The Tools of Science

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The Language of Matter

- Organization of Matter
  - Elements
  - Compounds
  - Substances
  - Mixtures
  - Homogeneous
  - Heterogeneous
  - Matter
- Phases of Matter
  - Solid, liquid, gas, plasma

Properties and Changes

- Physical - can be measured and observed without changing the identity

  Extensive - depends on the amount of matter present

    Examples: mass, length, volume

  Intensive - does not depend on the amount of matter present

    Examples: melting point, boiling point, color, crystalline form

- Chemical - can be measured and observed when it changes identity Example: reactivity properties

The Language of Measurement

- Significant Figures
- Scientific Notation
- SI and English Units
- Conversion Factors
- Example: Density

Significant Figures

The number of significant figures tells us how much info is contained in a numerical measurement and is determined by how many things are counted in the measurement as well as what type of counting instrument was used.

Examples:

How many significant figures would you think are in the following measurements?

453	90.0	0.055
500	46.80	620,600.

Using the number of significant figures to round an answer correctly.

Add/subtract - The place value of the answer depends on the least precise number added or subtracted.

Multiply/divide - The number of significant digits in the answer depends on the factor with the least number of significant figures.

Examples: Give the answer to the proper number of significant figures. The numbers are measurements and not exact quantities.

36 + 28.6 + 904.23 =

0.55/0.236 =

$$\frac{(67.5)(0.44)}{(1.55)(365)} =$$

509 - 0.76 =

Scientific Notation

Writing numbers in the form of a number between 1 and 10 multiplied by a power of 10.

Important - When writing in scientific notation, the number of sig. fig. does not change. The significant figures are always in the number between 1 and 10. The power of ten holds the placeholder zeros.

Examples:

Put in scientific notation

256	105,000.	0.0230
93,000	23.05	0.806

Write as a numeral

4.56×10^{3}	2.80×10^{-1}	9×10^{4}
2.443×10^{4}	7.810×10^{-2}	6.0×10^{3}

Putting it all together

$$\frac{(4.6 \times 10^{3})(5.07 \times 10^{-5})}{(0.81)\,(4.276 \times 10^{-1})} =$$

Measurement units

Toothbrush Numbers

Seven Fundamental Units in SI System		
Mass	kilogram	kg
Length	meter	m
Time	second	s
Temperature	Kelvin	K
Amount of substance	mole	mol
Luminous Intensity	candela	cd
Electrical current	Ampere	A

Common Root Words Used in SI System		
mass	gram	g
length	meter	m
volume	liter or Liter	l or L
time	second	s

SI Prefixes and Conversion Factors		
Prefix	Meaning	Example of Conversion Factor
pico	10^{-12}	1 pm = 10^{-12} m
nano	10^{-9}	1 nm = 10^{-9} m
micro	10^{-6}	1 µm = 10^{-6} m
milli	10^{-3}	1 mm = 10^{-3} m
centi	10^{-2}	1 cm = 10^{-2} m
deci	10^{-1}	1 dm = 10^{-1} m
kilo	10^{3}	1 km = 10^{3} m
mega	10^{6}	1 Mm = 10^{6} m

SI to English	Area and Volume conversions
1 qt = 946 ml	1 $cm^2 = (10^{-2} m)^2 = 10^{-4} m^2$
1 lb = 454 g	1 $cm^3 = (10^{-2} m)^3 = 10^{-6} m^3$
1 in = 2.54 cm	1 dm^3 = 1 L 1 cm^3 = 1 mL

Other useful relations
Density of water is about 1 g/mL
Density of air is about 1 g/L

Using Conversion factors

4.58×10^6 mg = __________ g

24,600 cm = ____________km

1.56 ft = _______________ cm

2.50 mL = ______________ L

4.6 lb = ________________ kg

760 nm = ________________ cm

1.00 m^3 = _______________ cm^3

Density

Density is defined as the ratio of mass divided by volume.

It is useful for identifying a material as well as predicting such properties as buoyancy.

A related quantity is specific gravity, which is the ratio of the density of a material to the density of water (taken to be 1.00 g/ml). Specific gravity is dimensionless (has no units).

Most materials have densities that range from 0.1 g/ml to 10. g/ml. The density of the earth is around 4 g/ml and the planet Jupiter is less than 1 g/ml. Air has a density around 1 g/Liter.

In equation form

$$D = \frac{M}{V}$$

Example: Suppose you have 20. ml of Mercury with a density of 13.6 g/ml. What mass of Mercury would you have?

Example: Aluminum has a specific gravity of 2.70. What is the volume in cm^3 of a block of aluminum that has a mass of 250. g?