Measurements

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

ENGLISH / US SYSTEM OF UNITS:

1 foot = 12 in 1 yard = 3 ft 1 mile = 1760 yd

1 mile = 5280 ft

So what's the problem?

The English system has many different units for measuring the same kind of property, and those many units don't relate to one another in meaningful ways.
The relationships that *do* exist between these units are not easy to use.

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 (or mc-)

MEMORIZE the common metric prefixes listed in the study guide

Applying prefixes

1 _____ m = _____ m

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

1 cm = 10^{-2} m ($\frac{1}{100}$ m) (0.01 m)

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 (1000)

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?

c = 10^{-2} (1/100)

8 cm

Derived Units

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

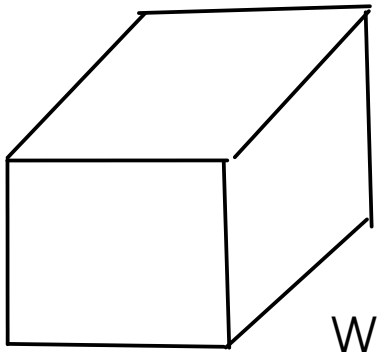
velocity: $\frac{\text{miles}}{\text{hr}}$ $\frac{\text{km}}{\text{hr}}$ $\left(\frac{\text{m}}{\text{s}}\right)$ $\frac{\text{length}}{\text{time}}$

Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

VOLUME

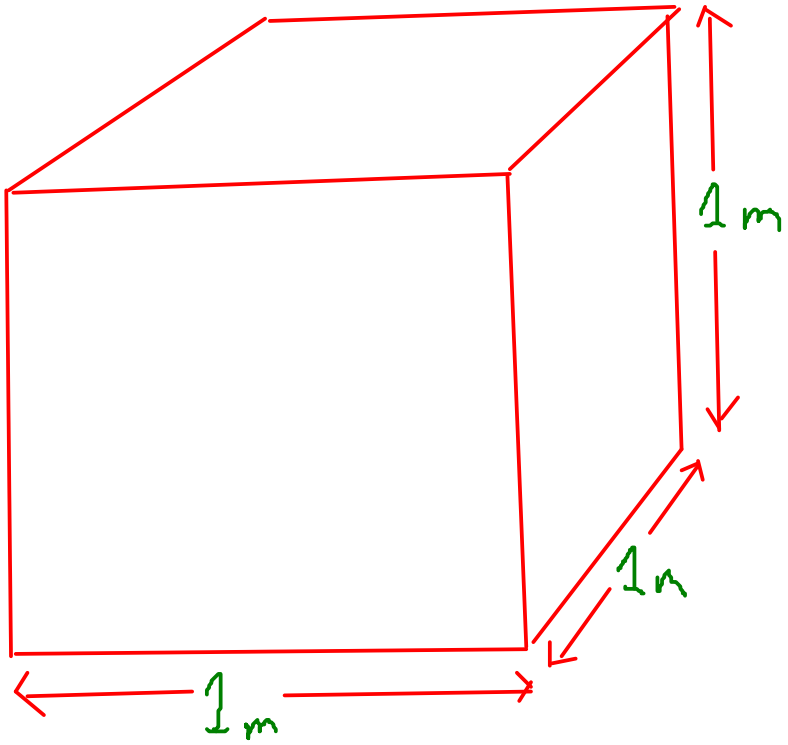


VOLUME = L × W × H

What are the units of volume in the metric system?

VOLUME = (m) × (m) × (m)

= m^3 "cubic meters"



Problem: Cubic meters are much too large for laboratory scale work. We need 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?

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

← base unit of mass

← simplest volume unit

We usually substitute the mass and volume units used in the lab for kg and cubic meters, because both are too large.

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

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

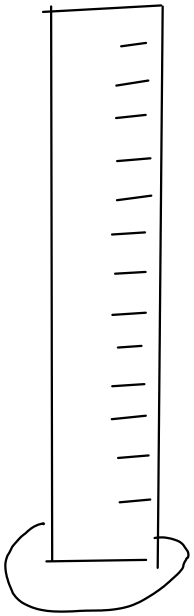
$$\left(\frac{g}{cm^3}\right) \quad \left(\frac{g}{cc}\right)$$

A useful density to remember:

WATER at room temp: Density = 1 g/mL

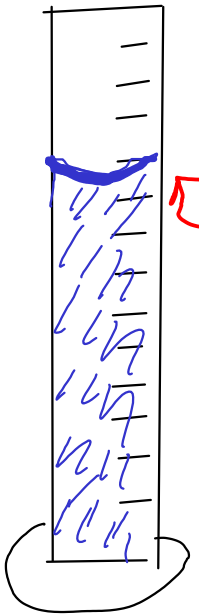
Measuring density

... 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

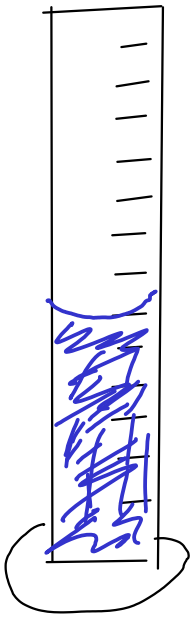
$$\text{Density} = \frac{33.20\ \text{g}}{25.3\ \text{mL}}$$

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

...of an object

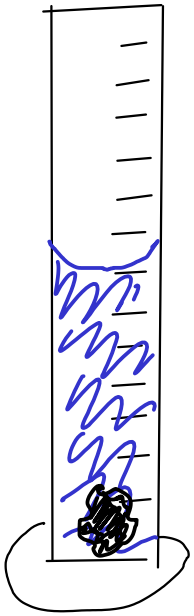
1) Measure mass of object

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

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

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

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

$$km = 10^3 m$$

$$ks = 10^3 s$$

$$kL = 10^3 L$$

$$kg = 10^3 g$$

Just apply the prefix to the base unit!