# Matter & Measurement

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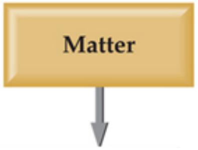
AP Chemistry

Monta Vista High School

# 1.2 & 1.3: The Basics

- *States of matter:* solid, liquid, gas, plasma, BEC
- *Elements:* substances that cannot be decomposed into simpler substances
- *Compounds:* substances composed of two or more elements
  - Law of constant composition, or law of definite proportions: the relative masses of elements are fixed in a given chemical substance.
- *Mixtures:* combinations of two or more substances
  - *Techniques for separating mixtures:* filtration, distillation, chromatography
- *Properties:*
  - *Physical vs. chemical:* Did the sample (really) change?
  - *Intensive vs. extensive:* Does the measurement depend on quantity of sample?

# Classification of Matter



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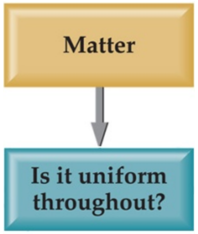

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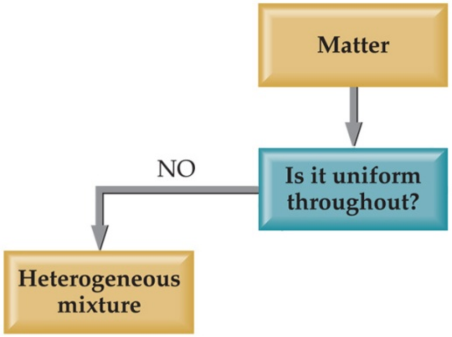

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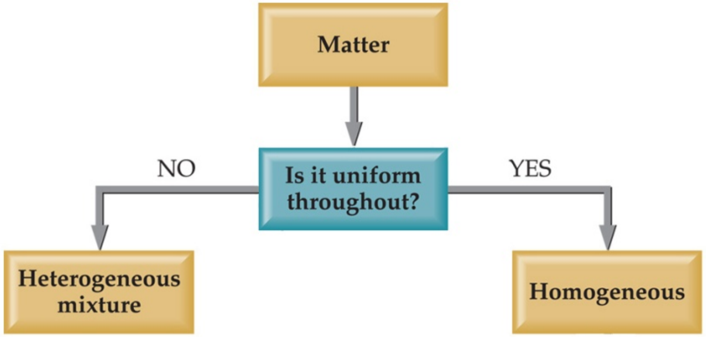

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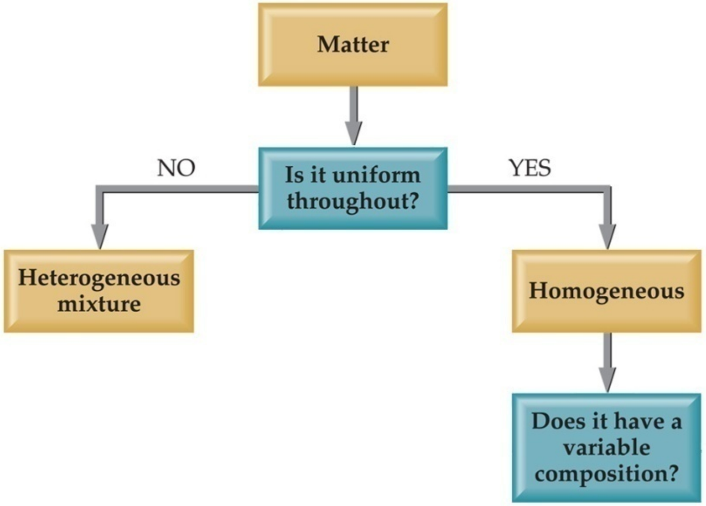

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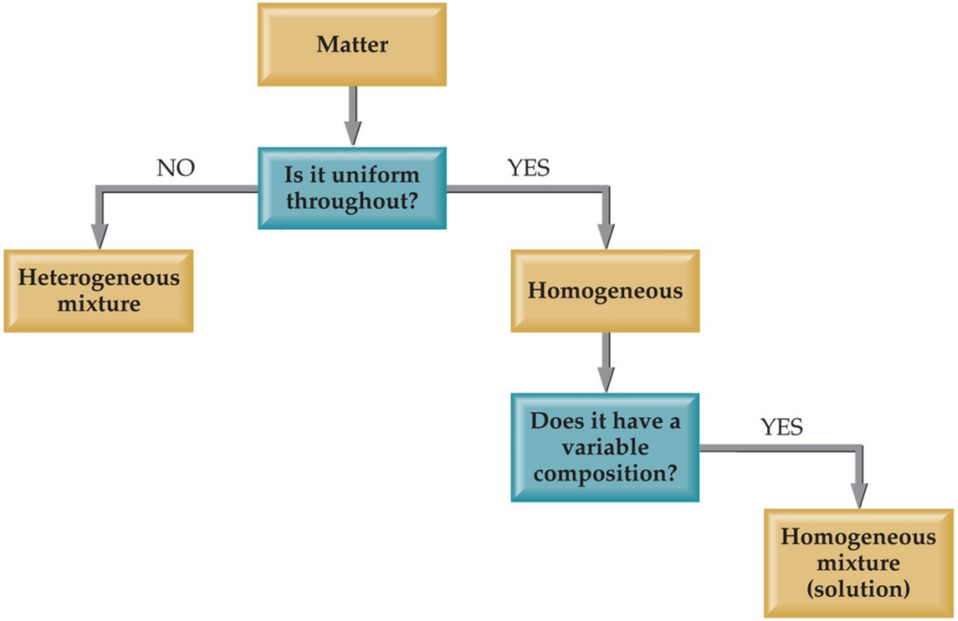

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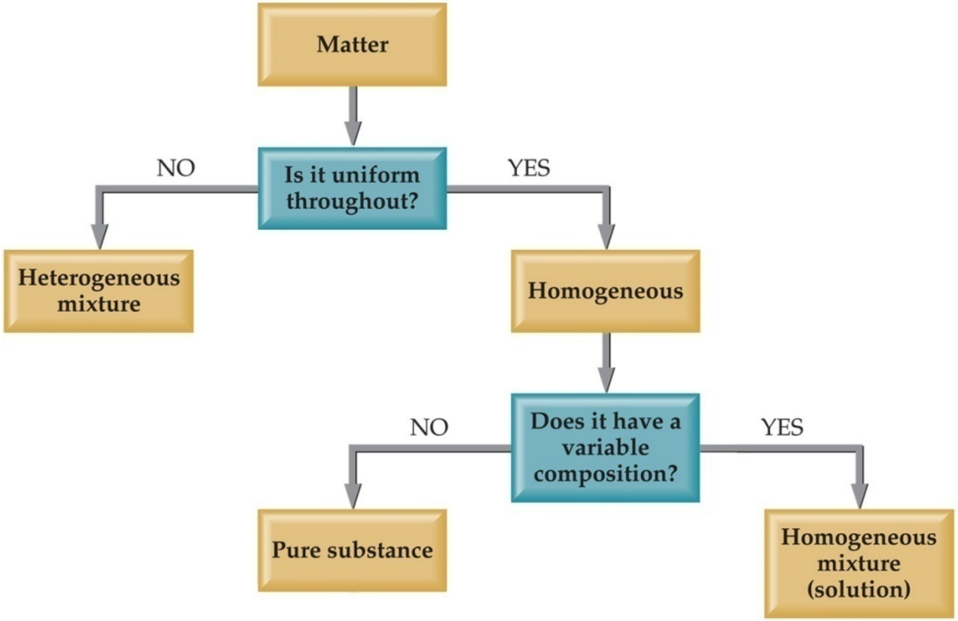

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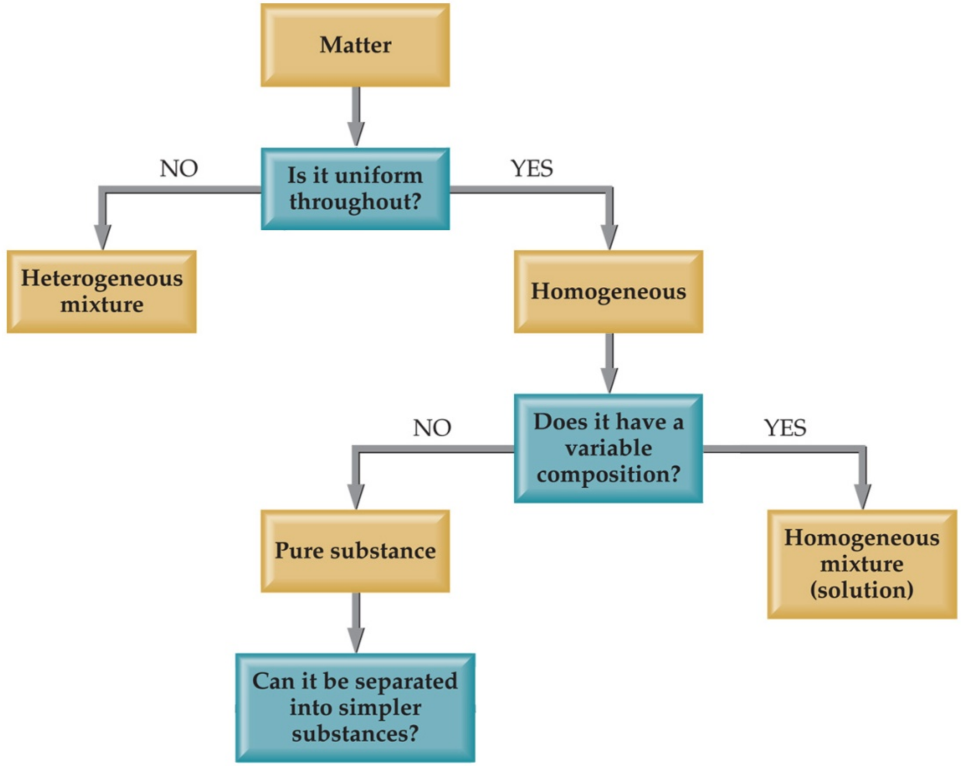

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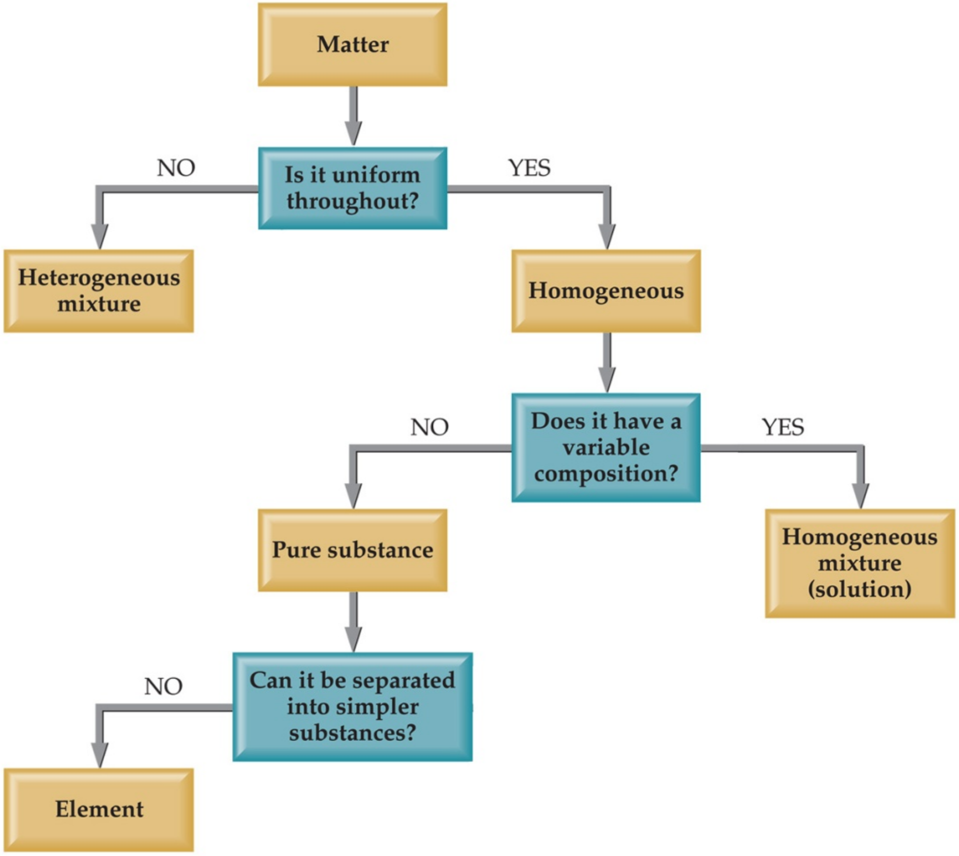

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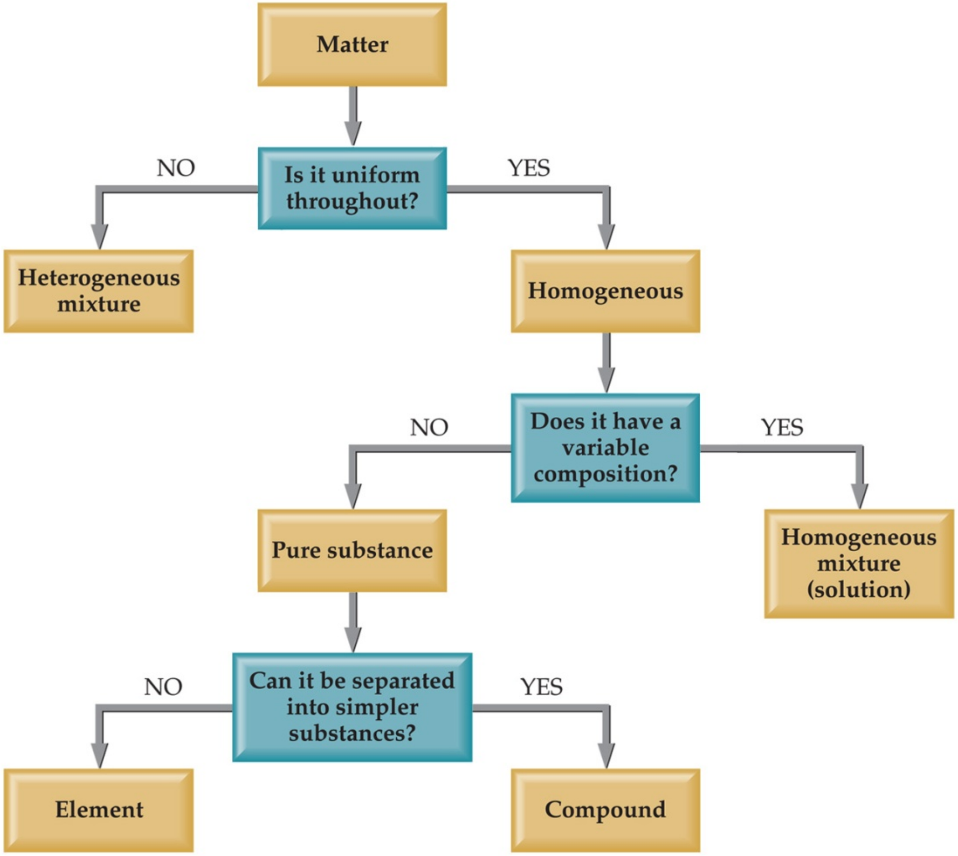


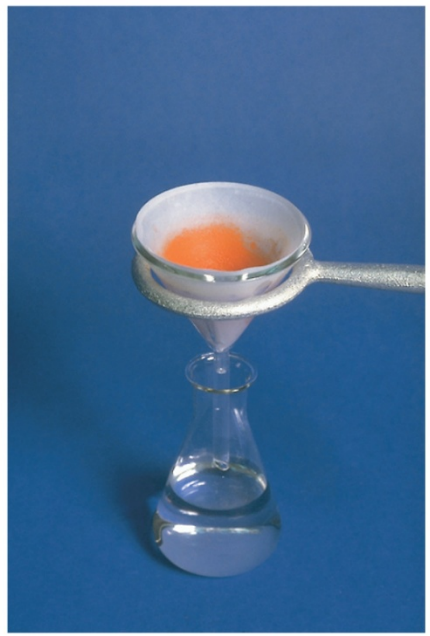
# Separation of Mixtures

# Hand Separation

Separate a mixture like this.....using your hand!

Hand separation is used when there is a visual difference in particle size, color or texture, so that the components of the mixture can be separated by hands.

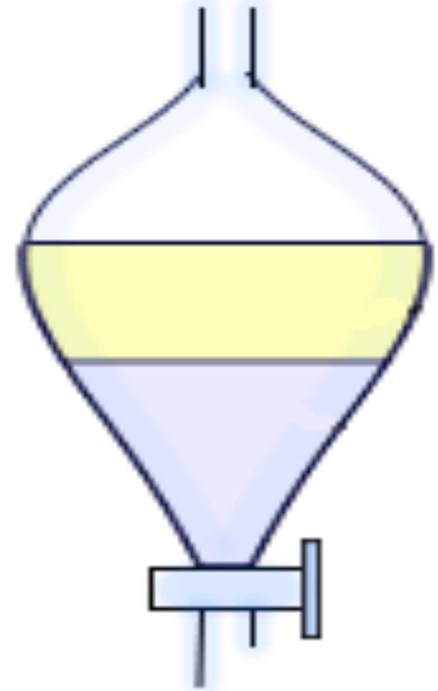
# Filtration



- In filtration solid substances are separated from liquids and solutions.
- What remains on the filter paper is called the "precipitate" and what passes through is called the "filtrate."
- Filtration is used to separated heterogeneous mixtures or suspensions.
- Ex. Separating sand from water, separating precipitate

# Separating funnel

Shake and let sit…



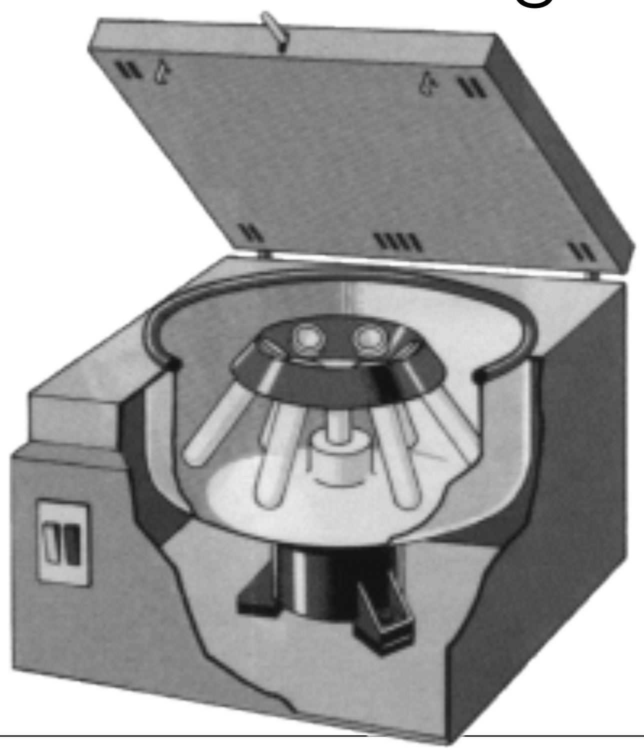
Usually used to separate immiscible liquids, like oil and water mixture. The immiscible mixture is shaken and allowed to settle. The parts separate out and then removed one by one in different beakers.

# Centrifuge

Separates particles of different masses based on centrifugal force. Heavier particles settle at the bottom followed by the lighter particles on top. These layers of different sized particles can be separated by dissolving them in appropriate solvents one by one and pouring them out.

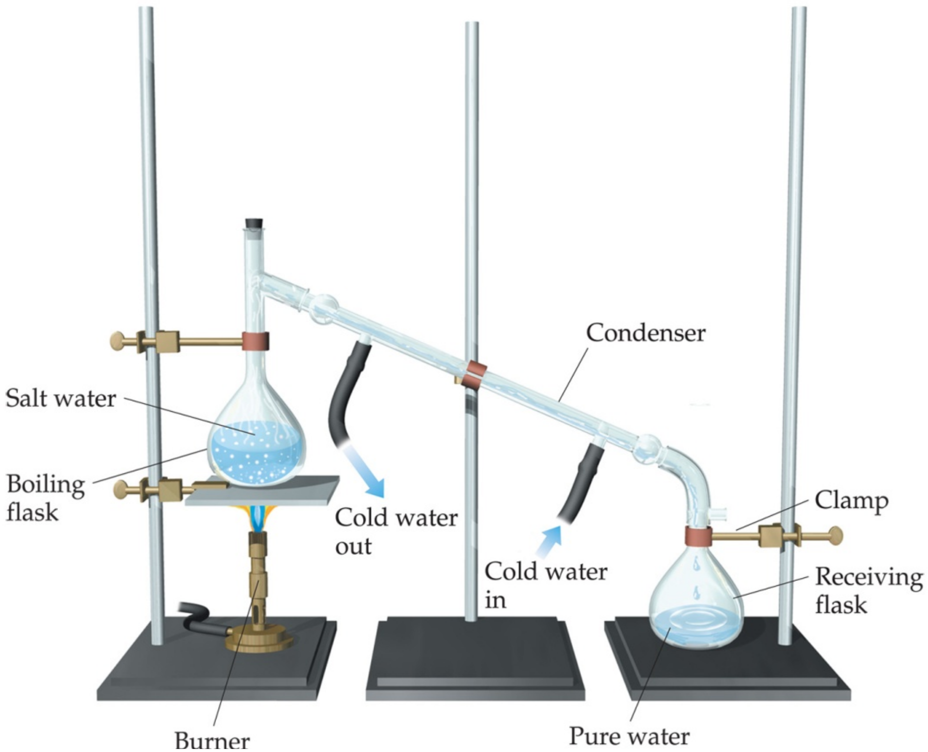
(Another good power point)

Place in centrifuge…



# Distillation

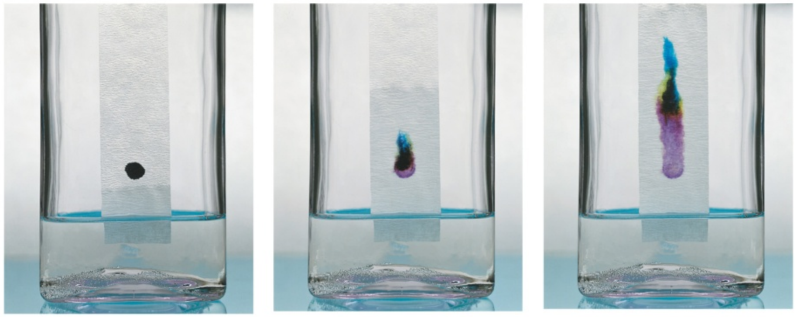
Animation




Distillation uses differences in the boiling points of substances to separate a homogeneous mixture into its components.
Ex. Homogenous mixture of two liquids that boil at different temperatures, can be separated by this method- ethanol and isopropanol.

# Chromatography Animation

This technique separates homogenous mixtures (mostly inks) on the basis of differences in solubility of the mixture in a solvent. There is a stationary and a mobile phase. Mobile phase acts as a solvent and the extent of separation depends upon the solubility of the mixture in the mobile phase. This separation is indicated by Rf factor.


(a) (b) (c)

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# Law of Constant Composition

- States that elements combine in the same MASS ratio in a pure compound.
- Ex. In pure $H_2O$, H and O combine in a 1:8 mass ratio
- Understanding check:

Turn to your partner and do the following :

-What do you understand by law of Constant Composition. How might this law be explained based upon Dalton's atomic model?

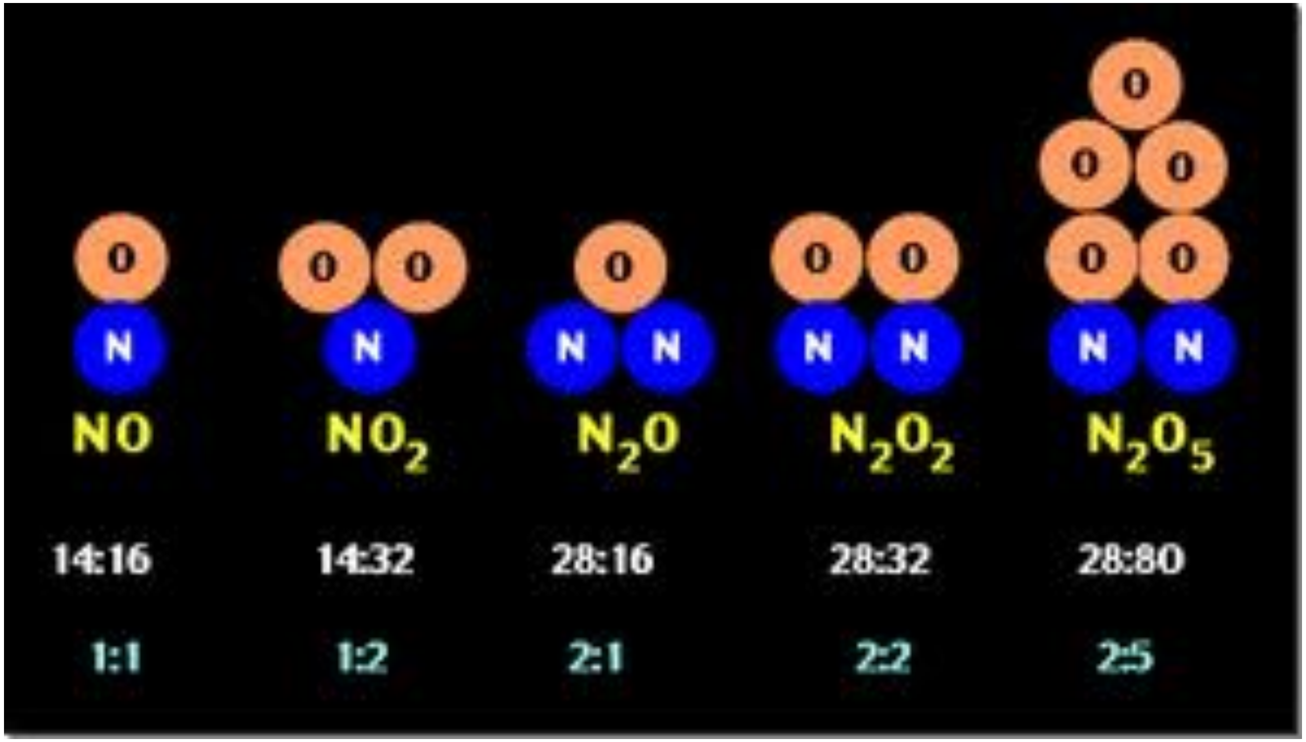
-Explain Law of Constant Composition taking the example of $N_2O$.

-Does law of constant composition hold good for $CuSO_4.5H_2O$? Why or why not?

# Law of Multiple Proportions animation

- Definition: It states that the masses of one element which combine with a fixed mass of the second element are in a ratio of whole numbers.
- Example: Carbon and Oxygen combine to form the following two compounds. The first compound contains 42.9% by mass carbon and 57.1% by mass oxygen. The second compound contains 27.3% by mass carbon and 72.7% by mass oxygen. Show that the data are consistent with the Law of Multiple Proportions.

- Explain the following image in terms of Law of Multiple Proportions:




Taken from Google Images

# 1.4: S.I. (the Metric System)

| *Figure 1. Selected S.I. base (or standard) units (Table 1.4)* | |
|---|---|
| **Mass** | **kg** |
| **Length** | **m** |
| **Electric current** | **A** |
| **Temperature** | **K = 273 + °C** |
| **Amount** | **mol** |

*Figure 2. Selected S.I. prefixes (Table 1.5)*

| **Prefix** | **Abbreviation** | **Value** |
| --- | --- | --- |
| kilo | k | $10^{3}$ |
| deci | d | $10^{-1}$ |
| centi | c | $10^{-2}$ |
| milli | m | $10^{-3}$ |
| micro | μ | $10^{-6}$ |
| nano | n | $10^{-9}$ |
| pico | p | $10^{-12}$ |

# 1.5: Uncertainty

- *Precision:* how closely individual measurements agree with one another; the "fineness" of a measurement

- *Accuracy:* how closely individual measurements agree with the "true" value

- *Significant figures:* for any measurement, all the digits that are "certain" plus one "uncertain" digit; an indication of precision

# Determining Significant Figures

1. Any nonzero digit is significant.

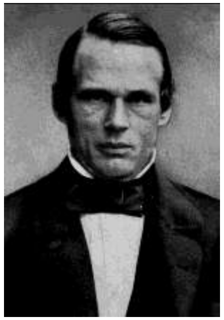
457 cm = 3 SF     29 cm = 2 SF

2. Any zero between nonzero digits is significant.

1005 kg = 4 SF     807 kg = 3 SF

3. Any zero at the “beginning” of a number is not significant; it’s a place holder.

0.0026 Å = 2 SF     0.41 Å = 2 SF



**Anders Ångström**
**(1814 – 1874)**

4. Any zero at the "end" of a number <u>and</u> after the decimal point is significant.

0.05000 K = 4 SF

3000 K = 1 SF

5. If a number ends with a decimal point, assume that all digits are significant.

7000. J = 4 SF

20. J = 2 SF

6. For *exact numbers* (*e.g.* 4 beakers) and those used in *conversion factors* (*e.g.* 1 inch = 2.54 cm), there is no uncertainty in their measurement. Therefore, IGNORE exact numbers when finalizing your answer with the correct number of significant figures.

- For more practice: http://lectureonline.cl.msu.edu/~mmp/applist/sigfig/sig.htm

# Calculating with Sig Figs

1. *Addition & subtraction:* a sum or difference may be no more precise than the least precise measurement. Consider the fewer number of decimal places.

   Ex: 15.047 g + 4.12 g = ?

$$\begin{array}{r} 15.047 \\ +\ \underline{4.12\phantom{0}} \\ 19.167 \end{array} \rightarrow \mathbf{19.17\ g}$$

   Ex: 25,040 mL + 37,200 mL = ?

$$\begin{array}{r} 25040 \\ +\ \underline{37200} \\ 62240 \end{array} \rightarrow \mathbf{62{,}200\ mL}$$

**or $6.22 \times 10^4$ mL**

# Calculating with Sig Figs

2. *Multiplication & division:* a product or quotient may be no more significant than the least significant measurement. Consider the fewer number of significant figures.

   Ex: 3.000 x 4.00 = 12.0

   (4 SF) x (3 SF) = (3 SF)

3. *Logarithms:* retain in the *mantissa* (the "decimal part" of the logarithm) the same number of SF there are in the original value.

- log (3.000 x $10^4$) = 4.<u>4771</u>

  log (4 SF) → 4 SF in mantissa
- log (3 x $10^4$) = 4.<u>5</u>

  log (1 SF) → 1 SF in mantissa

4. *Series of operations:* keep all non-significant digits during the intermediate calculations, and round to the correct number of SF only when reporting an answer.

   Ex: (4.5 + 3.50001) x 2.00 =?

   (<u>8.0</u>0001) x 2.00 = 16.0002 → 16

- AP Exam grading allows for answers to be off by +/- 1 SF without penalty. Example: If the correct answer is 46.2 mL, 46 mL or 46.21 mL are also acceptable.

*Figure 3. Rounding rules for significant figures.*

| **If the digit following the last digit to be retained is…** | **Then…** | **Ex: Assume all to be rounded to 3 SF** |
|---|---|---|
| Greater than 5 | Round up | $42.\underline{6}8$ g → 42.7 g |
| Less than 5 | No change (round down) | $17.\underline{3}2$ m → 17.3 m |
| 5, followed by nonzero digit(s) or only zeros | Round up | $2.7\underline{8}51$ cm → 2.79 cm<br>$2.7\underline{8}500$ cm → |
| Only a single 5, and preceded by an odd digit | Round up | $1.6\underline{5}5$ cm → 1.66 cm |
| Only a single 5, and preceded by an even digit | No change (round down) | $78.\underline{6}5$ mL → 78.6 mL |

# 1.6: Dimensional Analysis

- What is the volume (in3) of a 0.500 lb sample of Pb? (d = 11.34 g/mL)

$$\frac{0.500\ \text{lbs Pb}}{1} \times \frac{453.59\ \text{g}}{1\ \text{lb}} \times \frac{1\ \text{mL}}{11.34\ \text{g}} \times \frac{1\ \text{cm}^3}{1\ \text{mL}} \times \frac{1\ \text{in}^3}{16.4\ \text{cm}^3} =$$

$$= 1.219485 \rightarrow 1.22\ \text{in}^3$$

# Properties and Changes of Matter

# Types of Properties

- Physical Properties…
  - Can be observed without changing a substance into another substance.
    - Boiling point, density, mass, volume, etc.
- Chemical Properties…
  - Can *only* be observed when a substance is changed into another substance.
    - Flammability, corrosiveness, reactivity with acid, etc.

# Types of Properties

- Intensive Properties…
  - Are independent of the amount of the substance that is present.
    - Density, boiling point, color, etc.
- Extensive Properties…
  - Depend upon the amount of the substance present.
    - Mass, volume, energy, etc.