chapter 3

Review of Arithmetic and Calculation of Drug Dosages

Key Terms

apothecaries' system	*household measurements*
Celsius (C)	*improper fraction*
centigrade	*liter*
decimal	*metric system*
decimal fraction	*mixed decimal fraction*
denominator	*minim*
diluent	*mixed number*
dimensional analysis	*numerator*
dividend	*ounce*
divisor	*proper fraction*
dram	*quotient*
Fahrenheit (F)	*remainder*
fluid dram	*solute*
fluid ounce	*solvent*
grain	
gram	

Chapter Objective

On completion of this chapter, the student will:

- Accurately perform mathematical calculations when they are necessary to compute drug dosages.

REVIEW OF ARITHMETIC

Fractions

The two parts of a fraction are the **numerator** and the **denominator.**

$$\frac{2}{3}\begin{array}{l}\leftarrow \text{numerator}\\ \leftarrow \text{denominator}\end{array}$$

A **proper fraction** may be defined as a part of a whole or any number less than a whole number. An **improper fraction** is a fraction having a numerator the same as or larger than the denominator.

$$\text{proper fraction} \quad \frac{1}{2}$$

$$\text{improper fraction} \quad \frac{7}{3}$$

The numerator and the denominator *must be of like entities or terms*, that is:

Correct (like terms)	**Incorrect (unlike terms)**
$\frac{2 \text{ acres}}{3 \text{ acres}}$	$\frac{2 \text{ acres}}{3 \text{ miles}}$
$\frac{2 \text{ grams}}{3 \text{ grams}}$	$\frac{2 \text{ grams}}{5 \text{ milliliters}}$

Mixed Numbers and Improper Fractions

A **mixed number** is a whole number and a proper fraction. A whole number is a number that stands alone; 3, 25, and 117 are examples of whole numbers. A proper fraction is a fraction whose numerator is *smaller than* the denominator; 1/8, 2/5, and 3/7 are examples of proper fractions.

These are mixed numbers:

2 2/3 2 is the whole number and 2/3 is the proper fraction

3 1/4 3 is the whole number and 1/4 is the proper fraction

When doing certain calculations, it is sometimes necessary to change a mixed number to an improper fraction or change an improper fraction to a mixed number. An improper fraction is a fraction whose numerator is *larger than* the denominator; 5/2, 16/3, and 12 3/2 are examples of improper fractions.

To change a *mixed number to an improper fraction,* multiply the denominator of the fraction by the whole number, add the numerator, and place the sum over the denominator.

EXAMPLE Mixed number 3 3/5

1. Multiply the denominator of the fraction (5) by the whole number (3) or 5 × 3 = 15:

$$3 \times \frac{3}{5}$$

2. Add the result of multiplying the denominator of the fraction (15) to the numerator (3) or 15 + 3 = 18:

$$3 \times \frac{3}{5}$$

3. Then place the sum (18) over the denominator of the fraction:

$$\frac{18}{5}$$

To change an *improper fraction to a mixed number,* divide the denominator into the numerator. The **quotient** (the result of the division of these two numbers) is the whole number. Then place the remainder over the denominator of the improper fraction.

EXAMPLE Improper fraction 15/4

$$\frac{15 \leftarrow \text{numerator}}{4 \leftarrow \text{denominator}}$$

1. Divide the denominator (4) into the numerator (15) or 15 divided by 4 (15 ÷ 4):

$$\begin{array}{rl} 3 & \leftarrow \text{quotient} \\ 4\overline{)15} & \\ 12 & \\ \hline 3 & \leftarrow \text{remainder} \end{array}$$

2. The **quotient** (3) becomes the whole number:

$$\mathbf{3}\frac{3}{4}$$

3. The **remainder** (3) now becomes the numerator of the fraction of the mixed number:

$$3\frac{\mathbf{3}}{}$$

4. And the denominator of the improper fraction (4) now becomes the denominator of the fraction of the mixed number:

$$3\frac{3}{\mathbf{4}}$$

Adding Fractions With Like Denominators

When the denominators are the *same,* fractions can be added by adding the numerators and placing the sum of the numerators over the denominator.

EXAMPLES

2/7 + 3/7 = 5/7
1/10 + 3/10 = 4/10
2/9 + 1/9 + 4/9 = 7/9
1/12 + 5/12 + 3/12 = 9/12
2/13 + 1/13 + 3/13 + 5/13 = 11/13

When giving a final answer, fractions are *always* reduced to the lowest possible terms. In the examples above, the answers of 5/7, 7/9, and 11/13 cannot be reduced. The answers of 4/10 and 9/12 can be reduced to 2/5 and 3/4.

To reduce a fraction to the lowest possible terms, determine if any number, which always must be the same, can be divided into both the numerator and the denominator.

4/10: the numerator *and* the denominator can be divided by 2

9/12: the numerator *and* the denominator can be divided by 3

$$\text{For example: } \frac{4}{10} \frac{\div\ 2}{\div\ 2} = \frac{2}{5}$$

If when adding fractions the answer is an improper fraction, it may then be changed to a mixed number.

2/5 + 4/5 = 6/5 (improper fraction)
6/5 changed to a mixed number is 1 1/5

Adding Fractions With Unlike Denominators

Fractions with *unlike denominators* cannot be added until the denominators are changed to like numbers or numbers that are the same. The first step is to find the *lowest common denominator,* which is the lowest number divisible by (or that can be divided by) all the denominators.

EXAMPLE Add 2/3 and 1/4

$\frac{2}{3}$

$\frac{1}{4}$

The lowest number that can be divided by these two denominators is 12; therefore, 12 is the lowest common denominator.

1. Divide the lowest common denominator (which in this example is 12) by each of the denominators in the fractions (in this example 3 and 4):

$$\frac{2}{3} = \frac{}{12} \qquad (12 \div 3 = 4)$$
$$\frac{1}{4} = \frac{}{12} \qquad (12 \div 4 = 3)$$

2. Multiply the results of the divisions by the numerator of the fractions ($12 \div 3 = 4 \times$ the numerator $2 = 8$ and $12 \div 4 = 3 \times$ the numerator $1 = 3$) and place the results in the numerator:

$$\frac{2}{3} = \frac{}{12} \qquad \frac{\mathbf{8}}{12}$$
$$\frac{1}{4} = \frac{}{12} \qquad \frac{\mathbf{3}}{12}$$

3. Add the numerators (8 + 3) and place the result over the denominator (12):

$$\frac{8}{12}$$
$$\frac{3}{12}$$
$$\frac{11}{12}$$

Adding Mixed Numbers or Fractions With Mixed Numbers

When adding two or more mixed numbers or adding fractions and mixed numbers, the mixed number is first changed to an improper fraction.

EXAMPLE Add 3 3/4 and 3 3/4

$3\frac{3}{4}$ changed to an improper fraction $\rightarrow \frac{15}{4}$

$3\frac{3}{4}$ changed to an improper fraction $\rightarrow \frac{15}{4}$

The numerators are added $\rightarrow \frac{30}{4} = 7\ 2/4 = 7\ 1/2$

The improper fraction (30/4) is changed to a mixed number (7 2/4) and the fraction of the mixed number (2/4) changed to the lowest possible terms (1/2).

EXAMPLE Add 2 1/2 and 3 1/4

$2\frac{1}{2}$ changed to an improper fraction $\frac{5}{2}$

$3\frac{1}{4}$ changed to an improper fraction $\frac{13}{4}$

In the example above, 5/2 and 13/4 cannot be added because the denominators are not the same. It will be necessary to find the lowest common denominator first.

$\frac{5}{2} \nearrow \frac{10}{4}$

the lowest common denominator is 4

$\frac{13}{4} \rightarrow \frac{13}{4}$

$\frac{23}{4}$ changed to a mixed number $= 5\frac{3}{4}$

Comparing Fractions

When fractions with *like* denominators are compared, the fraction with the *largest numerator* is the *largest* fraction.

EXAMPLES

Compare: 5/8 and 3/8 Answer: **5**/8 is larger than **3**/8.
Compare: 1/4 and 3/4 Answer: **3**/4 is larger than **1**/4

When the denominators are *not* the same, for example, comparing 2/3 and 1/10, the lowest common denominator must first be determined. The same procedure is followed when adding fractions with unlike denominators (see above).

EXAMPLE Compare 2/3 and 1/10 (fractions with unlike denominators)

$$\frac{2}{3} = \frac{20}{30}$$

lowest common denominator

$$\frac{1}{10} = \frac{3}{30}$$

The largest numerator in these two fractions is 20; therefore, 2/3 is larger than 1/10.

Multiplying Fractions

When fractions are multiplied, the numerators are multiplied *and* the denominators are multiplied.

EXAMPLES

$$\frac{1}{8} \times \frac{1}{4} = \frac{1}{32} \qquad \frac{1}{2} \times \frac{2}{3} = \frac{2}{6} = \frac{1}{3}$$

In the above examples, it was necessary to reduce one of the answers to its lowest possible terms.

Multiplying Whole Numbers and Fractions

When whole numbers are multiplied with fractions, the numerator is multiplied by the whole number and the product is placed over the denominator. When necessary, the fraction is reduced to its lowest possible terms. If the answer is an improper fraction, it may be changed to a mixed number.

EXAMPLES

$$2 \times \frac{1}{2} = \frac{2}{2} = 1$$ (answer reduced to lowest possible terms)

$$2 \times \frac{3}{8} = \frac{6}{8} = \frac{3}{4}$$ (answer reduced to lowest possible terms)

$$4 \times \frac{2}{3} = \frac{8}{3} = 2\frac{2}{3}$$ (improper fraction changed to a mixed number)

Multiplying Mixed Numbers

To multiply mixed numbers, the mixed numbers are changed to *improper fractions* and then multiplied.

EXAMPLES

$$\boxed{2\frac{1}{2}} \times \boxed{3\frac{1}{4}} = \frac{5}{2} \times \frac{13}{4} = \frac{65}{8} = 8\frac{1}{8}$$

$$3\frac{1}{3} \times 4\frac{1}{2} = \frac{10}{3} \times \frac{9}{2} = \frac{90}{6} = 15$$

Multiplying a Whole Number and a Mixed Number

To multiply a whole number and a mixed number, *both* numbers must be changed to improper fractions.

EXAMPLES

$$3 \times 2\frac{1}{2} = \frac{3}{1} \times \frac{5}{2} = \frac{15}{2} = 7\frac{1}{2}$$

$$2 \times 4\frac{1}{2} = \frac{2}{1} \times \frac{9}{2} = \frac{18}{2} = 9$$

A whole number is converted to an improper fraction by placing the whole number over 1. In the above examples. 3 becomes 3/1 and 2 becomes 2/1.

Dividing Fractions

When fractions are divided, the *second* fraction (the divisor) is inverted (turned upside down) and then the fractions are multiplied.

EXAMPLES

$$\frac{1}{3} \div \boxed{\frac{3}{7}} = \frac{1}{3} \times \frac{7}{3} = \frac{7}{9}$$

$$\frac{1}{8} \div \frac{1}{4} = \frac{1}{8} \times \frac{4}{1} = \frac{4}{8} = \frac{1}{2}$$

$$\frac{3}{4} \div \frac{1}{2} = \frac{3}{4} \times \frac{2}{1} = \frac{6}{4} = 1\frac{1}{2}$$

In the above examples, the second answer was reduced to its lowest possible terms and the third answer, which was an improper fraction, was changed to a mixed number.

Dividing Fractions and Mixed Numbers

Some problems of division may be expressed as (1) fractions and mixed numbers, (2) two mixed numbers, (3) whole numbers and fractions, or (4) whole numbers and mixed numbers.

MIXED NUMBERS AND FRACTIONS. When a mixed number is divided by a fraction, the whole number is first changed to a fraction.

EXAMPLES

$$\boxed{2\frac{1}{3}} \div \frac{1}{4} = \frac{7}{3} \div \frac{1}{4} = \frac{7}{3} \times \frac{4}{1} = \frac{28}{3} = 9\frac{1}{3}$$

$$2\frac{1}{2} \div \frac{1}{2} = \frac{5}{2} \div \frac{1}{2} = \frac{5}{2} \times \frac{2}{1} = \frac{10}{2} = 5$$

MIXED NUMBERS. When two mixed numbers are divided, they are both changed to improper fractions.

EXAMPLE

$$\boxed{3\frac{3}{4}} \div \boxed{1\frac{1}{2}} = \frac{15}{4} \div \frac{3}{2} = \frac{15}{4} \times \frac{2}{3} = \frac{30}{12}$$
$$= 2\frac{6}{12} = 2\frac{1}{2}$$

WHOLE NUMBERS AND FRACTIONS. When a whole number is divided by a fraction, the whole number is changed to an improper fraction by placing the whole number over 1.

EXAMPLE

$$\boxed{2} \div \frac{2}{3} = \frac{2}{1} \div \frac{2}{3} = \frac{2}{1} \times \frac{3}{2} = \frac{6}{2} = 3$$

WHOLE NUMBERS AND MIXED NUMBERS. When whole numbers and mixed numbers are divided, the whole number is changed to an improper fraction and the mixed number is changed to an improper fraction.

EXAMPLE

$$4 \div 2\frac{2}{3} = \frac{4}{1} \div \frac{8}{3} = \frac{4}{1} \times \frac{3}{8} = \frac{12}{8} = 1\frac{4}{8} = 1\frac{1}{2}$$

Ratios

A ratio is a way of expressing *a part of a whole* or *the relation of one number to another.* For example, a ratio written as 1:10 means 1 in 10 parts, or 1 to 10. A ratio may also be written as a fraction; thus 1:10 can also be expressed as 1/10.

EXAMPLES

1:1000 is 1 part in 1000 parts, or 1 to 1000, or 1/1000

1:250 is 1 part in 250 parts, or 1 to 250, or 1/250

Some drug solutions are expressed in ratios, for example 1:100 or 1:500. These ratios mean that there is 1 part of a drug in 100 parts of solution or 1 part of the drug in 500 parts of solution.

Percentages

The term *percentage* or *percent* (%) means *parts per hundred.*

EXAMPLES

25% is 25 parts per hundred
50% is 50 parts per hundred

A percentage may also be expressed as a fraction.

EXAMPLES

25% is 25 parts per hundred or 25/100
50% is 50 parts per hundred or 50/100
30% is 30 parts per hundred or 30/100

The above fractions may also be reduced to their lowest possible terms:

$$25/100 = 1/4, \quad 50/100 = 1/2, \quad 30/100 = 3/10.$$

Changing a Fraction to a Percentage

To change a fraction to a percentage, divide the denominator by the numerator and multiply the results (quotient) by 100 and then add a percent sign (%).

EXAMPLES

Change 4/5 to a percentage

$$4 \div 5 = 0.8$$
$$0.8 \times 100 = 80\%$$

Change 2/3 to a percentage

$$2 \div 3 = 0.666$$
$$0.666 \times 100 = 66.6\%$$

Changing a Ratio to a Percentage

To change a ratio to a percentage, the ratio is first expressed as a fraction with the first number or term of the ratio becoming the numerator and the second number or term becoming the denominator. For example, the ratio 1:500 when changed to a fraction becomes 1/500. This fraction is then changed to a percentage by the same method shown in the preceding section.

EXAMPLE

Change 1:125 to a percentage

1:125 written as a fraction is 1/125

$$1 \div 125 = 0.008$$
$$0.008 \times 100 = 0.8$$
adding the percent sign = 0.8%

Changing a Percentage to a Ratio

To change a percentage to a ratio, the percentage becomes the numerator and is placed over a denominator of 100.

EXAMPLES

Changing 5% and 10% to ratios

$$5\% \text{ is } \frac{5}{100} = \frac{1}{20} \text{ or } 1{:}20$$
$$10\% \text{ is } \frac{10}{100} = \frac{1}{10} \text{ or } 1{:}10$$

Proportions

A proportion is a method of expressing equality between two ratios. An example of two ratios expressed as a proportion is: 3 is to 4 as 9 is to 12. This may also be written as:

3:4 as 9:12

or

3:4::9:12

or

$$\frac{3}{4} = \frac{9}{12}$$

Proportions may be used to find an unknown quantity. The unknown quantity is assigned a letter, usually X. An example of a proportion with an unknown quantity is 5:10::15:X.

The first and last terms of the proportion are called the *extremes*. In the above expression 5 and X are the extremes. The second and third terms of the proportion are called the *means*. In the above proportion, 10 and 15 are the means.

means
↙ ↘
5:10::15:X
↖ ↗
extremes

$$\begin{array}{rcl} \text{extreme } \dfrac{5}{\text{mean } 10} & = & \dfrac{15 \text{ mean}}{X \text{ extreme}} \end{array}$$

To solve for X:

1. Multiply the extremes and place the product (result) to the *left* of the equal sign.

   5:10::15:X
   5X =

2. Multiply the means and place the product to the *right* of the equal sign.

   5:10::15X
   5X = 150

3. Solve for *X* by dividing the number to the right of the equal sign by the number to the left of the equal sign (150 ÷ 5).

   5X = 150
   X = 30

4. To prove the answer is correct, substitute the answer (30) for X in the equation.

5:10::15:X
5:10::15:30

Then multiply the means and place the product to the left of the equal sign. Then multiply the extremes and place the product to the right of the equal sign.

5:10::15:30
150 = 150

If the numbers are the same on both sides of the equal sign, the equation has been solved correctly.

If the proportion has been set up as a fraction, cross multiply and solve for X.

$$\frac{5}{10} = \frac{15}{X}$$

5 times X = 5X and 10 times 15 = 150
5X = 150
X = 30

To set up a proportion, remember that a *sequence must be followed.* If a sequence is not followed, the proportion will be stated incorrectly.

EXAMPLES

If a man can walk 6 *miles* in 2 *hours*, how many *miles* can he walk in 3 *hours?*

miles is to *hours* and *miles* is to *hours*

or

miles:*hours*::*miles*:*hours*

or

$$\frac{\text{miles}}{\text{hours}} = \frac{\text{miles}}{\text{hours}}$$

The unknown fact is the number of miles walked in 3 hours:

6 miles:2 hours::X miles:3 hours
2X = 18
X = 9 miles (he can walk 9 miles in 3 hours)

If there are 15 *grains* in 1 *gram*, 30 *grains* equals how many *grams?*

15 grains:1 gram::30 grains:X grams
15X = 30
X = 2 grams (30 grains equals 2 grams)

Decimals

Decimals are used in the metric system. A **decimal** is a fraction in which the denominator is 10 or some power of 10. For example, 2/10 (read as two tenths) is a fraction with a denominator of 10; 1/100 (read as one one hundredth) is an example of a fraction with a denominator that is a power of 10 (ie, 100).

A power (or multiple) of 10 is the *number 1 followed by one or more zeros.* Therefore, 100, 1000, 10,000 and so on are powers of 10 because the number 1 is followed by two, three, and four zeros, respectively. Fractions whose denominators are 10 or a power of 10 are often expressed in decimal form.

Parts of a Decimal

There are three parts to a decimal:

1	·	25
number(s)	**d**	number(s)
to the	**e**	to the
left of	**c**	right of
the	**i**	the
decimal	**m**	decimal
	a	
	l	

Types of Decimals

A decimal may consist only of numbers to the right of the decimal point. This is called a **decimal fraction.** Examples of decimal fractions are 0.05, 0.6, and 0.002.

A decimal may also have numbers to the *left* and *right* of the decimal point. This is called a **mixed decimal fraction.** Examples of mixed decimal fractions are 1.25, 2.5, and 7.5.

Both decimal fractions and mixed decimal fractions are commonly referred to as decimals. When there is no number to the left of the decimal, a zero may be written, for example, 0.25. Although in general mathematics the zero may not be required, it should be used in the writing of drug doses in the metric system. *Use of the zero lessens the chance of drug errors,* especially when the dose of a drug is hurriedly written and the decimal point is indistinct. For example, a drug order for dexamethasone is written as dexamethasone .25 mg by one physician and written as dexamethasone 0.25 by another. If the decimal point in the first written order is indistinct, the order might be interpreted as 25 mg, which is 100 times the prescribed dose!

Reading Decimals

To read a decimal, the position of the number to the left or right of the decimal point indicates how the decimal is to be expressed.

hundred thousands	ten thousands	thousands	hundreds	tens	units	DECIMAL POINT	tenths	hundredths	thousandths	ten thousandths	hundred thousandths
0	0	0	0	0	0	.	0	0	0	0	0

Adding Decimals

When adding decimals, place the numbers in a column so that the whole numbers are aligned to the left of the decimal and the decimal fractions are aligned to the right of the decimal.

EXAMPLE

20.45 + 2.56 is written as: 2 + 0.25 is written as:

$$\begin{array}{r} 20.45 \\ +2.56 \\ \hline 23.01 \end{array} \qquad\qquad \begin{array}{r} 2.00 \\ +0.25 \\ \hline 2.25 \end{array}$$

Subtracting Decimals

When subtracting decimals, the numbers are aligned to the left and right of the decimal in the same manner as for the addition of decimals.

EXAMPLE

20.45 − 2.56 is written as: 9.74 − 0.45 is written as:

$$\begin{array}{r} 20.45 \\ -2.56 \\ \hline 17.89 \end{array} \qquad\qquad \begin{array}{r} 9.74 \\ -0.45 \\ \hline 9.29 \end{array}$$

Multiplying a Whole Number by a Decimal

To multiply a whole number by a decimal, move the decimal point of the product (answer) as many places to the left as there are places to the right of the decimal point.

EXAMPLE

$$\begin{array}{rcl} 500 & & \text{there are two places to the right} \\ \times.05 & \leftarrow & \text{of the decimal} \\ \hline 2500. & & \text{the decimal point is moved two places to the left} \end{array}$$

After moving the decimal point, the answer reads 25.

$$\begin{array}{rcl} 250 & & \text{there are two places to the right} \\ \times.3 & \leftarrow & \text{of the decimal} \\ \hline 750. & & \text{the decimal point is moved two places to the left} \end{array}$$

After moving the decimal point, the answer reads 75.

Multiplying a Decimal by a Decimal

To multiply a decimal by a decimal, move the decimal point of the product (answer) as many places to the left as there are places to the right in *both* decimals.

EXAMPLE

$$\begin{array}{rcl} & & \text{there are two places to the right} \\ 2.75 & \leftarrow & \text{of the decimal} \\ \times0.5 & \leftarrow & \text{plus one place to the right of the decimal move} \\ \hline 1375. & & \text{the decimal point three places to the left} \end{array}$$

After moving the decimal point, the answer reads 1.375.

Dividing Decimals

The **divisor** is a number that is divided into the **dividend.**

EXAMPLE

$$\underset{\text{dividend}}{\underset{\uparrow}{0.69}} \div \underset{\text{divisor}}{\underset{\uparrow}{0.3}} \qquad\qquad \underset{\text{divisor}}{\underset{\uparrow}{0.3}}\overline{)\underset{\text{dividend}}{\underset{\uparrow}{0.69}}}$$

This may be written or spoken as 0.69 divided by 0.3. To divide decimals:

1. The *divisor* is changed to a whole number. In this example, the decimal point is moved one place to the right so that 0.3 now becomes 3, which is a whole number.

$$0.3\overline{)0.69}$$

2. The decimal point in the *dividend* is now moved the *same number of places* to the right. In this example, the decimal point is moved one place to the right, the same number of places the decimal point in the divisor was moved.

$$0.3\overline{)0.69}$$

3. The numbers are now divided.

$$\begin{array}{r} 2.3 \\ 3\overline{)6.9} \end{array}$$

When only the dividend is a decimal, the decimal point is carried to the quotient (answer) in the same position.

EXAMPLES

$$\begin{array}{r} .375 \\ 2\overline{)0.750} \end{array} \qquad \begin{array}{r} 1.736 \\ 2\overline{)3.472} \end{array}$$

To divide when only the divisor is a decimal, for example,

$$.3\overline{)66}$$

1. The divisor is changed to a whole number. In this example the decimal point is moved one place to the right.

$$.3\overline{)66}$$

2. The decimal point in the dividend must also be moved one place to the right.

$$.3\overline{)66.0}$$

3. The numbers are now divided.

$$\begin{array}{r} 220 \\ 3\overline{)660} \end{array}$$

Whenever the decimal point is moved in the dividend *it must also be moved* in the divisor, and whenever the decimal point in the divisor is moved *it must be moved* in the dividend.

Changing a Fraction to a Decimal

To change a fraction to a decimal, divide the numerator by the denominator.

EXAMPLE

$$\frac{1}{5} = 5\overline{)1.0}\ \ (.2) \qquad \frac{3}{4} = 4\overline{)3.00}\ \ (.75) \qquad \frac{1}{6} = 6\overline{)1.000}\ \ (.166)$$

Changing a Decimal to a Fraction

To change a decimal to a fraction:

1. Remove the decimal point and make the resulting whole number the numerator: 0.2 = 2.
2. The denominator is stated as 10 or a power of 10. In this example, 0.2 is read as two *tenths*, and therefore the denominator is 10.

$$0.2 = \frac{2}{10} \text{ reduced to the lowest possible number is } \frac{1}{5}$$

ADDITIONAL EXAMPLES

$$0.75 = \frac{75}{100} = \frac{3}{4} \qquad 0.025 = \frac{25}{1000} = \frac{1}{40}$$

CALCULATION OF DRUG DOSAGES

Although most hospital pharmacies dispense drugs as single doses or in a unit dose system, on occasion the nurse must compute a drug dosage because it differs from the dose of the drug that is available. This is particularly true of small hospitals, nursing homes, physicians' offices, and outpatient clinics that may not have a complete range of all available doses for a particular drug. Because certain situations may require computing the desired amount of drug to be given, nurses must be familiar with the calculation of all forms of drug dosages.

Systems of Measurement

There are three systems of measurement of drug dosages: the **metric system,** the **apothecaries' system,** and **household measurements.** The metric system is the most commonly used system of measurement in medicine. A physician may prescribe a drug dosage in the apothecaries' system, but for the most part this ancient system of measurements is only occasionally used. The household system is rarely used in a hospital setting but may be used to measure drug dosages in the home.

DISPLAY 3-1 ● Metric Measurements

WEIGHT
The unit of weight is the gram.
1 kilogram (kg) = 1000 grams (g)
1 gram (g) = 1000 milligrams (mg)
1 milligram (mg) = 1000 micrograms (mcg)

VOLUME
The unit of volume is the liter.
1 decaliter (dL) = 10 liters (L)
1 liter (L) = 1000 milliliters (mL)
1 milliliter (mL) = 0.001 liter (L)

LENGTH
The unit of length is the meter.
1 meter (m) = 100 centimeters (cm)
1 centimeter (cm) = 0.01 meter (m)
1 millimeter (mm) = 0.001 meter (m)

The Metric System

The metric system uses decimals (or the decimal system). In the metric system, the **gram** is the unit of weight, the **liter** the unit of volume, and the **meter** the unit of length.

Display 3-1 lists the measurements used in the metric system. The abbreviations for the measurements are given in parentheses.

The Apothecaries' System

The apothecaries' system uses whole numbers and fractions. Decimals are *not* used in this system. The whole numbers are written as lowercase Roman numerals, for example, x instead of 10, or v instead of 5.

The units of weight in the apothecaries' system are **grains, drams,** and **ounces.** The units of volume are **minims, fluid drams,** and **fluid ounces.** The units of measurement in this system are not based on exact measurements.

Display 3-2 lists the measurements used in the apothecaries' system. The abbreviations (or symbols) for the measurements are given in parentheses.

DISPLAY 3-2 ● Apothecaries' Measurements

WEIGHT
The units of weight are grains, drams, and ounces.
60 grains (gr) = 1 dram (ʒ)
1 ounce (℥) = 480 grains (gr)

VOLUME
The units of volume are minims, fluid drams, and fluid ounces.
1 fluid dram = 60 minims (♏)
1 fluid ounce = 8 fluid drams

DISPLAY 3-3 ● Household Measurements

3 teaspoons (tsp) = 1 tablespoon (tbsp)
2 tablespoons (tbsp) = 1 ounce (oz)
2 pints (pt) = 1 quart (qt)
4 quarts (qt) = 1 gallon (gal)

Household Measurements

When used, household measurements are for volume only. In the hospital, household measurements are rarely used because they are inaccurate when used to measure drug dosages. On occasion, the nurse may use the pint, quart, or gallon when ordering, irrigating, or sterilizing solutions or stock solutions. For the ease of a patient taking a drug at home, the physician may order a drug dosage in household measurements.

Display 3-3 lists the more common household measurements, with abbreviations in parentheses.

Conversion Between Systems

To convert between systems, it is necessary to know the equivalents, or what is equal to what in each system. Table 3-1 lists the more common equivalents.

TABLE 3-1 Approximate Equivalents

METRIC	APOTHECARIES	HOUSEHOLD
Weight		
0.1 mg	gr 1/600	
0.15 mg	gr 1/400	
0.2 mg	gr 1/300	
0.3 mg	gr 1/200	
0.4 mg	gr 1/150	
0.6 mg	gr 1/100	
1 mg	gr 1/60	
2 mg	gr 1/30	
4 mg	gr 1/15	
6 mg	gr 1/10	
8 mg	gr 1/8	
10 mg	gr 1/6	
15 mg	gr 1/4	
20 mg	gr 1/3	
30 mg	gr ss (1/2)	
60 mg	gr 1	
100 mg	gr i ss (1 1/2)	
120 mg	gr ii	
1 g (1000 mg)	gr xv	
Volume		
0.06 mL	min (♏) i	
1 mL	min (♏) xv or xvi	
4 mL	fluidram i	1 teaspoon (tsp)
15 mL	fluidrams iv	1/2 ounce (oz)
30 mL	fluid ounce i	1 ounce (oz)
500 mL	1 pint (pt)	1 pint (pt)
1000 mL (1 liter)	1 quart (qt)	1 quart (qt)

These equivalents are only *approximate* because the three systems are different and are not truly equal to each other.

Several methods may be used to convert from one system to another using an equivalent, but most conversions can be done by using proportion.

EXAMPLES

Convert 120 mg (metric) to grains (apothecaries')

Using proportion and the known equivalent 60 mg = gr i (1 grain)

$$1 \text{ gr}:60 \text{ mg}::X \text{ gr}:120 \text{ mg}$$
$$60X = 120$$
$$X = 2 \text{ gr (grains or gr ii)}$$

Note the use of the abbreviations gr and mg when setting up the proportion. This shows that the proportion was stated correctly and helps in identifying the answer as 2 *grains.*

Convert gr 1/100 (apothecaries') to mg (metric)

Using proportion and the known equivalent 60 mg = 1 gr:

If there are 60 mg in 1 gr, there are X mg in 1/100 gr

$$60 \text{ mg}:1 \text{ gr}::X \text{ mg}:1/100 \text{ gr}$$
$$X = 60 \times \frac{1}{100} = \frac{60}{100} = \frac{3}{5}$$
$$X = \frac{3}{5} \text{ mg}$$

or

$$\frac{60 \text{ mg}}{1 \text{ gr}} = \frac{X \text{ mg}}{1/100} \text{ gr}$$
$$X = 60 \times \frac{1}{100} = \frac{60}{100} = \frac{3}{5}$$
$$X = \frac{3}{5} \text{ mg}$$

Fractions are *not* used in the metric system; therefore, the fraction must be converted to a decimal by dividing the denominator into the numerator, or 3 ÷ 5 = 0.6 or

$$5\overline{)3.0}\quad .6$$

Therefore, gr 1/100 is equal to 0.6 mg.

When setting up the proportion, the apothecaries' system was written in Arabic numbers instead of Roman numerals, and their order was reversed (1 gr instead of gr i) so that all numbers and abbreviations are uniform in presentation.

Convert 0.3 milligrams (mg) [metric] to grains (gr) [apothecaries']

Using proportion and the known equivalent 1 mg = gr 1/60

$$1/60 \text{ gr}:1 \text{ mg}::X \text{ gr}:0.3 \text{ mg}$$

$$X = \frac{1}{60} \times 0.3 = \frac{0.3}{60} = \frac{3}{600} = \frac{1}{200}$$

$$X = \frac{1}{200} \text{ grain}$$

or

$$\frac{1/60}{} = \frac{X \text{ gr}}{}$$

or

$$\frac{1/60}{1 \text{ mg}} = \frac{X \text{ gr}}{0.3 \text{ mg}}$$

$$X = \frac{1}{60} \times 0.3 = \frac{0.3}{60} = \frac{3}{600} = \frac{1}{200}$$

$$X = \frac{1}{200 \text{ gr}}$$

Therefore, 0.3 mg equals gr 1/200.

There is no rule stating which equivalent must be used. In the above problem, another equivalent (60 mg = 1 gr) also could have been used. If 60 mg = 1 gr is used, the proportion would be:

$$60 \text{ mg}:1 \text{ gr}::0.3 \text{ mg}:X$$

$$60X = 0.3$$

$$X = 0.005$$

or

$$\frac{60 \text{ mg}}{1 \text{ gr}} = \frac{0.3 \text{ mg}}{X \text{ gr}}$$

$$60X = 0.3$$

$$X = 0.005$$

Therefore, 0.3 mg equals 0.005 gr.

Because decimals are not used in the apothecaries' system, this decimal answer must be converted to a fraction: 0.005 is 5/1000, which, when reduced to its lowest terms, is 1/200. The final answer is now 0.3 mg = gr 1/200.

Converting Within a System

Sometimes it is necessary to convert within the same system, for example, changing grams (g) to milligrams (mg) or milligrams to grams. Proportion and a known equivalent also may be used for this type of conversion.

EXAMPLE

Convert 0.1 gram (g) to milligrams (mg)

Using proportion and the known equivalent 1000 mg = 1g

$$1000 \text{ mg}:1 \text{ g}::X \text{ mg}:0.1 \text{ g}$$

$$X = 1000 \times 0.1$$

$$X = 100 \text{ mg}$$

or

$$\frac{1000 \text{ mg}}{1 \text{ g}} = \frac{X \text{ mg}}{0.1 \text{ g}}$$

$$X = 1000 \times 0.1$$

$$X = 100 \text{ mg}$$

Therefore, 0.1 gram (g) equals 100 milligrams (mg).

Solutions

A **solute** is a substance dissolved in a **solvent.** A solvent may be water or some other liquid. Usually water is used for preparing a solution unless another liquid is specified. Solutions are prepared by using a solid (powder, tablet) and a liquid, or a liquid and a liquid. Today, most solutions are prepared by a pharmacist and not by the nurse.

Examples of how solutions may be labeled include:

- 10 mg/mL–10 mg of the drug in each milliliter
- 1:1000–a solution denoting strength or 1 part of the drug per 1000 parts
- 5 mg/teaspoon–5 mg of the drug in each teaspoon (home use)

Reading Drug Labels

Drug labels give important information the nurse must use to obtain the correct dosage. The unit dose is the most common type of labeling seen in hospitals. The unit dose is a method of dispensing drugs in which each capsule or tablet is packaged separately. At times the drug will come to the nursing unit in a container with a number of capsules or tablets or as a solution. The nurse must then determine the number of capsules/tablets or the amount of solution to administer.

Drug labels usually contain two names: the trade (brand) name and the generic or official name (see Chap. 1). The trade name is capitalized, written first on the label, and identified by the registration symbol. The official or generic name is written in smaller print and usually located under the trade name. Although the drug has only one official name, several companies may manufacture the drug, with each manufacturer using a different trade name. Sometimes the generic or official name is so widely known that all manufacturers will simply use that name. For example, atropine sulfate is a widely used drug that is so well known that all manufacturers use the official name. In this case only the official name, atropine sulfate, will be found on the label. Drugs may be prescribed by either the trade name or the official or generic name. See Figure 3-1 for an example of a drug label showing the trade and generic names.

The dosage strength is also given on the container. The dosage strength is the average strength given to a patient as one dose. If necessary, the dosage strength is used to calculate the number of tablets or the amount of

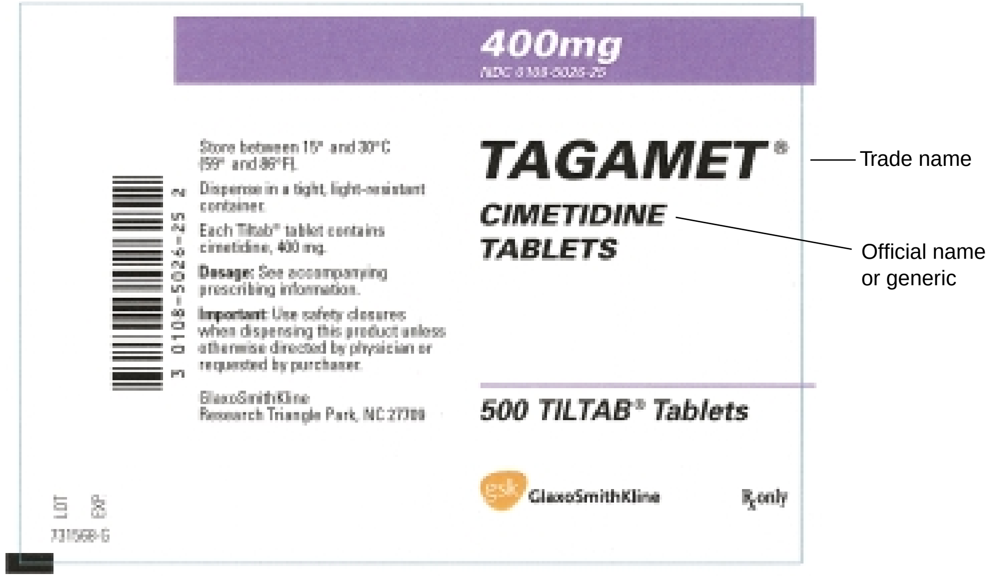

FIGURE 3-1. Drug label for Tagamet.

solution to administer. In liquid drugs there is a specified amount of drug in a given volume of solution, such as 50 mg in 2 mL.

Look at Figure 3-2. In this example, the dosage strength of the Augmentin is 125 mg/5 mL solution. If the physician orders 125 mg Augmentin, the nurse would administer 5 mL. More information on calculating drug dosages is given in the following section.

Oral Dosages of Drugs

Under certain circumstances, it may be necessary to compute an oral drug dosage because the dosage ordered by the physician may not be available, or the dosage may have been written in the apothecaries' system and the drug or container label is in the metric system.

Tablets and Capsules

To find the correct dosage of a solid oral preparation, the following formula may be used:

$$\frac{\text{dose desired}}{\text{dose on hand}} = \text{dose administered (the unknown or X)}$$

This formula may be abbreviated as

$$\frac{D}{H} = X$$

When the dose ordered by the physician (dose desired) is written in the *same system* as the dose on the drug container (dose on hand), these two figures may be inserted into the formula.

EXAMPLE

The physician orders ascorbic acid 100 mg (metric). The drug is available as ascorbic acid 50 mg (metric).

$$\frac{D}{H} = X$$

$$\frac{100 \text{ mg (dose desired)}}{50 \text{ mg (dose on hand)}} = 2 \text{ tablets of 50-mg ascorbic acid}$$

If the physician had ordered ascorbic acid 0.5 g and the drug container was labeled ascorbic acid 250 mg, a *conversion of grams to milligrams* (because the drug container is labeled in milligrams) would be necessary before this formula can be used. If the 0.5 g were *not*

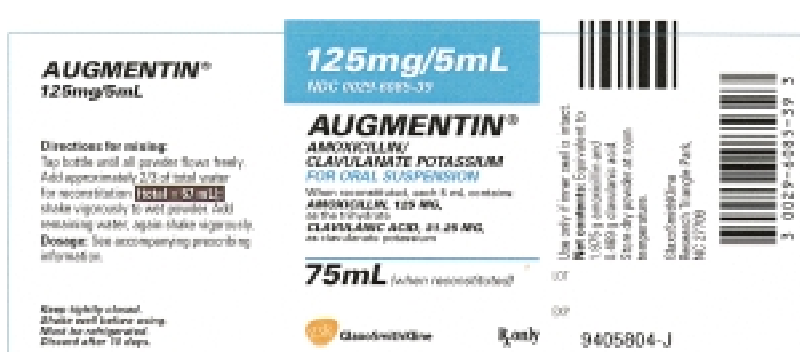

FIGURE 3-2. Drug label for Augmentin.

converted to milligrams, the fraction of the formula would look like this:

$$\frac{0.5 \text{ grams}}{250 \text{ milligrams}}$$

A fraction *must* be stated in *like terms;* therefore, proportion may be used to convert grams to milligrams.

$$1000 \text{ mg}:1 \text{ g}::X \text{ mg}:0.5 \text{ g}$$
$$X = 1000 \times 0.5$$
$$X = 500 \text{ mg}$$

After changing 0.5 g to mg, use the formula:

$$\frac{D}{H} = X$$
$$\frac{500 \text{ mg}}{250 \text{ mg}} = 2 \text{ tablets of 250 mg ascorbic acid}$$

As with all fractions, the numerator and the denominator must be of like terms, for example, milligrams over milligrams or grams over grams. Errors in using this and other drug formulas, as well as proportions, will be reduced if the entire dose is written rather than just the numbers.

$$\frac{100 \text{ mg}}{50 \text{ mg}} \text{ rather than } \frac{100}{50}$$

This will eliminate the possibility of using *unlike* terms in the fraction.

Even if the physician's order was written in the apothecaries' system, the drug container most likely would be labeled in the metric system. A conversion of *apothecaries' to metric* will now be necessary because the drug label is written in the metric system.

EXAMPLE

The physician's order reads: codeine sulfate gr 1/4 (apothecaries'). The drug container is labeled: codeine sulfate 15 mg (metric). Grains must be converted to milligrams *or* milligrams converted to grains.

Grains to milligrams:

$$60 \text{ mg}:1 \text{ gr}::X \text{ mg}:1/4 \text{ gr}$$
$$X = 60 \times \frac{1}{4}$$
$$X = 15 \text{ mg}$$

or

$$\frac{60 \text{ mg}}{1 \text{ gr}} = \frac{X \text{ mg}}{1/4 \text{ gr}}$$
$$X = 60 \times \frac{1}{4}$$
$$X = 15 \text{ mg}$$

Therefore, 1/4 grain is approximately equivalent to 15 mg.

Milligrams to grains:

$$60 \text{ mg}:1 \text{ gr}::15 \text{ mg}:X \text{ gr}$$
$$60X = 15$$
$$X = 1/4 \text{ gr}$$

or

$$\frac{60 \text{ mg}}{1 \text{ gr}} = \frac{15 \text{ mg}}{X \text{ gr}}$$
$$60X = 15$$
$$X = \frac{1}{4} \text{ grain}$$

Therefore, 15 mg is approximately equivalent to 1/4 grain.

The formula $\frac{D}{H} = X$ can now be used

$$\frac{D}{H} = X$$
$$\frac{15 \text{ mg}}{15 \text{ mg}} = 1 \text{ tablet}$$

or

$$\frac{1/4 \text{ gr}}{1/4 \text{ gr}} = 1 \text{ tablet}$$

Liquids

In liquid drugs, there is a specific amount of drug in a given volume of solution. For example, if a container is labeled as 10 mg per 5 mL (or 10 mg/5 mL), this means that for every 5 mL of solution there is 10 mg of drug.

As with tablets and capsules, the prescribed dose of the drug may not be the same as what is on hand (or available). For example, the physician may order 20 mg of an oral liquid preparation and the bottle is labeled as 10 mg/5 mL.

The formula for computing the dosage of oral liquids is:

$$\frac{\text{dose desired}}{\text{dose on hand}} \times \text{quantity} = \text{volume administered}$$

This may be abbreviated as

$$\frac{D}{H} \times Q = X$$

The quantity (or Q) in this formula is the amount of liquid in which the available drug is contained. For example, if the label states that there is 15 mg/5 mL, 5 mL is the *quantity* (or volume) in which there is 15 mg of this drug.

EXAMPLE

The physician orders oxacillin sodium 125 mg PO oral suspension. The drug is labeled as 250 mg/5 mL.The 5 mL is the amount (quantity or Q) that contains 250 mg of the drug.

$$\frac{D}{H} \times Q = X \text{ (the liquid amount to be given)}$$

$$\frac{125 \text{ mg}}{250 \text{ mg}} \times 5 = X$$

$$\frac{1}{2} \times 5 = 2.5 \text{ mL}$$

Therefore, 2.5 mL contains the desired dose of 125 mg of oxacillin oral suspension.

Liquid drugs may also be ordered in drops (gtt) or minims. With the former, a medicine dropper is usually supplied with the drug and is always used to measure the ordered dosage. Eye droppers are not standardized, and therefore the size of a drop from one eye dropper may be different than one from another eye dropper.

To measure an oral liquid drug in minims, a measuring glass *calibrated in minims* must be used.

Parenteral Dosages of Drugs

Drugs for parenteral use must be in liquid form before they are administered. Parenteral drugs may be available in the following forms:

1. As liquids in disposable cartridges or disposable syringes that contain a specific amount of a drug in a specific volume, for example, meperidine 50 mg/mL. After administration, the cartridge or syringe is discarded.
2. In ampules or vials that contain a specific amount of the liquid form of the drug in a specific volume. The vials may be single-dose vials or multidose vials. A multidose vial contains more than one dose of the drug.
3. In ampules or vials that contain powder or crystals, to which a liquid (called a **diluent**) must be added before the drug can be removed from the vial and administered. Vials may be single dose or multidose vials.

Parenteral Drugs in Disposable Syringes or Cartridges

In some instances a specific dosage strength is not available and it will be necessary to administer less than the amount contained in the syringe.

EXAMPLE

The physician orders diazepam 5 mg IM. The drug is available as a 2-mL disposable syringe labeled 5 mg/mL.

$$\frac{D}{H} \times Q = X$$

$$\frac{5 \text{ mg}}{10 \text{ mg}} \times 2 \text{ mL} = X$$

$$X = \frac{1}{2} \times 2 = 1 \text{ mL}$$

Note that since the syringe contains 2 mL of the drug and that *each* mL contains 5 mg of the drug, there is a total of 10 mg of the drug in the syringe. Because there is 10 mg of the drug in the syringe, half of the liquid in the syringe (1 mL) is discarded and the remaining half (1 mL) is administered to give the prescribed dose of 5 mg.

Parenteral Drugs in Ampules and Vials

If the drug is in liquid form in the ampule or vial, the desired amount is withdrawn from the ampule or vial. In some instances, the entire amount is used; in others, only part of the total amount is withdrawn from the ampule or vial and administered.

Whenever the dose to be administered is different from that listed on the label, the volume to be administered must be calculated. To determine the volume to be administered, the formula for liquid preparations is used. The calculations are the same as those given in the preceding section for parenteral drugs in disposable syringes or cartridges.

EXAMPLES

The physician orders chlorpromazine 12.5 mg IM.

The drug is available as chlorpromazine 25 mg/mL in a 1-mL ampule.

$$\frac{D}{H} \times Q = X$$

$$\frac{12.5 \text{ mg}}{25 \text{ mg}} \times 1 \text{ mL} = X$$

$$\frac{1}{2} \times 1 \text{ mL} = \frac{1}{2} \text{ mL (or 0.5 mL) volume to be administered.}$$

The physician orders hydroxyzine 12.5 mg. The drug is available as hydroxyzine 25 mg/mL in 10-mL vials.

$$\frac{D}{H} \times Q = X$$

$$\frac{12.5 \text{ mg}}{25 \text{ mg}} \times 1 \text{ mL} = \frac{1}{2} \text{ mL (or 0.5 mL)}$$

Therefore, 0.5 mL is withdrawn from the 10-mL multidose vial and administered. In this example, the amount in this or any multidose vial is *not* entered into the equation. What is entered into the equation as quantity (Q) is the amount of the available drug that is contained in a specific volume.

When the dose is less than 1 mL, it may be necessary, in some instances, to convert the answer to minims. A conversion factor of 15 or 16 minims/mL may be used.

EXAMPLES

The physician orders chlorpromazine 10 mg IM. The drug is available as chlorpromazine 25 mg/mL.

$$\frac{10 \text{ mg}}{25 \text{ mg}} \times 1 \text{ mL} = \text{X}$$

$$\frac{2}{5} \times 1 \text{ mL} = \frac{2}{5} \text{ mL}$$

$$\frac{2}{5} \times 15 \text{ minims} = 6 \text{ minims}$$

In this example 15 minims = 1 mL is used because 15 can be divided by 5.

The physician's order reads methadone 2.5 mg IM. The drug is available as methadone 10 mg/mL.

$$\frac{2.5 \text{ mg}}{10 \text{ mg}} \times 1 \text{ mL} = \text{X}$$

$$\frac{1}{4} \times 1 \text{ mL} = \text{X}$$

$$\frac{1}{4} \times 16 \text{ minims} = 4 \text{ minims}$$

Because 16 (and not 15) minims can be divided by 4, the conversion factor of 16 is used.

WARNING: ALWAYS CHECK DRUG LABELS CAREFULLY. Some may be labeled in a manner different from others.

EXAMPLE

a **2**-mL ampule labeled: **2** mL = 0.25 mg
a **2**-mL ampule labeled: **1** mL = 5 mg

In these two examples, one manufacturer states the entire dose contained in the ampule: 2 mL = 0.25 mg. The other manufacturer gives the dose per milliliter: 1 mL = 5 mg. In this 2-mL ampule, there is a total of 10 mg.

Parenteral Drugs in Dry Form

Some parenteral drugs are available as a crystal or a powder. Because these drugs have a short life in liquid form, they are available in ampules or vials in dry form and must be made a liquid (reconstituted) before they are removed and administered. Some of these products have directions for reconstitution on the label or on the enclosed package insert. The manufacturer may give either of the following information for reconstitution: (1) the name of the diluent(s) that must be used with the drug, or (2) the amount of diluent that must be added to the drug.

In some instances, the manufacturer supplies a diluent with the drug. If a diluent is supplied, no other stock diluent should be used. Before a drug is reconstituted, the label is carefully checked for instructions.

EXAMPLES

Methicillin sodium: To reconstitute 1 g vial add 1.5 mL of sterile water for injection or sodium chloride injection. Each reconstituted mL contains approximately 500 mg of methicillin.

Mechlorethamine: Reconstitute with 10 mL of sterile water for injection or sodium chloride injection. The solution now contains 1 mg/mL of mechlorethamine.

If there is any doubt about the reconstitution of the dry form of a drug and there are no manufacturer's directions, the hospital pharmacist should be consulted.

Once a diluent is added, the volume to be administered is determined. In some cases, the entire amount is given; in others, a part (or fraction) of the total amount contained in the vial or ampule is given.

After reconstitution of any multidose vial, the following information *must* be added to the label:

- Amount of diluent added
- Dose of drug in mL (500 mg/mL, 10 mg/2 mL, etc.)
- The date of reconstitution
- The expiration date (the date after which any unused solution is discarded)

Calculating Intravenous Flow Rates

When the physician orders a drug added to an intravenous (IV) fluid, the amount of fluid to be administered over a specified period, such as 125 mL/h or 1000 mL over 8 hours, must be included in the written order. If no infusion rate had been ordered, 1 L (1000 mL) of IV fluid should infuse over 6 to 8 hours.

To allow the IV fluid to infuse over a specified period, the IV flow rate must be determined. Before using one of the methods below, the drop factor must be known. Drip chambers on the various types of IV fluid administration sets vary. Some deliver 15 drops/mL and others deliver more or less than this number. This is called the *drop factor*. The drop factor (number of drops/mL) is given on the package containing the drip chamber and IV tubing. Three methods for determining the IV infusion rate follow. Methods 1 and 2 can be used when the known factors are the total amount of solution, the drop factor, and the number of hours over which the solution is to be infused.

METHOD 1

Step 1. Total amount of solution ÷ number of hours = number of mL/h

Step 2. mL/h ÷ 60 min/h = number of mL/min
Step 3. mL/min × drop factor = number of drops/min

EXAMPLE

1000 mL of an IV solution is to infuse over a period of 8 hours. The drop factor is 14.
Step 1. 1000 mL ÷ 8 hours = 125 mL/h
Step 2. 125 ÷ 60 minutes = 2.08 mL/min
Step 3. 2.08 × 14 = 29 drops/min

METHOD 2

Step 1. Total amount of solution ÷ number of hours = number of mL/h
Step 2. mL/h × drop factor ÷ 60 = number of drops/min

EXAMPLE

1000 mL of an IV solution is to infuse over a period of 6 hours. The drop factor is 12.
Step 1. 1000 mL ÷ 6 = 166.6 mL/h
Step 2. 166.6 × 12 ÷ 60 = 33.33 (33 to 34) drops/min

METHOD 3

This method may be used when the desired amount of solution to be infused in 1 hour is known or written as a physician's order.

$$\frac{\text{drops/mL of given set (drop factor)}}{\text{60 (minutes in an hour)}} \times \text{total hourly volume} = \text{drops/min}$$

EXAMPLE

If a set delivers 15 drops/min and 240 mL is to be infused in 1 hour:

$$\frac{15}{60} \times 240 = \frac{1}{4} \times 240 = 60 \text{ drops/min}$$

Oral or Parenteral Drug Dosages Based on Weight

The dosage of an oral or parenteral drug may be based on the patient's weight. In many instances, references give the dosage based on the weight in kilograms (kg) rather than pounds (1b). There are 2.2 1b in 1 kg.

When the dosage of a drug is based on weight, the physician, in most instances, computes and orders the dosage to be given. However, errors can occur for any number of reasons. The nurse should be able to calculate a drug dosage based on weight to detect any type of error that may have been made in the prescribing or dispensing of a drug whose dosage is based on weight.

To convert a known weight in kilograms to pounds, multiply the known weight by 2.2.

EXAMPLES

Patient's weight in kilograms is 54

$$54 \times 2.2 = 118.8 \text{ (or 119) lb}$$

Patient's weight in kilograms is 61.5

$$61.5 \times 2.2 = 135.3 \text{ (or 135) lb}$$

To convert a known weight in pounds to kilograms, divide the known weight by 2.2.

EXAMPLES

Patient's weight in pounds is 142

$$142 \div 2.2 = 64.5 \text{ kg}$$

Child's weight in pounds is 43

$$43 \div 2.2 = 19.5 \text{ kg}$$

Once the weight is converted to pounds or kilograms, this information is used to determine drug dosage.

EXAMPLES

A drug dose is 5 mg/kg/d. The patient weighs 135 1b, which is converted to 61.2 kg.

$$61.2 \text{ kg} \times 5 \text{ mg} = 306.8 \text{ mg}$$

Proportions also can be used:

$$5 \text{ mg:1 kg::X mg:61.2 kg}$$
$$X = 306.8 \text{ mg}$$

A drug dose is 60 mg/kg/d IV in three equally divided doses.

The patient weighs 143 Ib, which is converted to 65 kg.

$$65 \text{ kg} \times 60 \text{ mg} = 3900 \text{ mg/day}$$
$$3900 \text{ mg} \div 3 \text{ (dosess per day)} = 1300 \text{ mg each dose}$$

If the drug dose is based on body surface area (m^2) the same method of calculation may be used.

EXAMPLE

A drug dose is 60 to 75 mg/m^2 as a single IV injection.

The body surface area (BSA) of a patient is determined by means of a nomogram for estimating BSA (see Appendix E) and is found to be 1.8 m^2. The physician orders 60 mg/m^2.

$$60 \text{ mg} \times 1.8 \text{ m}^2 = 108 \text{ mg}$$

Proportion can also be used:

$$60 \text{ mg: 1 m}^2\text{::X mg:1.8 m}^2$$
$$X = 108 \text{ mg}$$

Dosage Calculation Using Dimensional Analysis (DA)

When using DA to calculate dosage problems, dosages are written as common fractions. For example:

$$\frac{1 \text{ mL}}{4 \text{ mg}} \quad \frac{5 \text{ mL}}{10 \text{ mg}} \quad \frac{1 \text{ tablet}}{100 \text{ mg}}$$

When written as common fractions the numerator is the top number. In the example above, 1 mL, 5 mL, and 1 tablet are the numerators.

The numbers on the bottom are called denominators. In the example above, 4 mg, 10 mg, and 100 mg are denominators.

EXAMPLE

The physician orders 10 mg of diazepam. The drug comes in dosage strength of 5 mg/mL. How many mL would the nurse administer?

Step 1. To work this problem using DA, always begin by identifying the unit of measure to be calculated. The unit to be calculated will be mL or cc if the drug is to be administered parenterally. Another drug form is the solid and the unit of measure would be a tablet or capsule. In the problem above, the unit of measure to be calculated is mL. If the drug is an oral liquid drug, the measurement might be ounces.

Step 2. Write the identified unit of measure to be calculated, followed by an equal sign. In the problem above, mL is the unit to be calculated, so the nurse writes:

$$\text{mL} =$$

Step 3. Next, the dosage strength is written, with the numerator *always expressed in the same unit that was identified before the equal sign.* For example:

$$\text{mL} = \frac{1\ \text{mL}}{5\ \text{mg}}$$

Step 4. Continue by writing the next fraction with the numerator having the same unit of measure as the denominator in the previous fraction.
For example, our problem continues:

$$\text{mL} = \frac{1\ \text{mL}}{5\ \text{mg}} \times \frac{10\ \text{mg}}{\text{X mL}}$$

Step 5. The problem is solved by multiplication of the two fractions.

$$\text{mL} = \frac{1\ \text{mL}}{5\ \text{mg}} \times \frac{10\ \text{mg}}{\text{X mL}} = \frac{10\ \text{mg}}{5\text{X mL}} = 2\ \text{mL}$$

NOTE: Each alternate denominator and numerator cancel, with only the final unit remaining.

EXAMPLE

Ordered: 200,000 U
On hand: Drug labeled 400,000 U/mL

$$\text{mL} = \frac{1\ \text{mL}}{400{,}000\ \text{U}} \times \frac{200{,}000\ \text{U}}{\text{X mL}} = \frac{1}{2}\ \text{mL or } 0.5\ \text{mL}$$

Metric Conversions Using Dimensional Analysis

Occasionally the physician may order a drug in one unit of measure, whereas the drug is available in another unit of measure.

EXAMPLE

The physician orders 0.4 mg of atropine. The drug label reads 400 mcg per 1 mL. This dosage problem is solved by expanding the DA equation by adding one step to the equation.

Step 1. As above, begin by writing the unit of measure to be calculated, followed by an equal sign.

Step 2. Next, express the dosage strength as a fraction with the numerator having the same unit of measure as the number before the equal sign.

Step 3. Continue by writing the next fraction with the numerator having the same unit of measure as the denominator in the previous fraction.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{\text{mcg}}{\text{mg}}$$

Step 4. Expand the equation by filling in the missing numbers using the appropriate equivalent. In this problem, the equivalent would be 100 mcg = 1 mg. This will convert mcg to mg.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{1000\ \text{mcg}}{1\ \text{mg}}$$

Repeat Steps 3 and 4. Continue with the equation by placing the next fraction beginning with the unit of measure of the denominator of the previous fraction.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{1000\ \text{mcg}}{1\ \text{mg}} \times \frac{0.4\ \text{mg}}{\text{X mL}}$$

When possible, cancel out the units, leaving only mL.

Step 5. Solve the problem by multiplication. Cancel out the numbers when possible.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{1000\ \text{mcg}}{1\ \text{mg}} \times \frac{0.4\ \text{mg}}{\text{X mL}} = \frac{400}{400\ \text{X}} = 1\ \text{mL}$$

Solve the following problems using DA. Refer to the equivalent table if necessary. (See Table 3-1.)

EXAMPLE

Ordered: 250 mg.
On hand: Drug labeled 1 gram per 1 mL

$$\text{mL} = \frac{1\ \text{mL}}{1\ \text{g}} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{250\ \text{mg}}{\text{X mL}} = \frac{1\ \text{mL}}{4}\ \text{or } 0.25\ \text{mL}$$

Temperatures

Two scales used in the measuring of temperatures are **Fahrenheit (F)** and **Celsius (C)** (also known as **centigrade**). On the Fahrenheit scale, the freezing point of water is 32° F and the boiling point of water is 212° F. On the Celsius scale, 0° C is the freezing point of water and 100° C is the boiling point of water.

To convert from Celsius to Fahrenheit, the following formula may be used: $F = 9/5\ C + 32$ (9/5 times the temperature in Celsius, then add 32).

EXAMPLE

Convert 38° C to Fahrenheit:

$$F = \frac{9}{5} \times 38° + 32$$
$$F = 68.4° + 32$$
$$F = 100.4°$$

To convert from Fahrenheit to Celsius, the following formula may be used: $C = 5/9\ (F-32)$ (5/9 times the temperature in Fahrenheit minus 32).

EXAMPLE

Convert 100° F to Celsius:

$$C = \frac{5}{9} \times (100 - 32)$$
$$C = \frac{5}{9} \times 68$$
$$C = 37.77 \text{ or } 37.8°$$

(See Appendix D for Celsius (Centigrade) and Fahrenheit temperatures chart.)

Pediatric Dosages

The dosages of drugs given to children are usually less than those given to adults. The dosage may be based on age, weight, or BSA.

Body Surface Area

Charts are used to determine the BSA (see Appendix D) in square meters according to the child's height and weight. Once the BSA is determined, the following formula is used:

$$\frac{\text{surface area of the child in square meters}}{\text{surface area of an adult in square meters*}} \times \text{usual adult dose} = \text{pediatric dose}$$

(See Appendix E for Body Surface Area Nomograms.)

Weight

Pediatric as well as adult dosages may also be based on the patient's weight in pounds or kilograms. The method of converting pounds to kilograms or kilograms to pounds is explained in a previous section.

EXAMPLE

5 mg/kg
0.5 mg/lb

Today, most pediatric dosages are clearly given by the manufacturer, thus eliminating the need for formulas, except for determining the dose of some drugs based on the child's weight or BSA.

* The figure for the average BSA of an adult in square meters is 1.7.