700\ mL}\left(\frac{\mathbf{24}}{\mathbf{35}}\right) = \mathbf{480\ ml\ (of\ 45\%)}$$

$$\mathbf{700\ mL}\left(\frac{\mathbf{11}}{\mathbf{35}}\right) = \mathbf{220\ ml\ (of\ 10\%)}$$

8) What is the percentage strength of a mixture containing 60 mL of a 10% solution and 180 mL of a 35% solution?

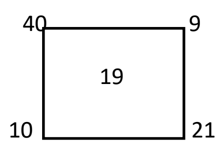
$$\mathbf{60\ mL}\left(\frac{\mathbf{10\ g}}{\mathbf{100\ mL}}\right) = \mathbf{6\ g}$$

$$\mathbf{180\ mL}\left(\frac{\mathbf{35\ g}}{\mathbf{100\ mL}}\right) = \mathbf{63\ g}$$

You now have 69 g in 240 mL. Change to a percent strength by multiplying by 100%.

$$\frac{\mathbf{69\ g}}{\mathbf{240\ mL}}(\mathbf{100\%}) = \mathbf{28.75\ \%\ \frac{w}{v}}$$

9) You are to prepare 200 mL of 19% dextrose solution from $D_{10}W$ and $D_{40}W$. How much of each is required? (Note: $D_{10}W$ = 10% dextrose in water and $D_{40}W$= 40% dextrose in water).



$$\mathbf{200\ mL}\left(\frac{\mathbf{9}}{\mathbf{30}}\right) = \mathbf{60\ mL\ (of\ 40\%)}$$

$$\mathbf{200\ mL}\left(\frac{\mathbf{21}}{\mathbf{30}}\right) = \mathbf{140\ mL\ (of\ 10\%)}$$

10) The same pharmacist in problem 5 mixes 100 mL of a 6% solution, 200 mL of a 100 mg/mL solution and 1 L of a 1:100 solution together, then he measures out 10 mL of that mixture and mixes it with 120 mL of diluent. What is the percent strength of the final solution?

$$\mathbf{100\ mL}\left(\frac{\mathbf{6\ g}}{\mathbf{100\ mL}}\right) = \mathbf{6\ g}$$

$$\mathbf{200\ mL}\left(\frac{\mathbf{100\ mg}}{\mathbf{mL}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right) = \mathbf{20\ g}$$

$$\mathbf{1000\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{100\ mL}}\right) = \mathbf{10\ g}$$

You now have 36 g of active ingredient in a total of 1300 mL. Now calculate the amount of active ingredient in 10 mL of this solution.

$$\mathbf{10\ mL}\left(\frac{\mathbf{36\ g}}{\mathbf{1300\ mL}}\right) = \mathbf{0.28\ g}$$

After adding this 10 mL to the 120 mL of diluent, you will have 0.28 g in 130 mL. Change this to a percent strength by multiplying by 100%.

$$\frac{\mathbf{0.28\ g}}{\mathbf{130\ mL}}(\mathbf{100\%}) = \mathbf{0.22\%}\frac{\mathbf{g}}{\mathbf{mL}} = \mathbf{0.22\%}\frac{\mathbf{w}}{\mathbf{v}}$$

Powder Volume Exercise Answers

1) The label of a vial states that it contains 3 g. It also says that to make the solution 100 mg/mL, you must add 15.3 mL. What is the powder volume?

Calculate the FV from WT and FC. Subtract the DV from FV.

Final Volume (FV)	**30 mL**
Powder Volume (PV)	**14.7 mL**
Diluent Volume (DV)	**15.3 mL**
Final Concentration (FC)	**100 mg/mL**
Weight of A.I. (WT)	**3 g**

2) An oral suspension once reconstituted will have a concentration of 250 mg/5 mL. The A.I. is 5 g with a powder volume of 14.9 mL. How much water must be added?

Same thing here, you are given three out of the five components and must calculate the other two.

Once again, you will first calculate the FV.

Final Volume (FV)	**100 mL**
Powder Volume (PV)	**14.9 mL**
Diluent Volume (DV)	**85.1 mL**
Final Concentration (FC)	**250mg/5 mL**
Weight of A.I. (WT)	**5 g**

3) A bottle of amoxicillin says to add 187 mL to the bottle to get a suspension of 125 mg/5 mL. The bottle contains 5 g of amoxicillin. What is the powder volume?

Final Volume (FV)	**200 mL**
Powder Volume (PV)	**13 mL**
Diluent Volume (DV)	**187 mL**
Final Concentration (FC)	**125mg/5 mL**
Weight of A.I. (WT)	**5 g**

4) A 30 g bulk vial label states that if you add 142 mL of a diluent, the concentration will be 1 g/5 mL. How much diluent would you add to get a concentration of 1 g/3 mL?

This problem consists of two different scenarios. In the first scenario you end up with a concentration of 1 g/ 5mL, while in the second scenario you end up with a concentration of 1 g/3 mL. The important thing to understand is that in both cases you will start with a 30 g vial, you will just be adding different amounts of diluent. Look at the five components and ask yourself which ones will remain the same for both scenarios and which ones will change.

Will the FV change? Yes
Will the PV change? No
Will the DV change? Yes
Will the FC change? Yes (The second FC is given in the problem)
Will the WT change? No

First Scenario		Second Scenario	
Final Volume (FV)	**150 mL**	**Final Volume (FV)**	**90 mL**
Powder Volume (PV)	**8 mL**	**Powder Volume (PV)**	**8 mL**
Diluent Volume (DV)	**142 mL**	**Diluent Volume (DV)**	**82 mL**
Final Concentration (FC)	**1 g/5 mL**	**Final Concentration (FC)**	**1 g/3 mL**
Weight of A.I. (WT)	**30 g**	**Weight of A.I. (WT)**	**30 g**

Serial Dilution Exercise Answer

10 g/100 mL is the same as 100 mg/mL, so this problem is done the same way as the example in the book.

Self-Assessment Exercise Answers

1) Round 3.545 to the nearest tenth.

3.5

2) Round 78.9315 to the nearest thousandth.

78.932

3) Express 0.000502 in scientific notation.

5.02×10^{-4}

4) Express 6.430×10^{4} as a numer.

64,300

5) How many significant figures are in 5.01 cm?

3

6) How many significant figures are in 650 cm?

2 (6,5)

7) You attempted to measure 120 mL, but later found out that you actually measured 125 mL. What is the percent error of the measurement?

125 mL-120 mL = 5 mL error $\left(\frac{\mathbf{5\ mL}}{\mathbf{120\ mL}}\right)\mathbf{100\%} = \mathbf{4.17\%}$

8) You attempted to weigh 35 g, but the actual weight was 37 g. What is the percent error of the measurement?

37 g-35 g = 2 g error $\left(\frac{\mathbf{2\ g}}{\mathbf{35\ g}}\right)\mathbf{100\%} = \mathbf{5.71\%}$

9) How many mL in a teaspoonful?

5 mL

10) What is the Roman numeral for 125?

CXXV

11) What is the number for XXXI?

31

12) Convert 5.12 g to mg.

$$\mathbf{5.12\ g}\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right) = \mathbf{5120\ mg}$$

13) Convert 0.3 kg to g.

$$\mathbf{0.3\ kg}\left(\frac{\mathbf{1000\ g}}{\mathbf{kg}}\right) = \mathbf{300\ g}$$

14) Convert 3 kg to mcg. State the answer in scientific notation.

$$\mathbf{3\ kg}\left(\frac{\mathbf{1000\ g}}{\mathbf{kg}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)\left(\frac{\mathbf{1000\ mcg}}{\mathbf{mg}}\right) = \mathbf{3,000,000,000} = \mathbf{3\ X\ 10^9\ mcg}$$

15) A patient is prescribed 500 mg of a drug which is available in a strength of 250 mg/2 mL. How many mL should be administered?

$$\mathbf{500\ mg}\left(\frac{\mathbf{2\ mL}}{\mathbf{250\ mg}}\right) = \mathbf{4\ mL}$$

16) A 194 lb patient is prescribed 10 mg/kg of a drug which is available in a strength of 100 mg/mL. How many mL should be administered?

$$\mathbf{194\ lb}\left(\frac{\mathbf{1\ kg}}{\mathbf{2.2\ lb}}\right)\left(\frac{\mathbf{10\ mg}}{\mathbf{kg}}\right)\left(\frac{\mathbf{1\ mL}}{\mathbf{100\ mg}}\right) = \mathbf{8.8\ mL}$$

17) A 201 lb patient is prescribed 15 mg/kg/day for 10 days. The drug is available in 10 mL vials of 80 mg/mL. How many vials will be need for the 10 days of therapy?

$$\mathbf{201\ lb}\left(\frac{\mathbf{1\ kg}}{\mathbf{2.2\ lb}}\right)\left(\frac{\mathbf{15\ mg}}{\mathbf{kg\ day}}\right)\left(\frac{\mathbf{10\ days}}{}\right)\left(\frac{\mathbf{1\ mL}}{\mathbf{80\ mg}}\right)\left(\frac{\mathbf{1\ vial}}{\mathbf{10\ mL}}\right) = \mathbf{17.1\ rounded\ up\ to\ 18\ vials}$$

18) A patient is prescribed 250 mg three times daily for 10 days. The dug is available in 125 mg capsules. How many capsules will be dispensed?

$$\mathbf{10\ days}\left(\frac{\mathbf{750\ mg}}{\mathbf{day}}\right)\left(\frac{\mathbf{1\ capsule}}{\mathbf{125\ mg}}\right) = \mathbf{60\ caps\ or\ 10\ days}\left(\frac{\mathbf{250\ mg}}{\mathbf{dose}}\right)\left(\frac{\mathbf{3\ doses}}{\mathbf{day}}\right)\left(\frac{\mathbf{1\ capsule}}{\mathbf{125\ mg}}\right) = \mathbf{60\ caps}$$

19) A patient has been prescribed 25 mg t.i.d. (3 times daily) for 10 days. The tablets are available in scored 50 mg tablets. How many tablets will be dispensed?

$$\mathbf{10\ days}\left(\frac{\mathbf{75\ mg}}{\mathbf{day}}\right)\left(\frac{\mathbf{1\ tab}}{\mathbf{50\ mg}}\right)=\mathbf{15\ tabs}$$

20) An IV is running at 50 mL/h with a drop factor of 20. How many gtt/min is that?

$$\frac{\mathbf{50\ mL}}{\mathbf{h}}\left(\frac{\mathbf{1\ h}}{\mathbf{60\ min}}\right)\left(\frac{\mathbf{20\ gtts}}{\mathbf{mL}}\right)=\frac{\mathbf{16.7\ gtts}}{\mathbf{min}}\ \mathbf{rounded\ to}\ \frac{\mathbf{17\ gtts}}{\mathbf{min}}$$

21) A 500 mL IV bag with a drop factor of 10 contains 5 g of drug. How many mg are in each drop?

$$\frac{\mathbf{5\ g}}{\mathbf{500\ mL}}\left(\frac{\mathbf{1\ mL}}{\mathbf{20\ gtts}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{1\ g}}\right)=\frac{\mathbf{0.5\ mg}}{\mathbf{gtt}}$$

22) How many g of NaCl are in 1000 mL of 5% NaCl?

$$\mathbf{1000\ mL}\left(\frac{\mathbf{5\%\ g}}{\mathbf{100\ \%\ mL}}\right)=\mathbf{50\ g}$$

23) Change 0.205 to a percent.

0.205 (100%)=20.5%

24) You have 2 mmol of $MgSO_4$. How many mEq of Mg^{+2} do you have?

$$\mathbf{2\ mmol}\left(\frac{\mathbf{2\ mEq}}{\mathbf{mmol}}\right)=\mathbf{4\ mEq}$$

25) Does 1 mEq of Na^+ weigh the same as 1 mEq of K^+?

No. They have the same number of ions, but different weights.

26) A prescription is written for 400 mL of a 15% solution. You have a 60% stock solution available. How many mL of the stock solution and how many mL of diluent will be used?

$400\ \mathrm{mL}\left(\frac{15\ \mathrm{g}}{100\ \mathrm{mL}}\right)=60\ \mathrm{g}$ 60 g are needed in the final solution. Calculate mL needed to provide 60 g from the stock solution. $60\ \mathrm{g}\left(\frac{100\ \mathrm{mL}}{60\ \mathrm{g}}\right)=100\ \mathrm{mL}$. **100 mL stock, 300 mL diluent.**

Using **V1C1=V2C2 400 mL (15%) = V2(60%) V2= 100 mL. Note: V1C1=V2C2 is the easier method on this problem, but it still important to know the basics in the first method.**

27) You are asked to prepare 1000 mL of a 5% solution from a 2% solution and a 40% solution. How many mL of each solution will be used?

40 3 $\left(\frac{3}{38}\right)\mathbf{1000\ ml}=\mathbf{78.9\ mL\ of\ 40\%}$

5

2 35 $\left(\frac{35}{38}\right)\mathbf{1000\ mL}=\mathbf{921.1\ mL\ of\ 2\%}$

28) You mix 60 mL of a 40% solution with 2000 mL of a 1:1000 solution. What will be the percent strength of the final solution?

Calculate total weight in g of active ingredient in final solution, then divide by total volume in mL and change to percent by multiply by 100%. $60\ \mathrm{mL}\left(\frac{40\ \mathrm{g}}{100\ \mathrm{mL}}\right)=24\ \mathrm{g}$ $2000\ \mathrm{mL}\left(\frac{1\ \mathrm{g}}{1000\ \mathrm{mL}}\right)=2\ \mathrm{g}$

The final solution contains 26 g in 2060 mL. $\left(\frac{\mathbf{26\ g}}{\mathbf{2060\ mL}}\right)\mathbf{100\%}=\mathbf{1.26\%}\frac{\mathbf{w}}{\mathbf{v}}$

29) You mix 30 mL of a 2 mg/mL solution with 90 mL of a 10 mg/mL solution. What is the final strength in mg/mL?

$$\mathbf{30\ mL}\left(\frac{\mathbf{2\ mg}}{\mathbf{mL}}\right)=\mathbf{60\ mg} \qquad \mathbf{90\ ml}\left(\frac{\mathbf{10\ mg}}{\mathbf{mL}}\right)=\mathbf{900\ mg} \qquad \frac{\mathbf{960\ mg}}{\mathbf{120\ mL}}=\frac{\mathbf{8\ mg}}{\mathbf{mL}}$$

30) How many mg of active ingredient are in 1000 mL of a 1:10,000 solution?

$$\mathbf{1000\ mL}\left(\frac{\mathbf{1\ g}}{\mathbf{10{,}000\ mL}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)=\mathbf{100\ mg}$$

31) The label of a vial states that it contains 4 g and says to make a solution of 100 mg/mL you must add 13.5 mL. What is the powder volume?

Final Volume	**40 mL**
Powder Volume	**26.5 mL**
Diluent Volume	**13.5 mL**
Final Concentration	**100 mg/mL**
Weight of A.I.	**4 g**

32) A 40 g bulk vial label states that if you add 130 mL of a diluent, the concentration will be 1 g/5 mL. How much diluent would you add to get a concentration of 1 g/4 mL?

	First Scenario	**Second Scenario**
Final Volume	**200 mL**	**160 mL**
Powder Volume	**70 mL**	**70 mL**
Diluent Volume	**130 mL**	**90 mL**
Final Concentration	**1 g/5 mL**	**1 g/4 mL**
Weight of A.I.	**40 g**	**40 g**

33) How many mg of active ingredient are in each g of a 0.5% oint?

$$\mathbf{1\ g\ oint}\left(\frac{\mathbf{0.5\ g\ AI}}{\mathbf{100\ g\ oint}}\right)\left(\frac{\mathbf{1000\ mg}}{\mathbf{g}}\right)=\mathbf{5\ mg\ AI}$$

34) What does 5000 mg/5 g equal?

$$\frac{\mathbf{5000\ mg}}{\mathbf{5\ g}}=\mathbf{1}$$

35) You have weighed out 3.2 mg, 5.09 mg, and 17.2 mg of a drug. What is the total weight of the three quantities expressed to the correct number of significant figures?

3.2 mg + 5.09 mg + 17.2 mg = 25.49 mg which must be rounded to 25.5 mg (tenth place).

36) A plot of land measures 16.42 m x 21 m. What is the area expressed in the correct number of significant figures?

16.42 m X 21 m = 344.82 m^2 which must be rounded to 340 m^2 (two significant figures).

37) An IV with a drop factor of 20 has been running at a drip rate of 40 gtts/min for 1 hour. How many mL have been administered?

$$\mathbf{1\ h}\left(\frac{\mathbf{60\ min}}{\mathbf{h}}\right)\left(\frac{\mathbf{40\ gtts}}{\mathbf{min}}\right)\left(\frac{\mathbf{1\ mL}}{\mathbf{20\ gtts}}\right)=\mathbf{120\ mL}$$

38) Round 3.9999 to the nearest tenth.

4.0

39) A patient is prescribed 5 mL of a drug, with a strength of 50 mg/mL, 4 times daily for 10 days. How many g of the drug will the patient receive over the 10 days? $\mathbf{10\ days}\left(\frac{\mathbf{20\ mL}}{\mathbf{day}}\right)\left(\frac{\mathbf{50\ mg}}{\mathbf{mL}}\right)\left(\frac{\mathbf{1\ g}}{\mathbf{1000\ mg}}\right) = \mathbf{10\ g}$

40) What is the flow rate in gtts/min of a 1 L bag with a drop factor of 20 infused over 12 hours?

$$\frac{\mathbf{1\ L}}{\mathbf{12\ h}}\left(\frac{\mathbf{1000\ mL}}{\mathbf{L}}\right)\left(\frac{\mathbf{1\ h}}{\mathbf{60\ min}}\right)\left(\frac{\mathbf{20\ gtts}}{\mathbf{mL}}\right) = \frac{\mathbf{27.8\ gtts}}{\mathbf{min}}\ \mathbf{rounded\ to}\ \frac{\mathbf{28\ gtts}}{\mathbf{min}}$$

41) What is the Roman Numeral for 2155?

MMCLV

42) If you are in a pharmacy tech math class and the instructor tells you to convert a number to a percent by multiplying by 100. What do you say to the instructor?

If you multiply 0.5 by 100, you get 50, not 50%. You multiply by 100%, not 100. 0.5(100%)=50%. You can also work backwards. 0.5x = 50%. Solving for x = $\frac{50\%}{0.5}$**=100%.**

43) How many mcg of a drug are in 1000 mL of a 1 mg/mL solution?

$$\mathbf{1000\ mL}\left(\frac{\mathbf{1\ mg}}{\mathbf{mL}}\right)\left(\frac{\mathbf{1000\ mcg}}{\mathbf{mg}}\right) = \mathbf{1{,}000{,}000\ mcg}$$

44) What is the percent strength of a 1000 mL solution which contains 90 mL of a 40% ethanol solution? (90 mL of the 40% solution was added to 910 mL of water).

$$\mathbf{90\ mL}\left(\frac{\mathbf{40\ mL}}{\mathbf{100\ mL}}\right) = \mathbf{36\ mL\ ETOH} \quad \left(\frac{\mathbf{36\ mL}}{\mathbf{1000\ mL}}\right)\mathbf{100\%} = \mathbf{3.6\%}$$

45) How many square cm are in an area which measures 20.00 cm x 20.00 cm? Round to the appropriate number of significant figures.

20.00 cm X 20.00 cm = 400.0 cm² (Four significant figures.)

46) A 154 lb patient has been prescribed a dosage of 2 mg/kg/day in 4 equally divided doses. The drug is available in 10 mL vials of 10 mg/mL. How many mL will be administered for 1 dose?

$$\mathbf{154\ lb}\left(\frac{\mathbf{1\ kg}}{\mathbf{2.2\ lb}}\right)\left(\frac{\mathbf{2\ mg}}{\mathbf{kg\ day}}\right)\left(\frac{\mathbf{1\ day}}{\mathbf{4\ doses}}\right)\left(\frac{\mathbf{1\ mL}}{\mathbf{10\ mg}}\right) = \frac{\mathbf{3.5\ mL}}{\mathbf{dose}}$$

47) Rank the following solutions from strongest to weakest. 100 mg/mL, 1%, 1:1000.

Change them all to the same units to compare. $\frac{\mathbf{1\ g}}{\mathbf{100\ mL}} = \frac{\mathbf{1000\ mg}}{\mathbf{100\ mL}} = \frac{\mathbf{10\ mg}}{\mathbf{mL}}$

$\mathbf{1:1000} = \frac{\mathbf{1\ g}}{\mathbf{1000\ mL}} = \frac{\mathbf{1000\ mg}}{\mathbf{1000\ mL}} = \frac{\mathbf{1\ mg}}{\mathbf{mL}}$ **100 mg/mL, 1%, 1:1000**

48) How many significant figures are in the measurement 29,000 ft? How about 29,002 ft?

29,000 ft has 2 significant figures. 29,002 ft has 5 significant figures. There is an interesting story regarding the first measurement of Mt. Everest. Look it up.

49) How many mmol are in a mol?

1000

50) 5 mL of a 50% solution are mixed with 25 mL of a 4% solution. What is the resulting percent strength?

$$\mathbf{5\ mL}\left(\frac{\mathbf{50\ g}}{\mathbf{100\ mL}}\right) = \mathbf{2.5\ g} \qquad \mathbf{25\ mL}\left(\frac{\mathbf{4\ g}}{\mathbf{100\ mL}}\right) = \mathbf{1\ g} \quad \left(\frac{\mathbf{3.5\ g}}{\mathbf{30\ mL}}\right)\mathbf{100\%} = \mathbf{11.7\%}$$

Pharmacy Calculation Puzzle Answers

Puzzle #1

- **Read the puzzle thoroughly before beginning. Note the units of the answer are mg Cl^-/mL. You must keep tract of the weight of Cl^- and the volume of the solution.**

- **Calculate weight of Cl^- in the glass container.**

$$6\ \mathrm{g\ NaCl}\left(\frac{35.45\ \mathrm{g\ Cl^-}}{58.44\ \mathrm{g\ NaCl}}\right) = 3.64\ \mathrm{g\ Cl^-}$$

$$4\ \mathrm{g\ KCl}\left(\frac{35.45\ \mathrm{g\ Cl^-}}{74.55\ \mathrm{g\ KCl}}\right) = 1.90\ \mathrm{g\ Cl^-}$$

  Total = 3.64 g + 1.90 g = 5.54 g

- **Calculate volume of 0.9% NaCl solution which dripped into the glass container over 2 weeks.**

$$14\ \mathrm{days}\left(\frac{24\ \mathrm{h}}{\mathrm{day}}\right)\left(\frac{60\ \mathrm{min}}{\mathrm{h}}\right)\left(\frac{3\ \mathrm{gtts}}{\mathrm{min}}\right)\left(\frac{1\ \mathrm{mL}}{20\ \mathrm{gtts}}\right) = 3024\ \mathrm{mL}$$

- **Calculate weight of Cl^- from the 3024 mL of 0.9% NaCl.**

$$3024\ \mathrm{mL}\left(\frac{0.9\ \mathrm{g\ NaCl}}{100\ \mathrm{mL}}\right)\left(\frac{35.45\ \mathrm{g\ Cl^-}}{58.44\ \mathrm{g\ NaCl}}\right) = 16.51\ \mathrm{g\ Cl^-}$$

- **Calculate total weight of Cl^- in the 3024 mL of solution.**
  Total= 5.54 g + 16.51 g = 22.05 g

- **Calculate weight of Cl^- in 1000 mL of the above solution.**

$$1000\ \mathrm{mL}\left(\frac{22.05\ \mathrm{g\ Cl^-}}{3024\ \mathrm{mL}}\right) = 7.29\ \mathrm{g\ Cl^-}$$

- **Calculate weight of Cl^- in 500 mL of 200 mEq/L solution.**

$$500\ \mathrm{mL}\left(\frac{200\ \mathrm{mEq\ Cl^-}}{1000\ \mathrm{mL}}\right)\left(\frac{1\ \mathrm{mmol}}{\mathrm{mEq}}\right)\left(\frac{35.45\ \mathrm{mg\ Cl^-}}{\mathrm{mmol}}\right)\left(\frac{1\ \mathrm{g}}{1000\ \mathrm{mg}}\right) = 3.55\ \mathrm{g\ Cl^-}$$

- **Total the weight of Cl^- from the 1000 mL and 500 mL, divide by 1500 mL and change to mg/mL.**

  7.29 g + 3.55 g = 10.84 g. $\frac{10.84\ \mathrm{g}}{1500\ \mathrm{mL}}\left(\frac{1000\ \mathrm{mg}}{\mathrm{g}}\right) = 7.23\ \mathrm{mg/mL}$

Puzzle #2

- **Calculate number of vials needed for 30 days of therapy. Note that any partial vial will be rounded up to a full vial.**

$$\mathbf{245\ lb}\left(\frac{\mathbf{1\ kg}}{\mathbf{2.2\ lb}}\right)\left(\frac{\mathbf{0.8\ mg}}{\mathbf{kg\ day}}\right)\left(\frac{\mathbf{30\ days}}{}\right)\left(\frac{\mathbf{1\ mL}}{\mathbf{10\ mg}}\right)\left(\frac{\mathbf{1\ vial}}{\mathbf{10\ mL}}\right)=\mathbf{26.7\ vials}=\ \mathbf{27\ vials}$$

- **Calculate number of weeks of work to pay for the 27 vials.**

$$\mathbf{27\ vials}\left(\frac{\mathbf{\$850}}{\mathbf{vial}}\right)\left(\frac{\mathbf{1\ h}}{\mathbf{\$10}}\right)\left(\frac{\mathbf{1\ week}}{\mathbf{40\ h}}\right)=\mathbf{57.375\ weeks}$$

- **Subtract out 52 weeks and note 1 year.**
  1 year, 5.375 weeks
- **Change 0.375 weeks into hours using 40 h/week.**

$$\mathbf{0.375\ wk}\left(\frac{\mathbf{40\ h}}{\mathbf{wk}}\right)=\mathbf{15\ h}$$

- **Change 15 h to 1 day, 7 hours.**

- **Total work time is 1 year, 5 weeks, 1 day, 7 hours.**
- **Now the patient hands you his insurance card because his copay is only $10.**

Index