Applying Mathematical Principles to Pharmaceutical Calculations

Most calculations in pharmacy can be solved by a series of conversions utilizing either ratio and proportion or dimensional analysis to perform the calculation. The student should pay particular attention to the information given and the information requested as the answer, making note of specified units. The pathway from the information given to the desired answer can be determined by establishing which conversions should be used, as shown in the following example problems.

Example calculations

1. *A typical college class period is 50 minutes. Express this time period in seconds.*
   Information given: 50 minutes
   Information requested as the answer: equivalent number of seconds
   Conversions to be used: 60 seconds per minute
   Solving by ratio and proportion:

$$\frac{50 \text{ minutes}}{x} = \frac{1 \text{ minute}}{60 \text{ seconds}};\ x = \mathbf{3000 \text{ seconds}}$$

   Solving by dimensional analysis:

$$50 \text{ minutes} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = \mathbf{3000 \text{ seconds}}$$

2. *A patient lives approximately 11 miles from the pharmacy. If the patient drives at an average speed of 45 miles per hour, how many minutes will it take him to reach the pharmacy?*
   Information given: 11 miles
   Information requested as the answer: time required for travel in minutes
   Conversions to be used: 45 miles per hour, 60 minutes per hour
   Solving by ratio and proportion:

$$\frac{11 \text{ miles}}{x} = \frac{45 \text{ miles}}{1 \text{ hour}};\ x = 0.244 \text{ hour}$$

$$\frac{0.244 \text{ hour}}{x} = \frac{1 \text{ hour}}{60 \text{ minutes}};\ x = \mathbf{14.67 \text{ minutes}}$$

   Solving by dimensional analysis:

$$11 \text{ miles} \times \frac{1 \text{ hour}}{45 \text{ miles}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = \mathbf{14.67 \text{ minutes}}$$

3. *Normal saline consists of 0.9% w/v sodium chloride in water and is a commonly used intravenous solution. How many milligrams of sodium chloride would be contained in 20 mL of this solution? NOTE: 0.9% sodium chloride is 0.9 g of sodium chloride in 100 mL of solution.*

   Although the information in this problem is not addressed until Chapter 6, the same format can be used.
   Information given: 20 mL of 0.9% w/v sodium chloride solution
   Information requested as the answer: amount of sodium chloride in milligrams

Conversions to be used: 0.9 g of sodium chloride per 100 mL of solution, 1000 mg per g
Solving by ratio and proportion:

$$\frac{0.9\text{ g}}{100\text{ mL}} = \frac{x}{20\text{ mL}};\ x = 0.18\text{ g}$$

$$\frac{1000\text{ mg}}{1\text{ g}} = \frac{x}{0.18\text{ g}};\ x = \mathbf{180\text{ mg}}$$

Solving by dimensional analysis:

$$20\text{ mL} \times \frac{0.9\text{ g}}{100\text{ mL}} \times \frac{1000\text{ mg}}{\text{g}} = \mathbf{180\text{ mg}}$$

CASE IN POINT 1.1 A pharmacist consults with a parent on the use of a cough syrup for her 5-year-old child. The nonprescription cough syrup contains, in each 5 mL (milliliters), 10 mg (milligrams) of dextromethorphan HBr, a cough suppressant, and 100 mg of guaifenesin, an expectorant. The package label indicates that the dose for a child 2 to 6 years of age is 1/4 of the adult dose of two teaspoonfuls. The pharmacist suggests using an oral syringe calibrated in 0.25-mL units for dosing. If a standard teaspoonful is equivalent to 5 mL, (a) how many milliliters should be administered to the child, and (b) how many milligrams of each of the 2 therapeutic ingredients would be administered per child's dose?

PRACTICE PROBLEMS

1. If an insulin injection contains 100 units of insulin in each milliliter, how many milliliters should be injected to receive 40 units of insulin?
2. An injection contains 2 mg of medication in each milliliter (mL). If a physician prescribes a dose of 0.5 mg to be administered to a hospital patient three times daily, how many milliliters of injection will be required over a 5-day period?
3. A formula for 1250 tablets contains 6.25 grams of diazepam. How many grams of diazepam should be used in preparing 550 tablets?
4. If 100 capsules contain 400 mg of an active ingredient, how many milligrams of the ingredient will 48 capsules contain?
5. Each tablet of TYLENOL WITH CODEINE contains 30 mg of codeine phosphate and 300 mg of acetaminophen. By taking 2 tablets daily for a week, how many milligrams of each drug would the patient take?
6. A cough syrup contains 10 mg of dextromethorphan hydrobromide per 5 mL. How many milligrams of the drug are contained in a 120-mL container of the syrup?
7. If an intravenous fluid is adjusted to deliver 15 mg of medication to a patient per hour, how many milligrams of medication are delivered in 30 seconds?
8. The biotechnology drug filgrastim (NEUPOGEN) is available in syringes containing 480 micrograms (mcg) of filgrastim per 0.8 mL. How many micrograms of the drug would be administered by each 0.5 mL injection?

(*Continued*)

9. An oral solution contains, in each milliliter, 80 mg of lopinavir and 20 mg of ritonavir. How many milligrams of each drug would be contained in a calculated dose of 0.4 mL?
10. Aripiprazole (ABILIFY) injection is available in single-dose vials containing 9.75 mg of aripiprazole in each 1.3 mL of injection. Calculate the volume of injection that would provide a dose of 5.25 mg of aripiprazole.
11. Acyclovir (ZOVIRAX) suspension contains 200 mg of acyclovir in each 5 mL. How many milligrams of acyclovir are contained in a pint (473 mL) of suspension?
12. A pediatric vitamin drug product contains the equivalent of 0.25 mg of fluoride ion in each milliliter. How many milligrams of fluoride ion would be provided by a dropper that delivers 0.6 mL?
13. If a pediatric vitamin contains 1500 units of vitamin A per milliliter of solution, how many units of vitamin A would be administered to a child given 2 drops of the solution from a dropper calibrated to deliver 20 drops per milliliter of solution?
14. An elixir contains 25 mg of drug in each 5 mL. How many milligrams of the drug would be used in preparing 4000 mL of the elixir?
15. An elixir of ferrous sulfate contains 220 mg of ferrous sulfate in each 5 mL. If each milligram of ferrous sulfate contains the equivalent of 0.2 mg of elemental iron, how many milligrams of elemental iron would be represented in each 5 mL of the elixir?
16. An estradiol transdermal patch is available in various patch sizes. The patch size is closely proportional to the amount of drug contained in the patch. If the patch containing 0.025 mg of estradiol is 6.5 cm^2 in size, calculate the approximate size of the patch containing 0.1 mg of estradiol.
17. If an ophthalmic solution contains 1 mg of dexamethasone phosphate in each milliliter of solution, how many milligrams of dexamethasone phosphate would be contained in 2 drops if the eyedropper used delivered 20 drops per milliliter?
18. A 15-mL package of nasal spray delivers 20 sprays per milliliter of solution, with each spray containing 1.5 mg of drug. (a) How many total sprays will the package deliver? (b) How many milligrams of drug are contained in the 15-mL package of the spray?
19. A penicillin V potassium preparation provides 400,000 units of activity in each 250-mg tablet. How many total units of activity would a patient receive from taking 4 tablets a day for 10 days?
20. The blood serum concentration of the antibacterial drug ciprofloxacin increases proportionately with the dose of drug administered. If a 250-mg dose of the drug results in a serum concentration of 1.2 micrograms of drug per milliliter of serum, how many micrograms of drug would be expected per milliliter of serum following a dose of 500 mg of drug?

Percent

The term ***percent*** and its corresponding sign, %, mean "in a hundred." So, *50 percent* (*50%*) means 50 parts in each one hundred of the same item.

In pharmacy, percent most often is used to: (a) define the concentration or strength of a pharmaceutical preparation (e.g., a 10% ointment), (b) describe the accuracy of a method or procedure (e.g., a 5% error in a measurement or weighing), and (c) quantify a parameter

in a clinical study (e.g., 15% of subjects exhibited a particular effect). Calculations relating to subject area (a) are presented in Chapter 6, and those of subject area (b) are presented in Chapter 3.

The following examples demonstrate the use of percent to define a clinical result.

1. *During a clinical study involving 2430 subjects, 2% of the subjects developed a headache. How many patients experienced this adverse effect?*

NOTE: In performing a pharmaceutical calculation, a given percent may be used directly (as when using a calculator), or it may be converted to a ratio or decimal fraction (e.g., 2% = 2/100 = 0.02).

$2430 \times 2\% = 48.6$ or **48 patients,**

or, $2430 \times 2/100 = 48.6$ or **48 patients,**

or, $2430 \times 0.02 = 48.6$ or **48 patients.**

2. *During a clinical study, 48 out of a total of 2430 patients developed a headache. Calculate the percent of patients who experienced this adverse effect.*

$$\frac{48}{2430} \times 100\% = 1.975\% \text{ or } \approx \mathbf{2\%}$$

PRACTICE PROBLEMS

1. In a clinical study of niacin as a lipid-altering agent, 60% of the 90 patients in the study group developed flushing. Calculate the number of patients having this reaction.
2. In a clinical study of divalproex sodium (DEPAKOTE) in patients prone to migraine headaches, nausea occurred in 62 of 202 patients, whereas the use of a placebo resulted in nausea in 8 of 81 patients. Compare these data in terms of percent of subjects reporting nausea in each study group.
3. If a clinical study of a new drug demonstrated that the drug met the effectiveness criteria in 646 patients of the 942 patients enrolled in the study, express these results as a decimal fraction and as a percent.
4. The literature for a pharmaceutical product states that 26 patients of the 2103 enrolled in a clinical study reported headache after taking the product. Calculate (a) the decimal fraction and (b) the percentage of patients reporting this adverse response.
5. In a clinical study, a drug produced drowsiness in 30 of the 1500 patients studied. How many patients of a certain pharmacy could expect similar effects, based on a patient count of 100?

Alligation

Alligation is an arithmetic method of solving problems relating mixtures of components of different strengths. There are two types of alligation: *alligation medial* and *alligation alternate*.

Alligation medial may be used to determine the strength of a common ingredient in a mixture of two or more preparations. For example, if a pharmacist mixed together known volumes of two or more solutions containing known amounts of a common ingredient, the strength of that ingredient in the resulting mixture can be determined by alligation medial.

Alligation alternate may be used to determine the proportion or quantities of two or more components to combine in order to prepare a mixture of a desired strength. For example, if a pharmacist wished to prepare a solution of a specified strength by combining two

or more other solutions of differing concentrations of the same ingredient, the proportion or volumes of each solution to use may be determined by alligation alternate.

Alligation medial and alligation alternate may be used as options in solving a number of pharmaceutical calculations problems. The methods and problem examples are presented in Chapter 15.

Estimation

It is important for pharmacy students and pharmacists to recognize the *reasonableness* of the result of a calculation. By performing an *estimation* of the answer *prior* to calculation, the approximate result may be predetermined. This helps assure the correct dimension of the answer, including the critical placement of a decimal point.

The technique of estimation is demonstrated by the examples that follow. Rounding of numbers is a component of this process.

Add the following numbers: 7428, 3652, 1327, 4605, 2791, and 4490.

Estimation:

The figures in the thousands column add up to 21,000, and with each number on the average contributing 500 more, or every pair 1000 more, we get 21,000 + 3000 = 24,000, *estimated answer* (actual answer, 24,293).

In *multiplication*, the product of the two leftmost digits plus a sufficient number of *zeros* to give the right place value serves as a fair estimate. The number of zeros supplied must equal the total number of all discarded figures to the left of the decimal point. Approximation to the correct answer is closer if the discarded figures are used to round the value of those retained.

Multiply 612 by 413.

Estimation:

$4 \times 6 = 24$, and because we discarded four figures, we must supply four zeros, giving 240,000, *estimated answer* (actual answer, 252,756).

In *division*, the given numbers may be rounded off to convenient approximations, but again, care is needed to preserve the correct place values.

Divide 2456 by 5.91.

Estimation:

The numbers may be rounded off to 2400 and 6. We may divide 24 by 6 mentally, but we must remember the two zeros substituted for the given 56 in 2456. The estimated answer is 400 (actual answer, 416).

PRACTICE PROBLEMS

1. Estimate the sums:

a. 5641	b. 3298	c. $75.82
2177	368	37.92
294	5192	14.69
8266	627	45.98
3503	4835	28.91
		49.87