The Tools of Science

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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 Matter

Organization of Matter

- Elements
- Compounds
- Substances
- Mixtures
- Homogeneous
- Heterogeneous
- Matter

Phases of Matter

- Solid, liquid, gas, plasma

The Language of Measurement

Significant Figures

Scientific Notation

SI and English Units

Conversion Factors

Accuracy and Precision

Example: Density

Example: Percentage

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 (actually the lb is a unit of weight not mass)	1 $cm^3 = (10^{-2}m)^3 = 10^{-6}\ m^3$
1 in = 2.54 cm (exact)	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 x 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

Accuracy and Precision

Accuracy is how close we are to a true value.

Absolute error is the difference between the accepted value and an individual measurement. Relative error is the absolute error divided by the accepted value. Percentage error is the relative error multiplied by 100. Thus absolute, relative, and % error are measures of accuracy.

Precision refers to the place value of a measuring instrument or how close a series of measurements are to each other.

The term precision is used either as it refers to one measurement or a group of measurements. The uncertainty of reading an individual measurement is called the precision of that measurement. Our top-loader balances are precise to 0.001g. Precision can also refer to how close a number of data points are to each other. In this case the precision of a group of points can be evaluated by calculating the standard deviation, which uses the average of the set of data points and the difference between the average and each point.

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?

Percentage

Percentage means "parts per 100" and can be expressed as a ratio. For example, many hot dogs are at least 30.% fat or more. This means that if we had 100. g of hot dogs we would have 30. g of fat. We can use this as a ratio to help set up and solve a problem.

Example: Suppose we eat a 75 g hot dog that is 30.% fat. How much fat are we eating?

Other examples:

Hydrochloric acid is made by dissolving hydrogen chloride gas in water. What percentage of concentrated hydrochloric acid is dissolved hydrogen chloride gas if 75 g of the acid contains 28 g of hydrogen chloride gas?

The soil test on the field in front of my home indicates that I need 40. lb/acre of P_2O_5 if I want to sow alfalfa for hay. If the fertilizer I want to use is 12-24-24, how many lb of this fertilizer must I spread per acre? (The numbers on a bag of fertilizer indicate the percentage of N, P_2O_5 and K_2O respectively.)