UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHEMISTRY - DMKC1033

# CHEMISTRY: THE STUDY OF CHANGE

Chapter 1

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***Chemistry*** is the study of matter and the changes it undergoes

1. ***Matter*** is anything that occupies space and has mass.
2. A ***substance*** is a form of matter that has a definite composition and distinct properties.

water, ammonia, sucrose, gold, oxygen

A ***mixture*** is a combination of two or more substances in which the substances retain their distinct identities.

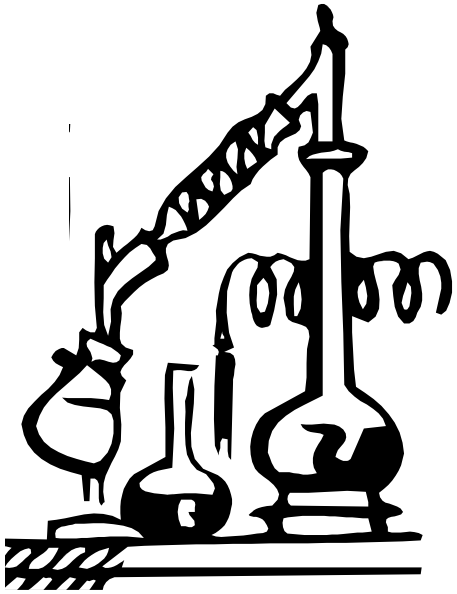
1. ***Homogenous mixture*** – composition of the mixture is the same throughout.


soft drink, milk, solder

2. ***Heterogeneous mixture*** – composition is not uniform throughout.

cement,
iron filings in sand

***Physical means*** can be used to separate a mixture into its pure components.



distillation

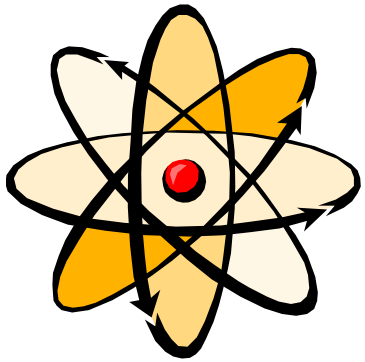
magnet

An ***element*** is a substance that cannot be separated into simpler substances by ***chemical means***.

- 118 elements have been identified
  - 92 elements occur naturally on Earth

    gold, aluminum, lead, oxygen, carbon
  - 26 elements have been created by scientists

    technetium, americium, seaborgium



A ***compound*** is a substance composed of atoms of two or more elements chemically united in fixed proportions.

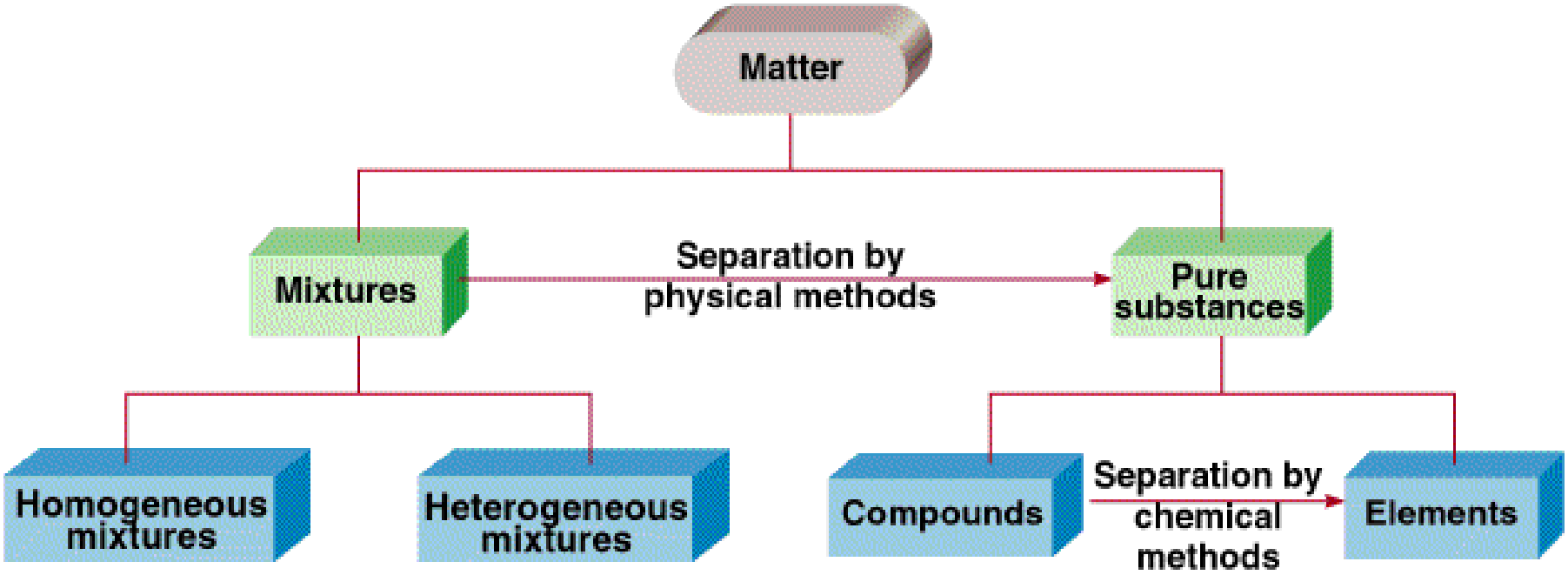
Compounds can only be separated into their pure components (elements) by ***chemical*** means.

Water ($H_2O$)

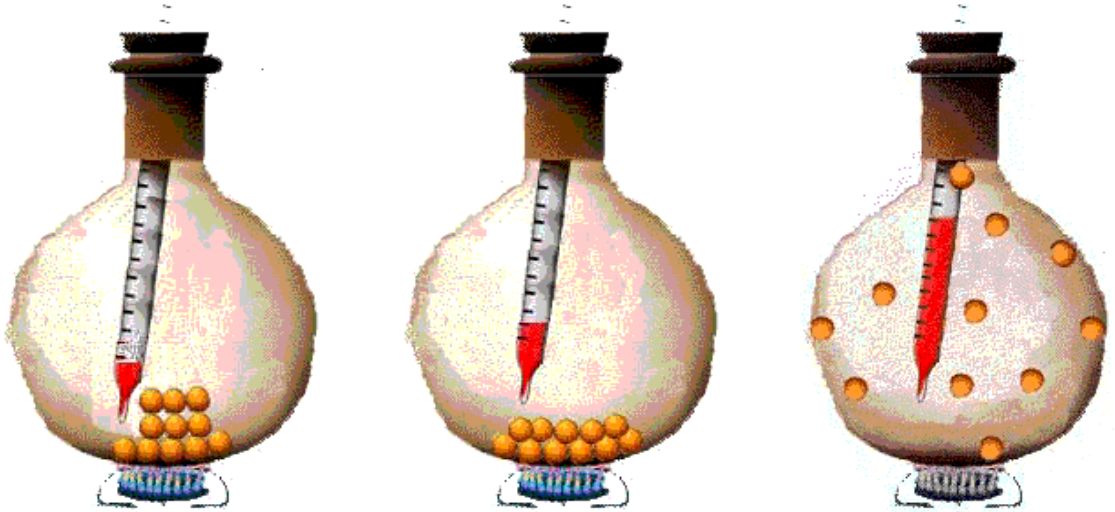
Glucose ($C_6H_{12}O_6$)

Ammonia ($NH_3$)

# Classification of Matter



# Three States of Matter



# Physical or Chemical?

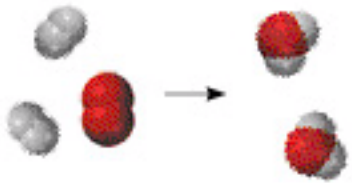
A ***physical change*** does not alter the composition or identity of a substance.

ice melting

sugar dissolving in water

A ***chemical change*** alters the composition or identity of the substance(s) involved.

hydrogen gas burns in oxygen gas to form water



Matter - anything that occupies space and has ***mass***.

***mass*** – measure of the quantity of matter

SI unit of mass is the ***kilogram*** (kg)

$1\ kg = 1000\ g = 1 \times 10^3\ g$

***weight*** – force that gravity exerts on an object

weight = *c* x mass

on earth, *c* = 1.0

on moon, *c* ~ 0.1

A 1 kg bar will weigh

1 kg on earth

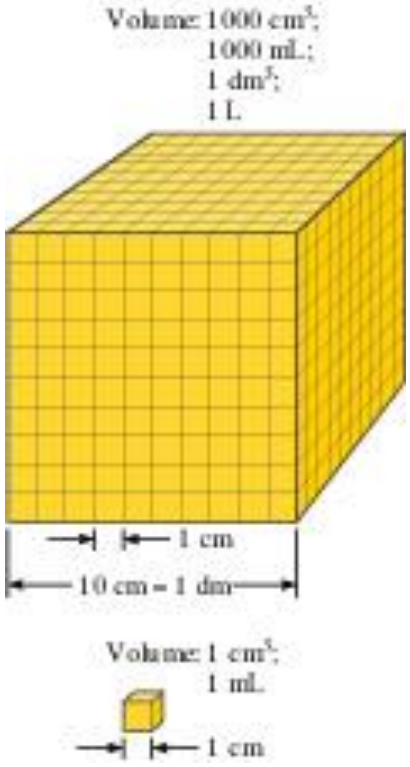
0.1 kg on moon

**Table 1.2 SI Base Units**

| Base Quantity | Name of Unit | Symbol |
|---|---|---|
| Length | meter | m |
| Mass | kilogram | kg |
| Time | second | s |
| Current | ampere | A |
| Temperature | kelvin | K |
| Amount of substance | mole | mol |
| Luminous intensity | candela | cd |

| Table 1.3 Prefixes Used with SI Units | | |
|---|---|---|
| Prefix | Symbol | Meaning |
| Tera- | T | $10^{12}$ |
| Giga- | G | $10^{9}$ |
| Mega- | M | $10^{6}$ |
| 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 | $10^{-12}$ |

# ***Volume*** – SI derived unit for volume is cubic meter ($m^3$)




$1\ cm^3 = (1 \times 10^{-2}\ m)^3 = 1 \times 10^{-6}\ m^3$

$1\ dm^3 = (1 \times 10^{-1}\ m)^3 = 1 \times 10^{-3}\ m^3$

$1\ L = 1000\ mL = 1000\ cm^3 = 1\ dm^3$

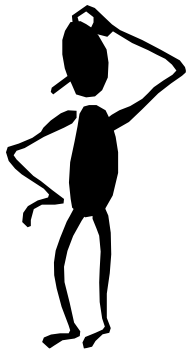
$1\ mL = 1\ cm^3$

***Density*** – SI derived unit for density is $kg/m^3$

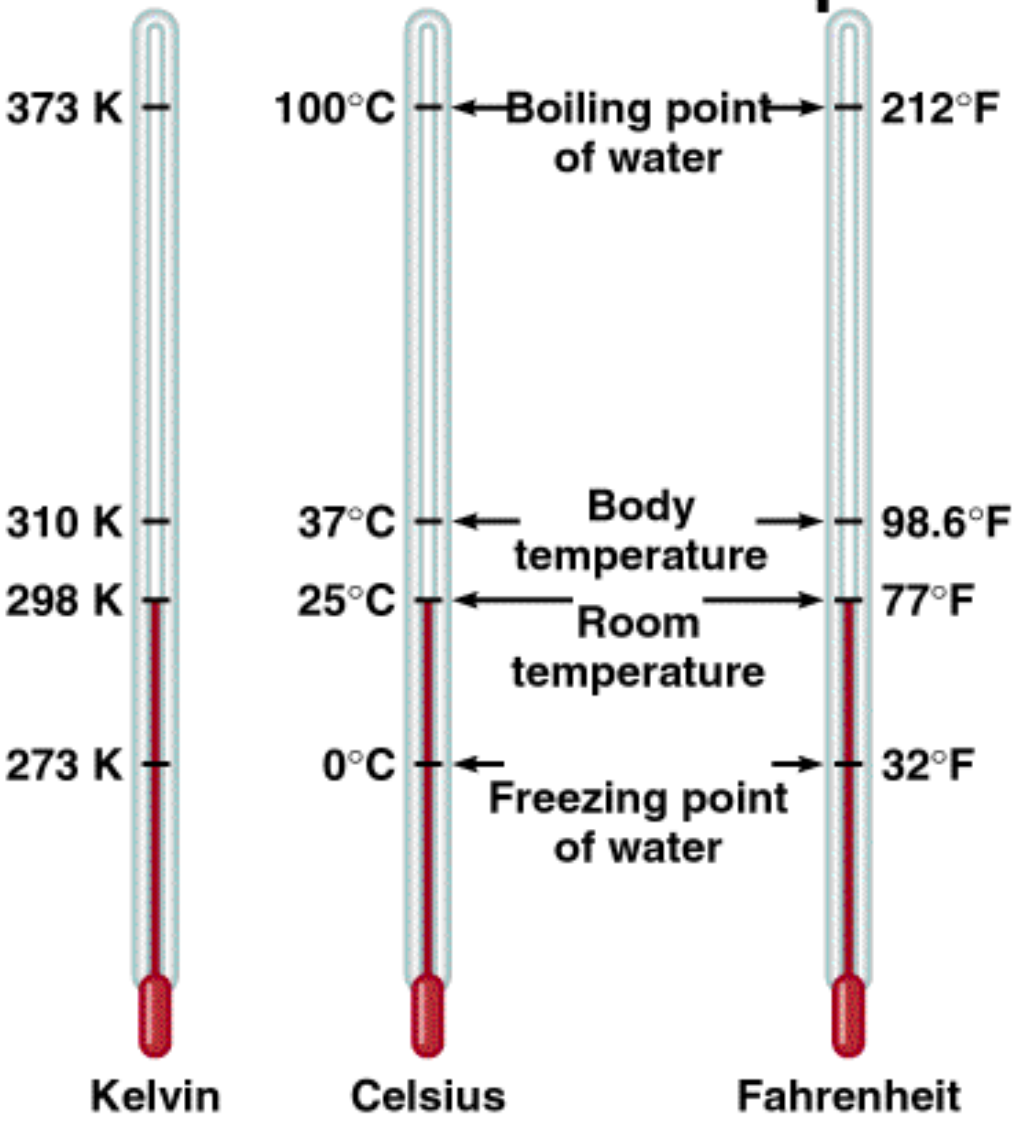
$$1\ g/cm^3 = 1\ g/mL = 1000\ kg/m^3$$

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad d = \frac{m}{V}$$

A piece of platinum metal with a density of 21.5 $g/cm^3$ has a volume of 4.49 $cm^3$. What is its mass?



# Comparison of the Three Temperature Scales




$K = °C + 273.15$

$273\ K = 0°C$

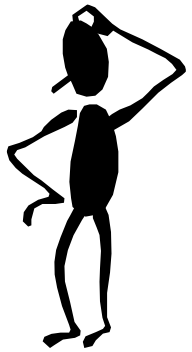
$373\ K = 100°C$

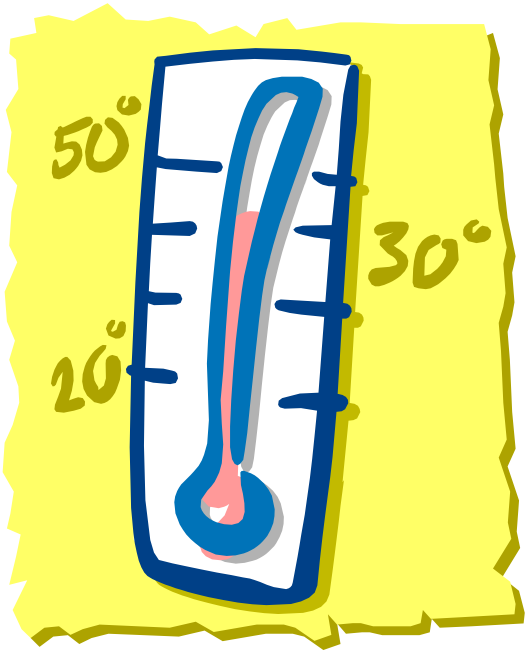
$°F = \left(\frac{9}{5} \times °C\right) + 32$

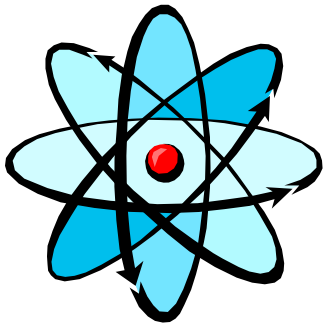
$32°F = 0°C$

$212°F = 100°C$

# Convert 172.9°F to degrees Celsius.







# Scientific Notation

The number of atoms in 12 g of carbon:

602,200,000,000,000,000,000,000

$6.022 \times 10^{23}$

The mass of a single carbon atom in grams:

0.000000000000000000000199

$1.99 \times 10^{-23}$

$N \times 10^{n}$

N is a number between 1 and 10

*n* is a positive or negative integer

# Scientific Notation

568.762

← move decimal left

$n > 0$

$568.762 = 5.68762 \times 10^{2}$

0.00000772

→ move decimal right

$n < 0$

$0.00000772 = 7.72 \times 10^{-6}$

## Addition or Subtraction

1. Write each quantity with the same exponent *n*
2. Combine $N_1$ and $N_2$
3. The exponent, *n*, remains the same

$4.31 \times 10^{4} + 3.9 \times 10^{3} =$

$4.31 \times 10^{4} + 0.39 \times 10^{4} =$

$4.70 \times 10^{4}$

# Scientific Notation

## Multiplication

1. Multiply $N_1$ and $N_2$
2. Add exponents $n_1$ and $n_2$

$(4.0 \times 10^{-5}) \times (7.0 \times 10^{3}) =$
$(4.0 \times 7.0) \times (10^{-5+3}) =$
$28 \times 10^{-2} =$
$2.8 \times 10^{-1}$

## Division

1. Divide $N_1$ and $N_2$
2. Subtract exponents $n_1$ and $n_2$

$8.5 \times 10^{4} \div 5.0 \times 10^{9} =$
$(8.5 \div 5.0) \times 10^{4-9} =$
$1.7 \times 10^{-5}$

# Significant Figures

- Any digit that is not zero is significant

  1.234 kg  4 significant figures

- Zeros between nonzero digits are significant

  606 m  3 significant figures

- Zeros to the left of the first nonzero digit are **not** significant

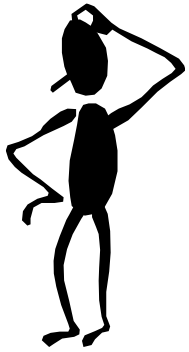
  0.08 L  1 significant figure

- If a number is greater than 1, then all zeros to the right of the decimal point are significant

  2.0 mg  2 significant figures

- If a number is less than 1, then only the zeros that are at the end and in the middle of the number are significant

  0.00420 g  3 significant figures



# How many significant figures are in each of the following measurements?

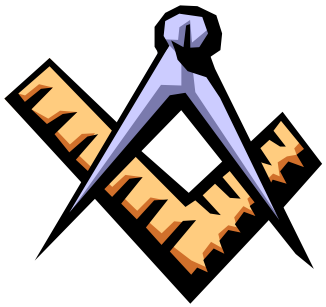
24 mL

3001 g

0.0320 $m^3$

6.4 x $10^4$ molecules

560 kg



# Significant Figures

## Addition or Subtraction

The answer cannot have more digits to the right of the decimal point than any of the original numbers.

89.332
+1.1 ⟵ one significant figure after decimal point
90.432 ⟵ round off to 90.4

3.70 ⟵ two significant figures after decimal point
-2.9133
0.7867 ⟵ round off to 0.79

# Significant Figures

## Multiplication or Division

The number of significant figures in the result is set by the original number that has the ***smallest*** number of significant figures

$$4.51 \times 3.6666 = 16.536366 = 16.5$$

3 sig figs

round to 3 sig figs

$$6.8 \div 112.04 = 0.0606926 = 0.061$$

2 sig figs

round to 2 sig figs

# Significant Figures

## Exact Numbers

Numbers from definitions or numbers of objects are considered to have an infinite number of significant figures

The average of three measured lengths; 6.64, 6.68 and 6.70?

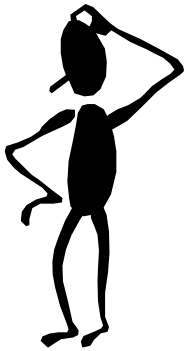
$$\frac{6.64 + 6.68 + 6.70}{3} = 6.67333 = 6.67 = \cancel{7}$$

Because  is an exact number

# Factor-Label Method of Solving Problems

1. Determine which unit conversion factor(s) are needed
2. Carry units through calculation
3. If all units cancel except for the desired unit(s), then the problem was solved correctly.

How many mL are in 1.63 L?



The speed of sound in air is about 343 m/s. What is this speed in miles per hour?

| Q | A |
| --- | --- |
| 1.267 x 42 x 0.9963 | |
| (63.7 x 49) / 6.664 | |
| √ 7.43 | |
| 0.00627 + 0.1956 + 0.00029 | |
| (4 x 972) + (76.4 x 29.3) – (12 x 7) | |

| Q | A |
| --- | --- |
| Liquid ethane boils at -89°C. What is its boiling point on the Kelvin scale? | |
| What is the volume of 755 g of a material with a density of 2.564 g/mL? | |
| Depending upon the amount of fat a person has, the human body has a density of about 0.95 g/cm$^3$. If a person weighed 150 lbs, what would be their volume in cm$^3$? | |