

## PROBLEM SOLVING BY DIMENSIONAL ANALYSIS IN GENERAL CHEMISTRY

**DIMENSIONAL ANALYSIS:** A Calculation Method using Conversion Factors to Change the Units in which Physical Quantities are expressed.

### Physical Quantity

- a representation of a measured or observed amount (e.g. 3.8 cm or 19.2 ft/sec).
- expressed as a numerical value followed by unit(s).
- mathematically treated as a number multiplied by unit(s).

The value for a physical quantity can be expressed in different units (e.g., 2.0 feet is the same quantity as 24 inches); a given value can be converted from one set of units to another.

### TABLE I: Relationships Between Selected Units:

12 in $\equiv$ 1 ft	2.54 cm $\equiv$ 1 in	100 cm $\equiv$ 1 m
3 ft $\equiv$ 1 yd	0.9463 L = 1.000 qt	1 mL $\equiv$ 1 cm <sup>3</sup>
4 qt $\equiv$ 1 gal	1.000 Lb = 453.6 g	5,280 ft $\equiv$ 1 mi

NOTE: The symbol  $\equiv$  is used when there is a defined exact relationship between the units.

Since  $x/x = 1$ , we can take equality relationships for different units and create conversion factors which are equal to 1.

$$\frac{1 \text{ ft}}{12 \text{ in}} = \frac{12 \text{ in}}{1 \text{ ft}} = 1$$

Since  $x \cdot 1 = x$ , we can multiply a value for a given physical quantity (e.g., length) measured in one set of units (e.g., length measured in feet) by the appropriate conversion factor to change its units (e.g., to length measured in inches) without changing the value of the quantity itself.

### Examples of Dimensional Analysis Calculations:

1. Convert a length of 118 inches to units of yards.

$$118 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ yd}}{3 \text{ ft}} = 3.27777777 \text{ yd} = 3.28 \text{ yd}$$

3 sf      exact      exact      (round answer to 3 significant figures to match data.)

A conversion factor of  $\frac{1 \text{ ft}}{12 \text{ in}}$  is used instead of  $\frac{12 \text{ in}}{1 \text{ ft}}$  since the latter would not cancel the original units of inches.

2. Convert a volume of 0.20001 gallons to units of milliliters.

$$0.20001 \text{ gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{0.9463 \text{ L}}{1.000 \text{ qt}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 757.077852 \text{ mL} = 757.1 \text{ mL}$$

5 sf      exact      4 sf      exact      (round answer to 4 significant figures to match liters-quarts conversion factor.)

3. Convert a length of 2.900 meters to units of feet.

$$2.900 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ ft}}{12 \text{ in}} = 9.514435696 \text{ ft} = 9.514 \text{ ft}$$

4 sf      exact      exact      exact      (round answer to 4 significant figures to match data.)

**TABLE II: COMMONLY USED PREFIXES FOR METRIC UNITS:**

<u>PREFIX</u>	<u>ABBREVIATION</u>	<u>EXAMPLE</u>	<u>PREFIX</u>	<u>ABBREVIATION</u>	<u>EXAMPLE</u>
mega-	M	$1 \times 10^6 \text{ g} \equiv 1 \text{ Mg}$	milli-	m	$1 \times 10^3 \text{ mL} \equiv 1 \text{ L}$ (or $1 \text{ mL} = 1 \times 10^{-3} \text{ L}$ )
kilo-	k	$1 \times 10^3 \text{ m} \equiv 1 \text{ km}$	micro-	$\mu$	$1 \times 10^6 \text{ } \mu\text{g} \equiv 1 \text{ g}$ (or $1 \text{ } \mu\text{g} = 1 \times 10^{-6} \text{ g}$ )
deci-	d	$10 \text{ dg} \equiv 1 \text{ g}$	nano-	n	$1 \times 10^9 \text{ nm} \equiv 1 \text{ m}$ (or $1 \text{ nm} = 1 \times 10^{-9} \text{ m}$ )
centi-	c	$100 \text{ cm} \equiv 1 \text{ m}$	pico-	p	$1 \times 10^{12} \text{ pL} \equiv 1 \text{ L}$ (or $1 \text{ pL} = 1 \times 10^{-12} \text{ L}$ )