SCIENTIFIC MEASUREMENT

- SCIENTIFIC NOTATION
  - A way to write very large or small numbers.
  - General form of:
    - $A \times 10^{B}$

Where A = a number between 1 and 10

B = any integer (Positive number = big number, Negative number = small number). *How many times I moved the decimal place*

Examples:

602,000,000,000,000,000,000,000 atoms H

6.02×10^{23} atoms H

0.000 000 000 000 000 000 000 327 grams Au

3.27×10^{-22} grams Au

Write these numbers in scientific notation or write them in normal notation:

1. 4500000000000000
2. 6500000000
3. 0.0000007500
4. 23403000000000000
5. $1.60x10^{10}$
6. 10200
7. $9.89x10^{-12}$

International System of Units

- World-wide recognized way to make measurements.
- 6 SI base units commonly used in chemistry include:
  - m (meter) Length
  - kg (kilogram) Mass
  - K (Kelvin) Temperature
  - s (second) Time
  - mol (mole) Amount of substance
  - J (Joule) Amount of energy

Metric/SI Conversions

Prefix	Abbreviation	Meaning	Example
Giga	G	10^9	1 gigameter (Gm) = 1×10^9 m
Mega	M	10^6	1 megameter (Mm) = 1×10^6 m
Kilo	k	10^3	1 kilometer (km) = 1×10^3 m
Deci	d	10^{-1}	1 decimeter (dm) = 0.1 m
Centi	c	10^{-2}	1 centimeter (cm) = 0.01 m
Milli	m	10^{-3}	1 millimeter (mm) = 0.001 m
Micro	μ[a]	10^{-6}	1 micrometer (μm) = 1×10^{-6} m
Nano	n	10^{-9}	1 nanometer (nm) = 1×10^{-9} m
Pico	p	10^{-12}	1 picometer (pm) = 1×10^{-12} m
Femto	f	10^{-15}	1 femtometer (fm) = 1×10^{-15} m

[a] This is the Greek letter mu (pronounced "mew").

Prefixes convert the base units into units that are appropriate for the item being measured.

To convert between units you have to multiply/divide by factors of ten.

Metric/SI Conversions

- OR you can move decimals!

Prefix	***M*ega**	***K*ilo**	***H*ecto**	***D*eka**	**Base *U*nit**	***D*eci**	***C*enti**	***M*illi**	***M*icro**
Means	10^6	1000	100	10	1	1/10	1/100	1/1000	$1/10^6$
Symbol	Mm Ml Mg	km kl kg	hm hl hg	dam *or* dkm dal *or* dkl dag *or* dkg	m (meter) l (liter) g (gram)	dm dl dg	cm cl cg	mm ml *or* cc mg	µm µl µg

- Ex: Convert 43.1 cm to km

Metric/SI Conversions

1. 100 g to kg.

2. 3540 mg to g.

3. 300 cg to kg.

Dimensional Analysis

- When performing Dimensional analysis follow the approach below.
  - Write your given (usually only one unit)
  - Write where you are ending up. (What's the answer's unit(s)?)
  - Supply the path you choose to use to get to the answer.
- This approach needs to be followed when performing unit conversions, especially when converting between English and SI units.

Dimensional Analysis Examples

- Convert 25 lbs to grams.

- Jane drove her tractor for 4.5 hours. If her tractor used 25.6 gallons (1 gal = 3.87 L) of diesel, how many liters per hour were used? How many mL per s were used?

Temperature Conversions, Sig Figs and Density

Qualitative vs Quantitative Data

Qualitative Data

Overview:

- Deals with descriptions.
- Data can be observed but not measured.
- Colors, textures, smells, tastes, appearance, beauty, etc.
- Qualitative → Quality

Quantitative Data

Overview:

- Deals with numbers.
- Data which can be measured.
- Length, height, area, volume, weight, speed, time, temperature, humidity, sound levels, cost, members, ages, etc.
- Quantitative → Quantity

Example 1: Latte

Qualitative data:

*robust aroma
*frothy appearance
* strong taste
*glass cup

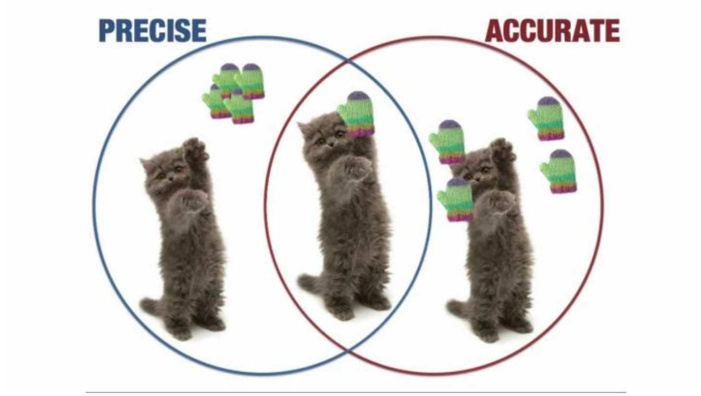
Example 1: Latte

Quantitative data:

*12 ounces of latte
*serving temperature 150^0 F.
*serving cup 7 inches in height
*cost $4.95

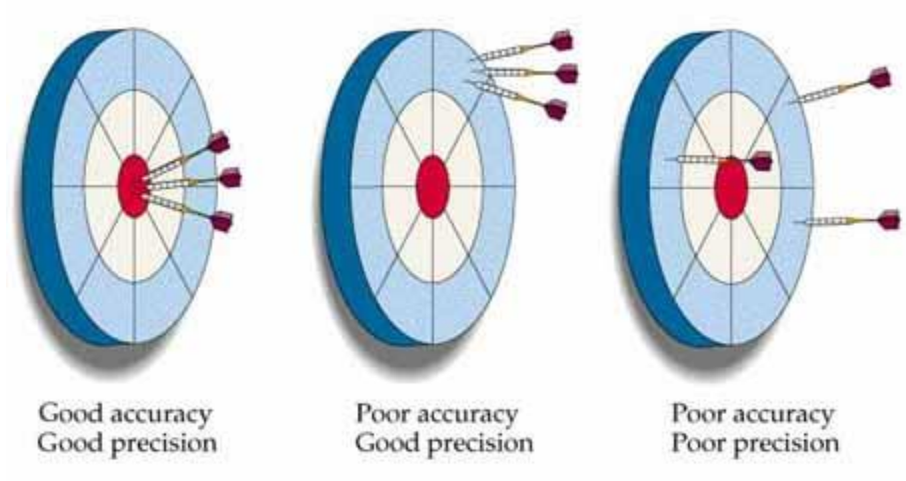
Accuracy, Precision, & Error

- Accuracy
  - How close a measurement is to the true value.
- Precision
  - How much a group of measurements agree with each other.
- Error
  - Error = experimental value – accepted value
- Percent Error
  - $\% \text{ Error} = \dfrac{|\text{error}|}{\text{accepted value}} \times 100\%$



OR

$$\text{Percent Error} = \left|\frac{\text{Observed Value - Accepted Value}}{\text{Accepted Value}}\right| \times 100\%$$



During an experiment, Sue collected 6.75 g of silver chloride. She should have collected a total of 7.50 g of silver chloride. What was her experimental error, and % error?

SIGNIFICANT FIGURES

- When making measurements you can't record as many numbers as you want!
- All measuring tools have limits, when we write down numbers they have to show these limits.
- In a measurement, significant figures include all the digits that are known **plus** the last digit, which is estimated.
- There are rules for adding/subtracting and multiplying/dividing sig figs too!

Rules for determining Sig. Figs.

1. All nonzero digits are significant.
    1. Ex: 19 m
2. Zeroes between two significant figures are themselves significant.
    1. 1,907 m   280,785 L   6,700,594 s
3. Zeroes at the beginning of a number are never significant.
    1. 0.00005697 Kg   0.004067 m
4. Zeroes at the end of a number are significant if a decimal point is written in the number.
    1. 7650.0 mL   1.05 m   45.00 s   60.070 nm
    2. 7650 mL   60 nm

Rounding Numbers- YOU WERE TAUGHT WRONG!

- If the digit to be rounded is less than 5, don’t round the number up.
  - 24.44 65.034 75.2
- If the digit to be rounded is greater than 5, round the number up.
  - 25.67 45.96 23.65
- If the digit to be rounded is 5, look at the digit prior to it, if it is even DO NOT round it up. If it is odd, round it up.
  - 28.55 39.65 95.5

Sig. Figs. In Calculations

- Addition and Subtraction
  - Answer should be rounded to the same number of decimal places as the measurement with the least number of decimal places.
  - 12.52m + 349.0 m + 8.24 m =
  - 36.00 mL – 12.0 mL =
  - 35.00 mm – 36 mm =
    - In addition, you can “gain” significant figures.

    Ex: 12.52 m + 49.10 m + 43.65 m =

    - In subtraction, you can “lose” significant figures.

    Ex: 45.74 m – 40.89 m =

- Multiplication and Division
  - Round the answer to the same number of significant figures as the measurement with the least number of significant figures.
  - Examples:
    - (3.9 cm) (4.596 cm) =
    - 65 701 g / 245 mL =
    - 75.02 g / 350 mL =
    - Note that in multiplication and division no sig. figs. can be gained, or lost.

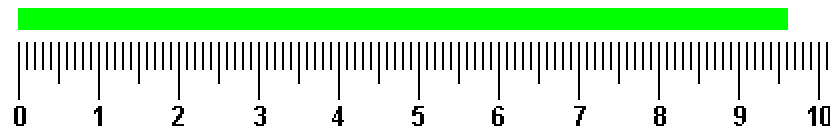
Some Sample Problems

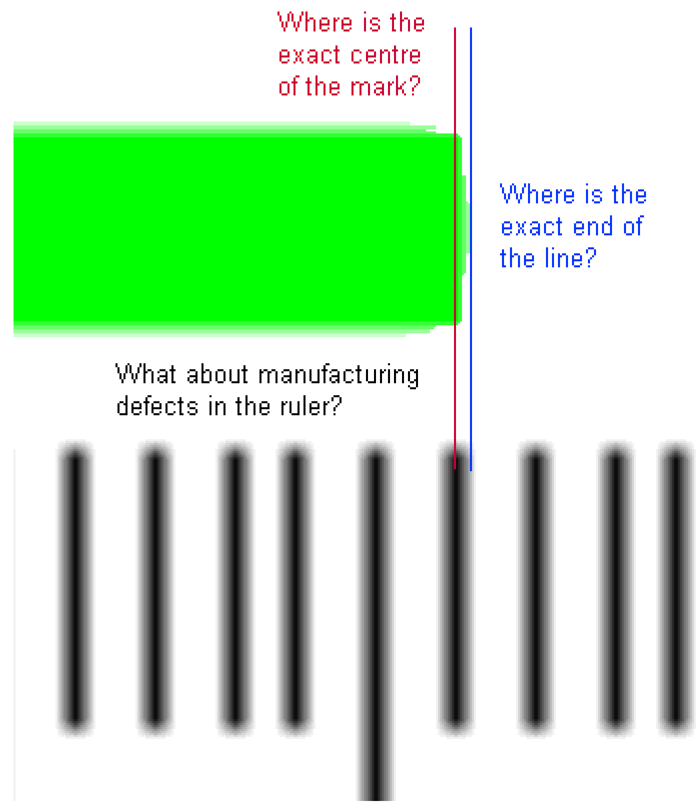
1) 17.50 cm – 1.7559 cm =
2) 35.934 m + 91.6 m =
3) 1750 g / 44.05 mL =
4) (4.50 g) (7.50 mL) =
5) $\frac{(15.75 \text{ m} - 16.03 \text{ m})}{7.43 \text{ mL}} =$
6) $\frac{(17.55 \text{ cm} - 14.9 \text{ cm})}{6.1 \text{ cm}} =$
7) $\frac{(19.85 \text{ g} - 19.157 \text{ g})}{1.75 \text{ mL}} =$
8) $\frac{(95.8 \text{ g})(0.77 \text{ g})}{(1.5 \text{ g} + 7.5 \text{ g})} =$

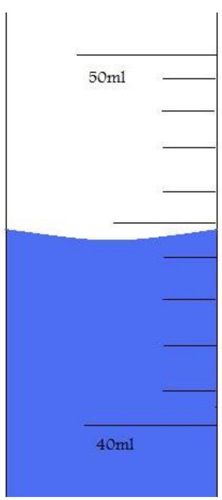
1) 15.74 cm
2) 127.5 m
3) 39.7 g/mL
4) 33.8 g mL
5) -0.038 m/mL
6) 0.43
7) 0.40 g/mL
8) 8.2 g

Limitations to Measurements

- Tools can only measure so much
  - Ruler: Down to about 0.1 for sure, can guess one more place.
  - Beaker: Maybe ~10mL depending on size
  - Graduated Cylinder: Down to the 0.1 mL with guess







Temperatures & Conversions

- Kelvin (K) – Zero is at absolute zero.
- Celsius (C) – Zero is where water freezes.
- Fahrenheit (F) – 32^0 is where water freezes.
- Converting from K to C or C to K:

  C = K - 273 or K = C + 273

- Converting from F to C, or C to F:

  C = 5/9(F + 40) – 40 or F = 9/5(C +40) – 40

DENSITY

A very powerful physical property that we use to identify, or help to identify substances.

Density = mass divided by volume.

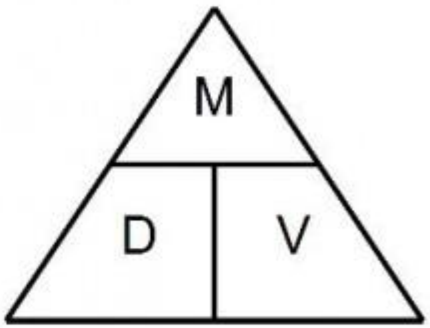
Common units of Density include:

g/mL   Kg/L   g/L or g/cm^3

SOME COMMON DENSITIES

- Wood 0.7 g/mL
- Corn Oil 0.925 g/mL
- Plastic 0.93 g/mL
- Water 1.00 g/mL
- Tar 1.02 g/mL
- Glycerin 1.26 g/mL
- Rubber Washer 1.34 g/mL
- Corn Syrup 1.38 g/mL
- Copper Wire 8.8 g/mL
- Mercury 13.6 g/mL
- Gold 19.3 g/mL

TO DETERMINE DENSITY:



- Measure mass. (Grams)
- Measure volume. (mL, or cm^3)
- Divide mass by volume.
- Example:

A metal block weighs 304.50 grams. It displaces 35 mL of water. The density is:

304.5 g/35mL = 8.7 g/mL