Units and prefixes

Mathematics for A-level Science

Why are units and prefixes important?

One of reasons we use the international system of units is because it makes the conversion of units (especially those with different prefixes) mathematically simple.

We use prefixes as shorthand for standard form when using commonly occurring very large or very small numbers.

This makes it easier to discuss and talk about sets of these numbers.

For example, the length 0.0000000023 m may be written as 2.3×10^{-9} m

2.3 is the **digit number** and is kept. 10^{-9} is known as the **exponential number** and can be replaced with the prefix *'n'* pronounced as '**nano**'.

Hence

$$0.0000000023\ \mathrm{m} = 2.3 \times 10^{-9}\ \mathrm{m} = 2.3\ \mathrm{nm}$$

Why are units important?

When measuring a variable in science we must consider the best unit (and prefix) to use. This often differs depending on the subject.

Variable	Prefix	Unit	Example
Length	centi (c)	metre (m)	15 cm
Volume	milli (m)	Litre (L)	330 mL
Force	kilo (k)	Newton (N)	0.8 kN
Area	centi	metre squared	624 cm^2

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Prefixes

- Here are the common unit prefixes you are likely to encounter:

Number		Exponential number	Prefix	
billion	1 000 000 000	10^9	G	'giga'
million	1 000 000	10^6	M	'mega'
thousand	1000	10^3	k	'kilo'
ten	10	10^2	d	'deci'
hundredth	0.01	10^{-2}	c	'centi'
thousandth	0.001	10^{-3}	m	'milli'
millionth	0.000 000 1	10^{-6}	μ	'micro'
billionth	0.000 000 000 1	10^{-9}	n	'nano'

Examples

Example 1

The length of a DNA nucleotide is 0.6 nm.

a) Convert this number into standard form.

b) If a strand of DNA is 1.6 m long, how many nucleotides is it made up of?

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b) If a strand of DNA is 1.6 m long, how many nucleotides is it made up of?

$1.8 \text{ m} / 0.6 \text{ nm} = 1.8 \text{ m} / (0.6 \times 10^{-9} \text{ m}) = 3 \times 10^{9} = 3$ billion

Manipulating units

- A number and a unit (like 3 m) is a magnitude (3) multiplied by a unit (metre).

- The rules of algebra apply not only to the numbers you are manipulating, but also to the units attached to them. For example:

$$3\ \mathrm{m} \times 3\ \mathrm{m} = 3 \times 3 \times \mathrm{m} \times \mathrm{m} = 9 \times \mathrm{m} \times \mathrm{m} = 9 \times \mathrm{m}^2 = 9\ \mathrm{m}^2$$

- Units can be multiplied and divided just like regular number. For example:

$$\frac{6\ \mathrm{m}^3}{2\ \mathrm{m}^2} = 3\frac{\mathrm{m}^3}{\mathrm{m}^2} = 3\frac{\mathrm{m} \times \mathrm{m} \times \mathrm{m}}{\mathrm{m} \times \mathrm{m}} = 3\ \frac{\mathrm{m} \times \cancel{\mathrm{m}} \times \cancel{\mathrm{m}}}{\cancel{\mathrm{m}} \times \cancel{\mathrm{m}}} = 3\ \mathrm{m}$$

Manipulating units

- At A-level, rather than write m/s to mean metres per second, we will write ms^{-1}.

- This makes it easier to combine units via the following rules:

$$unit^a \times unit^b = unit^{a+b}$$

$$\frac{unit^a}{unit^b} = unit^{a-b}$$

- Nb This means that: $\frac{1}{\mathrm{kg}^{-1}} = \mathrm{kg}$ or more generally $\frac{1}{a^{-n}} = a^n$

- **For more information about these properties see the indices lesson.**

Examples

Example 2

a) Calculate the following: $\frac{36\ \text{cm}^3}{12\ \text{cm}^2}$

b) Calculate the following: $\frac{36\ \text{kg cm}^{-3}}{12\ \text{cm}^{-2}}$

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a) Calculate the following: $\frac{36\ \text{cm}^3}{12\ \text{cm}^2}$

$\frac{36\ \text{cm}^3}{12\ \text{cm}^2} = 3\ \text{cm}^{3-2} = 3\ \text{cm}^1 = 3\ \text{cm}$

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b) Calculate the following: $\frac{36\ \text{kg cm}^{-3}}{64\ \text{cm}^{-2}}$

$$\frac{36\ \text{kg cm}^{-3}}{64\ \text{cm}^{-2}} = 0.5\frac{\text{kg cm}^{-3}}{\text{cm}^{-2}} = 0.5\ \text{kg cm}^{-3-(-2)} = 0.5\ \text{kg cm}^{-3+2} = 0.5\ \text{kg cm}^{-1}$$

Exam paper: Example

(c) The table below shows some features of gas exchange of a fish at rest.

Volume of oxygen absorbed by the gills from each dm^3 of water / cm^3	7
Mass of fish / kg	0.4
Oxygen required by fish / cm^3 kg^{-1} $hour^{-1}$	90

(i) Calculate the volume of water that would have to pass over the gills each hour to supply the oxygen required by the fish. Show your working.

.... dm^3

(2)

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(i) Calculate the volume of water that would have to pass over the gills each hour to supply the oxygen required by the fish. Show your working.

$\mathbf{90\ cm^3\ kg^{-1}\ hour^{-1}}$ means $90\ cm^3$ of oxygen required per kg per hour. Therefore,

$$90\ cm^3\ kg^{-1}\ hour^{-1} \times 0.4\ kg = 36\ cm^3\ hour^{-1} \text{ of oxygen required}$$

$\mathbf{7\ cm^3\ dm^{-3}}$ means $7\ cm^3$ of oxygen absorbed per dm^3 of water passing over gills

Therefore $$\frac{36\ \cancel{cm^3}\ hour^{-1}}{7\ \cancel{cm^3}\ dm^{-3}} = 5.1\ dm^3\ hour^{-1}$$

.... dm^3

(2)

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