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 feet = 1 mile

So what's the problem?

Units in the English system don't relate to one another in any meaningful or easily-applied way. Each kind of unit has different relationships, too - and all must be memorized to use the system!

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-)

Applying prefixes

1 ____ m = ____ m

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

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

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?

$$k = 10^3 \ (1000)$$

$$107 \ km$$

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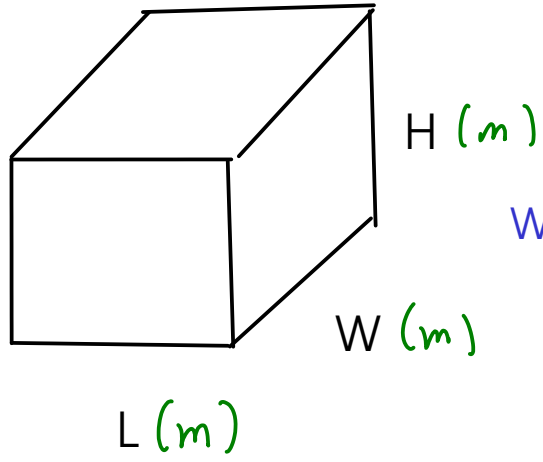
$$c = 10^{-2} \ (1/100)$$

$$8 \ cm$$

Derived Units

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

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

Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

VOLUME
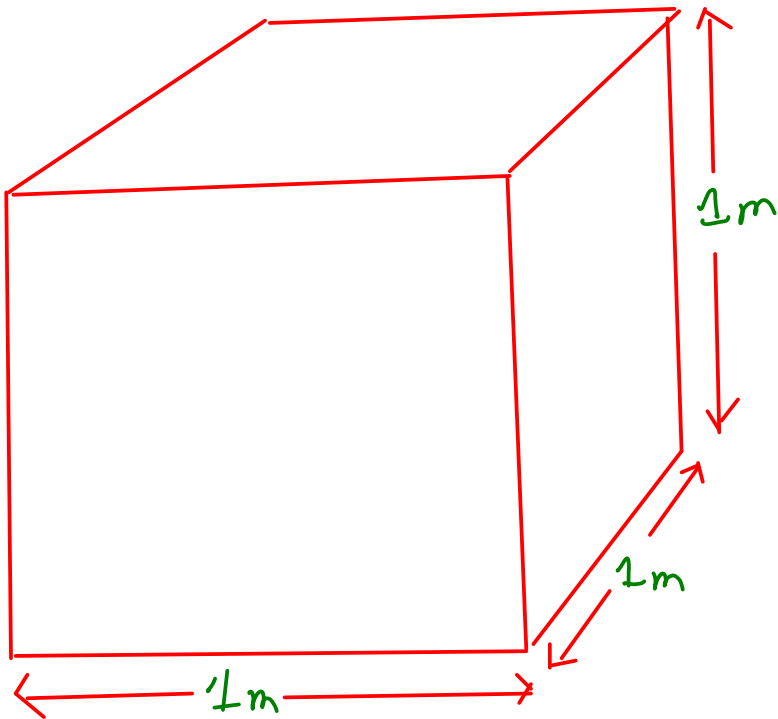
VOLUME = L $\times$ W $\times$ H

H (m)

W (m)

L (m)

What are the units of volume in the metric system?

$VOLUME = (m) \times (m) \times (m)$

$= m^3$ "cubic meters"

1m

1m

1m

Problem: The cubic meter is too large for laboratory work!

Solution: Use metric prefixes to scale it down!

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 <u>approximately a yard long on each side</u>!

A smaller unit for volume?

cubic decimeters! dm^3

$\left(decimeter = \frac{1}{10} \, meter \right)$

Cubic <u>decime</u>ters are given the name <u>"liters"</u>, abbreviation <u>"L"</u>

In the lab, we typically need an even smaller unit than the liter, so we use <u>millilite</u>rs (mL)

"CC"
cubic centimeter
=
milliliter

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

$- or -$

$1000 \, mL = 1 \, L$

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 ...

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

What are the metric units of DENSITY?

$$DENSITY = \boxed{\frac{Kg}{m^3}}$$

← base unit of mass

← simplest volume unit.

Typical lab balances (analytical balances) have a capacity of around 200 grams.

Like with volume itself, we need to scale down density units!

In the lab, we typically measure masses as <u>grams</u> and volumes as <u>milliliters</u>, so the density unit we will use most often is:
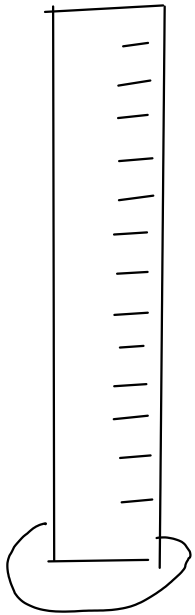
$$\frac{g}{mL} \qquad \left(\frac{g}{cm^3}\right) \quad \left(\frac{g}{cc}\right)$$

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

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

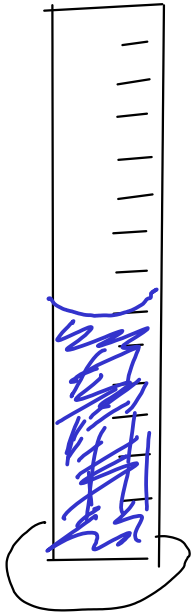5) Density = mass liquid / volume liquid

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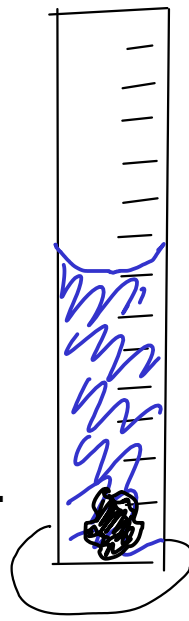
$$= \boxed{1.31 \ g/mL}$$

...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

$$26.6 \text{ mL}$$
$$- 25.0 \text{ mL}$$
$$\overline{1.6 \text{ mL}}$$

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

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