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 ft = mi

So what's the problem? The English system of units is a convoluted mess. Units don't relate to one another in meaningful ways. Each kind of unit has its own set of conversions that must be memorized separately.

English units are nonstandard and difficult to use. Solution?

THE METRIC SYSTEM

Metric Base Units:

All metric units are made up of COMBINATIONS of 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 ____ m = _____ m

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

$$1 \; km = 10^3 \; m \left(1000 \; m \right)$$

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?

$$Km = 10^3 m \quad (1000m)$$

$$107 \ Km$$

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?

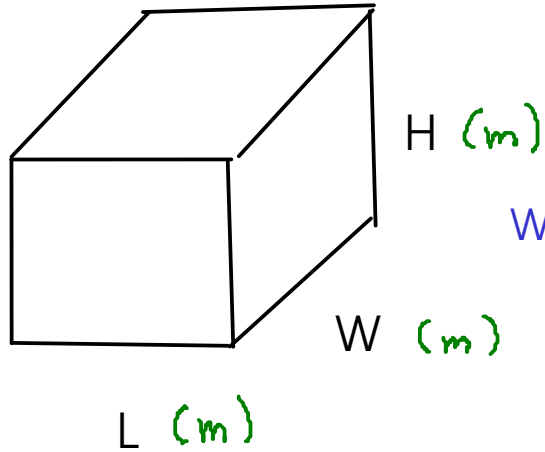$$cm = 10^{-2} m \quad \left(\frac{1}{100} m \right)$$

$$8.0 \ cm$$

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

Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

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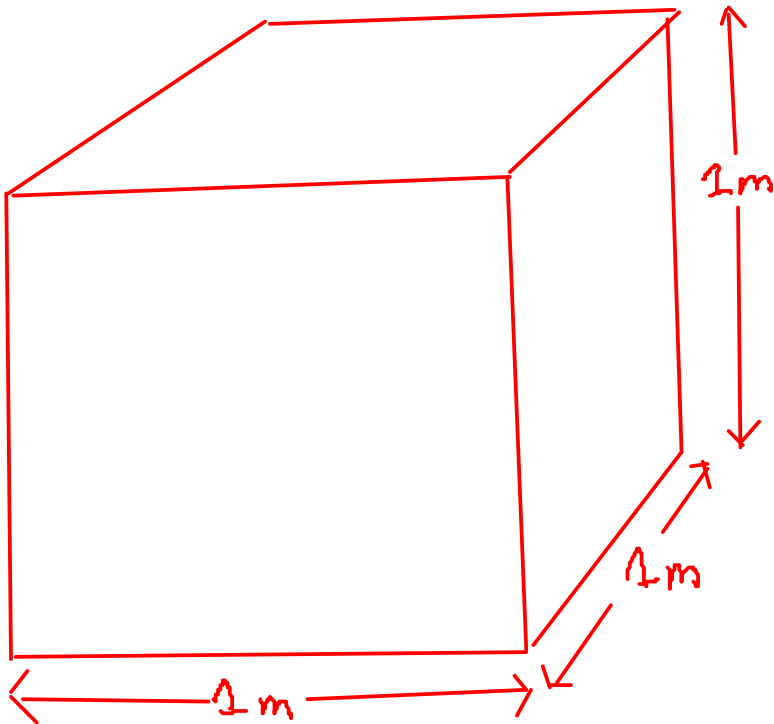
VOLUME = L $\times$ W $\times$ H

H (m)

W (m)

L (m)

What are the units of volume in the metric system?

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

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

1m

1m

1m

CUBIC METERS are too LARGE for lab-scale work! We must scale this unit 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

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

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

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

-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?

$$DENSITY = \frac{Kg \leftarrow mass}{m^3 \leftarrow volume}$$

... but we typically don't measure in either kilograms or cubic meters for lab-scale work. (Our scales support a maximum mass of about 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:
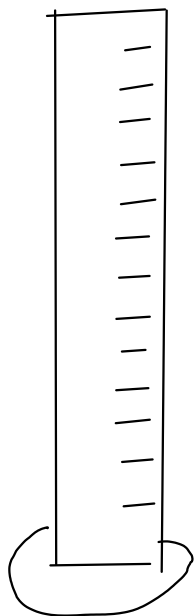
$$\frac{g}{mL} \qquad \left(\frac{g}{cm^3}\right)$$

A useful density to remember:

WATER at room temp: Density $= 1 \ g/mL$

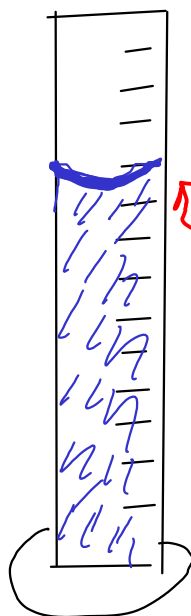# Measuring density

... 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

$$130.55 \text{ g}$$
$$- \quad 97.35 \text{ g}$$
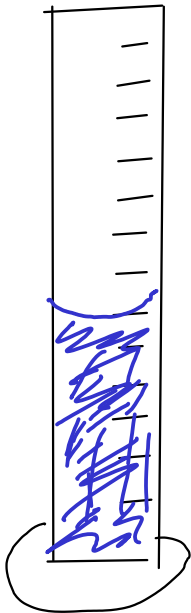$$\overline{\quad 33.20 \text{ g}}$$

5) Density = mass liquid / volume liquid

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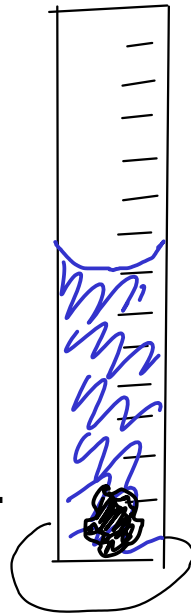
$$= 1.31 \text{ g/mL}$$

...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

$$\begin{array}{r} 26.6 \text{ mL} \\ -\ 25.0 \text{ mL} \\ \hline 1.6 \text{ mL} \end{array}$$

5) Density = mass object / volume object

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

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