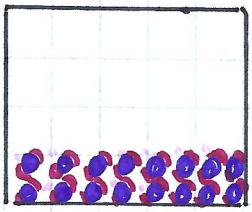
Unit 1 - Atomic Structure & Properties

1. Matter

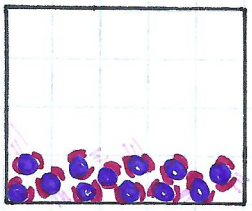
A. States of Matter

Solid



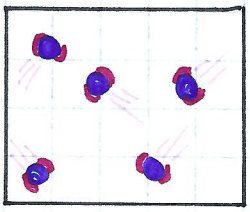
- defined shape
- defined volume
- incompressible
- particles held tightly together, wiggle slightly

Liquid



- defined volume
- no defined shape
- nearly incompressible
- particles very close together but moving/sliding rapidly

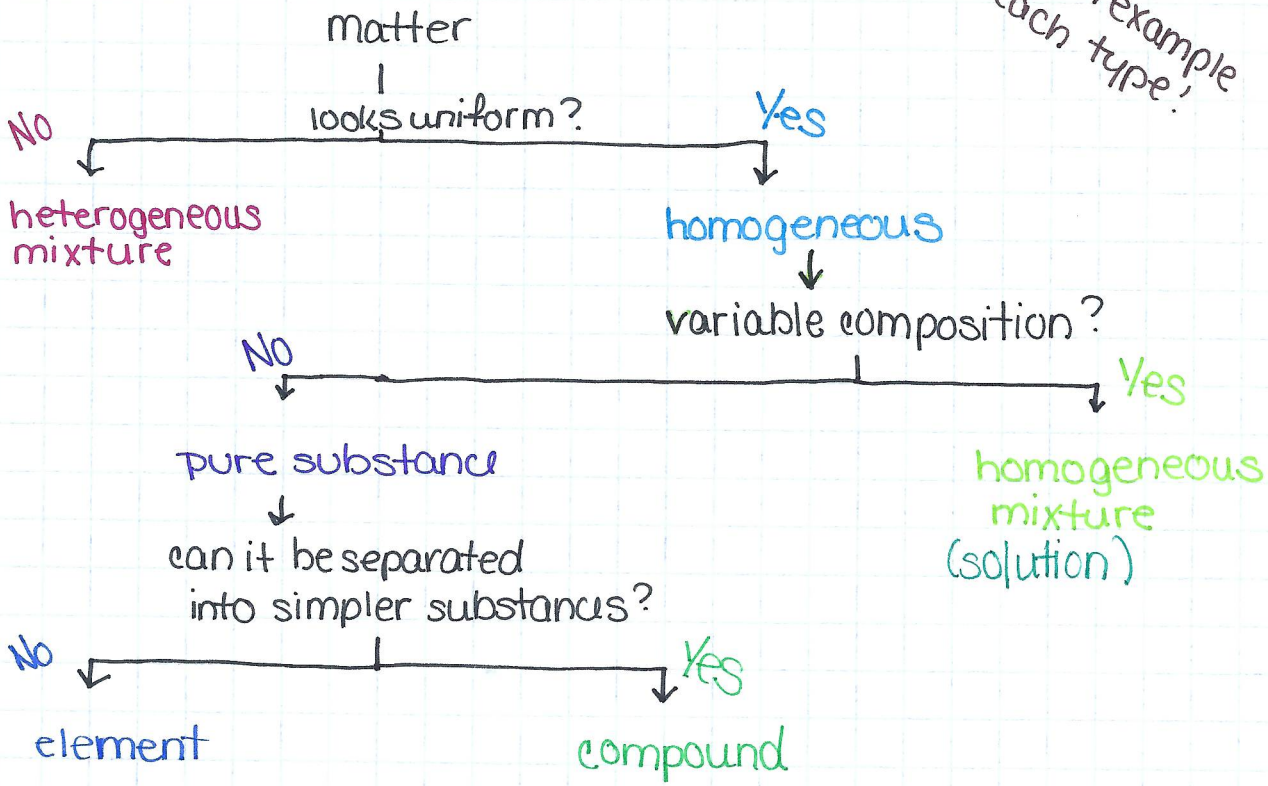
Gas



- no defined shape or volume
- easily compressed
- particles are far apart & moving @ high speeds, colliding w/ container walls repeatedly

B. Types of matter

Give an example of each type:



(1) Pure Substances - have distinct properties & composition that do not vary from sample to sample

(A) elements - only 1 kind of atom, cannot be broken down into simpler substances
- 118 elements, 92 occur naturally

(B) compounds - made of 2 or more elements
- Law of Definite Proportions (constant composition) - the elemental composition of a pure compound is always the same.
  Ex) pure H_2O is always 11% H and 89% O by mass - which leads to its having 2 H's and 1 O in its formula.

(2) mixtures - combinations of 2 or more pure substances, in which the composition can vary from sample to sample.

Ex)

chocolate chip cookie w/ 4 chips

chocolate cookie w/ 9 chips

(A) heterogeneous mixture - does not have a consistent appearance
Ex) sand on a beach

(B) homogeneous mixture (solution) - has a consistent appearance
Ex) air, hot tea

C. Properties of Matter

(1) Physical Properties - can be observed w/o changing the identity / composition of a substance
Ex) density, color, odor, melting / boiling point, texture, mass, length

can separate mixtures

(A) Physical changes - changing the appearance but not the composition of a substance
Ex) changing state of matter, grinding, tearing, squishing, dissolving

(2) Chemical Properties - describe a way a substance can change, or react, to form new substances
Ex) flammability, oxidizing ability

(A) chemical changes - (chemical reaction) - a substance becoming a new substance.
Ex) burning, rusting,
↳ only way to separate elements in a compound

(B) Separating Mixtures
(1) filtration - separates solids from liquids
(2) distillation - separates 2 liquids from each other, using each component's volatility (vaporization temperature)
(3) chromatography - separates 2 components based on their abilities to move through a specific media

2. Measurement
A. SI Units

physical quantity	name	abbreviation
mass	kilogram	kg
length	meter	m
time	second	s
temperature	Kelvin	K
amount	mole	mol
electric current	ampere	A
luminous intensity	candela	cd

B. Prefixes

prefix	abbreviation	meaning
Giga	G	10^9 (1 000 000 000)
mega	M	10^6 (1000 000)
kilo	k	10^3 (1000)
deci	d	10^{-1} (.1)
centi	c	10^{-2} (.01)
milli	m	10^{-3} (.001)
micro	μ	10^{-6} (.000 001)
nano	n	10^{-9} (.000 000 001)
pico	p	10^{-12} (.000 000 000 001)
femto	f	10^{-15} (.000 000 000 000 001)

C. Temperature
(1) °C to K $K = °C + 273.15$
(2) °C to °F $°F = 1.8(°C) + 32°$

D. Derived SI Units

(1) Volume

(A) $V_{cube} = l \times w \times h$, m^3, cm^3

(B) V_{liquid} = usually measure in mL, L

(2) Density

(A) density = mass/volume

$$d = m/V$$

E. Numbers and Significant Figures

(1). Types of Numbers

(A) exact numbers - have defined values, conversion factors

ex) 1 kg = 1000 g, 1 mole = 6.02×10^{23} particles

(B) inexact numbers - measurements that have some uncertainty. All equipment has inherent limitations (equipment error) or human error (variation in how measurements are read.

(2) Significant Figures - come about from inexact numbers. You are only as accurate as your least accurate measurement!

(A) Determining # of Significant Figures

- any non-zero numbers are significant
- captive zeroes - blw 2 numbers are significant
- leading zeroes - before numbers are NOT significant, they're place holders
- trailing zeroes - after numbers are significant ONLY if the number contains a decimal point.

(B) In calculations

- Adding / Subtracting - the result has the same number of decimal places as the least precise measurement

ex) 12.11 + 18.0 + 1.013 = 31.123 ⇒ 31.1

18.0: least precise; 31.1: corrected answer

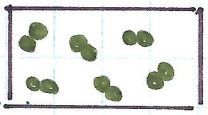
- Multiplying / Dividing - the result has the same number of significant figures as the least precise measurement

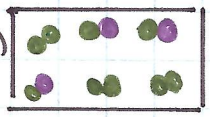
ex) 4.56 × 1.4 = 6.38 ⇒ 6.4

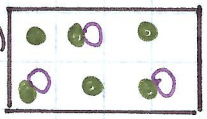
1.4: only 2 sf; 6.4: corrected answer

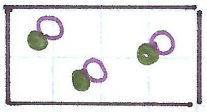
Practice Problems

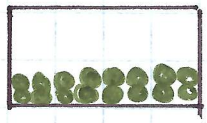
1. Which of the following figures represents...
   A. a pure element B. a mixture of 2 elements
   C. a pure compound D. a mixture of an element & a compound

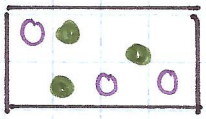
A
(1) C


(2) D


(3) D


(4) C


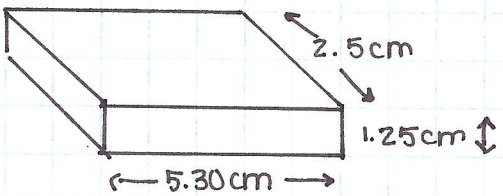
(5) A


(6) B


2. 3 spheres of equal size are composed of aluminum ($d = 2.70\ g/cm^3$), silver ($d = 10.49\ g/cm^3$), and nickel ($d = 8.90\ g/cm^3$). List the spheres from lightest to heaviest.

Al Ag Ni

Al → Ni → Ag

3.


$V = l \times w \times h$

(A) How many significant figures should be used when reporting the volume of the metal bar? 2 sf

(B) If the mass of the bar is 104.7g, how many significant figures should be reported for its density?
2 sf

4. A solid white substance A is heated strongly in the absence of air. It decomposes to form a new white substance B and a gas C. The gas has exactly the same properties as the product obtained when carbon is burned in an excess of oxygen. Based on these observations, can we determine whether solids A and B and the gas C are elements or compounds. Explain.
   A - compound b/c it separated into 2 substance
   B - cannot tell
   C - compound b/c same properties as 2 elements combining (C & O)

5. Suggest a method for separating the following mixtures:
   (A) sugar and sand filtration & boiling
   (B) iron and sulfur magnet

6. make the following conversions:

(A) 62°F to °C

$62° = 1.8(°C) + 32°$

$-32° \quad -32°$

$30° = 1.8(°C)$

$17°C = °C$

(B) 315K to °F

$315K = °C + 273.15$

$°C = 41.85°$

$°F = 1.8(41.85°) + 32°$

$°F = 107°$

7. A sample of carbon tetrachloride, a liquid once used in dry cleaning, has a mass of 39.73g and a volume of 25.0mL at 25°C. What is its density at this temperature? Will carbon tetrachloride float on water, $d = 1.00\ g/mL$)?

$d = \frac{m}{V} = \frac{39.73g}{25.0mL} = 1.59\ g/mL$ No, it will sink.

8. The density of magnesium is $1.738\ g/cm^3$ at 20°C. What is the volume of 87.50g of this metal?

$V = \frac{m}{d} = \frac{87.50g}{1.738\ g/cm^3} = 50.35\ cm^3$

9. Gold can be hammered into extremely thin sheets called gold leaf. If a 200.mg piece of gold ($d = 19.32 g/cm^3$) is hammered into a sheet measuring 2.4 × 1.0 ft, what is the average thickness of the sheet in meters?

$V = \frac{m}{d} = \frac{.200g}{19.32 g/cm^3} = .0104\ cm^3$

$V = l \times w \times h$

$\frac{2.4\ ft}{1} \left|\frac{12\ in}{1\ ft}\right| \frac{2.54\ cm}{1\ in} = 73.152\ cm$

$\frac{1.0\ ft}{1} \left|\frac{12\ in}{1\ ft}\right| \frac{2.54\ cm}{1\ in} = 30.48\ cm$

solve $V = l \times w \times h$ for h

$.0104\ cm^3 = 73.152\ cm \times 30.48\ cm \times h$

$.0000466\ cm = h$

or

$4.66 \times 10^{-6}\ cm$

10. An individual suffering from high cholesterol has a level in her blood of 223 mg of cholesterol per 100 mL of blood. If her total volume of her blood in her body is 5.2 L, how many grams of total blood cholesterol does her body contain?

$$\frac{5.2\,\cancel{L}}{1\,\cancel{L}} \left| \frac{1000\,\cancel{mL}}{100\,\cancel{mL}} \right| \frac{223\,mg}{1000\,\cancel{mg}} \left| \frac{1\,g}{} \right. = 12\,g$$

11. Car batteries contain sulfuric acid. Calculate the number of grams of sulfuric acid in 0.500 L if the battery solution has a density of 1.28 g/mL and is 38.1% sulfuric acid by mass.

$$m = d \cdot V = 1.28\,\frac{g}{\cancel{mL}} \cdot 500\,\cancel{mL} = 640\,g \cdot .381 =$$

244 g