CHRIST THE KING

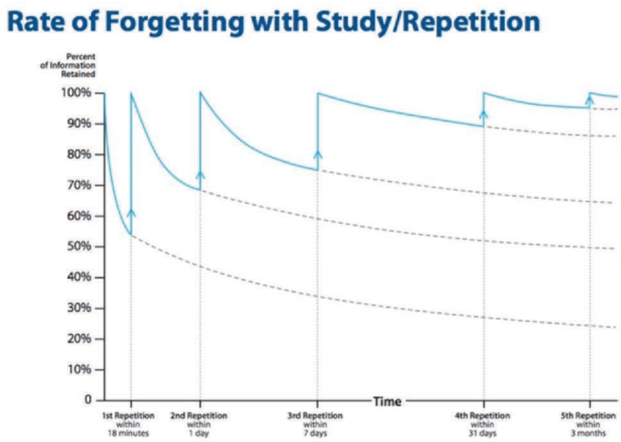
KNOWLEDGE ORGANISER

YEAR 9

Knowledge Organisers

As you move into Year 9, we would like you to continue to use knowledge Organisers to support your learning and help you achieve. Knowledge Organisers improve your confidence by helping you to understand how to learn and revise. This is part of our seven-year revision strategy that supports you to remember the core and powerful knowledge that is required to be successful in each subject.

The Ebbinghaus Forgetting Curve demonstrates that knowledge is lost over time if it is not revisited. A simple model for memory involves working memory and long term memory; working memory is limited, and can very easily become overloaded, whereas long-term memory is effectively limitless. You can support your limited working memory by storing key facts and processes in your long-term memory. Research evidence indicates that regular recall activities, known as retrieval practice, are an effective way of ensuring that knowledge is committed to long-term memory.



At the start of each term, you will receive a knowledge organiser that contains content for your core subjects of RE, English, Maths and Science. Your option subject teachers will then give you knowledge organisers for their subject depending on the subjects you have chosen, which you will add, to make it complete. You will continue to use your knowledge organiser in your lessons, in tutor time, and during independent learning tasks. An important aspect of your revision for assessments and end-of-year examinations will be to use the knowledge organisers for self-quizzing. If this core knowledge is secured, you will be in a strong position to use and apply this knowledge in a range of contexts. You will be given your knowledge organiser in a plastic wallet along with a homework booklet – the expectation is that you bring this to school every day – it should be placed on your desk in every lesson, ready to use.

How to use your Knowledge Organiser

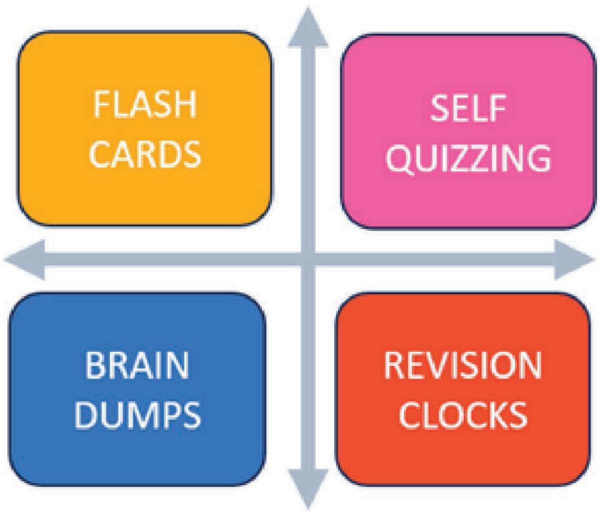
The best way to use your knowledge organisers is to regularly use one of our Core 4 Revision strategies as part of your home learning.

- **Flash Cards:** Use the information from your knowledge organiser to create flashcards – these could be double sided, with a question on one side and the answer on another, or a keyword on one side and the definition on the other.

- **Self Quizzing:** There are different ways you can self-quiz:
  - Look, cover, write, (say), check
  - Create gaps fills
  - Create questions for the information you want to learn and then answer them from memory

- **Brain dumps:** These are a small but powerful revision strategy which help makes the information 'sticky' so that it goes into your long-term memory, ready for you to recall it into your working memory. They are good to use at the end of topics. An effective brain dump involves you writing down everything you can about a topic you want to revise from your memory. You then check the information against the information on your Knowledge Organiser – you then mark your work and add any missing information onto your brain dump in a different colour pen, so that you know which information you need to revisit, either through using flash cards or self-quizzing.

- **Revision Clocks:** Revision Clocks are a blank clock shape – divided into 12 segments. In each segment put a sub-heading and then include the information linked to that. They are effective as they allow you to 'chunk' up the core knowledge from the topic into the segments. You can use colours and pictures to make the information more 'sticky'.



Homework Schedule

In Year 9, you should aim to complete at least 1 hour 30 minutes of Home Learning per school day. Your teachers will usually set you one homework per week, which should take you approximately 45 minutes to complete but may vary slightly depending on the task and subject. This may be a knowledge organiser based task, something online, a research task or something else depending on the subject. However, if you have no tasks set, please revisit your learning for that day and carry out knowledge organiser activities or consolidate your learning for a specific subject. You should also aim to continue to read for two periods of 20 minutes each week.

The following timetable illustrates how you could chunk up your time to ensure you cover all subjects per week, whilst also giving you a free evening to revise a specific subject or topic of your choice.

Week 1					
45 Minutes Per Subject	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Subject 1	RE	English	Your Choice	Maths	Science
Subject 2	Option 1	Option 2	Your Choice	Option 3	Option 4

Week 2					
45 Minutes Per Subject	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Subject 1	RE	English	Science	Maths	Your Choice
Subject 2	Option 4	Option 2	Option 3	Option 1	Your Choice

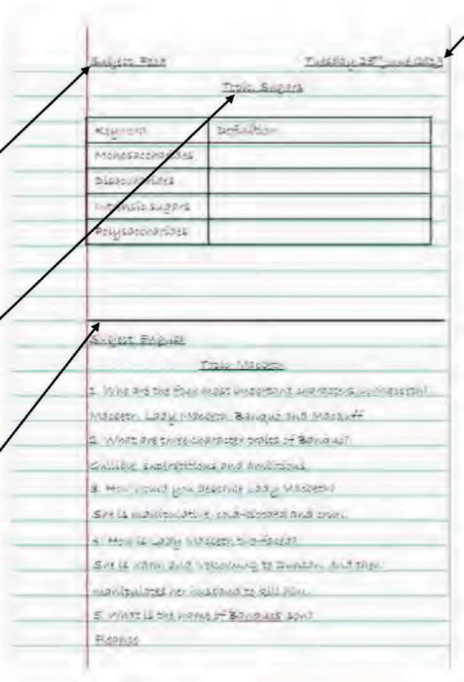
Read 20 minutes a day and you'll read 1,800,000 words per year.

Reading for 6 minutes a day reduces stress by 68%.

Children learn 4,000 to 12,000 words per year through reading,

Homework Expectations

Please remember that the same rules apply to the presentation of your homework as applies for your class work: dates and titles (which should be the name of the subject) need to be underlined with a ruler and you should present your work as neatly as you are able to.



Subject written on the left-hand side of the page and underlined.
For example: <u>Food</u>

Topic written on the centre of the page and underlined.
For example: <u>Sugars</u>

One single straight line between both pieces of homework.

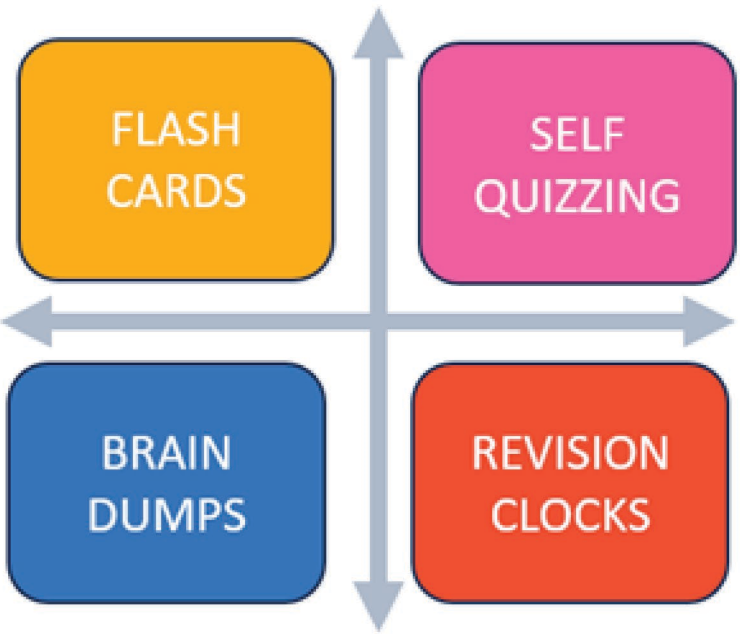
Date written fully on the right-hand side of the page and underlined. This should be the day you complete the homework.

Remember!

Research shows that homework and revision are most effective when the conditions support learning.

- Sit at a desk.
- Avoid distractions: NO PHONES/ MUSIC.
- Work in a quiet space i.e., bedroom/library.

Our library is open after school for revision and homework.



Use CTK's Core 4!

Use one of our Core 4 revision techniques to help you learn the information – remember do not just copy out the knowledge organiser, summarise and put into your own words.

Where relevant try to include diagrams or sketches to visually represent the topic.

If you are self-quizzing correctly, there should be evidence of green pen on your page.

THE CORE FOUR

How to Create Flash Cards

1. Identify Knowledge
- What are you creating flashcards on?
- Do you have your knowledge organiser?
- Use your book to look at previous misconceptions from whole class feedback.

2. Colour Coding
- Use different coloured flash cards for different topics. This helps with organisation, NOT recall.

3. Designing
- 1 Question per flash card - make them concise and clear
- Use a one-word prompt, so that you can recall as much as you can
- No extended answer questions
- Number your cards for self-quizzing.

4. Using
- Write your answers down, then check, or say your answers out loud. This clearly shows the gaps in your knowledge.
- Do not just copy and re-read.
- Shuffle the cards each time you use them.
- Use the Leitner system to use flash cards every day.

5. Feedback
- How have you performed when you look back at your answers?
- Is there anything you need to revisit in more detail?
- Is your knowledge secure? If so, move on to applying knowledge in that area in specific extended exam questions.

Brain Dumps

1. Identify Knowledge
- Identify the knowledge / topic area you want to cover.

2. Write it Down
- Take a blank piece of paper/white board and write down everything you can remember about that topic (with no prompts)
- Give yourself a timed limit (e.g 10 minutes)

3. Organise Information
- Once complete and you cannot remember any more, use different colours to highlight / underline words in groups.
- This categorises / links information

4. Check Understanding
- Compare your brain dump to your Knowledge Organiser or book and check your understanding.
- Add any key information you have missed (key words) in a different colour.

5. Store and Compare
- Keep your brain dump safe and revisit it.
- Next time you attempt the same topic, try and complete the same amount of information in a shorter period of time or add more information.

THE CORE FOUR

Revision Clocks

1. Identify Knowledge
Select a topic you wish to revise. Have your class notes, knowledge organiser or revision books ready.

2. Designing
You can make your own revision clock by drawing a clock in the centre of a page and dividing it into 12 chunks. You can also use an existing template from your teacher, or one you can find online.

3. Manageable Chunks
Organise your revision notes into 12 sub-topics and make brief notes for each sub-topic into one of the segments on the page, creating manageable chunks of information. Combine text with images to help retain the information.

4. Using Revision Clocks
Revise each segment for 5 minutes. Turn the clock over and recite the sections out loud or ask someone to quiz you.

Alternatively, you can revise certain sections for 5 minutes and use a blank revision clock with headings, recall as much information as you can in the segments.

5. Check Understanding
How have you performed when you compare you answers to what you have written? Is your knowledge secure?

Remember to repeat the process regularly, using different techniques to answer the questions.

Put it somewhere visible for you to use again.

Self Quizzing

1. Identify Knowledge
- Identify knowledge / content you wish to cover

2. Review and Create
- Spend around 5 – 10 minutes reviewing content (knowledge organisers / class notes / textbook.)
- Create 10 questions on the content (if your teacher has not provided you with questions already)

3. Cover and Answer
- Cover up your knowledge and answer the questions from memory.
- Take your time and where possible answer in full sentences.

4. Self Mark and Reflect
- Go back to the content and self-mark your answers in green pen.

5. Next Time
- Revisit the areas where there were gaps in knowledge and include these same questions next time.

RE – Judaism Beliefs

	Key Words	
1	Torah	The first 5 books of the Hebrew Bible
2	Tenakh	The Hebrew Bible consisting of the Torah, Nevi'im and Kethuvim
3	Talmud	The oral laws and traditions passed down from Moses, eventually written down as the Mishnah and Gemara.
4	Shema	The main Jewish declaration of faith
5	Messiah	The anointed one, the King sent from God
6	Messianic Age	A time when the Messiah is ruling the world
7	Yeshiva	Jewish school of Talmudic study
8	Rabbi	Jewish teacher or religious leader
9	Tikkun Olam	Acts of kindness performed to repair the world
10	Circumcision	Removing the foreskin of the penis; 'Brit Milah' is the name of the Jewish ceremony of circumcision
11	Shekinah	Means the presence of God

	Key Sources of Authority	
1	Shema	*'Hear O Israel, the Lord is our God, the Lord is One'*
2	Talmud Sanhedrin	*'whenever ten are gathered for prayer, there the Shekinah rests'*
3	Genesis	*'an everlasting covenant, to be a God to you and to your offspring'*

	Key Facts
1	God is One, Creator, Lawgiver and Judge
2	The qualities of God are generally agreed upon by all Jews, although they may interpret them in divergent ways
3	God has many names in the Bible, which helps Jews understand some of the characteristics of God
4	These characteristics and names of God are important in Judaism as they help Jews understand something of the nature of God
5	God is present in every aspect of life
6	Some Jews try and connect with the Shekinah through the study of the Torah, in prayer and during worship
7	The idea of the Messiah is an ancient one in Judaism and is based around a great leader rather than a saviour
8	The characteristic and tasks of the Messiah are described predominately in The Nevi'im
9	Many Jews live in expectation of the Messiah or Messianic Age and live their lives accordingly
10	In Judaism a covenant is an everlasting agreement between God and man
11	God and Abraham entered into a covenant that promised many descendants, a Promised Land, and a blessed nation
12	God showed that he would keep his promises; this remains important to Jews today
13	Israel is the Promised Land which Abraham and Sarah settled

RE – Judaism Beliefs

Key Words		
1	Pikuach Nefesh	Most Jewish laws can be broken to save a life
2	Mitzvot	Commandments which set rules or guide action (singular = mitzvah)
3	Halakhah	Teaches Jews how to perform or fulfil the Mitzvot
4	Omniscience	God's complete knowledge of all human actions, past, present and future
5	Olam Ha-Ba	'The World to Come'; term used for both the Messianic Age and a spiritual afterlife following physical death
6	Gan Eden	Garden of Eden – not the same place where Adam and Eve lived, but a pure spiritual heaven
7	Gehinnom	A place for a set time of purification of the soul
8	Mishneh Torah	Maimonides' compiled list of 613 Mitzvot
9	Sefer Madda	One of the books of the Mishneh Torah 'the Book of Knowledge' that explains the idea that the foundation of everything is God, and therefore moral principles should begin from the same point

	Key Sources of Authority	
1	Genesis	*'so God created Man in his Image'*
2	Maimonides	*' I believe with perfect faith that there will be a revival of the dead at the time when it shall please the Creator*
3	Deuteronomy	*'I present before you today a blessing and a curse*

	Key Facts
1	The Jewish people entered into a covenant with God after Moses had led them out of slavery in Egypt to the Promised Land
2	Moses received the Torah or Law, which continues to play an important role in Judaism today
3	The story of Creation in Genesis makes it clear that God is the giver of life, so life is sacred
4	Pikuach Nefesh influences how Jews approach moral and ethical decisions such as abortions and euthanasia
5	Jews follow the Mitzvot as they form part of the covenant between the Jewish people and God
6	Jews believe they have free will and a choice in following the Mitzvot
7	By carrying out good deeds towards other humans, Jews believe they are fulfilling an important part of Jewish life
8	Most Jews concentrate on living a righteous life rather than an afterlife
9	Jews do not agree on the nature or form of life after death, but are generally convinced death is not the end
10	Some Jews believe that in the world to come (Olam Ha-Ba), there will be a heaven (Gan Eden) and a place of purification (Gehinnom)
11	There is little scripture on life after death and so most teaching comes from ancient Rabbis such as Maimonides

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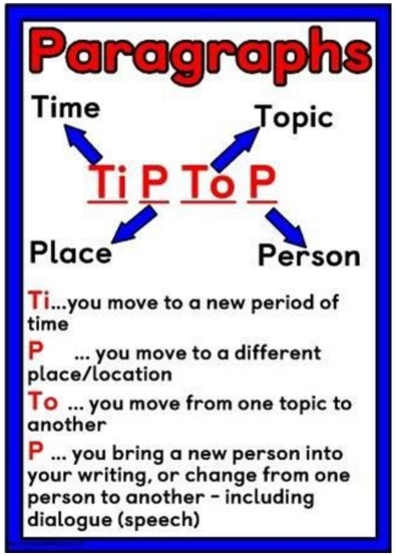
English – Speaking & Writing from a Viewpoint

Persuasive Devices	Definition/example
Direct address	Personal pronouns ‘you, we,’ used to speak directly to the audience/reader
Alliteration	Series of words beginning with the same consonant sound
Facts	Real information used as evidence in a letter or speech
Opinion	The personal and biased viewpoint of the writer/speaker
Repetition	Repeating the same words or phrases
Rhetorical questions	a question asked for dramatic effect or to make a point, rather than to get an answer
Emotive Language	Words which evoke some emotional response from the listener/reader
Statistics	numerical evidence used to support an idea e.g %
Triplets	Using the same language technique, three times, in a sentence

Text-type	Features
Persuasive letter	• Recipient’s address (top-right) • Sender’s address (top-left) • Title (beginning) – Dear Sir, • Direct address • Salutation (ending) – Yours sincerely,
Persuasive speech	• Greeting (Good morning/evening/ ladies and gentlemen) • Direct address • Salutation (ending) – Thank you for listening.

Connectives	Use to open paragraphs and link them together
Furthermore	To develop a point further
Therefore	To explain an idea
On the other hand	To introduce a counterargument
Firstly	To introduce your first paragraph



Punctuation	When to use
.	Mark end of a sentence
?	Mark end of a question
!	Mark end of an emotive sentence
“ “	Start and end of speech
‘ (apostrophe)	Indicate possession or omission
,	Separate lists, subordinate clauses
:	Start of a list
;	Separate two independent clauses
( )	Enclose extra information

1 Charge of the Light Brigade	The Crimean War was between the Russian and the British in 1854. The Russians were armed with canons and the British had swords. The Russians had the advantage of surrounding the higher land around the valley. **'Into the jaws of Death, Into the mouth of Hell'**	**Alfred Tennyson** Poem was based on a newspaper report that the poet saw in a newspaper. The order to charge was a mistake and it cost the British in terms of casualties. He was not directly involved in the war but wanted everyone to recognise how brave the soldiers had been.
2 Remains	The poem is an account from Guardsman Tromans about being one of a group of soldiers that kill a looter that is robbing a bank in Basra, Iraq. **'probably armed, possibly not' 'his bloody life in my bloody hands'**	**Simon Armitage** Wrote the poem to show the aftereffects of war on a real soldier, who was interviewed for a documentary and collection of poems called 'The Not Dead'. Armitage wanted to raise awareness of PTSD being experienced after war.
3 Poppies	The poem is from the perspective of a mother who sends her son off to fight. **'the world overflowing/ like a treasure chest' 'hoping to hear your playground voice catching on the wind'**	**Jane Weir** Commissioned to write Poppies by Carol Ann Duffy as a contemporary war poem. Written from the perspective of a mother letting her child go.
4 Bayonet Charge	The soldier in this poem is scared and worried. He is not ready to go to run and attack the enemy. **'Suddenly' 'A rifle as numb as a smashed arm' Sweating 'like molten iron'**	**Ted Hughes** Too young to have fought in the first world war but his father did. It's only about a single soldier and suggests that war is a terrifying experience.
5 War Photographer	The poem is not about a soldier but a civilian: whose job is to take photos of war situations without participating, or being able to help. **'In his dark room he is finally alone' 'Beneath his hands which did not tremble then / Though seem to now'**	**Carol Ann Duffy** Knew a real war photographer (Don McCullin) and is interested in whether it is right to take pictures of suffering like this.

Straight Line Graphs

Sparx Codes M797 M932 M544

1 Key Words

Gradient: The steepness of a line.
Intercept: Where two lines cross.
Y-intercept: Where the line meets the y-axis.
Parallel: Two lines that will never meet with the same gradient.
Co-ordinate: A set of values that show an exact position on a graph.
Linear: linear graphs (straight line)-linear common difference by addition or subtraction.
Asymptote: A straight line that a graph will never meet.
Reciprocal: A pair of numbers that multiply together to give 1.
Perpendicular: Two lines that meet at a right angle.

2 y = mx + c

The coefficient of x (the number in front of x) tells us the gradient of the line

$$y = mx + c$$

The value of c is the point at which the line crosses the y-axis. Y intercept

y and x are coordinates

The equation of a line can be rearranged. Eg:

$y = c + mx$

$c = y - mx$

Identify which coefficient you are identifying or comparing

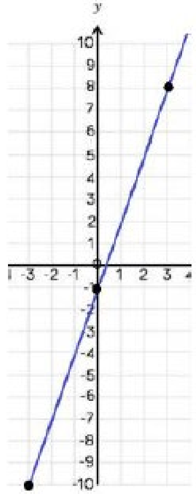
3 Plotting y = mx + c graphs

$y = 3x - 1$ → 3 x the x coordinate then – 1

x	-3	0	3
y	-10	-1	8

Draw a table to display this information

This represents a coordinate pair (-3, -10)



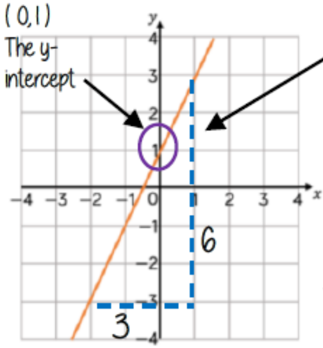
You only need two points to form a straight line

Plotting more points helps you decide if your calculations are correct (if they do make a straight line)

Remember to join the points to make a line

4 Find the equation from a graph

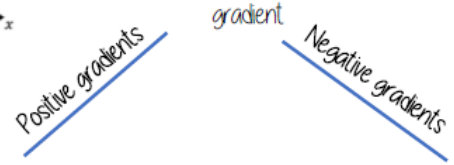
(0,1) The y-intercept



The Gradient $\frac{6}{3} = 2$

$$y = 2x + 1$$

The direction of the line indicates a positive gradient



Forming and Solving Equations

Sparx Codes M509 M957 M118 M554

Key Words (1)

Inequality: An inequality compares who values showing if one is greater than, less than or equal to another.

Variable: A quantity that may change within the context of the problem.

Rearrange: Change the order

Inverse operation: The operation that reverses the action.

Substitute: Replace the variable with a numerical value.

Solve: Find a numerical value that satisfies an equation.

(2) Equations with unknown on both sides

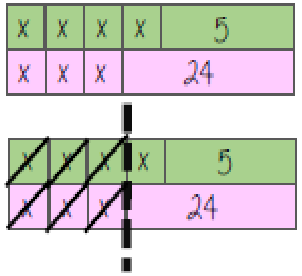
$4x + 5 = 3x + 24$

$-3x \quad -3x$

$x + 5 = 24$

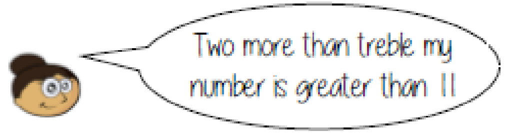
$-5 \quad -5$

$x = 19$



(3) Form and solve inequalities

R



Find the possible range of values

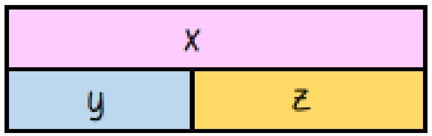
$3x + 2 > 11$

Solve

$x \leftarrow -3 \leftarrow -2 \leftarrow 11$

$x > 3$

Rearranging Formulae (one step) (4)



$x = y + z$

Rearrange to make y the subject

$y = x - z$

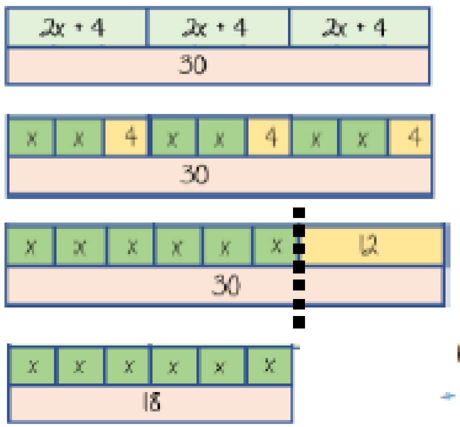
$y \longrightarrow +z \longrightarrow x$

$y \longleftarrow -z \longleftarrow x$

Using inverse operations or fact families will guide you through rearranging formulae

Solve equations with brackets (5)

R



$3(2x + 4) = 30$

Expand the brackets

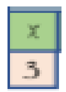
$6x + 12 = 30$

$-12 \quad -12$

$6x = 18$

$\div 6 \quad \div 6$

$x = 3$



Testing conjectures

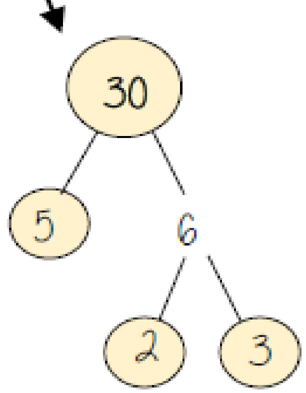
Sparx Codes M108 M227 M698

Key Words (1)

Multiples: found by multiplying any number by positive integers.
Factor: Integers that multiply together to get another number.
Prime: An integer with only 2 factors.
HCF: Highest common factor (biggest factor two or more numbers share)
LCM: Lowest common multiple (the first time the times table of two or more numbers match)
Verify: The process of making sure a solution is correct.
Proof: Logical mathematical arguments used to show the truth of a statement.
Binomial: A polynomial with two terms.
Quadratic: A polynomial with four terms (often simplified to three terms)

(2) Factors, Multiples and Primes

Multiplication part-whole models



All three prime factor trees represent the same decomposition

HCF – Highest common factor

HCF of 18 and 30

18	1, 2, 3, 6, 9, 18
30	1, 2, 3, 5, 6, 10, 15, 30

Common factors are factors two or more numbers share

LCM – Lowest common multiple

LCM of 9 and 12

9	9, 18, 27, 36, 45, 54
12	12, 24, 36, 48, 60

Common multiples are multiples two or more numbers share

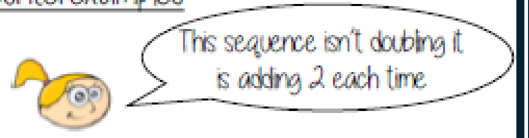
True or False? (3)

Conjecture

A pattern that is noticed for many cases

1, 2, 4.....
The numbers in the sequence are doubling each time.

Counterexamples



Only one counterexample is needed to disprove a conjecture

Always, Sometimes, Never true. (4)

Always	Every value always supports the statement
Sometimes	Examples show the statement being true and counter examples to show when it is false.
Never	No example supports the statement

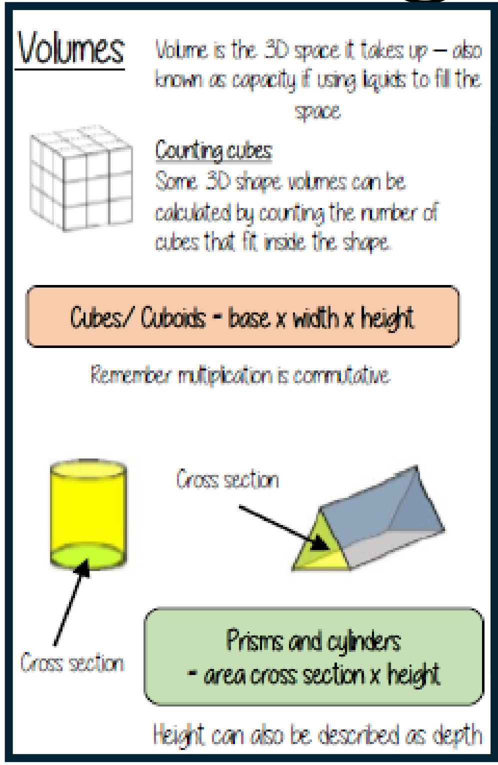
Examples to try
- 0 and 1
- Fractions
- Negative numbers

3D Shapes Sparx Codes Q675 M534 M765

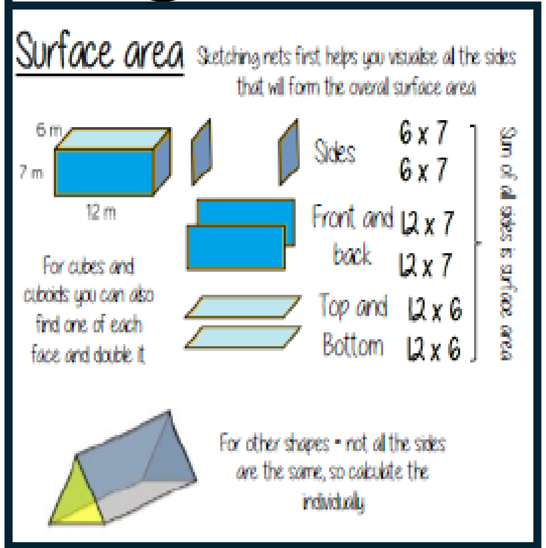
Key Words (1)

3D: Three dimensions to the shape e.g. length, width and height
Vertex: A point where two or more-line segments meet
Edge: A line on the boundary joining two vertex
Face: a flat surface on a solid object
Plan: a drawing of something when drawn from above (birds eye view)
Surface Area: Total area of all faces om a 3D shape
Volume: The amount of space taken up by a 3D shape

(2)



(3)



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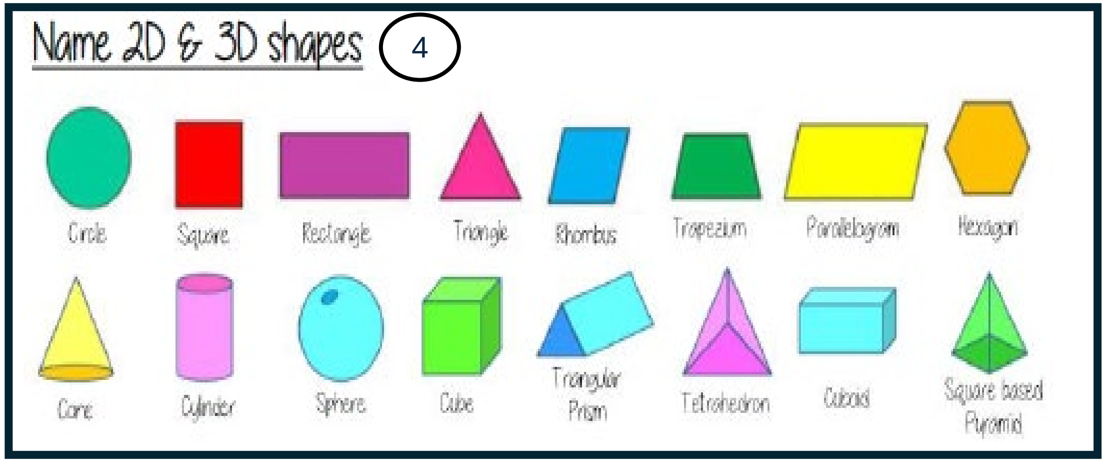

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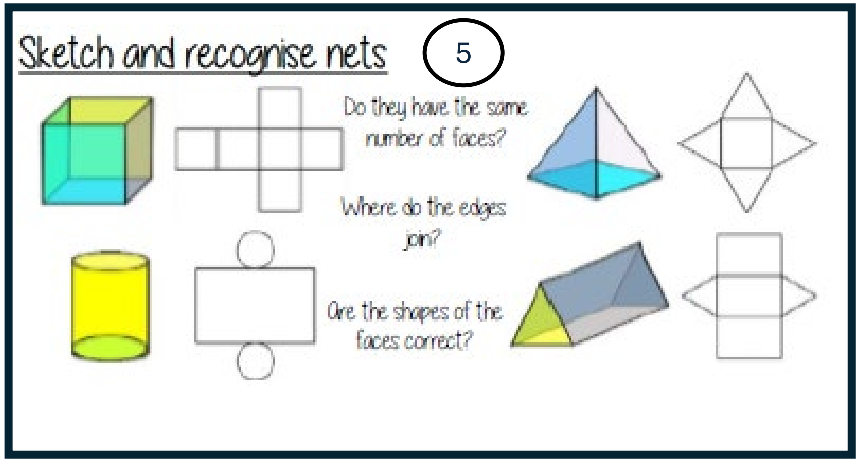


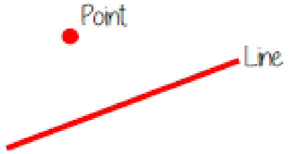
Constructions

Sparx Codes M565 M239 M253

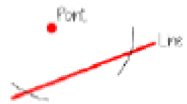
Key Words (1)

Protractor: Piece of equipment used to measure and draws angles
Locus: Set of points with a common property
Equidistant: The same distance.
Perpendicular: Lines that meet at 90°
Arc: Part of a curve.
Bisector: A line that divides something into two equal parts.
Congruent: The same shape and size.

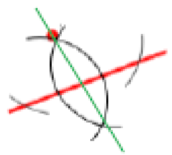
(2) Construct a perpendicular from a point



Use a compass and draw an arc that cuts the line. Use the point to place the compass



Keep the compass the same distance and now use your new points to make new interconnecting arcs



Connecting the arcs makes the bisector

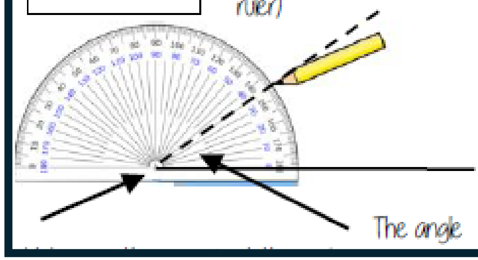
If P is a point on the line the steps are the same

(3) Draw and measure angles

R

Draw a 35° angle

Make a mark at 35° with a pencil And join to the angle point (use a ruler)



Congruent triangles (6)

Side-side-side

All three sides on the triangle are the same size

Angle-side-angle

Two angles and the side connecting them are equal in two triangles

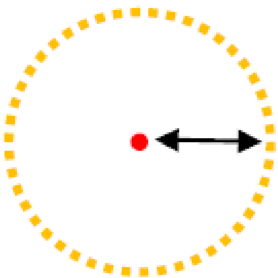
Side-angle-side

Two sides and the angle in-between them are equal in two triangles (it will also mean the third side is the same size on both shapes)

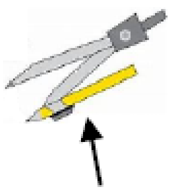
Right angle-hypotenuse-side

The triangles both have a right angle, the hypotenuse and one side are the same

Locus of a distance from a point (4)



All points are equidistant (the same distance) from the fixed point in the middle.



Equipment needed

The radius is the distance from the fixed point

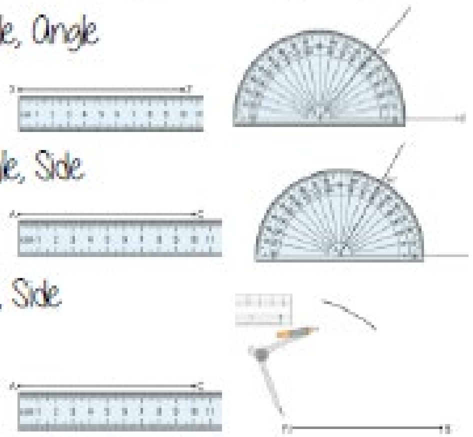
If the point is in the corner it can only make a quarter circle

Constructing Triangles (5)

Side, Angle, Angle

Side, Angle, Side

Side, Side, Side

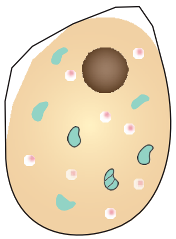


Biology - Cell biology and transport

1. Eukaryotic cells

Animal and plant cells are eukaryotic. They have genetic material (DNA) that forms **chromosomes** and is contained in a **nucleus**.

Animal cell



cell membrane: controls the movement of substances in and out of a cell

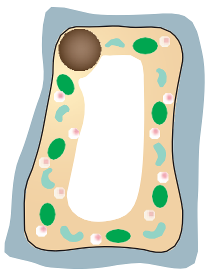
nucleus: contains DNA

mitochondria: where energy is released through respiration

ribosomes: site of protein synthesis

cytoplasm: jelly-like substance, where chemical reactions happen

Plant cell



permanent vacuole: contains cell sap

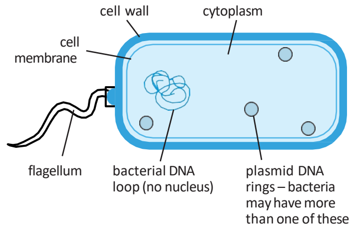
chloroplasts: contain chlorophyll to absorb light energy for photosynthesis

cell wall: made of cellulose, which strengthens the cell

2. Prokaryotic cells

Bacteria have the following characteristics:

- single-celled
- no nucleus – have a single loop of DNA
- have small rings of DNA called **plasmids**
- smaller than eukaryotic cells.



3. Microscopes

Light microscope	Electron microscope
uses light to form images	uses a beam of electrons to form images
living samples can be viewed	samples cannot be living
relatively cheap	expensive
low magnification	high magnification
low resolution	high resolution

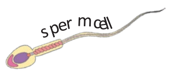
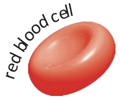
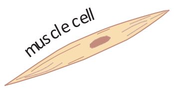
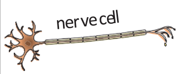
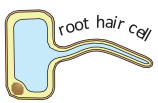
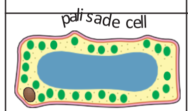
Electron microscopes allow you to see sub-cellular structures, such as ribosomes, that are too small to be seen with a light microscope.

To calculate the **magnification** of an image:

$$\text{magnification} = \frac{\text{image size}}{\text{actual size}}$$

4. Specialised cells

Cells in animals and plants differentiate to form different types of cells. Most animal cells differentiate at an early stage of development, whereas a plant's cells differentiate throughout its lifetime.

Specialised cell	Function	Adaptations
 sperm cell	Fertilise an ovum (egg)	• Tail to swim to the ovum and fertilise it • Lots of mitochondria to release energy from respiration, enabling the sperm to swim to the ovum
 red blood cell	Transport oxygen around the body	• No nucleus so more room to carry oxygen • Contains a red pigment called haemoglobin that binds to oxygen molecules • Flat bi-concave disc shape to increase surface area- to- volume ratio
 muscle cell	Contract and relax to allow movement	• Contains protein fibres, which can contract to make the cells shorter • Contains lots of mitochondria to release energy from respiration, allowing the muscles to contract
 nerve cell	Carry electrical impulses around the body	• Branched endings, called dendrites, to make connections with other neurones or effectors • Myelin sheath insulates the axon to increase the transmission speed of the electrical impulses
 root hair cell	Absorb mineral ions and water from the soil	• Long projection speeds up the absorption of water and mineral ions by increasing the surface area of the cell • Lots of mitochondria to release energy for the active transport of mineral ions from the soil
 palisade cell	Enable photosynthesis in the leaf	• Lots of chloroplasts containing chlorophyll to absorb light energy • Located at the top surface of the leaf where it can absorb the most light energy

5.

5.	Diffusion	Osmosis	Active Transport
Definition	The spreading out of particles, resulting in a net movement from an area of higher concentration to an area of lower concentration. Factors which affect the rate of diffusion: difference in concentration, temperature, and surface area of the membrane.	The diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.	The movement of particles from a more dilute solution to a more concentrated solution using energy from respiration.
Movement of Particles	Particles move down the concentration gradient – from an area of high concentration to an area of low concentration.	Water moves from an area of lower solute concentration to an area of higher solute concentration.	Particles move against the concentration gradient – from an area of low concentration to an area of high concentration.
Energy Required?	No – passive process	No – passive process	Yes – energy released by respiration
Examples	**Humans** • Nutrients in the small intestine diffuse into the capillaries through the villi. • Oxygen diffuses from the air in the alveoli into the blood in the capillaries. Carbon dioxide diffuses from the blood in the capillaries into the air in the alveoli. • Urea diffuses from cells into the blood for excretion in the kidney. **Fish** • Oxygen from water passing over the gills diffuses into the blood in the gill filaments. • Carbon dioxide diffuses from the blood in the gill filaments into the water. **Plants** • Carbon dioxide used for photosynthesis diffuses into leaves through the stomata. • Oxygen produced during photosynthesis diffuses out of the leaves through the stomata.	**Plants** • Water moves by osmosis from a dilute solution in the soil to a concentrated solution in the root hair cell.	**Humans** • Active transport allows sugar molecules to be absorbed from the small intestine when the sugar concentration is higher in the blood than in the small intestine. **Plants** • Active transport is used to absorb mineral ions into the root hair cells from more dilute solutions in the soil.

Keyterms

Make sure you can write a definition for these key terms.

cell membrane, cell wall, chloroplast, chromosome, concentration, cytoplasm, dilute, DNA, eukaryotic, gill filaments, gradient, magnification, mitochondria, nucleus, partially permeable membrane, passive process, permanent vacuole, plasmid, prokaryotic, resolution, ribosome, root hair cell, stomata

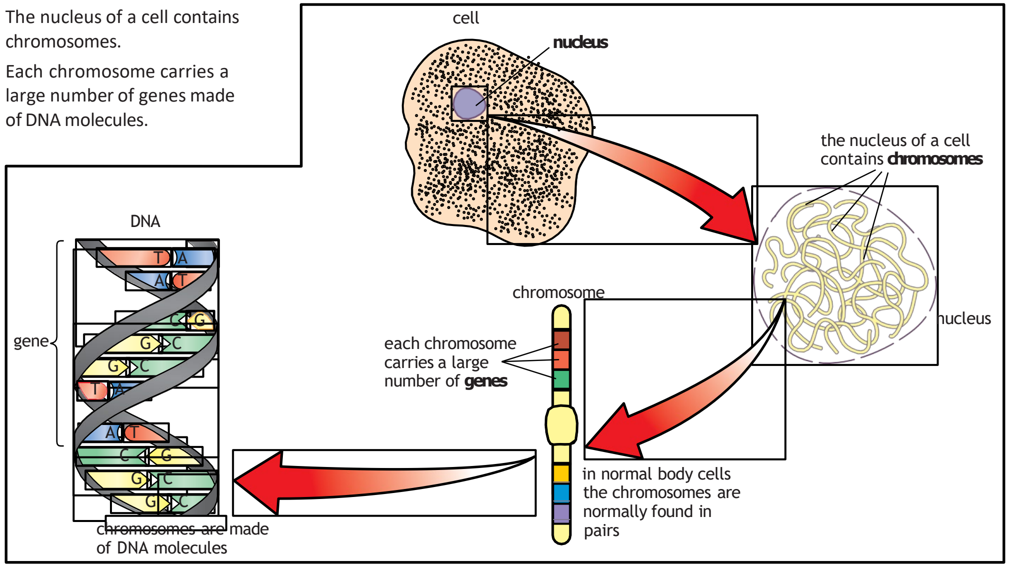
CHRIST THE KING - Knowledge Organisers

Biology - Cell Division

1. Chromosomes

The nucleus of a cell contains chromosomes.

Each chromosome carries a large number of genes made of DNA molecules.

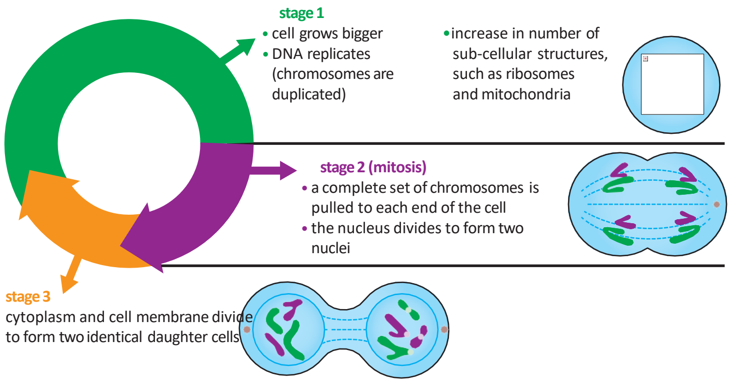


2. The cell cycle

Body cells divide to form two identical **daughter cells** by going through a series of stages known as the **cell cycle**.

Cell division by **mitosis** is important for the growth and repair of cells, for example, the replacement of skin cells. Mitosis is also used for asexual reproduction.

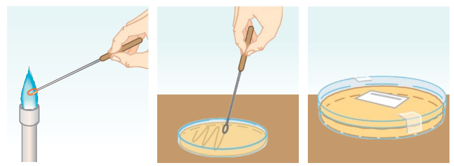
There are *three* main stages in the cell cycle:



3. Binary fission

Cell division in bacteria is called binary fission. In optimum temperature and nutrients, bacteria can multiply as often as every 20 minutes. In a lab, bacteria can be grown in sterile conditions on an agar gel plate or in a nutrient broth.

The lid of the petri dish must be sealed but not all the way so that oxygen can still get in. This is so that harmful bacteria that do not need oxygen aren't able to grow.



4. Stem cells in medicine

A stem cell is an undifferentiated cell that can develop into one or more types of specialised cell.

There are two types of stem cell in mammals: **adult stem cells** and **embryonic stem cells**.

Stem cells can be **cloned** to produce large numbers of identical cells.

Type of stem cell	Where are they found?	What can they differentiate into?	Advantages	Disadvantages
adult stem cells	specific parts of the body in adults and children – for example, bone marrow	can only differentiate to form certain types of cells – for example, stem cells in bone marrow can only differentiate into types of blood cell	• fewer ethical issues – adults can consent to have their stem cells removed and used • an already established technique for treating diseases such as leukaemia • relatively safe to use as a treatment and donors recover quickly	• requires a donor, potentially meaning a long wait time to find someone suitable • can only differentiate into certain types of specialised cells, so can be used to treat fewer diseases
embryonic stem cells	early human embryos (often taken from spare embryos from fertility clinics)	can differentiate into any type of specialised cell in the body – for example, a nerve cell or a muscle cell	• can treat a wide range of diseases as can form any specialised cell • may be possible to grow whole replacement organs • usually no donor needed as they are obtained from spare embryos from fertility clinics	• ethical issues as the embryo is destroyed and each embryo is a potential human life • risk of transferring viral infections to the patient • newer treatment so relatively under-researched – not yet clear if they can cure as many diseases as thought
plant meristem	meristem regions in the roots and shoots of plants	can differentiate into all cell types – they can be used to create clones of whole plants	• rare species of plants can be cloned to prevent extinction • plants with desirable traits, such as disease resistance, can be cloned to produce large numbers of identical plants • fast and low-cost production of large numbers of plants	• cloned plants are genetically identical, so a whole crop is at risk of being destroyed by a single disease or genetic defect

5. Therapeutic cloning

In **therapeutic cloning**

- cells from a patient's own body are used to create a cloned early embryo of themselves
- stem cells from this embryo can be used for medical treatments and growing new organs
- these stem cells have the same genes as the patient, so are less likely to be rejected when transplanted.

Key terms

Make sure you can write a definition for these key terms.

adult stem cell, binary fission, cell cycle, chromosome, clone, daughter cells, embryonic stem cell, gene, meristem, mitosis, nucleus, therapeutic cloning

Biology – Communicable Diseases

1. Communicable diseases

Communicable diseases can be spread from one organism to another.

Viruses live and reproduce rapidly inside an organism's cells. This can damage or destroy the cells.

Viruses	Spread by	Symptoms
measles	• inhalation of droplets produced by infected people when sneezing and coughing	• fever • red skin rash • complications can be fatal – young children are vaccinated to immunise them against measles
HIV (human immunodeficiency virus)	• sexual contact • exchange of body fluids (e.g., blood when drug users share needles)	• flu-like symptoms at first • virus attacks the body's immune cells, which can lead to AIDS – where the immune system is so damaged that it cannot fight off infections or cancers
TMV (tobacco mosaic virus – plants)	• direct contact of plants with infected plant material • animal and plant vectors • soil: the pathogen can remain in soil for decades	• mosaic pattern of discolouration on the leaves – where chlorophyll is destroyed • reduces plant's ability to photosynthesise, affecting growth

Bacteria reproduce rapidly inside organisms and may produce **toxins** that damage tissues and cause illness.

Bacteria	Spread by	Symptoms	Prevention and treatment
Salmonella	bacteria in or on food that is being ingested	*Salmonella* bacteria and the toxins they produce cause • fever • abdominal cramps • vomiting • diarrhoea	poultry are vaccinated against *Salmonella* bacteria to control spread
gonorrhoea	direct sexual contact – gonorrhoea is a **sexually transmitted disease (STD)**	• thick yellow or green discharge from the vagina or penis • pain when urinating	• treatment with antibiotics (many antibiotic-resistant strains have appeared) • barrier methods of contraception, such as condoms

Fungi	Spread by	Symptoms	Prevention and treatment
rose black spot	water and wind	• purple or black spots on leaves, which turn yellow and drop early • reduces plant's ability to photosynthesise, affecting growth	• **fungicides** • affected leaves removed and destroyed

Protists	Spread by	Symptoms	Prevention and treatment
malaria	mosquitos feed on the blood of infected people and spread the protist pathogen when they feed on another person – organisms that spread disease by carrying pathogens between people are called **vectors**	• recurrent episodes of fever • can be fatal	• prevent mosquito vectors breeding • mosquito nets to prevent bites • anti-malarial medicine

2. Detection and identification of plant diseases (Separate Only)

Signs that a plant is diseased

- stunted growth
- spots on leaves
- areas of rot or decay
- growths
- malformed stems or leaves
- discolouration
- pest infestation

Ways of identifying plant diseases

- gardening manuals and websites
- laboratory testing of infected plants
- testing kits containing monoclonal antibodies (Chapter 9 *Monoclonal antibodies*)

Keyterms

Make sure you can write a definition for these key terms.

aphid bacterium communicable disease fungicide fungus isolation mimic pathogen protist sexually transmitted disease (STD) toxin vaccination vector virus

CHRIST THE KING - Knowledge Organisers

Biology – Preventing and Treating Disease

1. Non-specific defences

Non-specific defences of the human body against all pathogens include:

Skin

- physical barrier to infection
- produces antimicrobial secretions
- microorganisms that normally live on the skin prevent pathogens growing

Nose

Cilia and **mucus** trap particles in the air, preventing them from entering the lungs.

Trachea and bronchi produce mucus, which is moved away from the lungs to the back of the throat by cilia, where it is expelled.

Stomach

Produces strong acid (pH 2) that destroys pathogens in mucus, food, and drinks.

2. Treating diseases

Antibiotics

- **Antibiotics** are medicines that can kill *bacteria* in the body.
- Specific bacteria need to be treated by specific antibiotics.
- Antibiotics have greatly reduced deaths from infectious bacterial diseases, but antibiotic-resistant strains of bacteria are emerging.

Treating viral diseases

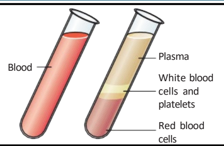
- Antibiotics *do not* affect viruses.
- Drugs that kill viruses often damage the body's tissues.
- Painkillers treat the symptoms of viral diseases but do not kill pathogens.

3. White blood cells

If a pathogen enters the body, the immune system tries to destroy the pathogen.

The function of **white blood cells** is to fight pathogens.

There are two main types of white blood cell – lymphocytes and phagocytes.



4. Lymphocytes

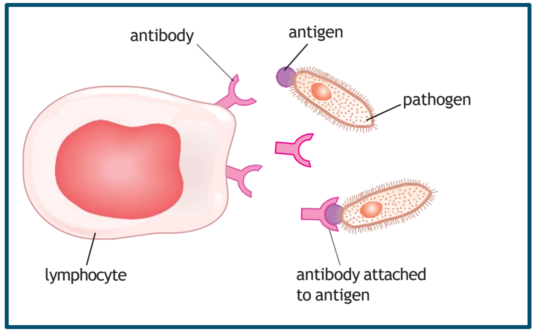
Lymphocytes fight pathogens in two ways:

Antitoxins

Lymphocytes produce **antitoxins** that bind to the toxins produced by some pathogens (usually bacteria). This *neutralises* the toxins.

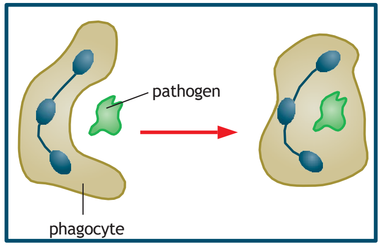
Antibodies

Lymphocytes produce **antibodies** that target and help to destroy specific pathogens by binding to **antigens** (proteins) on the pathogens' surfaces.



5. Phagocytes

1. Phagocytes are attracted to areas of infection.
2. The phagocyte surrounds the pathogen and engulfs it.
3. Enzymes that digest and destroy the pathogen are released.



9. Monoclonal antibodies (Separate only)

Monoclonal antibodies are produced by mouse lymphocytes which are combined with a tumour cell to make a hybridoma cell. These can divide to make an antibody which can later be cloned and used to treat diseases such as cancer or used in pregnancy tests.

6. Discovering and developing new drugs

Drugs were traditionally extracted from plants and microorganisms, for example

- the heart drug digitalis comes from foxglove plants
- the painkiller aspirin originates from willow trees
- penicillin was discovered by Alexander Fleming from *Penicillium* mould.

Most modern drugs are now synthesised by chemists in laboratories.

New drugs are extensively tested and trialled for

- **toxicity** – is it harmful?
- **efficacy** – does it work?
- **dose** – what amount is safe and effective to give?

7. Stages of clinical trials

Pre-clinical trials

Drug is tested in cells, tissues, and live animals.

Clinical trials

1. Healthy volunteers receive very low doses to test whether the drug is safe and effective.
2. If safe, larger numbers of healthy volunteers and patients receive the drug to find the optimum dose.

Peer review

Before being published, the results of clinical trials will be tested and checked by independent researchers. This is called **peer review**.

Double-blind trials

Some clinical trials give some of their patients a **placebo** drug – one that is known to have no effect.

Double-blind trials are when neither the patients nor the doctors know who has been given the real drug and who has been given the placebo. This reduces biases in the trial.

8. Vaccinations

Vaccinations involve injecting small quantities of dead or inactive forms of a pathogen into the body. This stimulates lymphocytes to produce the correct antibodies for that pathogen. If the same pathogen re-enters the body, the correct antibodies can be produced quickly to prevent infection. If a large proportion of the population is vaccinated against a disease, it is less likely to spread. This is called **herd immunity**.

Keyterms

Make sure you can write a definition for these key terms.

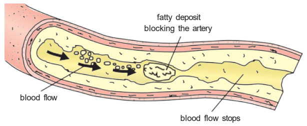
antibiotic antibody antigen antitoxin dose double-blind trial efficacy
Herd immunity monoclonal antibodies mucus peer review placebo toxicity
vaccination white blood cell

Biology – Non-communicable diseases

1. Coronary heart disease

Coronary heart disease (CHD) occurs when the coronary arteries become narrowed by the build-up of layers of fatty material within them.

This reduces the flow of blood, resulting in less oxygen for the heart muscle, which can lead to heart attacks.



2. Health issues

Health is the state of physical and mental well-being.

The following factors can affect health:

- communicable and non-communicable diseases
- diet
- stress
- exercise
- life situations.

Different types of disease may interact, for example:

- defects in the immune system make an individual more likely to suffer from infectious diseases
- viral infection can trigger cancers
- immune reactions initially caused by a pathogen can trigger allergies, for example skin rashes and asthma
- severe physical ill health can lead to depression and other mental illnesses.

3. Risk factors and non-communicable diseases

A **risk factor** is any aspect of your lifestyle or substance in your body that can increase the risk of a disease developing.

Some risk factors cause specific diseases. Other diseases are caused by factors interacting.

Risk factor	Disease	Effects of risk factor
diet (obesity) and amount of exercise	Type 2 diabetes	body does not respond properly to the production of insulin, so blood glucose levels cannot be controlled
	cardiovascular diseases	increased blood cholesterol can lead to CHD
alcohol	impaired liver function	long-term alcohol use causes liver cirrhosis (scarring), meaning the liver cannot remove toxins from the body or produce sufficient bile
	impaired brain function	damages the brain and can cause anxiety and depression
	affected development of unborn babies	alcohol can pass through the placenta, risking miscarriages, premature births, and birth defects
smoking	lung disease and cancers	cigarettes contain carcinogens, which can cause cancers
	affected development of unborn babies	chemicals can pass through the placenta, risking premature births and birth defects
carcinogens, such as ionising radiation, and genetic risk factors	cancers	for example, tar in cigarettes and ultraviolet rays from the Sun can cause cancers
		some genetic factors make an individual more likely to develop certain cancers

5. Cancer

Cancer is the result of changes in cells that lead to uncontrolled growth and division by mitosis.

Rapid division of abnormal cells can form a **tumour**.

Malignant tumours are cancerous tumours that invade neighbouring tissues and spread to other parts of the body in the blood, forming secondary tumours.

Benign tumours are non-cancerous tumours that do not spread in the body.

6. Treatment

Treatment of non-communicable diseases linked to lifestyle risk factors – such as poor diet, drinking alcohol, and smoking – can be very costly, both to individuals and to the Government.

A high incidence of these lifestyle risk factors can cause high rates of non-communicable diseases in a population.

7. Treating cardiovascular diseases

Treatment	Description	Advantages	Disadvantages
stent	inserted into blocked coronary arteries to keep them open	• widens the artery – allows more blood to flow, so more oxygen is supplied to the heart • less serious surgery	• can involve major surgery – risk of infection, blood loss, blood clots, and damage to blood vessels • risks from anaesthetic used during surgery
statins	drugs that reduce blood **cholesterol** levels, slowing down the deposit of fatty material in the arteries	• effective • no need for surgery • can prevent CHD from developing	• possible side effects such as muscle pain, headaches, and sickness • cannot cure CHD, so patient will have to take tablets for many years
replace faulty heart valves	heart valves that leak or do not open fully, preventing control of blood flow through the heart, can be replaced with biological or mechanical valves	• allows control of blood flow through the heart • long-term cure for faulty heart valves	• can involve major surgery – risk of infection, blood loss, blood clots, and damage to blood vessels • risks from anaesthetic used during surgery
transplants	if the heart fails a donor heart, or heart and lungs, can be transplanted **artificial hearts** can be used to keep patients alive whilst waiting for a heart transplant, or to allow the heart to rest during recovery	• long-term cure for the most serious heart conditions • treats problems that cannot be treated in other ways	• transplant may be rejected if there is not a match between donor and patient • lengthy process • major surgery – risk of infection, blood loss, blood clots, and damage to blood vessels • risks from anaesthetic used during surgery

Key terms

Make sure you can write a definition for these key terms.

artificial heart, benign, carcinogen, cholesterol, coronary heart disease, health, malignant, risk factor, statin, stent, transplant, tumour

CHRIST THE KING - Knowledge Organisers

Biology – Adaptations and interdependence

1. Ecosystem organisation

Individual organisms

↓

Population
the total number of organisms of the same species that live in one specific geographical area

↓

Community
group of two or more populations of different species living in one specific geographical area

↓

Ecosystem
the interaction of a community of living organisms with the non-living parts of their environment

A stable community is one where all the species and environmental factors are in balance so that population sizes remain fairly constant.

An example of this is the interaction between predator and prey species, which rise and fall in a constant cycle so that each remains within a stable range.

2. Competition

To survive and reproduce, organisms require a supply of resources from the their surroundings and from other living organisms there.

This can create competition, for resources, where organisms within a community compete

There are two types of competition – **interspecific competition** is between organisms of different species and **intraspecific competition** is between organisms of the same species.

Animals often compete for:

- food
- mates
- territory.

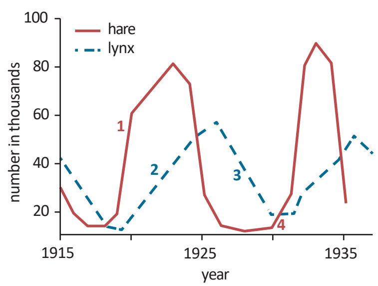
Plants often compete for:

- light
- space
- water and mineral ions from the soil.

Interdependence

Within a community each species **interacts** with many others and may depend on other species for things like food, shelter, pollination, and seed dispersal.

If one species is removed it can affect the whole community – this is called **interdependence**.



1 If the population of hares increases there is a larger food supply for the lynx.

2 This can therefore support more lynx, so more offspring survive.

3 The growing numbers of lynx eventually reduce the food supply. The number of predators starts to decrease.

4 The prey population starts to increase once more – the cycle then begins again.

3. Abiotic factors

Abiotic factors are non-living factors in the ecosystem that can affect a community.

Too much or too little of the following abiotic factors can negatively affect the community in an ecosystem:

- carbon dioxide levels for plants
- light intensity
- moisture levels
- oxygen levels for animals that live in water
- soil pH and mineral content
- temperature
- wind intensity and direction.

4. Biotic factors

Biotic factors are living factors in the ecosystem that can affect a community.

For example, the following biotic factors would all negatively affect populations in a community:

- decreased availability of food
- new predators arriving
- new pathogens
- competition between species, for example, one species outcompeting another for food or shelter, causing a decline in the other species' population.

5. Adaptations of organisms

Organisms have features – **adaptations** – that enable them to survive in the conditions in which they live. The adaptations of an organism may allow it to outcompete others, and provide it with an evolutionary advantage.

Structural adaptations

The physical features that allow an organism to successfully compete:

- sharp teeth to hunt prey
- colouring that may provide camouflage to hide from predators or hunt prey
- a large or small body-surface- area-to-volume ratio.

Behavioural adaptations

The behaviour of an organism that gives it an advantage:

- making nests to attract a mate
- courtship dances to attract a mate
- use of tools to obtain food
- working together in packs.

Functional adaptations

Adaptations related to processes that allow an organism to survive:

- photosynthesis in plants
- production of poisons or venom to deter predators and kill prey
- changes in reproduction timings.

You can work out how an organism is adapted to where it lives when given information on its environment and what it looks like.

For example, without the following adaptations the organisms below would be at a disadvantage in their environment.

Organism	Example adaptations
	• white fur for camouflage when hunting prey • feet with large surface area to distribute weight on snow • small ears to reduce heat loss • thick fur for insulation
	• feet with large surface area to distribute weight on sand • hump stores fat to provide energy when food is scarce • tough mouth and tongue to allow camel to eat cacti • long eyelashes to keep sand out of eyes
	• spines instead of leaves to reduce surface area and therefore water loss, and to deter predators • long roots to reach water underground • large, fleshy stem to store water

Some organisms are **extremophiles**, which means they live in environments that are very extreme where most other organisms could not survive. For example, areas with:

- very high or low temperatures
- extreme pressures
- high salt concentrations
- highly acidic or alkaline conditions
- low levels of oxygen or water.

Bacteria that live in deep sea vents are extremophiles.

Deep sea vents are formed when seawater circulates through hot volcanic rocks on the seafloor. These environments have very high pressures and temperatures, no sunlight, and are strongly acidic.

Keyterms

Make sure you can write a definition for these key terms.

abiotic factor | adaptation | biotic factor | community | ecosystem | extremophile | interaction | interdependence | interspecific competition | intraspecific competition | population

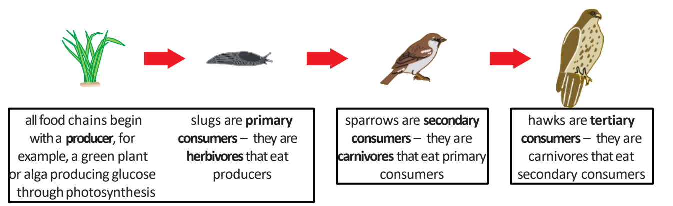
Biology – Organising an Ecosystem

1. Levels of organisation

Feeding relationships within a community can be represented by **food chains**.

Photosynthetic organisms that synthesise molecules are the producers of all **biomass** for life on Earth, and so are the first step in all food chains.

A range of experimental methods using transects and quadrats are used by ecologists to determine the distributions and abundances of different species in an ecosystem.



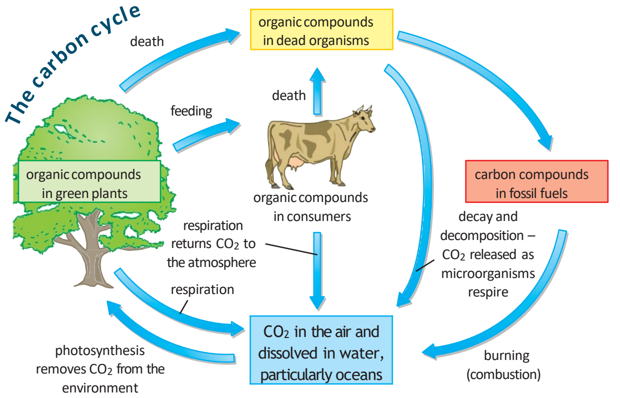
Consumers that kill and eat other animals are predators, and those that are eaten are **prey**.

Apex **predators** are carnivores with no predators.

Organisms usually have more complex feeding relationships, with more than one predator or more than one food source. These can be shown in a **food web**.

2. How materials are cycled

All materials in the living world are recycled, which provides the building materials for future organisms.



This loss of biomass moving up the food chain is due to several factors:

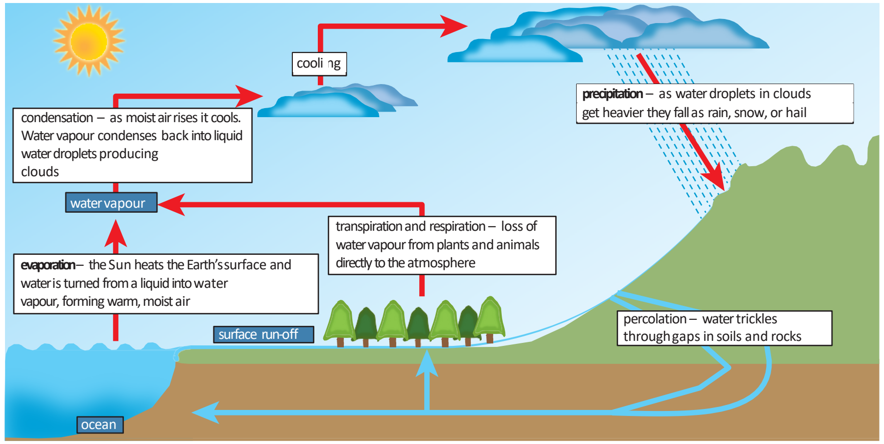
- use in life processes, such as respiration
- not all of the matter eaten is digested, some is egested as waste products
- some absorbed material is lost as waste
- energy is used in movement and to keep animals warm.

Keyterms

Make sure you can write a definition for these key terms.

carbon cycle, carnivore consumer, decomposer, evaporation, fertiliser, food chain, food web, herbivore, precipitation, predator, prey, producer, water cycle

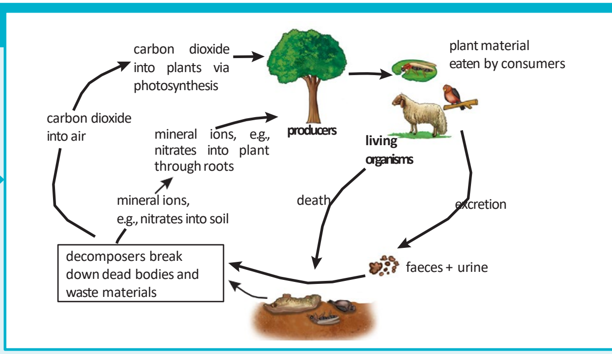
3. The water cycle



4. Decomposition

Decomposers, such as bacteria and fungi, break down dead plant and animal matter by secreting enzymes into the environment. The small soluble food molecules produced then diffuse into the decomposer.

These materials are cycled through an ecosystem by decomposers returning carbon to the atmosphere as carbon dioxide and mineral ions to the soil.



5. Impacts of environmental change

Environmental changes affect the distribution of species in ecosystems.

These changes may be seasonal, geographic, or caused by humans, and include:

- temperature – varies greatly between locations and seasons, and warming temperatures have contributed to species migrating away from the Equator
- availability of water – during droughts animals have to move away from their usual habitats to areas with more water, and cannot survive if this is not possible
- composition of atmospheric gases – human activities release greenhouse gases and pollutants, which cause harmful effects like climate change and acid rain.

CHRIST THE KING - Knowledge Organisers

Chemistry - Atomic structure

1. Development of the model of the atom

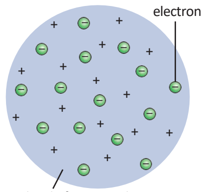
Dalton's model

John Dalton thought of the **atom** as a solid sphere that could not be divided into smaller parts. His model did not include **protons**, **neutrons**, or **electrons**.

The plum pudding model

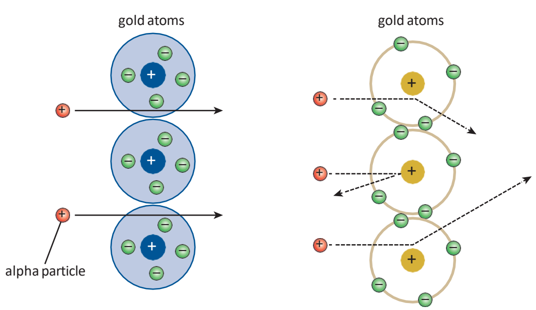
Scientists' experiments resulted in the discovery of sub-atomic charged particles. The first to be discovered were electrons – tiny, negatively charged particles.

The discovery of electrons led to the plum pudding model of the atom – a cloud of positive charge, with negative electrons embedded in it. Protons and neutrons had not yet been discovered.



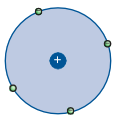
Alpha scattering experiment

1. Scientists fired small, positively charged particles (called alpha particles) at a piece of gold foil only a few atoms thick.
2. They expected the alpha particles to travel straight through the gold.
3. They were surprised that some of the alpha particles bounced back and many were deflected (alpha scattering).
4. To explain why the alpha particles were repelled the scientists suggested that the positive charge and mass of an atom must be concentrated in a small space at its centre. They called this space the **nucleus**.



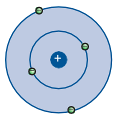
Nuclear model

Scientists replaced the plum pudding model with the nuclear model and suggested that the electrons **orbit** the nucleus, but not at set distances.



Electron shell (Bohr) model

Niels Bohr calculated that electrons must orbit the nucleus at fixed distances. These orbits are called **shells** or **energy levels**.



The proton

Further experiments provided evidence that the nucleus contained smaller particles called protons. A proton has an opposite charge to an electron.

The neutron

James Chadwick carried out experiments that gave evidence for a particle with no charge. Scientists called this the neutron and concluded that the protons and neutrons are in the nucleus, and the electrons orbit the nucleus in shells.

Relative mass

One property of protons, neutrons, and electrons is **relative mass** – their masses compared to each other. Protons and neutrons have the same mass, so are given a relative mass of 1. It takes almost 2000 electrons to equal the mass of a single proton – their relative mass is so small that we can consider it as 0.

Size

The atom has a radius of 1×10^{-10} m. Nuclei (plural of nucleus) are around 10000 times smaller than atoms and have a radius of around 1×10^{-14} m.

2. Elements and compounds

Elements are substances made of one type of atom. Each atom of an element will have the same number of protons.

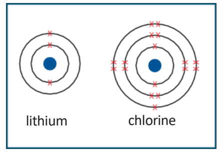
Compounds are made of different types of atoms chemically bonded together. The atoms in a compound have different numbers of protons.

3. Drawing atoms

Electrons in an atom are placed in fixed shells. You can put

- up to two electrons in the first shell
- eight electrons each in the second and third shells.

You must fill up a shell before moving on to the next one.



4. Mixtures

- A mixture consists of two or more elements or compounds that are not chemically combined together.
- The substances in a mixture can be separated using physical processes.
- These processes do not use chemical reactions.

Separating mixtures

- filtration – insoluble solids and a liquid
- crystallisation – soluble solid from a solution
- simple distillation – solvent from a solution
- fractional distillation – two liquids with similar boiling points
- paper chromatography – identify substances from a mixture in solution

5. Atoms and particles

	Relative charge	Relative mass	
Proton	+1	1	= atomic number
Neutron	0	1	= mass number – atomic number
Electron	−1	0 (very small)	= same as the number of protons

All atoms have equal numbers of protons and electrons, meaning they have no overall charge:

total negative charge from electrons = total positive charge from protons

6. Isotopes

Atoms of the same element can have a different number of neutrons, giving them a different overall mass number. Atoms of the same element with different numbers of neutrons are called **isotopes**.

The **relative atomic mass** is the average mass of all the atoms of an element:

$$\text{relative atomic mass} = \frac{(\text{abundance of isotope 1} \times \text{mass of isotope 1}) + (\text{abundance of isotope 2} \times \text{mass of isotope 2})...}{100}$$

Keyterms

Make sure you can write a definition for these key terms.

abundance, atom, atomic number, aqueous, compound, electron, element, energy level, isotope, neutron, nucleus, orbit, product, proton, reactant, relative atomic mass, relative charge, relative mass, shell

Chemistry – The Periodic Table

1. Development of the Periodic Table

The Periodic Table has changed over time as scientists have organised it differently. Mendeleev was able to accurately predict the properties of undiscovered elements based on the gaps in the table.

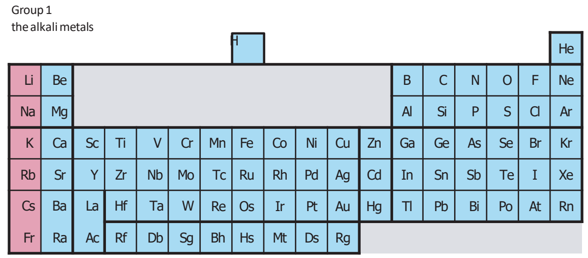
	First lists of elements	Mendeleev's Periodic Table	Modern Periodic Table
How are elements ordered?	by atomic mass	normally by atomic mass but some elements were swapped around	by atomic number
Are there gaps?	no gaps	gaps left for undiscovered elements	no gaps – all elements up to a certain atomic number have been discovered
How are elements grouped?	not grouped	grouped by chemical properties	grouped by the number of electrons in the outer shells
Metals and non-metals	no clear distinction	no clear distinction	metals to the left, non-metals to the right
Problems	some elements grouped inappropriately	incomplete, with no explanation for why some elements had to be swapped to fit in the appropriate groups	–

2. Group 1 elements

Group 1 elements react with oxygen, chlorine, and water, for example:

lithium + oxygen ➞ lithium oxide
lithium + chlorine ➞ lithium chloride
lithium + water ➞ lithium hydroxide + hydrogen

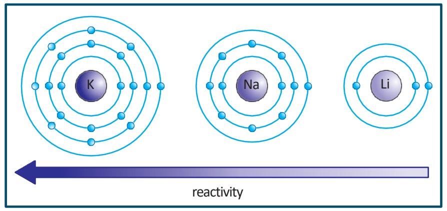
Group 1 elements are called **alkali metals** because they react with water to form an alkali (a solution of their metal hydroxide).



3. Group 1 properties

Group 1 elements all have one electron in their outer shell.
Reactivity increases down Group 1 because as you move down the group:

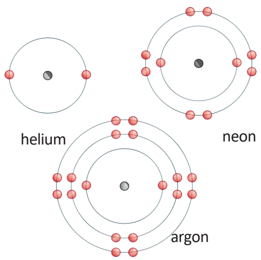
- the atoms increase in size
- the outer electron is further away from the nucleus, and there are more shells shielding the outer electron from the nucleus
- the electrostatic attraction between the nucleus and the outer electron is weaker so it is easier to lose the one outer electron
- the melting point and boiling point decreases down Group 1.



4. Group 0

Elements in **Group 0** are called the **noble gases**. Noble gases have the following properties:

- full outer shells with eight electrons, so do not need to lose or gain electrons
- are very unreactive (**inert**) so exist as single atoms as they do not bond to form molecules
- boiling points that increase down the group.



5. Group 7 elements

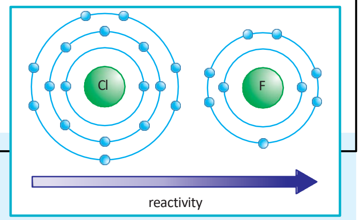
Group 7 elements are called the **halogens**. They are non-metals that exist as molecules made up of pairs of atoms.

Name	Formula	State at room temperature	Melting point and boiling point	Reactivity
fluorine	F_2	gas	increases down the group	decreases down the group
chlorine	Cl_2	gas		
bromine	Br_2	liquid		
iodine	I_2	solid		

6. Group 7 reactivity

Reactivity decreases down Group 7 because as you move down the group:

- the atoms increase in size
- the outer shell is further away from the nucleus, and there are more shells between the nucleus and the outer shell
- the electrostatic attraction from the nucleus to the outer shell is weaker so it is harder to gain one electron to fill the outer shell.



7. Group 7 displacement

More reactive Group 7 elements can take the place of less reactive ones in a compound. This is called **displacement**.
For example, fluorine displaces chlorine as it is more reactive:
fluorine + potassium chloride ➞ potassium fluoride + chlorine

8. Transition metals (Separate only)

Elements in the middle block of the periodic table are known as the **transition metals.** Metals in this block generally have the following properties:

- Hard
- Strong
- Malleable (can be bent into shape)
- Ductile (drawn out into wires)
- Form coloured compounds
- Used as catalysts
- Variable oxidation states (form ions with different charges)
- Good electrical and thermal conductors
- Less reactive than Group 1 and 2 metals

Key terms

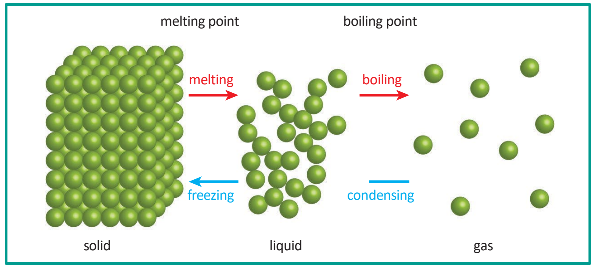
Make sure you can write a definition for these key terms.

alkali metals   chemical properties   displacement   groups   halogens   inert   isotopes
noble gas   organised   Periodic Table   reactivity   undiscovered   unreactive

Chemistry - Bonding

1. Particle model

The three states of matter can be represented in the particle model.



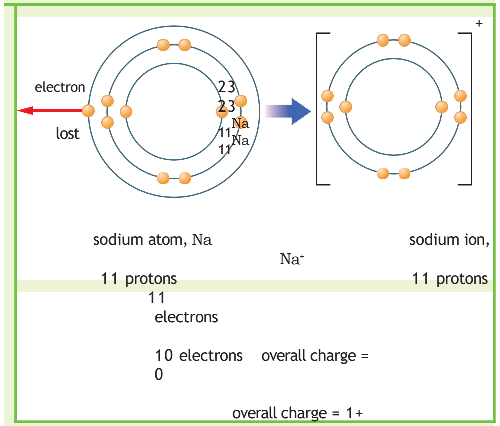
(HT only) This model assumes that:

- there are no forces between the particles
- that all particles in a substance are spherical
- that the spheres are solid.

The amount of energy needed to change the state of a substance depends on the forces between the particles. The stronger the forces between the particles, the higher the melting or boiling point of the substance.

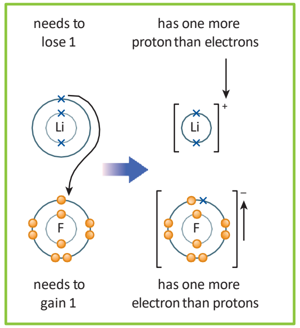
2. Ions

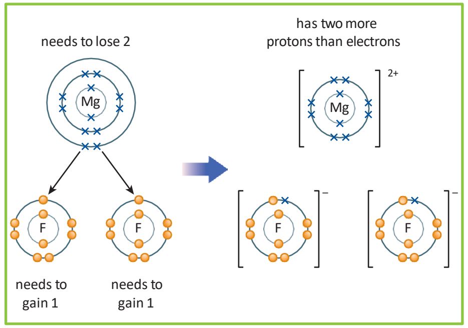
Atoms can gain or lose electrons to give them a full outer shell. The number of protons is then different from the number of electrons. The resulting particle has a charge and is called an **ion**.



3. Ionic bonding

When metal atoms react with non-metal atoms they **transfer** electrons to the non-metal atom.

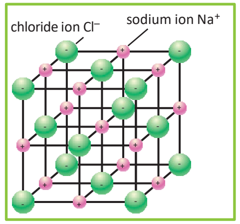




Metal atoms lose electrons to become positive ions. Non-metal atoms gain electrons to become negative ions.

4. Giant ionic lattice

When metal atoms transfer electrons to non-metal atoms you end up with positive and negative ions. These are attracted to each other by the strong **electrostatic force of attraction**. This is called ionic bonding.

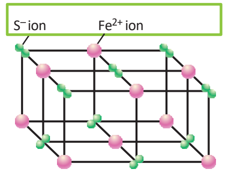


The electrostatic force of attraction works in all directions, so many billions of ions can be bonded together in a 3D structure.

5. Formulae

The formula of an ionic substance can be worked out

1. from its bonding diagram: for every one magnesium ion there are two fluoride ions – so the formula for magnesium fluoride is MgF_2
2. from a lattice diagram: there are nine Fe^{2+} ions and 18 S^{-} ions – simplifying this ratio gives a formula of FeS_2



6. Conductivity

Solid ionic substances do not conduct electricity because the ions are fixed in position and not free to carry charge.

When melted or dissolved in water, ionic substances do conduct electricity because the ions are free to move and carry charge.

7. Melting points

Ionic substances have high melting points because the electrostatic force of attraction between oppositely charged ions is strong and so requires lots of energy to break.

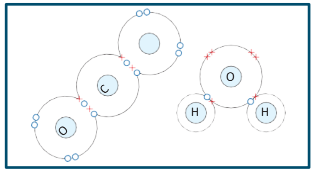
8. Covalent bonding

Atoms can share or transfer electrons to form strong chemical bonds.

A **covalent bond** is when electrons are *shared* between **non-metal** atoms.

The number of electrons shared depends on how many extra electrons an atom needs to make a full outer shell.

If you include electrons that are shared between atoms, each atom has a full outer shell. **Single bond** = each atom shares one pair of electrons. **Double bond** = each atom shares two pairs of electrons.



9. Covalent structures

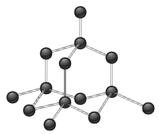
There are three main types of covalent structure:

Structure and bonding

Giant covalent

Many billions of atoms, each one with a strong covalent bond to a number of others.

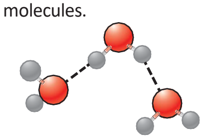
An example of a giant covalent structure is diamond.



Small molecules

Each molecule contains only a few atoms with strong covalent bonds between these atoms. Different molecules are held together by weak **intermolecular forces**.

For example, water is made of small molecules.



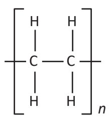
Large molecules

Many repeating units joined by covalent bonds to form a chain.

The small section is bonded to many identical sections to the left and right. The '*n*' represents a large number.

Separate chains are held together by intermolecular forces that are stronger than in small molecules.

Polymers are examples of long molecules.



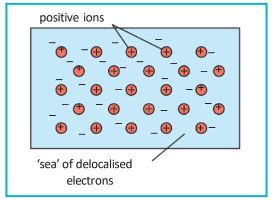
10. Metals: structure and properties

The atoms that make up metals form layers. The electrons in the outer shells of the atoms are **delocalised** – this means they are free to move through the whole structure.

The positive metal ions are then attracted to these delocalised electrons by the electrostatic force of attraction.

Some important properties of metals are:

- pure metals are **malleable** because the layers can slide over each other
- they are good **conductors** of electricity and of thermal energy because delocalised electrons are free to move through the whole structure
- they have high melting and boiling points because the electrostatic force of attraction between metal ions and delocalised electrons is strong so lots of energy is needed to break it.



Chemistry - Bonding

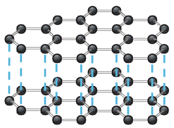
High melting and boiling points because the strong covalent bonds between the atoms must be broken to melt or boil the substances. This requires a lot of energy. Solid at room temperature.	Low melting and boiling points because only the intermolecular forces need to be overcome to melt or boil the substances, not the bonds between the atoms. This does not require a lot of energy as the intermolecular forces are weak. Normally gaseous or liquid at room temperature.	Melting and boiling points are low compared to giant covalent substances but higher than for small molecules. Large molecules have stronger intermolecular forces than small molecules, which require more energy to overcome. Normally solid at room temperature.

Most covalent structures do not conduct electricity because they do not have **delocalised electrons** or ions that are free to move to carry charge.

12. Graphite

Graphite is a giant covalent structure, but is different to other giant covalent substances.

Structure



Made only of carbon – each carbon atom bonds to three others, and forms hexagonal rings in layers. Each carbon atom has one spare electron, which is delocalised and therefore free to move around the structure.

Hardness

The layers can slide over each other because they are not covalently bonded. Graphite is therefore softer than diamond, even though both are made only of carbon, as each atom in diamond has four strong covalent bonds.

Conductivity

The delocalised electrons are free to move through graphite, so can carry charges and allow an electrical current to flow. Graphite is therefore a conductor of electricity.

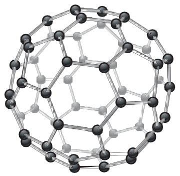
14. Graphene

Graphene consists of only a single layer of graphite. Its strong covalent bonds make it a strong material that can also conduct electricity. It could be used in composites and high-tech electronics.

13. Fullerenes

- hollow cages of carbon atoms bonded together in one molecule
- can be arranged as a sphere or a tube (called a **nanotube**)
- molecules held together by weak intermolecular forces, so can slide over each other
- conduct electricity

Spheres

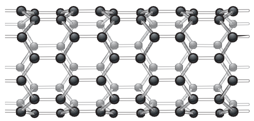


Buckminsterfullerene was the first fullerene to be discovered, and has 60 carbon atoms.

Other fullerenes exist with different numbers of carbon atoms arranged in rings that form hollow shapes.

Fullerenes like this can be used as lubricants and in drug delivery.

Nanotubes

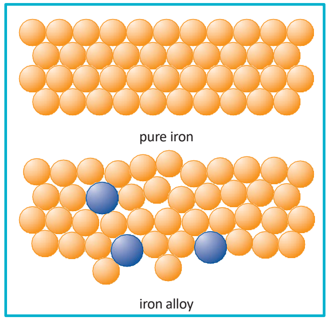


The carbon atoms in nanotubes are arranged in cylindrical tubes.
Their high **tensile strength** (they are difficult to break when pulled) makes them useful in electronics.

11. Alloys

Pure metals are often too soft to use as they are. Adding atoms of a different element can make the resulting mixture harder because the new atoms will be a different size to the pure metal's atoms. This will disturb the regular arrangement of the layers, preventing them from sliding over each other.

The harder mixture is called an **alloy**.



15. Measuring particles (SEPARATE ONLY)

We use different units and scales to measure the size of particles.

Particle	Particulate matter	Size	Standard form	Full form
grain of sand	N/A	0.1 mm	1×10^{-4} m	0.0001 m
coarse particles (e.g., dust)	PM_{10}	10 µm	1×10^{-5} m	0.00001 m
fine particles	$PM_{2.5}$	100 nm	1×10^{-7} m	0.0000001 m
nanoparticles	$< PM_{2.5}$	1 to 100 nm	1×10^{-9} to 1×10^{-7} m	0.000000001 m to 0.0000001 m

PM stands for **particulate matter** and is another way of measuring very small particles.

16. Uses of nanoparticles (SEPARATE ONLY)

Nanoparticles often have very different properties to bulk materials of the same substance, caused by their high surface area-to-volume-ratio.

Nanoparticles have many uses and are an important area of research. They are used in healthcare, electronics, cosmetics, and as catalysts.

However, nanoparticles have the potential to be hazardous to health and to ecosystems, so it is important that they are researched further.

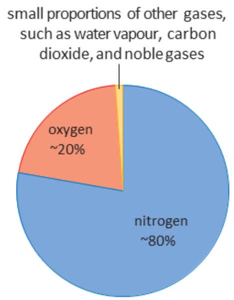
Key terms

Make sure you can write a definition for these key terms.

conductivity, conductor, delocalised electron, electrostatic force of attraction, ion, lattice, layer, malleable, nanoparticle, particulate matter surface, area to volume ratio, transfer

Chemistry – Our Atmosphere

1. The Earth's changing atmosphere

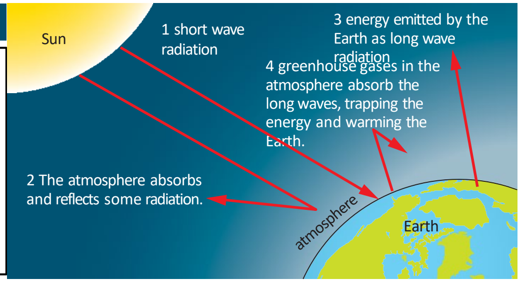
Period	Proportions of gases	Evidence
about 4.6 billion years to about 2.7 billion years ago	• **carbon dioxide, CO_2** Released by volcanoes. Biggest component of the **atmosphere**. • **oxygen, O_2** Very little oxygen present. • **nitrogen, N_2** Released by volcanoes. • **water vapour, H_2O** Released by volcanoes. Existed as vapour as Earth was too hot for it to condense. • **other gases** Ammonia, NH_3, and methane, CH_4, may also have been present.	Because it was billions of years ago there is very little evidence to draw upon.
about 2.7 billion years ago to about 200 million years ago	• **carbon dioxide, CO_2** Amount in atmosphere begins to reduce because: ◦ water condenses to form the oceans, in which CO_2 then dissolves ◦ algae (and later plants) start to photosynthesise carbon dioxide + water $\xrightarrow{\text{light}}$ glucose + oxygen $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$ ◦ CO_2 precipitates in the oceans as solid carbonates (sediments) that form rocks ◦ CO_2 taken in by plants and animals. When they die, the carbon in them is locked up as fossil fuels • **oxygen, O_2** Starts to increase as a product of photosynthesis. • **nitrogen, N_2** Continues to increase. Nitrogen is a very stable molecule so any process that produces it causes the overall amount to build up over time. • **water vapour, H_2O** Starts to decrease. As the Earth cools, the vapour condenses and forms the oceans.	Still limited as billions of years ago, but can look at processes that happen today (like photosynthesis) and make theories about the past.
about 200 million years ago until the present	• **carbon dioxide, CO_2** about 0.04% • **oxygen, O_2** about 20% • **nitrogen, N_2** about 80% • **water vapour, H_2O** Very little overall. Collects in large clouds as part of the water cycle. • **other gases** Small proportions of other gases such as the noble gases.  	Ice core evidence for millions of years ago and lots of global measurements taken recently.

2. Greenhouse gases

Greenhouse gases, such as carbon dioxide, methane, and water vapour, absorb radiation and maintain temperatures on the Earth to support life.

However, in the last 150 years, more greenhouse gases have been released due to human activities.

- carbon dioxide – combustion of fossil fuels, deforestation
- methane – planting rice fields, cattle farming



3. Global warming

Scientists have gathered peer-reviewed evidence to demonstrate that increasing the amount of greenhouse gases in the atmosphere will increase the overall average temperature of the Earth. This is called **global warming**.

However, it is difficult to make predictions about the atmosphere as it is so big and complex. This leads some people to doubt what scientists say.

4. Global climate change

Global warming leads to another process called **global climate change** – how the overall weather patterns over many years and across the entire planet will change.

There are many different effects of climate change, including:

- sea levels rising
- extreme weather events
- changes in the amount and time of rainfall
- changes to ecosystems and habitats
- polar ice caps melting.

5. Carbon footprints

Increasing the amount of greenhouse gases in the atmosphere increases the global average temperature of the Earth, which results in global climate change.

As such, it is important to reduce the release of greenhouse gases into the atmosphere. The amount of carbon dioxide and methane that is released into the atmosphere by a product, person, or process is called its **carbon footprint**.

6. Other pollutants released in combustion of fuels

Pollutant	Origin	Effect
carbon monoxide	incomplete combustion of fuels	colourless and odourless toxic gas
particulates (soot and unburnt hydrocarbons)	incomplete combustion of fuels especially in diesel engines	**global dimming**, respiratory problems, potential to cause cancer
sulfur dioxide	sulfur impurities in the fuel reacting with oxygen from the air	**acid rain** and respiratory problems
oxides of nitrogen	nitrogen from the air being heated near an engine and reacting with oxygen	acid rain and respiratory problems

Key terms

Make sure you can write a definition for these key terms.

acid rain · atmosphere · carbon footprint · global climate change · carbon monoxide · global dimming · global warming · greenhouse gas · particulate · pollutant

Chemistry – The Earth's Resources

1. Natural and synthetic resources

We use the Earth's resources to provide us with warmth, fuel, shelter, food, and transport.

- Natural resources are used for food, timber, clothing, and fuels.
- Synthetic resources are made by scientists. They can replace or supplement natural resources.

When choosing and synthesising resources, it is important to consider **sustainable development**. This is development that meets the needs of current generations without compromising the ability of future generations to meet their own needs.

2. Finite and renewable resources

Some resources are **finite**. This means that they will eventually run out.

Fossil fuels are an example of a finite resource. They take so long to form that we use them faster than they are naturally formed.

Resources that will not run out are called **renewable** resources.

Wood is an example of a renewable resource. Trees can be grown to replace any that are cut down for wood.

3. Potable water

Water is a vital resource for life. **Potable** water is water that is safe to drink. However, most water on Earth is not potable.

Type of water	What it has in it
pure water	just water molecules and nothing else
potable water	water molecules, low levels of salts, safe levels of harmful microbes
salty water (sea water)	water molecules, dangerously high levels of salt, can have high levels of harmful microbes
fresh water (from rivers, lakes, or underground)	water molecules, low levels of salt, often has harmful microbes at high levels

4. Fresh water

In the UK, potable water is produced from rain water that collects in lakes and rivers. To produce potable water:

1. Choose an appropriate source of fresh water.
2. Pass the water through filters to remove large objects.
3. **Sterilise** the water to kill any microbes using ozone, chlorine, or UV light.

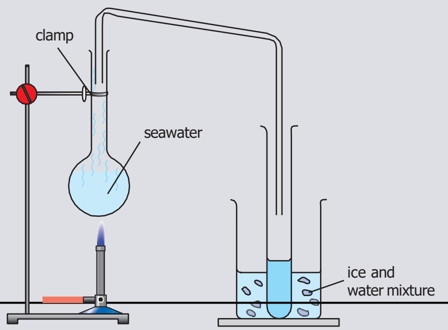
5. Salty water

Some countries do not have lots of fresh water available. **Desalination** is the process to turn saltwater into potable water. This requires a lot of energy and can be done by:

- distillation
- **reverse osmosis**

Reverse osmosis involves using membranes to separate the salts dissolved in the water. The water needs to be pressurised and the salty water corrodes the pumps. As such, it is an expensive process.

Distillation



6. Waste water

Human activities produce lots of waste water as sewage, agricultural waste, and industrial waste.

- **Sewage** and agricultural waste contain organic matter and harmful microbes.
- Industrial waste contains organic matter and harmful chemicals.

These need to be removed before the water can be put back into the environment.

7. Treating sewage water

screening and grit removal
The sewage passes through a metal grid that filters out large objects.

sedimentation
The sewage is left so that solid sediments settle out of the water. The sediments sink to the bottom of the tank. The liquid sits above the sediment.

8. Treating sludge

sewage sludge
This sediment is called **sludge**. Sludge contains organic matter, water, dissolved compounds, and small solid particles.

anaerobic treatment
Bacteria are added to digest the organic matter. These bacteria break down the matter anaerobically – with a limited supply of oxygen.

biogas
The anaerobic digestion of sludge produces biogas. Biogas is a mixture of methane, carbon dioxide and hydrogen sulfide. It can be used as fuel.

remaining sludge used as fuel
The remaining sludge can be dried out and can also be burnt as a fuel.

9. Treating effluent

effluent
The remaining liquid is called **effluent**. This effluent has no solid matter visible, but still contains some matter and harmful microorganisms.

aerobic treatment
Bacteria are added to the effluent. These bacteria feed on organic matter and the harmful microorganisms in the effluent. The bacteria break down the matter by aerobic respiration – oxygen needs to be present.

bacteria removed
The bacteria are allowed to settle out of the water.

discharged back to rivers
The water is now safe enough to be released back into the environment.

Chemistry – The Earth's Resources

10. Metal extraction (HT only)

Metals are used for many different things. Some metals can be extracted from their ores by reduction or electrolysis.

However, metal ores are a finite resource and these processes require lots of energy.

Scientists are looking for new ways to extract metals that are more sustainable.

Phytomining and **bioleaching** are two alternative processes used to extract copper from low grade ores (ores with only a little copper in them).

11. Phytomining

1. Grow plants near the metal ore.
2. Harvest and burn the plants.
3. The ash contains the metal compound.
4. Process the ash by electrolysis or displacement with scrap metal.

12. Bioleaching

1. Grow bacteria near the metal ore.
2. Bacteria produce leachate solutions that contain metal compound.
3. Process the leachate by electrolysis or displacement with scrap metal.

Both of these methods avoid the digging, moving, and disposing of large amounts of rock associated with traditional mining techniques.

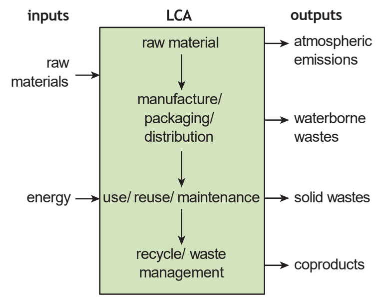
13. Life cycle assessment

A **life cycle assessment (LCA)** is a way of looking at the whole life of a product and assessing its impact on the environment and sustainability. It is broken down into four categories:

- extracting and processing raw materials
- manufacturing and packaging
- use and operation during its lifetime
- disposal at the end of its useful life, including transport and distribution at each stage

Some parts of an LCA are objective, such as the amount of water used or waste produced in the production of a product.

However, other parts of an LCA require judgements, such as the polluting effect, and so LCAs are not a completely objective process.



Key terms

Make sure you can write a definition for these key terms.

aerobic, anaerobic, biodegrade, bioleaching, distillation, effluent, finite resources, life cycle assessment, phytomining, potable water, recycling, renewable resources, reverse osmosis, screening, sedimentation, sewage, sludge, sterilisation, sustainable development

14. Disposal of products

When someone finishes with a product, it can be

- added to a landfill
  This can cause habitat loss and other problems in the local ecosystem. Some items persist in landfills as they do not **biodegrade** and could be there for hundreds of years.
- incinerated
  Some products can be incinerated to produce useful energy. However, the combustion can often be incomplete and result in harmful pollutants being released to the atmosphere.
- reused
  This is when an item is used again for a similar purpose.
- **recycled**
  Recycling requires energy, but conserves the limited resources and often requires less energy than needed to make brand new materials.

The table shows information about the extraction, processing, and disposal of some common materials. This information is used when making a LCA.

Material	Extraction/processing	Disposal
metal	• quarrying and mining cause habitat loss • machinery involved in mining release greenhouse gases • extraction from metal ores require lots of energy	• metals can normally be recycled by melting them down and then casting them into new shapes • metals in landfill can persist for a long time
plastic	normally come from fossil fuels that are non- renewable	• many plastic products can be reused and recycled • plastics often end up in landfills where they persist as they are not biodegradable • incinerating plastics releases lots of harmful pollutants like carbon monoxide and particulates
paper	produced from trees that require land and lots of water to grow lots of water also used in the production process	• many paper products can be recycled • paper products can also be incinerated or they can decay naturally in a landfill • incineration and decay release greenhouse gases
glass	produced by heating sand, which requires a lot of energy	• many glass products can be reused, or crushed and recycled • if glass is added to landfills it persists as it is not biodegradable
ceramics	• come from clay and rocks • generally require quarrying, which requires energy, releases pollutants from heavy machinery, and causes habitat loss	• most ceramics are not commonly recycled in the UK, and once broken cannot be reused • ceramics tend to persist in landfills

Physics - Conservation and dissipation of energy

1. Systems

A **system** is an object or group of objects.

Whenever anything changes in a system, energy is transferred between its stores or to the surroundings.

A **closed system** is one where no energy can escape to or enter from the surroundings. The total energy in a closed system never changes.

2. Energy stores

kinetic	energy an object has because it is moving
gravitational potential	energy an object has because of its height above the ground
elastic potential	energy an elastic object has when it is stretched or compressed
thermal (or internal)	energy an object has because of its temperature (the total kinetic and potential energy of the particles in the object)
chemical	energy that can be transferred by chemical reactions involving foods, fuels, and the chemicals in batteries
nuclear	energy stored in the nucleus of an atom
magnetic	energy a magnetic object has when it is near a magnet or in a magnetic field
electrostatic	energy a charged object has when near another charged object

3. Energy transfers

Energy can be transferred to and from different stores by:

Heating
Energy is transferred from one object to another object with a lower temperature.

Waves
Waves (e.g., light and sound) can transfer energy.

Electricity
An electric current transfers energy.

Forces (mechanical work)
Energy is transferred when a force moves or changes the shape of an object.

4. Examples of energy transfers

When you stretch a rubber band, energy from your chemical store is mechanically transferred to the rubber band's elastic potential store.

When a block is dropped from a height, energy is mechanically transferred (by the force of gravity) from the block's gravitational potential store to its kinetic store.

When this block hits the ground, energy from its kinetic energy store is transferred mechanically and by sound waves to the thermal energy store of the surroundings.

The electric current in a kettle transfers energy to the heating element's thermal energy store. Energy is then transferred by heating from the heating element's thermal energy store to the thermal energy store of the water.

When an object slows down due to friction, energy is mechanically transferred from the object's kinetic store to its thermal store, the thermal store of the object it is rubbing against, and to the surroundings.

5. Work done

When an object is moved by a force **work** is done on the object. The force transfers energy to the object. The amount of energy transferred is equal to the work done. You can calculate the work done (and the energy transferred) using the equation:

work done (J) = force (N) x distance moved along the line of action of the force (m)

6. Calculating the energy in an energy store

An object's gravitational potential energy store depends on its height above the ground, the gravitational field strength, and its mass.

gravitational potential energy (J) = mass (kg) × gravitational field strength (N/kg) × height (m)

$$E_p = m\,g\,h$$

An object's kinetic energy store depends only on its mass and speed.

kinetic energy (J) = 0.5 × mass (kg) × (speed)² (m/s)

$$E_k = \frac{1}{2} m v^2$$

The elastic potential energy store of a stretched spring can be calculated using:

elastic potential energy (J) = 0.5 × spring constant (N/m) × (extension)² (m)

$$E_e = \frac{1}{2} k e^2$$ (assuming the limit of proportionality has not been exceeded)

7. Power is how much work is done (or how much energy is transferred) per second. The unit of power is the watt (W).

1 watt = 1 joule of energy transferred per second

$$\text{power (W)} = \frac{\text{energy transferred (J)}}{\text{time (s)}}$$

$$P = \frac{E}{t}$$

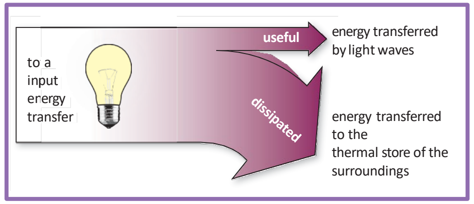
or

$$\text{power (W)} = \frac{\text{work done (J)}}{\text{time (s)}}$$

$$P = \frac{W}{t}$$

8. Useful and dissipated energy

Energy cannot be created or destroyed – it can only be transferred usefully, stored, or dissipated (wasted).



Energy is never entirely transferred usefully – some energy is always dissipated, meaning it is transferred to less useful stores.

All energy eventually ends up transferred to the thermal energy store of the surroundings.

In machines, work done against the force of friction usually causes energy to be wasted because energy is transferred to the thermal store of the machine and its surroundings.

HT ONLY:
Lubrication is a way of reducing unwanted energy transfer due to friction.

Streamlining is a way of reducing energy wasted due to air resistance or drag in water.

Use of thermal insulation is a way of reducing energy wasted due to heat dissipated to the surroundings.

Efficiency is a measure of how much energy is transferred usefully. You must know the equation to calculate efficiency as a *decimal*:

$$\text{efficiency} = \frac{\text{useful output energy transfer (J)}}{\text{total input energy transfer (J)}}$$

or

$$\text{efficiency} = \frac{\text{useful power output (W)}}{\text{total power input (W)}}$$

To give efficiency as a *percentage*, just multiply the result from the above calculation by 100 and add the % sign to the answer.

Keyterms

9. Make sure you can write a definition for these key terms.

chemical, closed system, dissipated, efficiency, elastic potential, electrostatic, gravitational potential, kinetic, lubrication, magnetic, nuclear, power, streamlining, system, thermal, work done

CHRIST THE KING - Knowledge Organisers

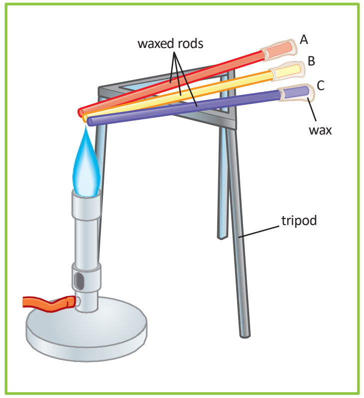
Physics - Energy transfer by heating

1. Thermal conductivity

The **thermal conductivity** of a material tells you how quickly energy is transmitted through it by thermal conduction.

You can test the thermal conductivity of rods made of different metals using this experimental set-up. Each rod must have the same diameter and length, and the same temperature difference between its ends.

One end of each rod is covered in wax and the other ends are heated equally. The faster the wax melts, the higher the thermal conductivity of the metal.



3. Insulating buildings

Heating bills can be expensive so it is important to reduce the rate of heat loss from buildings.

Some factors that affect the rate of heat loss from a building include:

1 the thickness of its walls and roof
2 the thermal conductivity of its walls and roof.

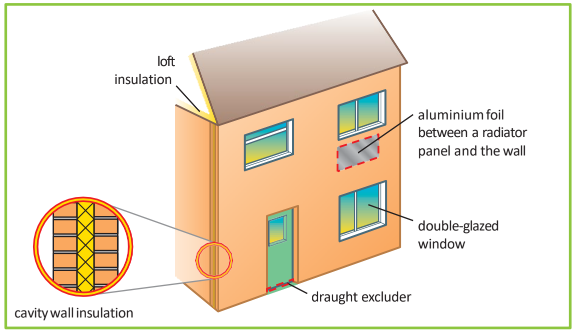
lower thermal conductivity = lower rate of heat loss

The thermal conductivity of the walls and roof can be reduced by using **thermal insulators**.

A thermal insulator is a material which has a low thermal conductivity. The rate of energy transfer through an insulator is low.

The energy transfer per second through a material depends on:

1 the material's thermal conductivity
2 the temperature difference between the two sides of the material
3 the thickness of the material.



2. Specific heat capacity

When a substance is heated or cooled the temperature change depends on:

- the substance's mass
- the type of material
- how much energy is transferred to it.

Every type of material has a **specific heat capacity** – the amount of energy needed to raise the temperature of 1 kg of the substance by 1°C.

The energy transferred to the thermal store of a substance can be calculated from the substance's mass, specific heat capacity, and temperature change:

change in thermal energy (J) = mass (kg) × specific heat capacity (J/kg°C) × temperature change (°C)

$$\Delta E = m\ c\ \Delta\theta$$

This equation will be given to you on the equation sheet, but you need to be able to select and apply it to the correct questions.

4. Infrared radiation

Infrared radiation is part of the **electromagnetic spectrum.**

All objects **emit** (give out) and **absorb** (take in) infrared radiation.

The higher the temperature of an object, the more infrared radiation it emits in a given time.

A good absorber of infrared radiation is also a good emitter. For an object at a constant temperature:

- infrared radiation emitted = infrared radiation absorbed
- infrared radiation is emitted across a continuous range of wavelengths.

An object's temperature will increase if it absorbs infrared radiation at a higher rate than it emits it. This rule applies to the planet Earth.

5. Black bodies

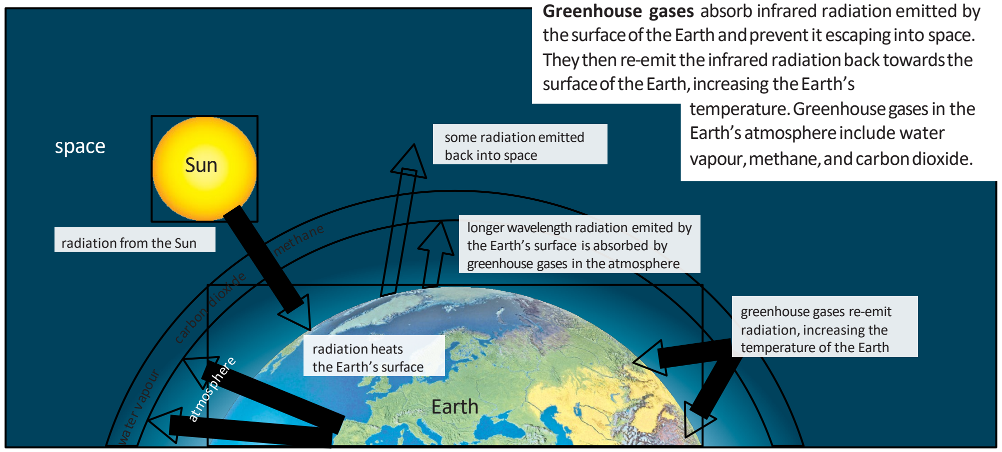
A **black body** is a theoretical object that absorbs 100% of the radiation that falls on it.

A perfect black body would not reflect or transmit any radiation, and would also be a perfect emitter of radiation.

6. Radiation and the Earth's temperature (HT ONLY)

The temperature of the Earth depends on lots of factors, including the rate at which visible light and infrared radiation are reflected, absorbed, and emitted by the Earth's atmosphere and surface.

Greenhouse gases absorb infrared radiation emitted by the surface of the Earth and prevent it escaping into space. They then re-emit the infrared radiation back towards the surface of the Earth, increasing the Earth's temperature. Greenhouse gases in the Earth's atmosphere include water vapour, methane, and carbon dioxide.



Human activities such as burning fossil fuels, deforestation, and livestock farming are increasing the amount of greenhouse gases in the Earth's atmosphere. This is causing the Earth's temperature to increase – a major cause of climate change.

Keyterms

7. Make sure you can write a definition for these key terms.

absorb | black body | electromagnetic spectrum | emit | greenhouse gas | infrared radiation | specific heat capacity | thermal conductivity | thermal insulator

Physics - Energy resources

1. Energy resources

The main ways in which we use the Earth's energy resources are:

- generating electricity
- heating
- transport.

Most of our energy currently comes from **fossil fuels** – coal, oil, and natural gas.

2. Reliability and environmental impact

Some energy resources are more reliable than others. **Reliable** energy resources are ones that are available all the time (or at predictable times) and in sufficient quantities.

Both **renewable** and **non-renewable** energy resources have some kind of **environmental impact** when we use them.

3. Non-renewable energy resources

- not replaced as quickly as they are used
- will eventually run out

For example, fossil fuels and nuclear fission.

4. Renewable energy resources

- can be replaced at the same rate as they are used
- will not run out

For example, solar, tidal, wave, wind, geothermal, biofuel, and hydroelectric energies.

4. Non-renewable energy resources

Resource	Main uses	Source	Advantages	Disadvantages
coal	generating electricity	extracted from underground	• enough available to meet current energy demands • reliable – supply can be controlled to meet demand • relatively cheap to extract and use	• will eventually run out • release carbon dioxide when burned – one of the main causes of climate change • release other polluting gases, such as sulfur dioxide (from coal and oil) which causes acid rain • oil spills in the oceans kill marine life
oil	generating electricity transpor t heating			
natural gas	generating electricity Heating			
nuclear fission	generating electricity	mining naturally occurring elements, such as uranium and plutonium	• no polluting gases or greenhouse gases produced • enough available to meet current energy demands • large amount of energy transferred from a very small mass of fuel • reliable – supply can be controlled to meet demand	produces nuclear waste, which is: • dangerous • difficult and expensive to dispose of • stored for centuries before it is safe to dispose of. nuclear power plants are expensive to: • build and run • decommission (shut down).

Renewable energy resources

Resource	Main uses	Source	Advantages	Disadvantages
solar energy	generatin g electricity	sunlight transfers energy to solar cells	can be used in remote places very cheap to run once installed no pollution/greenhouse gases produced	supply depends on weather expensive to buy and install cannot supply large scale demand
	heating	sunlight transfers energy to solar heating panels		
hydroelectric energy	generatin g electricity	water flowing downhill turns generators	low running cost no fuel costs reliable and supply can be controlled to meet demand	expensive to build hydroelectric dams flood a large area behind the dam, destroying habitats and resulting in greenhouse gas production from rotting vegetation
tidal energy	generatin g electricity	turbines on tidal barrages turned by water as the tide comes in and out	predictable supply as there are always tides can produce large amounts of electricity no fuel costs no pollution/greenhouse gases produced	tidal barrages: – change marine habitats and can harm animals – restrict access and can be dangerous for boats – are expensive to build and maintain cannot control supply supply varies depending on time of month
wave energy	generatin g electricity	floating generators powered by waves moving up and down	low running cost no fuel costs no pollution/greenhouse gases produced	floating generators: – change marine habitats and can harm animals – restrict access and can be dangerous for boats – are expensive to build, install, and maintain dependent on weather cannot supply large scale demand
wind energy	generatin g electricity	turbines turned by the wind	low running cost no fuel costs no pollution/greenhouse gases produced	supply depends on weather large amounts of land needed to generate enough electricity for large scale demand can produce noise pollution for nearby residents
geothermal energy	generatin g electricity heating	radioactive substances deep within the Earth transfer heat energy to the surface	low running cost no fuel costs no pollution/greenhouse gases produced	expensive to set up only possible in a few suitable locations around the world
biofuels	generatin g electricity transport	fuel produced from living or recently living organisms, for example, plants and animal waste	can be **carbon neutral** – the amount of carbon dioxide released when the fuel is burnt is equal to the amount of carbon dioxide absorbed when the fuel is grown reliable and supply can be controlled to meet demand	expensive to produce biofuels growing biofuels requires a lot of land and water that could be used for food production can lead to deforestation – forests are cleared for growing biofuel crops

Key terms

Make sure you can write a definition for these key terms.

biofuel carbon neutral environmental impact fossil fuel geothermal hydroelectric non-renewable reliability renewable

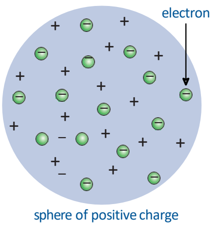
Physics – Radioactivity

1. Dalton's model

John Dalton thought the atom was a neutral solid sphere you cannot divide into smaller parts.

2. Plum pudding model

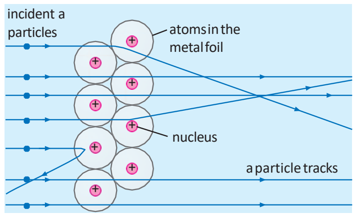
The discovery of negatively charged electrons led to the plum pudding model – a cloud of positive charge with electrons embedded in it.



3. Alpha scattering experiment

Positively charged alpha particles were fired at a thin sheet of gold foil.

- Most went straight through
- Some were deflected by small amounts
- 1 in 10 0000 deflected through large angles



4. Nuclear model

To explain the results, scientists deduced that there is a small positively charged nucleus at the centre of the atom where most of the mass is concentrated. The negative electrons orbit the nucleus.

5. Bohr's model

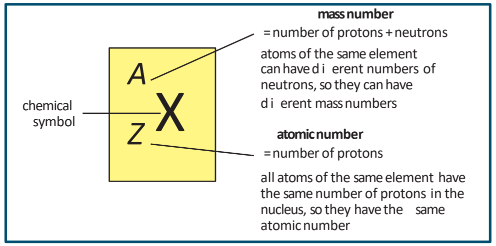
Bohr suggested the electrons orbit at specific distances called energy levels.

6. Basic structure of an atom

The nucleus, which is 10 000 times smaller than the radius of the atom, consists of two particles:

- positively charged protons
- neutrons which are neutral

An atom is uncharged overall and has equal numbers of protons and electrons.



Isotopes are atoms of the same element, with the same number of protons but a different numbers of neutrons.

7. Radioactive decay

Radioactive decay is when nuclear radiation is emitted by unstable atomic nuclei so that they become more stable. It is a *random* process. This radiation can knock electrons out of atoms in a process called **ionisation**.

Type of radiation	Change in the nucleus	Ionising power	Range in air	Stopped by	Decay equation
α alpha particle (two protons and two neutrons)	nucleus loses two protons and two neutrons	highest ionising power	travels a few centimetres in air	stopped by a sheet of paper	$^{A}_{Z}X \rightarrow {}^{(A-4)}_{(Z-2)}Y + {}^{4}_{2}\alpha$
β beta particle (fast-moving electron)	a neutron changes into a proton and an electron	high ionising power	travels ≈1 m in air	stopped by a few millimeters of aluminium	$^{A}_{Z}X \rightarrow {}^{A}_{(Z+1)}Y + {}^{0}_{-1}\beta$
γ gamma radiation (short-wavelength, high- frequency EM radiation)	some energy is transferred away from the nucleus	low ionising power	virtually unlimited range in air	stopped by several centimetres of thick lead or metres of concrete	$^{A}_{Z}X \rightarrow {}^{A}_{Z}X + {}^{0}_{0}\gamma$

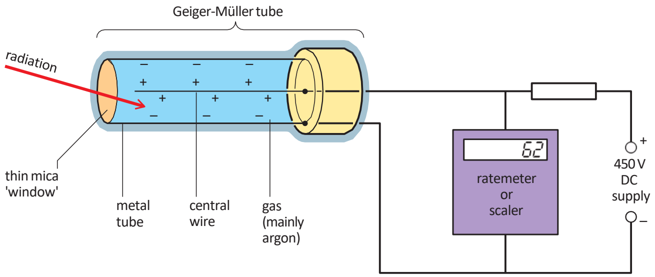
8. Activity and count rate

The **activity** of a radioactive source is the rate of decay of an unstable nucleus, measured in becquerel (Bq).

1 Bq = 1 decay per second

Detectors (e.g., **Geiger-Müller tubes**) record a **count rate** (number of decays detected per second).

$$\text{count rate after } n \text{ half-lives} = \frac{\text{initial count rate}}{2^n}$$



9. Half-life

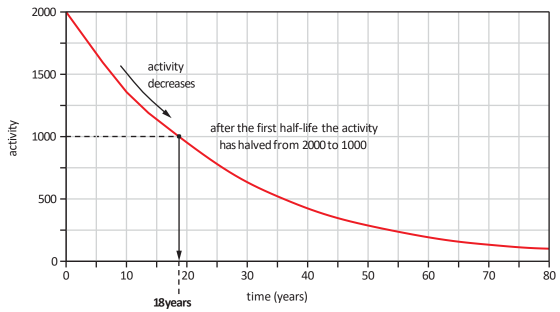
The **half-life** of a radioactive source is the time

- for half the number of unstable nuclei in a sample to decay
- for the count rate or activity of a source to halve.

The half-life of a source can be found from a graph of its count rate or activity against time.

To find the reduction in activity after a given number of half-lives:

1. calculate the activity after each half-life
2. subtract the final activity from the original activity.



The time taken for the activity to halve is 18 years. This is the half-life of this substance.

(**HT only**) **Net decline** can be given as a ratio: net daecline = $\frac{\text{reduction in activity}}{\text{original activity}}$

Keyterms

21. Make sure you can write a definition for these key terms.

atom alpha activity atomic number background radiation beta count rate

electron gamma Geiger-Müller tube half-life ionisation isotope

mass number neutron plum pudding model proton radioactive decay

Physics – Wave Properties

1. Waves in air, fluids, and solids

Waves transfer energy from one place to another without transferring matter. Waves may be **transverse** or **longitudinal**.

For waves in water and air, it is the wave and not the substance that moves.

- When a light object is dropped into still water, it produces ripples (waves) on the water which spread out, but neither the object nor the water moves with the ripples.
- When you speak, your voice box vibrates, making sound waves travel through the air. The air itself does not travel away from your throat, otherwise a vacuum would be created.

2. Mechanical waves

2. Mechanical waves require a substance (a medium) to travel through.

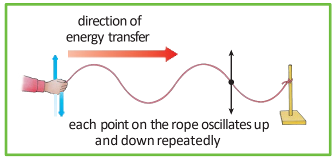
Examples of mechanical waves include sound waves, water waves, waves on springs and ropes, and seismic waves produced by earthquakes.

When waves travel through a substance, the particles in the substance **oscillate** (vibrate) and pass energy on to neighbouring particles.

3. Transverse waves

The oscillations of a transverse wave are *perpendicular* (at right angles) to the direction in which the waves transfer energy.

Ripples on the surface of water are an example of transverse waves.

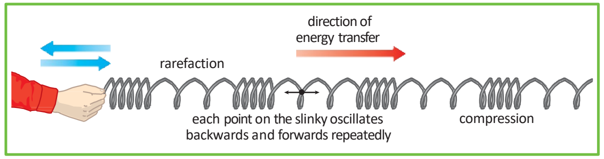


4. Longitudinal waves

The oscillations of a longitudinal wave are *parallel* to the direction in which the waves transfer energy.

Longitudinal waves cause particles in a substance to be squashed closer together and pulled further apart, producing areas of **compression** and **rarefaction** in the substance.

Sound waves in air are an example of longitudinal waves.



5. Properties of waves

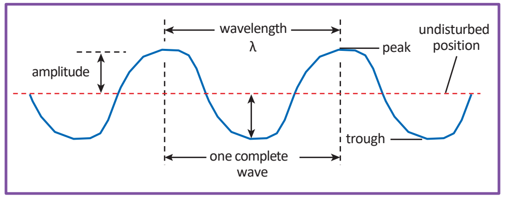
Frequency and period are related by the equation:

$$\text{period (s)} = \frac{1}{\text{frequency (Hz)}} \qquad T = \frac{1}{f}$$

All waves obey the wave equation:

wave speed (m/s) = frequency (Hz) × wavelength (m)

$$v = f\lambda$$



6.

6. When waves travel from one medium to another, their speed and wavelength may change but the frequency always stays the same.

The speed of ripples on water can be slow enough to measure using a stopwatch and ruler, and applying the equation:

$$\text{speed (m/s)} = \frac{\text{distance (m)}}{\text{time (s)}}$$

The speed of sound in air can be measured by using a stopwatch to measure the time taken for a sound to travel a known distance, and applying the same equation.

7. Reflection of waves (HT only)

When waves arrive at the boundary between two different substances, one or more of the following things can happen:

Absorption – the energy of the waves is transferred to the energy stores of the substance they travel into (for example, when food is heated in a microwave)

Reflection – the waves bounce back

Refraction – the waves change speed and direction as they cross the boundary

Transmission – the waves carry on moving once they've crossed the boundary, but may be refracted

8. Ray diagrams

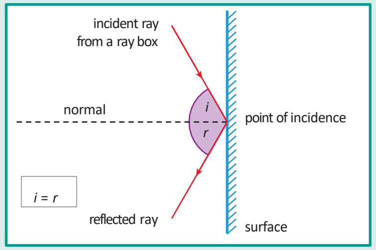
8. Ray diagrams can be used to show what happens when a wave is reflected at a surface.

To correctly draw a ray diagram for reflection:

1. use a ruler to draw all lines for the rays
2. draw a single arrow on the rays to show the direction the wave is travelling
3. draw a dotted line at right angles to the surface at the point of **incidence** (this line is normal to the surface)
4. label the normal, angle of incidence (*i*), and angle of reflection (*r*).

When reflection happens at a surface, the angle of incidence is always equal to the angle of reflection:

$$i = r$$



9. Wave motion

9. Wave motion is described by a number of properties.

Property	Description	Unit
amplitude A	maximum displacement of a point on a wave from its undisturbed position	metre (m)
frequency f	number of waves passing a fixed point per second	hertz (Hz)
period T	time taken for one complete wave to pass a fixed point	second (s)
wavelength λ	distance from one point on a wave to the equivalent point on the next wave	metre (m)
wave speed v	distance travelled by each wave per second, and the speed at which energy is transferred by the wave	metres per second (m/s)

Keyterms

9. Make sure you can write a definition for these key terms.

absorption · amplitude · compression · frequency · incidence · longitudinal · mechanical wave · oscillate · period · ray diagram · reflection · rarefaction · transmission · transverse · wavelength · wavespeed

CHRIST THE KING - Knowledge Organisers

Physics – Electromagnetic Waves

1. The electromagnetic spectrum

Electromagnetic (EM) waves are **transverse** waves that transfer energy from their source to an absorber. For example, infrared waves emitted from a hot object transfer thermal energy.

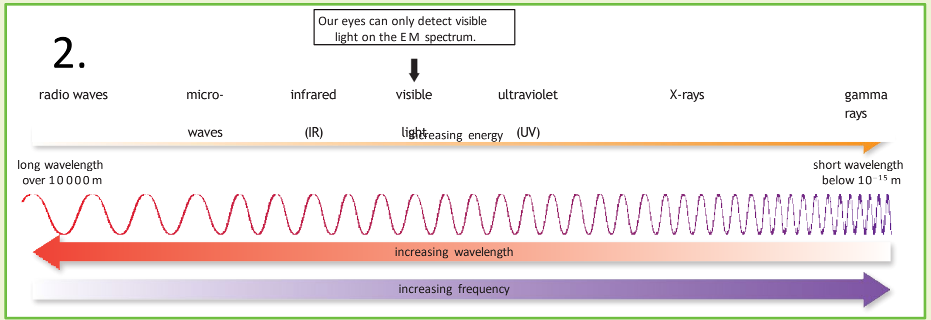
EM waves form a continuous **spectrum**, and are grouped by their wavelengths and frequencies.

EM waves all travel at the same velocity through air or a vacuum. They travel all at a speed of 3×10^8 m/s through a vacuum.

(HT only) Different substances may absorb, transmit, **refract**, or **reflect** EM waves in ways that vary with their wavelength.

Refraction occurs when there is a difference in the velocity of an EM wave in different substances.

2.



3. Infrared radiation (required practical)

This practical investigates the rates of absorption and radiation of infrared radiation from different surfaces.

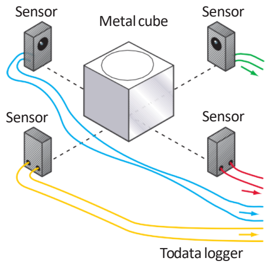
You should be able to plan a method to determine the rate of cooling due to emission of infrared radiation and evaluate your method.

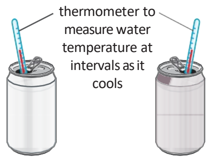
Using infrared detectors to measure the radiation emitted by different surfaces

Monitoring the rate of cooling in cans with different surfaces

To be accurate and precise in your investigation you need to:

- use an infrared detector with a suitable meter, where possible
- ensure that you always put the detector the same distance from the surface
- repeat measurements and calculate an average.





4. Properties of EM waves

EM waves of a wide range of frequencies can be absorbed or produced by changes inside an atom or nucleus. For example, gamma rays are produced by changes in the nucleus of an atom.

When electrons in an atom move down between energy levels, they emit EM waves.

5. Properties of radio waves (HT only)

Radio waves can be produced by **oscillations** in an electrical circuit.

When radio waves are absorbed by a receiver aerial, they may create an **alternating current** with the same frequency as the radio waves.

6. Uses of EM waves

EM waves have many practical applications, but exposure to some EM waves (such as those that are forms of ionising radiation) can have hazardous effects.

Radiation dose (in sieverts) is the risk of harm from exposure of the body to a particular radiation.

Type of EM wave	Use	Why is it suitable for this use? (HT only)	Hazards
radio waves	television and radio signals	• can travel long distances through air • longer wavelengths can bend around obstructions to allow detection of signals when not in line of sight	can penetrate the body and cause internal heating
microwaves	satellite communications and cooking food	• can pass through Earth's atmosphere to reach satellites • can penetrate into food and are absorbed by water molecules in food, heating it	
infrared	electrical heaters, cooking food, and infrared cameras	• all hot objects emit infrared waves – sensors can detect these to turn them into an image • can transfer energy quickly to heat rooms and food	can damage or kill skin cells due to heating
visible light	fibre optic communications	• short wavelength means visible light carries more information	can damage the retina
ultraviolet (UV)	energy efficient lights and artificial sun tanning	• carries more energy than visible light • some chemicals used inside light bulbs can absorb UV and emit visible light	can damage skin cells, causing skin to age prematurely and increasing the risk of skin cancer, and can cause blindness
X-rays	medical imaging and treatments	• pass easily through flesh, but not denser materials like bone • high doses kill living cells, so can be used to kill cancer cells – gamma rays can also be used to kill harmful bacteria	form of ionising radiation – can damage or kill cells, cause mutation of genes, and lead to cancers
gamma rays			

Keyterms

8. Make sure you can write a definition for these key terms.

alternating current · electromagnetic wave · electromagnetic spectrum · oscillation · radiation dose · reflection · refraction · transverse

Key Words

1	Consent	Freely given, enthusiastic and informed agreement to engage in any activity.
2	Consumerism	The belief that buying goods brings happiness and success.
3	Pornography	Material that shows sexual content, often in a way that can affect healthy views on sex and relationships.
4	Objectification	Seeing or treating a person like an object, ignoring their dignity or feelings.
5	Self-gratification	Doing something just to feel good for yourself, without thinking about others.
6	Love	Deep affection and care for another person that goes beyond physical attraction.
7	Intimacy	A close, familiar, and usually affectionate or loving personal relationship with another person.
8	Self-worth	Understanding and valuing yourself as a person.

Key Facts

1	Consent must be clear, ongoing, and freely given to respect human dignity and freedom.
2	Consumerism can lead people to value possessions more than people or relationships.
3	Pornography affects brain chemistry like addictive substances, distorting real intimacy.
4	Objectifying others ignores their dignity as children of God and harms mutual respect.
5	Self-gratification without self-control can negatively impact relationships and self-image.
6	Love is more than attraction—true love involves care, commitment, and respect.
7	Catholic teaching sees intimacy as a gift from God meant for loving, faithful relationships.
8	Faith teaches us to love people and use things—not the other way around.

Key Virtues & Scripture

1	Faith	Believing in God's presence and guidance.	This could mean trusting God during hard times, praying regularly, and making choices based on Catholic values.
2	Love	Caring for others selflessly, as God loves us.	This might look like helping others in need, being kind to classmates, or standing up against injustice.
3	Self-control	The ability to choose wisely and resist temptations.	In daily life, this means thinking before acting, saying no to peer pressure, or using social media responsibly.
“Love one another as I have loved you” John 13:34			This scripture speaks to the core message of Advent 1 – the call to authentic love, self-control in relationships, and respect for others. It reminds students that true love mirrors the self-giving love of Christ.

Key Words		
1	Community cohesion	The idea of all ethnic groups getting on with one another in the community.
2	Manifesto	The aims and objectives outlining a person or political party's intentions if they win an election.
3	Female Genital Mutilation	FGM - The illegal and harmful cutting of female genitalia for non-medical reasons.
4	Political party	A group of people with shared beliefs aiming to govern through elections.
5	Parliament	The place where laws are made and government actions are scrutinised.
6	Active citizenship	Someone who wants to change things for the better, is prepared to argue for and take action to change things or resist unwanted change.
7	Human rights	Basic rights and freedoms every person is entitled to.
8	Coercion	Forcing or pressuring someone to do something they don't want to do.

Key Facts	
1	Strong community cohesion encourages mutual respect, reduces crime, and supports peaceful coexistence.
2	A manifesto clearly outlines the priorities, promises, and plans of a political party before an election.
3	FGM causes serious physical and psychological harm and is considered a violation of human dignity and law.
4	Political parties play a vital role in shaping national policies, representing views, and forming governments to improve society.
5	Parliament ensures laws are fair and accountable by requiring debate and scrutiny in both Houses.
6	Active citizenship includes voting, campaigning, and helping local communities through voluntary actions.
7	The Universal Declaration of Human Rights. Human rights ensure everyone is treated fairly, with access to safety, education, and freedom of expression.
8	Coercion is a form of manipulation that removes freedom of choice and can lead to abuse or exploitation.

Key Virtues & Scripture			
1	Gratitude	Appreciating what we have and those around us.	Thanking others, valuing freedom, and recognising community support.
2	Compassion	Being moved to help others in need or suffering.	Listening, standing up for human rights, and supporting those affected by injustice.
3	Stewardship	Taking care of what God has entrusted to us.	Using our voices and actions to care for society and protect the vulnerable.
"Speak up for those who cannot speak for themselves." Proverbs 31:8			This scripture captures the mission of Advent 2 – defending human rights, acting as responsible citizens, and protecting the vulnerable. It calls students to be advocates for justice and active contributors to society.