CHAPTER TWO

MEASUREMENT I

In order to measure we need to know or define the quantity to be measured and the units for measuring it. In **1971** a system known as the **International System of Units** (*Systeme' Internationale*) and seven basic units were agreed upon as follows. Other quantities can be obtained from these basic quantities and are referred to as **derived quantities**.

Basic quantity	**SI units**	**Symbols**
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic temperature	Kelvin	K
Luminous intensity	Candela	Cd
Amount of substance	Mole	mol

Length

This is the measure of distance between two points in space. The SI unit for length is the **metre (m).**Therefore 1 km = 1000 m

1 Hm = 100 m

1 Dm= 10 m

1 mm = 0.001 m

Length is measured using a **metre rule** (100 cm), **tape measure** (100 m, 300 m, 500 m)

Area

This is the measure of the extent of a surface. It is a derived quantity of length. Its SI units are square metres (**m^2**). Other units are **cm^2, km^2**, etc. Formulas are used to determine areas of regular bodies while for irregular bodies an approximation of area is used.

Volume

This is the amount of space occupied by matter. The SI units for volume is cubic metre **(m^3**). Other sub-multiples are **cm^3**, **mm^3** and ***l*.** Hence **1 m^3 = 1,000,000 cm^3 and 1*l*= 1,000 cm^3**. Volume can be measured using a measuring cylinder, eureka can, pipette, burette, volumetric flask, beaker, etc.

Mass

This is the quantity of matter contained in a substance. Matter is anything that occupies space and has weight. The SI unit for mass is the Kilogram **(kg**). Other sub-multiples used are grams (**g**), milligrams (**mg**) and tonnes (**t**). **1 kg = 1,000 g = 1,000,000 mg=100 tonnes**. A beam balance is used to measure mass.

Density

This is mass per unit volume of a substance. It is symbolized by rho (**ρ**) and its SI units are **kg/m^3. Density = mass / volume.**

Examples

1. *A block of glass of mass 187.5 g is 5.0 cm long, 2.0 cm thick and 7.5 cm high. Calculate the density of the glass in kgm^{-3}.*
   Solution
   Density = mass / volume = (187.5 /1000) /(2.0 × 7.5 × 5.0 /1,000,000) = 2,500 kgm^{-3}.

2. *The density of concentrated sulphuric acid is 1.8 g/cm^{3}. Calculate the volume of 3.1 kg of the acid.*
   Solution
   Volume = mass / density = 3,100 / 1.8 = 1,722 cm^{3} or 0.001722 m^{3}.

The following is a list of densities of some common substances

Substance	**Density (g/cm^{3})**	**Density (kg/m^{3})**
Platinum	*21.4*	*21,400*
Gold	*19.3*	*19,300*
Lead	*11.3*	*11,300*
Silver	*10.5*	*10,500*
Copper	*8.93*	*8,930*
Iron	*7.86*	*7,860*
Aluminium	*2.7*	*2,700*
Glass	*2.5*	*2,500*
Ice	*0.92*	*920*
Mercury	*13.6*	*13,600*
Sea water	*1.03*	*1,030*
Water	*1.0*	*1,000*
Kerosene	*0.80*	*800*
Alcohol	*0.79*	*790*
Carbon (iv) oxide	*0.00197*	*1.97*
Air	*0.00131*	*1.31*
Hydrogen	*0.000089*	*0.089*

Example
The mass of an empty density bottle is 20 g. Its mass when filled with water is 40.0 g and 50.0 g when filled with liquid X. Calculate the density of liquid X if the density of water is 1,000 kgm^{-3}.
Solution
Mass of water = 40 – 20 = 20 g = 0.02 kg.
Volume of water = 0.02 / 1,000 = 0.00002 m^{3}. Volume of liquid = volume of bottle
Mass of liquid = 50 – 20 = 30 g = 0.03 kg
Therefore density of liquid = 0.03 / 0.00002 = 1,500 kgm^{-3}

Relative density

This is the density of a substance compared to the density of water.
It is symbolized by **(d)** and has no units since it's a ratio.
Relative density (d) = density of substance / density of water.
It is measured using a relative density bottle

Example
The relative density of some type of wood is 0.8. Find the density of the wood in kg/m^3.
Solution
Density of substance = d × density of water
Density of substance = 0.8 × 1,000 = 800 kgm^{-3}

Densities of mixtures

We use the following formula to calculate densities of mixtures
Density of the mixture = mass of the mixture / volume of the mixture

Example
100 cm^3 of fresh water of density 1,000 kgm^{-3} is mixed with 100 cm^3 of sea water of density 1030 kgm^{-3}. Calculate the density of the mixture.
Solution
Mass = density × volume
Mass of fresh water = 1,000 × 0.0001 = 0.1 kg
Mass of sea water = *1030* × 0.0001 = *0.103* kg
Mass of mixture = 0.1 + *0.103* = *0.203* kg
Volume of mixture = 100 + 100 = 200 cm^3 = 0.0002 m^3
Therefore density = mass / volume = *0.203* / 0.0002 =*1,015* kg/m^3.

Time

This is a measure of duration of an event. The SI unit for time is the second **(s).** Sub-multiples of the second are milliseconds, microseconds, minute, hour, day, week and year. It is measured using clocks, stop watches, wrist watches, and digital watches.

Accuracy and errors

Accuracy is the closeness of a measurement to the correct value of the quantity being measured. It is expressed as an error. ***An error is therefore the deviation of measurement to the correct value being measured***. The smaller the error the accurate the measurement.
% error = (sensitivity / size measured) × 100.