

Measurements

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

ENGLISH / US SYSTEM OF UNITS:

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

So what's the problem?

The English system is cumbersome and difficult to use. The system contains many units that were developed independently and don't relate to the others in meaningful ways. This means we must MEMORIZE lots of conversions in English.

Different kinds of units also have different conversions ... leading to EVEN MORE MEMORIZATION.

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

MEMORIZE the common metric prefixes listed in the study guide

Applying prefixes

$$1 \text{ ___ m} = \text{ ___ m}$$

$$1 \text{ M m} = 10^6 \text{ m} \quad (1,000,000 \text{ m})$$

$$1 \text{ m m} = 10^{-3} \text{ m} \quad \left(\frac{1}{1000} \text{ m}\right)$$

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?

$$k = 10^3 \text{ (1000)}$$

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?

$$c = 10^{-2} \text{ (1/100)}$$

8.0 cm

Derived Units

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

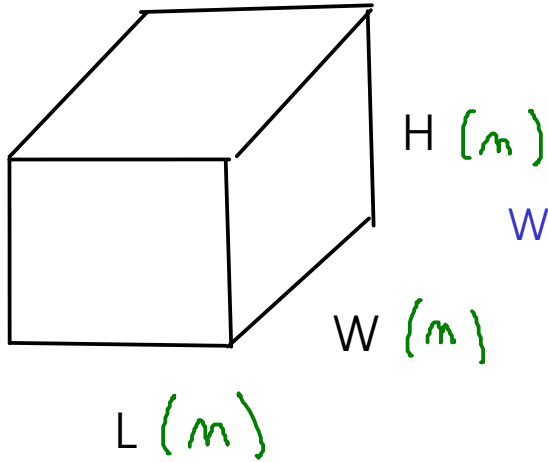
$$\text{velocity: } \frac{\text{miles}}{\text{hr}} \quad \frac{\text{km}}{\text{hr}} \quad \left(\frac{\text{m}}{\text{s}} \right) \quad \frac{\text{length}}{\text{time}}$$

Two derived units are particularly important in general chemistry:

1) VOLUME

2) DENSITY

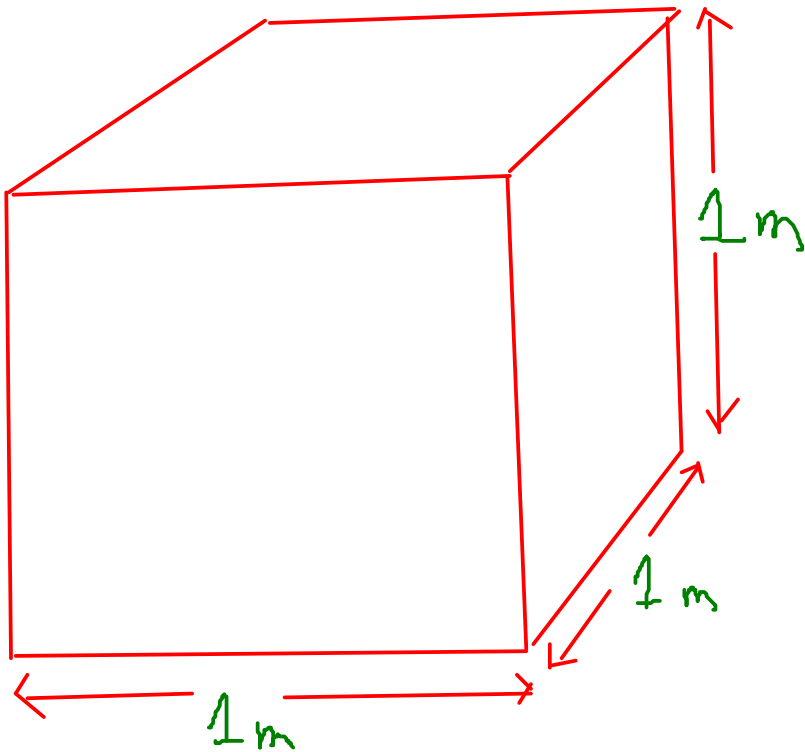
VOLUME



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

What are the units of volume in the metric system?

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



Problem - the cubic meter is TOO LARGE for laboratory and medical work.

In lab, we need a smaller unit, so we'll have to scale the cubic meter down to something more manageable!

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

... but we don't use cubic meters in the lab because they're too large.

Also, we don't measure mass in kilograms in a typical chemistry lab. Our scales here at Tech measure a maximum of 210 grams at a time (and this is typical for most labs).

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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:

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

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

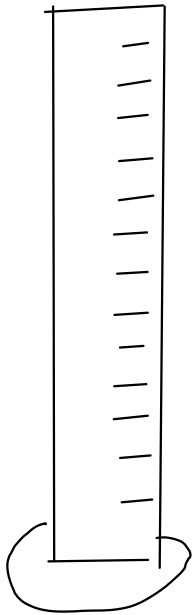
$$\left(\frac{g}{cc} \right)$$

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

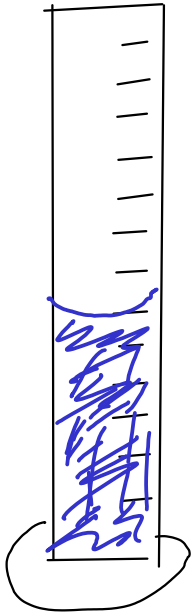
$$\text{Density} = \frac{33.20 \text{ g}}{25.3 \text{ mL}} = 1.31 \text{ g/mL}$$

11 ...of an object



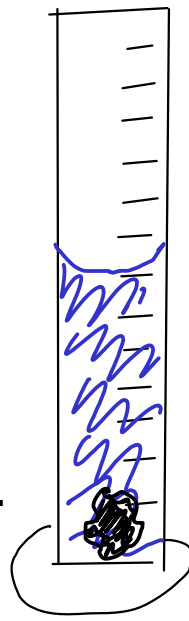
1) Measure mass of object

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



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

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

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