To change a metric denomination to the next smaller denomination, move the decimal point one place to the right.

To change a metric denomination to the next larger denomination, move the decimal point one place to the left.

1. *Convert 1.23 kilograms to grams.*

   1.23 kg = **1230 g**

2. *Convert 9876 milligrams to grams.*

   9876 mg = **9.876 g**

   In the first example, 1.23 kg is to be converted to grams. On the scale, the gram position is three decimal positions from the kilogram position. Thus, the decimal point is moved three places toward the right. In the second example, the conversion from milligrams also requires the movement of the decimal point three places, but this time to the left.

3. *Convert 85 micrometers to centimeters.*

   85 μm = 0.085 mm = **0.0085 cm**

4. *Convert 2.525 liters to microliters.*

   2.525 L = 2525 mL = **2,525,000 μL**

The 3-decimal point shift

In pharmacy practice, and health care in general, the denominations most used differ by 1000 or by a factor of 3 decimal places. Thus, on the decimal scale (Fig. 2.5), a 3-place decimal point shift, left to right or right to left, will yield most commonly used denominations.

3-Place Shift for Common Weight Denominations:

kilograms (kg) _ _ _ grams (g) _ _ _ milligrams (mg) _ _ _ micrograms (mcg)

3-Place Shift for Common Volume Denominations:

liters (L) _ _ _ milliliters (mL)

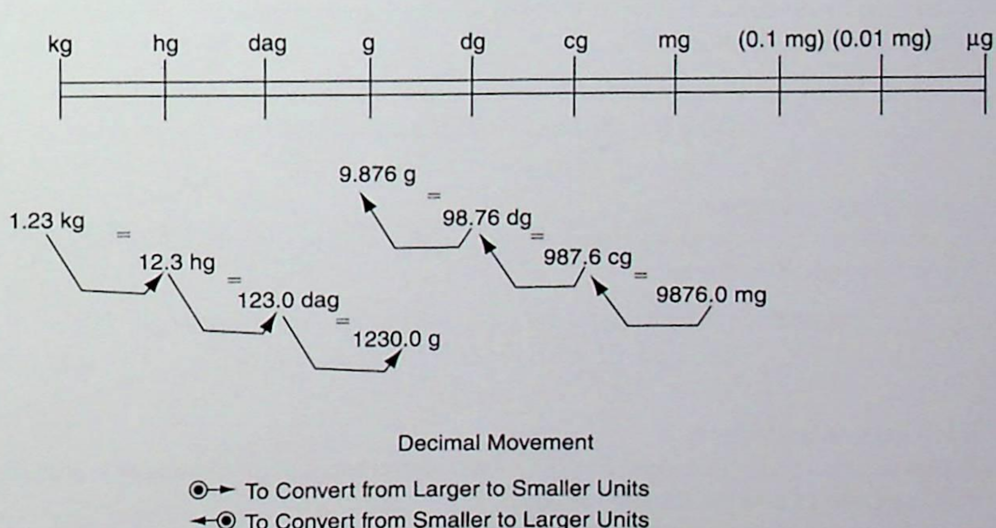

FIGURE 2.5. • Position scale of units of weight.

Converting SI units to lower or higher denominations by ratio and proportion or by dimensional analysis

5. *Convert 1.23 kilograms to grams.*
   1 kg = 1000 g
   By ratio and proportion:

$$\frac{1\text{ kg}}{1000\text{ g}} = \frac{1.23\text{ kg}}{\text{x g}};\ \text{x} = \mathbf{1230\ g}$$

   By dimensional analysis:

$$1.23\text{ kg} \times \frac{1000\text{ g}}{1\text{ kg}} = \mathbf{1230\ g}$$

6. *Convert 62,500 mcg to g.*
   1 mcg = 1×10^{-6} g or 1 g = 1×10^{6} mcg = 1,000,000 mcg
   By ratio and proportion:

$$\frac{1{,}000{,}000\text{ mcg}}{1\text{ g}} = \frac{62{,}500\text{ mcg}}{\text{x g}};\ \text{x} = \mathbf{0.0625\ g}$$

   By dimensional analysis:

$$62{,}500\text{ mcg} \times \frac{1\text{ g}}{1{,}000{,}000\text{ mcg}} = \mathbf{0.0625\ g}$$

CALCULATIONS CAPSULE

International System of Units (SI)

- The SI or decimal system of measurement is used in the practice of pharmacy and throughout the pharmaceutical industry.
- The primary SI units for calculating mass or weight (gram), volume (liter), and length (meter) are used along with prefixes to indicate multiples or subdivisions of the primary units.
- To change an SI denomination to the next *smaller* denomination, the decimal point is moved one place to the right:

  gram (g) > decigram (dg) > centigram (cg) > milligram (mg)

  5.555 g = 55.55 dg = 555.5 cg = 5555 mg

  Each value is equivalent.
- To change an SI denomination to the next *larger* denomination, the decimal point is moved one place to the left:

  kilogram(kg) > hectogram(hg) > dekagram(dag) > gram(g)

  5.555 kg = 55.55 hg = 555.5 dag = 5555 g

  Each value is equivalent.
- A unit position scale (e.g., see Fig. 2.5), ratio and proportion, or dimensional analysis may be used to change denominations.
- Only numbers of the same *denomination* may be added to or subtracted from one another.

Recognizing Equivalent Expressions

On occasion, it may be necessary to recognize, or prove by calculation, equivalent expressions. For example, a given quantity expressed in terms of "mg/100 mL" is equivalent to "mg/dL."

Practice problems #47 to #50 at the conclusion of this chapter provide exercises to determine equivalent expressions.

Addition and subtraction

To add or subtract quantities in the SI, convert them to a *common denomination*, preferably a base unit, and arrange their denominate numbers for addition or subtraction as ordinary decimals.

1. *Add 1 kg, 250 mg, and 7.5 g. Express the total in grams.*

$$\begin{aligned} 1\text{ kg} &= 1000.\ \text{g} \\ 250\text{ mg} &= 0.25\ \text{g} \\ 7.5\text{ g} &= \underline{7.5\ \text{g}} \\ &\quad \mathbf{1007.75\ g} \end{aligned}$$

2. *Add 4 L, 375 mL, and 0.75 L. Express the total in milliliters.*

$$\begin{aligned} 4\text{ L} &= 4000\text{ mL} \\ 375\text{ mL} &= 375\text{ mL} \\ 0.75\text{ L} &= \underline{750\text{ mL}} \\ &\quad \mathbf{5125\ mL} \end{aligned}$$

3. *A capsule contains the following amounts of medicinal substances: 0.075 g, 20 mg, 0.0005 g, 4 mg, and 500 mcg. What is the total weight of the substances in the capsule?*

$$\begin{aligned} 0.075\text{ g} &= 0.075\ \text{g} \\ 20\text{ mg} &= 0.02\ \text{g} \\ 0.0005\text{ g} &= 0.0005\ \text{g} \\ 4\text{ mg} &= 0.004\ \text{g} \\ 500\ \mu\text{g} &= \underline{0.0005\ \text{g}} \\ &\quad 0.1000\ \text{g or } \mathbf{100\ mg} \end{aligned}$$

4. *Subtract 2.5 mg from 4.85 g.*

$$\begin{aligned} 4.85\text{ g} &= 4.85\ \text{g} \\ 2.5\text{ mg} &= \underline{-0.0025\ \text{g}} \\ &\quad \mathbf{4.8475\ g} \end{aligned}$$

5. *A prescription calls for 0.06 g of one ingredient, 2.5 mg of another, and enough of a third to make 0.5 g. How many milligrams of the third ingredient should be used?*

$$\begin{aligned} \text{1st ingredient: } 0.06\text{ g} &= 0.06\ \text{g} \\ \text{2nd ingredient: } 2.5\text{ mg} &= \underline{0.0025\ \text{g}} \\ &\quad 0.0625\ \text{g} \end{aligned}$$

$$\begin{aligned} &\text{Total weight:} && 0.5\ \text{g} \\ &\text{Weight of 1st and 2nd:} && \underline{-0.0625\ \text{g}} \\ &\text{Weight of 3rd:} && 0.4375\ \text{g or } \mathbf{437.5\ mg} \end{aligned}$$

Multiplication and division

Because every measurement in the SI is expressed in a single given denomination, problems involving multiplication and division are solved by the methods used for any decimal numbers.

1. *Multiply 820 mL by 12.5 and express the result in liters.*

$$820 \text{ mL} \times 12.5 = 10250 \text{ mL} = \mathbf{10.25\ L}$$

2. *Divide 0.465 g by 15 and express the result in milligrams.*

$$0.465 \text{ g} \div 15 = 0.031 \text{ g} = \mathbf{31\ mg}$$

CASE IN POINT 2.1 A nurse telephones a pharmacy regarding the proper quantity of an injection to administer to a pediatric patient from a 1-mL vial containing 0.1 mg of digoxin. The attending physician had prescribed a dose of 25 mcg. How many milliliters should be the pharmacist's response?

Relation of the SI to Other Systems of Measurement

In addition to the International System of Units, the pharmacy student should be aware of two other systems of measurement: the ***avoirdupois*** and ***apothecaries'*** systems. The avoirdupois system, widely used in the United States in measuring body weight and in selling goods by the ounce or pound, is slowly giving way to the international system. The apothecaries' system, once the predominant pharmacist's system of volumetric and weight measure, has also largely been replaced by the SI. The pharmacist must still appreciate the relationship between the various systems of measurement, however, and deal effectively with them as the need arises.

The avoirdupois and apothecaries' systems of measurement, including all necessary equivalents and methods for intersystem conversion, are presented in Appendix A. The example equivalents presented in Table 2.3 are useful in gaining perspective and in solving certain problems in the text—for example, when there is need to convert fluid ounces to milliliters or kilograms to pounds. These equivalents should be committed to memory.

AUTHORS' NOTE: When quantities in units of the apothecaries' or avoirdupois systems of measurement (see Appendix A) are encountered, it is suggested that they be converted to equivalent quantities in SI units and the required calculation then solved in the usual manner.

TABLE 2.3 • SOME USEFUL EQUIVALENTS

Equivalents of length		
1 inch	=	2.54 cm
Equivalents of volume		
1 fluid ounce (fl. oz.)	=	29.57 mL
1 pint (16 fl. oz.)	=	473 mL
1 gallon, United States (128 fl. oz.)	=	3785 mL
Equivalents of weight		
1 pound (lb, avoirdupois)	=	454 g
1 ounce (oz, avoirdupois)	=	28.35 g
1 kilogram (kg)	=	2.2 lb

Example Problems

1. *An injection contains 5 mg of drug in each 10-mL vial. If the dose of the drug for a patient is determined to be 150 μg, how many milliliters should be administered?*

$$150\ \mu g \times \frac{1\ g}{1 \times 10^6\ \mu g} \times \frac{1000\ mg}{g} = 0.15\ mg$$

$$0.15\ mg \times \frac{10\ mL}{5\ mg} = \mathbf{0.3\ mL}$$

2. *A patient is determined to have a total serum cholesterol level of 240 mg/dL. What is the equivalent value in mg/100 mL?*

$$1\ dL \times \frac{1\ L}{10\ dL} \times \frac{1000\ mL}{L} = 100\ mL$$

Thus, 240 mg/dL = **240 mg/100 mL**

3. *The dose of a drug is 0.5 mg/kg of body weight/day. What is the equivalent dose in μg/lb/day?*

$$0.5\ mg \times \frac{1\ g}{1000\ mg} \times \frac{1 \times 10^6\ \mu g}{g} = 500\ \mu g$$

$$1\ kg = 2.2\ lb$$

Thus, 0.5 mg/kg/day = 500 μg/2.2 lb/day = **227.27 μg/lb/day**

4. *An oral suspension contains 1.5 g of the therapeutic agent in a pint of the suspension. Calculate the quantity of therapeutic agent, in milligrams, present in each 5-mL dose.*

$$5\ mL \times \frac{1.5\ g}{1\ pt} \times \frac{1000\ mg}{1\ g} \times \frac{1\ pt}{473\ mL} = \mathbf{15.86\ mg}$$

Or, by ratio and proportion:

$$1.5\ g = 1500\ mg$$

$$1\ pint = 473\ mL$$

$$\frac{1500\ mg}{473\ mL} = \frac{x\ mg}{5\ mL};\ x = \mathbf{15.86\ mg}$$

CASE IN POINT 2.2 A hospital pharmacist is asked to prepare an intravenous infusion of dopamine. Based on the patient's weight, the pharmacist calculates a dose of 500 mcg/min for continuous infusion. The concentration of a premixed dopamine infusion is 400 mg/250 mL. What is the concentration of the infusion on a mcg/mL basis? How many milligrams of dopamine is the patient to receive in the first hour of treatment? How long will the infusion last?