Measurements

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

1 foot = 12 inches   1 yard = 3 feet   1 mile = 1760 yards

5280 feet = 1 mile

So what's the problem?

The English system is hard to use and learn because relationships between different units are all essentially random numbers which 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

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

$$1 \ Km = 10^3 m \ (1000 \ m)$$

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

The distance between here and Columbia, SC is about 107,000 meters. What metric unit would be best suited for a distance like this?

$$K = 10^3 (1000)$$

$$107 \text{ km}$$

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?

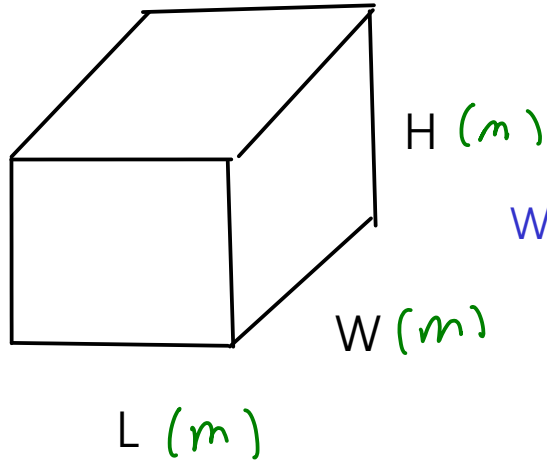$$C = 10^{-2} (1/100)$$

$$8 \text{ cm}$$

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

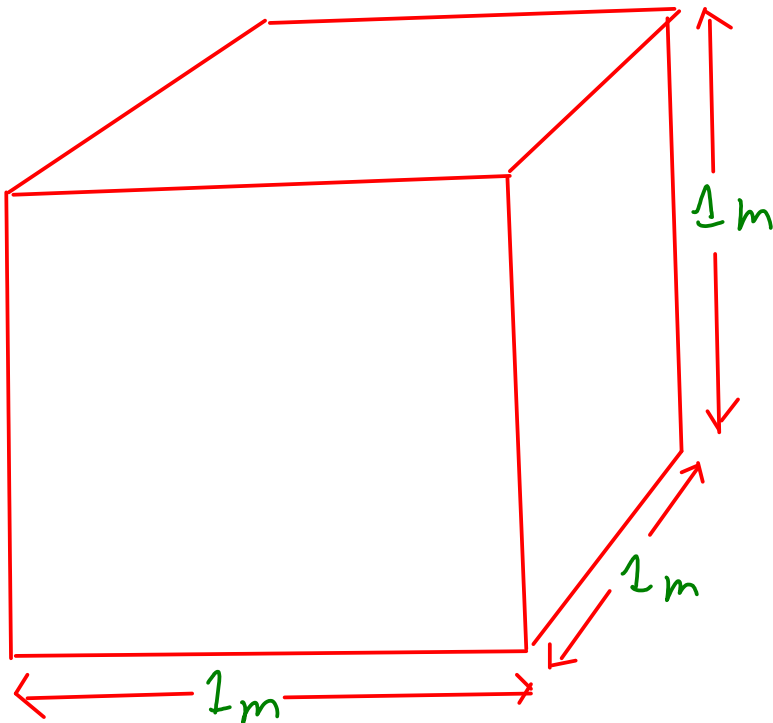Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

VOLUME

VOLUME = L × W × H

H (m)

What are the units of volume in the metric system?

W (m)

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

L (m)

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

1 m

1 m

1 m

Problem: Cubic meters are too large for lab-scale work.

Solution: Scale this down with a prefix.

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?

$$\boxed{\text{cubic decimeters!}} \quad dm^3$$

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

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)

$$\boxed{\begin{array}{c} \text{"cc"} \\ \text{cubic centimeter} \\ = \\ \text{milliliter} \end{array}}$$

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

- 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?

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

← base unit of mass

← simplest volume unit

This unit uses parts that are still too big for lab work!

Even the kilogram ... typical lab balances (analytical balances) have 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:
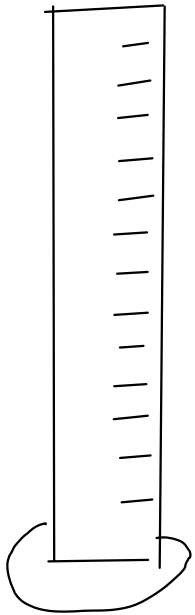
$$\dfrac{g}{mL} \qquad \left(\dfrac{g}{cm^3}\right) \quad \left(\dfrac{g}{cc}\right)$$

A useful density to remember:

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

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

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

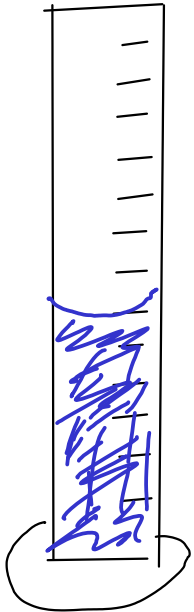5) Density = mass liquid / volume liquid

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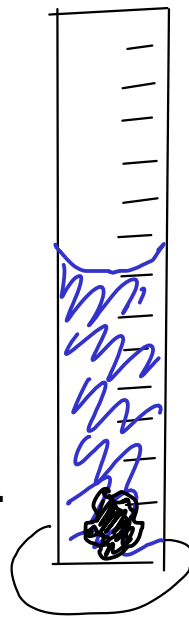
$$= 1.31 \text{ g/mL}$$

...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

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

5) Density = mass object / volume object

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

$$= 6.1 \quad g/mL$$