Principles of pharmacy practice

Lec 1

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Introduction

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

- and effective use of pharmaceuticals
- Success in performing pharmaceutical calculations is based on:

1. An understanding of the purpose or goal of the problem;
2. An assessment of the arithmetic process required to reach the goal
3. Implementation of the correct arithmetic manipulations.

The following steps are suggested in addressing the calculations problems

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.

Step 3. Perform the necessary calculations using the appropriate method both for efficiency and understanding

Step 4. Before assuming that an answer is correct, the problem should be read again and all calculations checked.

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.

Chapters covered

Fundamentals of Pharmaceutical Calculations

Upon successful completion of this chapter, the student will be able to:

- Convert common fractions, decimal fractions, and percentages to their corresponding equivalent expressions and apply each in calculations.
- Utilize exponential notations in calculations.
- Apply the method of ratio and proportion in problem-solving.

Common and Decimal Fractions

Common fractions are portions of a whole, expressed at **1/3** , **7/8** , and so forth.

They are used only rarely in pharmacy calculations nowadays.

It is recalled, that when adding or subtracting fractions, the use of a common denominator is required. The process of multiplying and dividing with fractions is recalled by the following examples.

- When common fractions appear in a calculations problem, it is often best to convert them to decimal fractions before solving.

- Decimal fraction is a fraction with a denominator of 10 or any power of 10 and is expressed decimally rather than as a common fraction. Thus,

1/10 is expressed as 0.10 and

45/100 as 0.45

- To convert a common fraction to a decimal fraction, divide the denominator into the numerator.

$$\frac{1}{8} = 1 \div 8 = 0.125.$$

To convert a decimal fraction to a common fraction, express the decimal fraction as a ratio and reduce.

$$0.25 = \frac{25}{100} = \frac{1}{4} \text{ or } ¼.$$

Common arithmetic symbols used in pharmaceutical calculations

SYMBOL	MEANING
%	percent; parts per hundred
‰	per mil; parts per thousand
+	plus; add; or positive
−	minus; subtract; or negative
±	add or subtract; plus or minus; positive or negative; expression of range, error, or tolerance
÷	divided by
/	divided by
×	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)
≠	is not equal to; does not equal
≈	is approximately equal to
≡	is equivalent to
≤	value on left is less than or equal to value on right
≥	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*)
∝	varies as; is proportional to

Percent

- The term percent and its corresponding sign, **%**, mean "in a hundred.
- 50 percent (50%) means 50 parts in each one hundred of the same item
- Common fractions maybe converted to percent by dividing the numerator by the denominator and multiplying by 100.

Convert $\frac{3}{8}$ to percent.

$$\frac{3}{8} \times 100 = 37.5\%, \text{ answer.}$$

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

Convert 0.125 to percent.

$$0.125 \times 100 = 12.5\%, \text{ answer.}$$

Practice problems

1. How many 0.000065-gram doses can be made from 0.130 gram of a drug?
2. Give the decimal fraction and percent equivalents for each of the following common fractions:
   (a) $\frac{1}{35}$
   (b) $\frac{3}{7}$
   (c) $\frac{1}{250}$
   (d) $\frac{1}{400}$
3. If a clinical study of a new drug demonstrated that the drug met the effectiveness criteria in 646 patients of the 942 patients enrolled in the study, express these results as a decimal fraction and as a percent.
4. A pharmacist had 3 ounces of hydromorphone hydrochloride. He used the following:
   $\frac{1}{8}$ ounce
   $\frac{1}{4}$ ounce
   $1\frac{1}{2}$ ounces

   How many ounces of hydromorphone hydrochloride were left?

5. A pharmacist had 5 grams of codeine sulfate. He used it in preparing the following:

   8 capsules each containing 0.0325 gram
   12 capsules each containing 0.015 gram
   18 capsules each containing 0.008 gram

   How many grams of codeine sulfate were left after he had prepared the capsules?

6. The literature for a pharmaceutical product states that 26 patients of the 2,103 enrolled in a clinical study reported headache after taking the product. Calculate (a) the decimal fraction and (b) the percentage of patients reporting this adverse response.

Ratio

- The relative magnitude of two quantities is called their **ratio**.
- Since a ratio relates the relative value of two numbers, it resembles a common fraction except in the way in which it is presented.
- Whereas a fraction is presented as, for example, **1⁄2,** a ratio is presented as **1:2** and is not read as "one half," but rather as "one is to two."
- All the rules governing common fractions equally apply to a ratio. Of particular importance is the principle that if the two terms of a ratio are multiplied or are divided by the same number, the value is unchanged, the value being the quotient of the first term divided by the second.
- For example, the ratio **20:4** or **20⁄4** has a value of **5**; if both terms are divided by **2**, the ratio becomes **10:2** or **10⁄2**, again the value of **5**.

- When two ratios have the same value, they are **equivalent**.
- An interesting fact about equivalent ratios is that the product of the numerator of the one and the denominator of the other always equals the product of the denominator of the one and the numerator of the other; that is, **the cross products are equal**:

$$\text{Because } \tfrac{2}{4} = \tfrac{4}{8},$$
$$2 \times 8 \text{ (or 16)} = 4 \times 4 \text{ (or 16)}.$$

It is also true that *if two ratios are equal, their reciprocals are equal:*

$$\text{Because } \tfrac{2}{4} = \tfrac{4}{8}, \text{ then } \tfrac{4}{2} = \tfrac{8}{4}.$$

An extremely useful practical application of these facts is found in **PROPORTION**

- A **proportion** is the expression of the equality of two ratios. It may be written in any one of three standard forms:

$$(1)\quad a:b = c:d$$
$$(2)\quad a:b :: c:d$$
$$(3)\quad \frac{a}{b} = \frac{c}{d}$$

- Each of these expressions is read: a is to b as c is to d, and a and d are called the extremes (meaning “outer members”) and b and c the means (“middle members”).

Example:

If 3 tablets contain 975 milligrams of aspirin, how many milligrams should be contained in 12 tablets?

$$\frac{3\ (\text{tablets})}{12\ (\text{tablets})} = \frac{975\ (\text{milligrams})}{x\ (\text{milligrams})}$$

$$x = \frac{12 \times 975}{3}\ \text{milligrams} = 3900\ \text{milligrams},\ \textit{answer}.$$

If 3 tablets contain 975 milligrams of aspirin, how many tablets should contain 3900 milligrams?

$$\frac{3\ (\text{tablets})}{x\ (\text{tablets})} = \frac{975\ (\text{milligrams})}{3900\ (\text{milligrams})}$$

$$x = 3 \times \frac{3900}{975}\ \text{tablets} = 12\ \text{tablets},\ \textit{answer}.$$

Example:

If 12 tablets contain 3900 milligrams of aspirin, how many milligrams should 3 tablets contain?

$$\frac{12\ \text{(tablets)}}{3\ \text{(tablets)}} = \frac{3900\ \text{(milligrams)}}{x\ \text{(milligrams)}}$$

$$x = 3 \times \frac{3900}{12}\ \text{milligrams} = 975\ \text{milligrams, } \textit{answer.}$$

If 12 tablets contain 3900 milligrams of aspirin, how many tablets should contain 975 milligrams?

$$\frac{12\ \text{(tablets)}}{x\ \text{(tablets)}} = \frac{3900\ \text{(milligrams)}}{975\ \text{(milligrams)}}$$

$$x = \frac{12 \times 975}{3900}\ \text{tablets} = 3\ \text{tablets, } \textit{answer.}$$

- Proportions need not contain whole numbers. If common or decimal fractions are supplied in the data, they may be included in the proportion without changing the method.
- For ease of calculation, it is recommended that common fractions be converted to decimal fractions prior to setting up the proportion.
- Example: If 30 millilitres (mL) represent 1⁄6 of the volume of a prescription, how many millilitres will represent 1⁄4 of the volume?

$$\tfrac{1}{6} = 0.167 \text{ and } \tfrac{1}{4} = 0.25$$

$$\frac{0.167 \text{ (volume)}}{0.25 \text{ (volume)}} = \frac{30 \text{ (mL)}}{x \text{ (mL)}}$$

$$x = 44.91 \text{ or} \approx 45 \text{ mL, } \textit{answer.}$$

Practice problems

1. If an insulin injection contains 100 units of insulin in each milliliter, how many milliliters should be injected to receive 40 units of insulin?

4. A formula for 1250 tablets contains 6.25 grams (g) of diazepam. How many grams of diazepam should be used in preparing 350 tablets?

6. Each tablet of TYLENOL WITH CODEINE contains 30 mg of codeine phosphate and 300 mg of acetaminophen. By taking two tablets daily for a week, how many milligrams of each drug would the patient take?

11. How many 0.1-mg tablets will contain the same amount of drug as 50 tablets, each of which contains 0.025 mg of the identical drug?

15. If a pediatric vitamin contains 1500 units of vitamin A per milliliter of solution, how many units of vitamin A would be administered to a child given 2 drops of the solution from a dropper calibrated to deliver 20 drops per milliliter of solution?

The International System of Units (SI)

Formerly called the metric system, is the internationally recognized decimal system of weights and measures.

Today, the pharmaceutical research and manufacturing industry, the official compendia, the United States Pharmacopeia—National Formulary, and the practice of pharmacy reflect conversion to the SI system. The reasons for the transition include

1. The simplicity of the decimal system,
2. The clarity provided by the base units and prefixes of the SI
3. The ease of scientific and professional communications through the use of a standardized and internationally accepted system of weights and measures

Measure of Volume

- The liter is the primary unit of volume
- The United States Pharmacopeia—National Formulary2 states: “One milliliter (mL) is used here in as the equivalent of 1 cubic centimeter (cc).”

1 kiloliter (kL)	=	1000.	liters
1 hectoliter (hL)	=	100	liters
1 dekaliter (daL)	=	10	liters
1 liter (L)	=	1.	liter
1 deciliter (dL)	=	0.1	liter
1 centiliter (cL)	=	0.01	liter
1 milliliter (mL)	=	0.001	liter
1 microliter (μL)	=	0.000,001	liter

Measure of Weight

- The primary unit of weight in the SI is the gram

1 kilogram (kg)	=	1000. grams
1 hectogram (hg)	=	100 grams
1 dekagram (dag)	=	10. grams
1 gram (g)	=	1. gram
1 decigram (dg)	=	0.1 gram
1 centigram (cg)	=	0.01 gram
1 milligram (mg)	=	0.001 gram
1 microgram (μg or mcg)	=	0.000,001 gram

1 nanogram (ng)	=	0.000,000,001 gram
1 picogram (pg)	=	0.000,000,000,001 gram
1 femtogram (fg)	=	0.000,000,000,000,001 gram

1000 micrograms (μg or mcg)	=	1 milligram (mg)
1000 milligrams (mg)	=	1 gram (g)
1000 grams (g)	=	1 kilogram (kg)

Fundamental Computations

- Reduce 85 micrometers to centimeters.

85 mcm = 0.085 mm = 0.0085 cm, answer.

- Reduce 2.525 liters to microliters.

2.525 L = 2525 mL = 2,525,000 L, answer

Reduce 62,500 mcg to g.

From the table: 1 g = 1,000,000 mcg

By ratio and proportion:

$$\frac{1{,}000{,}000 \text{ mcg}}{1 \text{ g}} = \frac{62{,}500 \text{ mcg}}{x \text{ g}}; \ x = 0.0625 \text{ g}, \textit{ answer.}$$

Examples: Reduce 1.23 kilograms to grams.

From the table: 1 kg =1000 g

By ratio and proportion:

$$\frac{1 \text{ kg}}{1000 \text{ g}} = \frac{1.23 \text{ kg}}{x \text{ g}}; \ x = 1230 \text{ g}, \textit{ answer.}$$

guidelines for the correct use of the SI

- Unit names and symbols generally are not capitalized except when used at the beginning of a sentence or in headings.

However, the symbol for liter (L) may be capitalized or not.

Examples: 4 L or 4 l, 4 mm, and 4 g; not 4 Mm and 4 G.

- In the United States, the decimal marker (or decimal point) is placed on the line with the denomination and denominate number; however, in some countries, a comma or a raised dot is used.

Examples: 4.5 mL (U.S.); 4,5 mL or 4·5 mL (non-U.S.).

- Periods are not used following SI symbols except at the end of a sentence.

Examples: 4 mL and 4 g, not 4 mL. and 4 g.

- A compound unit that is a ratio or quotient of two units is indicated by a solidus (/) or a negative exponent.

Examples: 5 mL/h or 5 mL·h1, not 5 mL per hour.

- Symbols should not be combined with spelled-out terms in the same expression.

Examples: 3 mg/mL, not 3 mg/milliliter.

- Plurals of unit names, when spelled out, have an added s. Symbols for units, however, are the same in singular and plural.

Examples: 5 milliliters or 5 mL, not 5 mLs.

- Two symbols exist for microgram: mcg (often used in pharmacy practice) and µg (SI).

- The symbol for square meter is m^2; for cubic centimeter, cm^3; and so forth. In pharmacy practice, cm^3 is considered equivalent to milliliter. The symbol cc, for cubic centimeter, is not an accepted SI symbol.

- Decimal fractions are used, not common fractions.

Examples: 5.25 g, not 51⁄4 g.

• A zero should be placed in front of a leading decimal point to prevent medication errors caused by uncertain decimal points. Example: 0.5 g, not .5 g.

• To prevent misreadings and medication errors, “trailing” zeros should not be placed following a whole number on prescriptions and medication orders.

Example:5 mg not 5.0mg.

However, in some tables (such as those of the SI in this chapter), pharmaceutical formulas, and quantitative results, trailing zeros often are used to indicate exactness to a specific number of decimal places.

• In selecting symbols of unit dimensions, the choice generally is based on selecting the unit that will result in a numeric value between 1 and 1000.

Examples: 500 g, rather than 0.5 kg; 1.96 kg, rather than 1960 g; and 750 mL, rather than 0.75 L.