CHAPTER 1

REVIEW OF BASIC MATHEMATICAL PRINCIPLES

LEARNING OBJECTIVES *After completing this chapter the student should be able to:*

1. Recall the skills of basic mathematical operations required to work in the health field.
2. Use estimation as a means of preventing errors.
3. Perform mathematical operations containing units.
4. Compare two quantities (ratio).
5. Apply ratio, proportion, and dimensional analysis in problem solving.

Pharmacists, nurses, doctors, and most health-related professionals perform basic calculations as a daily practice. While working in a variety of settings, pharmacists, for example, need to calculate doses and determine the number of dosage units required to fill prescriptions accurately, must determine the quantities of pharmaceutical ingredients required to compound formulas, and perform calculations related to dose adjustments for disease state management, and so on. The correct drug, strength, and amount of each medication prescribed that is dispensed in pharmacies must be finally checked by the pharmacist, who is legally accountable for an incorrect dose or dispensing of a wrong drug. The fact that most pharmaceuticals are prefabricated and not prepared inside the pharmacy does not lessen the pharmacist's responsibility.

Modern drugs are effective, potent, and therefore potentially toxic if not taken correctly. An overdose may be fatal. Knowing "how to" calculate the amount of each drug and "how to" combine them is not sufficient. Of course, dispensing a subpotent dose is not satisfactory either. The drug(s) given will probably not elicit the desired therapeutic effect and will therefore be of no benefit to the patient. Clearly, the only satisfactory approach is one that is completely free of error. Absolute accuracy is any health professional's goal. Since our goal when performing calculations is the correct answer, it is logical to suppose that any rational approach to a problem that results in the correct answer is acceptable. While this is true, some approaches are more coherent and practical than others. In this text we strive to use a method that requires as few steps as possible and that with which you will feel comfortable. Usually, the simplest, most direct pathway to the solution allows less opportunity for error in computation than does one that is more complicated.

In this chapter, we will review some techniques basic to all types of calculations. To help you regain the basic mathematical operations required to work in the health field, we will briefly review significant figures, rounding off, fractions, exponents, power-of-10 notation, and estimation, and will make sure that you can solve simple algebraic

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expressions. We will go over how units participate in arithmetic operations and how we can take advantage of units in our calculations. Finally, we will review dimensional analysis, ratio, and proportion.

You will probably find that you are already familiar with all or most of these techniques. After this refreshing, you will make rapid progress through the self-study format of this text. If you need further review or instruction, that will be provided.

1.1. SIGNIFICANT FIGURES

Significant figures are digits that have practical consequences in pharmacy. Sometimes, in a calculated dose at a clinical setting, or in a weighed or measured amount at a compounding pharmacy, zeros are significant; other times they just designate the order of magnitude of the other digits indicating the location of the decimal point. Since the majority of medications currently prescribed are manufactured products, significant figures have minor significance to the counter pharmacist, if no compounding is involved on a daily basis. For the compounding pharmacist, however, all weighing and measuring will have a degree of accuracy that is only approximate, due to the many sources of error related to the type and limitations of the instrument used, room temperature, personal skills, attentiveness, and so on.

While compounding pharmacists must achieve the highest accuracy possible with their equipment, one could never claim to have weighed 5 mg of a solid substance on a torsion balance with sensitivity of 10 mg, or that 33.45 mL of a liquid was measured in a 50 mL graduate with only 1 mL graduations. Consequently, when writing quantities, the numbers should contain only the digits that are *significant* within the precision of the instrument. However, when performing calculations, all digits should be retained until the end. The final result will then be rounded so that the accuracy is implied by the number of significant figures.

The following illustrate the practical meaning of significant figures:

(a) If 0.0125 g is weighed, the zeros are not significant and only indicate the location of the decimal point.

(b) For a measured weight of 1250.0 g, the last zero may or may not be significant, depending on the method of measurement. The zero will not be significant if indicating the decimal point; alternatively, it may indicate that the weight is closer to 1249 or 1251 g, in which case the zero is significant.

(c) For some recorded measurements, the last significant figure is "approximate," while all preceding figures are "accurate." For example, in a measured volume of 398.0 mL, all digits are significant but it is accurate to the nearest 0.1 mL, which means the measurement falls between 397.5 and 398.5, or that the measurement was made within ±0.05 mL. In 39.86 mL, the 6 is approximate, with the true volume being between 39.855 and 39.865 mL. This means that 39.8 mL is accurate to the nearest 0.01 mL, or that the measurement was made within ±0.005 mL.

(d) It is thus possible to calculate the maximum error incurred in every measurement. Using the examples above, we would have

$$\frac{0.05\ \text{mL}}{398.0} \times 100\% = 0.013\%$$

$$\frac{0.005\ \text{mL}}{39.86} \times 100\% = 0.013\%$$

(e) When establishing the number of significant figures in mathematical operations, use the following practical rules:

- The result of addition and subtraction should contain the same number of decimal places as the component with the fewest decimal places. For example, 12.5 g + 10.65 g + 8.30 g = 31.45 g = 31.5 g.
- The result of products and quotients should have no more significant figures than the component with the smallest number of significant figures. For example, 2.466 mg/dose × 15 doses = 36.99 = 37 mg.

Now practice with the following:

(a) What is the maximum percentage error experienced in the measurement of 248.0 mL? 12.60 g?

(b) Determine the number of significant figures.

Amounts weighed	Number of significant figures
i. 4.58 g **ii.** 4.580 **iii.** 0.0458 **iv.** 0.0046	

(c) Which of the following has the greatest degree of accuracy (solve as in 3.5 mL ± 0.05 mL, accurate to the nearest 0.1 mL)?

15.7 mL ±

15.70 mL ±

15.700 mL ±

(d) Using significant figure practical rules, calculate the following:

5.5 g + 12.35 g + 4.40 g =

2.533 mg/day × 5 days =

Answers

(a) 0.02%; 0.04%

(b) **(i)** 3, **(ii)** 4, **(iii)** 3, **(iv)** 2 significant figures

(c) 15.700 mL has the greatest degree of accuracy

(d) 22.3 g; 12.7 or 13 mg

SOLUTIONS

(a) The zero in 248.0 mL is a significant figure, implying that the measurement was made within the limits 247.95 and 248.05 mL. The possible error is then calculated as

$$\frac{0.05\ \text{mL}}{248.0} \times 100\% = 0.02\%$$

Applying the same reasoning for 12.60 g, the maximum error is $\frac{0.005\ \text{mL}}{12.60} \times 100\% = 0.0397\% = 0.04\%$

(b) 3, 4, 3, 2 significant figures, respectively.

(c) 15.7 mL = 15.7 mL ± 0.05 mL, accurate to the nearest 0.1mL.

15.70 mL = 15.70 mL ± 0.005 mL, accurate to the nearest 0.01 mL.

15.700 mL = 15.700 mL ± 0.0005 mL, accurate to the nearest 0.001 mL. (The last measurement has the greatest degree of accuracy.)

(d) 5.5 g + 12.35 g + 4.40 g = 22.25 g = 22.3 g

2.533 mg/day × 5 days = 12.665 = 12.7 mg = 13 mg

1.2. ROUNDING OFF

The number of decimal places to which a medical calculation can be precisely calculated is determined by the number of significant figures. As mentioned earlier, when performing calculations, all figures should be retained until the end, when rounding off is performed. Rounding off is based on the last decimal place. If it is ≥5, the preceding decimal place is rounded up to the next digit, for example, 2.356 = 2.36. If it is <5, the preceding decimal place is left as it is, for example, 2.33 = 2.3.

Practice rounding off with the following measurements:

(a) 2.344 g = ________________

(b) 1.5 × 2.1114 mg = ________________

(c) 5.246 mL (using a pipette calibrated 1/10 mL) = ________________

(d) How many powder charts (individual doses) would a compounding pharmacist be able to prepare from a 10.5 g mixture of powders, if each chart should contain 1.33 g?

Answers

(a) 2.34 g

(b) 3.2 mg

(c) 5.3 mL

(d) 7.9 charts = 7 powder charts (doses must be accurate) and 0.9 g waste

SOLUTIONS

(a) In 2.344 the last decimal place is <5, so it is rounded to 2.34 g.

(b) $1.5 \times 2.1114\text{ mg} = 3.167 = 3.2\text{ mg}$, with only one decimal point because 1.5 is the least precise number in the operation (limiting number of significant digits) and it has only one place after the decimal.

(c) In 5.246 the last decimal place is >5, so it would be rounded to 5.25. However, the measuring tool is calibrated in 1/10 mL, which means only fractions as large as 0.1 of a milliliter can be measured accurately so 5.3 mL should be measured.

(d) $10.5\text{ g} \times (\text{chart}/1.33\ \text{g}) = 7.8947 = 7.9$ charts (10.5 is the least precise number in the operation). Since each dose must be complete, there is enough powder mixture to dispense only seven charts with accurate doses and 0.9 g will be discarded as waste.

1.3. FRACTIONS

Most math skills required in health care fields require handling fractions, which measure a portion or part of a whole number and are usually written as ***common*** fractions or ***decimal*** fractions.

A *common fraction*, frequently referred simply as a fraction, can be exemplified as 1/5 or $\frac{1}{5}$, 3/16 or $\frac{3}{16}$, and so on. The first or upper number, the *numerator*, identifies the number of parts with which we are concerned, while the second or lower number, the *denominator*, indicates the number of aliquot parts into which *the numerator* is divided. When the numerator is divided by the denominator, the result is called the *quotient.*

When trying to perform pharmaceutical calculations with common fractions, you will find some principles and rules very handy:

(a) If the denominator of a fraction is 1, the value corresponds to the number in the numerator, for example, $\frac{3}{1} = 3$.

(b) If the value in the numerator of a fraction is lower than the one in the denominator, then the value of the fraction is <1. If the numerator and denominator are the same, the value of the fraction is =1. Numerator with greater value than the denominator will generate values >1.

Examples: $\frac{3}{5} < 1$; $\frac{3}{3} = 1$; $\frac{3}{2} > 1$

(c) If both the numerator and denominator are multiplied or divided by the same number, the value of a fraction does not change. By the other hand, the value will increase if a number is multiplied by the numerator and will decrease if multiplied by the denominator. The opposite occurs if either the nominator or the denominator is divided independently.

Examples: $\frac{3 \times 2}{4 \times 2} = \frac{6}{8} = 0.75$

$$\frac{3 \times 4}{4} = \frac{12}{4} > \frac{3}{4} \quad \text{as} \quad 3 > 0.75$$

$$\frac{3}{4 \times 4} = \frac{3}{16} < \frac{3}{4} \quad \text{as} \quad 0.188 < 0.75$$

(d) Practical consequences of the principles described above, which will reduce computing errors, are as follows:

(i) The ability to reduce fractions to the *lowest common denominator*, or the smallest number divisible by all denominators in consideration.

(ii) The possibility to *reduce a fraction to lower terms* when recording a final result or during a series of calculations.

Ex.1. Reducing $\frac{1}{5}, \frac{3}{4}, \frac{2}{3}$ to a common denomination:

By serial testing it can be found that 60 is the smallest number divisible by 5, 4, and 3, then

$$\left.\begin{array}{l} \frac{1}{5} = \frac{1 \times 12}{5 \times 12} = \frac{12}{60} \\ \frac{3}{4} = \frac{3 \times 15}{4 \times 15} = \frac{45}{60} \\ \frac{2}{3} = \frac{2 \times 20}{3 \times 20} = \frac{40}{60} \end{array}\right\}, \quad \text{all have the same denominator}$$

Ex.2. Reducing $\frac{12}{480}$ to the lowest term:

$$\frac{12}{480} = \frac{12 \div 12}{480 \div 12} = \frac{1}{40}$$

A *decimal fraction* is a fraction with a denominator of 10 or any other power of 10. Usually, the numerator and the decimal point are satisfactory to express a decimal fraction, for example, $\frac{1}{10} = 0.1$ and $\frac{25}{1000} = 0.025$.

Consequences of this definition include the following:

(a) Moving the decimal point one place to the *right* multiplies a number by 10, two places by 100, and so on. Similarly, moving the decimal point one place to the *left* divides the number by 10 and so on.

Examples: $0.1 \times 10 = 1$
$0.025 \div 100 = 0.00025$

(b) A decimal fraction may be changed to a common fraction, and if desired, reduced to lowest terms.

Example: $0.125 = \frac{125}{1000} = \frac{1}{8}$

(c) If the numerator of a common fraction is divided by the denominator, a decimal fraction will be obtained. However, this sometimes leads to an endless decimal fraction.

Examples: $\frac{1}{5} = 1 \div 5 = 0.2$
$\frac{1}{6} = 1 \div 6 = 0.166\overline{6}$

Decimals, in health care settings, are usually rounded to the nearest tenth or hundredth. For example, $10 \div 6 = 1.6666$. This value may be rounded to the nearest tenth, which is 1.7, or to the nearest hundredth, 1.67. It will depend on the accuracy of the instrument being used or the type of medication. For example, a 1 mL tuberculin syringe is calibrated in hundredths of a milliliter, so for a 0.468 mL dose to be measured, it will be rounded off to 0.47 mL. A 3 mL syringe is calibrated in tenths of a milliliter, so volumes must be rounded off to the nearest tenth of a milliliter, for example, 2.468 mL, is rounded off to 2.5 mL.

Now practice with the following problems:

(a) The dose of a drug is 1/200 gram. How many doses would a compounding pharmacist be able to prepare with 2/5 grams?

(b) Alesse™-28, a combination hormone medication used as oral contraceptive, contains 1/10, 000 g levonorgestrel and 2/100, 000 g of ethinyl estradiol per tablet. How many *milligrams* of each drug are present in each tablet?

(c) A compounded capsule is required to contain 5/8 gram of ingredient W, 1/4 gram of ingredient X, 1/100 gram of ingredient Y, and enough of ingredient Z to make a total of 1500 mg. The pharmacist is asked to prepare six capsules. How many total grams of ingredient Z will be required to fill the prescription?

(d) If a patient received the following doses of a drug, what is the total amount of drug received by the patient?

Four doses each containing 0.25 mg

Three doses each containing 0.5 mg

Two doses each containing 1.25 mg

One dose containing 1.5 mg

(e) How many 0.00025 g doses can be prepared with 0.150 g of a pure drug?

(f) A pharmacist had 5 g of promethazine HCl. How many grams were left after he compounded the following prescriptions?

℞$_1$: 6 suppositories each containing 10 mg

℞$_2$: 6 suppositories each containing 25 mg

℞$_3$: 10 suppositories each containing 40 mg

Answers

(a) 80 doses

(b) 0.1 mg levonorgestrel and 0.02 mg ethinyl estradiol in each tablet.

(c) 3.69 g = 3.7 g

(d) 6.5 mg

(e) 600 doses

(f) 4.39 g = 4.4 g

SOLUTIONS

(a) $\frac{2}{5} \times \frac{200}{1} = \frac{400}{5} = 80$ doses or $\frac{0.4 \times 200}{1} = 80$ doses

(b) $\frac{1}{10,000} = 0.0001\ \text{g} = 0.1\ \text{mg}$ levonorgestrel

$$\frac{2}{100,000} = 0.00002\ \text{g} = 0.02\ \text{mg ethinyl estradiol}$$

(c) $\frac{5}{8} + \frac{1}{4} + \frac{1}{100} + Z = 1.5 \rightarrow \frac{250 + 100 + 4 + 400\,Z}{400} = 1.5$

$$354 + 400\,Z = 600 \rightarrow Z = 0.615\ \text{g/caps}$$

$$\frac{6\ \text{caps}}{\text{Rx}} = 6 \times 0.615 = 3.69\ \text{g total}$$

(d) $(4 \times 0.25) + (3 \times 0.5) + (2 \times 1.25) + (1 \times 1.5)$

$= 1 + 1.5 + 2.5 + 1.5 = 6.5\ \text{mg}$

(e) $\frac{0.150\ \text{g}}{0.00025\ \text{g/dose}} = 600$ doses or $\frac{1.5 \times 10^{-1}\ \text{g}}{2.5 \times 10^{-4}\ \text{g/dose}} = 0.6 \times \left[10^{-1+4}\right] = 0.6 \times 10^{3} = 600$ doses

(f) $5\ \text{g} - (6 \times 0.01\ \text{g}) + (6 \times 0.025\ \text{g}) + (10 \times 0.04\ \text{g})$

$= 5 - (0.06 + 0.15 + 0.4) = 5 - 0.61 = 4.39\ \text{g}$

Or, $0.06 + 0.15 + 0.40 = 0.61 \rightarrow 5 - 0.61 = 4.39\ \text{g}$

1.4. EXPONENTS AND POWERS

An exponent, power, or index is a mathematical representation that indicates the number of times a number is to be multiplied by itself. For example, $2^4 = 2 \times 2 \times 2 \times 2 = 16$ can be read as “2 to the *power* of 4.” Exponents make it easier to write and read instead of several multiplications. Almost any number can be multiplied by itself as many times as desired: $a^n = a \times a \times \cdots \times a$. Exceptions include the exponent being 1, which means just the number itself (e.g., $5^1 = 5$) and the exponent being 0 (zero), when the result is 1 (e.g., $5^0 = 1$). Exponents may also be negative, in which case it is solved by the operation that is inverse to multiplication, that is, division. In other words, a negative exponent indicates the number of times *the number 1* will be divided by the number. For example, 4^{-3} can be solved as $1 \div 4 \div 4 \div 4 = 0.0156$ or represented and solved as $\frac{1}{4^3} = \frac{1}{64} = 0.0156$.

Scientific notation, also called *power-of-10 notation*, is particularly important in the health care field because of the use of the metric system, which is based on a power of 10 and also because many drugs are used at extremely diluted concentrations. Powers of 10 are very useful to write down very large or very small numbers, eliminating the need to use lots of zeros. Similarly, negative powers of 10 have special uses in all health care fields. When performing calculations remember that powers of 10 indicate how many places one needs to move the decimal point to the right or to the left (negative power of 10). This is also how we make conversions within the metric system. Metric conversions will be discussed in more detail in Chapter 2.

Some typical examples of scientific notation:

$10^3 = 10$ to the third power, 10 to the power of 3, or 10 cubed $= 10 \times 10 \times 10 = 1000$

$4000 = 4 \times 1000 = 4 \times 10^3$

$10{,}000 = 10 \times 1000 = 10^4$

$0.0005 = 5 \times 10^{-4}$

Let us also review some simple conversions of powers of 10 to ordinary numbers:

$$1.25 \times 10^3 = 1.25 \times (10 \times 10 \times 10) = 1.25 \times 1,000 = 1250$$

This calculation would be easier if you would just move the decimal point three places to the right: $1.25 \rightarrow 12.5 \rightarrow 125. \rightarrow 1250$

$$5.1 \times 10^{-4} = 5.1 \times \left(\frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}\right) = 5.1 \times \frac{1}{10,000}$$
$$= 5.1 \times 0.0001 = 0.00051$$

Again, it is easier to just move the decimal point four places to the left: $5.1 \rightarrow 0.51 \rightarrow 0.051 \rightarrow 0.0051 \rightarrow 0.00051$

Now it is your turn to practice.

(a) Write 5.26×10^3 as an ordinary number.

(b) Write 2.35×10^{-4} as an ordinary number.

(c) Circle below what corresponds to 8.725×10^{-3}?

- **(i)** 8725
- **(ii)** 87.25
- **(iii)** 0.8725
- **(iv)** 0.008725

(d) Write 510,000 in scientific notation (power-of-10).

(e) Write 0.0004506 in scientific notation.

(f) What is 1 trillion as a power of 10?

Answers

(a) 5260
(b) 0.000235
(c) 0.008725
(d) 5.1×10^5
(e) 4.506×10^{-4}
(f) 10^{12}

SOLUTIONS

(a) $5.26 \times 10^3 = 5.26 \times (10 \times 10 \times 10) = 5.26 \times 1000 = 5260$ or, moving the decimal point three places to the right: $52.6 \rightarrow 526 \rightarrow 5260$

(b) $$2.35 \times 10^{-4} = 2.35 \times \left(\frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}\right) = 2.35 \times 1/10,000$$
$$= 2.35 \times 0.0001 = 0.000235$$

Again, it is easier to just move the decimal point four places to the left:

$$2.35 \rightarrow 0.235 \rightarrow 0.0235 \rightarrow 0.00235 \rightarrow 0.000235$$

(c) $8.725 \times 10^{-3} = 0.008725$ by moving the decimal point three places to the left.
(d) 510,000 as a power of 10 is 5.1×10^5
(e) 0.0004506 in scientific notation is 4.506×10^{-4}
(f) 1 trillion $= 1 \times 1000 \times 1000 \times 1000 \times 1000 = 10^{12}$

If you completed these successfully, you are familiar with exponents and power-of-10 expressions and may proceed to reviewing estimation. If you had difficulty or feel a bit unsure of yourself, go to the end of this chapter and continue for a more thorough review by doing the practice problems.

1.5. ESTIMATION

Because medical errors are one of the leading causes of death and injury in medical practice, it is a good idea for members of a health care team to check all results when performing calculations. One might think that this is unnecessary, since calculators are habitually used and typically reliable. However, we tend to take their results for granted, without thinking about making an error in entering data, which is liable to go unnoticed. Additionally, sometimes we find a wrong answer by use of a wrong method and an inattentive, mechanical verification of our calculations may not reveal the error.

For patient's safety sake, it is necessary to check every calculation in some way, to make sure that the result is reasonable.

One kind of check is particularly useful in preventing errors of large magnitude such as *misplacement of the decimal point*. This kind of error will not likely be missed if we check it against an initial *estimation* of what the result should be. For example, how much would cost a compounding pharmacist to prepare 325 capsules of a drug at $1.80/100?

By estimation:

$$300 \times \frac{2}{100} = \$6$$

Solving:

$$325 \text{ caps} \times \frac{\$1.80}{100 \text{ caps}} = \$5.85$$

Analyzing the estimated amount, it is easy to verify the order of magnitude and spot a 10-fold error (not \$ 0.58 or \$58.50).

Estimation using *rounded values* involves rounding all values to one figure. The figure is kept as it appears in the original number if the figure following it is 4 or less. The single figure is promoted to the next higher number if it is followed by a 5 or higher number.

For example,

4.27 rounded to one figure is 4

0.37 rounded to one figure is 0.4

3508 rounded to one figure is 4000

0.00949 rounded to one figure is 0.009

Now it is your turn to practice estimation by rounding the following to 1 significant figure:

A. 72

B. 0.08294

C. 0.452

D. 0.75

E. 820

Answers

A. 70
B. 0.08
C. 0.5
D. 0.8
E. 800

Estimation of the answer before attempting to obtain the exact solution to a problem is found by rounding off the quantities involved in the calculation to one significant figure and then computing the result. After solving the problem, compare the exact solution with the estimate. Unless they are reasonably close to each other, both should be recalculated. Unfortunately, it is necessary to know how to do the problem in order to come up with an estimate. It is therefore possible to "solve" a problem incorrectly and to have that wrong answer check against the estimate. Estimation is helpful in preventing errors and will give an idea of the order of magnitude of a calculated value but is not infallible. For example, A formula for 42 capsules calls for 180 mg of sucrose. To estimate the amount of sucrose per capsule, round 42 capsules to 40 capsules and 180 mg to 200 mg:

$$\frac{200 \text{ mg}}{40 \text{ caps}} = \frac{5 \text{ mg}}{\text{caps}}$$

The exact answer is 4.28 mg per capsule.

Now try these two problems.

A certain tablet contains 32.5 mg of phenobarbital. Estimate the number of milligrams of phenobarbital in 24 tablets.

Answer
600 mg

Solution

$$\frac{30 \text{ mg}}{\text{tablet}} \times 20 \text{ tablets} = 600 \text{ mg}$$

The exact answer is 780 mg. You may think that 600 mg is rather a poor estimate, but it is good enough to tell you that your answer is in the ballpark. Certainly, if you were to solve the problem and come up with an answer of 78 mg or 7800 mg, you would realize that an error had been made.

A liquid costs $3.27 per pint. Estimate the cost of 418 pints.

Answer
$1200

Solution

$$\frac{\$3}{\text{pt}} \times 400 \text{ pt} = \$1200$$

The exact answer is $1366.86.

1.6. UNITS

In compounding and filling prescriptions, the pharmacist deals with measured quantities. The magnitude of each such quantity is expressed as the product of a number and a unit. The unit name specifies the scale of measurement. Changing the scale of measurement (unit) causes the multiplying number to change as well. Thus, in describing any measured quantity, it is *always* necessary to specify the unit used. The unit is an essential part of the designation of a value that is either measured directly or calculated from measured data. *Units must not be permitted to drop off or fade away during calculations*.

In most manufactured products containing one or more drugs, the units are metric, for example, benzonatate 100 mg/capsule, azithromycin 250 mg/tablet. However, other drug strengths are expressed in terms of units of activity or potency according to specific biologic assay (e.g., heparin, insulin, bacitracin, Vitamins A, D, and E). Thus, it is important to keep in mind that units of activity (also known as USP units or units of potency) and international units are *not* equivalent. Calculations involving units of potency will be discussed in detail later in Chapter 10.

Some basic rules we need to know when working with units, according to the SI (Système International d'Unités = International System of Units) Guide:

- Unit symbols are unaltered in the plural, for example, 1 mg and 10 mg.
- Unit symbols are not followed by a period unless at the end of a sentence. However, in common usage, "in." is used for inch. This is probably used so as not to be confused with the word "in".
- Unit symbols are printed in lowercase letters, except
  (a) if the symbol or the first letter of the symbol is an uppercase letter when the name of the unit is derived from the name of a person; examples: m (meter), s (second), V (volt), Pa (Pascal);
  (b) the recommended symbol for the *liter* in the United States is L, which was adopted by the CGPM (Conférence Générale des Poids et Mesures = General Conference on Weights and Measures) in order to avoid the risk of confusion between the letter l and the number 1. Thus, although both l and L are internationally accepted symbols for the liter, to avoid this risk the symbol to be used in the United States is L. The script letter ℓ is not an approved symbol for the liter.
- Because acceptable units generally have internationally recognized symbols and names, it is not permissible to use abbreviations for their unit symbols or names, such as sec (for either s or second), sq. mm (for either mm^2 or square millimeter), cc (for either cm^3 or cubic centimeter), mins (for either min or minutes), hrs (for either h or hours), and lit (for either L or liter). Although the values of quantities are normally expressed using symbols for numbers and symbols for units, if for some reason the name of a unit is more appropriate than the unit symbol, the name of the unit should be spelled out in full.
- Prefix names and symbols are printed in roman (upright) type regardless of the type used in the surrounding text, and are attached to unit symbols without a space between the prefix name or symbol and the unit name or symbol. This last rule also applies to prefixes attached to unit names. Examples: mL (milliliter), μg (microgram), pm (picometer), Gb (gigabite), and THz (terahertz).
- In the expression for the value of a quantity, the unit symbol is placed after the numerical value and a space is left between the numerical value and the unit symbol, for example 10 mL, not 10mL.
- When the value of a quantity is used as an adjective but the meaning has any ambiguity, the words should be rearranged accordingly. For example, "the samples were placed in 22 mL vials" should be replaced with "the samples were placed in vials of volume 22 mL." When unit names are spelled out, the normal rules of English apply. Thus, for example, "a roll of 35 millimeter film" is acceptable.
- Contrary to the recommendation by the SI regarding the symbol % as an internationally recognized symbol for the number 0.01, in order to prevent calculation mistakes within the health care fields it is common to use terms such as "percentage by weight, % (by

weight), % (W/W)," "percentage by volume, % (by volume), % (V/V)." Similarly, in the medical fields it is acceptable to use ppm, ppb, and ppt for part per million, part per billion, and part per trillion, though these terms are rarely used in clinical practice.

Along this text you will recognize that computations involving units will frequently require some knowledge of different systems of measurement and intersystem conversions, which will be reviewed in Chapter 2 and Appendix 1. This is because sometimes you find that the units in which a measured quantity is expressed are not convenient for the results you are searching. For example, an American traveling in France wants to buy 2 lb of beef at the neighborhood butchery. Before going to the store around the corner, the traveler may wish to convert this amount into the equivalent metric unit (grams or kilograms), used in that country. To perform the conversion, it is necessary to know that

$$1 \text{ lb} = 454 \text{ g}$$

One advantage of performing a calculation involving units is that they may be multiplied and divided in much the same way as numbers or algebraic symbols. If the same unit appears in both the numerator and denominator, they will cancel each other. For example,

$$2 \text{ lb} \times \frac{454 \text{ g}}{1 \text{ lb}} = 908 \text{ g}$$

The traveler can go to the butcher and ask for 900 g of beef to get approximately the 2 lb needed.

Perform the conversions indicated:

A. $3 \text{ dL} \times \frac{100 \text{ mL}}{1 \text{ dL}} =$

B. $154 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} =$

C. $250 \text{ mg} \times \frac{1 \text{ tablet}}{50 \text{ mg}} =$

Answers

A. 300 mL

B. 70 kg

C. 5 tablets

1.7. RATIO

Ratio is a relationship between two values, similar to fractions, the relationship of a part to the whole. It provides a comparison between two like quantities and may be expressed in several different ways (quotient, fraction, percentage, or decimal).

For example, if a comparison is made between 2 and 10, the ratio between these numbers could be expressed as 2:10; $\frac{2}{10}$; 20%; or 0.2. If a ratio contains a colon (2:10) it is read as 2 ***to*** 10; if it is written as a fraction $\left(\frac{2}{10}\right)$ it is read as 2 ***per*** 10. The form using a fraction is preferred for dosage calculations and to express drug concentrations, for example, 5 mg/mL, 15 drops/min, and 500 mg/tablet.

Because a ratio is a quotient, it is regulated by the same rules used for common and decimal fractions. Reviewing some useful rules:

- Both nominator and denominator may be multiplied or divided by the same number without changing the ratio. For example, the ratio 2:10 $\left(\text{or } \frac{2}{10} = 0.2\right)$ will not change if both terms are multiplied by 2. The ratio will then become 4: 20 or $\frac{4}{20} = \frac{2}{10} = 0.2$.
- To convert a decimal to a ratio, write the decimal as a fraction, reduce the fraction to lowest terms, and rewrite the fraction as a ratio. For example, $0.8 = \frac{8}{10} = \frac{4}{5} = 4 : 5$.
- To convert a ratio to a percent, convert the ratio to a decimal, multiply it by hundred, and add the percent symbol. For example, $1 : 40 = \frac{1}{40} = 0.025 \times 100 = 2.5\%$.
- Two ratios with the same value and their multipliers, as shown in the example, are equivalent.

$$\frac{2}{5} = \frac{4}{10} \quad \text{and} \quad 2 \times 10 = 5 \times 4$$

Ratios are very valuable to set up a problem as an equation offering the health care professional an organized mathematical approach to problem solving.

1.8. PROPORTION

Proportion, the practical application of ratio, is one of the most popular problem-solving methods used for pharmaceutical and medical calculations. It represents the equality between two or more ratios or fractions.

In the following example, the proportion $8 : 10 = 4 : 5$ is read as:

8 is to 10 as 4 is to 5.

8 and 5 are known as *extreme values,* while 10 and 4 are *mean values*. Since these two ratios are equal, the product of extreme values is equal to the product of mean values, or $\frac{8}{10} = \frac{4}{5}$ and $8 \times 5 = 10 \times 4$. This is known as *cross-multiplying*.

Consequently, this rule allows any unknown value to be determined when all other three values of a given proportion are known. For example, if 100 mL of a solution contains 250 mg of a drug, how many milligrams of the drug will be in a 5 mL dose taken by a patient?

$$\frac{250\text{ mg}}{100\text{ mL}} = \frac{x}{5\text{ mL}}$$

Solving for x:

$$100 \times x = 250 \times 5$$

$$\frac{100 \times x}{100} = \frac{250 \times 5}{100} \rightarrow x = 12.5 \text{ mg in a teaspoonful}$$

It is very important to know how to set up correctly a proportion (using the same dimensions on both sides of the proportion allowing cancelling of like units), and to not confuse multiplying fractions with cross-multiplying. For example, a pharmacy technician was set to compound 60 capsules, each to contain 250 mg of powder drug in 1000 mg powder mixture, when a phone call distracted her calculations.

Her initial proportion was correctly set as

$$\frac{250 \text{ mg drug}}{1000 \text{ mg mixture}} = \frac{x}{60 \times 1000 \text{ mg mixture}}$$

After the phone call she solved it as:

$$250 \times x = 1000 \times (60 \times 1000) \rightarrow x = 240,000 \text{ mg of drug}$$

It should be cross-multiplied:

$$1000 \times x = 250 \times (60 \times 1000) \rightarrow x = 15,000 \text{ mg of drug (correct answer)}$$

It would also lead to a serious error if she had set the proportion as below because the units would not cancel (units are different for both numerators):

$$\frac{250 \text{ mg drug}}{1000 \text{ mg mixture}} = \frac{60 \times 1000 \text{ mg mixture}}{x}$$

You are probably familiar with proportions as a problem-solving method, and the problems that follow should present no difficulty. Try them on if you feel you need some practice. Remember to *always* write the units of measurement and to make sure that the expressions on opposite sides of the equal signs have the same units. A serious error would be incurred if you had two solutions, one containing 5 mg of a drug in 30 mL and the other containing 5 µg (mcg) of a drug in 30 mL. While both have a ratio strength of 1:6, they are clearly different from each other.

Try to solve the following problems, using proportion, before verifying your answers.

A. $\frac{1 \text{ kg}}{\$3.50} = \frac{x}{\$2.00}$

B. If 5 mL of a medicated suspension contains 250 mg of drug, how many milligrams of drug will be in 2 fl oz of suspension? (in practice use 1 fl oz = 30 mL)

C. An analytical instrument that is in constant use needs a new battery every 73 days. How many batteries will be required for a year?

Answers

A. 0.571 kg

B. 3000 mg

C. 5 batteries

SOLUTIONS

A. $\frac{1\text{ kg}}{\$3.50} = \frac{x}{\$2.00} \rightarrow 3.5\,x = 2 \rightarrow x = 0.571\text{ kg}$

B. $\frac{5\text{ mL}}{250\text{ mg}} = \frac{2 \times 30\text{ mL}}{x\text{ mg}} \rightarrow x = 3000\text{ mg}$

C. $\frac{1\text{ battery}}{73\text{ days}} = \frac{x}{365\text{ days}} \rightarrow 73\,x = 365 \rightarrow x = 5\text{ batteries}$

Consider the next examples and try to solve the practice problems that follow on the text. If you do not need the practice, skip ahead to dimensional analysis.

Proportions are useful in those situations where two properties are directly related to each other. For example, if a drug costs 5¢ per gram, 2 g will cost 10¢. The two properties, cost and amount of drug, are directly related to each other. If the quantity of drug is increased five times, the cost will increase five times. If the amount of drug is cut in half, the cost will be halved also. If we wanted to know the cost of 12.5 g of this drug, we could write

$$\frac{1\text{ g}}{5¢} = \frac{12.5\text{ g}}{x}$$

This equation states, "If 1 g of a drug costs 5¢, then 12.5 g will cost x." Notice that the same units are found on both sides of the equality. The ratio on the left describes the known relationship between the related properties. The ratio on the right describes the unknown situation. The two ratios are equal to each other because there is a fixed relationship between cost and weight.

One sodium bicarbonate tablet contains 300 mg of the drug; we wish to find the number of tablets that will contain 1500 mg of sodium bicarbonate. Which of the following proportions will lead to the correct solution? Why are the others not correct?

A. $\frac{1\text{ tablet}}{300\text{ mg}} = \frac{1500\text{ mg}}{x}$

B. $\frac{1\text{ tablet}}{1500\text{ mg}} = \frac{x}{300\text{ mg}}$

C. $\frac{1\text{ tablet}}{300\text{ mg}} = \frac{x}{1500\text{ mg}}$

Answer and Solution

C is correct. The ratio on the left describes the known information; that on the right, the unknown situation. Both ratios have the same units. A is incorrect because the same units do not appear on both sides of the equality (tablets/mg do not equal mg/tablet). B is incorrect because the first ratio states that 1500 mg are found in each tablet (1500 and 300 mg are reversed). Although the units appear to be correct, the numbers have been jumbled.

$$\frac{1\text{ tablet}}{300\text{ mg}} = \frac{x}{1500\text{ mg}}$$

$$(1\text{ tablet}) \times (1500\text{ mg}) = x \times (300\text{ mg})$$

$$x = \frac{(1\text{ tablet})(1500\text{ mg})}{300\text{ mg}} = 5\text{ tablets}$$

If you need more practice with ratios and proportion try the following.

A. A formula for 42 capsules (caps) calls for 300 mg of a drug. Using proportion, find how many milligrams of the drug would be needed to make 24 capsules.

B. If 12 g of a powder occupy 7 mL, how many milliliters will be taken up by 150 g?

C. If a chemical costs $14 per kilogram, how many kilograms could be purchased for $128?

D. A compounding pharmacist has just finished preparing 250 mL of a solution containing 6 mg of a drug in every 100 mL when he learns that the physician wants a solution containing 8 mg of drug in 100 mL of solution. Assuming there will be no increase in the final volume of solution, how many additional milligrams of drug should be added to the first solution he prepared?

Answers

A. 171 mg
B. 87.5 mL
C. 9.14 kg
D. 5 mg

Solutions

A. $\dfrac{300\text{ mg}}{42\text{ caps}} = \dfrac{x}{24\text{ caps}} \rightarrow x = 300\text{ mg} \times \dfrac{24\text{ caps}}{42\text{ caps}} = 171\text{ mg}$

B. $\dfrac{12\text{ g}}{7\text{ mL}} = \dfrac{150\text{ g}}{x} \rightarrow x = 7\text{ mL} \times \dfrac{150\text{ g}}{12\text{ g}} = 87.5\text{ mL}$

C. $\dfrac{1\text{ kg}}{\$14} = \dfrac{x}{\$128} \rightarrow x = 1\text{ kg} \times \dfrac{\$128}{\$14} = 9.14\text{ kg}$

D. First solution : $\dfrac{6\text{ mg}}{100\text{ mL}} = \dfrac{x}{250\text{ mL}} \rightarrow x = 15\text{ mg}$

Solution needed : $\dfrac{8\text{ mg}}{100\text{ mL}} = \dfrac{x}{250\text{ mL}} \rightarrow x = 20\text{ mg}$

$20\text{ mg} - 15\text{ mg} = 5\text{ mg}$ additional

1.9. DIMENSIONAL ANALYSIS

You may or not have learned about *dimensional analysis* in your high school mathematics, chemistry, or physics courses. You may, however, have heard of it as the method in which "the units cancel out leaving the ones you are searching for." It is thus to your advantage to learn or review it now. Besides proportions, dimensional analysis is another particularly useful problem-solving method used by health care professionals when calculating dosages as it is a very reliable method for finding the correct dose every time.

The foundation for dimensional analysis is creating relationships between quantities such that like units of measurement (dimensions) and conversions will be cancelled until only the units desired will remain. Advantages of this method include:

- Alternative approach to using multiple proportions and conversions, by providing one single expression that takes the place of multiple calculation steps, reducing the opportunity for error.
- Convenience when one unit of measurement has to be converted into a different unit.
- The fact that any number or expression can be multiplied by one without changing its value.
- Delivery of a system for checking an equation or solution to a problem by the way one sets up the dimensions. An equation is incorrect if the two sides do not have the same dimensions.

Here is a stepwise approach to perform dimensional analysis:

1. Write out the desired unit(s) you would like to obtain followed by an equal [=] sign.

2. Collect all the information available in the problem and identify a relationship that contains the unit(s) desired for the answer (in numerator and denominator, when applicable), forming the frame of the process. Do not forget to include a unit for every number and if dealing with more than one drug or drug strength *label* them with the drug units and name. Also, be sure to differentiate between volume or weight of pure drug versus a solution or powder mixture.

3. Connect the relationships inverting dimensions as needed and adding known conversions so that the units cancel out.

4. Solve the problem mathematically.

The steps for this method are demonstrated through the following example.

A pharmacist wants to know how many inhalers should be dispensed to a patient to provide a 60 day supply of beclomethasone. The recommended dose is 168 μg twice daily. The commercial inhaler delivers 42 μg per metered dose and contains 200 doses.

1. Unit desired: # Inhalers =?
2. Data available:

$$60 \text{ day supply}; \frac{168\ \mu\text{g}}{\text{dose}}; \frac{2 \text{ doses}}{\text{day}}; \frac{1 \text{ inhaler}}{200 \text{ doses}}; \frac{1 \text{ dose}}{42\ \mu\text{g}}$$

3. $? \text{ Inhalers} = \frac{1 \text{ inhaler}}{200\ \cancel{\text{doses}}} \times \frac{1\ \cancel{\text{dose}}}{42\ \cancel{\mu\text{g}}} \times \frac{168\ \cancel{\mu\text{g}}}{1\ \cancel{\text{dose}}} \times \frac{2\ \cancel{\text{doses}}}{\cancel{\text{day}}} \times 60\ \cancel{\text{days}}$
4. Solve the math:

$$\text{Inhalers} = \frac{1 \text{ inhaler}}{200} \times \frac{1}{42} \times \frac{168}{1} \times \frac{2}{1} \times 60 = 2.4 \text{ inhalers}$$

= 3 inhalers will be dispensed for 60 day supply of beclomethasone

Now, try to solve the next problem using dimensional analysis.

A drug is administered as a single daily dose of 10 mg/kg. How many milliliters of a 10 mL vial containing 100 mg per milliliter would be administered to a patient weighing 154 lb? (1 kg = 2.2 lb)

Answer

7 mL

SOLUTION

$$?\text{mL} = \frac{\text{mL}}{100\ \cancel{\text{mg}}} \times \frac{10\ \cancel{\text{mg}}}{1\ \cancel{\text{kg}}} \times \frac{\cancel{\text{kg}}}{2.2\ \cancel{\text{lb}}} \times \frac{154\ \cancel{\text{lb}}}{\text{patient}} = 7\ \text{mL} \quad \text{OR}$$

$$?\text{mL} = \frac{10\ \text{mL}}{1000\ \text{mg}} \times \frac{10\ \text{mg}}{1\ \text{kg}} \times \frac{\text{kg}}{2.2\ \text{lb}} \times \frac{154\ \text{lb}}{\text{patient}} = 7\ \text{mL}$$

If you need more practice of your dimensional analysis skills try the following additional problems. For testing your mastering of this problem-solving technique, go to the practice problem section at the end of this chapter.

A. If the adult dose of a solution is 0.2 mL/kg of body weight to be administered once daily, how many teaspoons (tsp) should be administered to a person weighing 220 lb? (1 kg = 2.2 lb, 1 tsp = 5 mL)

B. An antibiotic provides 25,000 units of activity in each 250 mg tablet. How many total units would a patient receive by taking four tablets a day for 10 days?

C. A medication order calls for 500 mL of D5W/NS solution to be infused over 6 hours using an administration set that delivers 15 drops per milliliter. How many drops per minute should be delivered to the patient?

Answers

A. 4 tsp

B. 1,000,000 units

C. 21 drops/min

SOLUTIONS

A. $$?\text{tsp} = \frac{\text{tsp}}{5\ \text{mL}} \times \frac{0.2\ \text{mL}}{\text{kg}} \times \frac{\text{kg}}{2.2\ \text{lb}} \times \frac{220\ \text{lb}}{\text{patient}} = 4\ \text{tsp}$$

B. $$?\frac{\text{total units}}{\text{patient}} = \frac{25,000\ \text{units}}{\text{tab}} \times \frac{4\ \text{tab}}{\text{day}} \times \frac{10\ \text{days}}{\text{patient will receive}} = 1,000,000\ \text{units}$$

C. drops = gtt

$$?\frac{\text{gtt}}{\text{min}} = \frac{15\ \text{gtt}}{\text{mL}} \times \frac{500\ \text{mL}}{6\ \text{h}} \times \frac{\text{h}}{60\ \text{min}} = 20.8 = 21\ \text{drops/min}$$

PRACTICE PROBLEMS

1. Given the following:

   10^4 $(n = +4) = 10{,}000$

   10^{-3} $(n = -3) = 0.001$

   10^0 $(n = 0) = 1$

   Complete these:

   a. $10^2 =$
   b. $10^{-2} =$
   c. $10^1 =$
   d. $10^6 =$
   e. $10^{-4} =$
   f. $10^{-6} =$
   g. $10^0 =$
   h. $10^{-1} =$

2. Change the following expressions to a single ordinary number:

   a. $5 \times 10^1 =$
   b. $1.47 \times 10^4 =$
   c. $1.2 \times 10^{-3} =$
   d. $1.4 \times 10^{-2} =$
   e. $5.7 \times 10^6 =$
   f. $0.002 \times 10^3 =$

3. Fill in the proper *exponent* in the following expressions:

   a. $480 = 4.8 \times 10$
   b. $0.0095 = 9.5 \times 10$
   c. $38 = 3.8 \times 10$
   d. $0.013 = 1.3 \times 10$
   e. $1000 = 1 \times 10$
   f. $0.000001 = 1 \times 10$
   g. $0.728 = 7.28 \times 10$
   h. $270 = 2.7 \times 10$

4. Try the following, knowing that when multiplying powers of 10, the exponents are added and when dividing the exponents are subtracted.

   a. $10^6 \times 10^1 =$
   b. $10^6 \times 10^{-3} =$
   c. $\dfrac{10^2}{10^3} =$

d. $\frac{10^4}{10^7} \times 10^3 =$

e. $\frac{10^2 \times 10^{-1} \times 10^3}{10^3 \times 10^{-4}} =$

5. Write the following as ordinary numbers performing the required operations when required:

a. $10^2 =$

b. $5.7 \times 10^{-3} =$

c. $60 \times 10^6 =$

d. $3 \times 10^1 =$

e. $70{,}000 = 7 \times 10^?$

f. $0.02 = 2 \times$

g. $20 = 2 \times$

h. $10^3 \times 10^2 =$

i. $\frac{10^3}{10^1} =$

j. $\frac{10^0 \times 10^4}{10^4} =$

k. $10^1 \times 10^{-3} =$

l. $(3 \times 10^2) \times (2 \times 10^3) =$

m. $\frac{(16 \times 10^2) \times (2 \times 10^{-4})}{(4 \times 10^{-1}) \times 10^1} =$

n. $(3.83 \times 10^3) - (2.6 \times 10^2) =$

6. Complete the following operations, expressing the answers in powers of 10:

a. $(3 \times 10^1) \times (2 \times 10^2) =$

b. $\frac{9 \times 10^2}{3 \times 10^4} =$

c. $(3 \times 10^2) \times \frac{(4 \times 10^1)}{2 \times 10^{-1}} =$

d. $\frac{70{,}000 \times 0.8 \times 30}{20 \times 600 \times 0.02} =$

e. $\frac{(4 \times 10^1) \times (3 \times 10^{-2})}{(2 \times 10^{-2}) \times (1 \times 10^4)} =$

7. Estimate the results of the following problems, and then perform the calculations using the estimate as a check.

a. A formula for vitamin B_{12} tablets calls for 0.020 mg of the vitamin per tablet. How many milligrams are required to make 350,000 tablets?

b. A pharmacist bought a 500 g bottle of a drug for $3.79. What is the cost of 33 g of that drug?

c. A chemical costs 3.3¢ per milligram. What is the cost of 8.8 g?

8. How many fluid ounces are there in ½ qt of Scotch whiskey? (1 qt = 32 fl oz)

9. Convert 17 ft to meters (1 m = 39.4 in. and 1 ft = 12 in.).

10. How many fluidounces are there in 1.75 L? (1 L = 1000 mL; 1 fl oz = 29.6 mL)

11. If a mercury barometer reads 30.3 in., what is the pressure in atmospheres (atm)? (1 in. = 2.54 cm; 1 atm = 76 cm)

12. Calculate the equivalent values for the following. Round decimals to the nearest hundredth and percents to the nearest percent, when necessary.

a. 2:3 = ________(decimal) and ____________ (percent)

b. 3:50 = ________ (decimal)

c. 0.03 = ________ (fraction)

d. $\frac{5}{4}$ = ________ (decimal) and ________ percent)

13. If 10 prescription bottles for a compounded formulation costs $30, what is the cost of 6 prescription bottles of the same formulation?

14. If 4 buffered aspirin tablets contain 324 mg of aspirin, how many milligrams will be present in 15 tablets?

15. A hospital nurse was instructed to infuse 600 mL of an IV fluid every 6 h. How many hours will be needed to infuse 2000 mL of the solution?

16. A set of AA batteries lasts 3 h and 30 min in a radio under constant use. How many hours will the radio play on 14 sets of batteries?

17. If 4 chairs in an auditorium occupy 17 ft^2, how many square feet are needed to accommodate 304 chairs?

18. Five hundred penicillin tablets cost $43.09. What is the cost of 48 tablets?

19. A nasal spray is supplied as a 10 mL package, delivering 25 sprays per milliliter and each dose (spray) contains 2 mg of drug.

a. How many total sprays will the package deliver?

b. How many milligrams of the drug are contained in the package?

20. Nutr-E-Sol® contains 400 I.U. (international units of activity) of water-soluble natural vitamin E per tablespoonful (1 tbsp = 15 mL). How many units of vitamin E would be administered to a child if the dose was 45 drops of solution to be delivered through a dropper calibrated to deliver 15 drops per milliliter?

21. Ocuflox®, ofloxacin ophthalmic solution, contains 0.3 % (0.3 g/100 mL) of ofloxacin. How many milliliters would be needed to deliver 0.15 mg of ofloxacin?

22. A prescription for a pediatric patient calls for 600 mg per day of Omnicef® for oral suspension to be administered for 10 days divided into two equal doses per day. Omnicef® for oral suspension is supplied as a powder that requires reconstitution before administration.

a. How many milligrams of drug will the child receive in each dose?

b. After reconstitution, Omnicef® suspension contains 125 mg/5 mL. How many milliliters should be given in each dose?

c. If a child weighs 44 lb and a dose is chosen on the basis of 7 mg/kg every 12 h, how many total milliliters of Omnicef® suspension would be needed for a 5 day dosage regimen?

23. A male patient with high blood pressure was prescribed 12.5 mg Carvedilol with the following instructions: “Take one tablet by mouth twice daily.” Carvedilol is available as 6.25 mg tablets.

a. How many tablets should the patient receive per dose?

b. How many tablets should be dispensed to allow the patient to take this drug for 3 months (prescriptions are filled on the basis of 1 month = 30 days)?

24. A physician prescribed for M.F.P, male, 70 years, 40 mEq of potassium chloride per day divided into two equal doses and to be taken orally with food. The elderly patient asks for a liquid dosage form, which was compounded as a solution containing 30 mEq/tbsp. How many milliliters of potassium chloride should the pharmacist add to the label as a dose?

25. A 250 mL bag of D5W contains 5 mg of a drug. The physician orders a flow rate of 2.5 µg/min. As IV pumps deliver IV fluids at volume/time units, how many milliliters per hour (mL/h) would a nurse need to set the pump?

26. At which drip rate, in gtt/min, a solution set that delivers 20 gtt/mL needs to be set to deliver half liter of dextrose 5% infusion (D5W) over 8 h?

Answers to Practice Problems

1. **a.** 100
   b. 0.01
   c. 10
   d. 1,000,000
   e. 0.0001
   f. 0.000001
   g. 1
   h. 0.1

2. **a.** 50
   b. 14,700
   c. 0.0012
   d. 0.014
   e. 5,700,000

3. **a.** 2
   b. −3
   c. 1
   d. −2
   e. 3
   f. −6
   g. −1

4. **a.** 10^7
   b. 10^3
   c. 10^{-1}

d. $10^0 = 1$
e. 10^5

5. **a.** 100
b. 0.0057
c. 60,000,000
d. 30
e. 4
f. 10^{-2}
g. 10^1
h. 10^5
i. 10^2
j. $10^0 = 1$
k. 10^{-2}
l. 6×10^5
m. 8×10^{-2}
n. 3.57×10^3

6. **a.** 6×10^3
b. 3×10^{-2}
c. 6×10^4
d. 7×10^3
e. 6×10^{-3}

7. **a.** 8,000 mg (estimation); 7,000 mg (calculated)
b. 24¢ (estimation); 25¢ (calculated)
c. $270 (estimation); $290.40 (calculated)

8. 16 fl oz

9. 5.18 m

10. 59.1 fl oz

11. 1.01 atm

12. **a.** 0.67 and 67%
b. 0.06
c. $\frac{3}{100}$
d. 1.25 and 125%

13. \$18

14. 1215 mg

15. 20 h

16. 49 h

17. 1292 ft^2

18. \$4.14

19. **a.** 250 sprays
b. 500 mg

20. 80 I.U.

21. 0.05 mL

22. **a.** Each dose = 300 mg
b. 12 mL
c. 56 mL

23. **a.** 1 tablet
b. 180 tabs

24. 10 mL/dose (20 mL/day)

25. 7.5 mL/h

26. 21 gtt/min

Solutions to Practice Problems

1. See answers above

2. See answers above

3. See answers above

4. **a.** $10^{6+1} = 10^7$

b. $10^{6-3} = 10^3$

c. $10^{2-3} = 10^{-1}$

d. $10^{4-7+3} = 10^0 = 1$

e. $10^{2-1+3-3+4} = 10^5$

5. See answers above

6. **a.** $(3 \times 10^1) \times (2 \times 10^2) = (3 \times 2) \times (10^1 \times 10^2) = 6 \times 10^3$

b. $\frac{9}{3} \times 10^{2-4} = 3 \times 10^{-2}$

c. $3 \times 2 \times 10^{2+1-(-1)} = 6 \times 10^4$

d. $\frac{70,000 \times 0.8 \times 30}{20 \times 600 \times 0.02} = \frac{7 \times 10^4 \times 8 \times 10^{-1} \times 3 \times 10^1}{2 \times 10^1 \times 6 \times 10^2 \times 2 \times 10^{-2}} =$
$\frac{7 \times 8 \times 3}{2 \times 6 \times 2} \times 10^{4-1+1-1-2+2} = \frac{168}{24} \times 10^3 = 7 \times 10^3$

e. $\frac{(4 \times 10^1) \times (3 \times 10^{-2})}{(2 \times 10^{-2}) \times (1 \times 10^4)} = \frac{(4 \times 3) \times (10^1 \times 10^{-2})}{(2 \times 1) \times (10^{-2} \times 10^4)} = \frac{12 \times 10^{-1}}{2 \times 10^2} = 6 \times 10^{-3}$

7. **a.** $\frac{0.020 \text{ mg}}{\text{tablet}} \times 350,000 \text{ tablets} = 7000 \text{ mg}$

[Estimate: $(2 \times 10^{-2}) \times (4 \times 10^5) = 8 \times 10^3 = 8000$ mg]

b. $\frac{500 \text{ g}}{\$3.79} = \frac{33 \text{ g}}{x}$

$x = \$0.25 = 25¢$

$\left[\text{Estimate: } x = \frac{(3 \times 10^1) \times 4}{5 \times 10^2} = 2.4 \times 10^{-1} = \$0.24 = 24¢\right]$

c. $8.8 \text{ g} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 8.800 \text{ mg}$

$\frac{3.3¢}{1 \text{ mg}} = \frac{x}{8800 \text{ mg}}$

$x = \$290.40$

[Estimate: $x = 3 \times (9 \times 10^3) = 27,000¢$ (i.e., = \$270)]

8. $0.5 \text{ qt} \times \frac{32 \text{ fl oz}}{1 \text{ qt}} = 16 \text{ fl oz}$

9. Sometimes, the relationship between the units given and the units desired is not known. Although we do not know the number of feet in 1 m, we do know that 1 m = 39.4 in. and

1 ft = 12 in. We may therefore first convert feet to inches and then inches to meters. But rather than treat our problem as two separate parts, we may set it up as follows: $17\text{ ft}\times\frac{12\text{ in.}}{1\text{ ft}}\times\frac{1\text{ m}}{39.4\text{ in.}} = 5.18\text{ m}$

10. The first fraction converts feet to inches; the second converts inches to meters. Notice that all units except for meters cancel out. There is no change in the value of the length represented by "17 ft." This technique may be extended to any number of successive conversions.

$$1.75\text{ L}\times\frac{1000\text{ mL}}{1\text{ L}}\times\frac{1\text{ fl oz}}{29.6\text{ mL}} = 59.1\text{ fl oz}$$

11. $30.3\text{ in.}\times\frac{2.54\text{ cm}}{1\text{ in.}}\times\frac{1\text{ atm}}{76\text{ cm}} = 1.01\text{ atm}$

12. **a.** $2:3 = 2\div 3 = 0.66\overline{6} = 0.67$
$0.67\times 100\% = 67\%$

b. $3:50 = 3\div 50 = 0.06$

c. $0.03 = 3\times 10^{-2} = \frac{3}{10^2} = \frac{3}{100}$

d. $\frac{5}{4} = 5\div 4 = 1.25$
$1.25\times 100\% = 125\%$

13. Using ratio we can state a relationship between prescription bottles and cost (dollars), then:

10 bottles = \$30

6 bottles = ? \$

Thus, we can set the following proportion:

$$\frac{10\text{ bottles}}{\$30} = \frac{6\text{ bottles}}{x}$$

Solving the proportion: $10\times x_{\$} = 30\times 6 \rightarrow x = \frac{180}{10} = \$18$

14. 4 tablets = 324 mg
15 tablets = ? mg

$$\frac{4\text{ tabs}}{324\text{ mg}} = \frac{15\text{ tabs}}{x} \rightarrow x = 1215\text{ mg}$$

15. As there is a logical numerical relationship between the data, one could skip the set up process and go straight to the answer: 20 h.

$$600\text{ mL} : 6\text{ h} = 2000\text{ mL} : x \rightarrow x = 20\text{ h}$$

$$\text{Or}\quad \frac{600\text{ mL}}{6\text{ h}} = \frac{2000\text{ mL}}{x} \rightarrow x = 20\text{ h}$$

16. $\frac{1\text{ set}}{3.5\text{ h}} = \frac{14\text{ sets}}{x} \rightarrow x = 3.5\times 14 = 49\text{ h}$

17. $\frac{4\text{ chairs}}{17\text{ ft}^2} = \frac{304\text{ chairs}}{x} \rightarrow x = \frac{304\times 17}{4} = 1292\text{ ft}^2$

18. $\dfrac{500 \text{ tabs}}{\$43.09} = \dfrac{48 \text{ tabs}}{x} \to x = \dfrac{48 \times 43.09}{500} = \$4.136 = \$4.14$

19. **a.** Total sprays in pkg = ? $\to \dfrac{25 \text{ sprays}}{\text{mL}} \times 10 \text{ mL} = 250 \text{ sprays}$

b. Milligrams in pkg = ? $\to \dfrac{2 \text{ mg}}{\text{spray}} \times 250 \text{ sprays} = 500 \text{ mg}$

20. I.U. = Units = ?

$\dfrac{400 \text{ units}}{15 \text{ mL}} \times \dfrac{\text{mL}}{15 \text{ gtt}} \times 45 \text{ gtt} = \dfrac{18,000}{225} = 80 \text{ units or } 80 \text{ I.U.}$

21. $\dfrac{100 \text{ mL}}{0.3 \text{ g}} \times \dfrac{1 \text{ g}}{1000 \text{ mg}} \times 0.15 \text{ mg} = 0.05 \text{ mL}$

22. **a.** $\dfrac{600 \text{ mg}}{\text{day}} \times \dfrac{\text{day}}{2 \text{ doses}} = 300 \text{ mg/dose}$

b. $\dfrac{5 \text{ mL}}{125 \text{ mg}} \times \dfrac{600 \text{ mg}}{2 \text{ doses}} = 12 \text{ mL}$

OR $\dfrac{5 \text{ mL}}{125 \text{ mg}} \times 300 \text{ mg} = 12 \text{ mL}$

c. $\dfrac{5 \text{ mL}}{125 \text{ mg}} \times \dfrac{7 \text{ mg}}{\text{kg.dose}} \times \dfrac{\text{kg}}{2.2 \text{ lb}} \times 44 \text{ lb} \times \dfrac{2 \text{ doses}}{\text{day}} \times 5 \text{ days} = 56 \text{ mL}$

23. **a.** No calculations required : 1 tab = 6.25 mg = dose

or

$\dfrac{\text{tabs}}{\text{dose}} = \dfrac{1 \text{ tab}}{6.25 \text{ mg}} \times \dfrac{12.5 \text{ mg}}{\text{day}} \times \dfrac{\text{day}}{2 \text{ doses}} = 1 \text{ tablet/dose}$

b. $\text{tabs} = \dfrac{1 \text{ tab}}{\text{dose}} \times \dfrac{2 \text{ doses}}{\text{day}} \times \dfrac{30 \text{ days}}{\text{month}} \times 3 \text{ months} = 180 \text{ tabs}$

24. $\dfrac{\text{mL}}{\text{dose}} = \dfrac{15 \text{ mL}}{1 \text{ tbsp}} \times \dfrac{1 \text{ tbsp}}{30 \text{ mEq}} \times \dfrac{40 \text{ mEq}}{\text{day}} \times \dfrac{\text{day}}{2 \text{ doses}} = 10 \text{ mL/dose}$

25. $\dfrac{\text{mL}}{\text{h}} = \dfrac{250 \text{ mL}}{5 \text{ mg}} \times \dfrac{1 \text{ mg}}{1000 \text{ µg}} \times \dfrac{2.5 \text{ µg}}{\text{min}} \times \dfrac{60 \text{ min}}{\text{h}} = 7.5 \text{ mL/h}$

26. $\dfrac{\text{gtt}}{\text{min}} = \dfrac{20 \text{ gtt}}{\text{mL}} \times \dfrac{500 \text{ mL}}{8 \text{ h}} \times \dfrac{1 \text{ h}}{60 \text{ min}} =$

$= 20.8 = 21 \text{ gtt/min}$ (only round number of drops can be measured)