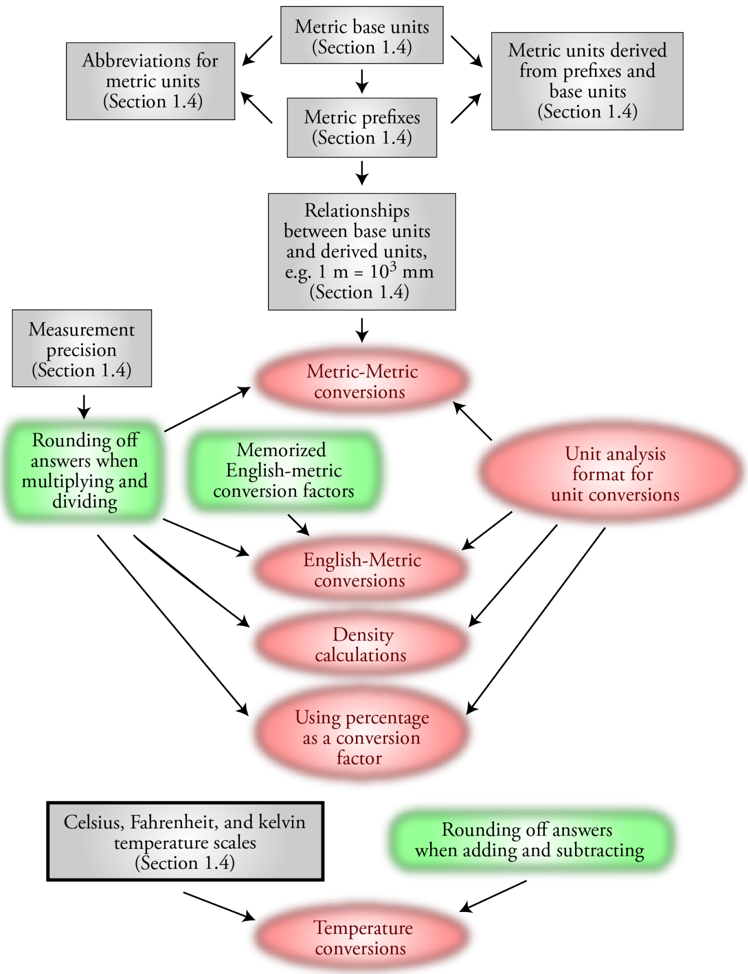
Chapter 8
Unit Conversions

An Introduction to Chemistry
by Mark Bishop

Chapter Map



Metric base units (Section 1.4)
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Metric prefixes (Section 1.4)
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Unit Conversions

All science requires mathematics. The knowledge of mathematical things is almost innate in us. . . [Mathematics] is the easiest of sciences, a fact which is obvious in that no one's brain rejects it…

Roger Bacon (c. 1214-c. 1294)

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)

Unit Analysis
Step 1

- **Step 1:** State your question in an expression that sets the unknown unit equal to the value given.
  - Start with the same number of units as you want.
    - If you want a single unit, start with a value that has a single unit.
    - If you want a ratio of two units, start with a value that has a ratio of two units, or start with a ratio of two values, each of which have one unit.
  - Put the correct type of unit in the correct position.

Unit Analysis
Step 2

- **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.
  - If you are not certain which conversion factor to use, ask yourself, "What is the fundamental conversion and what conversion factor do I use for that type of conversion?"

Unit Analysis Steps 3 & 4

- **Step 3:** Check to be sure you used correct conversion factors and that your units cancel to yield the desired unit.
- **Step 4:** Do the calculation, rounding your answer to the correct number of significant figures and combining it with the correct unit.

English-Metric Conversion Factors

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	$\frac{3.785\ \text{L}}{1\ \text{gal}}$	$\frac{1.057\ \text{qt}}{1\ \text{L}}$		

Rounding Answers from Multiplication and Division Step 1

- **Step 1:** Determine whether each value is exact, and ignore exact values.
  - Exact values
    - Numbers that come from definitions are exact.
    - Numbers derived from counting are exact.
  - Do Step 2 for values that are not exact.
    - Values that come from measurements are never exact.
    - We will assume that values derived from calculations are not exact unless otherwise indicated.

Rounding Answers from Multiplication and Division Step 2

- **Step 2:** Determine the number of significant figures in each value that is not exact.
  - All non-zero digits are significant.
  - Zeros between nonzero digits are significant.
  - Zeros to the left of nonzero digits are not significant.
  - Zeros to the right of nonzero digits in numbers that include decimal points are significant.
  - Zeros to the right of nonzero digits in numbers without decimal points are ambiguous for significant figures.

Rounding Answers from Multiplication and Division Step 3

- **Step 3:** When multiplying and dividing, round your answer off to the same number of significant figures as the value used with the fewest significant figures.
    - If the digit to the right of the final digit you want to retain is less than 5, round down (the last digit remains the same).
    - If the digit to the right of the final digit you want to retain is 5 or greater, round up (the last significant digit increases by 1).

Rounding Answers from Addition and Subtraction

- **Step 1:** Determine whether each value is exact, and ignore exact values.
  - Skip exact values.
  - Do Step 2 for values that are not exact.
- **Step 2:** Determine the number of decimal positions for each value that is not exact.
- **Step 3:** Round your answer to the same number of decimal positions as the inexact value with the fewest decimal places.

Density

- ***Mass density*** is mass divided by volume. It is usually just called density.

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

- It can be used as a unit analysis conversion factor that converts mass to volume or volume to mass.

Percentage and Percentage Calculations

- Mass percentages and volume percentage can be used as unit analysis conversion factors to convert between units of the part and units of the whole.

For X% by mass $\dfrac{\text{X (any mass unit) part}}{\text{100 (same mass unit) whole}}$

For X% by volume $\dfrac{\text{X (any volume unit) part}}{\text{100 (same volume unit) whole}}$

Conversion Types

From	Conversion factor	To
Metric unit	Conversion factors from prefixes on Table 1.2 (same type of measurement)	Another metric unit
English length unit	$\frac{2.54\ \text{cm}}{1\ \text{in.}}$ or conversion factors in Table 8.1	Metric length unit
English mass unit	$\frac{453.6\ \text{g}}{1\ \text{lb}}$ or conversion factors in Table 8.1	Metric mass unit
English volume unit	$\frac{3.785\ \text{L}}{1\ \text{gal}}$ or conversion factors in Table 8.1	Metric volume unit
English unit	Conversion factors in Table A.5 Appendix A (same type of measurement)	Another English unit
Mass	Density as a conversion factor	Volume
Mass of a part	For X% by mass $\frac{\text{X (any mass unit) part}}{\text{100 (same mass unit) whole}}$	Mass of a whole
Volume of a part	For X% by volume $\frac{\text{X (any volume unit) part}}{\text{100 (same volume unit) whole}}$	Volume of a whole

Temperature Conversions

$$? \,^{\circ}F = \text{---} \,^{\circ}C \left(\frac{1.8 \,^{\circ}F}{1 \,^{\circ}C} \right) + 32 \,^{\circ}F$$

$$? \,^{\circ}C = \left(\text{---} \,^{\circ}F - 32 \,^{\circ}F \right) \left(\frac{1 \,^{\circ}C}{1.8 \,^{\circ}F} \right)$$

$$? \, K = \text{---} \,^{\circ}C + 273.15$$

$$? \,^{\circ}C = \text{---} \, K - 273.15$$