AL-Mustaqbal university college
Pharmacy department

Principles of pharmacy practice

lec5

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The International System of Units (SI)
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Objectives

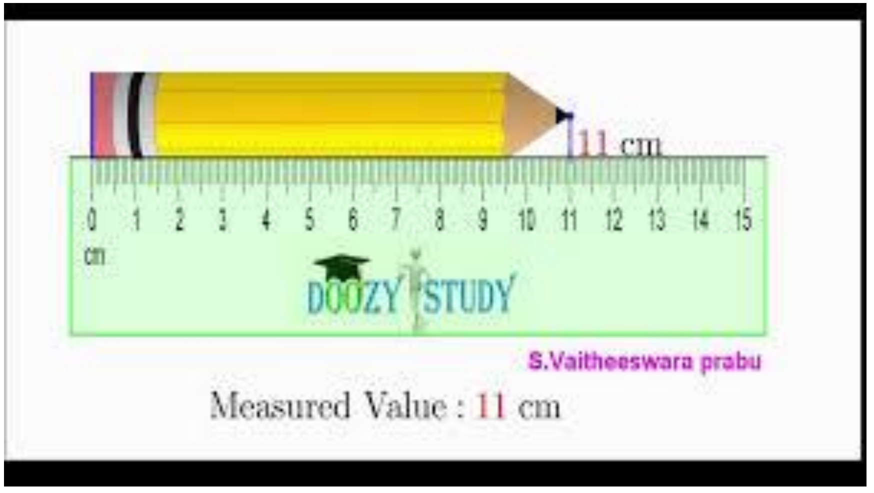
Upon successful completion of this chapter, the student will be able to:

- Demonstrate an understanding of the International System of Units.
- Convert measures within the International System of Units.
- State equivalent measures between the International System of Units and other systems of
- measure used in pharmacy practice.
- Convert measures between the International System of Units and other systems of measure
- used in pharmacy.
- Apply the International System of Units correctly in calculations.

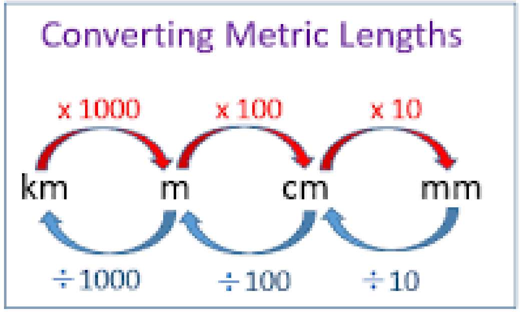
International System of Units (SI), formerly called the **metric system**, is the internationally recognized decimal system of weights and measures. The system was formulated in France in the late eighteenth century. The process of changing from the **common systems** and units of measurement (e.g., pounds, feet, gallons) to the SI metric system is termed metric transition or metrification. Today, the pharmaceutical research and manufacturing industry, the official compendia, the United States Pharmacopeia—National Formulary, and the practice of pharmacy reflect conversion to the SI system

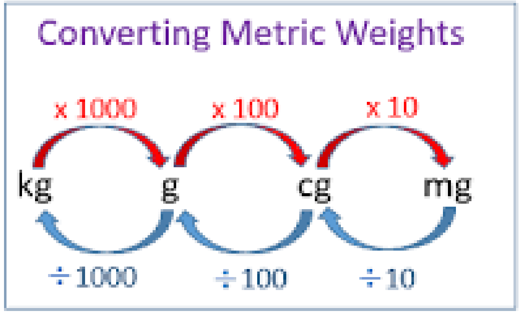
The **base units** of the SI are the meter and the kilogram. Originally, the meter was defined as 1⁄40,000,000 of the Earth's polar circumference. Modern science has refined the definition to be more precise: the distance light travels in a vacuum in 1⁄299,792,458 of a second. In common system terms, the meter is 39.37 inches, or slightly longer than the familiar 36-inch yard stick.

The mass (weight) of a kilogram, originally defined as the mass of a liter of water, is now represented by a standard mass of platinum-iridium preserved in a vault in France. For comparison to the common system, a kilogram is approximately equivalent to 2.2 pounds.



Each table of the SI contains a definitive, or primary, unit. For length, the primary unit is the **meter**; for volume, the **liter**; and for weight, the **gram** (although technically the kilogram is considered the historic base unit). Subdivisions and multiples of these primary units The standard subdivisions and multiples of the primary units are termed **denominations**, and the number used in conjunction with a denomination is termed a **denominate number**. 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





INTERNATIONAL SYSTEM (SI)

PREFIX	MEANING
Subdivisions	
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
Multiples	
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

Guidelines for the correct use of the 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.
- In the United States, the decimal marker (or decimal point) is placed on the line with the denomination and denominate number; however, in some countries, a comma or a raised dot is used. **Examples**: 4.5 mL (U.S.); 4,5 mL or 4·5 mL (non-U.S.).
- Periods are not used following SI symbols except at the end of a sentence.

Examples:

4mL and 4g, 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. e.g: 5mL/h or 5mL·h^{-1}, 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

- Plurals of unit names, when spelled out, have an added *s*. Symbols for units, however, are the same in singular and plural.
- **Examples**: 5milliliters or 5mL, *not* 5 mLs.

- Two symbols exist for microgram: **mcg** (often used in pharmacy practice) and **μg** (SI).
- The symbol for square meter is m^2; for cubic centimeter, cm^3; and so forth. In pharmacy practice, **cm^3** 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: 5.25g, not 51⁄4 g.

- A zero should be placed in front of a leading decimal point to prevent medication errors caused by uncertain decimal points.

Example: 0.5g, not .5g

- It is critically important for pharmacists to recognize that a misplaced or misread decimal point can lead to an error in calculation or in dispensing of a minimum of one tenth or ten times the desired quantity

- To prevent misreadings and medication errors, ‘‘trailing’’ zeros should not be placed following a whole number on prescriptions and medication orders.

  Example: 5mg, not 5.0 mg. However, in some tables pharmaceutical formulas, and quantitative results, trailing zeros often are used to indicate exactness to a specific number of decimal places.

- In selecting symbols of unit dimensions, the choice generally is based on selecting the unit that will result in a numeric value between 1 and 1000.

  Examples: 500g, rather than 0.5 kg; 1.96 kg, rather than 1960 g; and 750 mL, rather than 0.75 L

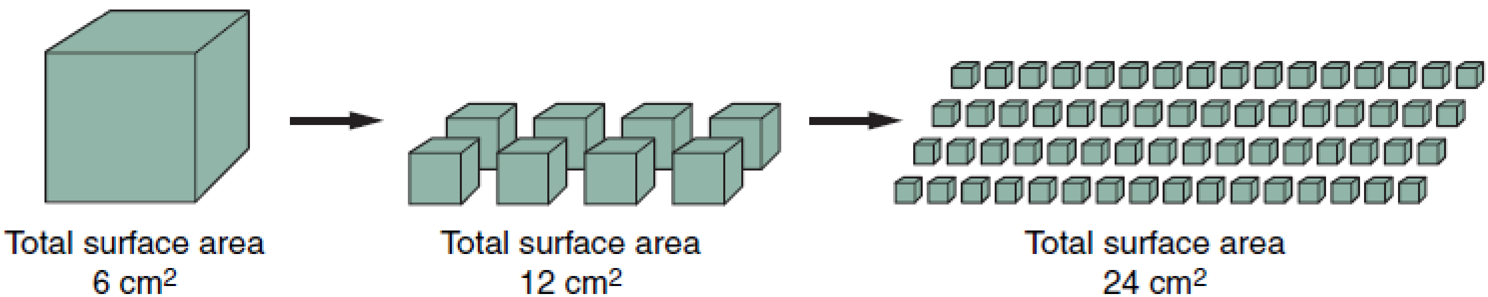
Special considerations of the SI in pharmacy.

- In the large-scale manufacture of dosage forms, pharmaceutical ingredients are measured in **kilogram** and **kiloliter** quantities.
- In the community and institutional pharmacy, compounding and dispensing in **milligram**, **gram**, and **milliliter** quantities are more common.
- 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., 30mg/5mL) or injection (e.g., 2mg/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).

Particle size &Nanotechnology

Drug particle size has long been an important consideration in pharmaceutical technology .Through the milling and reduction of drug materials to micron and nano size, the surface area of particles is increased ,and pharmaceutical and clinical benefits often accrue. These benefits may include:

- increased aqueous dissolution rates for poorly soluble substances;
- improved bioavailability, with increased rates of absorption of orally administered drugs;
- lower oral dosage possibilities with enhanced drug absorption;
- expanded formulation options in the preparation of stable and predictable pharmaceutical suspensions and colloidal dispersions for all routes of administration, including oral, parenteral ,respiratory , ophthalmic, and nasal



Drawing of increased surface area by particle size reduction

Nanotechnology may be defined as the development and use of materials on the nano-size scale.

Molecular nanotechnology refers to the method of building organic and inorganic structures atom by atom or molecule by molecule.

Nanotechnology has applications for many potential products, including those that **integrate chemistry**, the **biological sciences**, **medicine**, and **computer technology**.

The term **nano medicine** refers to the application of nanotechnology to the prevention and treatment of disease. It may further be defined as ‘‘the monitoring, repair, construction and control of human biological systems at the molecular level, using engineered nano devices and nanostructures

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 meter(m)   =1.000meter

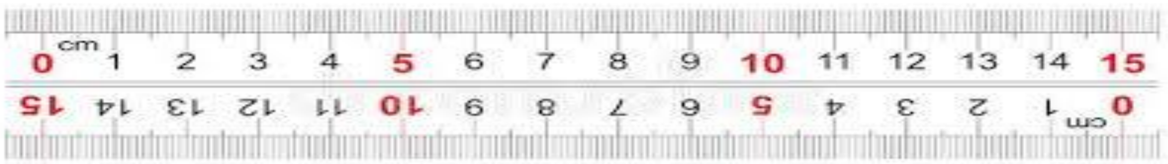
1 decimeter (dm) = 0.100 meter

1 centimeter (cm) = 0.010 meter

1 millimeter (mm)= 0.001 meter

1 micrometer (_m) = 0.000,001 meter

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



Ruler calibrated in millimeter, centimeter, and inch units

The table may also be written:

1 meter =0.001 kilometer

= 0.01 hectometer

= 0.1 dekameter

= 10 decimeters

=100 centimeters

=1000 millimeters

=1,000,000 micrometers

= 1,000,000,000 nanometers

Equivalencies of the most common length denominations:

1000 millimeters (mm) =100 centimeters (cm)

100 centimeters (cm) = 1 meter (m)

Distance exercise is undertaken by many people as a component of maintaining good health status and is usually measured by a combination of time and miles or meters.

Measure of Volume

The liter is the primary unit of volume. It represents the volume of the cube of one tenth of a meter, that is, of 1 dm^3.

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 (µL)= 0.000,001 liter

This table may also be written:

1 liter = 0.001 kiloliter

=0.010 hectoliter

= 0.100 dekaliter

= 10 deciliters

=100 centiliters

= 1000 milliliters

= 1,000,000 microliters

DEMONSTRATIONS OF LINEAR RELATIONSHIPS

	FEET	YARDS	MILES	METERS	KILOMETERS
1 mile	5280	1760	1	1609.3	1.6093
1 kilometer	3280.8	1093.6	0.62137	1000	1

Equivalencies of the most common volume denominations:1000 milliliters (mL) =1 liter (L)

Measure of Weight

The primary unit of weight in the SI is the *gram*, which is the weight of 1 cm^3 of water at4^{0}C,its temperature of greatest density.

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

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

This table may also be written:

1 gram = 0.001 kilogram

= 0.010 hectogram

= 0.100 dekagram

= 10 decigrams

= 100 centigrams

= 1000 milligrams

= 1,000,000 micrograms

= 1,000,000,000 nanograms

= 1,000,000,000,000 picograms

=1,000,000,000,000,000 femtograms

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)

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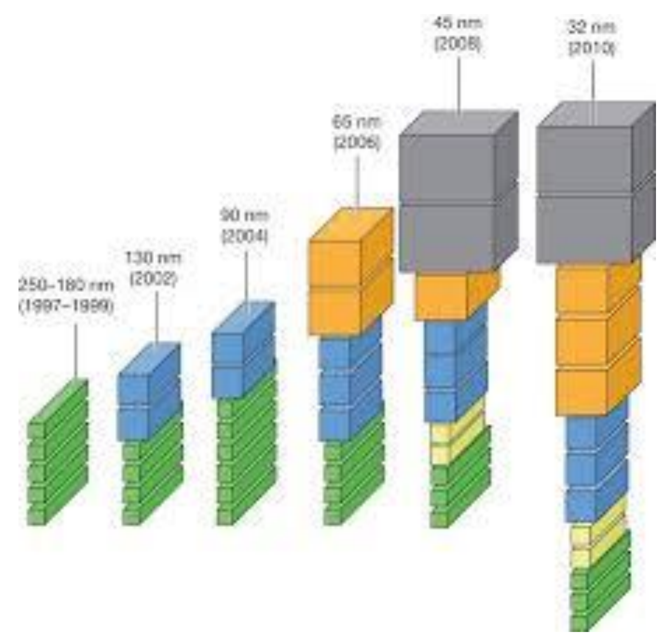
Fundamental Computations

Reducing SI Units to Lower or Higher Denominations by Using a Unit-Position Scale .The metric system is based on the decimal system; therefore, conversion from one denomination to another

- 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.

In the first example, 1.23 kg are 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.

Examples:

- **Reduce 85 micrometers to centimeters**.

85µm =0.085 mm=0.0085 cm, answer.

- **Reduce 2.525 liters to microliters**.

2.525 L =2525 mL=2,525,000 µL, 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.

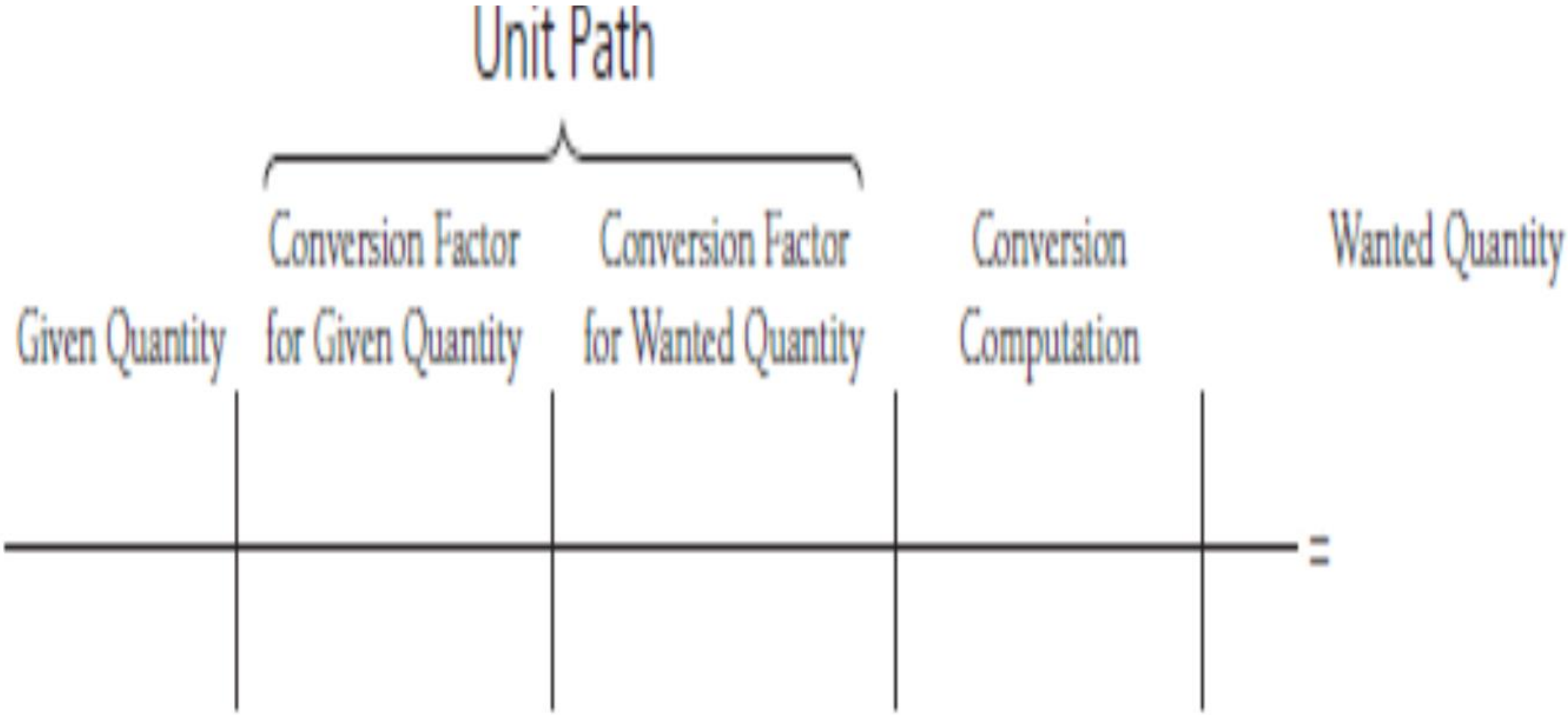
The avoirdupois system, widely used in the United States in measuring body weight and in selling goods by the ounce or pound, is slowly giving way to the international system.

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 .For example, when there is need to convert fluidounces to milliliters or kilograms to pounds. These equivalents should be committed to memory.

SOME USEFUL EQUIVALENTS

Equivalents of Length			
1 inch	=	2.54	cm
1 meter (m)	=	39.37	in
Equivalents of Volume			
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
Equivalents of Weight			
1 pound (lb, Avoirdupois)	=	454	g
1 kilogram (kg)	=	2.2	lb


Thank
You


Unit Path
Conversion Factor for Given Quantity
Conversion Factor for Wanted Quantity
Conversion Computation
Wanted Quantity
Given Quantity
=

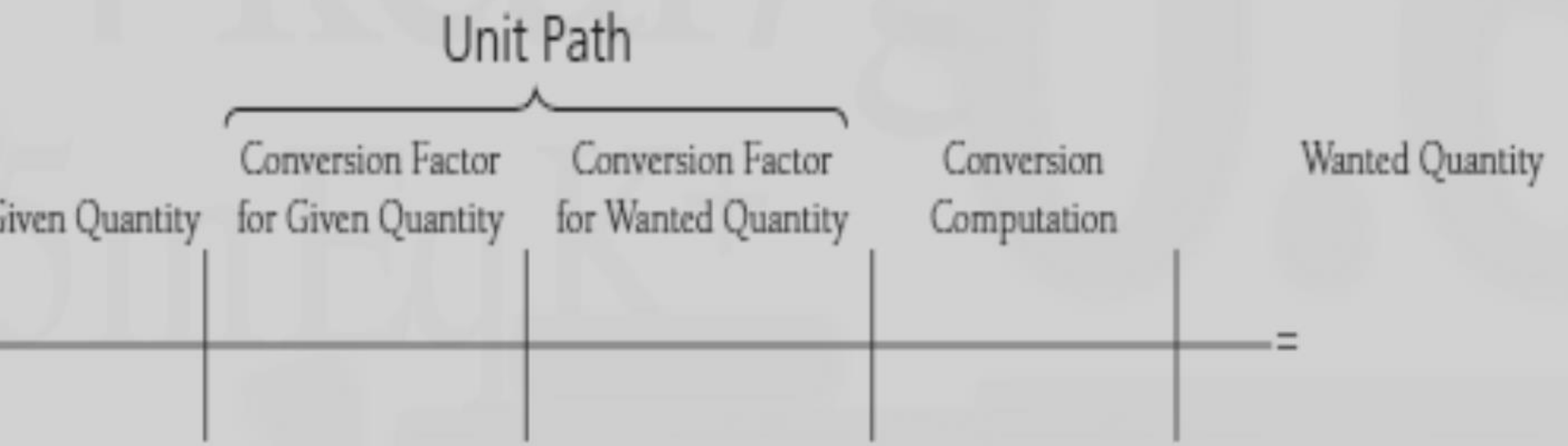
Dimensional Analysis

An alternative method to ratio and proportion in solving pharmaceutical calculation problems.

The method involves the logical sequencing and placement of a series of ratios to consolidate multiple arithmetic steps into a single equation.

By applying select conversion factors in the equation—some as reciprocals—unwanted units of measure cancel out, leaving the arithmetic result and desired unit.

Dimensional analysis scheme:



Dimensional analysis

When performing pharmaceutical calculations, some students prefer to use a method termed **dimensional analysis** (also known as **factor analysis**, **factor-label method**, or **unit-factor method**). This method involves the logical sequencing and placement of a series of ratios (termed **factors**) into an equation. The ratios are prepared from the given data as well as from selected conversion factors and contain both arithmetic quantities and their units of measurement. Some terms are inverted (to their reciprocals) to permit the cancellation of like units in the numerator(s) and denominator(s) and leave only the desired terms of the answer. One advantage of using dimensional analysis is the consolidation of several arithmetic steps into a single equation. In solving problems by dimensional analysis, the student unfamiliar with the process should consider the following steps

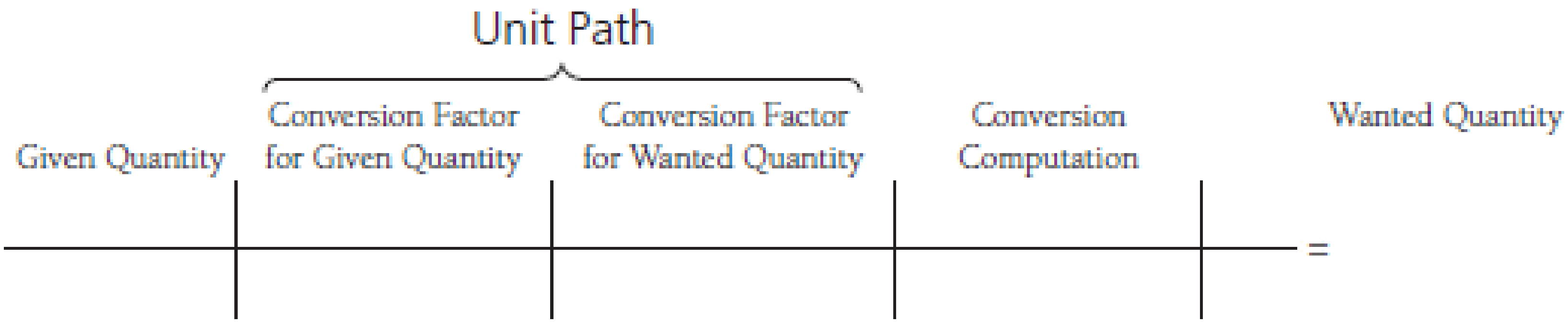
Step 1. Identify the **given quantity** and its unit of measurement.
Step 2. Identify the **wanted unit** of the answer.
Step 3. Establish the **unit path** (to go from the given quantity and unit to the arithmetic answer
in the wanted unit), and identify the conversion factors needed. This might include:
(a) a conversion factor for the **given quantity and unit**, and/or
(b) a conversion factor to arrive at the **wanted unit** of the answer.
Step 4. Set up the ratios in the unit path such that cancellation of units of measurement in the numerators and denominators will retain only the desired unit of the answer.
Step 5. Perform the computation by multiplying the numerators, multiplying the denominators, and dividing the product of the numerators by the product of the denominators

Example

A medication order calls for 1000 milliliters of a dextrose intravenous infusion to be administered over an 8-hour period. Using an intravenous administration set that delivers 10 drops/milliliter, how many drops per minute should be delivered to the patient?

Solving by dimensional analysis:

8 hours 480 minutes (min.)



$$1000\ \cancel{\text{mL}} \times \frac{10\ \text{drops}}{1\ \cancel{\text{mL}}} \times \frac{1}{480\ \text{min.}} = 20.8 \text{ or } 21 \text{ drops per minute, } \textit{answer}.$$