CHAPTER 1

MATTER – ITS PROPERTIES AND MEASUREMENT

KEY CONCEPTS:

1. FORMS AND PROPERTIES OF MATTER

2. SI UNITS & PREFIXES

3. ACCURACY VS. PRECISION

4. SIGNIFICANT FIGURES

5. SCIENTIFIC NOTATION

6. CONVERSION FACTORS (DIMENSIONAL ANALYSIS)

Properties of Matter

- Matter: occupies space and displays mass and inertia
- Composition: relative proportions of the components of a sample of matter

  ex. water is 11.19% H and 88.81% O by mass

- *Physical property:*
  - a property that can be measured or observed without changing the matter's composition
- *Chemical property:*
  - a property that comes with observing a change in chemical composition
- *Extensive property:* depends on the quantity of matter present
- *Intensive property:* does NOT depend on the quantity of matter present

Elements and Compounds

- *Element:*
  - cannot be decomposed into a simpler substance through chemical processes; distinguished by the unit of the atom
- *Compound:*
  - a substance made from the atoms of two or more elements bonded chemically in defined proportions

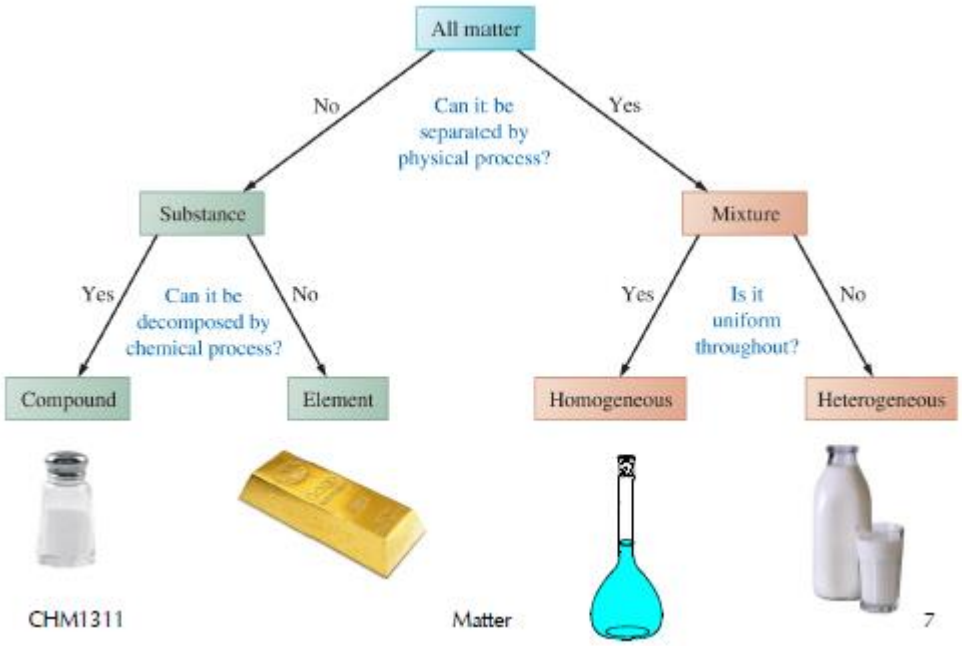
- Compounds can only be decomposed into their respective elements *via* chemical processes

Pure Substances and Mixtures

- A pure substance
  - A substance with a fixed and uniform composition and distinct properties (ex: pure water)
- A mixture:
  - A combination of two or more pure substances which can vary in composition and properties

  a) homogeneous: ex: salt water

  b) heterogeneous: ex: oil and water
- It is possible to separate mixtures through physical porcesses



Measuring Matter

an observed measurement not followed by a unit is meaningless!

The seven base SI units are:

TABLE 1.1 SI Base Quantities

Physical Quantity	Unit	Abbreviation
Length	meter[a]	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Amount of substance[b]	mole	mol
Electric current[c]	ampere	A
Luminous intensity[d]	candela	cd

SI Prefixes

Value	Prefix	Symbol
10^{12}	*tera-*	T
10^{9}	*giga-*	G
10^{6}	*mega-*	M
10^{3}	*kilo-*	k
10^{2}	*hecto-*	h
10^{1}	*deca-*	da
10^{-1}	*deci-*	d
10^{-2}	*centi-*	c
10^{-3}	*milli-*	m
10^{-6}	*micro-*	μ
10^{-9}	*nano-*	n
10^{-12}	*pico-*	p

Mass versus Weight

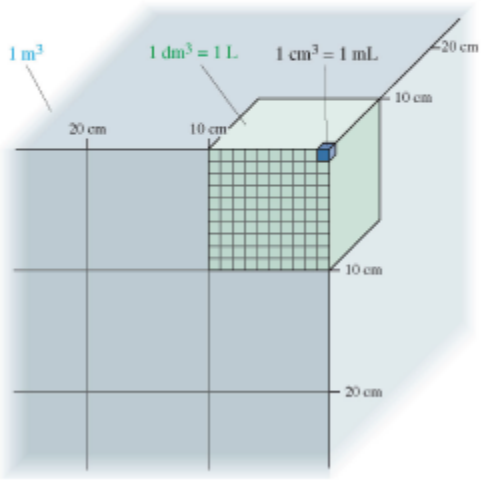
- mass:
  - measures the quantity of matter in an object
- weight:
  - the force of gravity on an object

The kilogram (kg) is the official SI unit, but we will most often use the gram (g):

$1\ kg = 1000\ g$

Volume

- volume: the size of a cube (i.e., m^3)
- we will most often use the litre (L) for measuring volumes



$1000\ mL = 1\ L$

$1000\ L = 1\ m^3$

Density

- density = $\rho = \frac{mass}{volume}$
- density is a *intensive property* and is a very useful conversion factor
- the SI unit is kg/m^3, but we will most often use g/cm^3 for solids and liquids and g/L for gases

$$1\ g/cm^3 = 1\ g/mL = 1000\ kg/m^3$$
$$1\ g/L = 0.001\ g/mL$$

Percent Composition

- number of parts of a component in 100 parts of the whole
  - ex. 10% means "10 parts *x* per 100 parts of the whole"
- IMPORTANT: must be defined by a unit!
  - ex. a rock contains 3.5% gold ***by mass*** means 3.5 g of gold per 100 g of rock
  - ex. a bottle of wine contains 10.7% alcohol ***by volume*** means 10.7 mL of alcohol per 100 mL of wine

Temperature

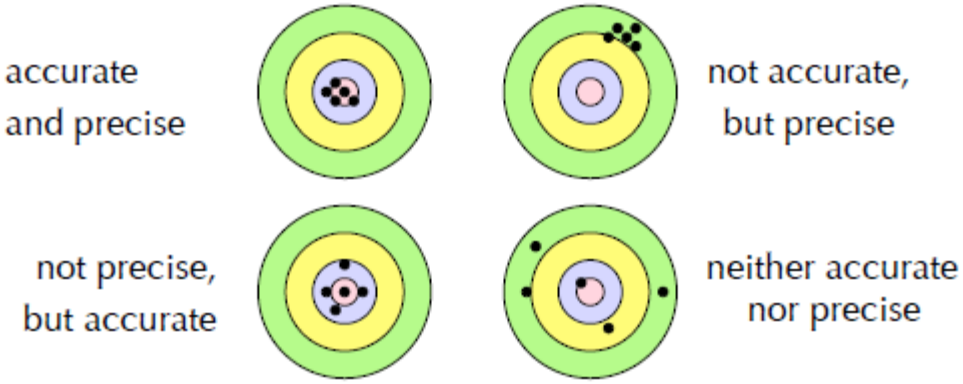
- the SI unit is the kelvin (K)
- *absolute zero* temperature is 0 K or -273.15°C
- the freezing point of water is 273.15 K or 0°C
- the boiling point of water is 373.15 K or 100°C

always use the temperature in K in your calculations!

Accuracy and Precision

- *Accuracy:*
  - indicates how close a measured value is to the actual (or accepted) value
- *Precision:*
  - indicates the degree of reproducibility of a measured quantity

Accuracy and Precision



accurate measurements are usually precise, but a systematic error will produce values which are precise but not accurate

Scientific measurements

- *Scientific notation:* N x 10^n

  6.022 045 x 10^{23} instead of 602 204 500 000 000 000 000 000

  N=6.022 045 and n=23

- *Significant figures*
  - digits considered to be significant in the calculation or measurement of a quantity

this balance is precise to ±0.01 kg
an object that has a mass of 6.732 kg
will give a measurement of 6.73 ± 0.01 kg

Rules for sig figs…

- all non zero digits are significant

6.732 kg has 4 significant figures

- zeros between two sig figs are also significant

6.0061 kg has 5 significant figures

- zeros to the left of a sig fig are not significant

0.0502 kg has 3 significant figures

  - if the value is greater than 1, all zeros to the right of the decimal point are significant

6.000 kg has 4 significant figures

  - when converting to scientific notation, it may sometimes be ambiguous whether "hanging zeros" are significant or not

4500 kg could be 4.5×10^3, 4.50×10^3, or 4.500×10^3 kg

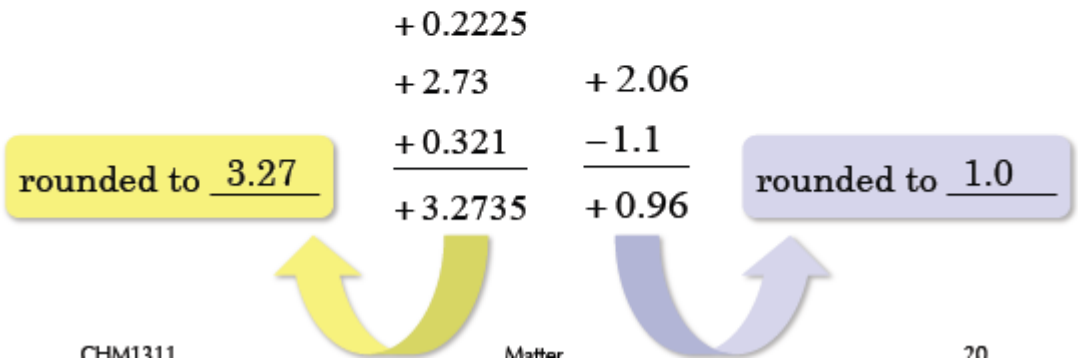
therefore 4500 kg could have 2, 3, or 4 sig figs!

  - a whole number with perfect precision has an infinite number of significant figures

if we determine the average of 3 trials, we can assume it's

3.000 000 000 … trials

- **addition/subtraction:**
  - the answer must have the same number of sig figs after the decimal as the element of the calculation with the least number of sig figs after the decimal point



- **multiplication/division:**
  - the answer must have the same number of sig figs as the element of the calculation with the least number of sig figs

2.2 x 3.7845 = 8.32590 → rounded to 8.3

3.76 / 4.236 = 0.8876298 → rounded to 0.888

(2.27 x 7.324) / 3.3 = 5.0380 → rounded to 5.0

- **Logarithms**
  - the answer must have the same number of sig figs as the log element

log(957) = 2.980911... → = 2.98 ??

= log(9.57 x 10^2)

= log(9.57) + log(10^2)

= 0.980911... + 2.00000... → = 2.981