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

$$1 \underline{\quad} m = \underline{\quad\quad} m$$

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

$$1 \, Km = 10^3 \, m \quad \left(1000 \, m \right)$$

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?

$$K = 10^3 \qquad Km = 10^3 m \; (1000m)$$

$$107 \; Km$$

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?

$$C = 10^{-2} \qquad cm = 10^{-2} m \; (1/100 \, m)$$
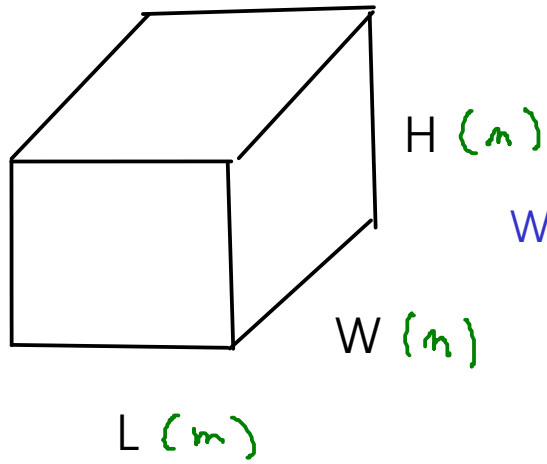
$$8.0 \; cm$$

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>

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

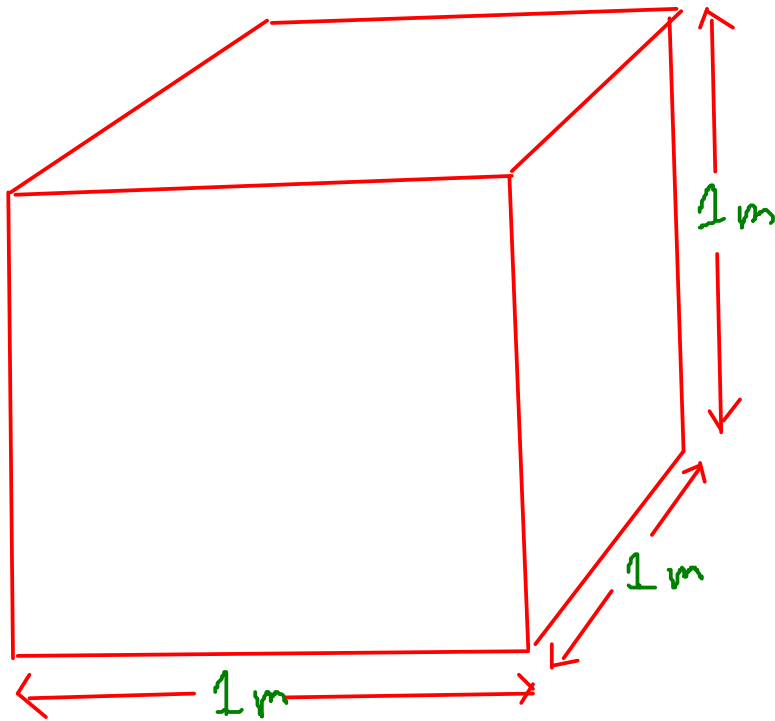Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

VOLUME

VOLUME = L × W × H

H (m)

W (m)

L (m)

What are the units of volume in the metric system?

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

$$= m^3 \quad (\text{"cubic meters"})$$

1 m

1 m

1 m

CUBIC METERS are too large for typical lab-scale or medical work. We need a smaller unit for routine use.

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

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

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>millili</u>ters (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 ...

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

What are the metric units of DENSITY?

Base unit of mass

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

Simplest metric volume unit.

... We have the same size issues with this unit that we have with the cubic meter. We typically don't measure volumes in cubic meters in the lab, and we typically don't measure masses in kilograms, either!

(A typical lab balance has a capacity of about 200 grams!)

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:

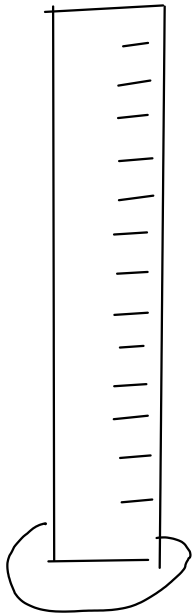$$\boxed{\frac{g}{mL}} \qquad \left(\frac{g}{cm^3}\right) \quad \left(\frac{g}{cc}\right)$$

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

$$130.55 \text{ g} - 97.35 \text{ g} = 33.20 \text{ g}$$

5) Density = mass liquid / volume liquid
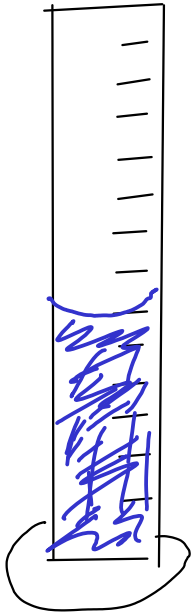
$$\text{Density} = \frac{33.20 \text{ g}}{25.3 \text{ mL}}$$
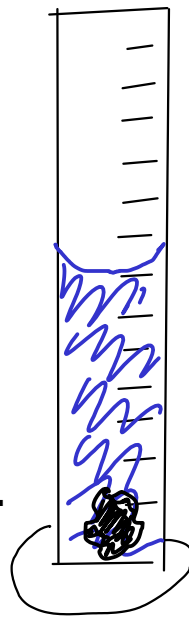
$$= 1.31 \text{ g/mL}$$

...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

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

5) Density = mass object / volume object

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

$$= 6.1 \quad g/mL$$

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 <u>metric prefixes</u>!

For example, "kilo-" means 10^3

$$K = 10^3$$

so

$$K_g = 10^3_g$$

$$K_m = 10^3_m$$

$$K_s = 10^3_s$$

$$KL = 10^3 L$$

Just apply the prefix to the base unit!

How do we actually USE a conversion factor?

Convert 15.75 m to cm

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

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

* Similar to...

If X = 2, then

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

$15.75 \, / \, \boxed{EE} \, -2$ .. 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

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

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

DRAG AND DROP
- Drag the part of the factor that contains the unit you want to get rid of (cancel out) to the BOTTOM.

- Then, drag the other half of the factor to the TOP