EDITION 8

Math for Nurses

A Pocket Guide to Dosage Calculation and Drug Preparation

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Wolters Kluwer Health | Lippincott Williams & Wilkins


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Measurement Systems

There are three systems of measurement in use today: the metric, household, and apothecary systems.

The **metric system** is the recommended system of choice for dosage calculations because it is the most accurate and consistent.

The **household system**, whichis used most frequently in home settings, is inaccurate because of the variations in household measuring devices.

The **apothecary system** is being phased out because it is an approximate system that is not as exact as the metric system and its use of symbols and Roman numerals is confusing. The Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) and the Institute for Safe Medication Practices (ISMP) have both recommended that the apothecary system should not be used. However, because the apothecary system is still used by physicians (drugs ordered in grains and minims) and two common measurement items (medicine cups and syringes) still include apothecary units, this system will bepresented here along with the metric and household systems.

- Each measurement system has three basic measures: weight, volume, and length. Drugs are commonly prescribed by weight (milligrams, grams, grains) and volume (milliliters, ounces). Length is usually used for assessment (inches, millimeters, and centimeters).

CHAPTER 5

The Metric, Household, and Apothecary Systems of Measurement

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- List the common rules for metric, household, and apothecary notations.
- Distinguish between the three basic units of measure: length (meter), weight (gram), and volume (liter) for each system.
- Make conversions within each system.

The Metric System

The metric system is the most popular system used today for drug prescription and administration because it is the most accurate system. The metric system of weights and measures is an international decimal system based on multiples of ten. It is also referred to as the International System of Units (SI Units).

The metric system has three basic units of measurement: length (meter), volume (liter), and weight (gram, milligram, microgram and kilogram). Five common prefixes are used to indicate subunits of measure:

micro = one millionth = mcg
milli = one thousandth = m
centi = one hundredth = c
deci = one tenth = deci
kilo = one thousand = kg

In the metric system, portions can be increased (multiplied) or decreased (divided) by multiples of 10 (10, 100, 1,000). Conversions are achieved by moving the decimal point to the right for multiplication or to the left for division. For example:

1.0 *increased by* 10 = 1.0 = 10

100 *increased by* 10 = 100.0 = 1,000

0.1 *decreased by* 10 = 0.1 = 0.01

100 *decreased by* 10 = 100. = 10

Common Rules for Metric Notations

1. RULE

Metric abbreviations always follow the unit amount or numbers.

0.2 mL, 10 kg

2. RULE

Metric abbreviations are written in lowercase letters except for the abbreviation for *liter,* for which the "L" is capitalized.

g = gram
mL = milliliter

3. RULE

Fractional units are expressed as decimals.

0.5 mL *not* 1/2 mL

4. RULE

Zeros are used *in front of* the decimal point when not preceded by a whole number to emphasize the decimal. Omit unnecessary zeros so the dosage is not misread.

0.5 mL *not* 0.50 mL
1 mL *not* 1.0 mL

Meter—Length

The meter is:

- The basic unit of *length*
- Equal to 39.37 inches
- Abbreviated as m

The primary linear measurements used in medicine are centimeters (cm) and millimeters (mm). Square meters are used for body surface area (m^2). Centimeters are used for calculating body surface area and measuring such things as the size of body organs, tumors, and wounds. Millimeters (of Hg) are used for blood pressure measurements.

Liter—Volume

The liter is:

- The basic unit of *volume*
- The total volume of liquid in a cube that measures 10 cm × 10 cm × 10 cm (1,000 = cm^3)
- Equal to 1,000 mL
- Has a mass (1 L of water) equal to one kilogram (1 kg) at 4°C (degrees Celsius)
- Abbreviated as L

Gram—Weight

The gram is:

- The basic unit of *weight*
- The most widely used unit of measurement for food products

Table 5.1 Common Metric Measurements and Equivalents

1 gram (g)	=	1,000 milligrams (mg)
1 milligram (mg)	=	1,000 micrograms (mcg)
1 kilogram (kg)	=	1,000 grams (g)
1 liter (L)	=	1,000 milliliters (mL)
1 meter (m)	=	100 centimeters (cm) 1,000 millimeters (mm)

- One, one-thousandths of the SI base unit of a kilogram
- Equal to a volume of 1 mL
- Abbreviated as g

Refer to Table 5.1 for common metric measures and equivalents.

The Apothecary System

Once the first system of measurement for medications, the apothecary system is *not recommended* for use today. The use of symbols and fractions is confusing and can lead to errors. Sometimes a medication label indicates grains, and the metric equivalent is in milligrams. Because the apothecary system may still be used in some instances, it is presented here.

The apothecary system uses approximate measures, fractions (for amounts less than 1), Arabic numbers, and Roman numerals (see Appendix A). The abbreviation “gr” is used for grain, the only unit of weight in this system. The symbols for the liquid measures of dram and ounce are no longer used; this is to avoid medication errors. If medications are ordered in drams or ounces, the words “drams” and “ounces” are written out. The abbreviation “gtt” is used for drop (see Chapter 10) and “m” for minim, which can be found on some syringes. One-half can be abbreviated ss or s¯s.

It is helpful to understand the relationship of these terms to the concepts of weight and volume. The original standard measurement of a grain was an amount equal to the weight of a grain of wheat. The minim is considered equal to the quantity of water in a drop that also weighs 1 grain. A dram is equal to 4 mL; an ounce is equal to 30 mL.

Common Rules for the Apothecary System

RULE

Lowercase Roman numerals are used to express whole numbers.

3 = iii 6 = vi

RULE

Arabic numbers are used for larger quantities (except for 5, 10, and 20) or when the amount is written out.

12 ounces

RULE

The apothecary abbreviation/word *always goes before* the quantity.

gr x = 10 grains

drams viii = 8 drams

RULE

Fractions are used to express quantities that are less than 1 (e.g., gr 1/3). The abbreviation ss or $\overline{ss}$ may be encountered for the fraction 1/2; however, its use is not recommended.

Refer to Table 5.2 for apothecary units of weight and volume.

Household Measurements

Household measurements are calculated by using containers easily found in the home. Common household measuring devices are those utensils used for cooking, eating, and measuring liquid proportions. They include medicine droppers, teaspoons, tablespoons, cups, and glasses. Because containers in the home differ in design, size, and capacity, it is impossible to establish a standard unit of measure. Patients should always be

Table 5.2 Common Apothecary Units of Weight and Volume

Unit	Weight or Volume	Abbreviation or Term
Grain		gr
Drop	One drop of water	gtt
Minim	One drop	m
Dram	60 grains	dram
Ounce	8 drams or 30 mL	ounce
Pound	12 ounces*	lb

*In this system a pound is slightly less (12 ounces) than the 16 ounces in the household system.

Table 5.3 Common Household Quantities and Metric Equivalents

Unit	Volume	Abbreviation	Metric Equivalent
Drop	—	gtt	—
Teaspoon	60 drops	tsp	5 mL
Tablespoon	3 tsp	tbsp	15 mL
Ounce	2 tbsp	oz	30 mL
Tea cup	6 ounces	c	180 mL
Measuring cup	8 ounces	C	240 mL
Pint	16 ounces	pt	500 mL
Quart	2 pt	qt	1,000 mL
Gallon	4 qt	gal	

advised to first use measuring cups or droppers packaged with medications.

It is expected that the household measurement system will increase as health care continues to move into the home and community. The nurse or health care provider will have to teach the patient and family how to measure the amount of medication prescribed, so every effort needs to be made to be as exact as possible. Refer to Table 5.3.

Probably the *most common* measuring device found in the home is the measuring cup, which calibrates ounces and is available for liquid and dry measures (Figure 5.1). Some pharmaceutical companies package 1-ounce measuring cups or calibrated medicine droppers with their over-the-counter medications (e.g., NyQuil, Children's Tylenol). A medication dropper (sometimes supplied with the prescription) marked in mg and mL or an oral syringe marked in teaspoons is commonly used for children (Figure 5.2).

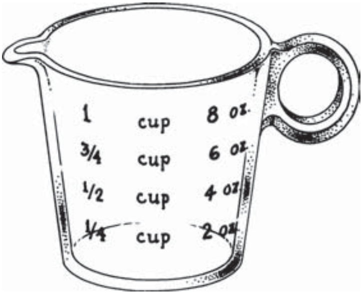

FIGURE 5.1 Standard liquid measuring cup (8-ounce capacity)—a common household container.

Common Rule for the Household System

RULE

Arabic whole numbers and fractions *precede* the unit of measure.

¼ cup 8 ounces 3 cups 2 pints

The household system of measurement uses Arabic whole numbers and fractions to precede the unit of measure. Standard cookbook abbreviations are also used (tsp, tbsp, oz). The basic unit of this system is the drop (gtt). A drop is equal to a drop, regardless of the liquid's viscosity (sticky or gummy consistency).

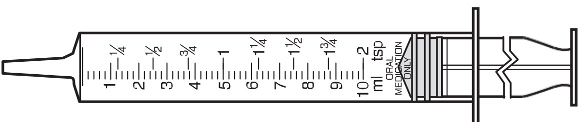

FIGURE 5.2 Oral dosage syringe. (From Craig, G. [2009]. *Clinical Calculations Made Easy* [4th ed.]. Philadelphia: Lippincott Williams & Wilkins.)

FIGURE 5.3 One-ounce medicine cup commonly used in hospitals. Indicates household, apothecary, and metric equivalents.

Therefore, when medicine needs to be given in drops, a standard dropper should be used. Household measurements are approximate in comparison to the exactness of the metric and apothecary systems. Hospitals use a standard 1-ounce medicine cup (Figure 5.3). These calibrated containers provide metric, apothecary, and household system equivalents.

RULE

When measuring a liquid medication in a household container, determine the container's capacity *prior to preparing* the medication.

When measuring a liquid medication, it is important that the container/dropper be held so that the calibrations are at eye level. When a container/dropper is held at eye level, the liquid will appear to be uneven or U-shaped. This curve, called a *meniscus,* is caused by surface tension; its shape is influenced by the viscosity of the fluid. Read the calibration at the bottom of the meniscus when measuring the level of a liquid medication. See Figure 5.4.

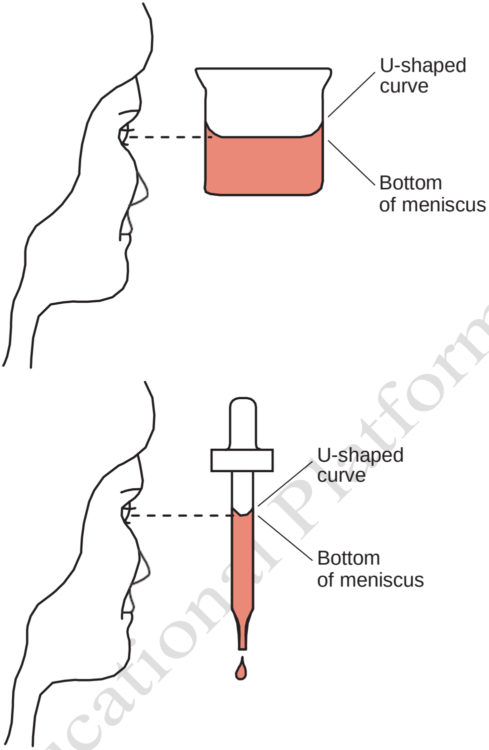

FIGURE 5.4 Liquid medication being read at the bottom of the meniscus; the container or dropper is held at eye level.

Converting Within the Same System: Metric System

Converting or changing units in the metric system is easily done by moving the decimal point. If you choose, you can always use ratio and proportion.

Refer to the following diagram to understand the concept of moving the decimal point when converting dosages. The liter is used as an example.

Move decimal point to the right (larger unit to smaller unit): multiply numeral by 10:

1 $\quad$ 10 $\quad$ 100 $\quad$ 1000

$\longrightarrow$

1 liter = 10 deciliters = 100 centiliters = 1,000 milliliters

Move decimal point to the left (smaller unit to larger unit): divide numeral by 10:

1 $\quad$ 10 $\quad$ 100 $\quad$ 1000

$\longleftarrow$

1 liter = 10 deciliters = 100 centiliters = 1,000 milliliters

RULE

To move *froma smaller* unit *to a larger* unit within the same system: *Divide* the numeral by moving the decimal point *to the left* the number of places to be moved (move one place for each increment).

EXAMPLE: Change millimeters (6,000) to decimeters. To move from milli to deci, you need to move the decimal point two places *to the left.*

60.00 = 60

(milli) = (deci)

ANSWER: 60 dm

RULE

To move *froma larger* unit *to a smaller* unit within the same system: *Multiply* the numeral by moving the decimal point *to the right* the number of places to be moved (move one place for each increment of 10).

EXAMPLE: Change decimeters (80) to centimeters. To move from deci to centi, you need to move the decimal point one place *to the right.*

80.0. = 800

c

(deci) = (centi)

ANSWER: 800 cm

PRACTICE PROBLEMS

Change the following units of metric length, volume, and weight:

1. 3.60 cm = ______________________ m
2. 4.16 m = ______________________ dm
3. 0.8 mm = ______________________ cm
4. 2 mm = ______________________ m
5. 20.5 mm = ______________________ cm

6. 18 cm = ______________________ mm

7. 30 dm = ______________________ mm

8. 2 cm = ______________________ m

9. 6 cm = ______________________ mm

10. 10 dm = ______________________ m

11. 3.6 mL = ______________________ L

12. 6.17 cL = ______________________ mL

13. 0.9 L = ______________________ mL

14. 6.40 cg = ______________________ mg

15. 1,000 mg = ______________________ g

16. 0.8 mg = ______________________ dg

17. 8 g = ______________________ cg

18. 16 dL = ______________________ mL

19. 41.6 mL = ______________________ L

20. 32 dg = ______________________ mg

Converting Within the Same System: Household and Apothecary

Conversions within the same system for the apothecary system and household measures *require the memorization of common equivalents,* which can be found in Tables 5.2 and 5.3. There is a standard rule to use to convert units *within the same system,* using ratio and proportion. Converting *between systems* will be covered in Chapter 6.

RULE

To change units within the same system: Determine equivalent values, write down in a fraction or colon format *what you know* followed by *what you desire,* and solve for *x.*

EXAMPLE #1:

- Select the equivalent values in the system. If you want to know how many milliliters (mL) there are in 2.5 ounces, look up the equivalent value of 30 mL = 1 ounce (Table 5.3).
- Write down *what you know* in a colon or fraction format:

$$\frac{30\text{ mL}}{\text{ounc}} \quad \text{r} \quad 30\text{ mL} \qquad \text{ounc}$$

- Write down *what you desire* in a colon or fraction format to complete the proportion. The numerators and denominators must be the same units of measurement. The answer x will be in ounces.

$$\frac{30\text{ mL}}{\text{ounce}} \quad \frac{\text{mL}}{2\ 5}$$

or

$$30\text{ mL} : 1\text{ ounce} = x\text{ mL} : 2.5\text{ ounces}$$

- Cross-multiply (fraction format) or multiply the extremes and then the means (colon format). Remember: The unit used for an answer will be mL.

$$30\text{ mL} : 1\text{ ounce} = x\text{ mL} : 2.5\text{ ounces}$$
$$x\text{ mL} = 30 \times 2.5$$
$$x\text{ mL} = 75\text{ mL}$$

EXAMPLE #2: Select the equivalent values in the system (see Table 5.3). If you want to know how many ounces there are in 4 tablespoons, look up the equivalent value of 1 ounce = 2 tablespoons.

- Write down *what you know* in a fraction or colon format.

$$\frac{2\text{ tb}}{\text{o}} \quad \text{r} \quad 2\text{ tbs} : \quad \text{z}$$

- Write down *what you desire* in a fraction or colon format to complete the proportion. The answer x will be in ounces. The numerators and denominators must be the same units of measurement.

$$\frac{2\text{ tb}}{\text{o}} : \frac{4\text{ tb}}{\text{z}}$$

or

$$2\text{ tbs} : 1\text{ oz} = 4\text{ tbs} : x\text{ oz}$$

- Cross-multiply (fraction format) or multiply the extremes and then the means (colon format). Remember: The unit used for an answer will be in ounces.

$$2\text{ tbs} \times 1\text{ ounce} = 4\text{ tbs} \times x\text{ ounces}$$
$$2x = 4$$

- Solve for x:

$$\frac{2}{2} \quad \frac{4}{2}$$

$$\frac{-}{-} \quad \frac{4}{2}$$

$$\frac{4^{2}}{-_{1}} \quad 2$$

ANSWER: 2 ounces

End of Chapter Review

Change the following units of metric length:

1. 7.43 mm = ______ m

2. 0.06 cm = ______ dm

3. 10 km = ______ m

4. 62.17 dm = ______ mm

Change the following units of metric volume:

5. 1.64 mL = ______ dL

6. 0.47 dL = ______ L

7. 10 L = ______ cL

8. 56.9 cL = ______ mL

Change the following units of metric weight:

9. 35.6 mg = ______ g

10. 0.3 g = ______ cg

11. 0.05 g = ______ mg

12. 93 cg = ______ mg

13. 100 mcg = ______ mg

14. 2 mg = ______ mcg

15. 1.0 mcg = ______ mg

16. 7 kg = ______ g

Perform the following miscellaneous conversions:

17. 4 mg = ______ mcg

18. 13 kg = ______ g

19. 2.5 L = ______ mL

20. 0.6 mg = ______ mcg

21. 0.08 g = ____ mg **22.** 0.01 mg = _____ mcg

23. 60 mg = _____ g **24.** 10.5 mg = ______ mcg

25. 0.5 mL = ______ L **26.** 100 mg = ______ dg

27. 3.5 dg = g **28.** 3.4 mg = g

29. 30 mg = _____ mcg **30.** 13 cg = ______ g

31. 2 kg = ______ g **32.** 18 L = _______ mL

33. 450 g = _____mg **34.** 40 mcg = ______mg

35. 8 L = _______dL **36.** 10 L = ________cL

37. 46 g = ______dg **38.** 0.5 g = ______mg

39. 500 mL = _____L **40.** 25 kg = _______g

Write the following, using Roman numerals and symbols:

41. 3 grains________ **42.** 5 drams __________

43. 5 grains_________ **44.** 10 minims ________

45. 20½ minims_____ **46.** 5 pints ___________

Solve the following:

47. 8 quarts = _________________________gallon(s)

48. 4 drams = _________________________ounce(s)

49. 2 tablespoons = ____________________ ounce(s)

50. gr xxx = ____________________ gram(s)

51. 4 pints = ____________________ quart(s)

52. 4 ounces = ____________________ pint(s)

53. 15 grams = ____________________ dram(s)

54. 12 ounces = ____________________ teacup(s)

55. 3 glasses = ____________________ ounces

56. 6 tablespoons = ____________________ ounce(s)

57. 2 teaspoons = ____________________ drops

58. 3 tablespoons = ____________________ teaspoons

59. 2 cups = ____________________ ounces

60. 8 ounces = ____________________ pint(s)

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CHAPTER 6

Approximate Equivalents and System Conversions

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Identify volume and weight equivalents for the metric and apothecary systems, as well as for household measurements.
- Identify linear equivalents for household measures and the metric system.
- Convert approximate equivalents between the metric, apothecary and household measurement systems.
- Apply three methods of converting between systems: conversion factor, ratio and proportion, and dimensional analysis.

In the preceding chapter, you learned how to change units from one measurement to another *within the same system*. Frequently, you will have to *convert between systems*. When converting, you work with *approximate equivalents* because exact measurements across different systems are not possible. It is essential that you memorize common equivalents and conversions.

A common example of such a discrepancy is between the metric and apothecary systems. For example, a medication label will indicate 5 gr, and its equivalent dosage may be written as 300 mg or 325 mg. Both dosages are correct; the equivalent values are approximate. Remember: Most dosage calculations use 60 mg = 1 gr.

Because you will have to convert between systems, a table of equivalent values is provided. You must memorize the equivalents found in Table 6.1. Remember that when calculating dosages, division is carried out to two decimal places and decimals are rounded off to ensure accuracy (Appendix B).

The metric and English household equivalents for length are rarely used for drug dosage calculations but can be used when applying a paste, cream, or ointment that needs to cover a certain area. However, both are used for linear measurements; for example, to measure wound size, head circumference, abdominal girth, and height.

Dosage Calculations: Converting Between Systems

Whenever the physician orders a drug in a unit that *is in a different system from the drug that is available,*

Table 6.1 Commonly Used Approximate Equivalents: Metric, Apothecary, and Household Systems of Measure

Metric	Apothecary	Household
—	1 gtt = 1 m (minim)	1 drop
4 mL	1 dram	—
5 mL	—	1 teaspoon (tsp)
15 mL	4 drams	1 tablespoon (tbsp)
30 mL	8 drams	2 tbsp (1 oz)
180 mL	—	1 teacup (6 oz)
240 mL	—	1 glass/measuring cup (8 oz)
500 mL	1 pt	1 pt (16 oz) = 2 cups
1,000 mL (1 L)	1 qt	1 qt (32 oz) = 4 cups
60–65 mg	1 gr	—
1 g (1,000 mg)	15 gr	—
1 kg (1,000 g)	—	2.2 lb
1 mg = 1,000 mcg	—	—
2.5 cm	—	1 inch

convert to the available system. You want to work in the system of the drug that you have on hand.

RULE

Whenever the desired and available drug doses are in two different systems: Choose the equivalent value and solve for *x*. Always change the desired quantity to the available quantity.

You can use one of three methods to convert between systems: the conversion factor method, ratio and proportion, or dimensional analysis. With each method you must first remember the equivalent value!

The Conversion Factor: Use the equivalent value and either *multiply* (going from a larger to a smaller unit) or *divide* (going from a smaller to a larger unit).

EXAMPLE: A physician ordered gr ⁄2 of a medication. You need to give mg.

Equivalent value: 1 gr = 60 mg

Move from a larger unit (grain) to a smaller unit (milligram). Multiply by the conversion factor (60 mg).

$$\text{gr } \tfrac{1}{2} \times \quad \frac{}{1} \quad \frac{\cancel{60}^{30}}{} \quad 90 \text{ mg}$$

ANSWER: 90 mg

Ratio and Proportion: Select the equivalent value and then set up the proportion using either a colon or fraction format.

EXAMPLE: #1 Give 1.5 ounces of an elixir that is available in mL.

- Change ounces to mL. Choose the equivalent value.

$$30 \text{ mL} = 1 \text{ ounce}$$

- Complete the proportion. Write down what you know. A fraction format is used here.

$$\frac{30 \text{ mL}}{\text{z}} \qquad \frac{\text{mL}}{.5 \quad \text{z}}$$

- Solve for x:

$$x = 30 \times 1.5 = 45 \text{ mL}$$

ANSWER: 45 mL

EXAMPLE: #2 Give gr 1/4 of a drug that is available in mg.

- Select the approximate equivalent value and convert to the system that you have available.

  Change gr 1/4 to mg
  (mg are available).

- Choose the equivalent value.

  60 mg = 1 gr

- Complete the proportion. Write down *what you know*. A colon format is used here.

  60 mg : 1 gr :: *x* mg : gr 1/4

  x = 60 × 1/4

- Solve for *x*:

$$ {}^{15}\cancel{60} \quad \frac{}{4} \qquad 15 \qquad 5\text{ mg} $$

ANSWER: 15 mg

Dimensional Analysis: This is presented in detail in Chapter 8.

PRACTICE PROBLEMS

Complete the following. Solve for x or the unknown by using a fraction or colon format.

1. 12 oz = _____ mL
2. 0.3 mL = _____ L
3. 30 mL = _____ tbsp
4. 45 mg = _____ gr
5. 2 tsp = _____ mL
6. 30 kg = _____ lbs

Complete the following. Solve for x or the unknown by using a fraction or colon format.

7. gr 1/200 = ___ mg
8. 3 pt = ______ mL
9. 30 gr = _____ g
10. 300 mcg = ___ mg
11. 30 mL = ____ oz
12. 4 tbsp = _____ mL
13. 6 mg = _____ gr
14. 3 g = ______ gr
15. 1 L = ______ qt
16. 2 qt = ______ L
17. 2.2 lb = _____ kg
18. s¯s oz = _____ mL

End of Chapter Review

Complete the following. Solve for x by using a fraction or colon format.

1. A child who weighs 55 lb weighs ________ kg.
2. Two (2) grams of Metamucil powder is equivalent to __________ gr.
3. A patient is restricted to four 8-ounce glasses of water per day or ____________ mL per day.
4. A patient's abdominal wound measures 10 cm in diameter. The nurse knows that this is equivalent to ____________ inch(es).
5. A child was prescribed 10 mL of cough syrup four times a day, as needed. The child's mother administered ____________ tsp each time the medication was given.
6. The nurse administered aspirin gr v. She knew this was equivalent to ____________ mg.
7. The nurse instilled 3 minims of an eye drop into the patient's right eye, three times per day. The nurse knew that 3 minims were equal to _______ gtt.

8. The physician prescribed 0.4 mg of atropine sulfate to be administered intramuscularly. The medication was labeled in gr per mL. The nurse knew to look for an ampule labeled__________gr per mL.

9. A patient was to take 2 tbsp of milk of magnesia. Because a medicine cup was available, he poured the milk of magnesia up to the___________________-ounce calibration line.

10. A 40-lb child was ordered a drug to be given at 10 mg per kg of body weight. The child weighs_____kg and should receive_________mg of the drug.

11. A woman was prescribed 60 mg of a daily vitamin. Her cumulative monthly dose (30 days) would be about__________g.

12. A patient who takes 1 tbsp of Kayexalate four times per day would be receiving a daily dose equivalent to___________ounces.

13. A patient takes a 500-mg tablet three to four times per day. He is advised not to exceed a daily dose of 3 g or___________tablets.

14. A patient is to receive 250 mg of a liquid medication, three times daily. The medicine is available in oral suspension, 250 mg per 5 mL. The nurse should give____________tsp for each dose.

15. A patient is to receive a 200-mg tablet every 12 hours. The tablet is available in 200-mg quantities. The patient would receive________g per day.

16. A child is prescribed a 250-mg tablet every 6 hours. The nurse gives two tablets, four times a day. Each dose would be__________mg for a daily total dosage of__________g.

17. A renal patient whose daily fluid intake is restricted to 1,200 mL per day is prescribed eight oral medications, three times daily. The nurse restricts the water needed for swallowing the medications so the patient can have fluids with his meals. The patient is allowed 5 ounces of water, three times a day, with his medications. Therefore, the patient has__________mL with his drugs.

18. Tylenol liquid is available as 325 mg per 5 mL. A patient who is prescribed 650 mg would be given__________tsp.

19. A patient is to receive 30 mg of a drug available as 10 mg per teaspoon. The nurse would give______tablespoon(s).

20. A physician prescribes 0.3 mg of a drug, twice daily. The medication is available in 0.15-mg tablets. The nurse would give__________tablets each dose, equivalent to________mg daily.

thePoint Additional practice problems to enhance learning and facilitate chapter comprehension can be found at **http://thePoint.lww.com/Boyer8e.**

End of Unit 2 Review

Convert each item to its equivalent value.

1. 0.080 g = __________ mg
2. 3.2 L = __________ mL
3. 1,500 mcg = __________ mg
4. 0.125 mg = __________ mcg
5. 20 kg = __________ g
6. 5 mg = __________ g
7. 155 lb = __________ kg
8. 30 minims = __________ gtt
9. 15 grains = __________ gram(s)
10. 1/2 qt = __________ ounces
11. 3 pt = __________ quart(s)
12. 8 drams = __________ ounce(s)

13. 1 tbsp = __________ tsp

14. 6 tsp = __________ ounce(s)

15. 1 teacup = __________ ounces

16. 2 tbsp = __________ ounce(s)

17. gr $\overline{\text{ss}}$ = __________ mg

18. 30 g = __________ ounce(s)

19. 1 oz = __________ mL

20. gr 1 = __________ mg

21. 3 tsp = __________ mL

22. 20 kg = __________ lb

23. gr 1/150 = __________ mg

24. 0.3 mg = __________ gr

25. 1.8 oz = __________ mL

26. 20 mL = __________ tsp

27. 8.5 g = __________ mg

28. 950 mg = __________ g

29. 15 mg = __________ gr

30. 6 mg = __________ mcg

3 Dosage Calculations

Accurate dosage calculations are an essential component of the nursing role in the safe administration of medications. Medications are prescribed by their generic (official) name or trade (brand) name and are usually packaged in an average unit dose. Oral medications contain a solid concentration of drug, per quantity of one. Liquid medications contain a specific amount of drug, usually gram weight, dissolved in solution (e.g., mL)—for example, Demerol, 50 mg per mL, or Vistaril, 25 mg per 5 mL. Medication orders refer to drug dosages, so calculations will be necessary if a dosage prescribed is different (with regard to system and/or unit of measurement) from the available dosage. This unit will present common dosage calculations for oral and parenteral routes for adults and children.

Parenteral medications are packaged in vials, ampules, and premeasured syringes. Some are available as single-dose preparations, and others are available in multiple doses. Dosages usually range from 1 mL to 3 mL. Some drugs are measured in units (e.g., heparin, insulin, penicillin), some are found in solutions as milliequivalents (mEq; grams per 1 mL of solution), and others need to be reconstituted from a powder. Oral and parenteral dosage calculations can be completed using ratio and proportion, the Formula Method, or dimensional analysis, which will be introduced in Chapter 8. Intravenous solutions are available in various quantities (e.g., 250 mL, 500 mL, and 1,000 mL). Critical care intravenous solutions are prescribed in smaller quantities and administered via an electronic infusion pump. Examples of these dosage calculations are given in Chapter 11.

All medications come packaged and are clearly labeled. Each label must contain specific information, as outlined in Chapter 7. Remember: You should never prepare or administer any medication that is not clearly labeled. To minimize the possibility or obtaining or preparing the wrong dosage, the Institute for Safe Medication Practices (ISMP) has recommended that the slash line (/) not be used when writing medication orders. Although not universally implemented, some institutions are starting to enforce this recommendation. Therefore, you will notice that the slash is not used in this text or in word problems. However, due to the necessity of brevity for this handbook, the slash line is used within calculations. You can read further about this recommendation at http://www.ismp.org.

Infants and children cannot receive the same dose of medication as adults because a child's physiologic immaturity influences how a drug is absorbed, excreted, distributed, and used. Therefore, pediatric dosages are based on age, body weight, or body surface area. If you are going to give pediatric drugs, you must become familiar with the rules for calculating pediatric dosages, which are given in Chapter 14. Refer to Appendix I for nursing concerns for pediatric drug administration. The older adult also responds differently in the metabolism of medications. See Appendix K for nursing concerns for geriatric drug administration. Appendix J suggests nursing considerations for critical care drug administration.

CHAPTER 7

Medication Labels

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Identify a drug's generic and trade name on a medication label.
- Identify drug dosage strength, form, and quantity on a medication label.
- Interpret drug administration requirements and precautions on a medication label.
- Interpret drug manufacturing information on a medication label.
- Interpret drug reconstitution or mixing directions on a medication label.
- Recognize when drug dosage calculations, including equivalent conversions, are necessary—for example, when the prescribed dose is different than the available dose.

To prepare the correct medication that is prescribed, you must be able to accurately read a drug label and be familiar with major key points presented in this chapter. Several drug labels will be depicted as examples, and sample drug problems will be presented.

Reading and Interpreting a Drug Label

Some labels are easy to read because they contain a limited amount of information—for example, labels for unit-dose preparation where each tablet or capsule is separately packaged. This is the most common type of label that you will see in a hospital setting. Other labels indicate multiple tablets or capsules, with the dosage of each drug clearly visible. You should be able to recognize the following information on a medication label.

- **Drug name:** Medications are prescribed by their trade or generic name. Drug labels contain *essential and comprehensive* information for the safe administration of medications.
- **Generic or official name:** This is the name given by the company that first manufactures the drug. It appears in smaller letters, sometimes in parentheses, under the brand name. However, because many physicians are now ordering by generic name, labeling is changing to show the generic name in uppercase letters and bolded (e.g., **ATROPINE, MEPERIDINE**).

A drug has only one chemical name, but it may have many different trade names. As a cost-control effort, some insurance companies are now requiring that pharmacists offer a generic brand first, unless contraindicated by the physician.

- **Trade, brand, or proprietary name:** This is the commercial or marketing name that the pharmaceutical company gives a drug. It is printed in bold, large, or capital letters on the label. The ® identifies manufacturer ownership. The drug may be manufactured and marketed by several companies, each using its own trade name.

If a trade name is followed by ™ it means that the trade name is trademarked and cannot be used by another manufacturer.

- **Drug dosage and strength:** This is the amount of drug available by weight per unit of measure (e.g., Nexium, 40-mg capsules; Demerol, 50 mg per mL). Sometimes the dosage is expressed in two systems (e.g., Nitrostat 0.4 mg [1/150 gr]). Dosage strength is indicated in a solid form (e.g., g, mg, mEq, mcg), in a solid form within a liquid (e.g., mg per mL), in solutions (e.g., 1:1,000), in units (e.g., 1,000 units per mL), or in other preparations such as ointments or patches (e.g., 1% in 0.5 oz).

Examine the drug label for multiple doses. For example, for Coreg (see Figure 7.1), each of the 100 tablets contains 12.5 mg of the solid drug carvedilol. The usual dose of 12.5 mg per day to 25 mg per day means that a patient may receive 1 to 2 tablets daily.

- **Drug form:** This refers to the form in which the drug is prepared by the manufacturer—for example, tablets, capsules, injectables, oral suspensions,

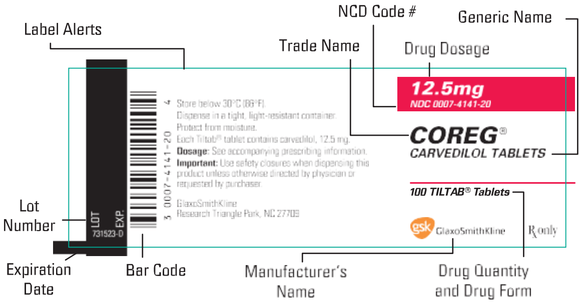


FIGURE 7.1 Coreg. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

suppositories, ointments, and patches. Some drugs are prepared in several forms. The drug label may also indicate specific characteristics of the drug's form—for example, sustained release (SR), controlled release (CR), long acting (LA), and double strength (DS).

- **Drug quantity:** This is the total amount of the drug in the container (e.g., 100 tablets, 30 capsules, 10 mL) or the total amount of liquid available after reconstitution (e.g., 5 mL, 50 mL). See Figure 7.2, which shows the drug label for Augmentin. When the powder is reconstituted with 47 mL of water, each 5 mL of liquid contains 200 mg of the drug.
- **Drug route of administration:** The route may be indicated on the label, such as oral, sublingual, IM, IV, SC, rectal, topical, otic, and so on. The label will also indicate single- or multiple-use vials, or doses expressed as a ratio or percent (e.g., lidocaine 2%).

Parenteral preparation labels indicate dosages in a variety of ways: percentage and ratio strengths, milliequivalents (number of grams in 1 mL of a solution), 100 units per mL (insulin dosages), and powdered forms that have reconstitution directions. See Figure 7.3, which presents the drug label for Ancef. Each vial contains approximately 330 mg per mL (IM use) after the addition of 2 mL of sterile water.

- **Drug reconstitution or mixing:** As shown in Figures 7.2 and 7.3, the directions for mixing and reconstitution are clear on the drug labels. *Always follow these directions* to ensure the accuracy of drug preparation.
- **Drug manufacturing information:** By federal law, drug labels must contain the following information: **manufacturer name, expiration or volume date, control numbers, a National Drug Code (NDC) number** that is different for every drug, **a bar code** (used for a drug distribution system), and a code identifying one of two official national lists of approved drugs: **USP (United States Pharmacopeia) and NF (National Formulary).** These are identified in Figure 7.1.
- **Drug precautions:** Drug labels also contain precautions about storage and protection from light. For example: Septra tablets (store at 59°F to 77°F in a dry place), heparin (store at controlled room temperature [59°F to 86°F]), promethazine HCl (protect from light and keep covered in the carton until time of use), and Coreg (protect from moisture). Expiration dates indicate the last date that the drug should be used. *Never give a drug beyond its expiration date!*

PRACTICE PROBLEMS

Fill in the blanks for the following questions, referring to the respective medication labels.

FIGURE 7.2 Augmentin. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

1. Generic name: ______________________________

2. Dosage strength: ____________________________

3. Precautions: ________________________________

4. Reconstitute: _______________________ reconstitution

5. Reconstituted dosage: _______________________

6. Drug volume after reconstitution: ____________

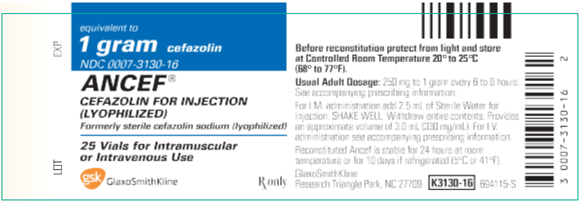


FIGURE 7.3 Ancef. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

1. Proprietary name: ______________________________

2. Identify two routes of administration: ____________________ and ______________________

3. Reconstitute: ___________________________________

4. Approximate dose per mL after reconstituting: ____

5. Usual adult dose: ______________________________

6. Precautions: ___________________________________

FIGURE 7.4 Requip. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

1. Generic name: ______________________________

2. NDC number: ______________________________

3. Dosage strength: ______________________________

4. Drug quantity: ______________________________

5. Drug form: ______________________________

6. Precautions: ______________________________

7. Trade name: ______________________________

8. Manufacturer: ______________________________

End of Chapter Review

Answer each question by referring to the specific drug labels presented in the accompanying figures.

FIGURE 7.5 Tagamet. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

1. A physician prescribed 600 mg of Tagamet, twice daily. The nurse would administer ____________ tablet(s) for each dose. The patient would receive ____________ mg of Tagamet in 24 hr.

FIGURE 7.6 Amoxil. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

2. A patient is to receive 2 g of amoxicillin (Amoxil) every 24 hr for 10 days. The medication is given every 6 hr. The patient would receive ____________ mg or____________tablet(s) for each dose.

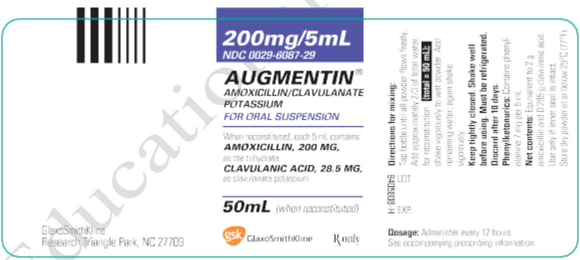


FIGURE 7.7 Augmentin. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

3. A physician prescribed 100 mg of Augmentin every 8 hr for a 3-year-old. The nurse would administer ____________ mL for each dose. The child would receive ____________ mg and ____________ mL in 24 hr.

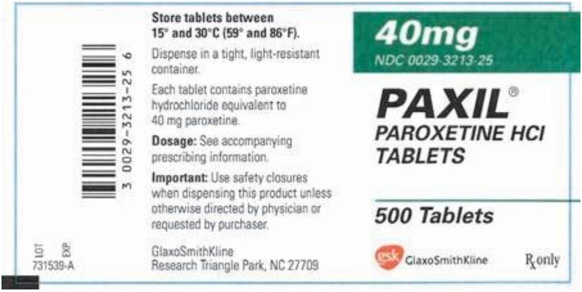
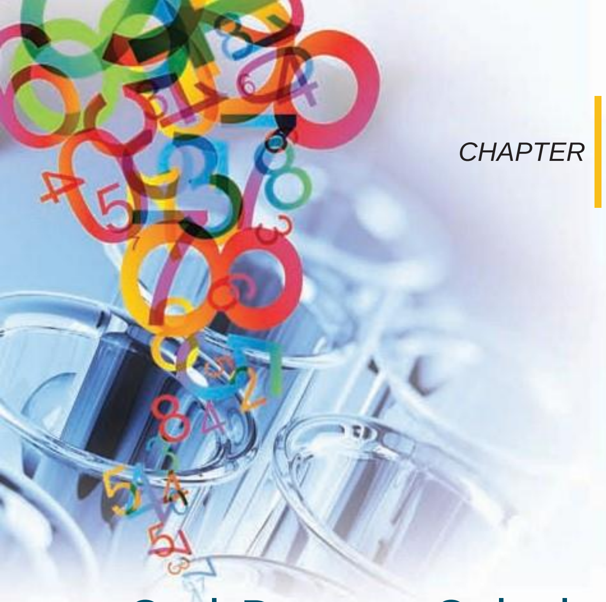


FIGURE 7.8 Paxil. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

4. A physician prescribed 40 mg of Paxil twice a day. The patient would receive ___________ tablet(s) per dose and___________mg per day.



CHAPTER 8

Oral Dosage Calculations

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Describe the various types of oral medications.
- Apply *ratio and proportion* to solve oral drug dosage problems.
- Apply the *Formula Method* to solve oral drug dosage problems.
- Apply *dimensional analysis* to solve oral drug dosage problems.
- Solve dosage calculation problems for medications in similar and different measurement systems (use equivalent values when necessary).
- Understand the rationales for critical thinking checks.

Oral medications come in a variety of forms: caplets (a capsule coated for ease of swallowing), capsules (a powdered or liquid form of a drug in a gelatin cover), liquids (elixirs, emulsions, solutions, suspensions, and syrups), tablets, and pills. Drugs are prescribed by mouth (PO), enterally, via a nasogastric (NG) tube, through a gastrostomy tube, or through a percutaneous endoscopic gastrostomy tube (PEG).

Dosage calculations for solid drugs usually involve tablets (grains, grams, milligrams, micrograms); liquid calculations usually involve milliliters. Most tablets, capsules, and caplets come in the dosage prescribed, or the prescription requires giving more than one pill, breaking a scored tablet in half, or crushing and/or mixing a dose when swallowing is difficult. Enteric-coated tablets (a coating that promotes intestinal rather than gastric absorption) and sustained-release (SR), controlled-release (CR), or extended release (XL) tablets should be taken whole. Sublingual tablets are placed under the tongue and absorbed through the circulation.

When the dosage prescribed by the health care provider (physician, nurse practitioner) differs from the available quantity, dosage calculation is required. This chapter will present three methods to solve dosage calculation problems: proportions (using either two ratios [colon format] or two fractions [fraction format]), the Formula Method, and dimensional analysis. Each method requires understanding measurement systems and system equivalencies. Each method of problem solving will be demonstrated, using sample problems. Each section is followed by practice problems. An end-of-chapter review is provided to

FIGURE 8.1 Tagamet. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

reinforce the steps of calculation. See Figure 8.1 for an example of an oral drug medication label.

Calculating Oral Dosages

When medications are prescribed and available in the same system (e.g., metric) and the same unit of size (e.g., grains, mcg, mg), dosage calculations are easy. When the prescribed or desired dosage is different from what is available or what "you have" (different systems or different units) you must convert to the same system (usually metric) and the same units (the smaller the better) before calculating dosages. To do this you need to use an equivalent value. When calculating oral dosages, you can use ratio and proportion, the Formula Method, or dimensional analysis.

Ratio and Proportion

Ratio and proportion is explained in detail in Chapter 4. For a quick review here, you need to remember that you can work with the two ratios, expressed as a proportion, in either a colon or fraction format When calculating dosage problems, the will be the unknown amount—the amount of medication that you want to give. If you are using a colon format, first write down the known ratio (25 mg : 1 mL). Follow this with the unknown ratio (10 mg : mL). Then multiply the means by the extremes to solve for . If you are using a fraction format, first write down the known fraction $\left(\frac{25\text{ mg}}{1\text{ mL}}\right)$, followed by the unknown fraction $\left(\frac{10\text{ mg}}{\text{mL}}\right)$ Cross-multiply and then divide both sides of the equation by the number in front of

The Formula Method

The Formula Method is a quick way to solve dosage calculations. Always use critical thinking checks to make sure that your answer is logical. Sometimes it will be necessary to convert between systems (use equivalents) before calculating the dosage. Two examples will be provided after the Rule. *The symbol* ℞ *is used throughout this book to indicate "desired amount."*

RULE

To apply the Formula Method: the *prescribed* amount of drug becomes the *desired* (*D*) amount and the numerator of the fraction; the drug that is *available*—the amount that *you have* (*H*)—becomes the denominator of the fraction; and the drug form (tablet, mL) is the *quantity* (*Q*) that is multiplied by the terms in the fraction labeled (D/H). The unknown (*x*) is what you need to calculate to give the medication.

The Formula Method: The Basic Equation:

$$\frac{\text{D desi d a ount)}}{\text{H have on hand)}} \quad \text{Q quantity)}$$

$$x \text{ (m unt to give)}$$

$$\frac{\text{D}}{\text{H}}$$

D desired (prescribed) amount in the given units of measurement

H what you have (available); the dosage strength

Q quantity; drug form (tablet, mL)

amount to give; the unknown dosage

EXAMPLE: #1 The physician prescribed 100 mg of a medication that is available as 50-mg tablets

$$\frac{\text{D desir d)}}{\text{H ha e)}} = x \text{ tablets}$$

$$\frac{\text{00 mg}}{\text{50 mg}}$$

$$\frac{\cancel{00}^{2}}{\cancel{50}_{1}}$$ (use cancellation, then multiplication)

2 1 2

ANSWER: 2 tablets

EXAMPLE: #2 The physician prescribed gr 1/2 of a medication that is available as 15 mg per tablet. Note: Because you have two systems, you need to first convert to the same system. Always convert to the system *that is available*! Therefore, for this problem, convert grain to mg. Use the equivalent 60 mg = 1 gr.

60 mg : 1 gr = mg : gr 1/2

= 60 1/2

30 mg

$$\frac{\text{D desi ed)}}{\text{H have)}} \times \quad = x \text{ tablets}$$

$$\frac{30 \text{ mg}}{15 \text{ mg}} \quad ı$$

$$\frac{\cancel{30}^{2}}{\rule{1em}{0.4pt}}$$

(use cancellation, then multiplication), 2 1 2

ANSWER: 2 tablets

Dimensional Analysis

Dimensional analysis (DA) is a problem-solving method also known as the unit-factor method or the factor-label method. Dimensional analysis is used frequently in the sciences to solve chemistry equations. Its popularity in nursing is increasing.

Dimensional analysis uses one equation (fraction method), thus minimizing errors and eliminating the need to memorize a formula. *The unit in the denominator of the second fraction must be the same as the unit in the numerator of the first fraction* Frequently, *conversion factors* (*equivalents*) will be needed if the units are not in the same system. Placement of the units of the fractions is important for multiplication and cancellations to be accurate

The Basic Terms for Dimensional Analysis:

- **Desired dose:** the dose to be given, *what you desire*. Also known as the given quantity.
- **Wanted quantity:** the answer (*x*); that is, mL, oz, mg.
- **Available dose:** the available amount of the drug, *what you have.*
- **Units:** the measure of the drug form (tablet, mL).
- **Unit placement or path and cancellation:** placement of the units of the fractions in the numerator and the denominator positions so cancellation can occur.
- **Factors:** dosages in fraction format.
- **Conversion factors:** the *equivalents* used to convert between systems.
- **Computation:** *the calculation process*. Cancel first, multiply the numerators, multiply the denominators, and then divide the product of the numerators by the product of the denominators.

There is more than one way to set up a dimensional analysis equation. You can begin with the *given quantity* (desired dose) or the *wanted quantity* (*x*). There are four ways to set up the equation. No matter which fraction placement you use, the equation is designed for multiplication and cancellation. Three of the following examples start with the given quantity, and one starts with the wanted quantity. One problem will be used to demonstrate each of the four approaches.

EXAMPLE: Give 120 mg of a drug that is available as gr i per tablet. Use a conversion factor.

Start with the Given Quantity: Use a Vertical Line to Separate the Fractions

$$\frac{120\text{ mg}}{} \left| \frac{\text{tabl t}}{\text{gr i}} \right| \frac{\text{gr i}}{60\text{ mg}}$$

$$\frac{120\,\cancel{\text{mg}}}{} \left| \frac{\text{tabl t}}{\cancel{\text{gr}}\text{ i}} \right| \frac{\cancel{\text{gr}}\text{ i}}{60\,\cancel{\text{g}}} \qquad \frac{2}{1} \qquad 2\text{ tablet}$$

$$\frac{120 \quad \text{ı} (\qquad)}{60} \qquad \frac{\cancel{20}^{2}}{\cancel{60}} \qquad -$$

Start with the Given Quantity: Use an to Separate the Fractions

$$\frac{120\text{ mg}}{} \quad \frac{\text{tablet}}{\text{gr i}} \quad \frac{\text{gr i}}{60\text{ mg}}$$

$$\frac{20\,\cancel{\text{mg}}}{} \quad \frac{\text{tablet}}{\cancel{\text{gr}}\text{ i}} \quad \frac{\cancel{\text{gr}}\text{ i}}{60\,\cancel{\text{mg}}}$$

$$\frac{120 \qquad (\qquad) \times}{60}$$

$$\frac{\cancel{20}^{2}}{\cancel{60}} \quad \frac{2}{1} = 2\text{ tabl ts}$$

Start with the Given Quantity: Use an Sign to Separate the Fractions

$$\frac{120\text{ mg}}{} \quad \frac{\text{tabl t}}{\text{gr i}} \quad \frac{\text{gr i}}{60\text{ mg}}$$

$$\frac{120\,\cancel{\text{mg}}}{} \quad \frac{\text{tabl t}}{\cancel{\text{gr}}\text{ i}} \quad \frac{\cancel{\text{gr}}\text{ ii}}{60\,\cancel{\text{mg}}}$$

$$\frac{120 \qquad (\qquad) \times}{60} \qquad \frac{\cancel{20}^{2}}{\cancel{60}}$$

$$\frac{2}{} \qquad 2\text{ tabl ts}$$

Start with the Wanted Quantity: Use an Sign After the

$$\text{tabl ts(s)} \quad \frac{\text{tabl t}}{\cancel{\text{gr}}\ \text{i}} \quad \frac{20\ \cancel{\text{mg}}}{60\ \cancel{\text{mg}}} \quad \cancel{\text{gr}}\ \text{i}$$

$$\frac{20\ 1\ (\text{tabl t})}{60} \quad \frac{\cancel{20}^{\,2}}{\cancel{60}} \quad \frac{2}{1}$$

$$2\ \text{tabl t}$$

Note: For this book, dimensional analysis equations will *begin with the given quantity*. Use an x to separate the fractions.

RULE

To apply the dimensional analysis formula: Follow the steps in the following example.

EXAMPLE: Give 250 mg of a drug. The drug is available as 500 mg per tablet.

Write down *what you desire* (250 mg). This given quantity will be the numerator of the first fraction.

$$250\ \text{mg}$$

Write down *what you have available* (500 mg per tablet) as the second fraction. Placement of the units must be set up to allow for cancellation. The denominator of the second fraction must be in the same units as the numerator of the first fraction

$$\frac{250\ \text{mg}}{} \quad \frac{\text{tablet}}{500\ \text{mg}}$$

Cancel the opposite and matching units of measure in the denominators and numerators. The remaining measure (tablet) is what is desired. Complete the mathematical calculations

$$\frac{250\text{ mg}}{} \quad \frac{\text{tabl t}}{500\text{ mg}} \quad x$$

$$\frac{250\cancel{\text{ mg}}}{} \quad \frac{\text{tabl t}}{500\cancel{\text{ mg}}} \quad \frac{250 \quad 1\,(\text{tablet})}{500}$$

$$\frac{\cancel{250}}{\cancel{500}\ ^{2}} \quad \frac{1}{2} \quad {}^{}/_{2}\text{ tabl t}$$

ANSWER: ½ tablet

RULE

To apply the dimensional analysis formula using a conversion factor (equivalent): Follow the steps in the following example.

EXAMPLE: Give 0.5 g of a drug. The medication is available as 250 mg per tablet.

Write down *what you desire* (0.5 g). This given quantity will be the numerator of the first fraction

$$0.5\text{ g}$$

Write down *what you have available* (250 mg per tablet) as the second fraction.

$$0 \quad \text{g} \quad \frac{\text{tablet}}{250\text{ mg}}$$

A conversion factor is needed because the units are not the same. The equivalent value is 1 g   1,000 mg. Cancel the opposite and matching units of measure in the denominators and numerators. The remaining measure (tablet) is what is desired. Complete the mathematical calculations.

$$\frac{0.}{} \quad \frac{\text{e.}}{250\cancel{\text{ mg}}} \quad \frac{000\cancel{\text{ mg}}}{}$$

$$\frac{0.5\times\ (\text{tablet})\times\ ,,000}{250} \quad \frac{\cancel{500}^{2}}{\cancel{2\ 0}}$$

$$\frac{2}{} \quad 2 \text{ tabl t}$$

ANSWER: 2 tablets

Dosage Calculations for Medications in the Same System and the Same Unit of Measurement

RULE

When the desired and available drug doses are different but in the same system and same unit of measurement: Use one of the following three methods to calculate dosages.

For this chapter, the *colon format will be used when working with ratio and proportion* You can also use the fraction format if you wish.

EXAMPLE #1: ℞: 0.250 mg
Have: 0.125-mg tablet
Give:________tablet(s)
This sample problem will be solved using all three methods

Ratio and Proportion

0.125 mg : 1 tablet = 0.250 mg :
0.125 0.250

$$\frac{\cancel{0\ 250}^{\,2}}{\cancel{0\ 2}} \qquad \frac{2}{\ } \qquad 2 \text{ tabl } \ t$$

ANSWER: 2 tablets

The Formula Method

$$\frac{D}{H}$$

$$\frac{0\ 250}{0.125} \quad x \quad \frac{\cancel{0\ 250}^{\,2}}{\cancel{0\ 2}} \qquad \frac{2}{\ } \qquad 2 \text{ tabl } \ t$$

ANSWER: 2 tablets

Dimensional Analysis

$$\frac{0\ 250 \text{ mg}}{\ } \qquad \frac{\text{tabl } \ t}{0\ 25 \text{ mg}}$$

$$\frac{0\ 250\ \cancel{\ \ }}{\ } \qquad \frac{\text{tablet}}{0\ \ 25\ \cancel{\text{mg}}}$$

$$\frac{0.250 \qquad (\text{tabl } \ t)}{0\ \ 25}$$

$$\frac{\cancel{250}^{\,2}}{\cancel{2}_{\,1}} \qquad \frac{2}{\ } = 2 \text{ tabl } \ t$$

ANSWER: 2 tablets

EXAMPLE #2: ℞: gr 1/2 p.r.n.

Have: gr 1/4 per tablet

Give:_______tablet(s)

Ratio and Proportion

gr 1/4 : 1 tablet   gr 1/2 : tablets

1/4   1/2

$$\frac{\cancel{\ }_{2}}{\cancel{\ }_{4}} \quad \frac{}{—_{1}} \quad \frac{\cancel{4}^{\,2}}{} \quad 2 \text{ tablets}$$

Answer 2 tablets

The Formula Method

$$\frac{D}{H}$$

$$\frac{\text{gr } \cancel{\tfrac{1}{2}}}{\text{gr } \cancel{\tfrac{1}{4}}} \quad \frac{}{—} \quad \frac{\cancel{4}^{\,2}}{} \quad \underline{2} \quad 2 \text{ tabl t}$$

Answer: 2 tablets

Dimensional Analysis

$$\underline{\text{gr } \cancel{\tfrac{1}{2}}} \quad \frac{\text{tabl t}}{\text{gr } \cancel{\tfrac{1}{4}}}$$

$$\frac{— \cancel{\ 1}}{} \quad \frac{\text{tabl t}}{\cancel{\text{gr}} \ \cancel{\ }_{4}} \quad \frac{\cancel{\ }_{2} \quad (\text{tablet})}{\cancel{\ }_{4}}$$

$$\frac{\cancel{\ }_{2}}{\cancel{\ }_{4}} \quad \frac{}{—} \quad \frac{\cancel{4}^{\,2}}{} \quad \underline{2} \quad 2 \text{ tabl t}$$

Answer: 2 tablets

EXAMPLE #3: ℞: 100 mg
Have: 20 mg per 5 mL
Give:_______mL

Ratio and Proportion

20 mg : 5 mL   100 mg:
20   500

$$\frac{500}{20} \quad \frac{\cancel{50}^{25}}{—} \quad 25\text{ mL}$$

ANSWER: 25 mL

The Formula Method

$$\frac{D}{H}$$

$$\frac{00\text{ mg}}{20\text{ mg}} \quad \frac{500}{20} \quad \frac{\cancel{50}^{25}}{—_1} \quad 25\text{ mL}$$

ANSWER: 25 mL

Dimensional Analysis

$$\frac{00\text{ mg}}{} \quad \frac{5\text{ mL}}{20\text{ mg}}$$

$$\frac{00\ —}{} \quad \frac{5\text{ mL}}{20\ \cancel{\text{mg}}} = \frac{00 \times 5\ (\text{mL})}{20}$$

$$\frac{\cancel{500}^{50}}{\cancel{20}_2} \quad \frac{\cancel{50}^{25}}{—} \quad 25\text{ mL}$$

ANSWER: 25 mL

Dosage Calculations for Medications in the Same System but with Different Units of Measurement

RULE

When the desired and available drug doses are in the same system but different units of measurement: Convert to like units, change to the smaller unit, and use one of the three methods to calculate dosages.

EXAMPLE #1: ℞: 4 g daily
Have: 500 mg per tablet
Give:_______tablet(s)

CONVERT TO LIKE UNITS: To convert 4 g to mg, move the decimal point (4.0 g) three places to the right: 4,000.
Then 4 g   4,000 mg

Ratio and Proportion

500 mg : 1 tablet   4,000 mg :
500   4,000

$$\frac{4\ 000}{500} \quad \frac{\cancel{40}}{—} \qquad \text{tabl t}$$

ANSWER: 8 tablets

The Formula Method

$$\frac{D}{H}$$

$$\frac{4\ 000\ \text{mg}}{500\ \text{mg}} \quad \text{I}$$

$$\frac{4\ 000}{500} \quad \frac{\cancel{40}}{—} \quad \text{tablets}$$

ANSWER: 8 tablets

Dimensional Analysis

$$\frac{4\ \text{g}}{} \cdot \frac{\text{tablet}}{500\ \text{mg}} \quad \frac{000\ \text{mg}}{\text{g}}$$

$$\frac{4\ \cancel{\text{g}}}{} \cdot \frac{(\text{tablet})}{500\ \cancel{\text{m}}} = \frac{000\ \cancel{\text{m}}}{—}$$

$$\frac{4 \times \text{I}\ (\text{tablet})\quad 0}{500} \quad \frac{^{40}\ \cancel{00}}{\cancel{0}\ _5} \quad \frac{40}{5} \quad \text{tablets}$$

ANSWER: 8 tablets

EXAMPLE #2: ℞: 1.2 g in two equally divided doses
Have: 600 mg per tablet
Give:______tablet(s)

CONVERT TO LIKE UNITS: To convert 1.2 g to mg, move the decimal p int (1.2 g) three places to the right: 1,200.
Then 1.2 g 1,200 mg

Ratio and Proportion

600 mg : 1 tablet   1,200 mg :

600   1,200

$$\frac{\cancel{200}^{2}}{\cancel{600}} \quad 2 \text{ tabl t}$$

Answer: 2 tablets in 2 divided doses or 1 tablet each dose

The Formula Method

$$\frac{D}{H}$$

$$\frac{200 \text{ mg}}{600 \text{ mg}}$$

$$\frac{\cancel{200}^{2} \cancel{\text{mg}}}{\cancel{600} \cancel{\text{mg}}} \quad \frac{2}{} \quad 2 \text{ tabl t}$$

Answer: 2 tablets in two divided doses or 1 tablet each dose

Dimensional Analysis

$$\frac{1}{} \quad \frac{\text{tablet}}{600 \text{ mg}} \quad \frac{000 \text{ mg}}{\text{g}}$$

$$\frac{.2 \cancel{\text{g}}}{} \quad \frac{(\text{tablet})}{600 \cancel{\text{mg}}} \quad \frac{000 \cancel{\text{mg}}}{}$$

$$\frac{2 \quad (\text{tablet}) \times \ ,000}{600 \times} = \frac{\cancel{200}^{2}}{\cancel{600}}$$

$$\frac{2}{} \quad 2 \text{ tablet}$$

Answer: 2 tablets in divided doses or 1 tablet each dose

Dosage Calculations for Medications in Different Systems

RULE

When the desired and available drug doses are in different systems: Convert to the available system, select the equivalent value, write down what you know in a fraction or colon format, and use ratio and proportion or the Formula Method to calculate dosages. Use a conversion factor for dimensional analysis.

EXAMPLE: ℞: morphine sulfate gr 1/4
Have: morphine sulfate 10-mg tablets
Give:______tablet(s)
To use ratio and proportion, use the equivalent and convert to the available system.

CONVERT TO SAME SYSTEM: Milligrams are *available*
Change gr 1/4 to mg.
Equivalent: 1 gr 60 mg

COMPLETE THE PROPORTION: 1 gr : 60 mg 1/4 gr : mg
1/4 60

SOLVE FOR X: 15
4

= 15 mg

Ratio and Proportion

10 mg : 1 tablet = 15 mg :

0 15

$$\frac{\text{—}}{\text{—}\!\!\!0\ _2} \quad \frac{3}{2} = \ {}^{/}_{2}\ \text{tabl ts}$$

Answer: 1½ tablets

The Formula Method

$$\frac{D}{H}$$

$$\frac{15\ \text{mg}}{0\ \text{mg}}$$

$$\frac{\text{— mg}}{\text{—}\!\!\!0\ \ \text{mg}} \quad \frac{}{2} \quad {}^{/}_{2}\ \text{tabl ts}$$

Answer: 1½ tablets

Dimensional Analysis

$$\underline{\text{gr}\ {}^{1}\!/_{4}} \quad \frac{\text{tabl t}}{0\ \text{mg}} \quad \frac{60\ \text{mg}}{\text{gr}}$$

$$\frac{\text{—}\ {}^{1}\!/}{} \quad \frac{\text{tabl t}}{0\ \cancel{\text{mg}}} = \frac{60\ \cancel{\text{mg}}}{\cancel{\text{gr}}}$$

$$\frac{/_{4} \quad (\text{tablet}) \times 60}{0} \quad \frac{\text{—}}{_2\ \text{—}\!\!\!0}$$

$$\frac{3}{2} \quad {}^{/}_{2}\ \text{tablet}$$

Answer: 1½ tablets

PRACTICE PROBLEMS

1. ℞: 160 mg daily
   Have: 40-mg tablets
   Give_________tablet(s).

2. ℞: 1,500 mg
   Have: 500 mg per 5 mL
   Give_________mL.

3. ℞: 150 mg
   Have: 300-mg tablets
   Give_________tablet(s).

4. ℞: 20 mg
   Have: 10 mg per 5 mL
   Give_________mL.

5. ℞: 7.5 mg t.i.d.
   Have: 2.5-mg tablets
   Give_________tablet(s), t.i.d.

6. ℞: 100 mg every 4 to 6 hr, as needed
   Have: 50-mg tablets
   Give_________tablet(s) for each dose.

7. ℞: 75 mg
   Have: 15 mg per mL
   Give_________mL.

8. ℞: 25 mg
   Have: 50-mg tablets
   Give_________tablet(s).

9. Rx: 4 g to be taken in four equally divided doses
Have: 500-mg tablets
Give__________tablet(s) each dose.

Critical Thinking Check

Refer to question 9. If 5 g were ordered in five divided doses, does it seem logical that one 500-mg tablet would be given?________**Yes or No?**

10. Rx: 0.5 g every 8 hr
Have: 250 mg per teaspoon
Give__________mL.

Critical Thinking Check

Refer to question 10. Since the suspension was ordered every 8 hr, does it seem logical that the patient should be awakened during the night for his medication?________**Yes or No?**

11. A medication is on hand in a syrup (2 mg per mL). The prescribed dose is 3 teaspoons. Give ________ mL, which would be equal to_________mg.

12. A drug is on hand in a liquid as 250 mg per 5 mL. The initial dose of 125 mg for 3 days requires giving_________teaspoon(s) each day for a total of_________mL over 3 days.

13. A medication is on hand in a transdermal patch containing 0.0015 g. The system delivers 0.5 mg over 72 hr. After 72 hr,________mg remain.

14. A physician prescribed 20 mg of syrup to be administered every 4 hr for pain. The drug was available as 50 mg per 5 mL. The nurse should give________mL q4h.

15. A physician prescribed 0.8 g of a liquid medication. The drug was available in a strength of 200 mg per mL. The nurse should give ________ mL.

16. A physician prescribed 60 mg of a diuretic. The mediation was available as 15 mg per tablet. The nurse should give________tablets.

17. A physician prescribed 0.4 mg of a medication for nutritional deficiency. The medication was available as 0.6 mg per mL. The nurse should administer________mL.

18. A physician prescribed 200 mcg of a medication for vertigo. The drug was available as 0.6 mg per mL. The nurse should give________mL.

19. The physician prescribed 7.5 mg of a drug, once daily. The medication was available as 2.5-mg tablets. The nurse should give________tablets.

20. The physician prescribed 100 mg of a drug that was available in 40-mg tablets. The nurse should give________tablets.

End of Chapter Review

Solve the following problems:

1. ℞: 30 mg daily
Have: 10-mg tablets
Give__________tablet(s).

2. ℞: 300 mg
Have: 100-mg tablets
Give__________tablet(s).

3. ℞: 1.5 g daily
Have: 250 mg per 5 mL
Give__________mL.

4. ℞: 0.2 g
Have: 50-mg tablets
Give__________tablet(s).

5. ℞: gr 1/200
Have: 0.3-mg tablets
Give__________tablet(s).

6. ℞: gr 1/2
Have: 15-mg tablets
Give__________tablet(s).

7. ℞: 20 g
Have: 30 g in 45 mL
Give__________ounce(s).

8. ℞: gr 1/150
Have: 0.4-mg tablets
Give__________tablet(s).

9. ℞: gr 1/4
Have: 10 mg per 5 mL
Give__________mL.

10. ℞: 0.1 g
Have: 100-mg tablets
Give__________tablet(s).

11. ℞: gr 1/4 four times a day
Have: 15-mg tablets
Give__________tablet(s) per dose for a total of_________tablet(s) daily.

12. ℞: 5 mg
Have: 1.25-mg tablets
Give__________tablet(s).

13. ℞: 100 mg q.i.d.
Have: 10 mg per mL
Give__________teaspoon(s) for each dose.

14. ℞: 1.5 g daily in three equal doses, 500 mg per tablet. The tablet is available as 500 mg. The nurse would give ________ mg, three times a day.

15. ℞: 2.4 g daily for rheumatoid arthritis
Have: 600-mg tablets
Give__________tablet(s) a day.

16. ℞: 10 mg daily, every 6 hr, for 2 weeks
Have: 2.5-mg tablets
Give__________tablets daily, equally divided over 6 hr.

Critical Thinking Check

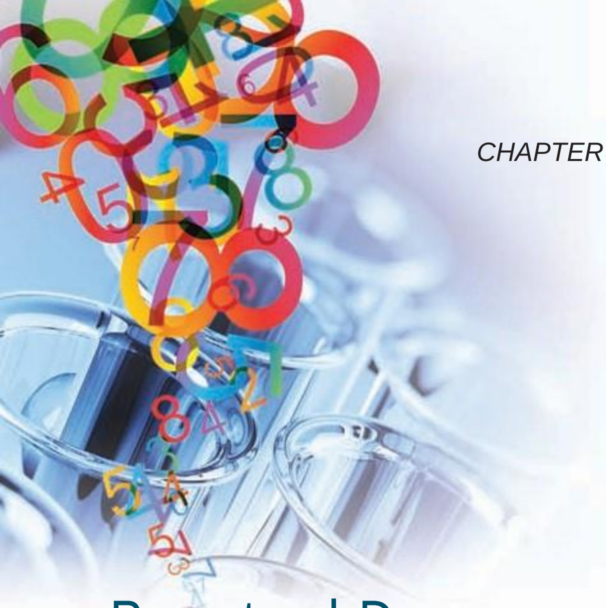
Refer to question 16. If the drug was ordered q.i.d. rather than every 6 hr, would you expect the patient to receive the same number of pills in 24 hr?_________**Yes or No?**

17. ℞: 500 mg
Have: 0.25 g per 5 mL
Give__________mL or_________teaspoon(s).

Critical Thinking Check

Refer to question 17. Does it seem logical that 1 g of the drug could also be prescribed based on the available dosage?________**Yes or No?**

thePoint Additional practice problems to enhance learning and facilitate chapter comprehension can be found on **http://thePoint.lww.com/Boyer8e.**



CHAPTER 9

Parenteral Dosage Calculations

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Define the term *parenteral* as it refers to medication administration.
- Distinguish among three types of parenteral injection: intradermal, subcutaneous, and intramuscular.
- Identify the parts of a syringe.
- Distinguish among the different types of syringes: hypodermic, tuberculin, U-100, and U-50 insulin.
- Describe the differences in needles (length, gauge, and use).
- Explain how parenteral medications are supplied (ampules, vials, and prefilled cartridges and syringes).
- Interpret a parenteral drug label.
- Calculate parenteral medication dosages using ratio and proportion, the Formula Method, and dimensional analysis.

The term *parenteral* refers to any route of drug delivery other than gastrointestinal. It is used when the oral route would be ineffective (delayed absorption time, drug interactions, or patient's inability to swallow) or the drug needs to be quickly absorbed. Medications can be administered intramuscularly (IM), subcutaneously (SQ), intradermally (ID), and intravenously (IV). Remember: Needle *precautions must always be followed* when administering parenteral medications

Insulin is covered in Chapter 12 and heparin in Chapter 13. Intravenous therapies, including IV piggyback (IVPB) and IV push, are covered in Chapters 10, 11, and 14. Pediatric calculations are covered in Chapter 14. Reconstitution of powders for injections is presented in Chapter 15.

Packaging, Syringes, and Needles

Packaging. Parenteral medications are commonly supplied in liquid or solution form and packaged in ampules (small, glass, sealed containers that hold a single dose), vials (small, glass or plastic bottles with a rubber tip and cover), or in prefilled cartridges and syringes that contain a single drug dose. Preparations that come in a powder form must be reconstituted according to the manufacturer's directions.

Syringes. There are three kinds of syringes: hypodermic, tuberculin, and insulin (U-100 and U-50, low dose). Syringes have three parts: a barrel with milliliter (mL) calibrations, a plunger, and a tip. Luer-Lok syringes have a tip that syringe-specific needles twist into; non–Luer-Lok syringes have a tip that needles

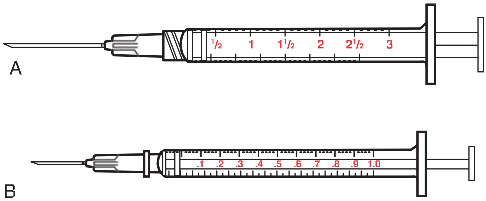


FIGURE 9.1 A. Standard 3-mL Luer-Lok syringe. B. Tuberculin syringe.

slip into. Some syringes have a safety glide (which covers the needle after use), whereas others are needleless (IV use). See Figure 9.1 for an example of a standard, 3-mL, Luer-Lok hypodermic syringe and a 1-mL tuberculin syringe; a picture of a needless port is given in Appendix L.

Hypodermic and Tuberculin Syringes. The standard, 3-mL syringe is marked on one side in 0.1-mL increments, with longer lines indicating 0.5 mL and 1.0 mL. Smaller syringes still indicate minims but are not used frequently, to avoid errors. Most injectable medications are given in a 3-mL syringe unless the dosage can easily be measured in a 1-mL syringe. Markings on the 1-mL narrow tuberculin syringe (commonly used for solutions less than 1 mL) can be found in tenths (0.1 mL) and hundredths (0.01 mL). It is essential that you read these calibrations accurately so that you give the correct amount of medication. When checking the liquid medication in the syringe, always remember to (a) hold the syringe *at eye level* (b) draw the medication into the barrel, and (c) use the *top of the black ring* to measure the correct amount. See Figures 9.2 and 9.3 for examples of labels for two different parenteral drug preparations.

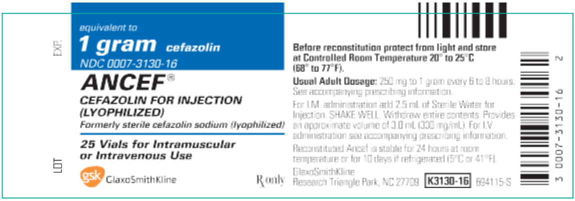


FIGURE 9.2 Ancef. (Courtesy of GlaxoSmithKline, Philadelphia, PA.)

Insulin syringes. Insulin syringes are only used for insulin! Insulin, supplied in quantities of 100 units per mL, is administered using a U-100 syringe (up to 1-mL volume, marked every 2 units) or a U-50, low-dose syringe (up to 0.5-mL volume, marked every 1 unit), which is no longer used very often in the hospital. It is used in home care. A U-30 syringe is being phased out but may be used in the home. Two insulin syringes are shown in Figure 12.3

Needles. Needles are distinguished by their length (inches) and their gauge (width or diameter) and have different uses. The lower the gauge number, the larger is the diameter. For example, a 14-gauge IV needle has a larger diameter than a 27-gauge needle

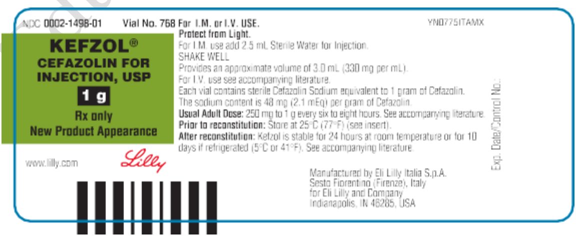


FIGURE 9.3 Kefzol. (Courtesy of Eli Lilly Company, Indianapolis, IN.)

Table 9.1 Needle Gauge and Length for Different Types of Injection

Type of Injection	Needle Gauge	Needle Length (inches)
Intradermal	25	3/8 to 5/8
Intramuscular	18 to 23	1 to 3
Intravenous	14 to 25	1 to 3
Subcutaneous	23 to 28	5/8 to 7/8

used for intradermal injections. See Table 9.1 for an example.

Types of Injections

Intradermal Injections: into the dermis (under the outer layer of skin or epidermis). Refer to the picture Administering an Intradermal Injection, in Appendix D.

The intradermal route is used for:

1. Small amounts of drugs (0.1 mL to 0.5 mL). The average dose is 0.1 mL.
2. Solutions that are nonirritating and slowly absorbed
3. Allergy testing, tuberculin skin testing, and local anesthesia
4. Common sites: inner surface of forearm and upper back below the scapula.

- **Subcutaneous Injections:** under the skin or dermis into the fibrous, subcutaneous tissue above the muscle. Refer to Appendix E.

The subcutaneous route is used for:

1. Small amounts of drugs (0.5 mL to 1 mL).
2. Insulin

3. Heparin
4. Tetanus toxoid

- **Intramuscular Injections:** into the body of a striated muscle. Refer to the picture Administering an Intramuscular Injection, in Appendix F.

  The intramuscular route is used for:

1. Drugs that require a rapid rate of absorption.
2. Drugs that would be ineffectively absorbed in the gastrointestinal tract.
3. Drugs that are given in large volume.

Dosage Calculations for Medications in the Same System and the Same Unit of Measurement

To calculate parenteral dosage problems, follow the same rules that you used for oral dosage calculations, using one of the three calculation methods. Ratio and proportion, the Formula Method, or dimensional analysis can be used. Remember to follow any guidelines regarding patient age, weight, or special considerations before administering parenteral medications.

RULE

Whenever the prescribed or desired and available drug dosages are different but in the same system and the same unit of measurement: Use one of three methods to calculate dosages. Refer to Chapter 8 for a quick review of these three methods.

EXAMPLE #1: ℞: 1 mg
Have: 5 mg per mL
Give:______mL

Ratio and Proportion

5 mg : 1 mL   1 mg :   mL
5

$$\frac{}{5} \quad \text{mL} = 0.2 \text{ mL}$$

ANSWER: 0.2 mL

The Formula Method

$$\frac{D}{H} \quad Q$$

$$\frac{\text{mg}}{5 \text{ mg}} \times$$

$$\frac{}{5} \quad \text{mL} = 0\ 2 \text{ mL}$$

ANSWER: 0.2 mL

Dimensional Analysis

$$\text{mg} \quad \frac{\text{mL}}{5 \text{ mg}}$$

$$\frac{\cancel{\text{mg}}}{} \quad \frac{\text{mL}}{5 \cancel{\text{mg}}} \quad \frac{\times \quad (\text{mL})}{5}$$

$$\frac{1}{5} \quad 0 \quad \text{mL}$$

ANSWER: 0.2 mL

EXAMPLE #2: ℞: 300 mg
Have: 150 mg per mL
Give:______mL

Ratio and Proportion

150 mg : 1 mL   300 mg :   mL
50   300

$$\frac{\cancel{300}^{2}}{\cancel{50}_{1}} \quad \frac{2}{} \quad 2\text{ mL}$$

ANSWER: 2 mL

The Formula Method

$$\frac{D}{H}$$

$$\frac{300}{150}$$

$$\frac{\cancel{300}^{2}}{\cancel{50}} \quad \frac{2}{} \quad \text{mL} = 2\text{ mL}$$

ANSWER: 2 mL

Dimensional Analysis

$$\frac{300\text{ mg}}{} \quad \frac{\text{mL}}{50\text{ mg}}$$

$$\frac{300\,\cancel{\text{mg}}}{} \times \frac{\text{mL}}{50\,\cancel{\text{mg}}} \quad \frac{300 \quad (\text{mL})}{150}$$

$$\frac{\cancel{300}^{2}}{\cancel{50}} \quad \frac{2}{1} = 2$$

ANSWER: 2 mL

EXAMPLE #3: ℞: 35 mg
Have: 50 mg per mL
Give:______mL

Ratio and Proportion

50 mg : 1 mL   35 mg :
50   35

$$\frac{\cancel{3}^{7}}{\cancel{50}_{10}} \quad \frac{7}{0} \quad 0 \quad \text{mL}$$

ANSWER: 0.7 mL

Formula Method

$$\frac{D}{H}$$

$$\frac{35}{50}$$

$$\frac{\cancel{3}^{7}}{\cancel{50}_{0}} \quad \frac{7}{0} \times \quad \text{mL} = 0\ 7\ \text{mL}$$

ANSWER: 0.7 mL

Dimensional Analysis

$$\frac{35\ \text{mg}}{} \quad \frac{\text{mL}}{50\ \text{mg}}$$

$$\frac{35\ \cancel{\text{mg}}}{} \times \frac{\text{mL}}{50\ \cancel{\text{mg}}} \quad \frac{35 \qquad (\text{mL})}{50}$$

$$\frac{\cancel{3}^{7}}{\cancel{50}_{0}} \quad \frac{7}{0} = 0\ \cancel{7}\ 7$$

ANSWER: 0.7 mL

Dosage Calculations for Medications in the Same System but Having Different Units of Measurement

RULE

Whenever the prescribed or desired and available drug dosages are in the same system but in different units of measurement: Convert to like units, change to the smaller unit, and use one of three methods to calculate dosages. Remember to use a conversion factor if you use dimensional analysis.

EXAMPLE: ℞: 0.25 mg
Have: 500 mcg per 2 mL
Give:______mL

CONVERT TO LIKE UNITS: To convert 0.25 mg to mcg, move the decimal point (0.25 mg) three places to the right. Then 0.25 mg 250 mcg.

Ratio and Proportion

500 mcg : 2 mL   250 mcg :   mL
500   500(250 × 2)

$$\frac{\cancel{500}}{\cancel{500}} \qquad \text{mL}$$

ANSWER: 1 mL

The Formula Method

$$\frac{D}{H}$$

$$\frac{250}{500} \qquad x$$

$$\frac{\cancel{250}\ \text{m g}}{\cancel{500}^{\,2}\ \text{m g}} \qquad \frac{}{2} \times \quad \text{mL} = \quad \text{mL}$$

ANSWER: 1 mL

Dimensional Analysis

$$\frac{0.\quad \text{mg}}{} \times \frac{\text{mL}}{500 \quad \text{g}}$$

$$\frac{0.\quad \cancel{\text{mg}}}{} \times \frac{\ldots}{500 \quad} \quad \frac{000}{1\ \cancel{\text{mg}}}$$

$$\frac{0.25 \times 2(\quad \text{L}) \times 1\ 000}{500} \quad \frac{\cancel{500}}{\cancel{500}} \quad 1\ \text{mL}$$

ANSWER: 1 mL

Dosage Calculations for Medications in Different Systems

RULE

Whenever the prescribed or desired and available drug dosages are in different systems: Convert to the same system (use available system), select the equivalent value, write down what you know in a fraction or ratio format, and use ratio and proportion to solve for *x*. Use one of three methods to calculate dosages. Use a conversion factor if you are using dimensional analysis.

EXAMPLE: ℞: gr 1½ IM, b.i.d.
Have: 60 mg per mL
Give:______mL, b.i.d.

EQUIVALENT: gr 1 60 mg

COMPLETE THE PROPORTION: gr 1 : 60 mg gr $\frac{}{2}$ mg

SOLVE FOR *x*

$$x = \frac{}{2} \; 60$$

$$\frac{3}{} \times \cancel{}^{30} \quad 90 \text{ mg}$$

Ratio and Proportion

60 mg : 1 mL 90 mg : mL
60 90

$$\frac{\cancel{90}}{\cancel{60}_{2}} \quad \frac{}{2} \; 1 \quad \text{L}$$

ANSWER: 1.5 mL

The Formula Method

$$\frac{D}{H} \quad Q$$

$$\frac{90}{60}$$

$$\frac{\cancel{90}}{\cancel{60}_{2}} \quad \frac{}{2} \quad 1 \quad \text{mL}$$

ANSWER: 1.5 mL

Dimensional Analysis

$$\frac{gr\ 1}{\quad} \qquad \frac{mL}{60\ mg}$$

$$\frac{\cancel{gr}\ 1}{\quad} \times \frac{mL}{60\ \cancel{mg}} \qquad \frac{60\ \cancel{mg}}{\cancel{gr}}$$

$$\frac{1.5 \times \ (\quad) \times 60}{60 \times}$$

$$\frac{\cancel{90}^{-}}{\cancel{60}_{\ 2}} \quad 1 \quad mL$$

ANSWER: 1.5 mL

Penicillin

Penicillin is one of a limited number of medications that is available in units per mL as well as mg per mL. Insulin (covered in Chapter 12) and heparin (covered in Chapter 13) are two other common medications that you will need to become familiar with. When calculating dosages for penicillin, you can use ratio and proportion, the Formula Method, or dimensional analysis.

RULE

To prepare penicillin for injection: Check the prescribed or desired units to be given, and use one of three methods to calculate dosages.

EXAMPLE: A patient is prescribed 300,000 units of penicillin G procaine to be administered every 12 hr (q12h). Penicillin G procaine is available as 600,000 units per 1.2 mL.

Ratio and Proportion

600,000 units : 1.2 mL   300,000 :   mL

600,000   300,000 × 1.2

600,000   360,000

$$\frac{\cancel{360\ 000}^{36}}{\cancel{600{,}000}_{60}} \qquad \frac{\cancel{36}^{6}}{\cancel{60}_{\ 0}} \qquad \frac{6}{0} \qquad 0. \quad \text{mL}$$

ANSWER: 0.6 mL

The Formula Method

$$\frac{D}{H} \quad Q$$

$$\frac{\cancel{300\ 000}}{\cancel{600\ 000}_{6}} \qquad \frac{-}{\cancel{6}_{2}} \qquad \frac{}{2}$$

$$\frac{}{2} \quad 1. \quad \ldots\text{L} \quad 0.6\ \text{mL}$$

ANSWER: 0.6 mL

Dimensional Analysis

$$\frac{300\ \ 0\ \ \text{un...}}{} = \frac{1.2\ \text{mL}}{600\ 000\ \ \ \text{its}}$$

$$\frac{300\ \ 0\ \ \cancel{\text{units}}}{} \qquad \frac{1.2\ (\text{mL})}{600\ 000\ \cancel{\text{its}}}$$

$$\frac{300\ 000 \times\ 1}{600\ 000} \qquad \frac{\cancel{360\ 000}^{36}}{\cancel{600\ 000}_{60}}$$

$$\frac{\cancel{36}^{6}}{\cancel{60}_{10}} \qquad \frac{6}{0} \equiv 0. \qquad \text{L}$$

ANSWER: 0.6 mL

End of Chapter Review

Complete the following problems:

Give 0.002 g of a drug, IM, per day, for 5 days, for severe intestinal malabsorption. The injection is on hand as 1.0 mg per mL. The nurse should give______mL a day for 5 days.

2 Give 60 mg of a diuretic IM in three equally divided doses every 8 hr for 2 days. The drug is available for injection as 10 mg per mL. The nurse should give______mL every 8 hr

3 Give 0.3 g of a drug that is available as 100 mg per mL for injection. The nurse should give ______ mL.

4 Give 10 mg of a drug that is available as 5 mg per mL. The nurse should draw up______mL.

5 Give 4 mg of a drug that is available as 5 mg per mL. The nurse should give______mL

6 Give 2 mg of a drug, p.r.n., every 4 to 6 hr. The medication is available as 5 mg per mL. The nurse should give______mL every 4 to 6 hours s needed

7. The physician requested that a patient receive 1.5 mg of a drug, IM, every 3 to 4 hr as needed for pain. The medication is available for injection as 2.0 mg per mL. The nurse should give _____ mL every 3 to 4 hr, p.r.n.

8. Give 35 mg, IM, of a drug that is available for injection as 50 mg per mL. The nurse should give______mL.

9. Give 6 mg of a drug, weekly. The medication is available as 2 mg per mL. The nurse should give______mL every week.

10. Give 3 mg, IM, of a drug preoperatively to induce drowsiness. The drug is available as 5 mg per mL. The nurse should give______mL.

11. Give 1 mg of a drug every 4 to 6 hr for analgesia. The drug is available as 4 mg per mL. The nurse should give mL every 4 to 6 hr.

12. Give 30 mg of a diuretic. The drug is available as 40 mg per mL. The nurse should give______mL.

13. Give 0.5 mg of a medication that is available in a vial as gr 1/150 per 1.0 mL. The nurse should give______mL.

14. Give 50 mg of a medication that is available in vials containing gr i per mL. The nurse should give mL.

15 Give gr 1/5, IM, every 4 to 6 hr for severe pain. The medication is available as 15 mg per mL. The nurse should give______mL, every 4 to 6 hr, as needed

Critical Thinking Check

Because the available medication strength (15 mg per mL) is a stronger drug concentration than the prescribed medication (gr 1/5), does it seem logical that greater than 1 mL would be given?_________**Yes or No?**

16 Give 6 mg of a drug. The medication is available as 10 mg per mL for injection. The nurse should give mL.

17. Give 0.15 mg IM of a drug that is available as 0.2 mg per mL. The nurse should give______mL.

18. Give 25 mg, IM, of a drug preoperatively. The drug is available as 100 mg per 2 mL. The nurse should give______mL.

19. Give 50 mg, q6h, of a drug that is available as 25 mg per mL. The nurse should give______mL.

20. Give 0.1 mg of a drug, IM, prior to an operative procedure. The drug is available as 50 mcg per mL. The nurse should give______mL.

21. Give 500 mcg, IM, of a drug that is available as 1 mg per mL. The nurse should give______mL.

22. Give 30 mg, of a drug that is available as 20 mg per mL. The nurse should give______mL.

23. Give 0.25 mg of a drug that is available as 250 mcg per mL. The nurse should give______mL.

24. Give 4 mg, IM, of a drug that is available as 2 mg per mL. The nurse should give______mL.

25. Give gr 1/4, q6h, of a drug that is available as 30 mg per mL. The nurse should give______mL.

26. Give 90 mg of a drug, IV, q6h, that is available as 120 mg per 2 mL. Give______mL.

27. Give 0.05 mg of a drug that is available as 100 mcg per 5 mL. Give______mL.

28. Give 0.4 g of a drug that is available as 500 mg per 5 mL. Give______mL.

29. Give 250 mg of a drug that is available as 0.75 grams per 3 mL. Give______mL.

30. The physician prescribed Crysticillin 600,000 units, IM, as a single dose. Crysticillin is available in a 12-mL vial labeled 500,000 units per mL. The nurse should give______mL.

31. The physician prescribed 300,000 units of Bicillin, IM, q12h for 5 days. Bicillin is packaged as 600,000 units per mL. The nurse should give______mL per dose.

32. The physician prescribed penicillin G potassium 125,000 units, IM, q12h. The medication is available in solution as 250,000 units per mL. The nurse should give______mL every 12 hr.

33. Penicillin G benzathine 1.2 million units was prescribed, IM, as a single injection. The drug is available as 300,000 Units per mL. The nurse should give______mL.

Critical Thinking Check

Would it seem logical to give a dosage of 1.2 M units as a single injection?_________**Yes or No?**

thePoint Additional practice problems to enhance learning and facilitate chapter comprehension can be found on **http://thePoint.lww.com/Boyer8e.**

CHAPTER 10

Intravenous Therapy

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Explain the purpose of intravenous therapy (fluids and medicine).
- Identify various infusion sets and tubing.
- Distinguish among infusion pumps, syringe pumps, and a patient-controlled analgesia (PCA) pump.
- Calculate infusion time in hours and minutes.
- Calculate flow rate in milliliters per hour (mL per hr) for gravity and pump infusion.
- Calculate rate of infusion of an intravenous (IV) push.
- Calculate flow in mL per hr for manual and electronic regulation when the infusion is *less than 1 hr*.
- Calculate flow rate in drops per minute (gtt per min) using the Standard Formula and dimensional analysis.
- Calculate flow rate using the Quick Formula with a constant factor.
- Describe intermittent intravenous fluid therapy (IV piggyback [IVPB] and IV push).

Intravenous (IV) fluid therapy involves the administration of water, nutrients (e.g., dextrose, protein, fats, and vitamins), electrolytes (e.g., sodium, potassium, and chloride), blood products, and medications directly into a vein. Intravenous fluids can be *continuous or intermittent* (IV push and IV piggyback [IVPB]). Continuous infusions are for fluid replacement or fluid maintenance to treat disorders like dehydration, malnutrition, and electrolyte imbalance. Blood and blood products are administered with special Y-type tubing according to highly specific protocols and institutional requirements.

Parenteral nutrition is nutritional supplementation given IV when the oral or enteral route cannot be used. Parenteral nutrition is given through a central venous access device (TPN) or a peripheral line (PPN). The same principles guiding IV therapy are used for parenteral therapy. Enteral tube feeding via a pump is covered in Chapter 15.

This chapter will discuss the basic information about types of equipment, fluids, and infusion calculations (drop factors, drip rates, flow rates, and infusion time). Special IV calculations used in critical care situations are treated in Chapter 11.

Key Terms

- **Drip rate:** the number of drops entering the drip chamber based on the size of the IV tubing (gtt per min).
- **Drop factor:** the size of the drop entering the drip chamber based on the size of the IV tubing.

Drop factors range from 10 gtt per mL to 60 gtt per mL.

- **Flow rate:** the rate in mL per hr given over time.
- **Infusion time:** the time in hours and minutes that it takes for an IV to completely infuse.
- **Titration:** adjustment of the IV medication dosage within prescribed parameters to achieve a desired effect.

Intravenous Fluids

A physician's order for intravenous fluid therapy *must include* the name and amount of the IV solution, any medication that should be added, and the time period for infusion (e.g., q8h, at 50 mL per hr, or in terms of mcg/kg/min, mcg/kg/hr, or mg per min) for critical care. The physician's order is usually written as mL per hr to be infused (flow rate). The flow rate is regulated manually by straight gravity, by volume control, or via an electronic infusion device.

Intravenous fluids are prepared in sterile, plastic bags (most common) or glass bottles, and the quantity of solution ranges from 50 mL to 1,000 mL. Solutions are clearly labeled.

Standard abbreviations are used for the type and concentration of IV solutions: D (dextrose), NS (normal saline), RL (Ringer's lactate), S (saline), and W (water). Numbers refer to the percentage of the solution strength. For example, D5W refers to 5% dextrose (solute) dissolved in a water solution (usually 500 mL to 1,000 mL). Normal saline is a 0.9% sodium chloride solution (900 mg per 100 mL). Percentages less than 0.9% are equivalent to 1/3 (0.33%) or 1/2

(0.45%). Ringer's lactate is an isotonic solution that replenishes fluids and electrolytes.

Review the types of IV fluids and abbreviations in Table 10.1 and interpret the following sample physician orders:

- Administer 1,000 mL of D5W at 125 mL per hr.
- Administer 1,000 mL of 0.9% NS every 12 hr for 2 days.

Table 10.1 Commonly Prescribed Intravenous Fluids

Fluid	Abbreviation
0.9% Sodium chloride solution	NS
0.45% Sodium chloride solution	1/2 NS
0.25% Sodium chloride solution	1/4 NS
5% Dextrose in water	5% D/W
	D5W
10% Dextrose in water	10% D/W
	D10W
5% Dextrose in 0.45% sodium chloride solution	D5 1/2NS
Dextrose with Ringer's lactate solution	D/RL
Lactated Ringer's solution	RL
Plasma volume expanders	
Dextran	
Albumin	
Hyperalimentation	
Total parenteral nutrition	TPN
Partial parenteral nutrition	PPN
Fat emulsions	
Intralipid	

- Administer 500 mL of D10W at 83 mL per hr.
- Administer 100 mL of RL over 4 hr at 25 mL per hr.

Intravenous Infusion Sets and Lines

Intravenous fluids are administered via an IV infusion set. The set consists of IV fluids in a sterile, plastic bag or glass bottle connected by IV tubing. An IV set includes a drip chamber with spike, one or more injection ports (access for IVPB and IVP drugs), a filter, and a slide or roller clamp used to regulate the drops per minute. The *primary* IV line is either a *peripheral* line, usually inserted into the arm or hand, or a *central* line, inserted into a large vein in the chest (subclavian) or neck (jugular). *Secondary* IV lines, also known as IV piggyback (IVPB), are used for intermittent, smaller-quantity infusions (e.g., a medication in 50 mL to 100 mL of fluid) and are attached to the primary line through an injection port. A *peripherally inserted central catheter* (PICC line) is threaded into the superior vena cava through a vein in the arm.

Infusion Devices

IV fluids can be regulated by several different electronic infusion devices: pumps, syringe pumps, patient-controlled analgesia (PCA) pumps, and a balloon device used in home care. Infusion pumps are used when small amounts of fluids/medications must be given over a strictly regulated period of time. The *infusion pump* consistently exerts pressure against the resistance of the tubing or the fluid at a preselected rate. Pumps are not gravity dependent! A pump delivers a set quantity (mL per hr); however, pumps can be dangerous because they continue to infuse even in the presence of infiltration or phlebitis. Infusion pumps can also regulate IVPB infusions by overriding the primary IV line. There are standard pumps and more complex ones that are used for specialty units.

A *syringe pump* (a syringe filled with medication and attached to a pump) regulates medications that must be given at a very low rate over 5 min to 20 min. A *PCA pump*, used by patients for pain management (the patient pushes a control button to self-administer the medication), delivers a set amount of a narcotic in a prefilled syringe over a specified time period. As a safety measure, there is a time interval when no medication can be delivered even if the patient pushes the button. The RN is responsible for the PCA loading dose, the narcotic injector vial, and the pump setting.

To set an electronic infusion pump, you must enter the quantity of fluid to be given (mL) and the milliliters per hour (mL per hr). To set a pump used in critical care units, you also enter information such as medication name, dosage concentration, fluid quantity, and the patent's weight. The medication may also be titrated to the patient's blood pressure.

Infusion pumps are used whenever possible. However, when IVs are administered by gravity flow, you need to know the drop factor (drops per milliliter) in order to calculate the drip rate (gtt per min). See Figure 10.1.

FIGURE 10.1 Electronic infusion pump. (From Taylor, C., Lillis, C., LeMone, P., and Lynn, P. [2008]. *Fundamentals of nursing. The art and science of nursing care* [6th ed.]. Philadelphia: Lippincott Williams & Wilkins.)

Calculate Intravenous Fluid Administration

The physician's IV order *always includes* the quantity of solution (mL) to be given and the time period, either in hours (e.g., q8h, q12h) or in terms of amount (e.g., 100 mL per hr). The nurse is responsible for regulating the infusion either by gravity or programming the milliliters per hour on the pump. The remainder of this chapter will cover what you need to know to:

Calculate infusion time in hours and minutes

- *Calculate* flow rate in milliliters per hour for either gravity infusion or an infusion device.
- *Calculate* drops per minute (gtt per min) for gravity infusion (the drop factor of the IV tubing is needed).
- *Regulate* the number of drops entering the drop chamber by using the roller clamp on the tubing to adjust the flow rate (count the number of drops for 1 min). Remember to always hold a watch up to the drip chamber at *eye level* to accurately count the drops!
- *Set* the electronic infusion pump by entering the total amount of milliliters to be infused and the milliliters per hour after connecting the IV fluids. *The pump is set in mL* per *hr*

Calculate drops per minute using the Quick Formula with a constant factor

Calculate drops per minute for intermittent intravenous infusion

Calculate infusion time for an IV push medication.

Calculate Infusion Time in Hours and Minutes

A simple one-step ratio (division) is all that is needed when total volume is known and milliliters per hour have been ordered. *Always round off to the nearest tenth!* Use this formula

$$\frac{\text{Total volume mL o dered)}}{\text{Millilite per h (mL/hr)}}$$

Numb r of hour t

Note: When the number of hours includes additional minutes, you need to round to the nearest tenth. Then multiply the part of an hour by 60 min to get the exact number of minutes.

EXAMPLE #1 The patient is to receive 1,000 mL of D5W solution at 125 mL per hr.

$$\frac{\text{Total volu}}{\text{mL/hr}} \quad \text{Numb r of hou s}$$

$$\frac{1{,}000\text{ mL}}{125\text{ mL/h}} \quad \frac{\text{hr}}{} \quad 8\text{ hr}$$

ANSWER: 8 hr

EXAMPLE #2 The patient is to receive 1,000 mL of NS at 80 mL per hr.

$$\frac{\text{Total vol}}{\text{mL/hr}} \quad \text{Numb r of hour}$$

$$\frac{1{,}000\text{ mL}}{80\text{ mL/hr}} \quad \frac{2\ 5\text{ hr}}{} \quad 2\ 5\text{ hr}$$

ANSWER: 12½ hr, or 12 hr and 30 min
(½ 60 min 30 min)

Calculate Flow Rate in Milliliters per Hour for Gravity or Pump Infusions

To calculate milliliters per hour, all you need to know is the total volume to be infused over time. When a pump is used, simply set the infusion rate at milliliters per hour after connecting the IV fluids, and start the infusion.

RULE

To calculate milliliters per hour: Use one of three methods to calculate dosages: ratio and proportion, dimensional analysis, or the Standard Formula (total volume divided by total time in hours), which is basically simple division. Note: ***When the infusion time is less than 1 hr, you need to use total time in minutes. For dimensional analysis, include the conversion factor (60 min) in the calculation.***

EXAMPLE #1: A patient is to receive 1,000 mL of lactated Ringer's solution over a 6-hr period. The patient should receive______mL per hr.

Ratio and Proportion

1,000 mL : 6 hr   mL : 1 hr

6   1,000

$$\frac{000}{6}$$

166.6 mL per hr

ANSWER: 167 mL per hr

The Standard Formula

$$\frac{\text{Total vol me mL)}}{\text{Total time (hr)}} \quad \text{mL/hr}$$

$$\frac{1\ 000}{6}\ \text{mL} \qquad 166.6\ \text{mL/h}$$

ANSWER: 167 mL per hr

Dimensional Analysis

Because two factors are already given, all that is necessary is simple division.

The given quantity is 1,000 mL and the wanted quantity ( ) is mL per hr.

$$\frac{,000\ (\text{mL})}{6\ (\text{hr})} \quad \frac{000}{6} \quad 66.6$$

$$\frac{67\ \text{mL}}{\text{hr}}$$

Answer: 167 mL per hr

Example #2: A patient is to receive 1 g of an antibiotic in 50 mL of NS over 30 min.

Ratio and Proportion

50 mL : 30 min mL : 60 min (1 hr)

30 3,000

$$\frac{\cancel{000}^{00}}{\cancel{30}} \quad 00\ \text{mL/h}$$

Answer: 100 mL per hr

The Standard Formula

$$\frac{\text{Total volume mL)}}{\text{Total time (min)}} \quad \frac{(\text{mL/h })}{60\ \text{min}}$$

$$\frac{50\ \text{mL}}{30\ \text{min}} \quad \frac{(\text{mL})}{60\ \text{min}}$$

30 3,000 (50 60)

$$\frac{\cancel{3000}^{100}}{\cancel{30}} \quad 00 \text{ mL/h}$$

ANSWER: 100 mL per hr

Dimensional Analysis

Two factors are already given. You need to include the conversion factor: 60 min 1 hr

$$\frac{50 \text{ mL}}{30 \cancel{\text{min}}} \quad \frac{60 \cancel{\text{min}}}{\text{hr}}$$

$$\frac{50\ (\text{mL})}{30} \quad \frac{60}{(\text{hr})} \quad \frac{50\ (\text{mL}) \quad 60}{30 \times \quad (\text{hr})}$$

$$\frac{^{00}\cancel{,,000}}{\cancel{30}} \quad \frac{00}{} \quad 00 \text{ mL/h}$$

ANSWER: 100 mL per hr

Calculate Drip Rate or Drops per Minute

To calculate drops per minute (gtt per min), you need three pieces of information:

- The *total volume* to be infused in milliliters
- The *drop factor* of the tubing you will use
- The *total time* for the infusion *in minutes or hours*

The flow rate of the IV solution as it passes through the drip chamber is determined by the drop

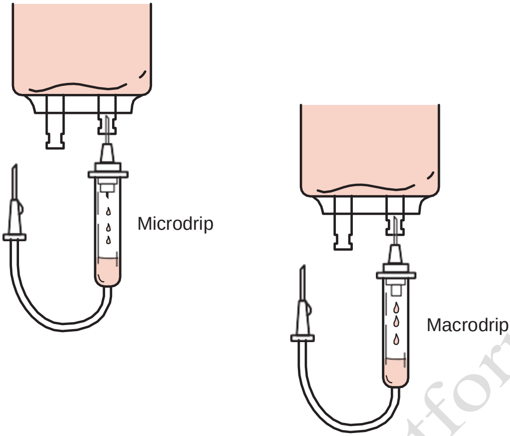


FIGURE 10.2 Left: A drip chamber of an IV tubing for a microdrip (60 gtt/mL). Right: A drip chamber of an IV tubing for a macrodrip (gtt/mL varies).

factor (drops per milliliter) of the tubing set. The drop factor is printed on the IV tubing package. It is either a *macrodrip* (10, 15, or 20 drops per min) or a *microdrip* (60 drops per min). The microdrip contains a needle in the chamber to make the drops smaller. See Figure 10.2 and Table 10.2.

Several formulas and dimensional analysis can be used to calculate flow rate in drops per minute. The

Table 10.2 Common Drop Factors for IV Tubing Sets

Macrodrop	10 gtt per mL
	15 gtt per mL
	20 gtt per mL
Microdrop	60 gtt per mL

Standard Formula for gtt per min and dimensional analysis will be used. Note: When a microdrip is used with a drop factor of 60, the drops per minute will always equal the milliliters per hour. If the physician orders an IV to run at 75 mL per hr with a microdrip, then the gtt per min is 75; if it runs at 35 mL per hr, then the gtt per min is 35.

Note: When an IV order includes a medication, usually the drug is already premixed. If you need to add the drug, simply prepare the medication as directed and then calculate the flow rate using one of the following formulas.

The Standard Formula

$$\frac{\text{Total vol} \quad \text{e} \quad \text{D p ct}}{\text{Total time (min)}}$$

Drops pe minute gtt/min)

EXAMPLE #1: Administer 1,000 mL of D5W every 8 hr. The drop factor is 15 gtt per mL.

The Standard Formula

$$\frac{\text{Total vol me} \times \text{Dr p ct r}}{\text{Total time (min)}}$$

Drops pe minut

$$\frac{0}{480 \text{ min } (60 \times 8)} \qquad \frac{000}{480}$$

31 25 gtt/min

ANSWER: 31 gtt per min

Dimensional Analysis

$$\frac{\text{Total vol}}{\text{hr}} \qquad \frac{\text{Dr} \quad \text{f ct}}{\text{mL}} \qquad \frac{1 \text{ hr}}{60 \text{ min}}$$

$$\frac{000\ \cancel{\text{mL}}}{8\ \cancel{\text{hr}}} \qquad \frac{5 \text{ gtt}}{\cancel{\text{mL}}} \qquad \frac{\cancel{\text{hr}}}{60 \text{ min}}$$

$$\frac{,000 \times \quad \text{gtt}}{8 \times \quad \times 60 \ (\text{min})}$$

$$\frac{5\ 000}{480} \qquad 31\ 25 \text{ gtt/min}$$

ANSWER: 31 gtt per min

EXAMPLE #2: Administer 500 mL of 0.9% NS over 6 hr. The drop factor is 20 gtt per mL.

The Standard Formula

$$\frac{\text{Total vol} \quad \text{e} \times \text{D} \quad \text{p} \quad \text{ct}}{\text{Total time (min)}} = \text{gtt/min}$$

$$\frac{500 \text{ mL} \quad 20}{360 \text{ min}} \qquad \frac{0\ 000}{360} \qquad 27\ 7 \text{ gtt/min}$$

ANSWER: 28 gtt per min

Dimensional Analysis

$$\frac{\text{Total volume}}{\text{hr}} \qquad \frac{\text{Drop f ct r}}{\text{mL}} \qquad \frac{1 \text{ hr}}{60 \text{ min}}$$

$$\frac{500\ \cancel{\text{mL}}}{6\ \cancel{\text{hr}}} \qquad \frac{20 \text{ gtt}}{\cancel{\text{mL}}} \qquad \frac{\cancel{\text{hr}}}{60 \text{ min}}$$

$$\frac{500 \qquad (\text{gtt})}{6 \times \quad \times 60\ (\text{min})} \qquad \frac{0\ \ 000}{360}$$

$$27.7 \text{ gtt/mi}$$

ANSWER: 28 gtt per min

EXAMPLE #3: Administer 500 mL of a 5% solution of normal serum albumin over 30 min. The drop factor is 10.

The Standard Formula

$$\frac{\text{Total volume} \times \text{D p ctor}}{\text{Total time (min)}} \text{ gtt/min}$$

$$\frac{500 \text{ mL} \qquad 0 \text{ gtt/mL}}{30 \text{ min}} \qquad \frac{5\ \ 000}{30}$$

$$66\ 6 \text{ gtt/min}$$

ANSWER: 167 gtt per min

Dimensional Analysis

$$\frac{\text{Total vol m}}{\text{hr}} \qquad \frac{\text{Drop f ct r}}{\text{mL}} \qquad \frac{1 \text{ hr}}{60 \text{ min}}$$

$$\frac{500\ \cancel{\text{mL}}}{0 \quad \cancel{\text{hr}}} \qquad \frac{0 \text{ gtt}}{\cancel{\text{mL}}} \qquad \frac{\cancel{\text{hr}}}{60\ \ \text{min}}$$

$$\frac{500 \qquad (\text{gtt})}{0. \qquad \times 60\ (\text{min})} = \frac{5.\ 00}{30}$$

$$66\ 6 \text{ gtt/min}$$

ANSWER: 167 gtt per min

Constant Factors

Quick Formula with Constant Factor

$$\frac{\text{Milliliter per hour (mL/hr)}}{\text{C nstant f ct r}}$$
$$= \text{Drops pe minute gtt/min)}$$

The constant factor is derived from the drop factor (of the administration set) divided into the fixed time factor of 60 min. It can only be used with the time factor of 60 min. Because the drop factor of 60 has the same numerical value as 60 min, these numbers cancel themselves out. A constant factor of 1 can be used in the division to replace both of these numbers. Therefore, for this Quick Formula, you can use the constant factor (1) to replace 60 min and 60 gtt per mL.

Because 60 remains constant for this Quick Formula, you can calculate constant factors for other drop factors by dividing by 60. For example, when working with a drop factor of 10, you can use the constant factor of 6 (60 10); 15 would give a constant factor of 4 (60 15), and 20 would give a constant factor of 3 (60 20).

EXAMPLE Administer 1,000 mL of RL over 10 hr. The drop factor is 15 drops per mL.

Use the Quick Formula to Calculate mL per hr

CALCULATE mL PER HR:

$$\frac{\text{T tal vol m}}{\text{otal hour}} \quad \text{Milliliter perh r}$$

$$\frac{\text{mL}}{\text{0 hr}} \quad \text{00 mL/h}$$

Use the Constant Factor to Calculate Drops per Minute

$$\frac{\text{mL/h}}{\text{Con tant f}_{\text{i}}\text{ct r}} \quad \text{gtt/min}$$

$$\frac{100 \text{ mL/hr}}{4 \quad 60 \div 15)} \quad 25 \text{ gtt/mi}$$

ANSWER: 25 gtt per min

Intermittent Intravenous Administration

Intravenous Piggyback Medications

An intermittent intravenous infusion is an intravenous preparation (usually electrolytes or antibiotics) that is "piggybacked" (IVPB) or connected to an existing IV line. The IVPB solution, usually 50 mL to 100 mL, is administered over 30 min to 60 min or less. The tubing for the secondary set will be shorter than the primary set and will have a drop factor of 60. It should be hung higher than the existing IV to allow the force of gravity to override the infusion of the primary IV. Remember: The greater the height, the greater is the pressure, and the faster is the rate of infusion! See Figure 10.3. If a piggyback medication is to be given at the same time as the primary infusion, the bag/bottle is hung at the same height and the setup is referred to as a *tandem setup* Smaller quantities of solution (100 mL to 150 mL) and medications can be given via a burette chamber. These volume-controlled sets (Buretrol, Soluset, and Volutrol) are frequently used for pediatric doses (see Chapter 14).

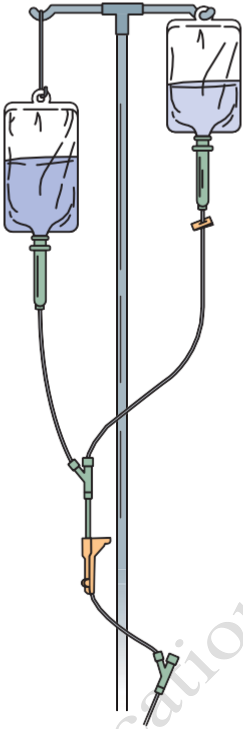


FIGURE 10.3 IV piggyback delivery system. (From Taylor, C., Lillis, C., and LeMone, P. [2001]. *Fundamentals of nursing. The art and science of nursing care* [4th ed.]. Philadelphia: Lippincott Williams & Wilkins.)

Frequently, the IVPB medication has to be reconstituted from a powder form (the type and amount of diluent will be specified), although some come premixed. You calculate the drip rate for the IVPB using the same formula that you used for the primary IV. If you are using an infusion pump, use the secondary IV setting and a drop factor of 60. Program the pump for the rate in mL per hr.

EXAMPLE: The physician ordered 1 g of Ancef in 100 mL of NS to be infused over 30 min via IVPB. The drop factor is 20 drops per mL. The IV should be infused at drops per minute.

The Standard Formula

$$\frac{\text{Total volume} \times \text{Drop factor}}{\text{Time in minutes}}$$

$$\text{Drops per minute}$$

$$\frac{100\text{ mL}\ (\quad)}{30\text{ min}} \quad \frac{\times 20}{30}$$

$$\frac{2\,000}{30} \quad 66.6\ \text{gtt/min}$$

ANSWER: 67 gtt per min

Intravenous Push (IVP) Medications

Intravenous push medications should normally be given over 1 min to 5 min. Institution guidelines and reference materials provide acceptable rates of delivery and dilution requirements. Because the medication will have rapid effects, the total volume should be divided by the total minutes and then further divided into 15-sec increments. Use a watch to verify the time of infusion. See Figure 10.4.

FIGURE 10.4 IV push medication. (From Taylor, C., Lillis, C., LeMone, P., and Lynn, P. [2008]. *Fundamentals of nursing. The art and science of nursing care* [6th ed.]. Philadelphia: Lippincott Williams & Wilkins.)

EXAMPLE: The physician ordered 30 mL, IV push, STAT. The literature recommends dilution with 10 mL of NS and injection over 5 min. Flush with 10 mL of NS.

Determine the total volume to be infused.

30 mL 10 mL of dilution 40 mL

$$\text{Us} \quad \frac{\text{Total volum}}{\text{Total minut}}$$

$$\text{Milliliters pe minut}$$

$$\frac{40\ \text{mL}}{5\ \text{min}} \quad 8\,\text{mL/min}$$

Calculate mL to be given over 15 sec

$$\text{Us} \quad \frac{\text{Total vol}}{4\ (60 \quad 5\ \text{ec})}$$

Millilite v r 15 s

$$\frac{\text{mL}}{4} \quad 2\ \text{mL e} \quad \text{ry} \quad 5$$

ANSWER: 2 mL given every 15 sec
Flush with 10 mL of NS

PRACTICE PROBLEMS

1. The physician prescribed 1,000 mL of RL to infuse over 12 hr. You should give_________mL per hr.

Critical Thinking Check

Does it seem logical that if 1,000 mL is to be infused over 12 hr, the hourly amount would be <100 mL?_______**Yes or No?**

2. You are to give 500 mL of NS over 4 hr. You should give_________mL per hr.

3. Administer 800 mL of NS over 10 hr. The drop factor is 20 drops per mL. You should give _________ drops per min.

4. You are to give 1,000 mL of 0.45% NS to infuse over 6 hours. The drop factor is 15 drops per mL. You should give_________drops per min.

5. Administer 500 mL of solution over 24 hr. The drop factor is 60 drops per mL. You should give _________ drops per min.

6. You are to give 600 mL of solution over 12 hr. The drop factor is 20 drops per mL. You should give_________drops per min.

Critical Thinking Check

Should you expect the rate of the infusion to be faster or slower if the drop factor was 15 gtt per mL instead of 20 gtt per mL?__ **Faster or slower?**

7. The physician prescribed an IV of 100 mL of D5W to run at 100 mL per hr. The drop factor is 10. You should set the flow rate at ________ drops per min.

8. The physician prescribed an IV of 500 mL of Ringer's lactate at 75 mL per hr. The drop factor is 15. You should administer________drops per min.

9. The physician prescribed an IV of 250 mL of NS to be run at 50 mL per hr. The drop factor is 20. You should run the IV at________drops per min.

10. Give 50 mg of an antibiotic in 100 mL of D5W over 30 min. The drop factor is 15 drops per mL. You should piggyback this medication into the main IV and give at________drops per min.

11. The physician prescribed an IV of 1,500 mL of Ringer's lactate solution to infuse over 20 hr. The drop factor is 15 gtt per mL. You should give ________ drops per min.

12. Administer 1 g of an antibiotic in 50 mL of D5W over 30 min. The drop factor is 10 gtt per mL. The nurse should give_________drops per min.

13. The physician prescribed an IV of 250 mL of D5 0.22% NS to infuse over 10 hr. The drop factor is 60 drops per min. The nurse should give _________ mL per hr and_________drops per min.

Critical Thinking Check

If the drop factor of 60 is equal to the number of minutes in an hour (60), does it seem logical that the gtt per min should always equal the mL per hr?________**Yes or No?**

14. Administer 1 g of an antibiotic in 100 mL of D5W to run over 30 min. The drop factor is 20 drops per mL. You should give _________ drops per min.

End of Chapter Review

Complete the following IV calculations:

1. To infuse 500 mL of solution over 8 hr, you should give_______mL per hr.

2. Administer 1,000 mL over 10 hr. You should give_______mL per hr.

3. To deliver 1,000 mL of D5 0.45% NS over 4 hr, the nurse should administer_______mL per hr.

4. To deliver 500 mL of D5W over a 6-hr period, the nurse should set the flow rate to deliver ______ mL per hr.

5. To deliver 250 mL of NS over a 5-hr period, the nurse should set the flow rate to deliver ______ mL per hr.

6. A patient is to receive 500 mL of 0.45% NS to run over 8 hr. The drop factor is 20 drops per mL. The nurse should give_______mL per hr.

7. Administer 1,000 mL of 0.9% NS over 8 hr. The drop factor is 10 drops per mL. The flow rate should be_______drops per min.

8. Administer 500 mL of D5W over a 12-hr period as KVO. The microdrip provides 60 drops per mL. Use the Quick Formula with the constant factor. The flow rate should be_______drops per min.

9. To administer 1.0 L of Ringer's lactate over 6 hr, you should give_______mL per hr. The drop factor is 10 drops per mL. The flow rate should be ______ drops per min.

10. The physician prescribed 1,000 mL of D5W to infuse over 24 hr. With a drop factor of 15 drops per mL, you should give_______drops per min. Use the Quick Formula with the constant factor.

11. The physician prescribed 1,000 mL of D5W 0.9% NS to infuse at 75 mL per hr. The drop factor is 15 drops per mL. You should give ______ drops per min.

12. Ringer's lactate, 500 mL, is to infuse at 50 mL per hr. The drop factor is 10. You should set the rate at_______drops per min. Use the Quick Formula and the constant factor.

13. Administer 1,000 mL of RL at 50 mL per hr. The total infusion time should be_______hr.

14. You are to give 500 mL of NS at 40 mL per hr. The total infusion time should be_______hr.

15. The physician prescribed 250 mL of D5W at 20 mL per hr. The total infusion time should be ______ hr.

16. The physician prescribed 100 mL of albumin to be absorbed over 2 hr. The drop factor is 15 drops per mL. The nurse should run the IV at ______ drops per min.

17. A patient is to receive 1,000 mL of NS with 20,000 units of heparin over 24 hr. The drop factor is 60 drops per mL. The nurse should give ______ drops per min.

18. A patient is to receive 350 mg of an antibiotic in 150 mL of D5W over a 1-hr period of time. The drop factor is 15 drops per mL. The nurse should give______drops per min.

19. Administer 100 mL of an antibiotic solution via an infusion pump over 60 min. The microdrip provides 60 drops per mL. You should give ______ drops per min.

20. The physician prescribed 500 mL of a 10% Intralipid solution to infuse over 4 hr. Using a pump, the nurse should set the rate at ______ mL per hr.

thePoint Additional practice problems to enhance learning and facilitate chapter comprehension can be found on **http://thePoint.lww.com/Boyer8e.**

CHAPTER 11

Intravenous Therapies

CRITICAL CARE APPLICATIONS

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Calculate flow rate when critical care dosage is known.
  Calculate critical care dosages, per hour and per minute.
- Titrate IV fluids.

In critical care situations small amounts of potent medications are ordered intravenously and must be carefully monitored. Some medications are ordered in units to be given over a specified time (e.g., heparin and insulin). Other medications are ordered by amount of drug. Frequently, the dosage is based on the patient's weight in kilograms. Some very potent medications (antiarrhythmics, vasopressors, and vasodilators) may be titrated to the patient's heart rate, blood pressure, or other parameters.

Intravenous infusions with critical care drugs must be administered with an electronic infusion pump or volume-controlled device. If these are not available, then a microdrip set at 60 drops per mL is necessary. Critical care medications can be prescribed accordingly:

- grams per minute (g per min), milligrams per minute (mg per min), micrograms per minute (mcg per min), or milliequivalents per minute (mEq per min)
- grams per hour (g per hr), milligrams per hour (mg per hr), micrograms per hour (mcg per hr), or milliequivalents per hour (mEq per hr)
- grams per kilogram per minute (g/kg/min), milligrams per kilogram per minute (mg/kg/min), micrograms per kilogram per minute (mcg/kg/min), or milliequivalents per kilogram per minute (mEq/kg/min).

The nurse must be able to calculate both the desired dosage and mL per hr for the IV infusion. *Remember* You must always know the safe dosage dilution and rate of the medications you are administering before you begin the infusion. Refer to institutional guidelines or drug references when necessary.

This chapter will focus on critical care problems. Heparin and insulin infusions will be covered in their respective chapters. Refer to Appendix J for a review of nursing considerations for critical care drug administration. Please note: Due to the size of this book, only a small sampling of critical care problems can be provided here.

thePoint Additional practice problems to enhance learning and facilitate chapter comprehension can be found on **http://thePoint.lww.com/Boyer8e.**

Calculate Flow Rate (mL per hr) When Dosage Is Known. Use Ratio and Proportion, the Formula Method, or Dimensional Analysis

To calculate milliliters per hour, you use one of the same three methods shown in Chapter 10. Note: When calculating critical care infusions, do not round up to the whole number if the pump can be set in tenths. The rate is more likely to be changed to a whole number when the dosage is titrated and then the dosage change is documented

RULE

To calculate flow rate (mL per hr) when the dosage is known: Convert to like units, calculate dosage per kilogramper minute or per kilogram per hour if the drug is ordered by weight, change dosage per minute to dosage per hour (multiply by 60 before or after you calculate mL per hr), if dosage is ordered per minute, and calculate mL per hr using ratio and proportion, the Formula Method, or dimensional analysis.

EXAMPLE #1: Give a critical care medication, 500 mg in 250 mL D5W, at 5 mcg/kg/min for a patient weighing 152 lb. The electronic infusion pump should be set at _______ mL per hr.

CONVERT TO LIKE UNITS: Change pounds to kilograms (2.2 lb 1 kg): 152 lb 2.2 lb/kg 69.1 or 69 kg. Change milligrams to micrograms (1 mg 1,000 mcg): 500 mg 1,000 mcg/mg 500,000 mcg

CALCULATE MCG/MIN: 5 mcg/kg/min 69 kg = 345 mcg/min

Ratio and Proportion

345 mcg/min : mL 500,000 mcg : 250 mL
500,000 345 mcg/min 250 mL
500,000 86,250

$$\frac{86\ 250}{500\ 000} \quad 0\ \ 725\ \text{mL/mi}$$

(rry out two p to hundredths)

CALCULATE ML/HR: 0 17 mL/min 60 min/hr 10.2 mL/hr

ANSWER: 10.2 mL per hr

The Formula Method

CALCULATE ML/MIN USING FORMULA: -

$$\frac{345\ \text{mcg/min}}{500\ 000\ \text{m g}} \quad 250\ \text{mL}$$

$$\frac{86\ 250}{500{,}000} \quad 0\ \ 725\ \text{mL/mi}$$

(rry out two p to hundredths)

CALCULATE mL/HR: 0.17 mL/min 60 min/hr 10.2 mL/hr

ANSWER: 10.2 mL per hr

Dimensional Analysis

To set up this equation, you will need to use three conversion factors: 1 mg 1,000 mcg; 60 min = 1 hr; and 1 kg 2.2 lb

$$\frac{5}{\cancel{kg/min}} \quad \frac{250\ (mL)}{500\ \cancel{mg}} \quad \frac{\cancel{mg}}{,000} \quad \frac{60\ \cancel{min}}{hr} \quad \frac{\cancel{kg}}{2\ \cancel{lb}} \quad \frac{152\ \cancel{lb}}{}$$

$$\frac{5 \quad (mL) \times \quad \times \quad 152}{500 \quad . \quad (hr) \times 2.2}$$

$$\frac{\cancel{1} \quad \cancel{000}^{114}}{\cancel{000}_{1}}$$

$$\frac{14}{.1} \quad 0\ 4\ mL/h \quad o \quad 0\ mL/hr$$

ANSWER: 10.4 mL per hr

EXAMPLE #2: The physician ordered 400 mcg of Precedex in 100 mL of NS to infuse at 0.3 mcg/kg/hr for a person who weighs 132 lb

CONVERT TO LIKE UNITS: Convert pounds to kilograms
132 lb 2.2 lb/kg = 60 kg

CALCULATE MCG/HR: 0.3 mcg/kg/hr 60 kg = 18 mcg/hr

Ratio and Proportion

18 mcg/hr :   mL   400 mcg : 100 mL
400   18 mcg/hr   100 mL
400   1,800

$$\frac{800}{400} \quad 4 \quad \text{mL/hr}$$

ANSWER: 4.5 mL per hr

The Formula Method

$$\frac{D}{H}$$

$$\frac{8 \quad \text{g/hr}}{400 \quad \text{g}} \qquad \text{mL} = 4\ 5\ \text{mL/h}$$

ANSWER: 4.5 mL per hr

Dimensional Analysis

To set up this equation, you will need one conversion factor: 1 kg   2.2 lb

$$\frac{0.3\ \cancel{\text{mcg}}}{\cancel{\text{kg}}\ /\text{h}} \quad \frac{00\ (\text{mL})}{400 \quad \text{———}}$$

$$\frac{\cancel{\text{kg}}}{2 \quad \cancel{\text{lb}}} \quad 32\ \underline{\text{lb}}$$

$$\frac{0.3 \times \quad \text{mL} \quad \times\ 32}{400 \times 2.2}$$

$$\frac{3\ 960}{880} \quad 4 \quad \text{mL/hr}$$

ANSWER: 4.5 mL per hr

EXAMPLE #3: The physician ordered 900 mg of amiodarone in 500 mL D5W to run at 0.5 mg/min. How many milliliters per hour should the patient receive?

Ratio and Proportion

900 mg : 500 mL 0.5 mg/min : mL

900 250 (500 0.5)

$$\frac{\cancel{250}\ 25}{\cancel{900}\ 90} \quad \frac{25}{90} = 0 \quad 77$$

(0 2) mL/mi

CALCULATE mL/HR: 0.28 mL/min 60 min/hr 16.8 mL/hr

ANSWER: 16.8 mL per hr

The Formula Method

CALCULATE MG/MIN USING FORMULA: $\frac{\cdot}{}$ 500 mL

0 mg/min

900 mg

0.278 mL/min (0.28 mL/min)

CALCULATE mL/HR: 0.28 mL/min 60 min/hr

16.8 mL/hr

ANSWER: 16.8 mL per hr

Dimensional Analysis

To set up this equation, you will only need one conversion factor: 60 min   1 hr

$$\frac{0. \ \cancel{\text{mg}}}{\cancel{\text{mi}}} \quad \frac{500 \text{ mL}}{900 \ \cancel{\text{mg}}} \quad \frac{60 \ \cancel{\text{min}}}{\text{hr}}$$

$$\frac{0 \quad 500 \ (\text{mL}) \times 60}{900 \quad (\text{hr})} \quad \frac{\cancel{000}^{150}}{\cancel{900}_{9}}$$

$$\frac{50}{9} \quad 6\ 7 \text{ mL/hr}$$

ANSWER: 16.7 mL per hr

Calculate Dosage, per Hour or per Minute, When Flow Rate Is Known

RULE

To calculate dosage when the flow rate (mL per hr) is known: Convert to like units and calculate the dose (grams per minute, milligrams per minute, micrograms per minute) using ratio and proportion, the Formula Method, or dimensional analysis. If the drug is ordered by weight, calculate dosage per kilogram per minute (g/kg/min, mg/kg/min, mcg/kg/min).

EXAMPLE #1: A medication, 400 mg in 250 mL D5W, is to be infused at 20 mL/hr to maintain a systolic blood pressure (BP) of 100 mm Hg in a patient weighing 110 lb. How many mcg/kg/min should be infusing?

Ratio and Proportion

CONVERT TO LIKE UNITS: Change mg to mcg (400 mg 1,000 mcg/mg 400,000 mcg)
Convert pounds to kilograms
110 lb ÷ 2.2 lb/kg 50 kg

CALCULATE MCG/HR: 400,000 mcg : 250 mL : 20 mL/hr
250 8,000,000 (400,000 20)

$$\frac{8 \quad 0 \quad 000}{250} \quad 32 \qquad \text{mcg/hr}$$

CHANGE MCG/HR TO MCG/MIN: 32,000 mcg/hr 60 min 533 mcg/min

CHANGE TO MCG/KG/MIN: 533 mcg/min 50 kg 10.66 mcg/kg/min

ANSWER: 10.7 mcg/kg/min

The Formula Method

CONVERT TO LIKE UNITS: Change mg to mcg (400 mg 1,000 mcg/mg 400,000 mcg)
Convert pounds to kilograms
110 lb 2.2 lb/kg 50 kg

CONVERT ML/HR TO ML/MIN: 20 mL/hr 60 min 1,200 mL/min

USE

$$\frac{\text{mcg/min}}{400\ 000\ \text{m}\ \ \text{g}} \quad 250\ \text{mL}$$

= 0 mL/min

0.000625 0.33
528 mL/min

CHANGE TO MCG/KG/MIN: 528 mcg/min ÷ 50 kg 10.56 mcg/kg/min (10.6)

ANSWER: 10.6 mcg/kg/min

Dimensional Analysis

To set up this equation, you will use three conversion factors (1 mg 1,000 mcg, 60 min 1 hr, and 2.2 lb 1 kg) to get mcg/kg/minute.

- Use three conversion factors

$$\frac{20\ \cancel{mL}}{\cancel{hr}} \quad \frac{400\ \cancel{mg}}{250\ \cancel{mL}} \quad \frac{.000\ (\quad g)}{\cancel{mg}}$$

$$\frac{\cancel{hr}}{60\ min} \quad \frac{2.2\ \cancel{lb}}{1\ kg} \quad 10\ lb$$

$$\frac{20 \qquad ,000\ (mcg) \qquad \times 2.2}{\times 60 \times \qquad 10}$$

$$\frac{7,,600,000}{.5\ 000}$$

066 (07) g/kg/min

ANSWER: 10.7 mcg/kg/min

EXAMPLE #2: A physician prescribes 4 mg of a drug in 250 mL D5W to be titrated to 4 mL per hr to control pain in a patient who weighs 115 lb. How many mcg/kg/hr or mcg/kg/min should be infused?

Use Ratio and Proportion

CONVERT TO LIKE UNITS: Change mg to mcg (4 mg 1,000 mcg/mg 4,000 mcg)
Change 115 lb to kg (115 lbs 2.2 lb/kg 52 kg)

CALCULATE MCG/HR: 4,000 mcg : 250 mL : 4 mL/hr
250 16,000 (4,000 4)

$$\frac{6\ 000}{250} \quad 64 \text{ m g/hr}$$

CALCULATE DOSAGE IN MCG/KG/HR: 64 mcg/hr 52 kg 1.23 mcg/kg/hr

CHANGE TO MCG/KG/MIN: 1.23 mcg/kg/min 60 min 0.02 mcg/kg/min

ANSWER: 1.23 mcg/kg/hr or 0.02 mcg/kg/min

The Formula Method

CONVERT TO LIKE UNITS: Change mg to mcg (4 mg 1,000 mcg/mg 4,000 mcg)
Change 115 lb to kg (115 lb 2.2 lb/kg 52 kg)

CALCULATE MCG/HR: $\frac{D}{H}$

$$\frac{\text{cg/hr}}{4{,}000 \quad \text{g}} \qquad 4 \text{ mL/h}$$

0.0625 4 mL/hr
64 mcg/hr

CALCULATE DOSAGE IN MCG/KG/HR: 64 mcg ÷ 52 kg 1.23 mcg/kg/hr

CHANGE TO MCG/KG/MIN: 1.23 mcg/kg/hr 60 min 0.02 mcg/kg/min

ANSWER: 1.23 mcg/kg/hr or 0.02 mcg/kg/min

Dimensional Analysis

To set up this equation, you will need to use two conversion factors (1 mg 1,000 mcg and 1 kg 2.2 lb) to get mcg/kg/hr and three conversion factors (1 mg 1,000 mcg; 60 min 1 hr; and 1 kg 2.2 lb) to get mcg/kg/min.

Use two conversion factors

$$\frac{4\ \cancel{mL}}{hour} \quad \frac{4\ \cancel{mg}}{250\ \cancel{mL}} \quad \frac{1.\ 00\qquad g}{\cancel{mg}}$$

$$\frac{2.\ \ \cancel{lb}}{kg} \quad 15\ \cancel{lb}$$

$$\frac{4 \times \qquad ,000\ (\quad g) \qquad \times 2.2}{15}$$

$$\frac{35\ 200}{28\ 750} \quad 1 \qquad cg/kg/hr$$

- Use three conversion factors

$$\frac{4\ \cancel{mL}}{\cancel{hour}} \quad \frac{4\ \cancel{mg}}{250\ \cancel{mL}} \quad \frac{1.\ 00\qquad g}{\cancel{mg}}$$

$$\frac{\cancel{hr}}{60\ min} \quad \frac{2.\ \ \cancel{lb}}{kg} \quad 15\ \cancel{lb}$$

$$\frac{4 \times \quad ,000 \ (\quad g) \quad \times 1 \times 2.2}{250 \quad \times 60 \times \quad 5}$$

$$\frac{35\ 200}{72 \quad 000} \quad 0 \quad 2 \quad g/kg/hr$$

ANSWER: 1.22 mcg/kg/hr
or 0.02 mcg/kg/min

Titrate IV Fluids

When a medication is titrated (e.g., dopamine, Neo-Synephrine), the lowest dose of medication is given first, and then the dosage is increased or decreased to achieve the desired result. Sometimes a bolus dose is initially given. An infusion pump should always be used, so you will need to calculate the infusion in mL per hr.

RULE

When solving a solution problem involving titration:

- **Convert to like units.**
- **Calculate the concentration in mcg per mL.**
- **Convert the upper and lower dose ranges into mL/min.**
- **Convert mL per min into mL per hr.**

EXAMPLE: A critical care medication was ordered to be titrated (2 to 4 mcg per min) to maintain a systolic blood pressure below 130 mm Hg. The solution being titrated contains 25 mg of medication in 500 mL D5W. The nurse needs to determine the setting for the infusion pump. The nurse should set the pump to mL per hr.

CONVERT TO LIKE UNITS: 25 mg 25,000 mcg (1 mg 1,000 mcg)

CONVERT THE UPPER AND LOWER DOSE RANGES INTO mL/MIN: The solution concentration is 50 mcg/mL

25,000 mcg : 500 mL = 2 mcg/min : *x*

25,000 1,000 (= 2 500)

$$\frac{000}{25\ 000} \quad \frac{}{25} \quad 0\ \ 4$$

0.04 mL/min *lower dosage range*

25,000 mcg : 500 mL 4 mcg :

25,000 2,000 (4 500)

$$\frac{2\ 000}{25\quad 0} \quad \frac{2}{} \quad \frac{}{5} \quad 0$$

x 0.08 mL/min *upper dosage range*

CONVERT mL/MIN TO mL/HR: *Lower dosage range:* 0.04 60 min 2.4 mL/hr

Upper dosage range: 0.08 60 min 4.8 mL/hr

ANSWER: The nurse should titrate the dosage range of 2 to 4 mcg per min by setting the pump to infuse at a flow rate of 2.4 to 4.8 mL per hr.

End of Chapter Review

Complete the following problems:

1. The physician prescribes 50 mg of a drug in 250 mL D5W to start at 10 mcg per min to relieve chest pain. You should set the infusion pump at______mL per hr.

Critical Thinking Check

If the prescribed dosage is doubled to 20 mcg per min, would you expect the infusion pump setting to double (set at 6 mL per hr)? _______
Yes or No?

2. The nurse increased a lidocaine infusion of 2 g in 250 mL D5W to 30 mL per hr to control the patient's dysrhythmia. You should document that the patient is now receiving______mg per min.

3. The physician prescribes dopamine 400 mg in 250 mL D5W to start at 5 mcg/kg/min for a patient weighing 178 lb. You should set the infusion pump at______mL per hr.

Critical Thinking Check

If the physician prescribed 800 mg of dopamine in 250 mL at 5 mcg/kg/min, would you expect the mL per hr to_______ **Increase, Decrease, or Remain the Same?**

4. A 75-kg patient on a mechanical ventilator is sedated with propofol (Diprivan) 1,000 mg in 100 mL at 10 mL per hr. You should document that the patient is receiving______mcg/kg/min.

5. The physician prescribes lorazepam (Ativan) 250 mg in 250 mL to run at 3 mg per hr. You should set the infusion pump at______mL per hr.

6. The physician prescribes a continuous infusion of a drug to control hypertension. The label directs you to remove 90 mL from a 250-mL NS bag and add 200 mg of the medication. The medication vial has 5 mg per mL. You should add ______ mL of the drug to the IV bag. The concentration of medication should be______mg per mL (remember to include the volume of the of the drug in the calculation of the total volume). In order to administer 1 mg per min, you should set the infusion pump at______mL per hr.

7. The physician prescribes a loading dose of procainamide 500 mg in 100 mL NS over 30 min. The label reads procainamide 500 mg per mL. You should add______mL of procainamide to 100 mL NS. You should set the infusion pump at

_____ mL per hr to deliver this bolus. The loading dose is to be followed with a continuous infusion of procainamide 2 g in 250 mL D5W to run at 2 mg per min. You should set the infusion pump at_____mL per hr.

8. A patient is to receive a diltiazem (Cardizem) bolus of 10 mg followed by a continuous infusion of Cardizem at 10 mg per hr. The Cardizem vials contain 5 mg per mL. To administer the bolus you should give_____mL over 2 min. To mix the continuous infusion you should inject 125 mg in a 100-mL bag of NS. You should add _____ mL of Cardizem to the IV bag. Keeping in mind the new total volume in the IV bag, you should set the infusion pump at_____mL per hr to deliver 10 mg per hr.

9. Dopamine 800 mg in 250 mL D5W is infusing at 12 mL per hr in a patient weighing 195 lb. You should document that the patient is receiving _____ mcg/kg/min.

Critical Thinking Check

If the flow rate were to increase to 18 mL per hr, would you expect the mcg/kg/min to _______
Increase or Decrease?

10. The physician prescribes phenylephrine (Neo-Synephrine) 100 mg in 250 mL D5W continuous infusion to run at 50 mcg per min. You should set the infusion pump at_____mL per hr.

To maintain the systolic BP above 90 mm Hg, the rate is increased to 12 mL per hr. You document that the patient is now receiving______mcg per min.

11. Tirofiban (Aggrastat) 12.5 mg in 250 mL is prescribed to be infused at a rate of 0.1 mcg/kg/min in a patient weighing 82 kg. You should set the pump at______mL per hr.

12. A hypertensive patient weighs 165 lb. His physician prescribed nitroprusside (Nipride) 3 mcg/kg/min, IV. Nipride 50 mg is added to a 250-mL solution of D5W. This solution should contain a concentration of Nipride,______mcg per mL. Using an infusion pump, the nurse should set the flow rate at______mL per hr.

13. A patient is to receive nitroglycerine (Nitrostat) 20 mcg per min, IV. Nitrostat is available in a 10-mL vial labeled 5 mg per mL. To prepare a 200-mcg per mL solution, with a concentration of 50 mg in 250 mL, the nurse should add ______ mL of Nitrostat to 250 mL of D5W and set the infusion pump flow rate at______mL per hr to deliver 20 mcg per min.

14. Give 400 mg of dopamine in 250 mL of D5NS to infuse at 300 mcg per min. Calculate flow rate in mL per hr. You should give______mL per hr.

Critical Thinking Check

If the infusion increased to 500 mcg per min, should you expect the mL per hr to ______ **Increase or Decrease?** If the quantity of solution increased to 500 mL of D5NS, at the same infusion of 300 mcg per min, should the mL per hr______**Increase or Decrease?**

15. A patient is started on a furosemide (Lasix) infusion to promote diuresis. Lasix 2,000 mg in 200 mL is prescribed at 1 mg per min. You should set the pump at_____mL per hr.

16. A patient is started on norepinephrine 4 mg in 250 mL D5W at 15 mL per hr. You should document that the patient is receiving_____mcg per min

17. Octreotide (Sandostatin) 1,250 mcg in 250 mL is prescribed at 50 mcg per hr. Using an infusion pump, you should set the rate at_____mL per hr.

18. A patient is to receive dobutamine 1,000 mg in 250 mL NS at 10 mcg/kg/min to maintain a systolic BP of 90 mm Hg. In a patient weighing 95 kg, you should set the pump at _____ mL per hr.

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SWER: 1.1 mL