

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

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

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

$$1 \text{ K m} = 10^3 \text{ m} \left(1000 \text{ m} \right)$$

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?

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

$$107 \text{ km}$$

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?

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

$$8.0 \text{ cm}$$

Derived Units

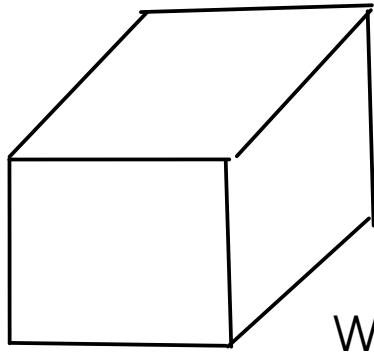
- are units that are made up of combinations of metric base units with each other and/or with prefixes

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

H (m)

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

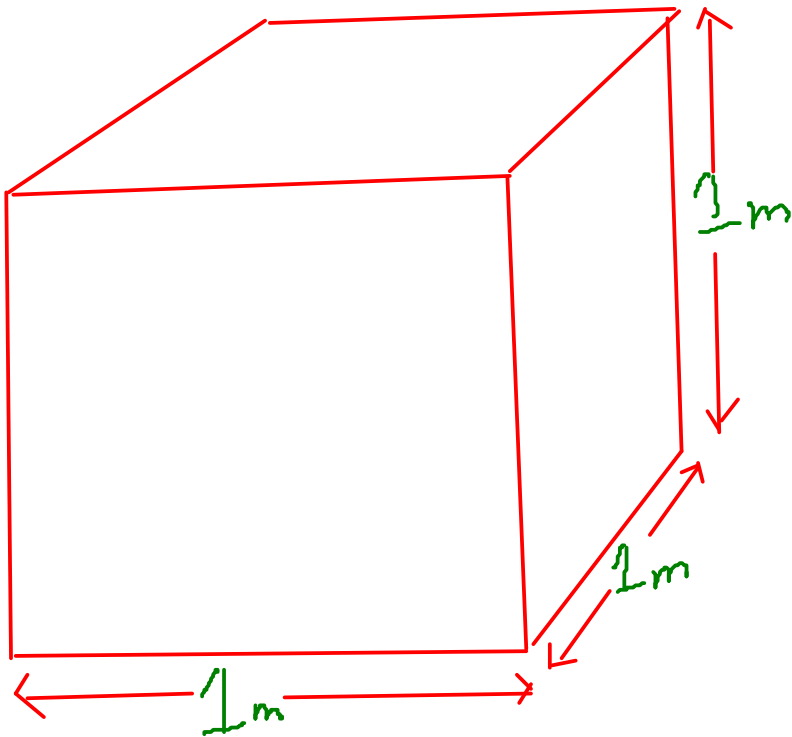
What are the units of volume in the metric system?

W (m)

$$\text{VOLUME} = (m) \times (m) \times (m) = m^3$$

$$= \text{"CUBIC METERS"}$$

L (m)



CUBIC METERS are a large unit. For lab-scale work, we need a much smaller volume unit.

We must scale down the cubic meter.

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:

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

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

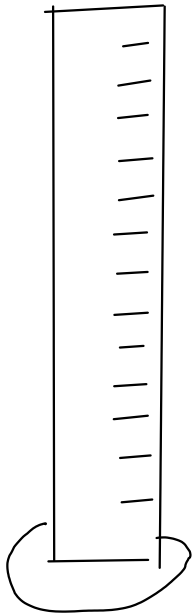
$$\left(\frac{g}{cc} \right)$$

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

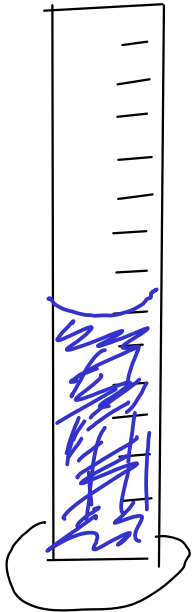
$$\text{Density} = \frac{33.20 \text{ g}}{25.3 \text{ mL}} = 1.31 \text{ g/mL}$$

...of an object



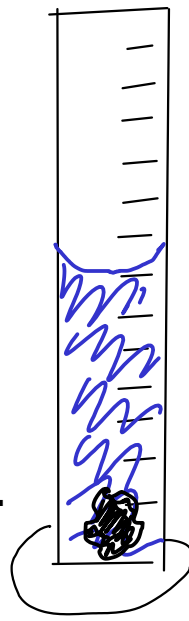
1) Measure mass
of object

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



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

$$kg = 10^3 g$$

$$kL = 10^3 L$$

$$kS = 10^3 S$$

$$km = 10^3 m$$

Just apply the prefix to the base unit!

How do we actually USE a conversion factor?

Convert 15.75 m to cm

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

Handwritten notes: $\text{cm} = 10^{-2} \text{m}$ (with an arrow pointing to the fraction), and a box around the result 1575 cm .

* Similar to...

If $X = 2$, then

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

15.75 / [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

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

Handwritten notes: $\text{kg} = 10^3 \text{g}$ (with an arrow pointing to the fraction), and a box around the result 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