Office Hours: M 1:30pm – 3:00pm
(in Park 169) W 11:00am – 12:00pm
or by appointment (email me)
or just email me with questions!

TA Hours w/ Dana: Th 6:00pm – 7:00pm
(in Park ____) F 4:30pm – 6:00pm

Park 273
Chem lounge

Q-center: https://www.brynmawr.edu/inside/offices-services/q-center/q-center-schedule

Unit Conversion

Brief History of Atomic Theory

9/4/2026

No recitation this afternoon.

Achieve HW #1 due Wednesday 9/9 at 10:00am

Quiz #1 in Recitation next Friday (9/11)

Learning Objectives

- Perform basic unit calculations and conversions in the metric and other unit systems
- Explain the dimensional analysis (factor label) approach to mathematical calculations involving quantities
- Use dimensional analysis to carry out unit conversions for a given property and computations involving two or more properties

- Apply the law of conservation of matter
- Define and give examples of atoms and molecules

- Outline milestones in the development of modern atomic theory
- Summarize and interpret the results of the experiments of Thomson, Millikan, Rutherford, and Chadwick

- Write and interpret symbols that depict the atomic number, mass number, and charge of an atom or ion

Unit Conversion

Given one or more quantities, convert them into different units.

Units are multiplied, divided, and canceled like any other algebraic quantities.

ie "x"

$1\,cm \cdot 1\,cm \rightarrow 1\,cm^2$

Always write every number with its associated unit!!! No shortcuts!!

Some conversion factors

Length	1 km = 0.6214 mi	Mass	1 kg = 2.205 lb
	1 m = 39.37 in = 1.094 yd		1 lb = 453.59 g
	1 ft = 30.48 cm		1 oz = 28.35 g
	1 in = 2.54 cm		

Volume	1 L = 1000 mL = 1000 cm^3
	1 L = 1.057 qt
	1 gal = 3.785 L

You will always be provided with any unit conversion factors needed for a problem.

You **do not** need to memorize unit conversion factors. (i.e. 1 kg = 2.205 lb)

recommend knowing

$\boxed{1 cm^3 = 1 mL}$

You **do** need to memorize conversion factors for the unit *prefixes* (i.e. 1 kg = 10^3 g) indicated a ~~few slides ago~~. on Wednesday

nano, micro, milli, centi, kilo

Problem Solving Using the Factor-Label Method

Conversion factor: A term that converts a quantity in one unit to a quantity in another unit.

original quantity	x	conversion factor	=	desired quantity
in lb				in kg

Conversion factors are usually written as equalities.

2.21 lb = 1 kg

To use them, they must be written as fractions.

$$\frac{2.21\ lb}{1\ kg} \quad \text{or} \quad \frac{1\ kg}{2.21\ lb}$$

Solving Problems Using Conversion Factors

→ label units! & make sure they cancel as needed.

Factor-label method: Using conversion factors to manage a complex problem involving many units. Also called Dimensional Analysis.

- units are treated like numbers
- make sure all unwanted units cancel
- ***all*** quantities in the calculation have units **labeled**!

no shortcuts! units help us organize the problem & strategize our solution.

To convert 130 lb into kilograms:

1.3×10^2 lb	x	$\boxed{\text{conversion factor}}$	=	? kg
original quantity				desired quantity

How many kg in 1.3×10^2 lb ?

$2.21 \text{ lb} = 1 \text{ kg}$

want ans. in kg.

$$1.3\times10^2\ \cancel{\text{lb}} \quad \times \quad \boxed{\frac{2.21\text{ lb}}{1\text{ kg}}} \;\rightarrow\; \frac{\text{lb}^2}{\text{kg}} \quad ✗$$

or

$$\boxed{\frac{1\text{ kg}}{2.21\ \cancel{\text{lb}}}} \quad = \quad 59 \text{ kg}$$

$$\rightarrow \frac{\cancel{\text{lb}}\cdot\text{kg}}{\cancel{\text{lb}}} \quad ✓$$

Set up the conversion factor with original unit in the <u>bottom</u> of the fraction.

- The unwanted unit lb cancels.
- The desired unit kg does not cancel, and is on the **<u>top</u>** of the fraction
  → final unit is kg

Solving Multistep Unit Conversion Problems

Each step should have a conversion factor set up to cancel the units of the previous step

given

$1\,km = 1000\,m$

Example: How many km are there in $1.2x10^4$ ft? 2 s.f.

1 foot = 0.3048 m

$$1.2 \times 10^4 \cancel{ft} \times \frac{0.3048 \cancel{m}}{1 \cancel{ft}} \times \frac{1\,km}{1000 \cancel{m}} = 3.6576\,km$$

$$\boxed{3.7\,km}$$

must have correct s.f. + units labled for full credit.

Conversion with Units Raised to a Power

Example: converting cm^3 to in^3

$$\frac{x^3}{x} = x^2$$

1 in = 2.54 cm

Must cube both sides of the equality to obtain the proper conversion factor.

in^3

How many cubic inches in 251 cm^3?

$$251\ cm^3 \times \frac{1\,in}{2.54\ cm} \times \frac{1\,in}{2.54\,cm} \times \frac{1\,in}{2.54\,cm} = \boxed{15.3\ in^3}$$

or

$$251\ cm^3 \times \left(\frac{1\,in}{2.54\,cm}\right)^3$$

Density - intensive property

The density of a substance is the ratio of its mass to its volume.

$$\text{Density} = \frac{\text{Mass (g)}}{\text{Volume (mL)}} \quad \text{or} \quad d = \frac{m}{V}$$

Water has a density of 1.0 g/mL (or 1.0 g/cm^3)

Things that are less dense (like oil) will float in water.
Things that are more dense (like CH_2Cl_2) will sink.

Calculating Density

Example: a sample of liquid has a volume of 22.5 mL and a mass of 27.2 g.

Assuming this liquid is not *miscible* with water (that is, they will separate like oil and water and not mix), will this liquid float or sink in water?

$$D = \frac{\text{mass}}{\text{volume}} = \frac{27.2\text{ g}}{22.5\text{ mL}} = 1.20889\text{ g/mL}$$

$$\rightarrow \boxed{1.21\text{ g/mL}}$$

more dense, so sink in water

Density as a Conversion Factor

We can use the density of a substance as a conversion factor between the mass of the substance and its volume.

for water: $D = 1.0\ g/mL$ or $1.0\ g$ water $= 1.0\ mL$ water

$\frac{1.32\ g}{cm^3}$ or $\frac{cm^3}{1.32\ g}$?

For a liquid substance with a density of 1.32 g/cm^3, what volume in liters should be measured to deliver a mass of 68.4 g?

↑ start w/ number w/ simpler unit.

$$68.4\ \cancel{g} \times \frac{1\ cm^3}{1.32\ \cancel{g}} \times \frac{1\ L}{1000\ cm^3} = \boxed{0.0518\ L}$$

A 23.5 kg sample of ethanol is needed for a large scale reaction. What volume in liters of ethanol should be used? The density of ethanol is 0.789 g/cm^3. → need L

Conversion factors: 0.789 g/cm^3 1 cm^3 = 1 mL

kg → g → cm^3 → mL → L

$$23.5\,\cancel{kg} \times \frac{10^3\,\cancel{g}}{1\,\cancel{kg}} \times \frac{1\,\cancel{cm^3}}{0.789\,\cancel{g}} \times \frac{1\,\cancel{mL}}{1\,\cancel{cm^3}} \times \frac{10^{-3}\,L}{1\,\cancel{mL}} = 29.78\,L$$

$\boxed{29.8\,L}$

↑ 3 s.f.

Convert 2.6 lb/in^3 to g/ml .

Mass	1 kg = 2.205 lb
	1 lb = 453.59 g
	1 oz = 28.35 g
Length	1 km = 0.6214 mi
	1 m = 39.37 in = 1.094 yd
	1 ft = 30.48 cm
	1 in = 2.54 cm

$$lb \longrightarrow g$$

$$in^3 \longrightarrow cm^3 \longrightarrow mL$$

$$1\,mL = 1\,cm^3$$

$$\frac{2.6\,\cancel{lb}}{in^3} \times \frac{453.59\,g}{1\,\cancel{lb}} \times \left(\frac{1\,in}{2.54\,cm}\right)^3$$

$$\boxed{72\ g/mL}$$

Law of Conservation of Mass

summary of many observations

There is no new matter.

- Matter is neither created nor destroyed in a **chemical reaction.**

  - In a **nuclear reaction**, significant changes in mass can occur.

    chem 104

    mass ⟷ energy

    $E = mc^2$

- During physical and chemical changes, the total amount of matter remains constant.

  melting point etc.

  ie reaction

Ex: Conservation of Mass

Butane + Oxygen → Carbon Dioxide + Water

$\underbrace{58\text{ g} \quad 208\text{ g}}_{266\text{g}}$ $\quad$ $\underbrace{176\text{ g} \quad 90\text{ g}}_{266\text{g}}$

Example: 12 g of natural gas combines with 48 g of oxygen in a flame. The chemical reaction produces 33 g of carbon dioxide and how many grams of water?

Natural gas + oxygen → carbon dioxide + water

$\underbrace{12\text{ g} \quad 48\text{ g}}_{60\text{g}}$ $\quad$ $\underbrace{33\text{ g} \quad ?}_{60\text{g}}$ 27g

60g - 33g

27g

Early Ideas About Atoms

<u>ca. 400 BCE</u>: Ancient Greek philosophers Leucippus and Democritus

All matter is made of irreducible "building blocks" that couldn't be divided further

"atomos" = "indivisible"

a | tomos

not

↳ to cut

Empedocles (and Aristotle) believed matter was composed of four "elements:"

water earth fire air

Atomic Theory

<u>1808 CE</u>: John Dalton's Atomic Theory expanded on the centuries-old Greek philosophies…

1. **All matter** is composed of **atoms**.

2. For a given element, all atoms have the same mass and other properties.

3. Different elements have atoms with different properties.

4. A compound consists of atoms of two or more elements combined in whole-number ratios.

   Example: Water H_2O has 2 atoms of hydrogen for every 1 atom of water

5. Atoms are not created or destroyed in a chemical change. They rearrange to make new compounds (with new ratios of atoms).