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English units are nonstandard and difficult to use. Solution?

THE METRIC SYSTEM

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

Metric Base Units:

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

*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

$$1 \text{ m} = \text{m}$$

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

$$1 \text{ mm} = 10^{-3} \text{ m} \quad \left(\frac{1}{1000} \text{ m}\right)$$

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?

$$K = 10^3 \quad Km = 10^3 m \text{ (1000 m)}$$

$$107 \text{ km}$$

By "best suited", we mean a metric unit that would represent the number without many beginning or end zeros. These kinds of numbers are easier for us to remember!

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

$$c = 10^{-2} \quad cm = 10^{-2} m \text{ (1/100 m)}$$

$$8.0 \text{ cm}$$

Derived Units

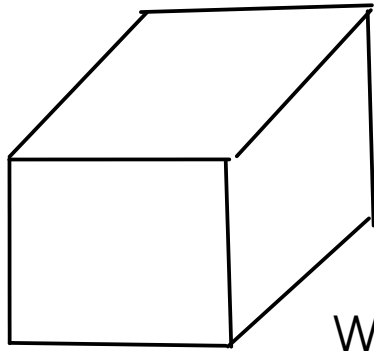
- are units that are made up of combinations of metric base units with each other and/or with prefixes

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

$$\text{VOLUME} = L \times W \times H$$

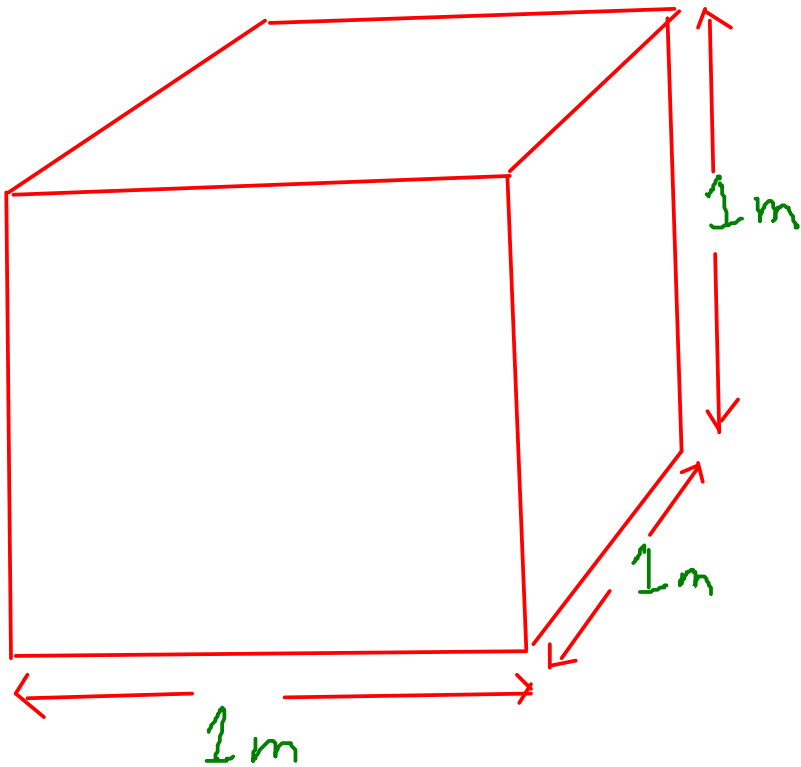
What are the units of volume in the metric system?

L (m)

W (m)

H (m)

$$\begin{aligned} \text{VOLUME} &= (m) \times (m) \times (m) \\ &= m^3 \quad \text{"cubic meters"} \end{aligned}$$



CUBIC METERS are too big for routine laboratory and medical use. So, we need to scale down the volume unit to something more manageable.

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 = $\frac{1}{10}$ 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)

mL
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?

$$\text{DENSITY} = \frac{\text{kg} \leftarrow \text{Base unit of mass}}{\text{m}^3 \leftarrow \text{Simplest volume unit}}$$

.. but we typically don't measure volumes in cubic meters in the lab. We also don't usually measure masses in kilograms, either!

(A typical laboratory analytical balance has a maximum capacity of about 200 grams!)

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

$$\frac{g}{mL}$$

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

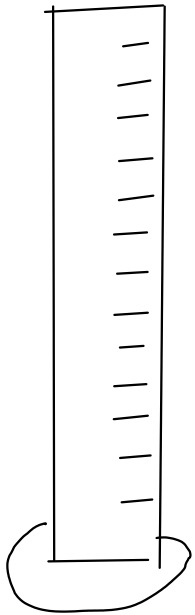
$$\left(\frac{g}{cc} \right)$$

A useful density to remember:

WATER at room temp: Density = $1 \frac{g}{mL}$

Measuring density

... of a liquid



1) Measure mass of empty cylinder

$$\text{mass} = 97.35 \text{ g}$$



2) Fill cylinder and measure volume of liquid

$$\text{volume} = 25.3 \text{ mL}$$

3) Measure mass of filled cylinder

$$\text{mass} = 130.55 \text{ g}$$

4) Subtract to find mass of liquid

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

5) Density = mass liquid / volume liquid

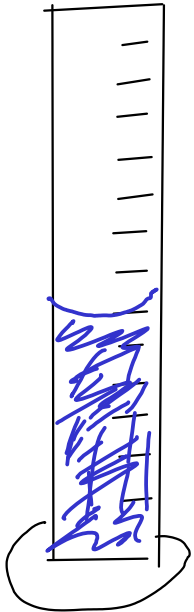
$$\begin{aligned} \text{Density} &= \frac{33.20 \text{ g}}{25.3 \text{ mL}} \\ &= 1.31 \text{ g/mL} \end{aligned}$$

...of an object



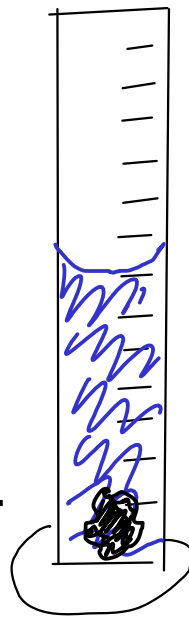
1) Measure mass
of object

$$\text{mass} = 9.78 \text{ g}$$



2) Partially fill cylinder
with liquid, record volume.

$$\text{volume} = 25.0 \text{ mL}$$



3) Put object into cylinder, record new
volume

$$\text{volume} = 26.6 \text{ mL}$$

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

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

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

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

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

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

$$k_m = 10^3 m$$

$$k_g = 10^3 g$$

$$k_L = 10^3 L$$

$$k_s = 10^3 s$$

Just apply the prefix to the base unit!

How do we actually USE a conversion factor?

Convert 15.75 m to cm

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

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

* Similar to...

If $X = 2$, then

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

15.75 / $\boxed{\text{EE}}^{-2}$.. on TI-83

* 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

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

$\text{kg} = 10^3 \text{ g}$

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

Convert 14500 mg to kg $mg = 10^{-3}g$ $kg = 10^3g$

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

Convert 0.147 cm^2 to m^2 $\text{cm} = 10^{-2} \text{ m}$

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

0.0000147 m^2

For squared units, we have to convert BOTH PARTS of the unit, so we use each conversion factor TWICE. If you think of a square centimeter as

$$\text{cm}^2 = \text{cm} \times \text{cm}$$

... then this should make sense. For CUBED units, use each factor THREE times.

8.45 kg to μg
 $=$ $=$

$$\text{Kg} = 10^3 \text{g}$$

$$\mu\text{g} = 10^{-6} \text{g}$$

$$8.45 \text{ kg} \times \frac{10^3 \text{g}}{\text{Kg}} \times \frac{\mu\text{g}}{10^{-6} \text{g}} = \boxed{\begin{array}{l} 8450000000 \mu\text{g} \\ 8.45 \times 10^9 \mu\text{g} \end{array}}$$

88100 kHz to MHz

$$\text{Hz} = 1/\text{s (frequency)}$$