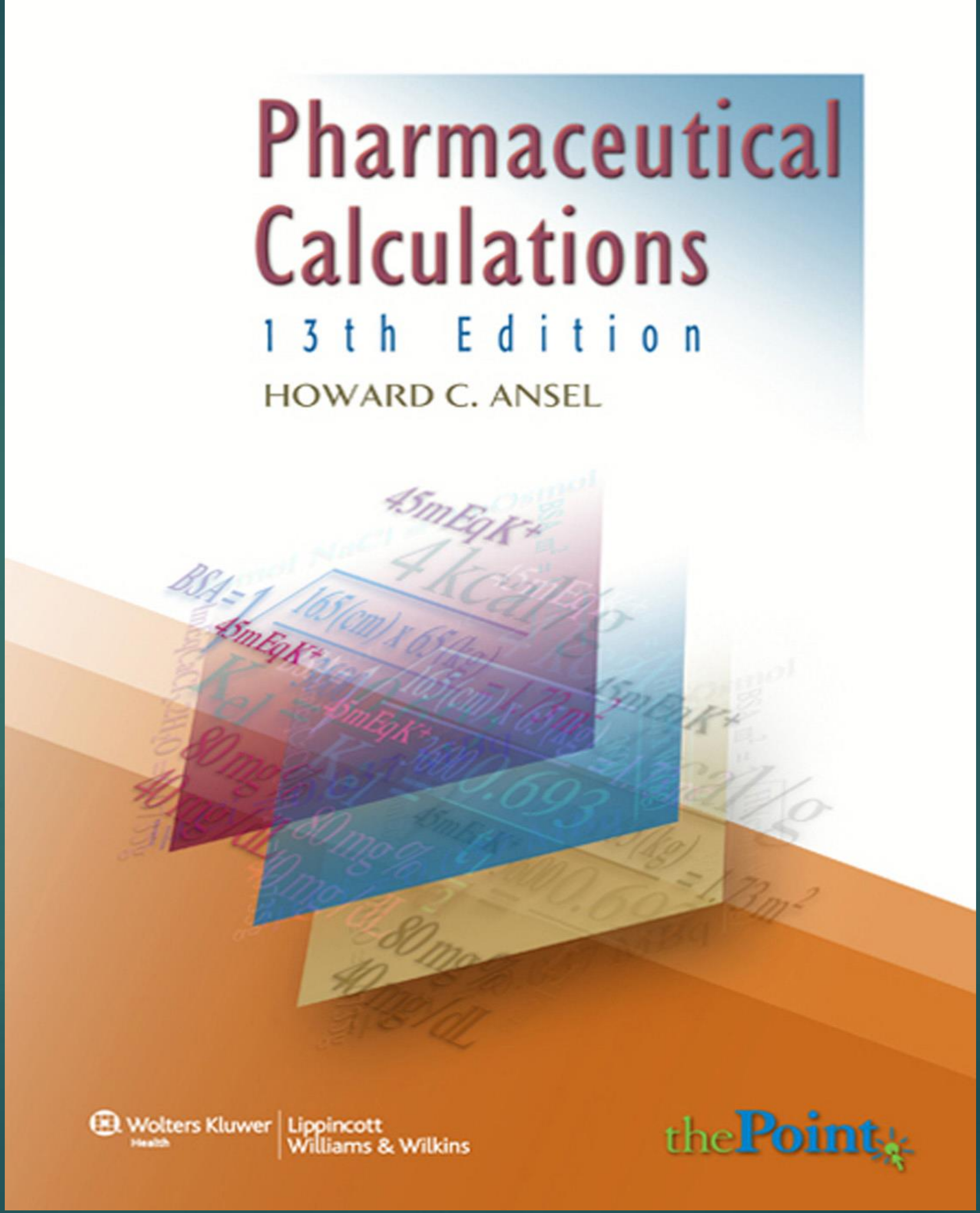
Fundamentals of Pharmaceutical Calculations

Lecture 1 PHT 224


Pharmaceutical Calculations
13th Edition
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Scope of Pharmaceutical Calculations

The use of calculations in pharmacy is varied and broad-based. It encompasses calculations performed by pharmacists in traditional as well as in specialized practice settings and within operational and research areas in industry, academia, and government. In the broad context, the scope of pharmaceutical calculations includes computations related to:

- chemical and physical properties of drug substances and pharmaceutical ingredients;
- biological activity and rates of drug absorption, bodily distribution, metabolism and excretion (pharmacokinetics);
- statistical data from basic research and clinical drug studies;
- pharmaceutical product development and formulation;
- prescriptions and medication orders including drug dosage, dosage regimens, and patient compliance;
- pharmacoeconomics; and other areas.

A Step-Wise Approach Toward Pharmaceutical Calculations

Step 1. Take the time necessary to carefully read and thoughtfully consider the problem *prior to* engaging in computations. An understanding of the purpose or goal of the problem and the types of calculations that are required will provide the needed direction and confidence.

Step 2. Estimate the dimension of the answer in both quantity and units of measure (e.g., milligrams) to satisfy the requirements of the problem. A section in Chapter 1 provides techniques for *estimation*.

Step 3. Perform the necessary calculations using the appropriate method both for efficiency and understanding. For some, this might require a step-wise approach whereas others may be capable of combining several arithmetic steps into one. Mathematical equations should be used only after the underlying principles of the equation are understood.

Step 4. Before assuming that an answer is correct, the problem should be read again and all calculations checked. In pharmacy practice, pharmacists are encouraged to have a professional colleague check all calculations prior to completing and dispensing a prescription or medication order. Further, if the process involves components to be weighed or measured, these procedures should be double-checked as well.

Step 5. Consider the *reasonableness* of the answer in terms of the numerical value, including the proper position of a decimal point, and the units of measure.

Pharmaceutical calculations is the area of study that applies the basic principles of mathematics to the preparation and safe and effective use of pharmaceuticals.

Number and Numerals

A number is a total quantity or amount whereas numeral is a word, sign, or group of words and signs representing a number:

For example, 3, 6, and 48 are Arabic numerals expressing numbers that are, respectively, 3 times, 6 times, and 48 times the unit.

Arabic numerals

Arabic numerals , such a 1,2,3, etc are used universally to indicate quantities. These numerals, which are represented by a zero and nine digits, are easy to read and less likely to confused.

Kind of Numbers

- Arabic Numerals:

Called decimal system with only 10 figures – a zero and nine digits (0,1,2,3,4,5,6,7,8,9)

- Roman numerals:

Expresses a fairly large range of numbers by using few letters of the alphabet (ss, i, v, x, l, c, d and m)

Roman Numerals

Roman numerals commonly are used in prescription writing to designate *quantities*, as the:

(1) quantity of medication to be dispensed and/or

(2) quantity of medication to be taken by the patient per dose.

- To express quantities in the Roman System, eight letters of fixed values are used:

Roman Numerals	
SS or ss	1/2
I or I	1
V or v	5
X or x	10
L or l	50
C or c	100
D or d	500
M or m	1000

- In the usage of Roman numerals the following set of rules apply:

1. A letter repeated once or more, repeats its value (e.g., xx= 20; xxx=30).
2. One or more letters placed *after* a letter of greater value *increases* the value of the greater letter (e.g., vi 6; xij 12; lx 60).

- Two or more letters express a quantity if the sum of their values, if they are successively equal or smaller in value:

ii = 2	Li = 51
iii = 3	Lxvi = 50 + 10 + 5 + 1 = 66
vi = 6	Lxxxviii = 50 + 30 + 8 = 88
xii = 12	dv = 500 + 5 = 505
xxxiii = 33	
dc = 500 + 100 = 600	

mdclxvi = 1000 + 500 + 100 + 50 + 10 + 5 + 1 = 1666

- When the second of the two letters have a value equal to or smaller than that of the first, their values are added.

3. A letter placed *before* a letter of greater value *decreases* the value of the greater letter (e.g., iv 4; xl 40).
4. When Roman numerals of lesser value is placed between tow greater values, it is first subtracted from the greater numeral placed after it and then that value is added to the other numeral (s) (i.e.. subtraction rule applies first then the addition rule)

    Example

    XXIX = 10+10+(10-1) = 29

    XIV = 10+(5-1)= 14

- Two or more letters express a quantity that is the sum of the values remaining after the value of each smaller letter has been subtracted from that of a following greater letter:

iv = 5 – 1 = 4	ix = 10 – 1 = 9
Xiv = 10 + 5 – 1 =14	xix = 10 + 10 – 1 = 19
xxiv = 10 + 10 + 5 – 1 =24	xL = 50 – 10 = 40
XLiv = 50 – 10 + 5 – 1 = 44	xc = 100 – 10 = 90

Question: MCDXCII = ? 1000 + 400 + 90 + 2 = 1492

= 1000 + (500 – 100) + (100 – 10) + 2 = 1492

cdxc = ? 400 + 90 = 490

= (500 – 100) + (100 – 10) = 490

- When the second has a value greater than the first , the smaller is to be subtracted.

- I, X and C are customarily used as “subtractors”

Each is used to subtract only from the two characters on next higher value than itself thus x is used to subtract from L and C, but not D or M.

XLIX = 50 – 10 + 10 – 1 = 49, but not IL so;-

(i is subtracted from V & X),

(x is subtracted from L & C),

(c is subtracted from D & M).

- Roman numerals may <u>not be repeated more than three </u>times in succession

  e.g. 4 is written as IV but not IIII

- When possible, largest value numerals should be used

  15 is written as XV bun not as VVV

- Roman numerals are sometimes combined with abbreviation for one half, **ss**. The abbreviation **should always be at the end of Roman numeral**. Generally, Roman numerals are written in lowercase when used with ss such as ***<u>iss</u>*** to indicate $1\frac{1}{2}$

Fractions

- A fraction is a portion of a whole number. Fractions contain two numbers:
- The bottom number (referred to as denominator) and the top number (referred to as numerator). The denominator in the fraction is the total number of parts into which the whole number is divided. The numerator in the fraction is the number of parts we have.
- A proper fraction should always be less than 1, i.e. the numerator is smaller than the denominator

  e.g. 5/8, 7/8, 3/8
- A proper fraction such as 3/8 may be read as " 3 of 8 parts'" or as '" 3 divided by 8."'
- An improper fraction has a numerator that is equal to or greater than denominator. It is therefore equal to or greater than one.

  e.g. 2/2=1 , 5/4, 6/5

Common fractions and decimal fractions:

- 1- Common fractions written as ¾ , ½
- 2- Decimal fraction written as 0.12 , 0.004

	Example
Addition	$\frac{2}{4}+\frac{3}{4}=\frac{5}{4}=1\frac{1}{4}$ $\frac{9}{12}+\frac{8}{12}=\frac{17}{12}=1\frac{5}{12}$
Subtraction	$\frac{2}{3}-\frac{1}{2}=\frac{4}{6}-\frac{3}{6}=\frac{1}{6}$
Multiplication	$\frac{5}{6}x\frac{7}{8}=\frac{5x7}{6\times 8}=\frac{35}{48}$
Division	$5\div\frac{1}{2}=5x\frac{2}{1}=10$

Percent

- The term precent and its corresponding sign, %, mean ‘ in a hundred.’ So, 50 precent (50%) means 50 parts in each one hundred of the same item.
- Common fractions may be converted to precent by dividing the numerator by the denominator and multiplying by 100.
- Example

Convert 3/8 to precent

3/8 X 100= 37.5 %

- Decimal fractions may be converted to percent by multiplying by 100.
- Example

Convert 0.125 to percent

0.125 x 100 =12.5%

Exponential Notation “Power of 10”

121 could be expressed as $1.21 X 10^2$

1210 could be expressed as $1.21 X 10^3$

1st part (1.21) called coefficient, 2nd part is the exponential factor or power of 10.

In the multiplication of exponentials, the exponents are added:

$(2.5 X 10^2) X (2.5 X 10^4) = 6.25 X 10^6$

$(2.5 X 10^2) X (2.5 X 10^{-4}) = 6.25 X 10^{-2}$

$(5.4 X 10^2) X (4.5 X 10^3) = 24.3 X 10^5 = 2.4 X 10^6$

In the division of exponentials, the exponents are subtracted:

$10^2 / 10^5 = 10^{-3}$

Exponential Notation

- In the addition and subtraction of exponentials, the expressions must be changed (by moving the decimal points) and the coefficients only are added or subtracted

$(1.4 \times 10^4) + (5.1 \times 10^3)$

$5.1 \times 10^3 \Rightarrow 0.51 \times 10^4$

$1.4 \times 10^4 + 0.51 \times 10^4 = 1.91 \times 10^4$

Ratios and Proportions:

- Rations relates the magnitudes of two quantities.
- For example: 1 : 5 is the expression used and it is read as (one to five).
- The equality of two ratios is called proportion.

- All the rules governing common fractions equally apply to a ratio
- For example: a:b = c:d or a/b = c/d.
- Also: If (a/b = c/d) then a = (b*c)/d and d = a/(b*c).
- Example: If 5 tablets contain 550 mg of aspirin, then how many mg should be in 15 tablets?

5: 550 = 15 : x **or** $\frac{5}{550} = \frac{15}{x} \longleftrightarrow x = \frac{15 \times 550}{5} = 1650$ mg of aspirin

Variation

Preceding examples (Proportional relationship) deals with twice the cause, double the effect and so on

- Occasionally, we have inverse relationships, half the effect, as when you decrease the strength of solution by increasing the amount of diluents

- **Example:** If 10 pints of a 5% solution are diluted to 40 pints, what is the percentage strength of the solution?
  - $\frac{10}{40} = \frac{x}{5}$
  - $x = \frac{10 \times 5}{40} = 125\%$
- V1XC1=V2XC2
- 10 X 5% = 4 X (X%) $= \frac{10 \times 5}{40} = 125\%$

Significant Figures:

- Significant figures are consecutive figures the express the value of a denominate number accurately enough for a given purpose. All the figures affect the accuracy and the last figure is called uncertain.
- Zero is significant only when:

1- Between digits, for example, 202, 101

2- One or more final zero to the right decimal point may be taken as significant.

Example 1: How many significant figures are in (0.25, 0.025, 0.205, 0.2050)?

* Always consider the sensitivity of your instrument before reporting your significant figures.

Rules of Rounding:

- Your last figure should be the only uncertain figure.
- When rounding a number add 1 to the last figure retained if the following figure is 5 or more.

- Example 1:

$2.43 \approx 2.4$ and $2.46 \approx 2.5$

However, the determining factor for rounding is the sensitivity of the used instrument.

During a pharmaceutical calculation the resulting value should retain the same significant figures of those used in the calculations.

TABLE 1.1 SOME ARITHMETIC SYMBOLS USED IN PHARMACY[a]

SYMBOL	MEANING
%	percent; parts per hundred
‰	per mil; parts per thousand
$+$	plus; add; or positive
$-$	minus; subtract; or negative
$\pm$	add or subtract; plus or minus; positive or negative; expression of range, error, or tolerance
$\div$	divided by
/	divided by
$\times$	times; multiply by
$<$	value on left is less than value on right (e.g., $5<6$)
$=$	is equal to; equals
$>$	value on left is greater than value on right (e.g., $6>5$)
$\neq$	is not equal to; does not equal
$\approx$	is approximately equal to
$\equiv$	is equivalent to
$\leq$	value on left is less than or equal to value on right
$\geq$	value on left is greater than or equal to value on right
.	decimal point
,	decimal marker (comma)
:	ratio symbol (e.g., a:b)
::	proportion symbol (e.g., a:b::c:d)
$\propto$	varies as; is proportional to

[a] Table adapted from *Barron's Mathematics Study Dictionary* (Barron's Educational Series, Inc. Hauppauge, NY: 1998.) by Frank Tapson with the permission of the author. Many other symbols (either letters or signs) are used in pharmacy, as in the metric and apothecaries' systems of weights and measures, in statistics, in pharmacokinetics, in prescription writing, in physical pharmacy, and in other areas. Many of these symbols are included and defined elsewhere in this text.