CHRIST THE KING

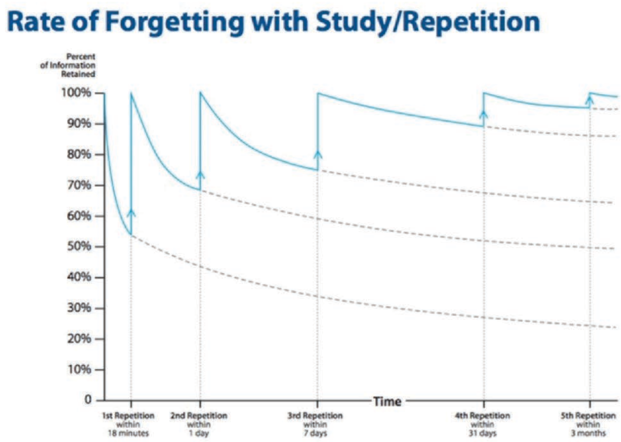
KNOWLEDGE ORGANISER

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.

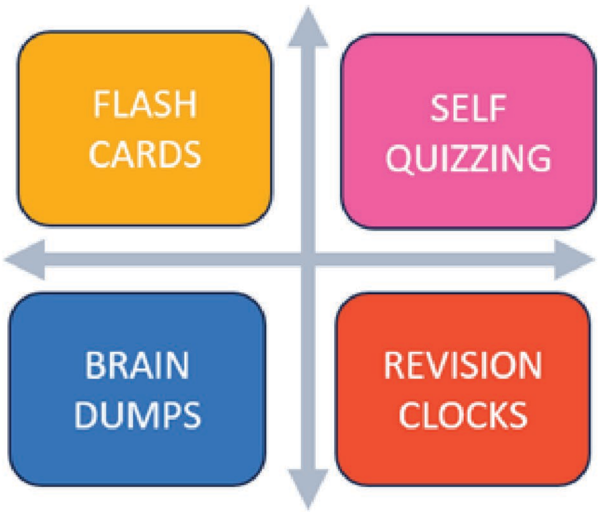
How to use your Knowledge Organiser

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

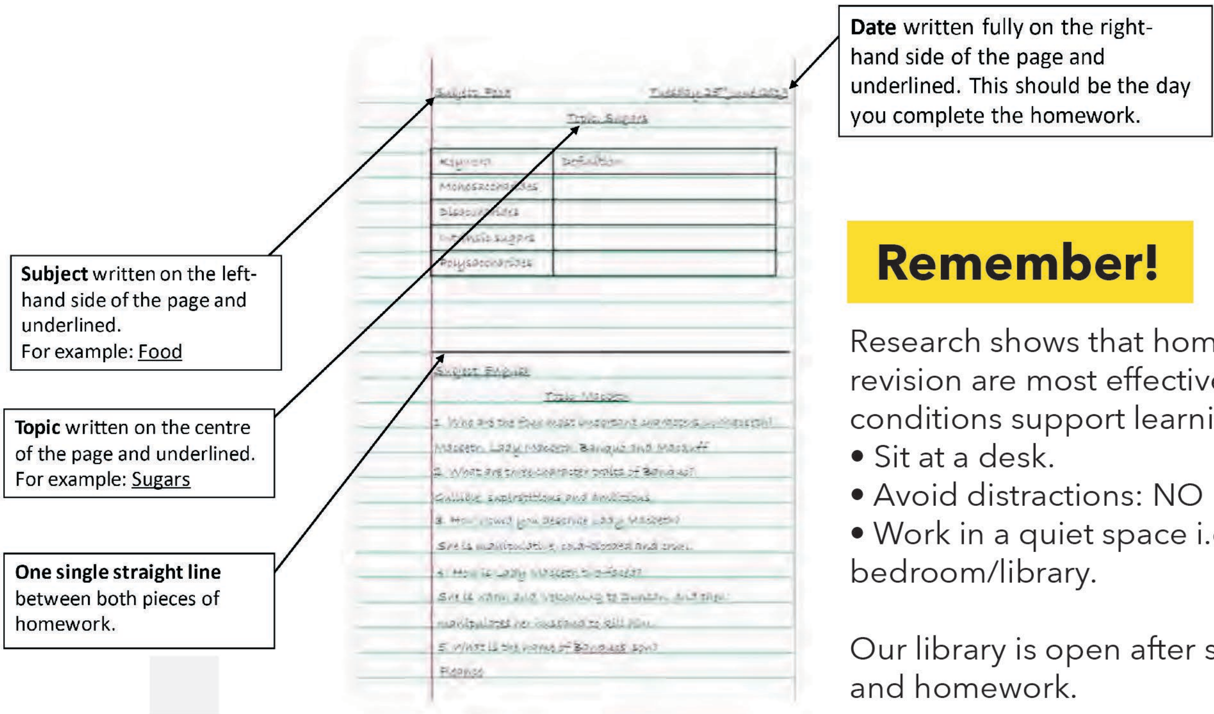
Read 20 minutes a day and you'll read 1,800,000 words per year.

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.

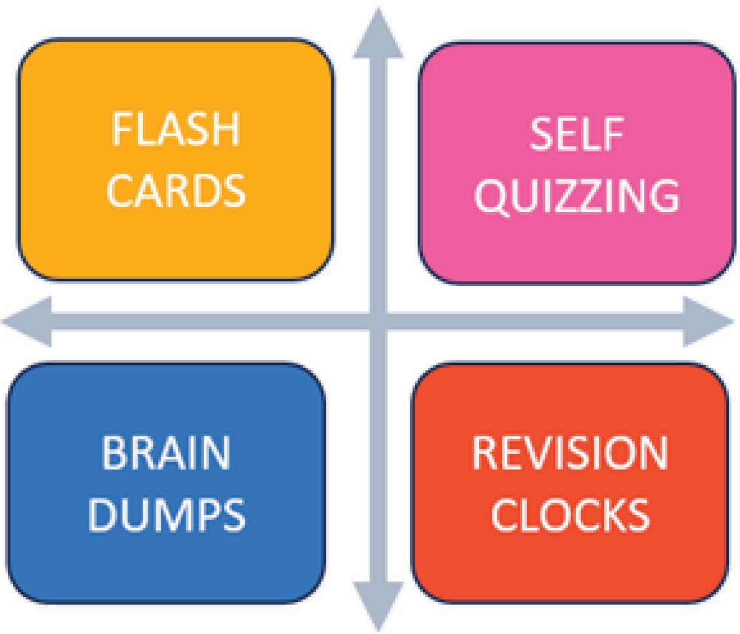


Remember!

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.

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 specific 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.

THE CORE FOUR REVISION TECHNIQUES

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.

THE CORE FOUR REVISION TECHNIQUES

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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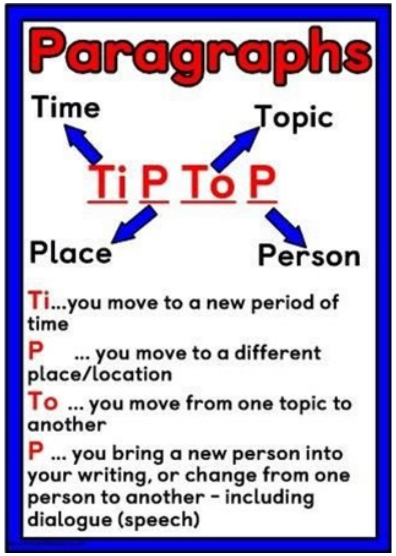
English – Speaking & Writing from a Viewpoint

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

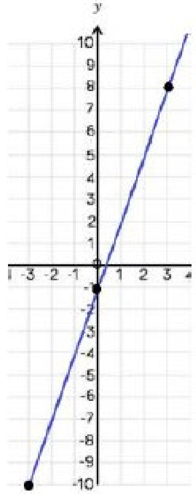
3 Plotting y = mx + c graphs R

$y = 3x - 1$ → 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)

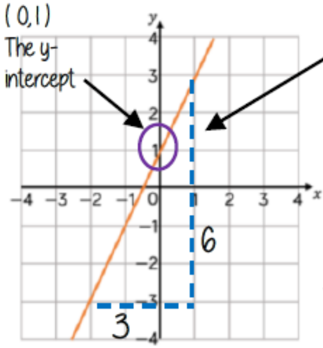


You only need two points to form a straight line

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

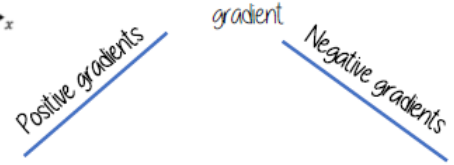
4 Find the equation from a graph



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

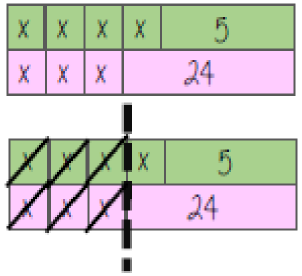
$4x + 5 = 3x + 24$

$-3x \qquad -3x$

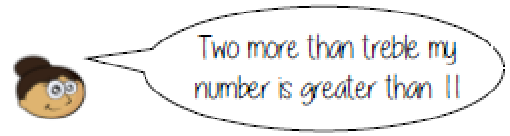
$x + 5 = 24$

$-5 \qquad -5$

$x = 19$



(3) Form and solve inequalities (R)



Find the possible range of values

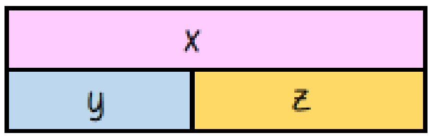
$3x + 2 > 11$

Solve

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

$x > 3$

Rearranging Formulae (one step) (4)



$x = y + z$

Rearrange to make y the subject

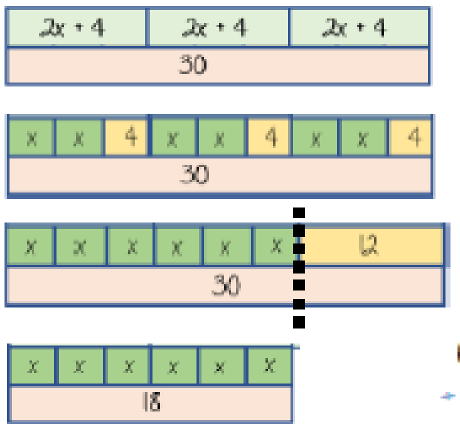
$y = x - z$

$y \rightarrow +z \rightarrow x$

$y \leftarrow -z \leftarrow x$

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

Solve equations with brackets (R) (5)



$3(2x + 4) = 30$

Expand the brackets

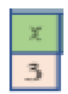
$6x + 12 = 30$

$-12 \qquad -12$

$6x = 18$

$\div 6 \qquad \div 6$

$x = 3$



Testing conjectures

Sparx Codes M108 M227 M698

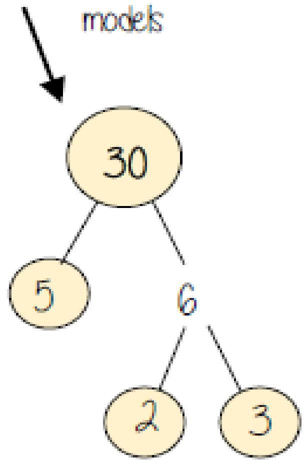
Key Words (1)

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

R

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

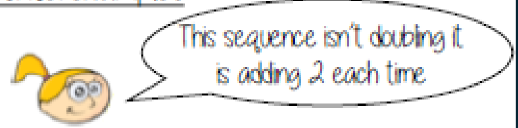
True or False? (3)

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

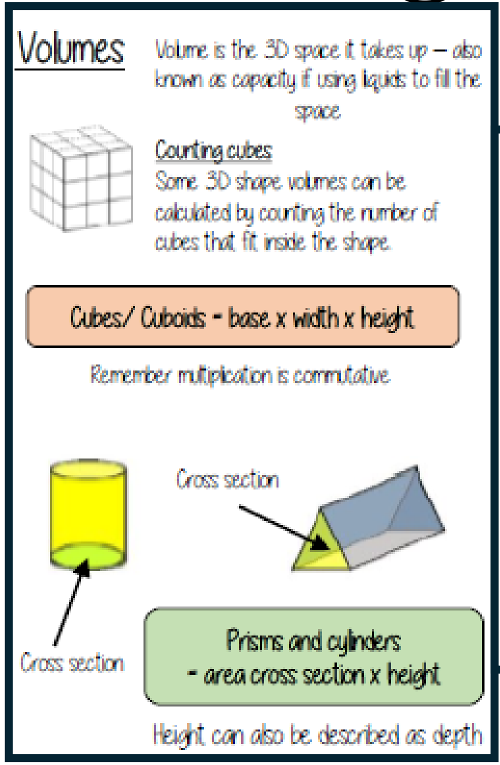
Face: a flat surface on a solid object

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



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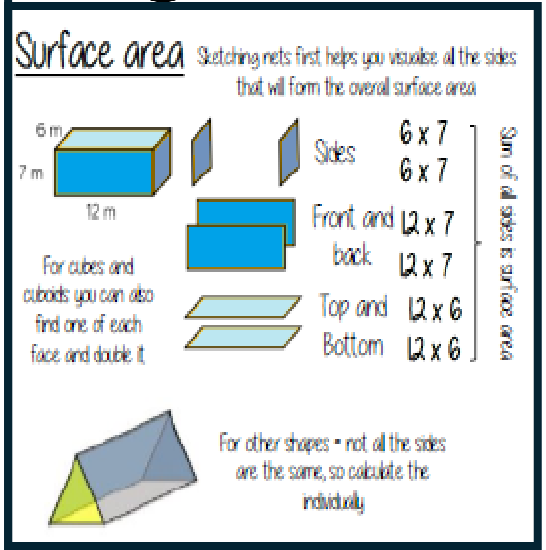
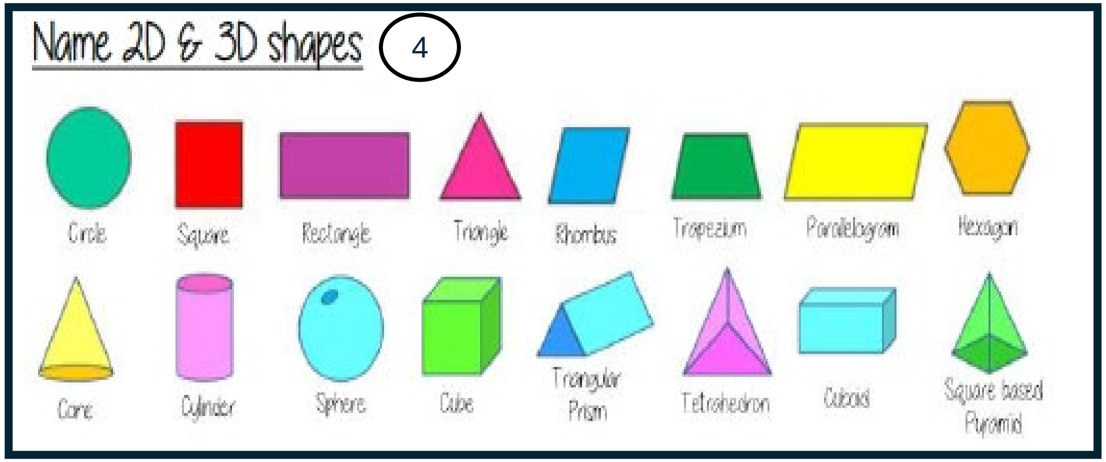
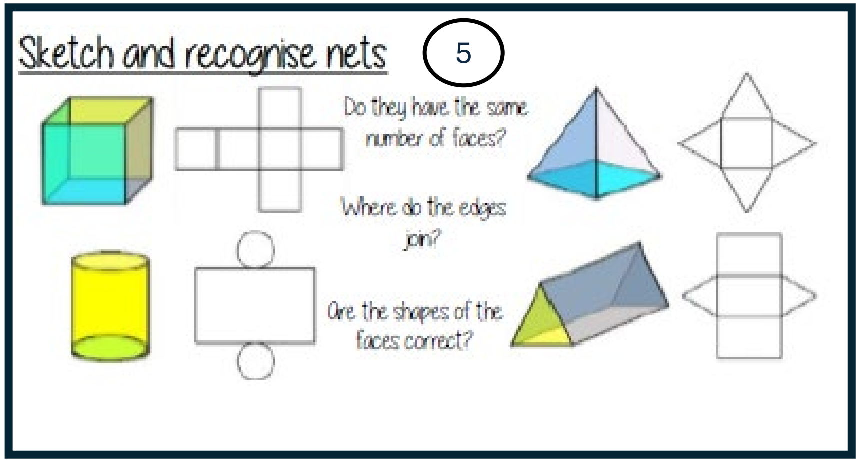






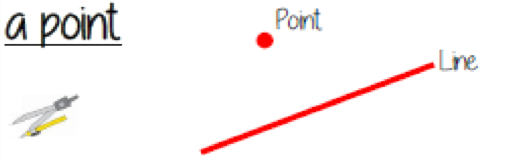
Constructions

Sparx Codes M565 M239 M253

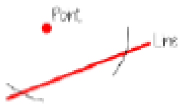
Key Words (1)

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.

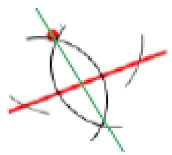
(2) Construct a perpendicular from a point



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

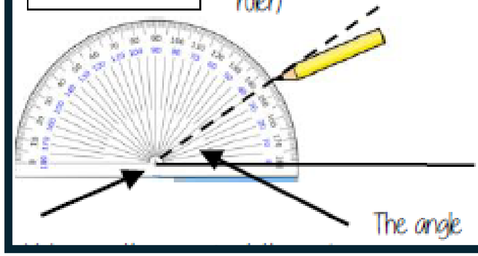
If P is a point on the line the steps are the same

(3) Draw and measure angles

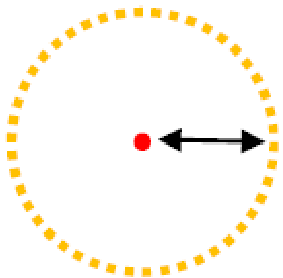
R

Draw a 35° angle

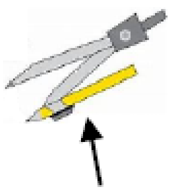
Make a mark at 35° with a pencil And join to the angle point (use a ruler)



(4) Locus of a distance from a point



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



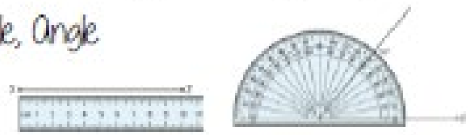
Equipment needed

The radius is the distance from the fixed point

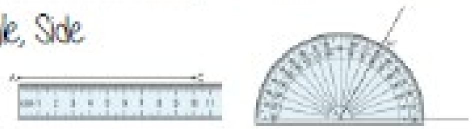
If the point is in the corner it can only make a quarter circle

(5) Constructing Triangles

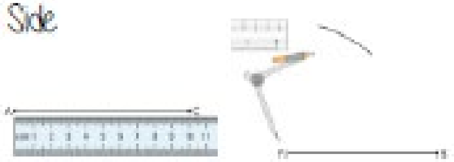
Side, Angle, Angle



Side, Angle, Side



Side, Side, Side



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

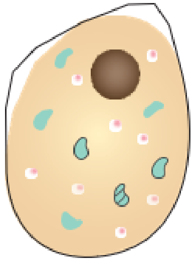
CHRIST THE KING - Knowledge Organisers

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

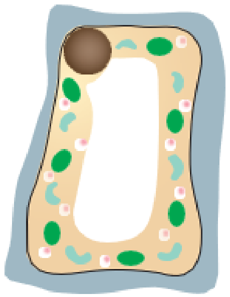
nucleus: contains DNA

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

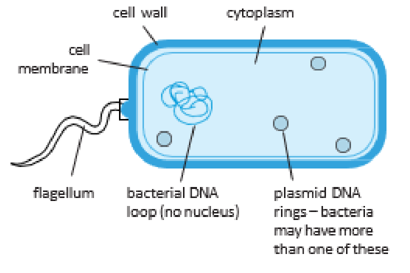
chloroplasts: contain chlorophyll to absorb light energy for photosynthesis

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

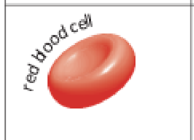
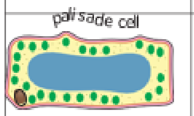
Electron microscopes allow you to see sub-cellular structures, such as ribosomes, that are too small to be seen with a light microscope.

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
	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
	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
	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
	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
	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
	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

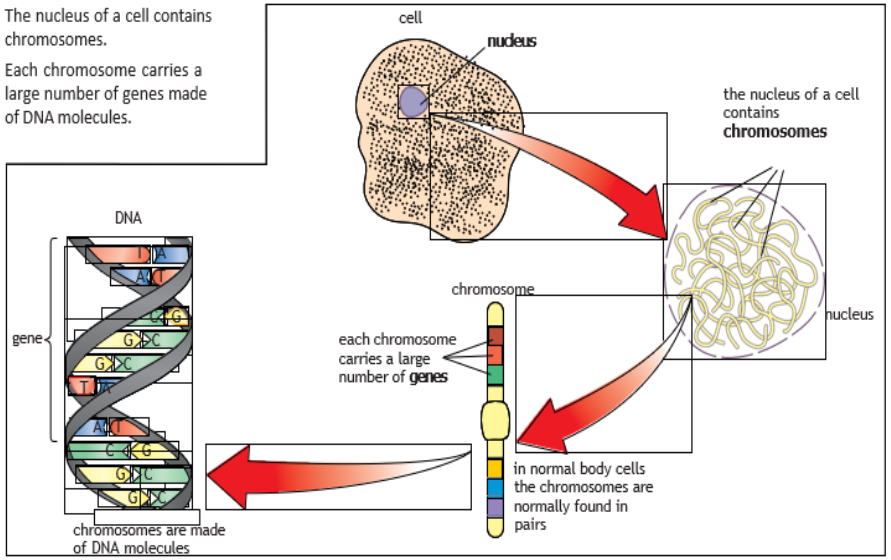
Make sure you can write a definition for these key terms.

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

1. Chromosomes

The nucleus of a cell contains chromosomes.

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

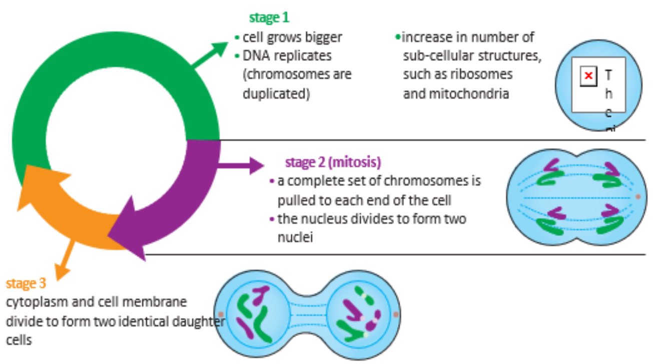


2. The cell cycle

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:



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.**

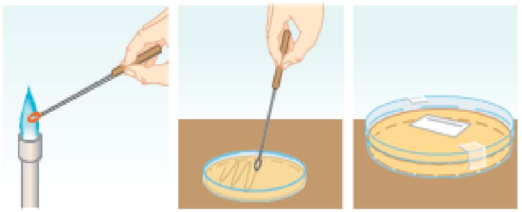
Stem cells can be **cloned** to produce large numbers of identical cells.

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

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.



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)

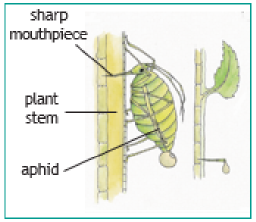
Signs that a plant is diseased
- stunted growth
- spots on leaves
- areas of rot or decay
- growths
- malformed stems or leaves
- discolouration
- pest infestation

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

3. Plant diseases and insects (Separate Only)

Plant diseases can also be directly caused by insects.

Aphids are insects that suck sap from the stems of plants. This results in
- reduced rate of growth
- wilting
- discolouration of leaves.



Ladybirds can be used to control aphid infestations as ladybird larvae eat aphids.

4. Plant defences (Separate Only)

Physical barriers
- cellulose cell walls – provide a barrier to infection
- tough waxy cuticle on leaves
- bark on trees – a layer of dead cells that can fall off

Chemical barriers
- many plants produce antibacterial chemicals
- poison production stops animals eating plants

Mechanical adaptations
- thorns and hairs stop animals eating plants
- leaves that droop or curl when touched to scare herbivores or dislodge insects
- some plants **mimic** the appearance of unhealthy or poisonous plants to deter insects or herbivores

5. Controlling the spread of communicable disease

There are a number of ways to help prevent the spread of communicable diseases from one organism to another.

Hygiene
Hand washing, disinfecting surfaces and machinery, keeping raw meat separate, covering mouth when coughing/sneezing, etc.

Isolation
Isolation of infected individuals – people, animals, and plants can be isolated to stop the spread of disease.

Controlling vectors
If a vector spreads a disease destroying or controlling the population of the vector can limit the spread of disease.

Vaccination
Vaccination can protect large numbers of individuals against diseases.

Key terms

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

Chemistry – Atomic Structure

1. Development of the model of the atom

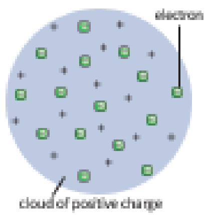
Dalton's model

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

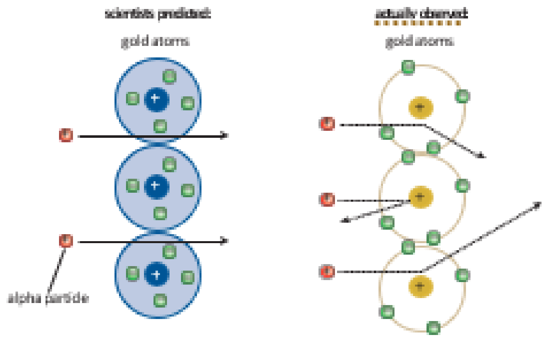
Scientists' experiments resulted in the discovery of sub-atomic charged particles. The first to be discovered were electrons – tiny, negatively charged particles.

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.



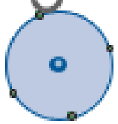
Alpha scattering experiment

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**.



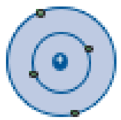
Nuclear model

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 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.

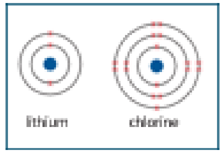
Compounds are made of different types of atoms chemically bonded together. The atoms in a compound have different numbers of protons.

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:

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

Key terms

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.

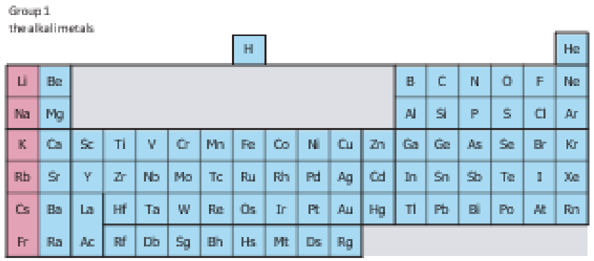
	First lists of elements	Mendeleev's Periodic Table	Modern Periodic Table
How are elements ordered?	by atomic mass	normally by atomic mass but some elements were swapped around	by atomic number
Are there gaps?	no gaps	gaps left for undiscovered elements	no gaps – all elements up to a certain atomic number 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

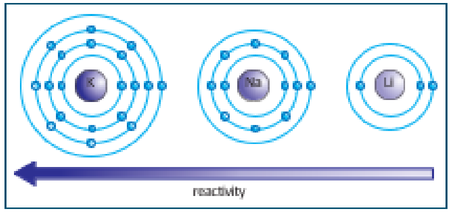
Group 1 elements are called **alkali metals** because they react with water to form an alkali (a solution of their metal hydroxide).



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:

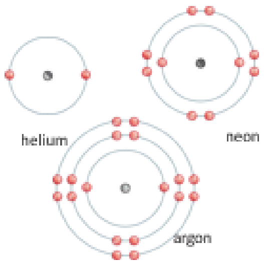
- the atoms increase in size
- the outer electron is further away from the nucleus, and there are more shells shielding the outer electron from the nucleus
- the electrostatic attraction between the nucleus and the outer electron is weaker so it is easier to lose the one outer electron
- the melting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

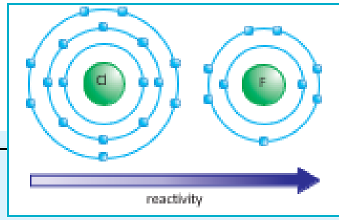
Group 7 elements are called the **halogens**. They are non-metals that exist as molecules made up of pairs of atoms.

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

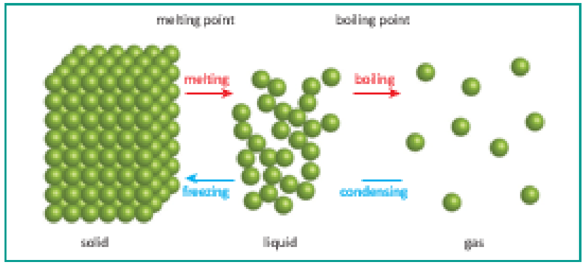
Make sure you can write a definition for these key terms.

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.



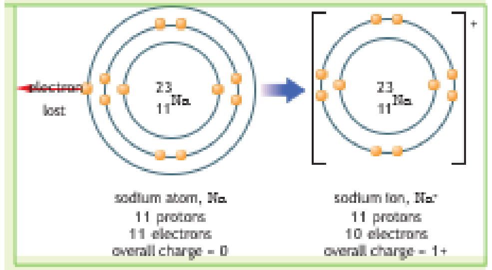
(HT only) This model assumes that:

- 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.

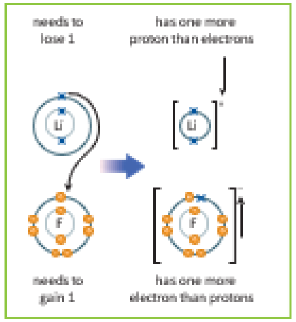
2. Ions

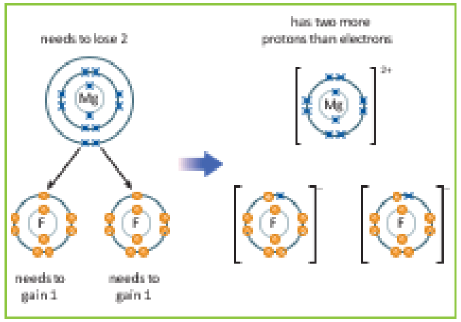
Atoms can gain or lose electrons to give them a full outer shell. The number of protons is then different from the number of electrons. The resulting particle has a charge and is called an **ion**.



3. Ionic bonding

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

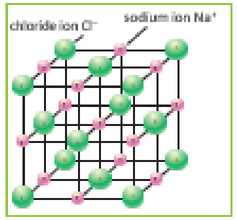




Metal atoms lose electrons to become positive ions. Non-metal atoms gain electrons to become negative ions.

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.

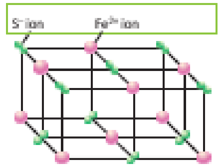


The electrostatic force of attraction works in all directions, so many billions of ions can be bonded together in a 3D structure.

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

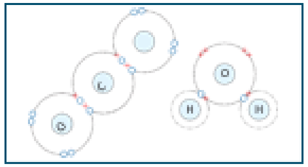
Atoms can share or transfer electrons to form strong chemical bonds.

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

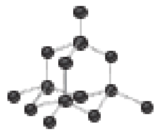
There are three main types of covalent structure:

Structure and bonding

Giant covalent

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

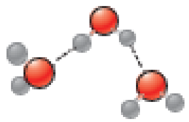
An example of a giant covalent structure is diamond.



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.



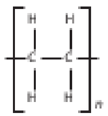
Large molecules

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.



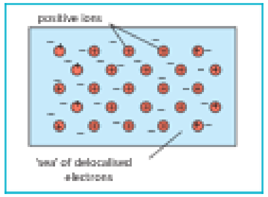
10. Metals: structure and properties

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.



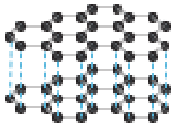
High melting and boiling points because the strong covalent bonds between the atoms must be broken to melt or boil the substances. This requires a lot of energy. Solid at room temperature.	Low melting and boiling points because only the intermolecular forces need to be overcome to melt or boil the substances, 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.

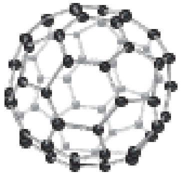
14. Graphene

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

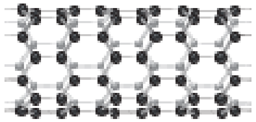


Buckminsterfullerene was the first fullerene to be discovered, and has 60 carbon atoms.

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



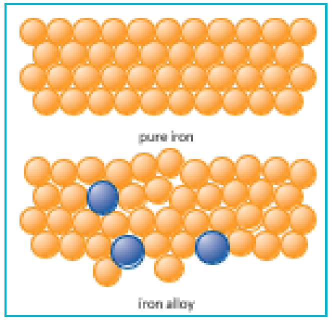
The carbon atoms in nanotubes are arranged in cylindrical tubes.

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

CHRIST THE KING - Knowledge Organisers

Physics – Conversation & 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:

L 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

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

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

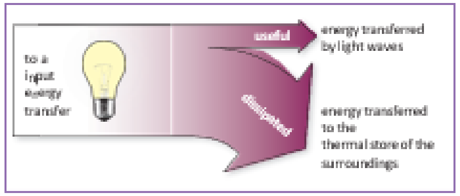
or

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*:

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

or

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

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.

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

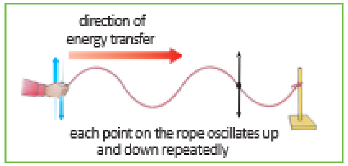
Examples of mechanical waves include sound waves, water waves, waves on springs and ropes, and seismic waves produced by earthquakes.

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.

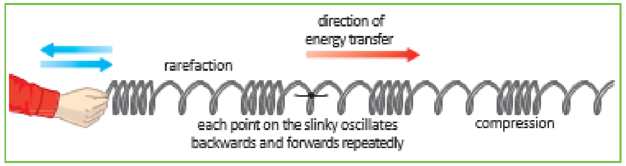


4. Longitudinal waves

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

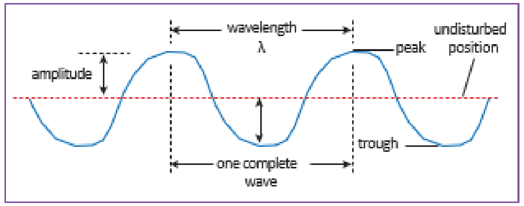
Frequency and period are related by the equation:

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

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.

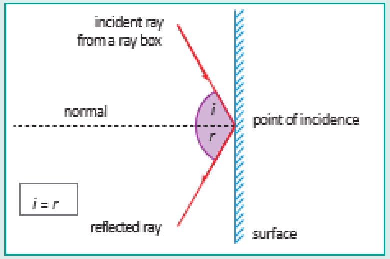
8. Ray diagrams can be used to show what happens when a wave is reflected at a surface.

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.

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 · wave speed

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.

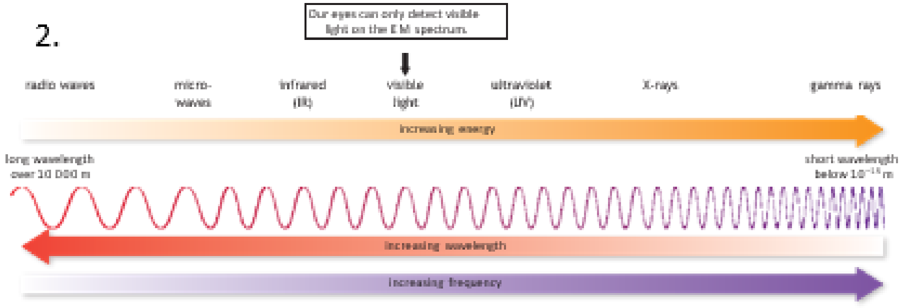
EM waves form a continuous **spectrum**, and are grouped by their wavelengths and frequencies.

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.

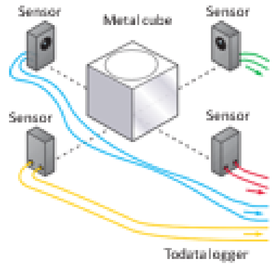
You should be able to plan a method to determine the rate of cooling due to emission of infrared radiation and evaluate your method.

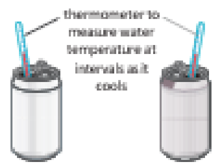
Using infrared detectors to measure the radiation emitted by different surfaces

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.

7. 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			

Key terms

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

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