

## Chapter 2 :International System of Units

It is formerly called the metric system, is the internationally recognized decimal system of weights and measures. The system was formulated in France in the late eighteenth century.

For length, the primary unit is the *meter*; for volume, the *liter*; and for weight, the *gram*. Subdivisions and multiples of these primary units, their relative values, and their corresponding prefixes are shown in Table 2.1.

**TABLE 2.1 PREFIXES AND RELATIVE VALUES OF THE INTERNATIONAL SYSTEM (SI)**

PREFIX	MEANING
<u>Subdivisions</u>	
atto-	one quintillionth ( $10^{-18}$ ) of the basic unit
femto-	one quadrillionth ( $10^{-15}$ ) of the basic unit
pico-	one trillionth ( $10^{-12}$ ) of the basic unit
nano-	one billionth ( $10^{-9}$ ) of the basic unit
micro-	one millionth ( $10^{-6}$ ) of the basic unit
milli-	one thousandth ( $10^{-3}$ ) of the basic unit
centi-	one hundredth ( $10^{-2}$ ) of the basic unit
deci-	one tenth ( $10^{-1}$ ) of the basic unit
<u>Multiples</u>	
deka-	10 times the basic unit
hecto-	100 times ( $10^2$ ) the basic unit
kilo-	1000 times ( $10^3$ ) the basic unit
myria-	10,000 times ( $10^4$ ) the basic unit
mega-	1 million times ( $10^6$ ) the basic unit
giga-	1 billion times ( $10^9$ ) the basic unit
tera-	1 trillion times ( $10^{12}$ ) the basic unit
peta-	1 quadrillion times ( $10^{15}$ ) the basic unit
exa-	1 quintillion times ( $10^{18}$ ) the basic unit

**Denominations:** the standard subdivisions and multiples of the primary units.

**Denominate number:** the number used in conjunction with a denomination.

For example, in 5 milligrams, 5 is the denominate number and milligrams is the denomination. The short forms for SI units (such as cm, for centimeter) are termed symbols, not abbreviations.

## **Guidelines for the correct use of SI:**

The following are select guidelines for the correct use of the SI from the U.S.

- Unit names and symbols generally **are not capitalized** except when used at the beginning of a sentence or in headings. However, the symbol for liter (L) may be capitalized or not. Examples: 4 L or 4 l, 4 mm, and 4 g; not 4 Mm and 4 G.
- **Periods are not used** following SI symbols except at the end of a sentence. Examples: 4 mL and 4 g, not 4 mL. and 4 g.
- A compound unit that is a ratio or quotient of two units is indicated by **a solidus (/) or a negative exponent**. Examples: 5 mL/h or 5 mL·h<sup>-1</sup>, not 5 mL per hour.
- **Symbols should not be combined with spelled-out terms** in the same expression. Examples: 3 mg/mL, not 3 mg/milliliter.
- **Symbols for units, however, are the same in singular and plural**. Examples: 5 milliliters or 5 mL, not 5 mLs.
- **Two symbols exist for microgram: mcg (often used in pharmacy practice) and µg (SI)**.
- The symbol for square meter is m<sup>2</sup>; for cubic centimeter, cm<sup>3</sup>; and so forth. In pharmacy practice, **cm<sup>3</sup> is considered equivalent to milliliter**. The symbol cc, for cubic centimeter, is not an accepted SI symbol.
- Decimal fractions are used, not common fractions. Examples: **5.25 g**, not 5  $\frac{1}{4}$  g.
- A zero should be placed in front of a leading decimal point to prevent medication errors caused by uncertain decimal points. Example: **0.5 g**, not .5 g.

## Special consideration of the SI in pharmacy

The system is used to

- 1) Manufacture and label pharmaceutical products (Fig. 2.1);
- 2) Write, fill, and compound prescriptions and institutional medication orders; dose patients;
- 3) Express clinical laboratory test results;



**FIGURE 2.1** Example of a pharmaceutical product with the label indicating the quantity (10 mL) and strength (5 mg/mL) in SI or metric units. (Reprinted with permission from Lacher BE. *Pharmaceutical Calculations for the Pharmacy Technician*. Philadelphia: Lippincott Williams & Wilkins, 2007.)

- Drug doses are typically administered in milligram or microgram amounts and prepared in solid dosage forms, such as tablets or capsules,
- Or in a stated volume of a liquid preparation, such as an oral solution (e.g., 30 mg/5 mL) or injection (e.g., 2 mg/mL).
- Doses for certain drugs are calculated on the basis of body weight and expressed as mg/kg, meaning a certain number of milligrams of drug per kilogram of body weight.
- Clinical laboratory values are in metric units and expressed, for example, as mg/dL, meaning milligrams of drug per deciliter of body fluid (such as blood).

## Measure of length

The **meter** is the primary unit of length in the SI

The table of metric length:

1 kilometer (km) = 1000.000 meters

1 hectometer (hm) = 100.000 meters

1 dekameter (dam) = 10.000 meters

1 decimeter (dm) = 0.100 meter

1 centimeter (cm) = 0.010 meter

1 millimeter (mm) = 0.001 meter

1 micrometer ( $\mu\text{m}$ ) = 0.000,001 meter

1 nanometer (nm) = 0.000,000,001 meter

Equivalencies of the most common length denominations:

1000 millimeters (mm) = 100 centimeters (cm)

100 centimeters (cm) = 1 meter (m)

A ruler calibrated in millimeter and centimeter units is shown in Figure 2.3.



**FIGURE 2.3** Ruler calibrated in millimeter, centimeter, and inch units. (Courtesy of Schlenker Enterprise, Ltd.)

## Measure of volume

The **liter** is the primary unit of volume, the table of metric volume:

1 kiloliter (kL) = 1000.000 liters

1 hectoliter (hL) = 100.000 liters

1 dekaliter (daL) = 10.000 liters

1 liter (L) = 1.000 liter

1 deciliter (dL) = 0.100 liter

1 centiliter (cL) = 0.010 liter

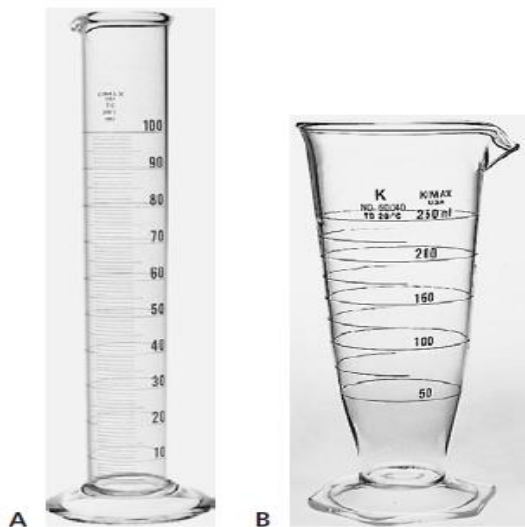
1 milliliter (mL) = 0.001 liter

1 microliter ( $\mu\text{L}$ ) = 0.000,001 liter

Equivalencies of the most common volume denominations:

1000 milliliters (mL) = 1 liter (L)

Examples of metric graduates for measuring volume are shown in Figure 2.4.



**FIGURE 2.4** Examples of metric-scale cylindrical **(A)** and conical pharmaceutical graduates **(B)**. (Courtesy of Kimble/Kontes Glass.)

## Measure of weight

The primary unit of weight in the SI is the gram, which is the weight of 1 cm<sup>3</sup> of water at 4°C,

The table of metric weight:

1 kilogram (kg) = 1000.000 grams

1 hectogram (hg) = 100.000 grams

1 dekagram (dag) = 10.000 grams

1 gram (g) = 1.000 gram

1 decigram (dg) = 0.1000 gram

1 centigram (cg) = 0.010 gram

1 milligram (mg) = 0.001 gram

1 microgram (µg or mcg) = 0.000,001 gram

1 nanogram (ng) = 0.000,000,001 gram

1 picogram (pg) = 0.000,000,000,001 gram

1 femtogram (fg) = 0.000,000,000,000,001 gram

Equivalencies of the most common weight denominations:

1000 micrograms (µg or mcg) = 1 milligram (mg)

1000 milligrams (mg) = 1 gram (g)

1000 grams (g) = 1 kilogram (kg)



FIGURE 3.4 Sartorius BasicLite analytical balance.  
(Courtesy of Sartorius Corporation.)

### Prescription writing style using the SI

Quantities of weight are usually written as grams and decimals of a gram, and volumes as milliliters and decimals of a milliliter.

Example:

Rx

Dextromethorphan HBr	320 mg
Guiafenesin	3.2 g
Cherry Syrup, to make	240 mL

### Fundamentals computations

- Reducing SI units to lower or higher denominations by using a unit position scale

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.

Examples:

Reduce 1.23 kilograms to grams.

1.23 kg = 1230 g, answer.

Reduce 9876 milligrams to grams.

9876 mg = 9.876 g, answer

➤ **Reducing SI units to lower or higher denominations by ratio and proportion by dimensional analysis**

Examples:

Reduce 1.23 kilograms to grams.

From the table: 1 kg = 1000 g

By ratio and proportion:

$$\frac{1 \text{ kg}}{1000 \text{ g}} = \frac{1.23 \text{ kg}}{x \text{ g}}; x = 1230 \text{ g, answer.}$$

By dimensional analysis:

$$1.23 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 1230 \text{ g, answer.}$$

**Recognizing equivalent expressions**

*Addition and Subtraction*

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

Examples:

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



Examples:

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

$$\begin{array}{rcl} 1 \text{ kg} & = & 1000. \text{ g} \\ 250 \text{ mg} & = & 0.25 \text{ g} \\ 7.5 \text{ g} & = & \underline{7.5 \text{ g}} \\ & & 1007.75 \text{ g or } 1008 \text{ g, answer.} \end{array}$$

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

$$\begin{array}{rcl} 4 \text{ L} & = & 4000 \text{ mL} \\ 375 \text{ mL} & = & 375 \text{ mL} \\ 0.75 \text{ L} & = & \underline{750 \text{ mL}} \\ & & 5125 \text{ mL, answer.} \end{array}$$

A capsule contains the following amounts of medicinal substances: 0.075 g, 20 mg, 0.0005 g, 4 mg, and 500  $\mu\text{g}$ . What is the total weight of the substances in the capsule?

$$\begin{array}{rcl} 0.075 \text{ g} & = & 0.075 \text{ g} \\ 20 \text{ mg} & = & 0.02 \text{ g} \\ 0.0005 \text{ g} & = & 0.0005 \text{ g} \\ 4 \text{ mg} & = & 0.004 \text{ g} \\ 500 \mu\text{g} & = & \underline{0.0005 \text{ g}} \\ & & 0.1000 \text{ g or } 100 \text{ mg, answer.} \end{array}$$

Subtract 2.5 mg from 4.85 g.

$$\begin{array}{rcl} 4.85 \text{ g} & = & 4.85 \text{ g} \\ 2.5 \text{ mg} & = & \underline{- 0.0025 \text{ g}} \\ & & 4.8475 \text{ g or } 4.848 \text{ g, answer.} \end{array}$$

### *Multiplication and division*

Examples:

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

$$820 \text{ mL} \times 12.5 = 10250 \text{ mL} = 10.25 \text{ L, answer.}$$

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

$$0.465 \text{ g} \div 15 = 0.031 \text{ g} = 31 \text{ mg, answer.}$$

## **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,

**TABLE 2.3 SOME USEFUL EQUIVALENTS**

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<b>Equivalents of Length</b>		
1 inch	=	2.54 cm
1 meter (m)	=	39.37 in
<b>Equivalents of Volume</b>		
1 fluidounce (fl. oz.)	=	29.57 mL
1 pint (16 fl. oz.)	=	473 mL
1 quart (32 fl. oz.)	=	946 mL
1 gallon, US (128 fl. oz.)	=	3785 mL
1 gallon, UK	=	4545 mL
<b>Equivalents of Weight</b>		
1 pound (lb, Avoirdupois)	=	454 g
1 kilogram (kg)	=	2.2 lb

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