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?

$km = 10^3 m$ (1000m)

107 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?

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

8.0 cm

Derived Units

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

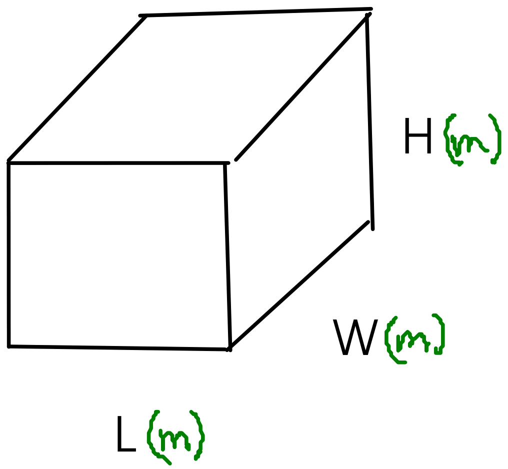
velocity: $\frac{miles}{hr}$ $\frac{km}{hr}$ $\left(\frac{m}{s}\right)$ $\frac{length}{time}$

Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

VOLUME

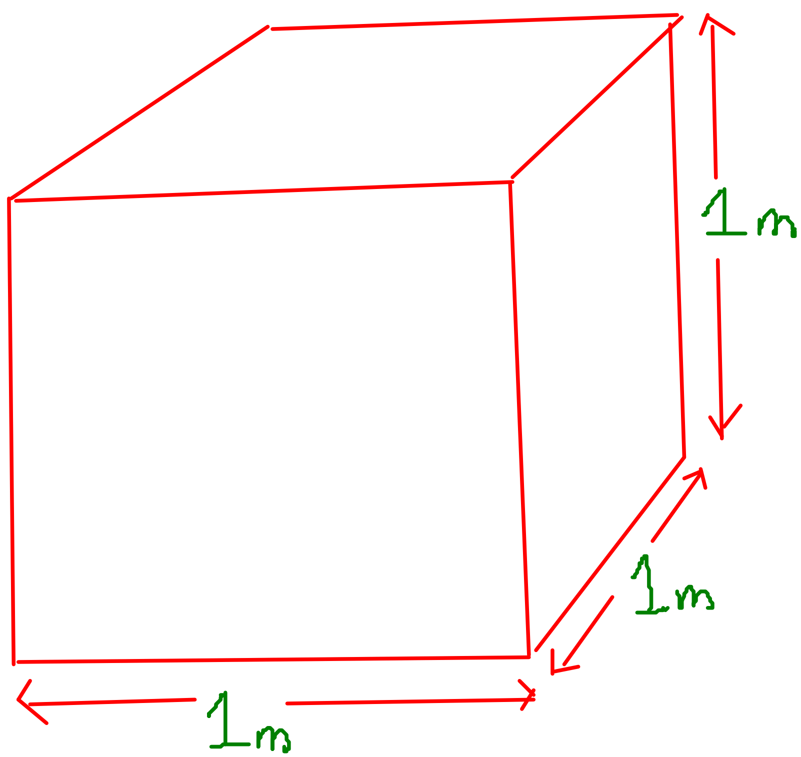


VOLUME = L × W × H

What are the units of volume in the metric system?

VOLUME = (m) x (m) x (m)

= m^3 (cubic meters)



CUBIC METERS are too large for lab scale work, so we use a smaller unit.

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

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

-or-

$1000\ mL = 1\ L$

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?

$$\text{DENSITY} = \frac{kg}{m^3}$$

kg ← mass

m^3 ← volume

... we typically don't measure in either kilograms or cubic meters for lab scale work. (Our scales only measure a maximum of 0.200 kg)

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

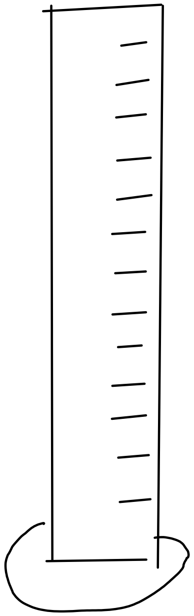
$$\frac{g}{mL} \quad \left(\frac{g}{cm^3}\right)$$

A useful density to remember:

WATER at room temp: Density = 1 g/mL

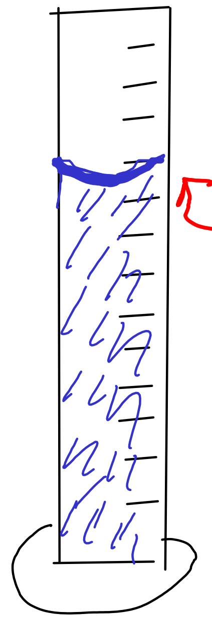
Measuring density

... 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

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

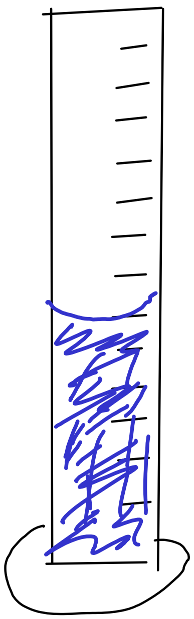
5) Density = mass liquid / volume liquid

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

$$= 1.31 \text{ g/mL}$$

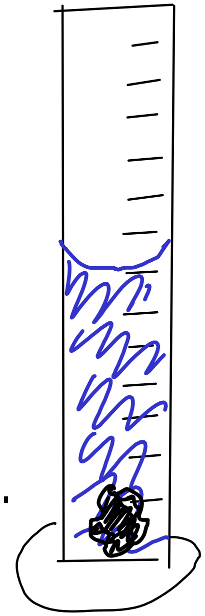
1) Measure mass of object

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

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

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

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 in = 1 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

$$km = 10^3 m$$

$$kg = 10^3 g$$

$$kL = 10^3 L$$

$$ks = 10^3 s$$

Just apply the prefix to the base unit!

How do we actually USE a conversion factor?

Convert 15.75 m to cm

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

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

* 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

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

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

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

Convert 14500 mg to kg

$mg = 10^{-3}\,g \qquad kg = 10^{3}\,g$

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

Convert 0.147 cm^2 to m^2

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

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

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

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

$(0.0000147\,m^2)$

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.