

Measurements

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

ENGLISH / US SYSTEM OF UNITS:

$$1 \text{ foot} = \underline{12} \text{ inches} \quad 1 \text{ yard} = \underline{3} \text{ feet} \quad 1 \text{ mile} = \underline{\underline{1760}} \text{ yards}$$
$$\underline{\underline{5280}} \text{ feet} = 1 \text{ mile}$$

So what's the problem?

The English system of units is hard to use. Relationships between different-sized units for the same kind of comparison are essentially random and must be memorized. Also, each kind of comparison has a different set of relationships - which must also be memorized (compare length and volume!)

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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.

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-)

MEMORIZE the common metric prefixes listed in the study guide

Applying prefixes

$$1 \text{ km} = 10^3 \text{ m} \quad (1000 \text{ m})$$

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

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

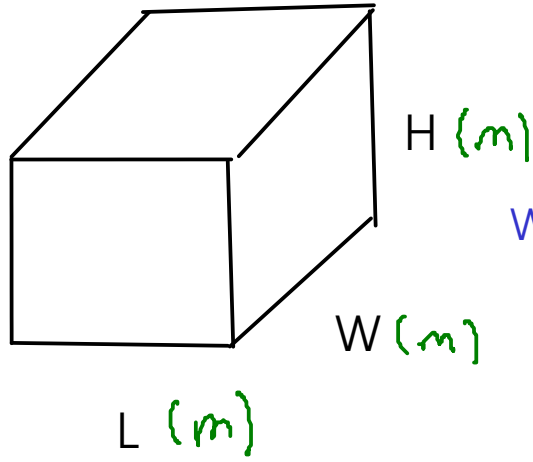
- are units that are made up of combinations of metric base units with each other and/or with prefixes

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

Two derived units are particularly important in general chemistry:

1) VOLUME

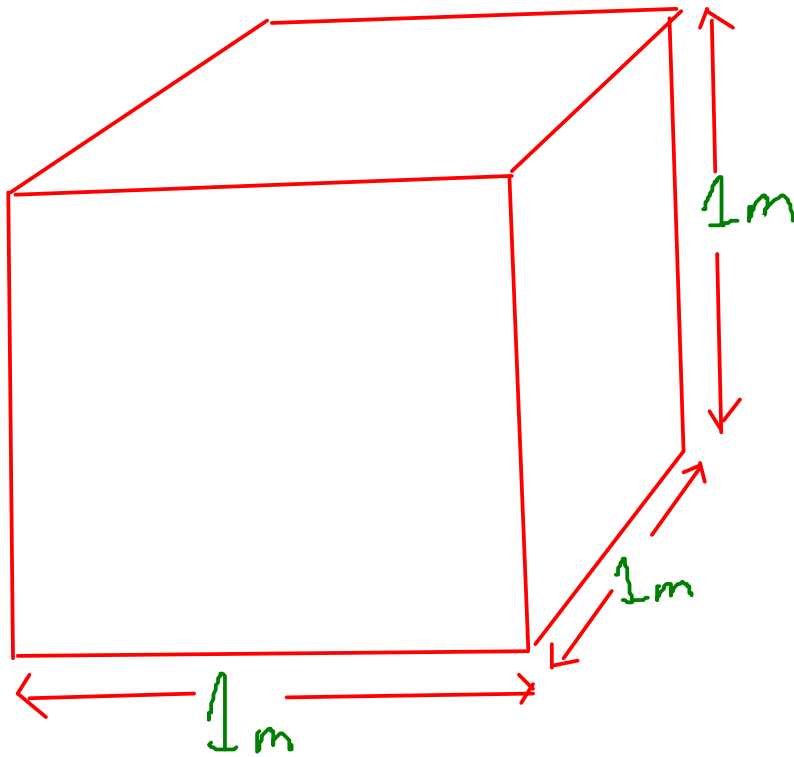
2) DENSITY

VOLUME

$$\text{VOLUME} = L \times W \times H$$

What are the units of volume in the metric system?

$$\begin{aligned} \text{VOLUME} &= \text{meters} \times \text{meters} \times \text{meters} \\ &= m^3 \quad \text{"cubic meters"} \end{aligned}$$



Problem: The cubic meter is too large of a unit for laboratory or medical scale work.

We need to scale this unit down to make it more convenient.

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! dm^3

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

mL
cubic centimeter
=
milliliter

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

-or-

$$1000 \text{ mL} = 1 \text{ L}$$

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?

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

base unit of MASS

simplest VOLUME unit

Problems:

- 1) The cubic meter is too large for lab work (so it isn't used routinely)
- 2) The kilogram is also too large for lab work. Typical lab balances have a capacity of a few hundred grams at most. (Ours are 200 g)

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

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

$$\left(\frac{g}{cm^3} \right)$$

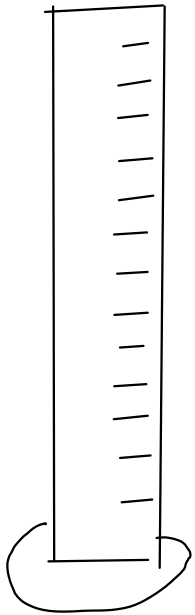
$$\left(\frac{g}{cc} \right)$$

A useful density to remember:

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

Measuring density

... of a liquid



1) Measure mass of empty cylinder

$$\text{mass} = 97.35 \text{ g}$$



2) Fill cylinder and measure volume of liquid

$$\text{volume} = 25.3 \text{ mL}$$

3) Measure mass of filled cylinder

$$\text{mass} = 130.55 \text{ g}$$

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

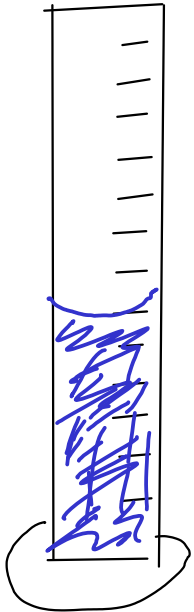
$$\begin{aligned} \text{Density} &= \frac{33.20 \text{ g}}{25.3 \text{ mL}} \\ &= 1.31 \text{ g/mL} \end{aligned}$$

...of an object



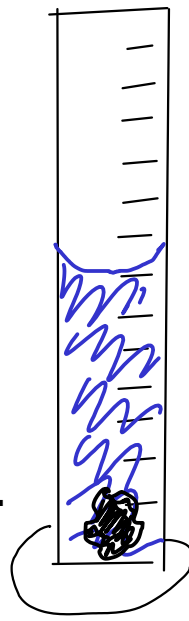
1) Measure mass
of object

$$\text{mass} = 9.78 \text{ g}$$



2) Partially fill cylinder
with liquid, record volume.

$$\text{volume} = 25.0 \text{ mL}$$



3) Put object into cylinder, record new
volume

$$\text{volume} = 26.6 \text{ mL}$$

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

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

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