CHAPTER

5

Pharmaceutical Measurements and Calculations

OBJECTIVES

After reading this chapter, you will be able to:

- Implement systems of measurement commonly used in pharmacy practice.
- Practice operations involving ratios and proportions.
- Calculate drug doses.
- Describe four systems of measurement commonly used in pharmacy, and convert units from one system to another.
- Explain the meanings of the prefixes most commonly used in metric measurement.
- Convert from one metric unit to another (e.g., grams to milligrams).
- Convert Roman to Arabic numerals
- Convert standard time to 24-hour military time.
- Convert temperatures to and from the Fahrenheit and Celsius scales.
- Round decimals up and down.
- Perform basic operations with proportions, including identifying equivalent ratios and finding an unknown quantity in a proportion using cross-multiplication.
- Convert percentages to and from fractions, ratios, and decimals.
- Perform fundamental dosage calculations and conversions.
- Solve problems involving powder solutions and dilutions.
- Use the alligation method to prepare solutions.
- Identify the basic units and prefixes of the metric system.
- Convert units within the metric system by moving the decimal place, using the ratio-proportion method, and using the dimensional-analysis method.
- Calculate drug doses using the ratio-proportion and dimensional-analysis methods.
- Calculate doses based on weight and body surface area (BSA).
- Calculate a pediatric dose using the patient's weight or age and the appropriate adult dose.

KEY TERMS

Accuracy
Admixture
Alligation
Body-surface area (BSA)
Compounding
Concentration
Dilution
Dose
Dosage
Precision
Proportion
Ratio
Ratio strength
Specific gravity

Chapter Overview

Mathematics is important in pharmacy practice. A mistake in a calculation or measurement could lead to serious consequences, such as underdosing or overdosing. This, in turn, may lead to inadequate treatment or drug toxicity.

Virtually all tasks within pharmacy practice relate to mathematics and calculations: dispensing the correct volume of a solution, compounding a medication or determining a dose. These tasks involve basic arithmetic as well as an understanding of fractions, rounding numbers, ratios and proportions, and percentages. This chapter covers important topics relating to pharmaceutical measurements and calculations.

Numbers and Numerals

Number refers to a total quantity or amount, while a *numeral* is a word or symbol that represents a number. The Arabic, or decimal, system and Roman numerals are the most commonly recognized and used systems of notation in pharmacy practice.

Roman Numerals

The Roman system of notation uses combinations of eight letters whose position indicates addition or subtraction from a succession of base numbers TABLE 5.1. Bases include ½, 1, 5, 10, 50, 100, 500, and 1,000. Roman numerals are used for expression only and are not used for calculations. The values of each letter are shown here.

By combining letters, quantities other than the base values can be expressed. The letters indicate a sum of their values when they are represented in equal or successively smaller values. For example:

II = 2
III = 3
VI = 6

Table 5.1 Roman Numeral Base

Letter	Value
SS or ss	½
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	1,000

VII = 7
VIII = 8
XI = 11
LI = 51
LV = 55
CX = 110

In Roman-numeral notation, letters are not repeated more than three times in a row. For example, XXX = 30, but XL = 40.

If a smaller value precedes a larger value, then the smaller value is subtracted from the larger value before the quantities are added together. For example:

IV = 4
IX = 9
XIV = 14
XIX = 19
XL = 40
XCIX = 99
CM = 900

Usually, capital letters are used to express years, while lowercase letters are used to express numerical values. Traditionally, capital Roman numerals have been used in pharmacy practice on prescriptions to designate the number of units prescribed or the quantity of medication to be administered. However, Roman numerals are increasingly being replaced by the decimal system in pharmacy practice.

Roman numerals are sometimes preferred on prescriptions because they cannot be easily altered.

Systems of Measurement Used in Pharmacy Practice

Several systems of measurement are employed in pharmacy: the common household system, the avoirdupois system, the apothecary system, and the metric system. Other notations of quantity and measurement include international units and milliequivalents. Pharmacy technicians should be familiar with all these systems, and be able to use them interchangeably. However, the metric system is the most common, and safest, system used in pharmacy practice.

Advise

Help patients understand how to convert between the metric system and the household measuring system. Many will be more familiar with teaspoonfuls than milliliters.

Household and Avoirdupois Systems of Measurement

The household and avoirdupois systems are the common measurements used in the United States for selling goods and food products, although they have been replaced in most other countries throughout the world by the metric system.

The household system of measurement is the one with which patients in the United States will be the most familiar. This system includes teaspoons, tablespoons, pints, quarts, and gallons for measuring liquid. The household system and the avoirdupois system are synonymous for measuring weight, and include ounces and pounds. In both systems, a pound is 16 ounces.

Communicate

Household measuring devices vary in actual capacity. Remind patients to use the calibrated administration devices that come with medications.

Calibrated spoons and droppers for medications administered by mouth often display household and metric units.

Instructions to patients are often provided in the household measuring system. In these cases, pharmacy representatives should caution patients, because household measuring instruments vary considerably in their actual capacity.

The Apothecary System of Measurement

The apothecary system is an outdated system of measurement previously used in medicine and science. Unlike the household and avoirdupois systems, the pound in the apothecary system is based on 12 ounces. The only equivalent unit of measure between the apothecary system and the avoirdupois system is the grain, used for measuring dry weight. Interestingly 1 grain is equal to 64.79891 milligrams, but this can be expressed as 64.8, 65, and in some cases 60. Remnants of this unit of measure can be seen in older drugs like aspirin 325mg (equal to 5gr), ferrous sulfate 325mg, Tylenol with codeine #2 (¼gr codeine), Tylenol with codeine #3 (½gr codeine), and Tylenol with codeine #4 (1gr codeine). In general, the use of the apothecary system is discouraged in pharmacy practice today because of safety concerns and inaccuracies. Two common exceptions are thyroid medications and phenobarbital dosing.

Metric System of Measurement

The metric system is by far the most commonly used system of measurement throughout the world, as well as throughout science and medicine. The metric system is the legal standard of measurement for pharmacy and medicine in the United States. The metric system is based on the decimal system, and all units are described as multiples of 10. The correlations among units of measure are more distinct than in other systems of measurement, simplifying calculations and aiding in the **accuracy** (that is, how well a measurement represents the true value) and **precision** (that is, how well a series of measurements can be reproduced or how close the measurements are to each other) of measurements.

One cubic centimeter (cm^3) of water is equivalent to one milliliter. One gram is equivalent to the weight of $1cm^3$ of water at 4°C.

The basic units of measurement in the metric system are the meter (m), for measuring length or distance; the liter (L), for measuring liquid volume; and the gram (g), for measuring dry weight. The gram is based on an actual cylinder of metal that is considered *the* kilogram. A cylinder locked away in Paris serves as the basis for all metric weight measurements. It was determined to be exactly 1kg in 1889. Copies were made to match it; then, it was locked up and has only been weighed two other times.

Prefixes Used in the Metric System

In the metric system, prefixes are added to the base units to specify a particular measurement. Common prefixes and conversions used in pharmacy practice are provided in **TABLE 5.2**.

The use of the abbreviation m for micro is discouraged because it can be easily misinterpreted. Instead, mc is the preferred abbreviation for micro.

Table 5.2 Common Prefixes and Conversions in the Metric System

Prefix	Symbol	Meaning	Conversion
Kilo	K	one thousand times	Base unit × 10^{3}
Hecto	H	one hundred times	Base unit × 10^{2}
Deci	D	one tenth	Base unit × 10^{-1}
Centi	C	one hundredth	Base unit × 10^{-2}
Milli	M	one thousandth	Base unit × 10^{-3}
Micro	mc or μ	one millionth	Base unit × 10^{-6}

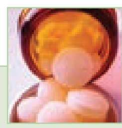
Table 5.3 Common Systems of Measurement and Equivalents Used in Pharmacy Practice

	System	Unit (Symbol)	Equivalent
Volume	Apothecary	Minim (♏)	0.06mL
		Fluidram (fʒ)	60♏ = 5mL
		Fluidounce (f℥)	6 fʒ = 30mL
		Pint (pt)	16f℥ = 480mL
		Quart (qt)	2pt = 32f℥ = 960mL
		Gallon (gal)	4qt = 8pt = 3,840mL
	Household	Teaspoon (tsp or t)	5mL
		Tablespoon (tbsp or T)	3tsp = 15mL
		Fluid ounce (fl oz)	2tbsp = 30mL
		Cup (c)	8fl oz
		Pint (pt)	2c = 480mL
		Quart (qt)	2pt = 4c = 960mL
		Gallon (gal)	4qt = 16c = 3,840mL
Weight	Avoirdupois	Grain (gr)	65mg
		Ounce (oz)	437.5gr = 30g
		Pound (lb)	16oz = 7,000gr = 454g
	Apothecary	Grain (gr)	65mg
		Scruple (℈)	20gr = 1.3g
		Dram (ʒ)	3℈ = 60gr = 3.9g
		Ounce (℥)	8ʒ = 480gr = 30g
		Pound (#)	12℥ = 5760gr = 373.2g
	Household	Ounce (oz)	30g
		Pound (lb)	16oz = 454g

Converting Between Systems of Measurement

The base units and equivalents of the primary systems of measurement used in pharmacy for measuring weight and volumes are provided in TABLE 5.3.

Some discrepancies exist when converting from one system to another. For example, 1f ʒ in the apothecary system actually contains 3.75mL, but the value is often rounded to 5mL, or one household



In the apothecary system, fluidram and fluidounce are written as one word, but in the household system, fluid ounce is separated into two words.

Abbreviations for the apothecary system are discouraged, because they can be easily misinterpreted—for example, ♏ could be read as mL, and ℥ or ℈ read as 3. If the apothecary system must be used, write out the entire word indicating the units.

Do not abbreviate cup. The common abbreviation, c, can be easily misinterpreted as a 0 or a c with a horizontal line over it, indicating "with."

Get the Pharmacist

When in doubt, ask the pharmacist to double-check abbreviations, conversions, and calculations.

Table 5.4 Common Equivalents Used in Pharmacy Practice

1mL = 16.23♏	1mg = 1,000mcg
1pt = 473mL	1g = 1,000mg
1g = 15.432gr	1kg = 1,000g
1gr = 64.8mg	1in = 2.54cm
1oz = 28.35g	1m = 39.37in
1kg = 2.2lb	1cm = 0.394in

teaspoonful. Similarly, if ℥ in the apothecary system and 1 fl oz in the household system contain 29.57mL, but this is often rounded to 30mL. This difference is negligible at small volumes, but accounts for more significant differences at larger quantities such as the gallon. For the purposes of practice exercises in this chapter, the rounded volumes will be used. However, the actual values of common equivalents are presented in TABLE 5.4, and should be committed to memory for future pharmacy practice.

International Units

The international unit (IU) expresses drug amounts. Examples of drugs measured in international units include insulin and vitamin D. They are most frequently used in hospital pharmacy practice. The IU per milligram varies with each drug, so standard conversion factors are not possible. If necessary, the conversion factor will be provided by the drug manufacturer.

The use of the abbreviations t and tsp for teaspoon and T and tbsp for tablespoon are discouraged in pharmacy because they can be easily misinterpreted. Instead, write out "teaspoonfuls" or "tablespoonfuls."

International units (IUs) are often used to denote the quantity of vitamins present in a multivitamin tablet.

Milliequivalents

The milliequivalent expresses electrolyte concentration. A milliequivalent is the number of positively charged ions per liter of salt solution and indicates the composition of intravenous fluids. Examples of electrolytes measured in milliequivalents per a volume of solution include potassium acetate 2mEq/mL or sodium chloride 38.5 mEq/L. One equivalent (Eq) equals 1,000mEq, and is determined by dividing the molecular weight of a substance by its valence, both of which are found in the periodic table of the elements.

Measuring Time

In hospital and institutional settings, time is expressed in 24-hour military style, also called international time. This reduces errors and ambiguity in medication administration. Military time is based on a 24-hour clock rather than the commonly used 12-hour clock. One day is divided into 24 one-hour segments, noted from 0000 through 2300. The first two digits indicate the hours passed since midnight, and the last two digits, the minutes.

Example:	0000 means midnight
Example:	0630 means 6:30 in the morning, or 6:30 a.m.
Example:	1200 means noon
Example:	1845 means 6:45 in the evening, or 6:45 p.m.

In military time, no "a.m." or "p.m." is used, reducing confusion and eliminating potential errors.

In institutional settings, time is indicated by 24-hour notation, based on a 24-hour clock, rather than 12-hour notation.

Measuring Temperature

As with systems of weight and liquid measurement, the most commonly used system for measuring temperature in the United States, the Fahrenheit scale, is not the preferred system within medicine or pharmacy. The Fahrenheit scale, used daily in many households to evaluate temperature, identifies 32°F as the temperature when water freezes and 212°F as the temperature when water boils.

An alternative is the Celsius scale, which uses 0°C as the temperature when water freezes and 100°C as the temperature when water boils. The Celsius scale is used commonly throughout the world, and in science and health care.

Because proper storage of drugs and medical devices often relies on accurate temperatures, pharmacy technicians must be able to correctly convert from one temperature scale to the other. In most pharmacy settings, it is the pharmacy technician's responsibility to maintain daily records of refrigerator and freezer temperatures. Additionally, technicians may be asked to help interpret temperatures for patients.

Every 5° change in the Celsius scale is equivalent to a 9° change in the Fahrenheit scale. Therefore, several equations exist to convert between the two scales:

To convert from Fahrenheit to Celsius:
$°F = (1.8 \times °C) + 32°$

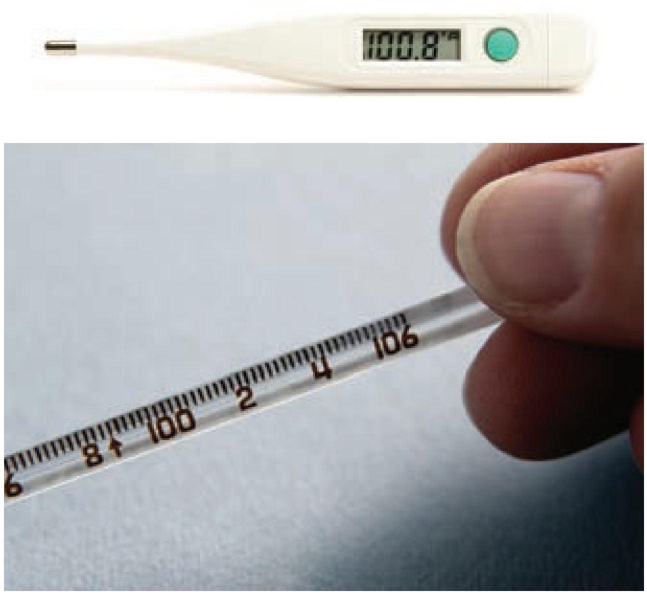
To convert from Celsius to Fahrenheit:
$°C = (°F - 32°) \div 1.8$ or $5 \times °F = 9 \times °C + 160$

> At one temperature, the values on the Celsius and Fahrenheit scales are equal. That is –40°F = –40°C.

Rounding Decimals

In pharmacy, calculations are commonly rounded to the nearest one-tenth, but carrying the calculation out to the nearest hundredth or thousandth to ensure accuracy may be appropriate for certain medications or certain patients.

To round decimals, choose the place that is appropriate for rounding (the rounding digit). Then, look at the number directly to the right. If this num-



Pharmacy technicians may be asked to interpret or convert temperatures taken by digital or alcohol- or mercury-filled glass thermometers.

ber is 5 or greater, round up by adding 1 to the rounding digit and omitting the remaining digits. If the number to the right of the rounding digit is less than 5, round the original number down by leaving the rounding digit as is and omitting the remaining digits. For example, when rounding to the nearest hundredth, 0.847 rounds up to 0.85. When rounding to the nearest thousandth, 0.5134 rounds down to 0.513.

The same procedure can be followed for rounding whole numbers. Simply locate the appropriate rounding digit and look at the digit to the right. If this number is 5 or greater, add 1 to the rounding digit and change the digits to the right to 0. If the number to the right of the rounding digit is less than 5, do not change the rounding digit, but change the remaining digits to the right to 0. For example, when rounding to the nearest 10, 756 rounds up to 760. When rounding to the nearest hundred, 135 rounds down to 100.

Converting Decimals to Fractions

Fractions indicate a part of a whole. A fraction is represented by two numbers: the numerator (the number on top) and the denominator (the number on bottom). Simply, a fraction signifies that the numerator is to be divided by the denominator. Therefore, fractions can be noted as a numerator and a denominator, or as a decimal value. For example, $\frac{3}{4} = 3 \div 4 = 0.75$. The value of a fraction, or the result of the division, is called the quotient.

Any decimal can be converted to a fraction using a denominator that is a multiple of 10. To convert a decimal to a fraction, first use the decimal value as the numerator and place it over a denominator of 1. Next, multiply both the numerator and the denominator by 10 for each digit to the right of the decimal point. The numerator will become a whole number. For example, if there are two numbers to the right of the decimal point, multiply the numerator and the denominator by 10 two times, or 100. Once the decimal is expressed as a fraction, the fraction can be reduced, or simplified, by multiplying by a factor of one.

Example: $0.3 = \frac{0.3}{1}$
$\frac{0.3}{1} \times \frac{10}{10} = \frac{3}{10}$

Example: $0.45 = \frac{0.45}{1}$
$\frac{0.45}{1} \times \frac{10}{10} \times \frac{10}{10}$ (because two numbers are to the right of the decimal = $\frac{45}{100}$ which can be further reduced to $\frac{9}{20}$)

Ratios

A **ratio** is a representation of how two similar quantities are related to each other. A ratio may express either the relationship between two parts of one whole or between one part and the whole. Simply, a ratio is a comparison. Traditionally, ratios are expressed in odds notation, using a colon to separate the numbers, such as 1:2. Alternatively, a ratio can also be expressed as a fraction, such as $\frac{1}{2}$.

In pharmacy practice, ratios are often used to express the concentration of a drug in solution or the weight or dose of a drug in a delivery unit or volume. For example, a tablet that contains 25mg of active ingredient can be expressed as 25mg:1 tablet or 1 tablet:25mg. Similarly, this value can be expressed as a fraction: $\frac{25\text{mg}}{1\text{ tablet}}$ or $\frac{1\text{ tablet}}{25\text{mg}}$. Similarly, a solution that contains 1g of drug per 100mL can be expressed as a ratio (1g:100mL) or a fraction ($\frac{1\text{g}}{100\text{mL}}$).

When two ratios have the same value, they are equivalent. You can find equivalent ratios by multiplying or dividing both sides of the ratio by the same number. This is the same process as finding equivalent fractions.

Example: 1:2
Multiply both sides by 2 to get 2:4 (1 × 2):(2 × 2) = 2:4
Multiply both sides by 4 to get 4:8 (1 × 4):(2 × 4) = 4:8
Multiply both sides by 100 to get 100:200 (1 × 100):(2 × 100) = 100:200

Example: 50:100
Divide both sides by 25 to get 2:4 (50 ÷ 25):(100 ÷ 25) = 2:4
Divide both sides by 50 to get 1:2 (50 ÷ 50):(100 ÷ 50) = 1:2

When two ratios are equivalent and expressed as fractions, the product of the first numerator multiplied by the opposite denominator is equivalent to the product of the first denominator multiplied by the opposite numerator. That is, 3:5 = 6:10. Therefore, $\frac{3}{5} = \frac{6}{10}$. Note: 3 × 10 = 5 × 6.

Proportions

A **proportion** is an equation that states two ratios are equal. When the terms of a proportion are multiplied, the cross products are equal.

Example: $\frac{2}{8} = \frac{5}{20}$
2 × 20 = 8 × 5
Answer: 40 = 40

A practical application of ratios comes in the form of a proportion. A proportion is the expression of equality between two equivalent ratios. A proportion is designated by a double colon (::) between two ratios or as a fraction—for example, 3:5::6:10 or $\frac{3}{5} = \frac{6}{10}$. In a proportion, the inside numbers are termed the "means" and the outside numbers are termed the "extremes." As with equivalent ratios expressed as fractions, the product of the means always equals the product of the extremes in a proportion.

The ratio-proportion method is based on comparing a known ratio with an unknown ratio.

Calculating the Value of a Missing Term in a Proportion

Because this relationship is always true in a proportion, it can be used to calculate the value of a missing term in a proportion. For example, if a:b::c:d, then $\frac{a}{b} = \frac{c}{d}$ and a × d = b × c. Therefore, if any one of the variables is unknown, you can use the three known variables and solve for the unknown using basic algebra.

A stock solution is a solution of known concentration. It may be supplied from a manufacturer or made in advance of dispensing by a pharmacist.

Ratio-Proportion Method for Pharmacy Calculations

The ratio-proportion method is commonly used to calculate drug doses in pharmacy practice. For example, the concentration of a stock solution and the dose needed for administration are often known. The volume of the dose is the unknown. A ratio or proportion can be established to solve for the missing value.

Cross-Multiplication

Cross-multiplication is the multiplication of the numerator of the first fraction by the denominator of the second fraction, and the multiplication of the denominator of the first fraction by the numerator of the second fraction (see FIGURE 5.1). Cross-multiplication is used frequently within pharmacy practice to determine correct doses

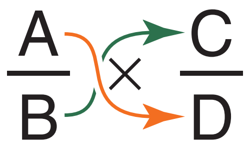


FIGURE 5.1 Cross-multiplication.

and amounts of drugs needed to mix medications or to make specific doses for a prescription.

To cross multiply is to go from $a/b \times c/d$ to ad = bc. This is used when the value of a is proportional to the value of c and the value of b is proportional to the value of d.

If one term of the proportion is unknown—meaning that three of the four values are known, cross-multiplication can be used to find the value of the unknown term.

Example: $x \div 8 = 5/20$

$20x = 8 \times 5$

$20x = 40$

$20x/20 = 40/20$

Answer: $x = 2$

Percents

Like fractions and ratios, percentages are parts of a whole. More specifically, percentages and their symbol (%) refer to parts per a total of 100 parts. Therefore, a percentage can be expressed as a percent, a fraction, a decimal, or a ratio. For example, 1% = $1/100$ = 0.01 = 1:100.

Converting Between Ratios and Percents

To convert a ratio to a percent, first convert the ratio to a fraction, selecting the first number as the numerator and the second number as the denominator. Next, multiply the fraction by 100. Express the final value followed by a percent sign.

Reverse the process to convert a percent to a ratio. First, express the percent as a fraction, with a denominator of 100. Then reduce the fraction to its most simplified form, if possible. Finally, express the final value as a ratio, designating the numerator as the first number and the denominator as the second number.

Converting Between Percents and Decimals

To convert a percent to a decimal, remove the percent symbol and divide the number by 100. This is equivalent to moving the decimal point two places to the left.

Conversely, to convert a decimal to a percent, multiply by 100, moving the decimal point two spaces to the right, and add a percent sign.

Calculating Drug Doses, Dosages, and Quantities

One of the critical functions of pharmacy practice is ensuring that patients get the correct drug for the most appropriate length of time. There are many methods for accurately calculating drug quantity, as well as expressing and communicating the treatment regimen. Regardless of the drug or how the quantity is determined, accuracy and appropriateness must be verified by the pharmacist.

Dose and Dosage

A **dose** of a drug is the quantity that is intended to be administered, usually taken at one time or during one specified period such as per day. **Dosage** refers to the determination and regulation of the size, frequency, and number of doses. The dosage is the entire regimen or schedule of doses. Although often used interchangeably, the terms “dose” and “dosage” do have slightly different connotations. The dose refers to a quantity of drug. The dosage implies treatment duration and a cumulative effect.

Doses can be expressed as a single dose, a daily dose, or a total dose. A daily dose, in turn, may be expressed as divided doses.

Example: A dose of 50 mg is prescribed once daily for 10 days.
Solution: In this case, the single dose, as well as the daily dose, is 50mg.
Total dose: 50mg/day × 10 days = 500mg

Example: A dose of 500mg, three times daily, is prescribed for seven days.
Solution: The single dose = 500mg.
Daily dose: 500mg × 3 = 1,500mg
Total dose: 1,500mg/day × 7 days = 10,500mg

Doses and dosage regimens are highly variable among substances. Each is determined by a drug's biochemical and physical properties, the route of administration, and individual patient factors. A dose may be based on age, body weight, body-surface area (BSA), overall health, liver or kidney function, or the specific illness or condition being treated. Additionally, prescription recommendations may be based on clinical trials, studies, or manufacturers' guidelines.

Determining the Number of Doses in a Quantity of Drug

To determine the number of doses in a given quantity of drug, simply divide the total amount of drug available by the size of the dose. Note that the total amount of drug and the dose must be expressed in the same units.

Example: The total amount of drug available is 1,000mg and each dose is 100mg. Determine the number of doses available in 1,000mg.
Solution: 1,000mg ÷ 100mg/dose = 10 doses (Note that the total amount of drug and the amount of dose are both expressed in milligrams.)

Determining the Size of a Dose

To determine the size of a dose, given the total number of doses in a quantity of drug, divide the total amount of drug available by the number of doses. As always, check the units to ensure accuracy in calculations.

Example: A 10g vial of vancomycin is used to make eight doses. Determine the number of milligrams in each dose.
Solution: First convert the grams to milligrams: 10g × 1,000mg/g = 10,000mg. Then divide the total amount of the drug by the number of doses: 10,000mg ÷ 8 doses = 1,250mg/dose.

Determining the Total Amount of a Drug to Be Administered

To determine the total amount of drug to be administered given the total number of doses and the quantity of drug in each dose, multiply the number of doses by the quantity of each dose.

It is most efficient to convert the units to the denomination in which the final answer should be expressed.

Example: A nurse practitioner writes an order for 2 grams of Rocephin IV to be given once daily for six weeks for home IV therapy. Determine the total amount of drug to be administered over that period of time.

Solution: Use the following calculation: 2 g/day × 7 days/week × 6 weeks = 84 g.

The pharmacy technician often places the drug order. This type of calculation is used when determining how much drug to order. In this case, the pharmacy would need to have 84 grams of Rocephin in the inventory each time the order is filled (14 g/week × 6 weeks).

Determining Doses Based on Weight

The usual adult dose for most drugs is based on an average body weight of 70kg (154lb). However, some drugs act differently in the body depending on body size and composition and the concentration of drug desired at the site of action. Therefore, some doses need to be increased or decreased for particularly lean or overweight individuals. Also, body weight is often used to determine pediatric doses because age may not be a reliable indicator of body composition or function in children.

When drugs are intended to be dosed based on body weight, the dose will usually be expressed as a quantity of drug (usually in milligrams) per kilogram body weight. Therefore, to determine the dose, multiply the patient's body weight by the dose required.

Example: An antibiotic is dosed 15mg/kg/day. Determine how many milligrams the patient will receive in his daily dose if he weighs 85kg.

Solution: Use the following equation to solve for the dosage in milligrams: 15mg/kg × 85kg = 1,275mg.

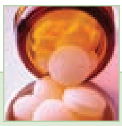
As with all calculations, note the units. If a patient's weight is given in pounds, but the dose is prescribed in mg/kg, the weight must first be converted to kilograms before proceeding with the calculation.

Determining Doses Based on Body-Surface Area

Body-surface area (BSA) is a representation of a patient's weight and height relative to each other. Some patient populations or certain drugs require dosing based on BSA, such as cancer patients receiving chemotherapy and pediatric patients who require special assessment for drug response or adverse reactions.

BSA is calculated using the following equation:

$$\text{BSA (m}^2\text{)} = [\text{Height (cm)} \times \text{Weight (kg)}/3600]^{1/2}$$



***Usual adult doses are based on a weight of 70kg and a BSA of 1.73m²*.**

If inches and pounds are used to measure height and weight, respectively, the following equation can be used:

$$\text{BSA (m}^2\text{)} = [\text{Height (in)} \times \text{Weight (lb)}/3131]^{1/2}$$

The average adult has a BSA of 1.73m². Using this value, a pediatric dose can be calculated by using the ratio-proportion method, defining the pediatric dose as a relative portion of the adult dose.

Alternatively, to determine a pediatric dose based on an adult dose and BSA, convert the child's BSA to a percent or fraction of usual adult BSA and multiply the result by the adult dose.

Considerations for Pediatric Patients

Patient age is often considered in calculating doses, particularly for very young or very old patients. For example, both newborns and the elderly are especially sensitive to the actions of certain drugs because of immature or abnormal liver or kidney function, which are required for healthy drug metabolism.

Several rules have been established to estimate the pediatric dose based on age or weight of the patient relative to the usual adult dose of a drug. However, these calculations are generally no longer used because age and weight are not always considered single reliable criteria for determining pediatric doses. Also, these calculations relate a pediatric dose to an adult dose, assuming that a child is simply a small adult. This is not always the case, however, because of different body composition and organ function between children and adults. Therefore, doses based directly on a child's BSA or body weight are the safest and most common choices to establish pediatric doses. Also, manufacturers often provide pediatric dosing tables with the drug information to aid in determining doses.

Doses based on body weight are often most accurate for pediatric patients.

Young's Rule

Young's rule for determining pediatric doses is based on age:

$$\text{Pediatric dose} = [\text{age of child (years)} \div (\text{age of child [years]} + 12)] \times \text{adult dose}$$

Clark's Rule

Clark's rule for determining pediatric doses is based on weight:

$$\text{Pediatric dose} = (\text{weight of child [pounds]} \times \text{adult dose}) \div 150\text{lb}$$, where 150lb is the average weight of an adult

Preparing Solutions and Compounded Products

Solutions are liquids containing one or more drugs dispersed in a solvent. Pharmaceutical solutions are used for oral administration, topical application, nasal, otic or ophthalmic instillation, parenteral administration, or irrigation of body cavities or wounds. Solutions are a flexible dosage form because they can be used in any route of administration and the doses can be easily adjusted.

> ***When converting between pounds and kilograms, 1kg = 2.2lb. This conversion can be used to solve dosing problems based on patient weight.***

However, not every drug is suitable for preparation in a solution. Some drugs are not stable as liquids, and some drugs are not soluble in liquid. Also, solutions are more difficult to store and transport than dry, solid dosage forms.

Compounding is the preparation of a drug product pursuant to a prescription or medication order. Solutions may need to be compounded to achieve a specific concentration of drug that is not commercially available or to accommodate an individual's medical or dietary restrictions. Solid and semi-solid dosage forms may also need to be compounded for the same reason. In any case, compounding and preparing drug products require accurate calculations to ensure proper doses and safety and consistency in the dosage form.

> ***%w/v = grams of substance/100mL of liquid vehicle***
> ***%v/v = milliliters of a liquid/100mL of liquid vehicle***
> ***%w/w = grams of a substance/100g of solid vehicle***

Concentration

Concentration indicates the amount of active ingredient per total volume or weight of a substance.

- For solutions or suspensions of solids in liquids, the concentration is expressed as weight-in-volume; the percent weight-in-volume (%w/v) is presented as the number of grams of a substance per 100mL of liquid vehicle.

  Example: A 5%(w/v) solution of dextrose in water contains 5g of dextrose in every 100mL of total vehicle, or 5g dextrose/100mL total vehicle. Note: The volume of water needed to make 100mL of total solution will be less than 100mL.

- For solutions of liquids in liquids, the concentration is expressed as volume-in-volume; the percent volume-in-volume (%v/v) is presented as the number of milliliters of a liquid per 100mL of liquid vehicle.

  Example: A 70% (v/v) isopropyl alcohol solution contains 70mL of isopropyl alcohol in every 100mL of total solution, or 70mL isopropyl alcohol/100mL total solution. Note: Less than 30mL of water must be added to 70mL of isopropyl alcohol to obtain 100mL of the 70% solution.

- For mixtures of solids, the concentration is expressed as weight-in-weight; the percent weight-in-weight (%w/w) is presented as the number of grams of a substance in 100grams of a solid vehicle.

  Example: A 10% (w/w) hydrocortisone cream contains 10g of hydrocortisone in every 100g of cream, or 10g hydrocortisone/100g cream.

Ratio Strength

The **ratio strength** is used to express the concentration of weak solutions. Ratio strengths and percent concentrations may be converted to ratios or proportions for ease of calculations.

The percent concentration of sodium chloride solution indicates that there are 0.9 grams of sodium chloride in every 100mL of liquid.

Example: Epinephrine is available in very dilute concentrations, such as 1:200,000. For every 200,000 total parts of epinephrine solution, only one part is epinephrine. What is the percent concentration of a 1:200,000 concentration epinephrine ampule?

Solution: As a percent concentration, this is equivalent to 0.0005%, because $1/200{,}000 = 0.000005 \times 100 = 0.0005\%$.

Reconstitutable Powder Preparations

Sometimes, a drug must be reconstituted before it is dispensed or administered to a patient. In such cases, the drug product is a dry powder to which a specified volume of diluent must be added. A diluent is an inactive liquid used to increase the volume and decrease the concentration of another substance. The powder volume is the amount of volume occupied by the dry substance.

The powder volume equals the final volume of the product minus the diluent volume after the powder has been mixed with the vehicle.

Example: A vial of powder contains 1.5g of a drug. The manufacturer instructs adding 3.3mL of sterile water to obtain 4mL of solution with a final concentration of 375mg/mL. What volume does the powder occupy in the final solution?

Solution: If 4mL of sterile water were added to the vial, the concentration would be less than the required 375mg/mL, because the powder displaces some volume of vehicle. The powder occupies 0.7mL in the final solution.

Dilutions

Dilution is the process of decreasing the concentration of a liquid. A dilution may be necessary to obtain the correct quantity for administration, to individualize a dose, or to accurately measure a final quantity. Pharmaceutical products are often diluted by adding a diluent to the original preparation. Additionally, an **admixture**—that is, a mixture of small volumes of drugs in a large volume of fluid of lower strength—can be added to a higher-strength product to achieve a dilution. Admixtures are often prepared to administer doses of concentrated medications that could cause toxicity or tissue damage when administered alone.

Example: Promethazine cannot be administered in single doses of greater than 100mg. How does the pharmacy technician dilute the promethazine dose?

Solution: Concentrated promethazine doses must be diluted in normal saline to a concentration of 25mg/mL.

Stock solutions are available in a pharmacy for ease of dispensing. These solutions contain a known concentration of drug and allow pharmacy staff to dispense small quantities of active drug in larger volumes of solution.

If a solution or product requires dilution, the amount of active drug in the final product will remain constant, but the volume will increase. The relationship between the concentration and the volume is inversely proportional. That is, as the percent of concentration or ratio strength decreases, the total quantity of product increases.

This fact is expressed in the following equation:

$$\text{Quantity of the first solution} \times \text{Concentration of the first solution} = \text{Quantity of the second solution} \times \text{Concentration of the second solution}$$

This equation can also be expressed as follows:

$$Q1 \times C1 = Q2 \times C2$$

That is, the quantity of the first product multiplied by its concentration is equivalent to the quantity of the final product multiplied by its concentration. In this equation, the first product is the stock solution or product that requires dilution, and the second product is the final product produced after dilution. Therefore, calculating the quantities or concentrations needed for a final product becomes simple algebra.

Further, if the concentration and quantity of a final product are known, the amount or concentration of the stock solution can be determined.

Alligation Method for Compounded Products

Alligation is a mathematical problem-solving method that involves mixing solutions or solids that have different strengths of the same active ingredient in order to obtain another strength of the ingredient. In pharmacy practice, alligation may be necessary if a physician prescribes a concentration of drug that is not available commercially. In this case, two different-strength solutions containing the same active ingredient can be combined to achieve the desired strength.

Simply, alligation is the weighted average of a mixture of two or more substances. The percentage strength of each component is expressed as a decimal fraction and multiplied by its quantity. The sum of all the products is divided by the total quantity and converted to a percent to present the final strength of the compounded product. The alligation method may be used for weight or volume.

The alligation method can be used to calculate the amounts of a high-strength product and a low-strength product that must be added together to make an intermediate-strength product.

Alternatively, a matrix arrangement may be used to visualize the known quantities and solve for the unknown value. Subtract on the diagonals and read the answers across the horizontals.

(highest concentration)		(highest concentration parts)
	(desired concentration)	
(lowest concentration)		(lowest concentration parts)

1. Draw a box or matrix. In the upper-left corner, place the highest concentration as a whole number. In the lower-left corner, place the lowest concentration. In the center of the box, place the desired concentration.
2. Write the difference between the upper-left number and the center number in the lower-right corner, subtracting the smaller number from the larger number. Next, write the difference between the lower-left number and the center number in the upper-right corner. The numbers on the right represent the parts of each solution that are required to make the new solution.
3. Read across the box to determine the strength and amount of each original solution. Add the numbers in the right column to determine the total parts needed for the new solution.

Finally, the results of the alligation calculation can be established as ratios. Then, you can proceed with calculations of weight or volume as previously described. In the previous example, the ratio of 70% solution to 20% solution is 10:40, or 1:4; the ratio of 70% solution to the final 30% solution is 10:50, or 1:5; and the ratio of 20% solution to the final 30% solution is 4:5. Therefore, for a total of five parts of 30% solution, one part will be 70% solution and four parts will be 20% solution.

If 20mL is desired, then determining the volume of each solution proceeds with simple ratio calculations:

Example: 5 parts 30% solution/1 part 70% solution = 20mL/*x*mL
Solution: Solving for *x*, *x* = 4mL of 70% solution.

Example: 5 parts 30% solution/4 parts 20% solution = 20mL/*y*mL
Solution: Solving for *y*, *y* = 16mL of 20% solution.

Knowledge of basic mathematics and calculations is essential to safe and effective pharmacy practice. Always check units to ensure consistency, and double-check calculations. These simple reminders will help minimize medication errors and maintain patient safety.

Specific Gravity

Specific gravity has no units.

Specific gravity is the ratio of the weight of a substance to the weight of an equal volume of water at the same temperature. Or, specific gravity is a ratio of the density of a substance to the density of water. Specific gravity itself is a value that has no units, but when you calculate specific gravity, you use units of milliliters for volume and grams for weight. Specific gravity can be calculated using the following equation:

Specific gravity = weight of substance ÷ weight of an equal volume of water

Because the reference standard of 1mL of water weighs 1g, the specific gravity of water is 1. And because 1mL of water weighs 1g, the equation can be converted to the following:

Specific gravity = number of grams of a substance ÷ number of milliliters of a substance

Alternatively, if the specific gravity is known, the volume or weight of a desired quantity can be determined.

If different quantities of two or more liquids with known specific gravities must be combined, the alligation method can be used to determine the relative quantities of each component.

Similarly, a matrix can be used to solve for unknown quantities when compounding a product with a desired specific gravity.

The relative amounts can be established as ratios or proportions, as previously described, and calculations may proceed to determine the weights or volumes of each component required.

A specific gravity greater than 1 indicates a solution or substance that is thick and viscous. Substances with a specific gravity of greater than 1 are heavier than water. A specific gravity less than 1 indicates a solution or substance that contains volatile chemicals or is prone to evaporation. Substances with a specific gravity of less than 1 are lighter than water.

Tech Math Practice

***Question:* How do you convert 0.513 to a fraction?**

Answer: To convert 0.513 to a fraction, first use the decimal value as the numerator and place it over a denominator of 1: $^{0.513}/_{1}$. Then note how many numbers are to the right of the decimal point—here, three. Next, multiply the value in the numerator by 10 three times: 0.513 × 10 × 10 × 10 = 513. Then multiply the value in the denominator by 10 three times: 1 × 10 × 10 × 10 = 1,000. The fraction, then, is $^{513}/_{1,000}$.

***Question:* How do you convert 0.82 to a fraction?**

Answer: To convert 0.82 to a fraction, first use the decimal value as the numerator and place it over a denominator of 1: $^{0.82}/_{1}$. Then note how many numbers are to the right of the decimal point—here, two. Next, multiply the value in the numerator by 10 two times: 0.82 × 10 × 10 = 82. Then multiply the value in the denominator by 10 two times: 1 × 10 × 10 = 100. The fraction, then, is $^{82}/_{100}$. Divide that fraction by a factor of one to simplify it: $^{82}/_{100} \div {}^{2}/_{2} = {}^{41}/_{50}$.

***Question:* If a stock solution contains 25mg of drug per 5mL, and the patient needs a dose of 37.5mg, how many milliliters are in each dose?**

Answer: First, determine the equation using the ratio proportion method: $^{x\text{mL}}/_{37.5\text{mg}} = {}^{5\text{mL}}/_{25\text{mg}}$. Next, solve for *x*: *x* = (37.5mg × 5mL) ÷ 25mg = 7.5mL. Therefore, the dose needed is 7.5mL. To confirm the answer, establish a proportion and verify that the product of the means equals the product of the extremes:

5mL:25mg::7.5mL:37.5mg = 5:25::7.5:37.5

(5×37.5) = (25×7.5)

187.5 = 187.5

***Question:* What is the value of x in the following proportion: $^{4}/_{5} = {}^{x}/_{20}$?**

Answer: First, multiply the first numerator by the second denominator: 4 × 20 = 80. Next, multiply the first denominator by the second numerator: 5 × *x* = 5*x*. The result is the following equation: 80 = 5*x*. To solve for *x*, divide both sides of the proportion by 5: 80 ÷ 5 = 16 and 5*x* ÷ 5 = *x*. So *x* = 16.

***Question:* What is the value of x in the following proportion: $^{3}/_{7} = {}^{x}/_{21}$?**

Answer: First, multiply the first numerator by the second denominator: 3 × 21 = 63. Next, multiply the first denominator by the second numerator: 7 × *x* = 7*x*. The result is the following equation: 63 = 7*x*. To solve for *x*, divide both sides of the proportion by 7: 63 ÷ 7 = 9 and 7*x* ÷ 7 = *x*. So *x* = 9.

***Question:* What is the result of converting 1:4 to a percent?**

Answer: To convert 1:4 to a percent, first convert the ratio to a fraction: 1:4 = $^{1}/_{4}$. Next, multiply the fraction by 100: $^{1}/_{4}$ × 100 = 25%.

Question: **What is the result of converting 2:1 to a percent?**

Answer: To convert 2:1 to a percent, first convert the ratio to a fraction: 2:1 = $^{2}/_{1}$. Next, multiply the fraction by 100: $^{2}/_{1} \times 100$ = 200%.

Question: **What is the result of converting 80% to a ratio?**

Answer: To convert 80% to a ratio, express the percent as a fraction: $^{80}/_{100}$, which simplifies to $^{4}/_{5}$. The ratio, then, is 4:5.

Question: **What is the result of converting 5% to a ratio?**

Answer: To covert 5% to a ratio, first express the percent as a fraction: $^{5}/_{100}$, which simplifies to $^{1}/_{20}$. The ratio, then, is 1:20.

Question: **What is the result of converting 3% to a decimal?**

Answer: To convert 3% to a decimal, use the following equation: 3 ÷ 100 = 0.03.

Question: **What is the result of converting 25% to a decimal?**

Answer: To convert 25% to a decimal, use the following equation: 25 ÷ 100 = 0.25.

Question: **What is the result of converting 150% to a decimal?**

Answer: To convert 150% to a decimal, use the following equation: 150 ÷ 100 = 1.5.

Question: **What is the result of converting 0.18 to a percent?**

Answer: To convert 0.18 to a percent, use the following equation: 0.18 × 100 = 18%

Question: **What is the result of converting 5.2 to a percent?**

Answer: To convert 5.2 to a percent, use the following equation: 5.2 × 100 = 520%

Question: **What is the result of converting 0.004 to a percent?**

Answer: To convert 0.004 to a percent, use the following equation: 0.004 × 100 = 0.4%

Question: **If each dose is 5mL, and the total amount of drug to be administered is 200mL, what is the total number of doses available?**

Answer: The total number of doses available is 200mL ÷ 5mL = 40 doses.

Question: **If the dose is 100mg, and the total amount to be administered is 4g, what is the total number of doses available?**

Answer: To calculate this, the quantities must first be converted to the same unit: 4g = 4 × 1,000mg = 4,000mg. Then, the total number of doses to be administered is 4,000mg ÷ 100mg = 40 doses.

Question: **How many milliliters will be in each dose if 1 fluid ounce of medicine contains 60 doses?**

Answer: First, convert 1 fluid ounce to the same units as the dose: 1 fluid ounce = 30mL. Then, divide the number of milliliters by the number of doses: 30mL ÷ 60 doses = 0.5mL/dose.

Question: **What is the total amount of drug to be administered if each dose is 25mg and the total number of doses is 40?**

Answer: Multiply the number of doses by the quantity of each dose: 25mg/dose × 40 doses = 1,000mg.

Question: **What is the total amount of drug to be administered at a dose of 1,200mg, three times daily, for seven days?**

Answer: Multiply the number of doses by the quantity of each dose: 1,200mg/dose × 3 doses/day × 7 days = 25,200mg.

Question: **What is the total dose for a man weighing 70kg and requiring a dose of 0.5mg/kg?**

Answer: The total dose is 70kg × 0.5mg/kg = 35mg.

Question: **What is the total dose for a woman weighing 110lb and requiring a dose of 2mg/kg?**

Answer: First, convert her weight to kg: 110lb × 1kg/2.2lb = 50kg. Then proceed with the dose calculation: 50kg×2mg/kg = 100mg.

Question: **If an average adult with a BSA of 1.73m^2 requires a dose of 20mg, what would be the dose for a pediatric patient with a BSA of 0.63m^2?**

Answer: First, establish a proportion: $\text{Child's dose}/\text{child's BSA} = \text{Adult dose}/\text{adult BSA}$, or $x\text{mg}/0.63\text{m}^2 = 20\text{mg}/1.73\text{m}^2$. Cross-multiplying and solving for the unknown variable yields $x$mg = $(20\text{mg} \times 0.63\text{m}^2)/1.73\text{m}^2$ = 7.28mg.

Question: **Referring to the previous question, if the average adult dose is 20mg and a child has a BSA of 0.63m^2, what is the child's dose?**

Answer: First, convert the child's BSA to a fraction of adult BSA: $0.63\text{m}^2/1.73\text{m}^2$ = 0.364. The child's dose equals the fraction of the adult BSA multiplied by the adult dose: 0.364 × 20mg = 7.28mg.

Question: **The adult dose of a medication is 325mg. What is the dose for an 8-year-old child who weighs 55 pounds, based on Young's rule?**

Answer: Dose = (8y ÷ (8y + 12y)) × 325mg = 130mg.

***Question:* The adult dose of a medication is 325mg. What is the dose for an 8-year-old child who weighs 55 pounds, based on Clark's rule?**

Answer: Dose = (55lb × 325mg) ÷ 150lb = 119.2mg.

***Question:* How do you calculate the ratio strength of a 0.05% solution?**

Answer: The ratio strength of a 0.05% solution can be calculated as follows: $\frac{0.05\%}{100\%} = \frac{1 \text{ part}}{x \text{ parts}}$. Solving for *x*, *x* = 2,000. Therefore, the ratio strength is 1:2000.

***Question:* How do you express the ratio strength of 1:4,000 as a percent concentration?**

Answer: To express the ratio strength of 1:4,000 as a percent concentration, convert the values to fractions: $\frac{1 \text{ part}}{4{,}000 \text{ parts}} = \frac{x\%}{100\%}$. Solving for *x*, *x* = 0.025%.

***Question:* Suppose the manufacturer directs adding 15mL of distilled water to the powder to reconstitute 1g of an antibiotic. If the final concentration is 250mg/5mL, what is the powder volume of the dry antibiotic?**

Answer: First, determine the amount of active drug ingredient in 1g of powder: 1g = 1,000mg.

The total number of milliliters that will contain the active drug is represented by fractions: $\frac{250\text{mg}}{5\text{mL}} = \frac{1{,}000\text{mg}}{x\text{mL}}$. Solving for *x*, *x* = 20mL. Subtracting the diluent volume from the final volume yields the powder volume: 20mL − 15mL = 5mL.

***Question:* If 250mL of a 10% solution is diluted with 750mL of diluent, what is the concentration of the final product?**

Answer: Using Q1 × C1 = Q2 × C2, calculate the concentration of the final product, where Q1 and C1 are the respective volume and concentration of the first solution, and Q2 and C2 are the respective volume and concentration of the final product: 250mL × 10% = (250+750)mL × C2. Solving for C2, $C2 = \frac{250\text{mL} \times 10\%}{(250 + 750)\text{mL}} = \frac{2{,}500}{1{,}000} = 2.5\%$.

***Question:* If 25mL of a 1:20 solution is needed, and the stock solution is a 1:5 solution, what is the quantity needed to make the final product?**

Answer: Using Q1 × C1 = Q2 × C2, calculate the quantity of the final product, where C1 is the initial concentration, Q2 is the second or final quotient, and C2 is the second or final concentration: Q1 × $\frac{1}{5}$ = 25mL × $\frac{1}{20}$. Solving for Q1, Q1 = 6.25mL. In this example, 6.25mL of the stock solution will contain the required amount of active drug. This volume will be increased with an inactive diluent to the total volume of 25mL required for the final product.

***Question:* What is the final strength of a product that was compounded by combining 200g of 5% ointment and 100g of 1% ointment?**

Answer: To calculate the final strength of the product, express the strengths as decimal fractions and multiply by the known quantities: 0.05 × 200g = 10g active ingredient, and 0.01 × 100g = 1g active ingredient. Adding the total grams and dividing by the total quantity yields the following: (10g + 1g active ingredient) ÷ (200g + 100g ointment) = 0.0367. Finally, converting the decimal fraction to a percent yields the final concentration of the compounded product: 0.0367 × 100 = 3.67%.

Question: **How do you mix a 30% solution from a 70% solution and a 20% solution?**

Answer: First, place the known quantities in a matrix:

70 (highest concentration)		
	30 (desired concentration)	
20 (lowest concentration)		

Next, subtract 30 from 70 and write the difference in the lower-right corner. Then subtract 20 from 30 and write the difference in the upper-right corner.

70 (highest concentration)		10 parts
	30 (desired concentration)	
20 (lowest concentration)		40 parts

Reading across the matrix, 10 parts of 70% solution and 40 parts of 20% solution are needed to make 50 parts (10 parts + 40 parts) of a 30% solution.

Question: **What is the specific gravity of a liquid if 100mL of it weighs 85g?**

Answer: To calculate the specific gravity of the liquid, divide the weight by the volume: 85g ÷ 100mL = 0.85.

***Question:* If the specific gravity of a solution is 1.2, and 20g of the liquid is needed, what is the total volume required?**

Answer: The total volume required is determined by basic algebra: Specific gravity = number of grams of a substance ÷ number of milliliters of a substance, or 1.2 = 20g ÷ *x*mL. Solving for *x*, *x* = 16.67mL.

***Question:* If the specific gravity of a solution is 0.5, and 35mL is available, what is the total weight of the solution?**

Answer: Specific gravity = number of grams of a substance ÷ number of milliliters of a substance, or 0.5 = *x*g ÷ 35mL. Solving for *x*, *x* = 17.5g.

***Question:* How do you calculate the specific gravity of a compounded product made from the following ingredients:**

- 500mL of a solution with a specific gravity of 1.2
- 300mL of a solution with a specific gravity of 0.75
- 600mL of a solution with a specific gravity of 0.9

Answer: First, multiply the specific gravity of each component by its volume. Then add the products and divide by the total volume:

- $1.2 \times 500 = 600$
- $0.75 \times 300 = 225$
- $0.9 \times 600 = 540$
- $(600 + 225 + 540) \div (500 + 300 + 600) = 0.975$

The specific gravity of the final product is 0.975.

***Question:* If a final product with a specific gravity of 0.8 is desired, and the available products possess specific gravities of 1.25 and 0.6, what are the relative quantities needed of each component?**

Answer: You can use a matrix to calculate the relative quantities needed of each component:

1.25 (highest specific gravity)		
	0.8 (desired specific gravity)	
0.6 (lowest specific gravity)		

Subtracting on the diagonals yields the following:

1.25 (highest specific gravity)		0.2 parts
	0.8 (desired specific gravity)	
0.6 (lowest specific gravity)		0.45 parts

Reading across the matrix, 0.2 parts of the solution with a specific gravity of 1.25 and 0.45 parts of the solution with the specific gravity of 0.6 are needed to compound a final product with a specific gravity of 0.8.

WRAP UP

Chapter Summary

- An understanding of basic mathematics and calculations is essential to pharmacy practice to ensure safe, accurate, and effective drug administration.
- The decimal system is the primary system used for calculations in pharmacy. The scheme of the decimal system is based on powers of 10.
- Roman numerals are used to express quantity, but are not used much in pharmacy today.
- The household system of measurement is familiar to patients.
- The metric system is the most accurate, and preferred, system of measurement in pharmacy. Prefixes are added to base units of measurement in the metric system to denote larger or smaller quantities.
- The apothecary system is an antiquated system of measurement whose use is discouraged because of inaccuracies and safety concerns. However, thyroid medications and phenobarbital are often dosed in grains, the base unit of the apothecary system of dry weight.
- In hospitals, time is expressed using 24-hour or military time. In this case, time is based on a 24-hour clock rather than a 12-hour clock. This reduces ambiguities and errors in medication administration.
- The preferred system for measuring temperature in pharmacy and medicine is the Celsius scale. In this scale, water freezes at a temperature of 0°C and boils at 100°C.
- In the Fahrenheit scale, water freezes at a temperature of 32°F and boils at 212°F.
- Fractions represent part of a whole. Fractions contain a numerator and a denominator.
- A ratio represents how two quantities are related to each other. A ratio may also be expressed as a fraction, and vice versa.
- Proportions are equivalent ratios, often used to calculate unknown quantities or concentrations in pharmacy.
- Percents are the number of parts per 100 total parts. A percent can also be expressed as a fraction or a ratio.
- Concentrations, quantities, specific gravities, doses, and dosage regimens can be determined using basic algebra or the ratio-proportion method, when some of the values are known.
- Doses of drugs are highly variable and can be based on the drug's chemical composition or physical properties, the route of administration, or the condition being treated. Alternatively, patient factors such as age, body weight, body-surface area, or organ function may be used to calculate the correct dose.
- Pediatric patients require special consideration when determining doses, because children have immature organ function and a different body composition from adults.

Learning Assessment Questions

1. 68°F is equivalent to how many degrees Celsius?
   A. 20°C
   B. 154.4°C
   C. 64.8°C
   D. 37.8°C
2. Aminophylline contains 80% theophylline. The concentration of an aminophylline injection is 25mg/mL. How many milliliters of aminophylline are needed to provide a dose of 640mg theophylline?
   A. 25.6mL
   B. 512mL
   C. 20.5mL
   D. 32mL
3. The ratio 4:25 is equivalent to what percent?
   A. 4%
   B. 25%
   C. 16%
   D. 40%

4. If 8g of powder are needed to make 50mL of a product, how many grams of powder are needed to make 725mL of product?
   A. 35g
   B. 116g
   C. 55g
   D. 290g
5. If a patient is prescribed 2 teaspoonfuls of medicine four times daily for 10 days, what is the total dose of medicine the patient will receive?
   A. 100mL
   B. 8mL
   C. 80mL
   D. 400mL
6. How many ounces are in 6 avoirdupois pounds?
   A. 96oz
   B. 72oz
   C. 454oz
   D. 30oz
7. How is 37 expressed in Roman numerals?
   A. XLVII
   B. XXLIIIX
   C. XXXVII
   D. VIIXX
8. How is the following Roman numeral expressed in the Arabic system: MCMLIX?
   A. 1959
   B. 2199
   C. 2011
   D. 1987
9. How many grains of aspirin are in one 325mg tablet?
   A. 65gr
   B. 21gr
   C. 5gr
   D. 15gr
10. If the concentration of an antibiotic solution is 200mg/5mL, how many milligrams of drug will be in 1 ounce of solution?
    A. 40mg
    B. 1,200mg
    C. 200mg
    D. 13.3mg
11. A physician orders a drug at a dose of 2mg/kg. The patient weighs 187lb. What is the correct dose?
    A. 42.5mg
    B. 374mg
    C. 170mg
    D. 823mg
12. If the dose of a drug is 75mcg, how many doses are contained in 0.35g?
    A. 4666.67 doses
    B. 4.67 doses
    C. 26.25 doses
    D. 466,667 doses
13. A physician prescribes 2 teaspoonfuls of a medication three times daily for seven days. What is the total volume that should be dispensed to the patient?
    A. 630mL
    B. 42mL
    C. 210mL
    D. 35mL
14. If the adult dose of a drug is $0.8mg/m^2$, what dose should be administered to a child with a body-surface area of $1.32m^2$? (Remember, the average adult BSA is $1.73m^2$.)
    A. $10.5mg/m^2$
    B. $1.38mg/m^2$
    C. $1.06mg/m^2$
    D. $0.61mg/m^2$
15. What is the body-surface area of an adult woman who is 5′4″ tall and weighs 115lb?
    A. $1.42m^2$
    B. $1.53m^2$
    C. $1.02m^2$
    D. $1.17m^2$

16. What times should a medication be given, expressed in 24-hour time, if it is ordered to be given every eight hours beginning at midnight?

A. 0000M, 08 a.m., and 16 p.m.

B. 8:00 a.m. and 4:00 p.m.

C. 0000, 0800, 1600

D. 0, 8, 16

17. What time is 2130, expressed in 12-hour time?

A. 9:30 p.m.

B. 2:13 a.m.

C. 1:30 p.m.

D. 3:21 a.m.

18. A syrup contains 0.1% (%w/v) active ingredient. If a physician prescribes 8 ounces to be dispensed, how many milligrams will be contained in the total prescription?

A. 80mg

B. 240mg

C. 800mg

D. 378mg

19. A lotion contains 15mg drug in 750mg base. What is the percentage concentration (%w/w) of the lotion?

A. 200%

B. 0.2%

C. 2%

D. 50%

20. If 250mL of a 1:750 (v/v) solution is diluted to 1,000mL, what is the ratio strength (v/v) of the final product?

A. 1:187.5

B. 1:3,030

C. 1:425

D. 1:625

21. How many milliliters of water should be added to 1 pint of 70% solution to prepare a 30% solution?

A. 1,120mL

B. 640mL

C. 205mL

D. 2.4mL

22. Round the following number to the nearest hundredth: 345.648.

A. 345.6

B. 300

C. 345.65

D. 345.680

23. A physician prescribes three tablets to be taken four times daily. If 100 tablets are dispensed, how many days supply will the patient receive?

A. 8.3 days

B. 33.3 days

C. 12.6 days

D. 25 days

24. How many milligrams are equivalent to 6g?

A. 600mg

B. $\frac{1}{6}$mg

C. 6,000mg

D. 60,000mg