Alchemists

- Attempted to change "base" materials (like lead) into valuable materials (like gold) in accordance with ARISTOTLE'S ideas about elements.

- Developed a fair protion of the techniques and glassware that the early MODERN chemists used.

- Discovered many previously unknown elements.

Modern

Lavosier

1. Made chemistry a QUANTITATIVE science. Made very careful MEASUREMENTS of all things going into and coming out of chemical processes.
2. Discovered the nature of combustoin (role of oxygen in combustion!)
3. Compiled a list of known elements

... unfortunately, he was beheaded during the French Revolution

Dalton

- Developed ATOMIC THEORY (in 1808) ... a modern application of the "atoms" idea that Democritus and Leucippus had proposed in ancient Greece.

Measurements

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

English/US units:

1 foot = 12 in

1 yard = 3 ft

1 mile = 1760 yd

5280 ft = 1 mile

So what's the problem? Units are not consistent. This makes the English system difficult to learn (lots of DIFFERENT factors relating units) and use.

English units are nonstandard and difficult to use. Solution?

THE METRIC SYSTEM

Metric Base Units:

Length	meter	m
Mass	kilogram*	kg
Temperature	Kelvin	K
Time	second	s

All metric units are made up of COMBINATIONS of BASE UNITS!

*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.

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 these prefixes!

Applying prefixes

1 ______ m = ______ m

$1\ km = 10^3\ m\ (1000\ m)$ $10 \times 10 \times 10$

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

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?

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

$km = 10^3 m = 1000 m$

107 km

A piece of chalk is 0.080 meters long. What metric unit would be best suited for this length?

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

8 cm

Derived Units

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

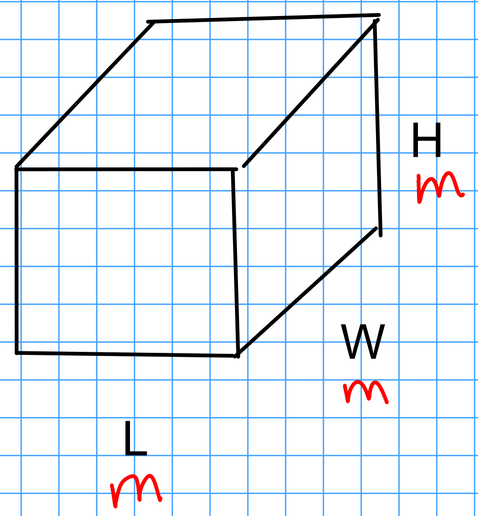
Example: speed $\frac{\text{miles}}{\text{hr}}$, $\frac{\text{km}}{\text{hr}}$ $\left(\frac{\text{length}}{\text{time}}\right)$

Two derived units are particularly important in introductory chemistry:

1) VOLUME

2) DENSITY

VOLUME



VOLUME = L × W × H

What are the units of volume in the metric system?

L = length, Metric unit is the meter!

VOLUME = m × m × m = m^3 "cubic meters"

... but the cubic meter is a very large volume unit! We want to use something more convenient for lab and medical work.

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!

(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?

mass unit = kilogram

volume unit = m^3 (cubic meter)

So, density unit = $\frac{kg}{m^3}$

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

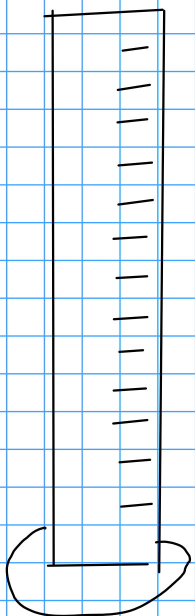
$$\frac{g}{mL}$$

A useful density to remember:

WATER at room temp: Density = 1 g/mL

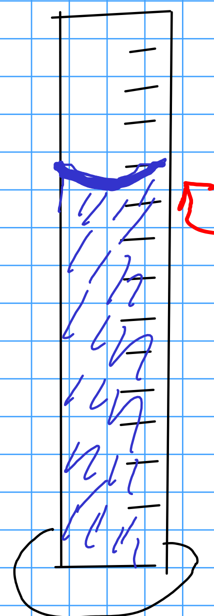
Measuring density

... 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

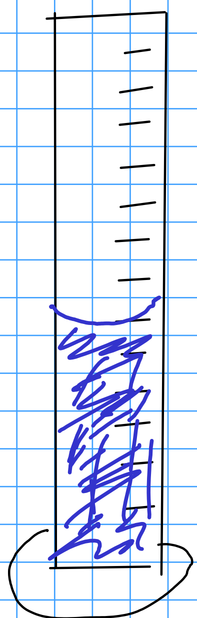
$$\text{Density} = \frac{33.20\ \text{g}}{25.3\ \text{mL}}$$

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

...of an object

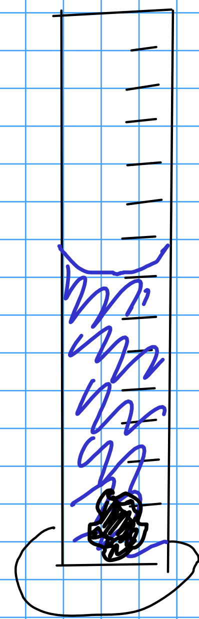
1) Measure mass of object

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 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?

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

Convert 15.75 m to cm

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

DRAG AND DROP!

Put what you want to cancel on the bottom, then ...

... put what it equals on the top!

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

Convert 0.01893 kg to g

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

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 mm to μm

$mm = 10^{-3}\,m \qquad \mu m = 10^{-6}\,m$

$$0.147\,mm \times \frac{10^{-3}\,m}{mm} \times \frac{\mu m}{10^{-6}\,m} = 147\,\mu m$$

Convert 38.47 in to m, assuming 2.54 cm = 1 in

$1 \text{ in} = 2.54 \text{ cm}$ $\qquad$ $\text{cm} = 10^{-2} \text{ m}$

$$38.47 \cancel{\text{in}} \times \frac{2.54 \cancel{\text{cm}}}{1 \cancel{\text{in}}} \times \frac{10^{-2} \text{ m}}{\cancel{\text{cm}}} = \boxed{0.9771 \text{ m}}$$

Even though English units are involved, we can solve this problem the same way we solved the previous problem where only metric units were used!

For nurses, one use of this method is for drug calculations.

Example: A patient is ordered 40 mg of codeine phosphate by subcutaneous injection. 50 mg in 1 mL liquid is available. How much of this liquid should be adminstered?

$$50 \text{ mg drug} = 1 \text{ mL}$$

This is a conversion factor. Use like you would use any other conversion factor.

$$40 \text{ mg drug} \times \frac{1 \text{ mL}}{50 \text{ mg drug}} = 0.8 \text{ mL}$$