

Name.....



Welcome to A level Biology!

Biology Summer work - moving from GCSE to A level

Moving from GCSE Science to A Level can be a daunting leap. You'll be expected to remember a lot more facts, equations, and definitions, and you will need to learn new maths skills and develop confidence in applying what you already know to unfamiliar situations.

[Here are a series of videos explaining which parts of GCSE biology you will need to remember to access the AS level content. Please watch these videos and revise anything you don't remember.](#)

We advise that you print out this document and complete it. Bring it to your VERY FIRST biology lesson. You will need 2 pieces of graph paper. (You can download and print graph paper for free on the internet.)

We do not expect that you complete all this in one go!

This worksheet aims to give you a head start by helping you:

- to pre-learn some useful knowledge from the first chapters of your A Level course
- Understand and practise some of the maths skills you'll need.

Learning objectives

After completing the worksheet you should be able to:

- define practical science key terms
- recall the answers to the retrieval questions
- perform maths skills including:
 - converting between units, standard form, and prefixes
 - using significant figures
 - rearranging formulae
 - magnification calculations
 - calculating percentages, errors, and uncertainties
 - Drawing and interpreting line graphs.
- Revise key terms about basic chemistry for biologists

Retrieval questions

- You need to be confident about the definitions of terms that describe measurements and results in A Level Biology.
- **Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.**

When is a measurement valid?	when it measures what it is supposed to be measuring,
When is a result accurate?	when it is close to the true value
What are precise results?	when repeat measurements are consistent/agree closely with each other
What is repeatability?	how precise repeated measurements are when they are taken by the <i>same</i> person, using the <i>same</i> equipment, under the <i>same</i> conditions
What is reproducibility?	how precise repeated measurements are when they are taken by <i>different</i> people, using <i>different</i> equipment
What is the uncertainty of a measurement?	the interval within which the true value is expected to lie
Define measurement error	the difference between a measured value and the true value
What type of error is caused by results varying around the true value in an unpredictable way?	random error
What is a systematic error?	a consistent difference between the measured values and true values

What does zero error mean?	a measuring instrument gives a false reading when the true value should be zero
Which variable is changed or selected by the investigator?	independent variable
What is a dependent variable?	a variable that is measured every time the independent variable is changed
Define a fair test	a test in which only the independent variable is allowed to affect the dependent variable
What are control variables?	variables that should be kept constant to avoid them affecting the dependent variable

Biological molecules

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What are monomers?	smaller units from which larger molecules (polymers) are made
What are polymers?	molecules made from a large number of monomers joined together
What is a condensation reaction?	a reaction that joins two molecules together to form a chemical bond whilst eliminating of a molecule of water
What is a hydrolysis reaction?	a reaction that breaks a chemical bond between two molecules and involves the use of a water molecule
What is a monosaccharide?	monomers from which larger carbohydrates are made
How is a glycosidic bond formed?	a condensation reaction between two monosaccharides
Name the three main examples of polysaccharides.	Glycogen, starch, cellulose
Describe Benedict's test for reducing sugars	Add Benedict's solution and heat, the solution turns from blue to a brick red precipitate if reducing sugar is present
Name the two main groups of lipids	fats and oils. You will need to know the words triglycerides and phospholipids at A level.
Give four roles of lipids	source of energy, waterproofing, insulation, protection
What is an ester bond?	a bond formed by a condensation reaction between glycerol and a fatty acid
Describe the emulsion test for lipids	mix the sample with ethanol in a clean test tube, shake the sample, add water, shake the sample again, a white emulsion indicates that lipid is present
What are the monomers that make up proteins?	amino acids
Draw the structure of an amino acid	$ \begin{array}{c} \text{R} \\ \\ \text{H}_2\text{N} - \text{C} - \text{COOH} \\ \\ \text{H} \end{array} $
How is a peptide bond formed?	a condensation reaction between two amino acids
What is a polypeptide?	many amino acids joined together
Describe the biuret test for proteins	Add Biuret solution, a change from blue to purple colour indicates that peptide bonds are present
How does an enzyme affect a reaction?	it lowers the activation energy
Give five factors which can affect enzyme action.	temperature, pH, enzyme concentration, substrate concentration, inhibitor concentration
What is a competitive inhibitor?	a molecule with a similar shape to the substrate, allowing it to occupy the active site of the enzyme
What is a non-competitive inhibitor?	a molecule that changes the shape of the enzyme by binding somewhere other than the active site.

Maths skills

1 Numbers and units

1.1 Units and prefixes

A key criterion for success in biological maths lies in the use of correct units and the management of numbers. The units scientists use are from the *Système Internationale* – the SI units. In biology, the most commonly used SI base units are metre (m), kilogram (kg), second (s), and mole (mol). Biologists also use SI derived units, such as square metre (m²), cubic metre (m³), degree Celsius (°C), and litre (l).

To accommodate the huge range of dimensions in our measurements they may be further modified using appropriate prefixes. For example, one thousandth of a second is a millisecond (ms). Some of these prefixes are illustrated in the table below.

Multiplication factor	Prefix	Symbol
10 ⁹	giga	G
10 ⁶	mega	M
10 ³	kilo	k
10 ⁻²	centi	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n

Practice questions

- A burger contains 4 500 000 J of energy. Write this in:
a kilo joules (1 mark) b mega joules. (1 mark)
- HIV is a virus with a diameter of between 9.0×10^{-8} m and 1.20×10^{-7} m.
Write this range in nanometres. (2 marks)

1.2 Powers and indices

Ten squared = $10 \times 10 = 100$ and can be written as 10^2 . This is also called 'ten to the power of 2'.

Ten cubed is 'ten to the power of three' and can be written as $10^3 = 1000$.

The power is also called the index.

Fractions have negative indices:

$$\text{one tenth} = 10^{-1} = 1/10 = 0.1$$

$$\text{one hundredth} = 10^{-2} = 1/100 = 0.01$$

Any number to the power of 0 is equal to 1, for example, $29^0 = 1$.

If the index is 1, the value is unchanged, for example, $17^1 = 17$.

When multiplying powers of ten, you must *add* the indices.

$$\text{So } 100 \times 1000 = 100\,000 \text{ is the same as } 10^2 \times 10^3 = 10^{2+3} = 10^5$$

When dividing powers of ten, you must *subtract* the indices.

$$\text{So } 100/1000 = 1/10 = 10^{-1} \text{ is the same as } 10^2/10^3 = 10^{2-3} = 10^{-1}$$

But you can only do this when the numbers with the indices are the same.

$$\text{So } 10^2 \times 2^3 = 100 \times 8 = 800$$

And you can't do this when adding or subtracting.

$$10^2 + 10^3 = 100 + 1000 = 1100$$

$$10^2 - 10^3 = 100 - 1000 = -900$$

Remember: You can only add and subtract the indices when you are multiplying or dividing the numbers, not adding or subtracting them.

Practice questions

3 Calculate the following values. Give your answers using indices. (4 marks)

a $10^8 \times 10^3$

b $10^7 \times 10^2 \times 10^3$

c $10^3 + 10^3$

d $10^2 - 10^{-2}$

4 Calculate the following values. Give your answers with and without using indices. (4 marks)

a $10^5 \div 10^4$

b $10^3 \div 10^6$

c $10^2 \div 10^{-4}$

d $100^2 \div 10^2$

1.3 Converting units

When doing calculations, it is important to express your answer using sensible numbers. For example, an answer of 6230 μm would have been more meaningful expressed as 6.2 mm.

If you convert between units and round numbers properly, it allows quoted measurements to be understood within the scale of the observations.

To convert 488 889 m into km:

A kilo is 10^3 so you need to divide by this number, or move the decimal point three places to the left.

$$488\,889 \div 10^3 = 488.889 \text{ km}$$

However, suppose you are converting from mm to km: you need to go from 10^3 to 10^{-3} , or move the decimal point six places to the left.

$$333 \text{ mm is } 0.000\,333 \text{ km}$$

Alternatively, if you want to convert from 333 mm to nm, you would have to go from 10^{-9} to 10^{-3} , or move the decimal point six places to the right.

$$333 \text{ mm is } 333\,000\,000 \text{ nm}$$

Practice question

5 Calculate the following conversions: (4 marks)

a 0.004 m into mm

b 130 000 ms into s

c 31.3 ml into μl

d 104 ng into mg

6 Give the following values in a different unit so they make more sense to the reader.

Choose the final units yourself. (Hint: make the final number as close in magnitude to zero as you can.

For example, you would convert 1000 m into 1 km.)

a 0.000 057 m (2 marks)

b 8 600 000 μl (2 marks)

c 68 000 ms (2 marks)

d 0.009 cm (2 marks)

2 Decimals, standard form, and significant figures

2.1 Decimal numbers

A decimal number has a decimal point. Each figure *before* the point is a whole number, and the figures *after* the point represent fractions.

The number of decimal places is the number of figures *after* the decimal point. For example, the number 47.38 has 2 decimal places, and 47.380 is the same number to 3 decimal places.

In science, you must write your answer to a sensible number of decimal places.

Practice questions

1 New antibiotics are being tested. A student calculates the area of clear zones in Petri dishes in which the antibiotics have been used. List these in order from smallest to largest. (1 mark)

0.0214 cm^2

0.03 cm^2

0.0218 cm^2

0.034 cm^2

2 A student measures the heights of a number of different plants. List these in order from smallest to largest. (1 mark)

22.003 cm

22.25 cm

12.901 cm

12.03 cm

22 cm

2.2 Standard form

Sometimes biologists need to work with numbers that are very small, such as dimensions of organelles, or very large, such as populations of bacteria. In such cases, the use of scientific notation or standard form is very useful, because it allows the numbers to be written easily.

Standard form is expressing numbers in powers of ten, for example, 1.5×10^7 microorganisms.

Look at this worked example. The number of cells in the human body is approximately 37 200 000 000 000. To write this in standard form, follow these steps:

Step 1: Write down the smallest number between 1 and 10 that can be derived from the number to be converted. In this case it would be 3.72

Step 2: Write the number of times the decimal place will have to shift to expand this to the original number as powers of ten. On paper this can be done by hopping the decimal over each number like this:

6.3900000000

until the end of the number is reached.

In this example that requires 13 shifts, so the standard form should be written as 3.72×10^{13} .

For very small numbers the same rules apply, except that the decimal point has to hop backwards. For example, 0.000 000 45 would be written as 4.5×10^{-7} .

Practice questions

3 Change the following values to standard form. (4 marks)

a 3060 kJ b 140 000 kg c 0.000 18 m d 0.000 004 m

4 Give the following numbers in standard form. (4 marks)

a 100 b 10 000 c 0.01 d 21 000 000

5 Give the following as decimals. (4 marks)

a 10^6 b 4.7×10^9 c 1.2×10^{12} d 7.96×10^{-4}

2.3 Significant figures

When you use a calculator to work out a numerical answer, you know that this often results in a large number of decimal places and, in most cases, the final few digits are 'not significant'. It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

Numbers to 3 significant figures (3 s.f.):

7.88 25.4 741

Bigger and smaller numbers with 3 significant figures:

0.000 147 0.0147 0.245 39400 96200 000 (notice that the zeros before the figures and after the figures are *not* significant – they just show you how large the number is by the position of the decimal point).

Numbers to 3 significant figures where the zeros *are* significant:

207 4050 1.01 (any zeros between the other significant figures *are* significant).

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^8

If the value you wanted to write to 3.s.f. was 590, then to show the zero was significant you would have to write:

590 (to 3.s.f.) or 5.90×10^2

Remember: For calculations, use the same number of figures as the data in the question with the lowest number of significant figures. It is not possible for the answer to be more accurate than the data in the question.

Practice question

6 Write the following numbers to i 2 s.f. and ii 3 s.f. (8 marks)

a 7644 g

b 27.54 m

c 4.3333 g

d $5.995 \times 10^2 \text{ cm}^3$

7 The average mass of oxygen produced by an oak tree is 11800 g per year.

Give this mass in standard form and quote your answer to 2 significant figures. (2 marks)

3 Working with formulae

It is often necessary to use a mathematical formula to calculate quantities. You may be tested on your ability to substitute numbers into formulae or to rearrange formulae to find specific values.

3.1 Substituting into formulae

Think about the data you are given in the question. Write down the equation and then think about how to get the data to substitute into the equation. Look at this worked example.

A cheek cell has a 0.06 mm diameter. Under a microscope it has a diameter 12 mm. What is the magnification?

$$\text{Magnification} = \text{image size (mm)} \div \text{object size (mm)} \quad \text{or} \quad M = \frac{I}{O}$$

Substitute the values and calculate the answer:

$$M = 12 \text{ mm} / 0.06 \text{ mm} = 12 / 0.06 = 200$$

Answer: magnification = $\times 200$ (magnification has no units)

Sometimes an equation is more complicated and the steps need to be carried out in a certain order to succeed. A general principle applies here, usually known by the mnemonic BIDMAS. This stands for **B**rackets, **I**ndices (functions such as squaring or powers), **D**ivision, **M**ultiplication, **A**ddition, **S**ubtraction.

Practice questions

1 Calculate the magnification of a hair that has a width of 6.6 mm on a photograph. The hair is 165 μm wide. (1 mark)

2 Estimate the area of a leaf by treating it as a triangle with base 2 cm and height 9 cm. (2 marks)

3 Estimate the area of a cell by treating it as a circle with a diameter of 0.7 μm . Give your answer in μm^2 . (2 marks)

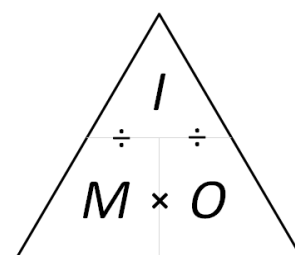
4 An *Amoeba* population starts with 24 cells. Calculate how many *Amoeba* cells would be present in the culture after 7 days if each cell divides once every 20 hours. Use the equation $N_t = N_0 \times 2^n$ where N_t = number after time t , N_0 = initial population, n = number of divisions in the given time t . (1 mark)

3.2 Rearranging formulae

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, the relationship between magnification, image size, and actual size of specimens in micrographs usually uses the

equation $M = \frac{I}{O}$, where M is magnification, I is size of the image, and O = actual size of the object.

You can use the algebra you have learnt in Maths to rearrange equations, or you can use a triangle like the one shown.



Practice questions

- 6 A fat cell is 0.1 mm in diameter. Calculate the size of the diameter seen through a microscope with a magnification of $\times 50$. (2 marks)
- 7 A Petri dish shows a circular colony of bacteria with a cross-sectional area of 5.3 cm^2 . Calculate the radius of this area. (2 marks)
- 8 In a photograph, a red blood cell is 14.5 μm in diameter. The magnification stated on the image is $\times 2000$. Calculate the real diameter of the red blood cell. (2 marks)
- 9 Rearrange the equation $34 = 2a/135 \times 100$ and find the value of a . (1 mark)
- 10 The cardiac output of a patient was found to be $2.5 \text{ dm}^3 \text{ min}^{-1}$ and their heart rate was 77 bpm. Calculate the stroke volume of the patient.
Use the equation: cardiac output = stroke volume \times heart rate. (2 marks)

11 In a food chain, efficiency = $\frac{\text{biomass transferred}}{\text{biomass taken in}} \times 100$

A farmer fed 25 kg of grain to his chicken. The chicken gained weight with an efficiency of 0.84. Calculate the weight gained by the chicken. (2 marks)

4 Magnification

To look at small biological specimens you use a microscope to magnify the image that is observed. The microscope was developed in the 17th century. Anton van Leeuwenhoek used a single lens and Robert Hooke used two lenses. The lenses focus light from the specimen onto your retina to produce a magnified virtual image. The magnification at which observations are made depends on the lenses used.

4.1 Calculating the magnifying power of lenses

Lenses each have a magnifying power, defined as the number of times the image is larger than the real object. The magnifying power is written on the lens.

To find the magnification of the virtual image that you are observing, multiply the magnification powers of each lens used. For example, if the eyepiece lens is $\times 10$ and the objective lens is $\times 40$ the total magnification of the virtual image is $10 \times 40 = 400$.

Practice questions

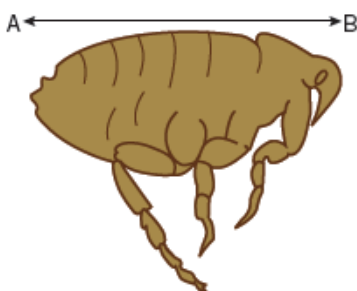
- 1 Calculate the magnification of the virtual image produced by the following combinations of lenses: (2 marks)
- a objective $\times 10$ and eyepiece $\times 12$ b objective $\times 40$ and eyepiece $\times 15$

4.2 Calculating the magnification of images

Drawings and photographs of biological specimens should always have a magnification factor stated. This indicates how much larger or smaller the image is compared with the real specimen.

The magnification is calculated by comparing the sizes of the image and the real specimen. Look at this worked example.

The image shows a flea which is 1.3 mm long. To calculate the magnification of the image, measure the image (or the scale bar if given) on the paper (in this example, the body length as indicated by the line A–B).



For this image, the length of the image (A to B) is 42 mm and the length of the real specimen is 1.3 mm.

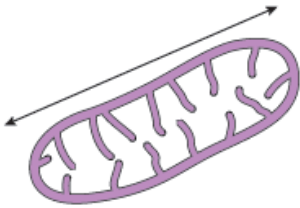
$$\text{magnification} = \frac{\text{length of image}}{\text{length of real specimen}} = 42/1.3 = 32.31$$

The magnification factor should therefore be written as $\times 32.31$

Remember: Use the same units. A common error is to mix units when performing these calculations. Begin each time by converting measurements to the same units for both the real specimen and the image.

Practice question

- 2 Calculate the magnification factor of a mitochondrion that is $1.5 \mu\text{m}$ long. (1 mark) (the measurement came to 39mm on my printout, these can vary)



4.3 Calculating real dimensions

Magnification factors on images can be used to calculate the actual size of features shown on drawings and photographs of biological specimens. For example, in a photomicrograph of a cell, individual features can be measured if the magnification is stated. Look at this worked example.

The magnification factor for the image of the open stoma is $\times 5000$.

This can be used to find out the actual size of any part of the cell, for example, the length of one guard cell, measured from A to B.

Step 1: Measure the length of the guard cell as precisely as possible. In this example the image of the guard cell is 52 mm long.

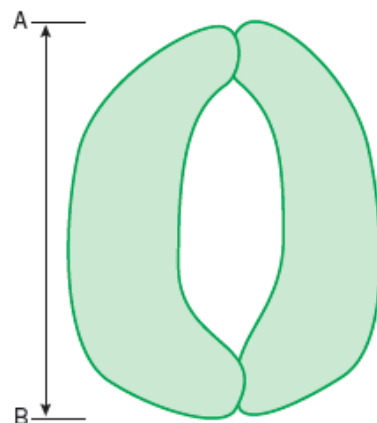
Step 2: Convert this measurement to units appropriate to the image. In this case you should use μm because it is a cell.

So the magnified image is $52 \times 1000 = 52\,000 \mu\text{m}$

Step 3: Rearrange the magnification equation (see Topic 3.2) to get:

real size = size of image/magnification = $52\,000/5000 = 10.4$

So the real length of the guard cell is $10.4 \mu\text{m}$.



Practice question

- 3 Use the magnification factor to determine the actual size of a bacterial cell. (2 marks) (the measurement



came to 26mm on my printout, these can vary!)

5 Percentages and uncertainty

A percentage is simply a fraction expressed as a decimal. It is important to be able to calculate routinely, but is often incorrectly calculated in exams. These pages should allow you to practise this skill.

5.1 Calculating percentages as proportions

To work out a percentage, you must identify or calculate the total number using the equation:

$$\text{percentage} = \frac{\text{number you want as a percentage of total number}}{\text{total number}} \times 100\%$$

For example, in a population, the number of people who have brown hair was counted.

The results showed that in the total population of 4600 people, 1800 people had brown hair.

The percentage of people with brown hair is found by calculating:

$$\begin{aligned} & \frac{\text{number of people with brown hair}}{\text{total number of people}} \times 100 \\ & = \frac{1800}{4600} \times 100 = 39.1\% \end{aligned}$$

Practice questions

- 1 The table below shows some data about energy absorbed by a tree in a year and how some of it is transferred.

Energy absorbed by the tree in a year	3 600 000 kJ/m ²
Energy transferred to primary consumers	2240 kJ/m ²
Energy transferred to secondary consumers	480 kJ/m ²

Calculate the percentage of energy absorbed by the tree that is transferred to
a primary consumers (1 mark) **b** secondary consumers. (1 mark)

- 2 One in 17 people in the UK has diabetes.

Calculate the percentage of the UK population that have diabetes. (1 mark)

5.2 Calculating the percentage change

When you work out an increase or a decrease as a percentage change, you must identify, or calculate, the total original amount:

$$\% \text{ increase} = \frac{\text{increase}}{\text{original amount}} \times 100$$

$$\% \text{ decrease} = \frac{\text{decrease}}{\text{original amount}} \times 100$$

Remember: When you calculate a percentage change, use the total *before* the increase or decrease, not the final total.

Practice questions

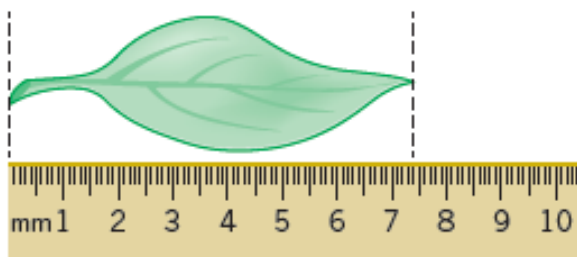
- 3 Convert the following mass changes as percentage changes. (5 marks) (remember to state if the change is + or -)

Sucrose conc. / mol dm ⁻³	Initial mass / g	Final mass / g	Mass change / g	Percentage change in mass
0.9	1.79	1.06		
0.7	1.86	1.30		
0.5	1.95	1.70		
0.3	1.63	1.76		
0.1	1.82	2.55		

5.3 Measurement uncertainties

When you measure something, there will always be a small difference between the measured value and the true value. This may be because of the size of the scale divisions on your measuring equipment, or the difficulty of taking the measurement. This is called an uncertainty.

To estimate the uncertainty of a measurement with an instrument with a marked scale such as a ruler, a good rule of thumb is to let the uncertainty be equal to half the smallest division on the scale being used.



Using a ruler with a mm scale, the length of the leaf seems to be 74 mm. The smallest division is 1 mm, so the uncertainty is 0.5 mm.

The true length is therefore 74 mm \pm 0.5 mm.

Practice question

- 4 Give the uncertainty for the following pieces of equipment: (3 marks)
- a large measuring cylinder with 2 cm³ divisions
 - b digital stopwatch timer measuring to the nearest hundredth of a second
 - c thermometer with 0.1 °C divisions.

5.4 Calculating percentage uncertainties

The uncertainty is the range of possible error either side of the true value due to the scale being used, so the value recorded for the measurement = closest estimate \pm uncertainty.

The difference between the true value and the maximum or minimum value is called the **absolute error**.

Once the absolute error has been established for a particular measurement, it is possible to express this as a percentage uncertainty. The calculation to use is:

$$\text{percentage uncertainty} = \frac{\text{absolute error}}{\text{measured value}} \times 100\%$$

In the leaf example above, the absolute error is ± 0.5 mm.

The relative error is therefore:

$$0.5/74 \times 100\% = 0.7\%$$

Practice questions

5 Complete the table to show the missing values in the last two columns. (5 marks)

Measurement made	Equipment used	Absolute error	Percentage uncertainty/%
Length of a fluid column in a respirometer is 6 mm	mm scale	0.5 mm	
Volume of a syringe is 12 cm ³ of liquid	0.5 cm ³ divisions		
Change in mass of 1.6 g	balance with 2 d.p.		

6 Scatter graphs and lines of best fit

The purpose of a scatter graph with a line of best fit is to allow visualisation of a trend in a set of data. The graph can be used to make calculations, such as rates, and also to judge the correlation between variables. It is easy to draw such a graph but also quite easy to make simple mistakes.

6.1 Plotting scatter graphs

The rules when plotting graphs are:

- Ensure that the graph occupies the majority of the space available:
 - In exams, this means more than half the space
 - Look for the largest number to help you decide the best scale
 - The scale should be based on 1, 2, or 5, or multiples of those numbers
- Ensure that the dependent variable that you measured is on the y-axis and the independent variable that you varied is on the x-axis
- Mark axes using a ruler and divide them clearly and equidistantly (i.e. 10, 20, 30, 40 not 10, 15, 20, 30, 45)
- Ensure that both axes have full titles and units are clearly labelled
- Plot the points accurately using sharp pencil 'x' marks so the exact position of the point is obvious
- Draw a neat best fit line, either a smooth curve or a ruled line. It does not have to pass through all the points. Move the ruler around aiming for:
 - as many points as possible on the line
 - the same number of points above and below the line
- If the line starts linear and then curves, be careful not to have a sharp corner where the two lines join. Your curve should be smooth
- Confine your line to the range of the points. Never extrapolate the line beyond the range within which you measured
- Add a clear, concise title.

Remember: Take care, use only pencil and check the positions of your points.

Practice questions

2 Use your calculated data in Topic 5.2 question 3 to plot a graph of % mass change against sucrose concentration. Add a line of best fit (remember a line can be straight or a smooth curve) (4 marks)
At what concentration of sucrose was there no percentage change? (1 mark)

3 a Plot a graph of the data on photosynthesis below. (4 marks)

b Describe the graph (3 marks)

c What is the name for when many factors are involved in a reaction such as photosynthesis? The L.... of L..... F..... (1 mark)

d what is limiting the rate of photosynthesis on the graph? (1 mark)

Sodium bicarbonate concentration / %	Rate of oxygen production by pondweed / mm ³ s ⁻¹
6.5	1.60
5.0	1.50
3.5	1.20
2.0	0.80
1.0	0.50
0.5	0.30

Basic chemistry for A level Biology

Complete the missing words (20 marks)

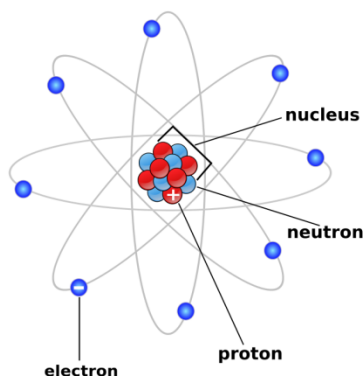
MISSING WORDS

Neutrons, arrangement, carbon-14, charge, weak, alkaline, covalently, number, accepts, ions, compound, acid, same, glucose, protons, nitrate, sodium, four, neutrons, bond.

ATOMS MOLECULES AND IONS

To survive grow and reproduce organisms need a constant supply of materials. This exercise is about the building blocks from which materials are made.

ATOMS



All matter is made up from atoms. Atoms are made up from three subatomic particles, 1 and protons which form the nucleus. Neutrons have no overall charge, 2 a positive charge and electrons a negative charge. Atoms contain equal numbers of protons and electrons, so they have no overall 3.

IONS

Since electrons have a negative charge, atoms which gain electrons develop a negative charge and those that lose them develop a positive charge.

- Ions are represented using the chemical symbols for their elements and a + or - sign to indicate charge. E.g. Na^+ is a positively charged 4 atom.
- Groups of atoms can be charged. You need to learn 5 ion = NO_3^- , and phosphate ion = PO_4^{3-}

ELEMENT

All atoms contain the 6 number of protons. E.g. oxygen is the element which has 8 protons. Carbon contains 6 protons. The names and symbols of atoms you need to learn are Carbon (C), Hydrogen (H), Oxygen (O), sulphur (S), potassium (K), Sodium (Na), phosphorous (P), nitrogen (N), chlorine (Cl), iron (Fe), magnesium (Mg)

ISOTOPES

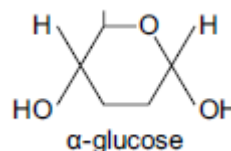
The atoms which form elements always contain the same number of protons. However they can have different numbers of 7. e.g. carbon atoms always have 6 protons in their nucleus and most also have 6 neutrons too. Their mass number is therefore 12. Some carbon atoms have 8 neutrons instead. Their mass number is therefore 14 so they are referred to as 8 (^{14}C). The 2 isotopes have the same chemical properties. However carbon-14 is radioactive. Isotopes can be used in biology as a marker to track the sequence of chemicals in a metabolic pathway or to carbon date fossils.

MOLECULE

A molecule consists of 2 or more atoms chemically joined together. This can be ionic or 9 bonded. The atoms may be the same element (e.g. O_2) or they can be different elements, e.g. 10 ($\text{C}_6\text{H}_{12}\text{O}_6$). If the atoms are different elements we call it a 11.

FORMULAE

- Molecular formula shows the 12 of atoms of each element joined together e.g. glucose $\text{C}_6\text{H}_{12}\text{O}_6$
- Structural formula shows the 13 of these atoms



ACIDS BASES AND BUFFERS

- An 14 is a substance which releases H^+ ions (protons) in solution e.g. carboxylic acid $-\text{COOH} \rightarrow \text{COO}^- + \text{H}^+$
- A base is a substance which 15 a proton e.g. the amino group $-\text{NH}_2$

- An alkali is a type of base which increases the concentration of hydroxyl ions (OH⁻) when it dissolves in water. This raises the pH i.e. makes it more 16 .
- Buffers are substances which fulfil the roles of acids and bases, so pH is maintained within a narrow range under normal conditions. E.g. amino acids/proteins like haemoglobin act as buffers.

pH

Living organisms can usually only survive a narrow range of pH. Acidity and alkalinity are measured with a logarithmic scale called **pH**. Here is why: a strongly acidic solution can have one hundred million million (100,000,000,000,000) times more hydrogen ions than a strongly basic solution! The flip side, of course, is that a strongly basic solution can have 100,000,000,000,000 times more hydroxide ions than a strongly acidic solution. Moreover, the hydrogen ion and hydroxide ion concentrations in everyday solutions can vary over that entire range.

In order to deal with these large numbers more easily, scientists use a *logarithmic* scale, the pH scale. Each one-unit change in the pH scale corresponds to a ten-fold change in hydrogen ion concentration. The pH scale ranges from 0 to 14. It's a lot easier to use a logarithmic scale instead of always having to write down all those zeros.

pH is the negative logarithm of the hydrogen ion concentration:

$$\text{pH} = -\log [\text{H}^+]$$

The square brackets around the H⁺ automatically mean "concentration" to a chemist. We will teach you about the logarithmic scale as part of your A level Biology.

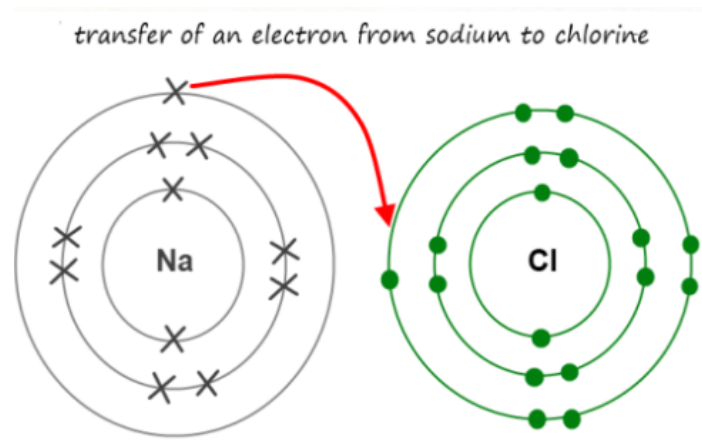
pH Value = $-\log [\text{H}^+]$	H ⁺ Concentration Relative to Pure Water	Example
0	10 000 000	battery acid
1	1 000 000	concentrated sulfuric acid
2	100 000	lemon juice, vinegar
3	10 000	orange juice, soda
4	1 000	tomato juice, acid rain
5	100	black coffee, bananas
6	10	urine, milk
7	1	pure water
8	0.1	sea water, eggs
9	0.01	baking soda
10	0.001	Great Salt Lake, milk of magnesia
11	0.000 1	ammonia solution
12	0.000 01	soapy water
13	0.000 001	bleach, oven cleaner
14	0.000 000 1	liquid drain cleaner

CHEMICAL BONDS

When atoms combine they are held together by forces called chemical bonds. There are 3 types of bond you need to know;

IONIC BOND

These are formed when atoms either gain or lose electrons to form 17. e.g. the electrons lost from a sodium atom as it ionises can be taken up by a chlorine atom as it ionises. Since sodium ions are positive and chloride ions are negative, they will attract each other. The ionic 18 is the electrostatic force which attracts them and holds them near each other in a salt crystal.



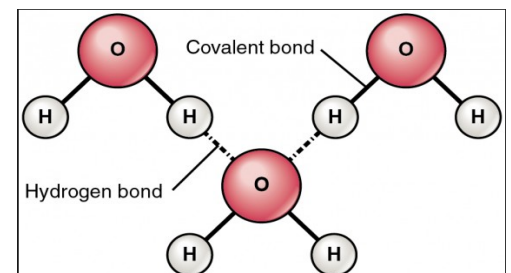
COVALENT BOND

This is when the atoms share the electrons. Carbon plays a unique role in biology as it can form strong covalent bonds with up to 19 other (carbon) atoms. The main groups of chemicals in living organisms, proteins, carbohydrates, lipids and nucleic acids (DNA etc.) are made mostly from a mixture of carbon, hydrogen, oxygen and nitrogen which are covalently bonded. Some of these atoms share two or even three pairs of electrons with another atom forming double or triple covalent bonds.

HYDROGEN BOND

A hydrogen bond is a 20 bond (1/20th the strength of a covalent bond). It occurs as the electrons are unevenly distributed in a molecule such as water. The electrons are more attracted to the oxygen than the hydrogen leaving the oxygen very slightly negative and the hydrogen very slightly positive. This means the slightly positive hydrogen of one water molecule will be attracted to the slightly negative oxygen molecule of a different water molecule. This attraction is the hydrogen bond.

Hydrogen bonding can occur between other molecules which have the uneven distribution of electrons e.g. in cellulose between chains.



The end! (Well done)