Sections 2.1 (Atoms-First) and 8.1 (Chemistry-First) Unit Conversions

An Introduction to Chemistry

by Mark Bishop

Stand firm in your refusal to remain conscious during algebra. In real life, I assure you, there is no such thing as algebra.

Fran Lebowitz (b. 1951)

General "Unit Analysis" Procedure and Terminology

- Let's convert 0.00003617 kg to milligrams (mg).
- Be patient…take small steps.
- **Step 1:** Identify the unit or units you want, and set that equal to the unit or units you are given. (See Appendix A for a list of units and their abbreviations.)

Desired unit

? mg = 0.00003617 kg

Given value

General Procedure and Terminology

- **Step 2:** Multiply the expression to the right of the equals sign by one or more conversion factors that cancel the unwanted units and generate the desired unit.
  - Units can be cancelled like algebraic variables.
  - Set up the skeleton of the next conversion with the first unit you want to cancel in correct position.

Skeleton to cancel the first unit

$$? \text{ mg} = 0.00003617 \text{ kg} \left(\frac{\text{/}}{\text{kg}} \right)$$

General Procedure and Terminology

- **Step 2 (cont.):**
  - Ask yourself, “Do I know a conversion factor that will take me directly from the unit I have to the unit I want?”.
  - In this case, “Do I know how many mg there are per kg?”.
  - If the answer is no, ask yourself, “What type of unit do I have, and what type of unit do I want?”.
  - In this case, we are converting from one SI mass unit to another SI mass unit.
  - Apply strategies you have learned for different types of conversions.

General Procedure and Terminology

- **Step 2 (cont.):**
  - When converting from one SI unit to another SI unit for the same type of measurement (such as both mass), convert from the unit you have to the base unit and the from the base unit to the unit you want. See Table 1.1 on page 11 of the text.

Skeleton to convert from the unit you have to the base unit unit

$$? \text{ mg} = 0.00003617 \text{ kg} \left(\frac{\text{g}}{\text{kg}} \right) \left(\frac{\text{mg}}{\text{g}} \right)$$

Skeleton to convert from the base unit to the unit you want

Metric-Metric Conversion Factors

- The relationships between metric (SI) units can be derived from the metric prefixes. (See Table 1.2 for a useful list of metric prefixes.)
- These relationships can easily be translated into conversion factors.
  - For example, two possible sets of conversion factors for relating milliliters to liters can be obtained from the definition of the prefix *milli*.
  - *Milli* is defined as 10^{-3}, so $1\ mL = 10^{-3}\ L$.
  - If a milliliter is 1/1000 of a liter, there must be 1000 milliliters in a liter, so $10^{3}\ mL = 1\ L$.

Metric-Metric Conversion Factors

- The relationship between milliliters and liters yields two possible sets of conversion factors.

$10^3\ \text{mL} = 1\ \text{L}$ leads to $\dfrac{10^3\ \text{mL}}{1\ \text{L}}$ or $\dfrac{1\ \text{L}}{10^3\ \text{mL}}$

$1\ \text{mL} = 10^{-3}\ \text{L}$ leads to $\dfrac{1\ \text{mL}}{10^{-3}\ \text{L}}$ or $\dfrac{10^{-3}\ \text{L}}{1\ \text{mL}}$

https://preparatorychemistry.com/conversion_factors_Canvas.html

General Procedure and Terminology

- **Step 2 (cont.):**
  - Set up your conversion factors to cancel the units that you do not want and generate the units that you do want.
  - Because the k in kg represents kilo, and because kilo is defined as 10^3, there must be 10^3 g per kg.

Converts given SI unit to SI base unit

$$? \text{ mg} = 0.00003617 \text{ kg} \left(\frac{10^3 \text{ g}}{1 \text{ kg}} \right)$$

General Procedure and Terminology

- **Step 2 (cont.):.**
  - Our next step is to set up the skeleton for the conversion of grams to milligrams.

$$? \text{ mg} = 0.00003617 \text{ kg} \left(\frac{10^3 \text{ g}}{1 \text{ kg}} \right) \left(\frac{\quad}{\text{g}} \right)$$

Skeleton to convert SI base unit to desired SI unit

General Procedure and Terminology

- **Step 2 (cont.):**.
  - We can use either of the following conversion factors.

$$\left(\frac{1\ \text{mg}}{10^{-3}\ \text{g}}\right) \quad \text{or} \quad \left(\frac{10^{3}\ \text{mg}}{1\ \text{g}}\right)$$

  - I recommend using the positive exponentials, so I recommend the second conversion factor.
  - The positive exponent goes with the smaller unit.

$$?\ \text{mg} = 0.00003617\ \cancel{\text{kg}}\left(\frac{10^{3}\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}}\right)\left(\frac{10^{3}\ \text{mg}}{1\ \cancel{\text{g}}}\right)$$

Converts SI base unit to desired SI unit

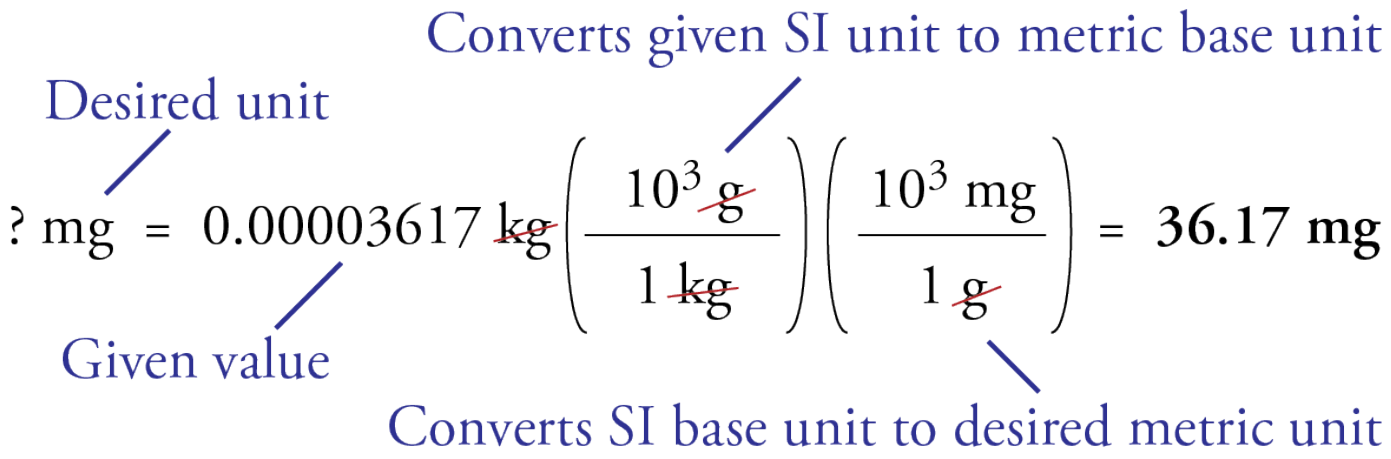
General Procedure and Terminology

- **Step 3:** Check to be sure you used correct conversion factors and that your units cancel to yield the desired unit.

$$? \text{ mg} = 0.00003617 \cancel{\text{kg}} \left(\frac{10^3 \cancel{\text{g}}}{1 \cancel{\text{kg}}} \right) \left(\frac{10^3 \text{ mg}}{1 \cancel{\text{g}}} \right)$$

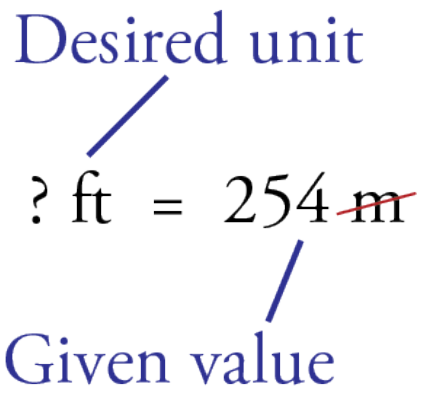
General Procedure and Terminology

- **Step 4:** Do the calculation, rounding your answer to the correct number of significant figures and combining it with the correct unit. (See Section 2.2/8.2 for the rules for rounding.)



General "Unit Analysis" Procedure and Terminology

- Let's convert 254 meters (m) to feet (ft).
- **Step 1:** Identify the unit or units you want, and set that equal to the unit or units you are given.



General Procedure and Terminology

- Set up the skeleton of the next conversion with the first unit you want to cancel in the correct position.

$$? \text{ ft} = 254 \cancel{\text{m}} \left(\frac{}{1 \cancel{\text{m}}} \right)$$

- Ask yourself, “Do I know a conversion factor that will take me directly from the unit I have to the unit I want?”. In this case, “Do I know how many feet there are per meter?”.
- If the answer is no, ask yourself, “What type of unit do I have, and what type of unit do I want?”.
- In this case, we are converting from an SI length unit to an English length unit.
- Apply strategies you have learned for different types of conversions.

English-Metric Conversion Factors

Table 2.1 for atoms-first and **Table 8.1** for chemistry-first

Type of Measurement	Probably Most Useful to Know	Others Useful to Know		
Length	$\frac{2.54\ \text{cm}}{1\ \text{in.}}$	$\frac{1.609\ \text{km}}{1\ \text{mi}}$	$\frac{39.37\ \text{in.}}{1\ \text{m}}$	$\frac{1.094\ \text{yd}}{1\ \text{m}}$
Mass	$\frac{453.6\ \text{g}}{1\ \text{lb}}$	$\frac{2.205\ \text{lb}}{1\ \text{kg}}$		
Volume	$\frac{3.785\ \text{L}}{1\ \text{gal}}$	$\frac{1.057\ \text{qt}}{1\ \text{L}}$		

General Procedure and Terminology

- **Step 2 (cont.):**
  - We will use 2.54 cm/1 in., which is exact.
  - We can view our problem as three steps: m to cm, cm to in., and in. to ft.
  - We can think of the steps one at a time.

$$? \text{ ft} = 254 \text{ m} \left(\frac{\quad}{1 \text{ m}} \right)$$

$$? \text{ ft} = 254 \text{ m} \left(\frac{10^2 \text{ cm}}{1 \text{ m}} \right)$$

General Procedure and Terminology

- **Step 2 (cont.):**.
  - Now we can do the core conversion from centimeters to inches.

$$? \text{ ft} = 254 \cancel{\text{m}} \left(\frac{10^2 \cancel{\text{cm}}}{1 \cancel{\text{m}}} \right) \left(\frac{\quad}{\cancel{\text{cm}}} \right)$$

$$? \text{ ft} = 254 \cancel{\text{m}} \left(\frac{10^2 \cancel{\text{cm}}}{1 \cancel{\text{m}}} \right) \left(\frac{1 \text{ in.}}{2.54 \cancel{\text{cm}}} \right)$$

General Procedure and Terminology

- **Step 2 (cont.):.**
  - The last conversion is from inches to feet.

$$? \text{ ft} = 254 \cancel{\text{m}} \left(\frac{10^2 \cancel{\text{cm}}}{1 \cancel{\text{m}}} \right) \left(\frac{1 \cancel{\text{in.}}}{2.54 \cancel{\text{cm}}} \right) \left(\frac{\quad}{\cancel{\text{in.}}} \right)$$

$$? \text{ ft} = 254 \cancel{\text{m}} \left(\frac{10^2 \cancel{\text{cm}}}{1 \cancel{\text{m}}} \right) \left(\frac{1 \cancel{\text{in.}}}{2.54 \cancel{\text{cm}}} \right) \left(\frac{1 \text{ ft}}{12 \cancel{\text{in.}}} \right)$$

General Procedure and Terminology

- **Step 3:** Check to be sure you used correct conversion factors and that your units cancel to yield the desired unit.

$$? \text{ ft} = 254 \cancel{\text{m}} \left(\frac{10^2 \cancel{\text{cm}}}{1 \cancel{\text{m}}} \right) \left(\frac{1 \cancel{\text{in.}}}{2.54 \cancel{\text{cm}}} \right) \left(\frac{1 \text{ ft}}{12 \cancel{\text{in.}}} \right)$$

- **Step 4:** Do the calculation, rounding your answer to the correct number of significant figures and combining it with the correct unit.

$$? \text{ ft} = 254 \cancel{\text{m}} \left(\frac{10^2 \cancel{\text{cm}}}{1 \cancel{\text{m}}} \right) \left(\frac{1 \cancel{\text{in.}}}{2.54 \cancel{\text{cm}}} \right) \left(\frac{1 \text{ ft}}{12 \cancel{\text{in.}}} \right) = 833 \text{ ft}$$