Chemistry and Measurement

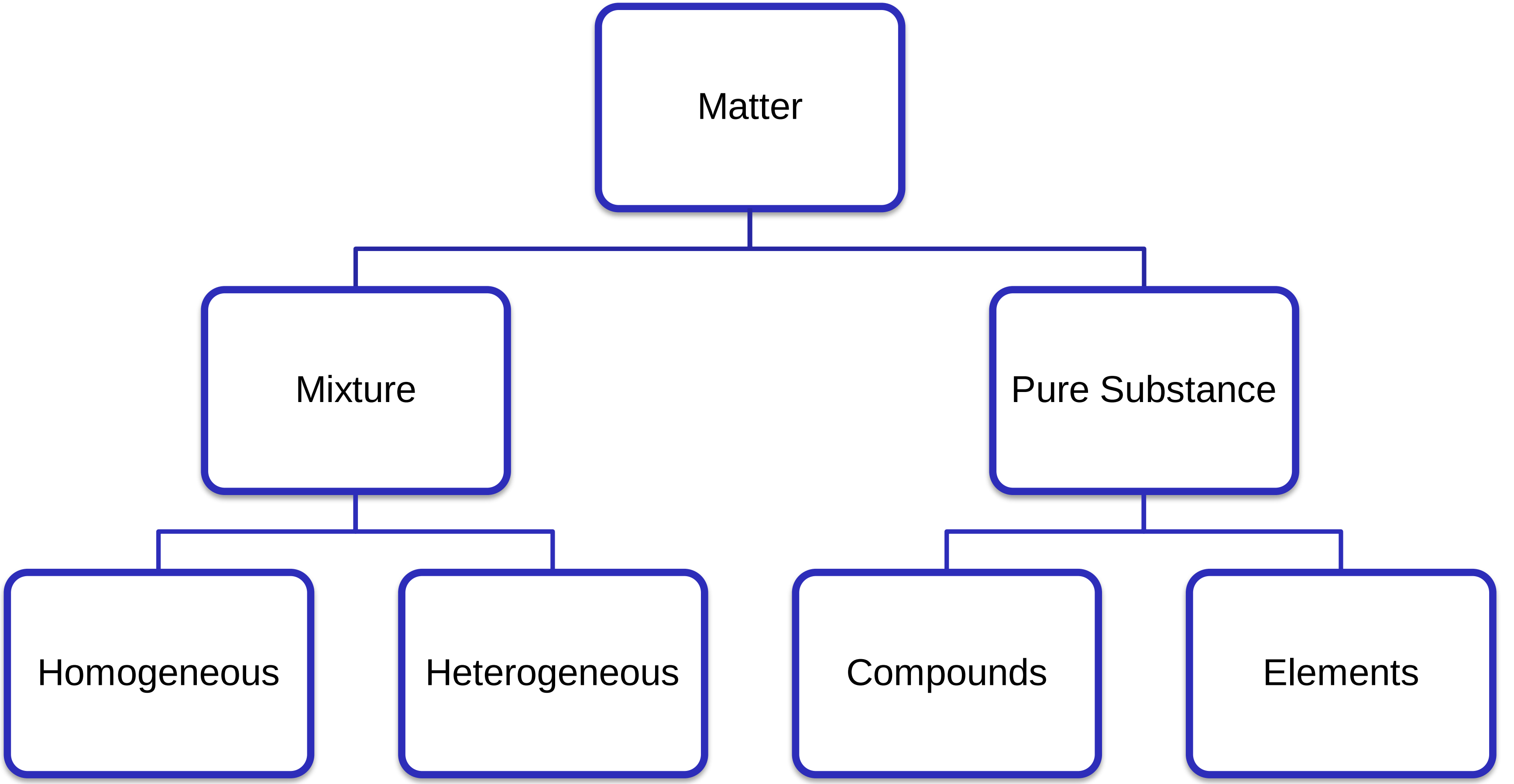
Chapter 1

DMKC1033

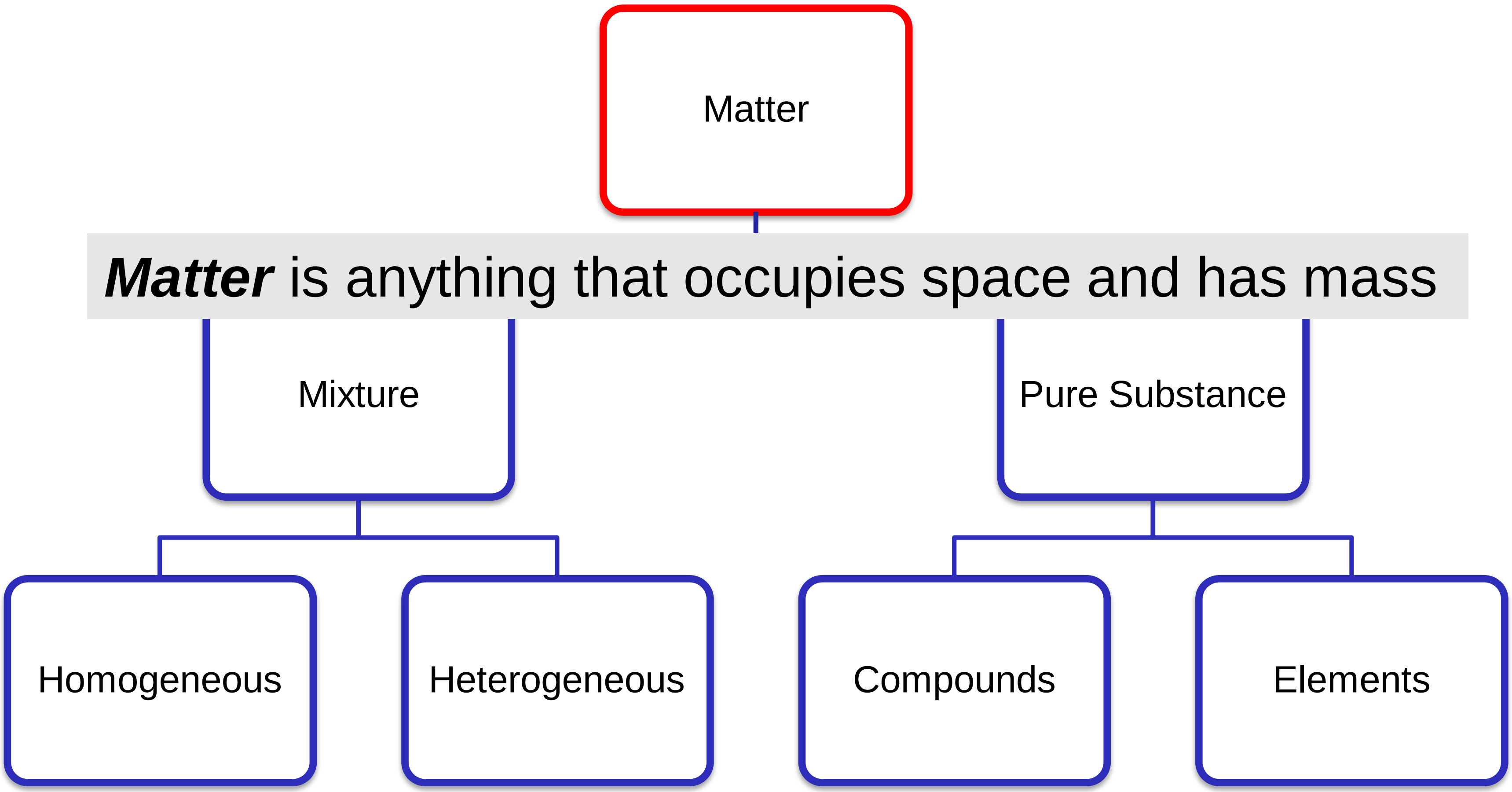
Chemistry

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

Classification of Matter

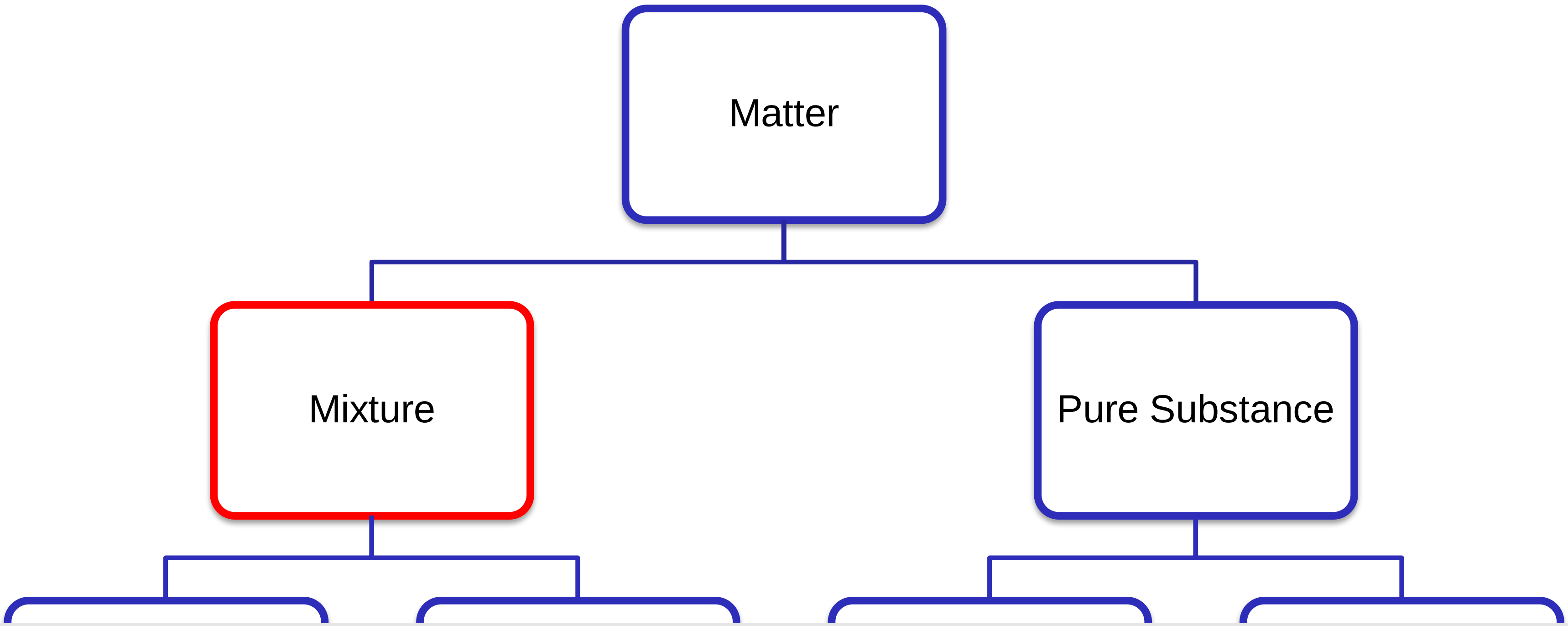


Classification of Matter



Matter is anything that occupies space and has mass

Classification of Matter

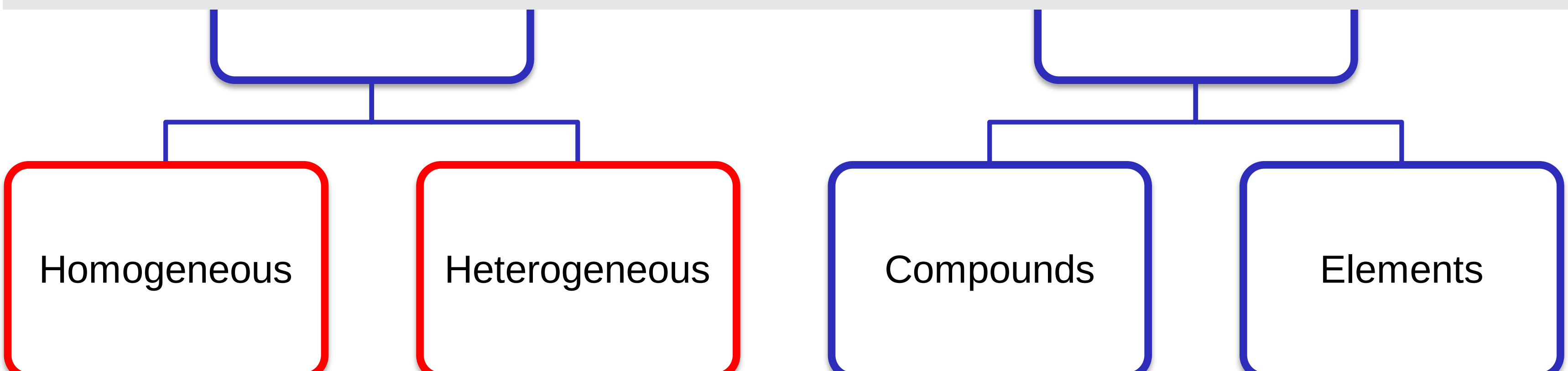


mixture is a combination of two or more substances in which the substances retain their distinct identities.

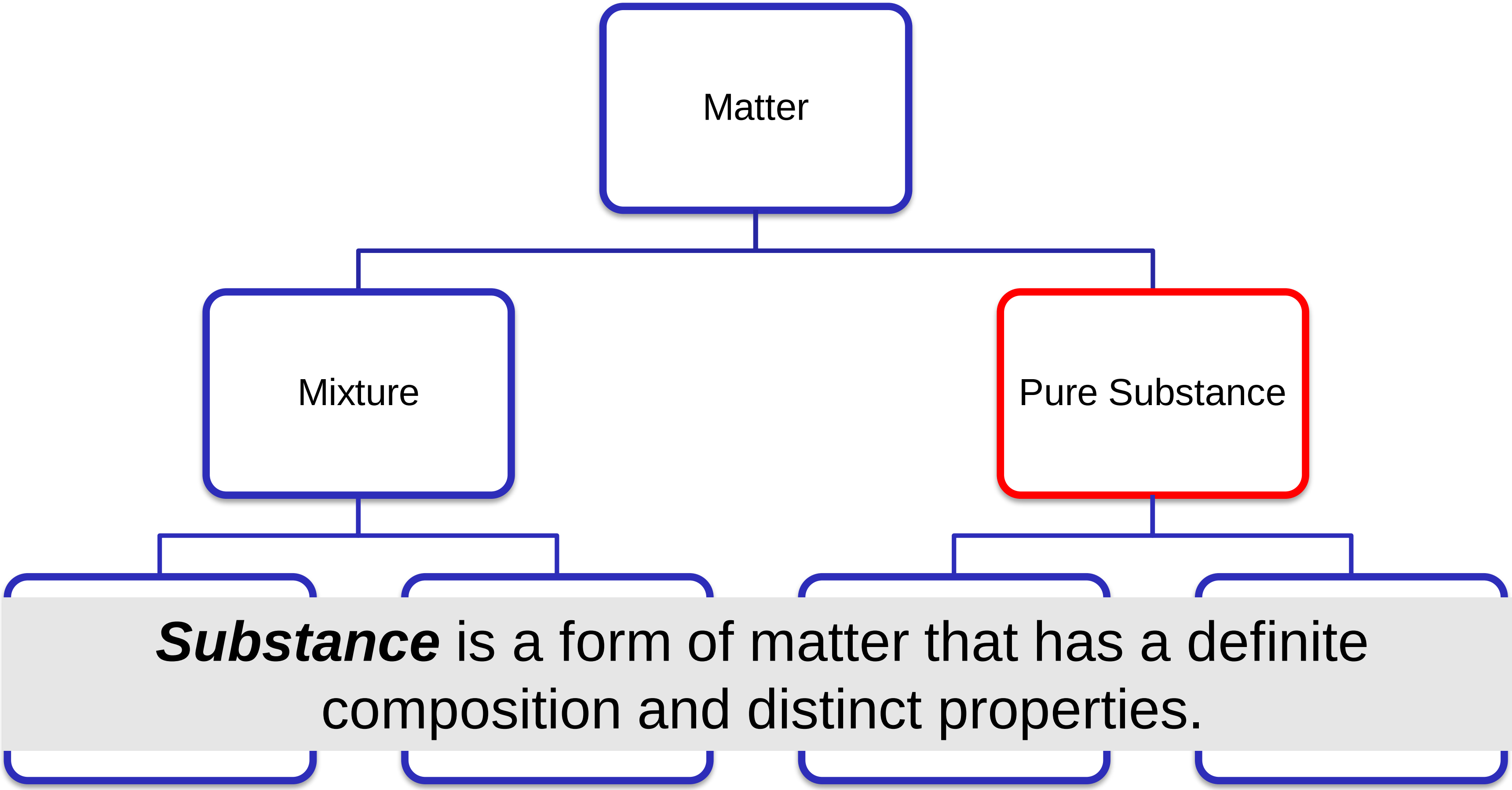
Classification of Matter

Homogenous mixture – composition of the mixture is in the same throughout.

Heterogeneous mixture – composition is not uniform throughout.



Classification of Matter



Substance is a form of matter that has a definite composition and distinct properties.

Classification of Matter

Element is a substance that cannot be separated into simpler substances by ***chemical means***

Total 118 elements

94 elements occur naturally on Earth.
Eg: gold, aluminum, lead, oxygen, carbon

24 elements have been created by scientists.
Eg: technetium, americium, seaborgium

Homogeneous

Heterogeneous

Compounds

Elements

Classification of Matter

Compound is a substance composed of atoms of two or more different elements chemically united in fixed proportions.

Water (H_2O), Glucose ($C_6H_{12}O_6$)

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

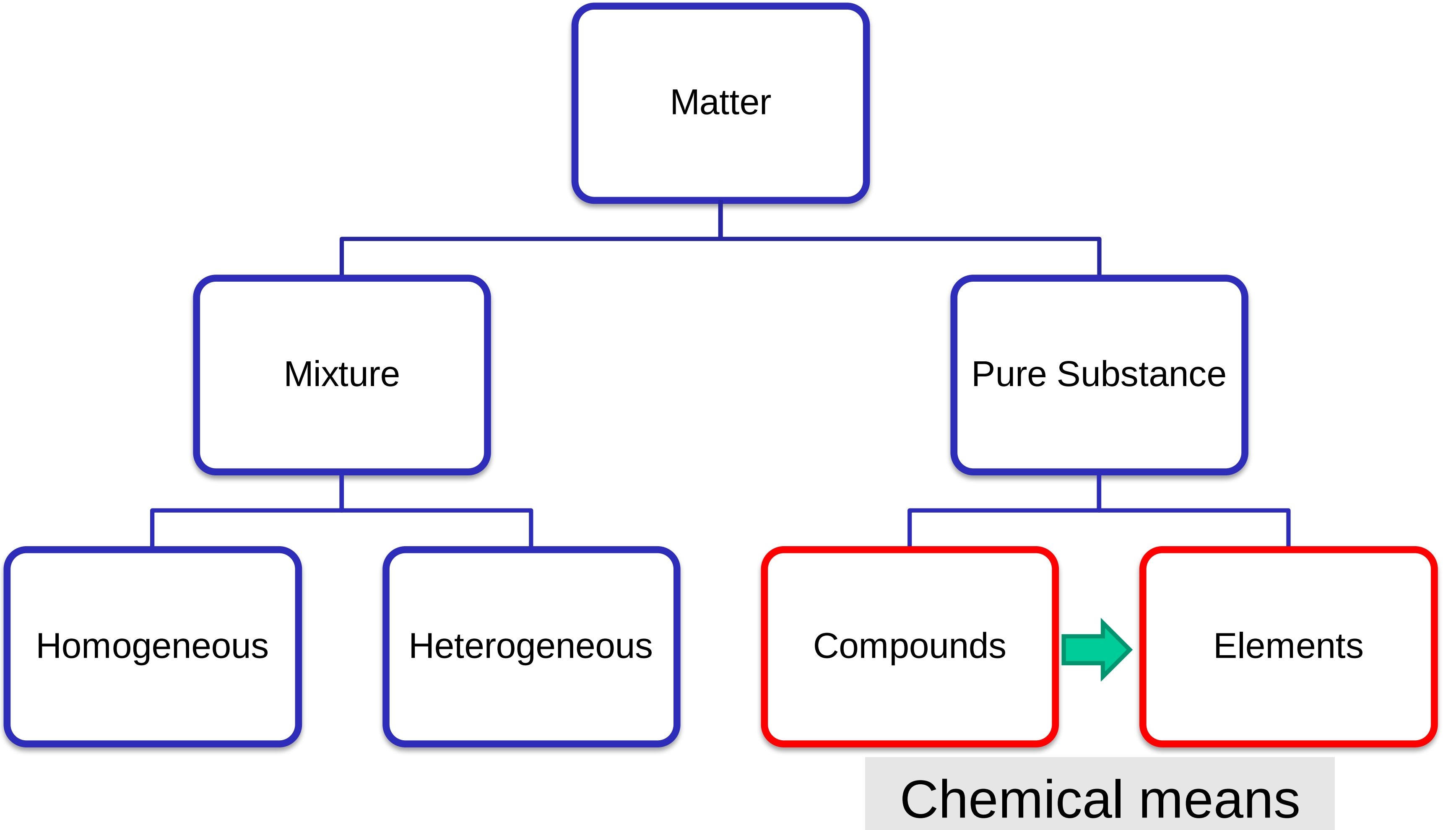
Homogeneous

Heterogeneous

Compounds

Elements

Classification of Matter



Classification of Matter

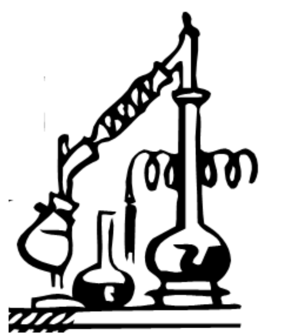
Matter

Mixture

Physical means

Pure Substance

Homogeneous



distillation

magnet

ments

Classify each of the following as an element, compound, homogeneous mixtures or heterogeneous mixture.

i. Gasoline

ii. Methane

iii. Hazelnut Coffee

iv. Lead

(4 marks)

What is the differences between molecule and compound?

Molecule

2 or more same or different atoms join together chemically. **Eg. N_2, H_2O**

Compound

A molecule that contains at least 2 different atoms. **Eg. H_2O, NaCl**

All compounds are molecules
But not all molecules are compounds

What is the differences between atom and element?

Atom

Smallest particle of matter. **Eg. H**

Element

Pure substance that made up from 1 type of atom. **Eg. H H H**

What is the differences between element and molecule?

Element

Pure substance that made up from 1 type of atom. Eg. H_2 H_2 H_2

Molecule

2 or more same or different atoms join together chemically. Eg. H_2, H_2O

Explain the differences between physical and chemical changes.

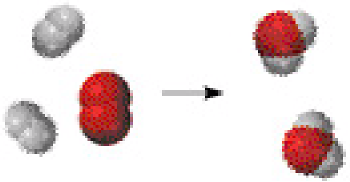
A ***physical change*** does not alter the composition or identity of a substance.

ice melting

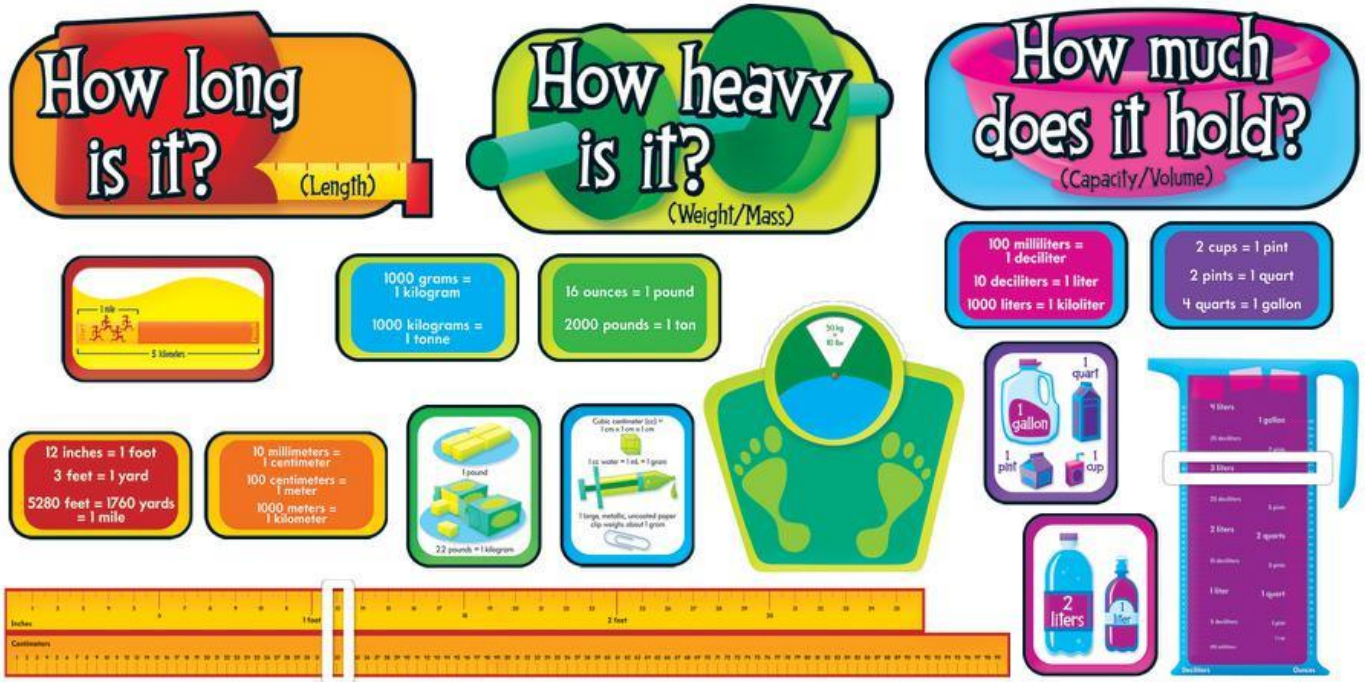
sugar dissolving in water

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

hydrogen gas burns in oxygen gas to form water



Units of measurement



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

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}

mass – measure of the quantity of matter

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

$1 \text{ kg} = 1000 \text{ g} = 1 \times 10^3 \text{ g}$

weight – force that gravity exerts on an object

weight = *c* x mass

on earth, *c* = 1.0

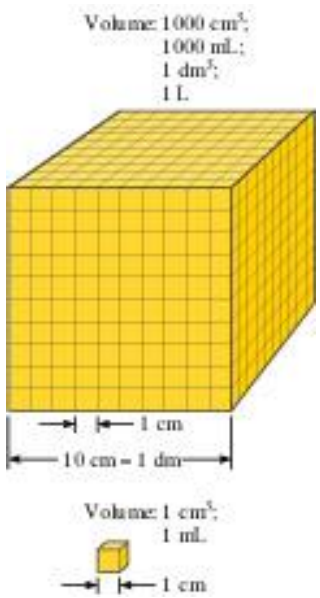
on moon, *c* ~ 0.1

A 1 kg bar will weigh

1 kg on earth

0.1 kg on moon

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



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

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

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

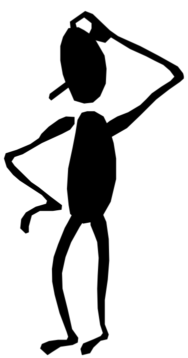
$$\boxed{1\ mL = 1\ cm^3}$$

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

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

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

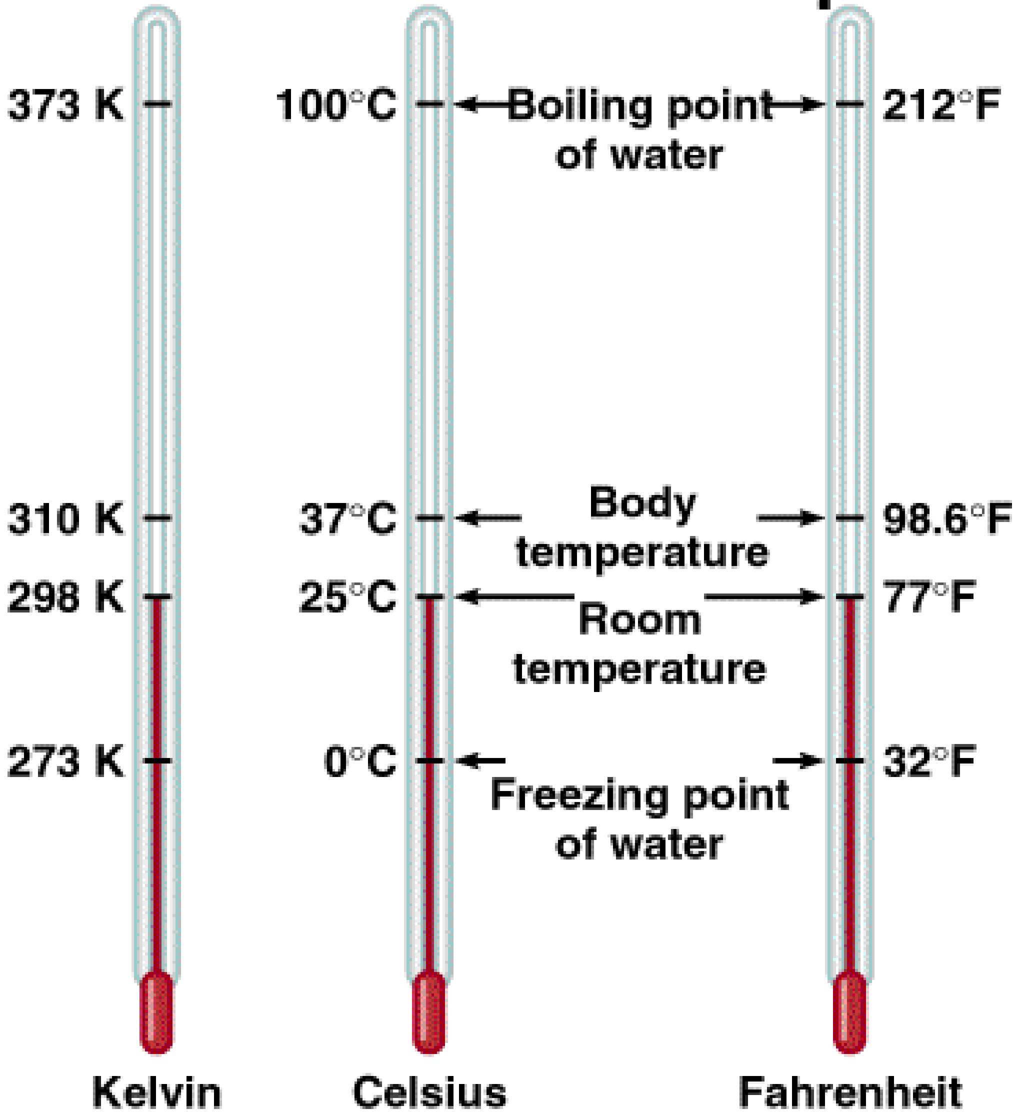
A piece of platinum metal with a density of 21.5 g/cm^3 has a volume of 4.49 cm^3. What is its mass?



$$\mathbf{d = \frac{m}{V}}$$

$$m = d \times V = 21.5\ \text{g}/\cancel{\text{cm}^3} \times 4.49\ \cancel{\text{cm}^3} = 96.5\ \text{g}$$

Comparison of the Three Temperature Scales



$K = {}^{\circ}C + 273.15$

$273\ K = 0\ {}^{\circ}C$
$373\ K = 100\ {}^{\circ}C$

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

$32\ {}^{\circ}F = 0\ {}^{\circ}C$
$212\ {}^{\circ}F = 100\ {}^{\circ}C$

Express normal body temperature, 98.60 °F in:

i. Degree Celsius, °C

ii. Kelvin, K

(6 marks)

$$°F = \left(\frac{9}{5} \times °C\right) + 32 \quad — 1$$

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

$$= \frac{5}{9}\left(98.60 - 32\right)$$

$$= 37\ °C \quad — 2$$

$$K = °C + 273.15 \quad — 1$$

$$= 37 + 273.15$$

$$= 310.15\ K \quad — 2$$

Factor Label Method

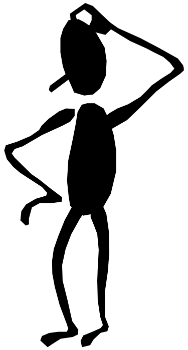
Factor-Label Method of Solving Problems

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?

1 L = 1000 mL

$$1.63\ \cancel{L} \times \frac{1000\ mL}{1\cancel{L}} = 1630\ mL$$



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

meters to miles

seconds to hours

1 mi = 1609 m   **1 min = 60 s**   **1 hour = 60 min**

$$343\ \frac{\cancel{m}}{\cancel{s}} \times \frac{1\ mi}{1609\ \cancel{m}} \times \frac{60\ \cancel{s}}{1\ \cancel{min}} \times \frac{60\ \cancel{min}}{1\ hour} = 767\ \frac{mi}{hour}$$

The mass of fuel in an airplane must be carefully accounted before takeoff. If a Boeing 747 contains 1.55211 x 10^5 L of fuel, what is the mass of the fuel in kilograms? *(Density of the fuel = 0.768 g/cm^3)*

1.55211 x 10^5 L	***1000 cm^3***	***0.768 g***	***1 kg***
	1 L	***cm^3***	***1000 g***

= 119202.048 kg @ 1.19 x 10^5 kg

(4 marks)

A running track measures 1056 ft per lap. How many laps needed to run for 15.0 km?

(Given: 1 mile = 5280 ft, 1 km = 0.6214 mile)

1 lap	5280 ft	0.6214 mile	15 km
1056 ft	1 mile	1 km	

= **46.61 laps**

The commonly accepted measurement now used by dietary specialist in assessing whether a person is overweight is the body mass index (BMI). BMI is based on a person's weight and height. It is the mass, in kilograms, divided by the square of the height in meters that is, expressed in kg/m^2. Generally speaking, if the BMI exceeds 25, a person considered overweight. What is the BMI of a person which is 69.0 inches tall and weight 158.0 lb? Show detail calculation using Factor Label Method. *(Given: 1 inch = 2.54 cm, 1 lb = 453.59 g)*.

(4 marks)

$$\Rightarrow \frac{158\ \text{lb}}{(69\ \text{inch})^2}\left|\frac{453.59\ \text{g}}{1\ \text{lb}}\right|\frac{1\ \text{kg}}{1000\ \text{g}}\left|\frac{(1\ \text{inch})^2}{(2.54\ \text{cm})^2}\right|\frac{(100\ \text{cm})^2}{(1\ \text{m})^2}$$

Show calculation using FLM — 2

$$= \frac{71667.2200\ \text{kg}}{30716.0676\ \text{m}^2}$$

$$= \underline{23.33\ \text{kg/m}^2} \quad \text{— 2}$$

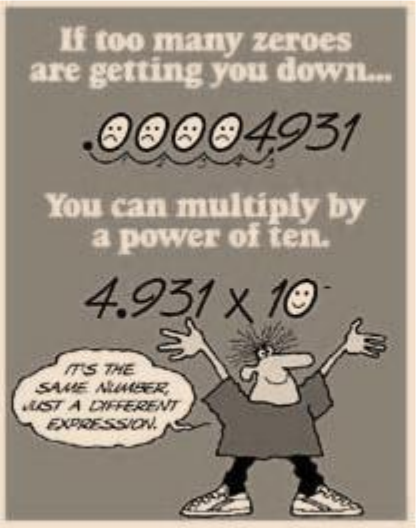
$$\text{Weight} : \frac{158\ \text{lb}}{}\left|\frac{453.59\ \text{g}}{1\ \text{lb}}\right|\frac{1\ \text{kg}}{1000\ \text{g}} \quad \text{— } \tfrac{1}{2}$$

$$= \underline{71.67\ \text{kg}} \quad \text{— } \tfrac{1}{2}$$

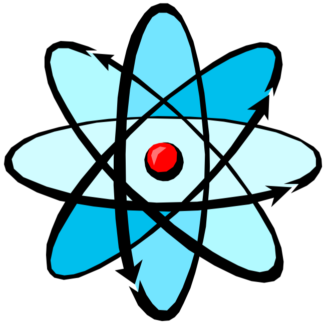
$$\text{height} = \frac{69\ \text{inch}}{}\left|\frac{2.54\ \text{cm}}{1\ \text{inch}}\right|\frac{1\ \text{m}}{100\ \text{cm}} \quad \text{— } \tfrac{1}{2}$$

$$= \underline{1.753\ \text{m}} \quad \text{— } \tfrac{1}{2}$$

$$\text{BMI} = \frac{W}{(H)^2} = \frac{71.67\ \text{kg}}{(1.753)^2\ \text{m}^2} = 23.33\ \text{kg/m}^2 \quad \text{— 2}$$



Scientific Notation



Scientific Notation

The number of atoms in 12 g of carbon:

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

6.022×10^{23}

The mass of a single carbon atom in grams:

0.0000000000000000000000199

1.99×10^{-23}

$$\boxed{N \times 10^{n}}$$

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

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

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

4.70×10^{4}

Scientific Notation

Multiplication

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

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

Division

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

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

Write the following in scientific notation:

i. 123456700 grams

1.23456700×10^{8} grams @ 1.234567×10^{8} grams

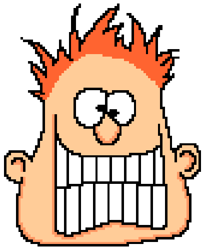
ii. 0.0001234 milligrams

1.234×10^{-4} milligrams

(4 marks)

Significant Figure

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

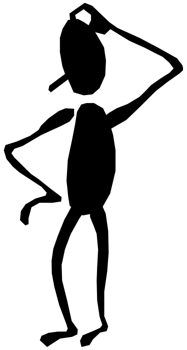
  0.08 L 1 significant figure

- 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

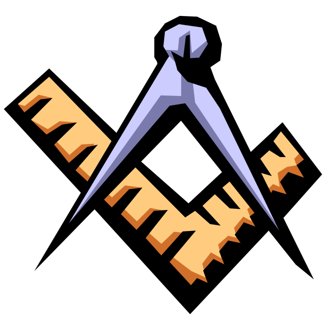
- If a number is less than 1, then only the zeros that are at the end and in the middle of the number are significant

  0.00420 g 3 significant figures



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

24 mL	**2 significant figures**
3001 g	**4 significant figures**
0.0320 m^3	**3 significant figures**
6.4×10^4 molecules	**2 significant figures**
500.0 kg	**4 significant figures**



How many SF for 1000 cm?

The significance of trailing zeros
in a number not containing a decimal point can be **unclear**.

It may not always be clear if a number like 1000
is **precise to the nearest unit**
or it is only shown to the **nearest hundred due to rounding**.

How many SF for 1000 cm?

Some of the method to clearly state the SF of trailing zeros…

How many SF for 1000 cm?

1. An **overline**, sometimes also called an **overbar**, may be placed over the last significant figure; any trailing zeros following this are insignificant.

For example, 1OŌO cm has **three** significant figures

How many SF for 1000 cm?

2. Sometimes, the last significant figure of a number may be **underlined.**

For example, 1<u>0</u>00 cm has **two** significant figures

How many SF for 1000 cm?

3. A **decimal point** may be placed after the number; indicates specifically that all significant figures are meant

For example, 1000**.** cm has **four** significant figures.

How many SF for 1000 cm?

???

Round the number to the correct number of significant figures in **Table 1.1**.

Table 1.1: Significant figure

Number	Rounded to four significant figures	Rounded to two significant figures	Rounded to one significant figures
84.0505	**84.05**	**84**	**80**
0.0904090	**0.09041**	**0.090**	**0.09**

(6 marks)

Significant Figures

Addition or Subtraction

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

$$\begin{array}{r} 89.332 \\ +1.1 \\ \hline 90.432 \end{array}$$

+1.1 ← one significant figure after decimal point

90.432 ← round off to 90.4

$$\begin{array}{r} 3.70 \\ -2.9133 \\ \hline 0.7867 \end{array}$$

3.70 ← two significant figures after decimal point

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**

$4.51 \times 3.6666 = 16.536366 = 16.5$

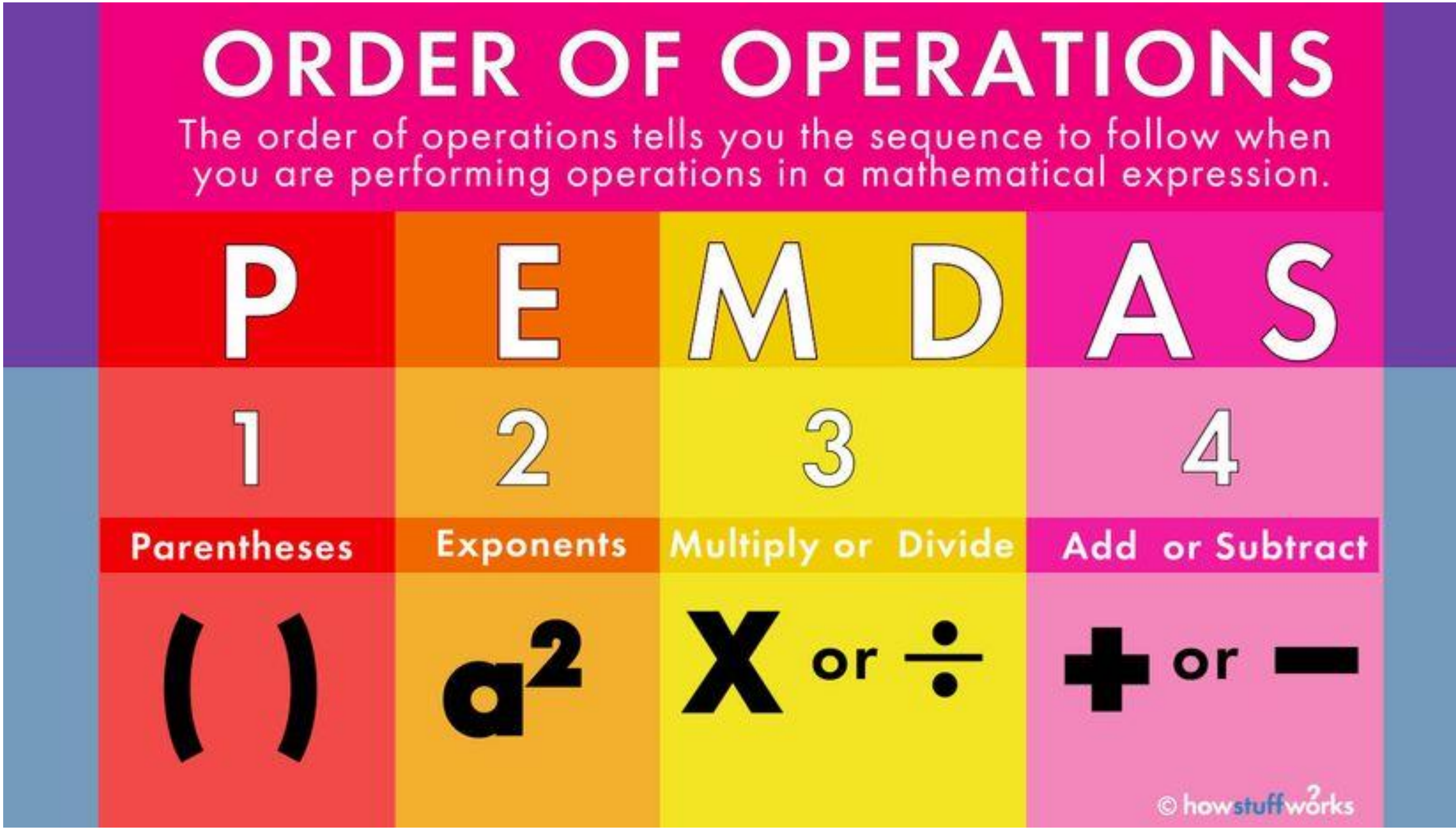
3 sig figs

round to
3 sig figs

$6.8 \div 112.04 = 0.0606926 = 0.061$

2 sig figs

round to
2 sig figs


ORDER OF OPERATIONS
The order of operations tells you the sequence to follow when you are performing operations in a mathematical expression.
P E M D A S
1
2
3
4
Parentheses
Exponents
Multiply or Divide
Add or Subtract
( )
a²
X or ÷
+ or −
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Carry out the following operations with the correct number of significant figures:

a) (1.600 - 20.0) x (1.004 + 3.0300) *(2 marks)*

b) (0.00510 x 2.020) - (0.2210 ÷ 2.000) *(2 marks)*

c) (4.020 x 10^6 dm) ÷ (7.70 x 10^7 dm) *(2 marks)*

4sf $\frac{1}{2}$ 3sf $\frac{1}{2}$

(a) $(-18.4) \times (4.034)$

-74.2256 @ -74.3912

≈ -74.2 (3 sf) @ ~~-74.4~~ (1)

3sf $\frac{1}{2}$ 4sf $\frac{1}{2}$

(b) $(0.0103) - (0.1105)$

$= -0.1002$ (4 sf) — (1)

(c) 0.052207

$\approx$ 0.0522 (3 sf)

@ 5.22×10^{-2} (3 sf) — (2)

@ 0.522×10^{-1}

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 **3** is an **exact number**