Chp 2. Unit Conversion

- English-English
- Metric-metric
- Metric-English or English-Metric

1 ft = 12 in

1 yd = 3 ft

1 gal = 4 qt

5280 ft = 1 mi

2.1 Unit Analysis

- A ratio that specifies how one unit of measurement is related to another unit of measurement.
- Used to convert from one unit value to another unit value

How many seconds are there in 3.55 years?

Conversion factors

- A ratio that specifies how one unit of measurement is related to another unit of measurement.
- Used to convert from one unit value to another unit value

How many seconds are there in 3.55 years?

Conversion Factors (cont.)

- Sometimes called UNIT factors

Conversion factors (cont.)

How many seconds are there in 3.55 years?

1. ? s = 3.55 yr → s

- Several conversion units required.

- Other conversion factors that might be useful would be derived from:

60 min = 1 hr

24 hr = 1 day

365.25 days = 1 yr

- Other conversion factors that might be useful would be derived from:

? s = 3.55 yr → s

365.25 days = 1 yr
24 hr = 1 day
60 min = 1 hr
60 sec = 1 min

} TOOLS

Conversion factors (cont.)

- English-English

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

For converting ft to in

For converting in to ft

Conversion factors (cont.)

- English-English
- Metric-metric
- Metric-English or English-Metric

Metric-metric conversion (cont.)

- Conversion factors are derived from the meaning of the prefixes
- The numerical value of the prefix is always associated with the base unit.

1 km = 1000 m

1 μm = 1×10^{-6} m

The prefixed unit always has the numerical value 1

Metric-metric conversion (cont.)

- Conversion factors are derived from the meaning of the prefixes
- The numerical value of the prefix is always associated with the base unit.

1 km = 1000 m } $\frac{1000\ \text{m}}{1\ \text{km}}$ & $\frac{1\ \text{km}}{1000\ \text{m}}$

Metric-metric conversion (cont.)

- Conversion factors are derived from the meaning of the prefixes
- The numerical value of the prefix is always associated with the base unit.

The number 1 always goes with the *prefixed* unit.

$\frac{1\ \text{km}}{10^3\ \text{m}}$

The power of 10 always goes with the *unprefixed* unit.

Conversion factors (cont.)

- English-English
- Metric-metric
- Metric-English or English-Metric

$$\frac{1\ \text{in}}{2.54\ \text{cm}} = 1 \qquad 1 = \frac{2.54\ \text{cm}}{1\ \text{in}}$$

Dimensional Analysis

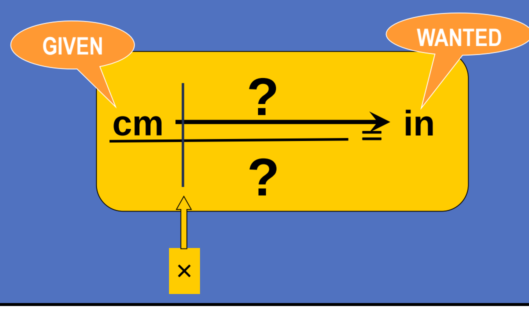
- **The "Cancel-Unit" Method**
  - Units, or "labels" are canceled, or "factored" out
  - Considering only the units, how would you calculate the number of inches in 10.0 cm?

Dimensional Analysis (cont.)

- **Steps:**
  1. Identify the starting (given) & ending (wanted) unit(s).
  2. Use one or more conversion factors so given units cancel when multiplied, leaving wanted unit(s).

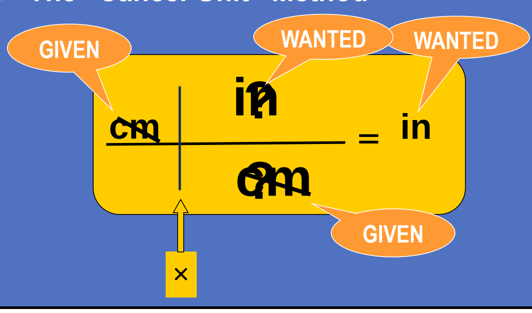
Dimensional Analysis (cont.)

- **The "Cancel-Unit" Method**



Dimensional Analysis (cont.)

- **The "Cancel-Unit" Method**



Dimensional Analysis (cont.)

- **Steps:**
  1. Identify the starting (given) & ending (wanted) unit(s).
  2. Use one or more conversion factors so given units cancel when multiplied, leaving wanted unit(s).
  3. Multiply all top numbers & divide by each bottom number.
  4. Check units & answer.

Dimensional Analysis (cont.)

- **The "Cancel-Unit" Method**
  - How many inches are there in 10.0 cm?

? in = 10.0 cm

GIVEN / WANTED / GIVEN

$$10.0\ \text{cm} \times \frac{1\ \text{in}}{2.54\ \text{cm}} = 3.94\ \text{in}$$

Multi-step Dimensional Analysis

- How many milliliters are in 1.00 quart of milk?

? mL = 1 qt milk

qt → → mL

$$1.00\ \text{qt} \times \frac{1\ \text{L}}{1.057\ \text{qt}} \times \frac{1\ \text{mL}}{0.001\ \text{L}} = 946\ \text{mL}$$

2.1 Scientific Notation

65,000 kg → 6.5×10^4 kg

- **Converting into Sci. Notation:**
  - Move decimal until there's 1 digit to its left. Places moved = exponent.
  - Large # (>1) ⇒ positive exponent
    Small # (<1) ⇒ negative exponent
  - Only include sig figs.

Scientific Notation (cont.)

Practice Problems

7. 2,400,000 μg — **sci. notation**
8. 0.00256 kg — **sci. notation**
9. 7×10^{-5} km — **decimal notation**
10. 6.2×10^4 mm — **decimal notation**

Scientific Notation

- **Calculating with Sci. Notation**

$(5.44 \times 10^7\ \text{g}) \div (8.1 \times 10^4\ \text{mol}) =$

Type on your calculator:

5.44 [EXP / EE] 7 [÷] 8.1 [EXP / EE] 4 [EXE / ENTER]

= 671.6049383

Scientific Notation

- **Rounding**

$(5.44 \times 10^7\ \text{g}) \div (8.1 \times 10^4\ \text{mol}) =$

3 sig figs — 2 sig figs

= 671.6049383 = 670 g/mol = 6.7×10^2 g/mol

Conversion of units with an exponent

- $m^2 \rightarrow mm^2$
- $yd^2 \rightarrow km^2$
- $m^3 \rightarrow gal$

2.2 Calculating with Significant Figures

Rounding numbers

Definition - Dropping insignificant digits after a calculation.

DOES NOT APPLY TO MEASUREMENTS

Calculating with Significant Figures (cont)

Rounding rules:

1. **Round starting from the first digit to the right of the uncertain digit.**
2. **If the digit to be dropped is less than 5 leave the digit before it unchanged**

Example: round *6.784998* to 3 sig. figs.:

6.784998

Numbers to be kept

Numbers to drop

rounds to 6.78

Calculating with Significant Figures (cont)

Rounding rules (cont):

3. **If the digit to be dropped is 5 or more increase the digit before it by one.**

Example: round *6.785498* to 3 sig. figs.:

6.785498

Numbers to be kept

Numbers to drop

rounds to 6.79

Calculating with Significant Figures (cont)

- **Multiply/Divide - The # with the fewest sig figs determines the # of sig figs in the answer.**

$(13.91 g/cm^3)(23.3 cm^3) = 324.103 g$

4 SF 3 SF 3 SF

324 g

Calculating with Significant Figures (cont)

Add/Subtract - The # with the lowest decimal value determines the place of the last sig fig in the answer.

3.75 mL	224 g
+ 4.1 mL	+ 130 g
7.85 mL → 7.9 mL	354 g → 350 g

Calculating with Significant Figures (cont)

- **Calculating with Sig Figs (con't)**
  - Exact Numbers do not limit the # of sig figs in the answer.
    - Counting numbers: 12 students
    - Exact conversions: 1 m = 100 cm
    - "1" in any conversion: 1 in = 2.54 cm

Calculating with Significant Figures (cont)

Practice Problems

(15.30 g) ÷ (6.4 mL) = 2.390625 g/mL

18.9 g
\- 0.84 g
18.06 g

2.3 Density

Density is the ratio of the mass of a substance to the volume occupied by that substance.

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

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Table 3.3 Densities of Selected Solids, Liquids, and Gases

Solids	Density (g/cm^3 at 25°C)*	Liquids	Density (g/mL at 25°C)*	Gases	Density (g/L at 25°C, 1 atm)*
Gold	19.3	Mercury	13.55	Chlorine	3.17
Lead	11.3	Milk	1.028–1.035	Carbon dioxide	1.96
Copper	8.93	Blood plasma	1.027	Oxygen	1.42
Aluminum	2.70	Urine	1.003–1.030	Air (dry)	1.29
Table salt	2.16	Water	0.997	Nitrogen	1.25
Bone	1.7–2.0	Olive oil	0.92	Methane	0.66
Table sugar	1.59	Ethyl alcohol	0.79	Hydrogen	0.08
Wood, pine	0.30–0.50	Gasoline	0.56		

*Density changes with temperature. (In most cases it decreases with increasing temperature, since almost all substances expand when heated.) Consequently, the temperature must be recorded along with a density value. In addition, the pressure of gases must be specified.

Notice units are different for solids, liquids and gases

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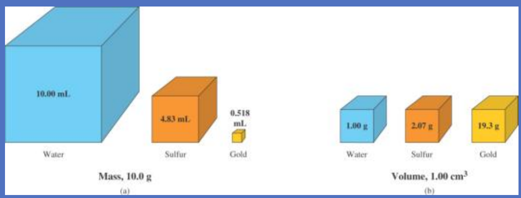

"Gold is more dense than sulfur and water"

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Densities of solids and liquids are compared to water. 1.0 g/mL

- If density>water it sinks. Salt=2.16 g/cm^3
- If density<water it floats. Olive oil=0.92 g/mL

Densities of gases are compared to air (1.29 g/L).

- If density>air it sinks. CO_2=1.96 g/L
- If density<air it rises. H_2=0.08 g/L

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Problems

1. Calculation of density

Measure mass and volume and divide as shown to calculate density

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

2. Calculation of mass

mass = density x volume

3. Calculation of volume

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

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A 13.5 mL sample of an unknown liquid has a mass of 12.4 g. What is the density of the liquid?

$$D = \frac{M}{V} = \frac{12.4\,\text{g}}{13.5\,\text{mL}} = 0.919\ \text{g/mL}$$

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A graduated cylinder is filled to the 35.0 mL mark with water. A copper nugget weighing 98.1 grams is immersed into the cylinder and the water level rises to the 46.0 mL. What is the volume of the copper nugget? What is the density of copper?

$$V_{\text{copper nugget}} = V_{\text{final}} - V_{\text{initial}} = 46.0\,\text{mL} - 35.0\,\text{mL} = 11.0\,\text{mL}$$

$$D = \frac{M}{V} = \frac{98.1\,\text{g}}{11.0\,\text{mL}} = 8.92\ \text{g/mL}$$

98.1 g

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The density of ether is 0.714 g/mL. What is the mass of 25.0 milliliters of ether?

Method 1

(a) Solve the density equation for mass.

$$\text{volume} \times d = \frac{\text{mass}}{\text{volume}} \times \text{volume}$$

mass = density x volume

(b) Substitute the data and calculate.

$$25.0\,\text{mL} \times \frac{0.714\,\text{g}}{\text{mL}} = 17.9\,\text{g}$$

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The density of ether is 0.714 g/mL. What is the mass of 25.0 milliliters of ether?

Method 2 Dimensional Analysis. Use density as a conversion factor. Convert: mL → g

The conversion of units is $\text{mL} \times \frac{\text{g}}{\text{mL}} = \text{g}$

$$25.0\,\text{ml} \times \frac{0.714\,\text{g}}{\text{mL}} = 17.9\,\text{g}$$

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The density of oxygen at 0°C is 1.429 g/L. What is the volume of 32.00 grams of oxygen at this temperature?

Method 1

(a) Solve the density equation for volume.

$$d = \frac{\text{mass}}{\text{volume}} \qquad \text{volume} = \frac{\text{mass}}{\text{density}}$$

(b) Substitute the data and calculate.

$$\text{volume} = \frac{32.00\,\text{g}\,O_2}{1.429\,\text{g}\,O_2/\text{L}} = 22.40\ \text{L}$$

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The density of oxygen at 0ºC is 1.429 g/L. What is the volume of 32.00 grams of oxygen at this temperature?

Method 2 Dimensional Analysis. Use density as a conversion factor. Convert: g → L

The conversion of units is $\text{g} \times \frac{\text{L}}{\text{g}} = \text{L}$

$$32.00 \text{ g } O_2 \times \frac{1 \text{ L}}{1.429 \text{ g } O_2} = 22.40 \text{ L } O_2$$

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Metric-English Conversion using density

- **You have 1.5 pounds of gold. Find its volume in cm³ if the density of gold is 19.3 g/cm³.**

lb → kg → g → cm³

? cm³ Au = 1.5 lb Au

$$\frac{1.5 \text{ lb}}{} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ cm}^3}{19.3 \text{ g}} = 35 \text{ cm}^3$$

2.4 Percentage and Percentage Calculations

I

II

III

Definition

- **Percent can be defined as "of one hundred."**

of 100

Definition

- **A part per 100**
- **Calculated as follows:**

$$\frac{\text{part}}{\text{total}} \times 100 = \text{percent}$$

Example

An assortment of coins contains 6 pennies, 14 nickels, 9 dimes, 16 quarters and 5 half dollars. What percentage of coins are quarters?

Part quarters = 16

Total coins = 6 + 14 + 9 + 16 + 5 = 50

$$\text{Percent} = \frac{\text{part}}{\text{total}} \times 100 = \frac{16}{50} \times 100 = 32\%$$

Percents Have Equivalents in Decimals and Fractions

Percent	Decimal	Fraction	Fraction Simplified
20% =	.20 =	$\frac{20}{100}$ =	$\frac{1}{5}$

Using percent

A bronze alloy contains 61% copper and 39% tin. How many grams of copper are needed to make 454 g of bronze?

remember 61% Cu = $\frac{\text{61 units Cu}}{\text{100 units bronze}}$

$\frac{\text{61 units Cu}}{\text{100 units bronze}} = \frac{\text{61 g Cu}}{\text{100 g bronze}}$

Using percent

- Using dimensional analysis:

?g Cu = 454 g bronze x $\frac{\square \text{ g Cu}}{\square \text{ g bronze}}$

454 ~~g bronze~~ x $\frac{\text{61 g Cu}}{\text{100 g bronze}}$ = 277 g Cu

2.6 Temperature Conversions

Heat

- A form of energy that is associated with the motion of small particles of matter.
- Heat refers to the quantity of this energy associated with the matter.
- Temperature is how we measure the heat content of matter.

To convert between the scales use the following relationships.

$$^{o}F - 32 = 1.8^{o} \times {}^{o}C$$

$$K = {}^{o}C + 273.15$$

It is not uncommon for temperatures in the Canadian planes to reach –60ºF and below during the winter. What is this temperature in ºC and K?

$$^{o}F - 32 = 1.8^{o} \times {}^{o}C$$

$$\frac{^{o}F - 32}{1.8} = \frac{1.8\,{}^{o}C}{1.8}$$

$$\frac{^{o}F-32}{1.8} = {}^{o}C$$

$$\frac{-60 - 32}{1.8} = -51\ {}^{o}C$$

It is not uncommon for temperatures in the Canadian planes to reach –60ºF and below during the winter. What is this temperature in ºC and K?

$$K = {}^{o}C + 273.15$$

$$K = -51^{o}C + 273.15 = 222\ K$$