Measurements

Measurements are comparisons of properties against accepted standards, called units.

ENGLISH / US SYSTEM OF UNITS:

1 foot = 12 inches

1 yard = 3 feet

1 mile = 1760 yards

5280 ft = mi

So what's the problem? The English system of units is a mess! Units don't relate to one another in a meaningful way, and there are different relationships for each kind of unit.

Lots to memorize!

English units are nonstandard and difficult to use. Solution?

THE METRIC SYSTEM

Metric Base Units:

Length	meter	m
Mass	kilogram*	kg
Temperature	Kelvin	K
Time	second	s

All metric units are made up of COMBINATIONS of BASE UNITS!

*we usually treat the gram as if it's the base unit for mass!

- One meter is approximately 3.3 feet.
- One kilogram is approximately 2.2 pounds.

What about SIZE?

Metric units may be made larger or smaller by adding PREFIXES.

A few common metric prefixes:

mega-	10^6	M
kilo-	10^3	k
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ

Bigger units

smaller units

MEMORIZE the common metric prefixes listed in the study guide

Applying prefixes

1 _____ m = ______ m

$1\ \text{km} = 10^3\ \text{m}\ (1000\ \text{m})$

$1\ \text{cm} = 10^{-2}\ \text{m}\ \left(\frac{1}{100}\ \text{m}\right)$

Scaling units with metric prefixes ... examples

The distance between here and Columbia, SC is about 107,000 meters. What metric unit would be best suited for a distance like this?

$k = 10^3 \quad km = 10^3 m \quad (1000 m)$

$$\boxed{107\ km}$$

A piece of chalk is 0.080 meters long. What metric unit would be best suited for this length?

$c = 10^{-2} \quad cm = 10^{-2} m \quad \left(\frac{1}{100} m\right)$

$$\boxed{8.0\ cm}$$

Derived Units

- are units that are made up of combinations of metric base units with each other and/or with prefixes

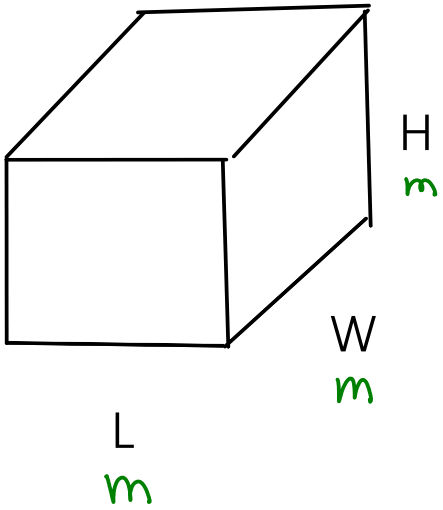
velocity: $\frac{\text{miles}}{\text{hr}}$ $\frac{\text{km}}{\text{hr}}$ $\left(\frac{\text{m}}{\text{s}}\right)$ $\frac{\text{length}}{\text{time}}$

Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

VOLUME

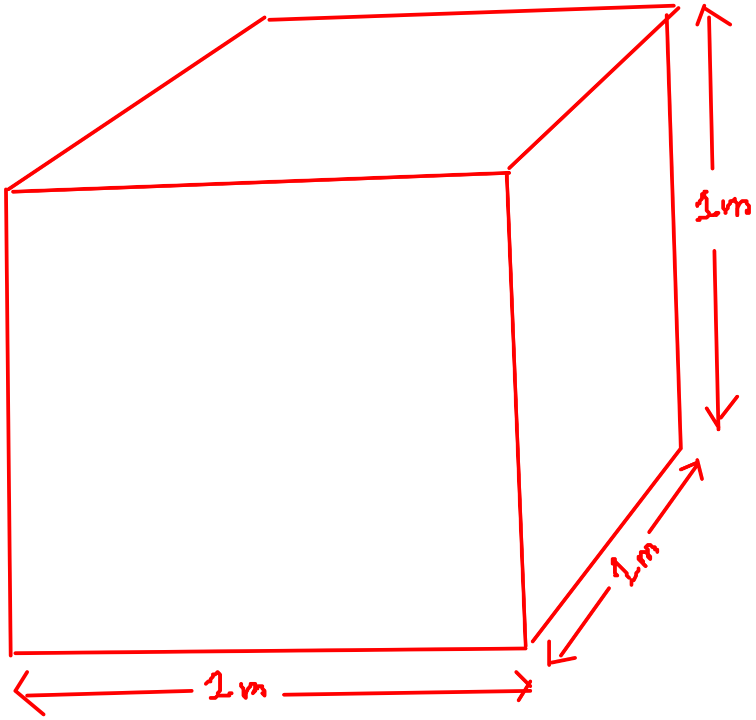


VOLUME = L × W × H

What are the units of volume in the metric system?

VOLUME = (m) × (m) × (m)

= m^3 (cubic meters)



Cubic meters are TOO LARGE for typical lab work.

Practical issues for volume units

- Cubic meters are too large! A meter is very similar in length to a yard, so a cubic meter is a cube that is approximately a yard long on each side!

A smaller unit for volume?

cubic decimeters!

dm^3

(decimeter = 1/10 meter)

Cubic decimeters are given the name "liters", abbreviation "L"

In the lab, we typically need an even smaller unit than the liter, so we use milliliters (mL)

"cc"

cubic centimeter

=

milliliter

$1 \text{ mL} = 10^{-3} \text{ L}$

-or-

$1000 \text{ mL} = 1 \text{ L}$

DENSITY

- Density is a measure of the concentration of matter; of how much matter is present in a given space

- Density is defined as the MASS per unit VOLUME, or ...

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

What are the metric units of DENSITY?

$$\text{DENSITY} = \frac{\overset{\swarrow \text{mass}}{kg}}{\underset{\nwarrow \text{volume}}{m^3}}$$

... but we typically don't measure volume in cubic meters OR mass in kilograms in lab. (Our lab scales have a maximum capacity of 210 g - 0.210 kg)

In the lab, we typically measure masses as grams and volumes as milliliters, so the density unit we will use most often is:

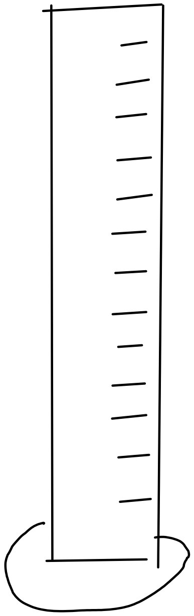
$$\boxed{\frac{g}{mL}} \quad \left(\frac{g}{cm^3}\right)$$

A useful density to remember:

WATER at room temp: Density = 1 g/mL

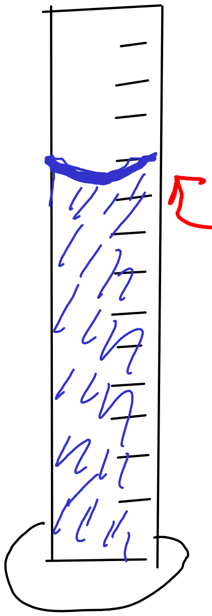
Measuring density

... of a liquid



1) Measure mass of empty cylinder

mass = 97.35 g



2) Fill cylinder and measure volume of liquid

volume = 25.3 mL

3) Measure mass of filled cylinder

mass = 130.55 g

4) Subtract to find mass of liquid

$$\begin{array}{rl} & 130.55 \text{ g} \\ - & 97.35 \text{ g} \\ \hline & 33.20 \text{ g} \end{array}$$

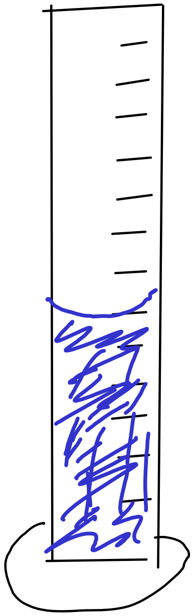
5) Density = mass liquid / volume liquid

$$\text{Density} = \frac{33.20 \text{ g}}{25.3 \text{ mL}} = \boxed{1.31 \text{ g/mL}}$$

...of an object

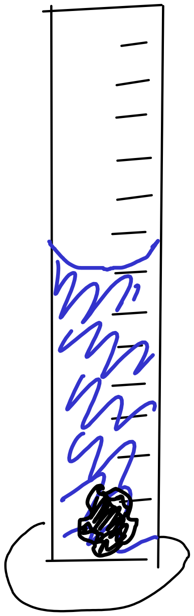
1) Measure mass of object

mass = 9.78 g



2) Partially fill cylinder with liquid, record volume.

volume = 25.0 mL



3) Put object into cylinder, record new volume

volume = 26.6 mL

4) Subtract to find volume of object

$$\begin{array}{r} 26.6\ \text{mL} \\ -\ 25.0\ \text{mL} \\ \hline 1.6\ \text{mL} \end{array}$$

5) Density = mass object / volume object

$$\text{Density} = \frac{9.78\ \text{g}}{1.6\ \text{mL}}$$

$$\boxed{= 6.1\ \text{g/mL}}$$

Converting from one unit to another

We will use the method of dimensional analysis, sometimes called the factor-label method.
... or, the "drag and drop" method!

Dimensional analysis uses conversion factors to change between one unit and another

What's a conversion factor? A simple equality.

Example

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

Conversion factors in metric

In the metric system, conversion factors between units may always be made from the metric prefixes!

For example, "kilo-" means 10^3

$$k = 10^3$$

so

$$km = 10^3 m$$

$$kg = 10^3 g$$

$$kL \quad 10^3 L$$

$$ks = 10^3 s$$

Just apply the prefix to the base unit!

How do we actually USE a conversion factor?

Convert 15.75 m to cm

$cm = 10^{-2} m$

$$15.75\,\cancel{m} \times \frac{cm}{10^{-2}\,\cancel{m}} = \boxed{1575\ cm}$$

* Similar to...

If X = 2, then

$$\frac{X}{2} = 1$$

* This fraction equals one, so multiplying by it does not change the VALUE of the number, only its UNITS!

Convert 0.01893 kg to g

$kg = 10^{3} g$

$$0.01893\,\cancel{kg} \times \frac{10^{3} g}{\cancel{kg}} = \boxed{18.93\ g}$$

DRAG AND DROP

- Drag the part of the factor that you want to cancel out to the BOTTOM.

- Then, drag the other half of the factor to the TOP

$mg = 10^{-3}\,g$ $\quad Kg = 10^{3}\,g$

Convert 14500 mg to kg

$$14500\,\cancel{mg} \times \frac{10^{-3}\,\cancel{g}}{\cancel{mg}} \times \frac{Kg}{10^{3}\,\cancel{g}} = \boxed{0.0145\,kg}$$

Convert 0.147 cm^2 to m^2

$cm = 10^{-2}\,m$

$$0.147\,\cancel{cm^2} \times \frac{10^{-2}\,m}{\cancel{cm}} \times \frac{10^{-2}\,m}{\cancel{cm}} = \boxed{1.47 \times 10^{-5}\,m^2}$$

We have to convert BOTH PARTS of the squared unit, so we use the factor TWICE.

$cm^2 = cm \times cm$

For CUBED units, apply the factors THREE times.