Unit 1 Working like a chemist
1.1 Units

We are learning how to:

- express quantities in different units
- use prefixes to alter the values of units

SI base units

Chemists, like all scientists, carry out experiments in which they often take measurements. These measurements are made in **SI units**. These are an internationally agreed set of units used by all scientists around the world. Using the same units makes it easier for scientists to communicate their work to others.

There are five SI base units used in chemistry. See Table 1.1.1.

Unit name	Unit symbol	Quantity measured	Additional information
Metre	m	Length and distance	
Kilogram	kg	Mass	
Second	s	Time	
Kelvin	K	Temperature	Degrees Celsius (°C) normally used
Mole	mol	Amount of substance	This is not the same as mass

TABLE 1.1.1

SI derived units

In addition to the base units, there are a number of other units derived from them. The one you will use most in chemistry is the unit of volume, which is derived from the unit of length.

The volume of a regular shape like a cuboid = length × width × height. Since each of those quantities is measured in a unit of length the volume will be given in that unit^3. The metre is the SI unit of length, therefore the cubic metre will be the SI unit of volume.

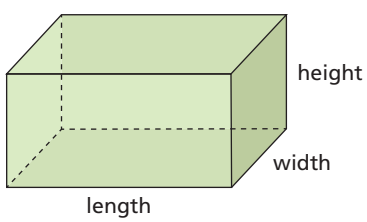


FIG 1.1.1 Volume of a cuboid

Prefixes

Although the SI unit of mass is the kilogram, this unit is not suitable for expressing the mass of all objects since the values would require large numbers of zeroes. For example:

The mass of the Earth = 5 972 000 000 000 000 000 000 000 kg
The mass of an atom of carbon =
0.000 000 000 000 000 000 000 019 9 kg

To get around this problem we use a series of **prefixes** which denote different powers of 10 (see Table 1.1.2).

Prefix	Symbol	Multiplying factor	Multiplying factor in scientific notation
Mega	M	1 000 000	10^6
Kilo	k	1000	10^3
Deci	d	0.1	10^{-1}
Centi	c	0.01	10^{-2}
Milli	m	0.001	10^{-3}
Micro	μ	0.000 001	10^{-6}

TABLE 1.1.2

Notice that the symbol for mega is 'M' while the symbol for milli is 'm'. It is important to write all of these prefixes in upper or lower case as appropriate to avoid confusion.

You will already be familiar with some combinations of 'prefix' + 'unit'. Many of the foods we eat are sold by the kilogram.

1 kilogram = 1000 gram

The active ingredients in the medicines we take when we are not feeling well are often expressed in milligrams.

1 milligram = 0.001 gram

You probably have a ruler that measures length in centimetres, and each centimetre is divided into 10 millimetres.

1 centimetre = 0.01 metre 1 millimetre = 0.001 metre

Liquids are sold in bottles measured in litres (l) and millilitres (ml). These are not SI units but can be easily converted:

1 litre = 1 dm^3 1 millilitre = 1 cm^3

FIG 1.1.2 Fruits and vegetables are sold by the kilogram in the supermarket

FIG 1.1.3 Amounts of drugs are often expressed in milligrams

FIG 1.1.4 Liquids are measured in cubic centimetres and cubic decimetres

Activity 1.1.1

SI units in everyday life

1. Look at the packaging on foods and other materials in your home. Make a note of any SI units used to show quantities.

Check your understanding

1. What is the SI unit used to measure:

a) mass **b)** temperature **c)** volume?

2. Copy and complete the following:

a) 1 mg = ... g **c)** 1 cm = ... mm

b) 1 km = ... m **d)** 1 cm^3 = ... dm^3

Key terms

SI units group of internationally agreed units used in science

prefix group of letters or a short word put in front of other words to modify their meaning

1.2 Measuring quantities

We are learning how to:

- use apparatus to measure physical quantities
- measure mass, volume, time and temperature

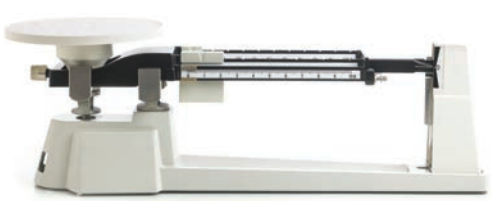
A **physical quantity** is a quantity that can be measured. To obtain knowledge, chemists carry out experiments in which they make careful observations and measurements. In order to do this they use a variety of measuring instruments and containers which are collectively called apparatus.

Mass

The **mass** of a substance is the amount of matter it contains. The units of mass are the kilogram (kg), for large masses, and the gram (g), for small masses.

1 kg = 1000 g

Mass is measured on a balance. There are two types in common use in laboratories.



beam balance

electronic balance

FIG 1.2.1 Balances measure mass

Volume

The **volume** of a substance is the amount of space that it occupies. The units of volume are the cubic decimetre (dm^3), for large volumes and the cubic centimetre (cm^3) for smaller volumes. For very large volumes the cubic metre (m^3) may also be used.

$1\ m^3 = 1\ 000\ dm^3$ $\qquad$ $1\ dm^3 = 1000\ cm^3$

Chemical apparatus for measuring volume can conveniently be divided into two groups – apparatus which shows approximate volume, and apparatus which shows accurate volume.

FIG 1.2.2 Apparatus that shows approximate volume

FIG 1.2.3 Apparatus that shows accurate volume

Time

For most chemical experiments, time is measured in minutes and seconds. A wristwatch will provide sufficiently accurate measurements or a digital stopwatch may be used.

FIG 1.2.4 Digital stopwatch

Temperature

Temperature is a measure of the degree of hotness of a body. Although the systematic unit of temperature is the degree Kelvin (K), temperature is generally measured in degrees Celsius (Centigrade) (°C). The relationship between degrees Celsius and degrees Kelvin is very simple.

Celsius = Kelvin – 273 Kelvin = Celsius + 273

The most common device for measuring temperature in the laboratory is the liquid-in-glass thermometer. A thermometer which has a scale from –10 °C to 110 °C is frequently used but thermometers which have different scales may also be used where lower or higher temperatures are to be measured.

FIG 1.2.5 Liquid-in-glass thermometers

Activity 1.2.1

Taking measurements

Here is what you will need:

- tripod stand
- wire gauze
- heat source
- eye protection
- thermometer
- beaker 100 cm^3
- measuring cylinder 25 cm^3
- triple beam balance
- digital stopwatch

1. Weigh a dry 100 cm^3 beaker and record its mass.
2. Measure out approximately 25 cm^3 of water and the water into the beaker. Reweigh the beaker and water and record the total mass.
3. Calculate the mass of the water used.
4. Measure the initial temperature of the water and record it. Place the beaker on a tripod and gauze and heat it for exactly 5 minutes. Measure the final temperature of the water.
5. What was the temperature increase of the water?

Key terms

mass amount of matter a substance contains

volume amount of space a substance occupies

temperature hotness of a body

physical quantity quantity that can be measured

Check your understanding

1. **a)** The mass of a beaker containing some powder is measured on an electronic balance (Fig 1.2.6). What is the reading on the balance?

   b) The mass of the empty beaker is 119.87 g. What is the mass of the powder?
2. What is the level of aqueous solution in the measuring cylinder shown in Fig 1.2.7?

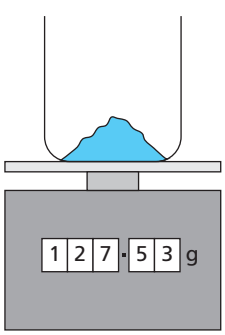


FIG 1.2.6

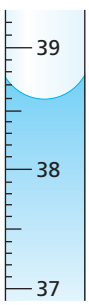


FIG 1.2.7