Science Knowledge Organisers

Year 9 PC3 (June Exam)

Kettering science Academy

What is a 'knowledge organiser'?

A knowledge organiser is simply a collection of the all of the information which your teacher would like you to be able to **recall** from a particular topic. That means that it **does not have everything on it** for a unit of study but it does have **the most essential things to learn.**

A knowledge organiser has lots of facts and definitions on it. Did you know that there is as many new words in studying science as there is in studying a language?

A knowledge organiser does **not develop skills**, so good revision will involve **lots of practice questions** as well as learning the content of these organisers.

What do I do with it?

For most of us, the first thing that we learned at school in reception was our phonics sounds. We learned them by repetition – seeing them again and again until the association between the sound and the image stuck. We need to do the same thing with these knowledge organisers!

Your teacher will probably be using knowledge organisers as you are taught. They will be referred to in class and you should have regular small tests on what you have learned.

Our knowledge organisers are deliberately broken into small lesson sized chunks for you to learn. Typically a teacher may ask you to 'learn box 2 and 3' for a homework.

By the time you come to an assessment – an exam or test – you should already be familiar with the knowledge organisers and already know some of it. They can then be relearned as a part of the revision and assessment preparation procedure.

Retrieval Practice

A key part of learning anything is the act of trying to remember. In class, your teacher will be helping you to do this by asking lots of questions and setting quizzes. **The more often you try to remember something the more likely you are to remember it**. With knowledge organisers you can achieve the same thing at home.

Why are we doing this?

Research has shown that **the more you know** the **more you can learn.** By being able to recall the facts, you are able to understand more complicated ideas because you **already know what the key words mean.** You will also already have a set of ideas in your mind that the new ideas can connect to (this is often referred to as a **schema**).

What are the best techniques for memorising using a knowledge organiser?

READ COVER WRITE

Make sure you are working somewhere quiet and that you have something to write with and some paper. Focus on learning on part of the knowledge organiser only, for example box one. Read through it carefully several times. When you think you've got it, cover over the knowledge organiser and write it all down. Then check what you've been able to remember. Read the bits that you could not recall, cover and write again.

TEST ME

Once you have learned the sections, its time to see if you can remember larger amounts.

Ask a friend or family member to test you on the content of the knowledge organiser page. They don't need to be experts – only to say whether you have remembered it correctly.

TEST EACH OTHER

If you are revising with class mates, testing each other is great. By doing this you are thinking about what you need to know when you are answering questions but also when you are checking to see if your class mate is right. This works well on video calls!

MAKING FLASH CARDS

Some students find making flash cards really helps. You are thinking about what needs to be learned as you write! But don't fall into the trap of writing them and never using them! Once written they should be used regularly – you can test yourself with them or test each other!

Spaced Learning

All of the techniques work best when they are done **little and often**. Aim to repeat something you have learned a week – studies have shown that once you learn something, if you see it again after a week recall is better long term. Then again after a month… and so on.

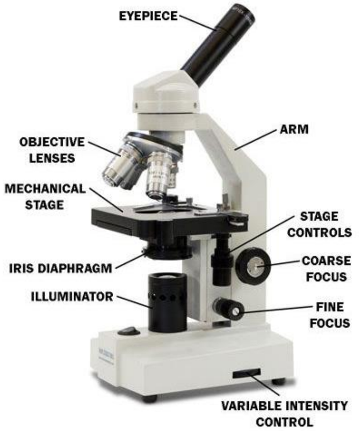
Application

Once you have memorised some of the information, or have made a good start, it's a good idea to start trying to **use that knowledge**. Websites like **Seneca** and **Educake** provide great banks of questions for this.

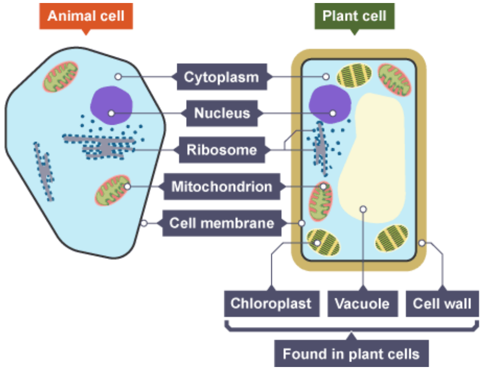
B1a: Biology key concepts

1. Microscopes	
Magnification	The number of times bigger something appears under a microscope.
Eyepiece lens	The lens on a microscope that you look through.
Objective lens	The lens at the bottom of a microscope. There are normally three you can choose from.
Total magnification	Eyepiece lens x objective lens.
Resolution	The smallest distance between two points so that they can still be seen as two separate points.
Stains	Dyes added to microscope slides to show the details more clearly.
Milli	Thousandth, $1x10^{-3}$ (a millimetre is a thousandth of a metre).
Micro	Millionth, $1x10^{-6}$ (a micrometre is a millionth of a metre).
Nano	Billionth, $1x10^{-9}$ (a nanometre is a billionth of a metre).
Pico	Trillionth, $1x10^{-12}$ (a picometre is a trillionth of a metre).

2. Plant and animal cells	
Cell	The basic structural unit of all living things (the building blocks of life).
Parts of an animal cell	Cell membrane, cytoplasm, nucleus, ribosomes, mitochondria.
Parts of a plant cell	Cell membrane, cytoplasm, nucleus, ribosomes, mitochondria, cell wall, permanent vacuole, chloroplasts.
Cell membrane	Controls what enters and leaves the cell.
Cytoplasm	A jelly-like substance where chemical reactions take place.
Nucleus	Contains DNA and controls the cell.
Ribosome	Produces proteins.
Mitochondria	Releases energy by aerobic respiration.



Cell wall	Protects and supports the cell, made of cellulose.
Permanent vacuole	Stores sap and helps to support the cell.
Chloroplast	Where photosynthesis happens, contains chlorophyll.

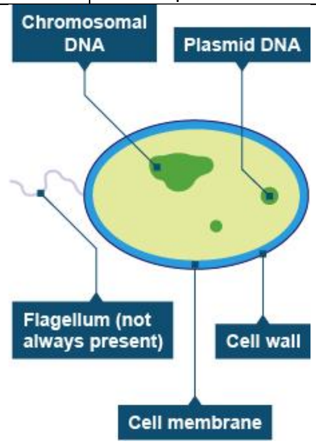


3. Measuring cells	
Micrograph	A picture produced by a microscope.
Light microscope	A microscope that uses light, can magnify up to 1500 times.
Electron microscope	A microscope that uses electrons to produce an image, can magnify up to 1,000,000 times.
Actual size of a cell	Actual size = measured size / magnification
Convert mm to µm	Micrometres (µm) = millimetres (mm) x 1000

4. Core practical – using microscopes (CP1)	
CP1 – key question	What do cells look like under a light microscope?
CP1 – Prepare the slide	Collect the cells you are studying and place them on the slide. Add a drop of stain and cover with a cover slip.
CP1 – Select lens	Choose between the 4x, 10x and 40x objective lenses.
CP1 – Place slide in microscope	Place slide on microscope stage, adjust the coarse focus until the lens is just touching the slide.
CP1 – Rough focus	Looking through the eyepiece, slowly adjust the coarse focus until you see a rough image.
CP1 – Fine focus	Looking through the eyepiece, slowly adjust the fine focus until you see a sharply focussed image.
CP1 – Record the image	Draw what you see, label any cell parts you can recognise and repeat with different objective lenses.
CP1 - Results	As you increase the magnification of the objective lens, the cells appear larger and more detailed.

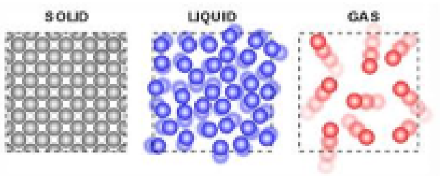
5. Specialised cells	
Small intestine cell	**Job:** To absorb small food molecules produced during digestion. **Adaptations:** Tiny folds called microvilli that increase their surface area.
Sperm cell	**Job:** Fertilise an egg and deliver male DNA. **Adaptations:** A tail to swim, mitochondria to give energy for swimming, an acrosome to break through the egg's jelly coat, haploid nucleus with only half the total DNA.
Egg cell	**Job:** To be fertilised by a sperm and then develop into an embryo. **Adaptations:** Jelly coat to protect the cell, many mitochondria and nutrients to provide energy for growth, haploid nucleus with only half the total DNA.
Ciliated epithelial cell	**Job:** To clear mucus out of your lungs (and other internal surfaces). **Adaptations:** Small hairs on the surface – called cilia – which wave to sweep mucus along.

6. Bacterial cells	
Parts of a bacterial cell	**All bacteria:** Cell membrane, cell wall, cytoplasm, ribosomes, chromosomal DNA, plasmid DNA **Some bacteria:** flagellum.
Chromosomal DNA	Large piece of DNA containing most genes.
Plasmid DNA	Small loops of DNA containing a few genes.
Flagellum	A tail used for movement.
Eukaryotic cells	Cells with a nucleus.
Prokaryotic cells	Cells without a nucleus.
Standard form	A way of writing numbers in terms of powers of ten. E.g. $0.015 = 1.5 \times 10^{-2}$ $0.000458 = 4.56 \times 10^{-4}$ The index of ten (the 'minus' number) tell you which decimal point to start on.



CC1-SC2: States of matter, separating and purifying knowledge organiser (H)

Lesson 1 States of matter



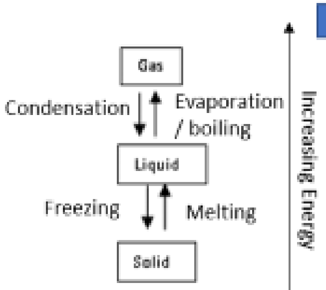
Arrangement of particles

Solid	Liquid	Gas
Ordered Neat rows	Random Some touch	Random Apart

Movement of particles

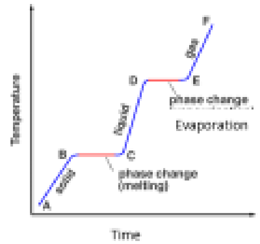
Solid	Liquid	Gas
Vibrating about fixed position	Rolling over each other	Flying around with high energy

State Changes



Sublimation is going from a solid straight to a gas

Lesson 2 Heating / Cooling curves



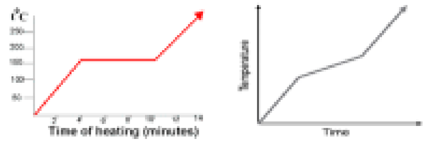
A heating or cooling curve shows how the temperature changes with time
State changes are shown as horizontal lines
During this time the energy is used to change state and not temperature

Lesson 3 Mixtures

- Mixtures contain substances which are not chemically combined and they can be separated
- Pure materials contain only one substance
- Impure materials contain a mixture of substances

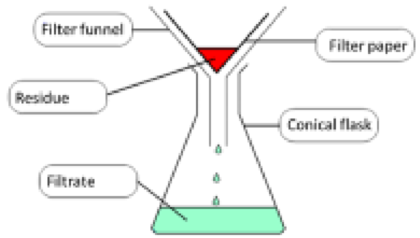
Pure substances have a sharp melting point
Impure substances have a range of melting points

Pure **Impure**



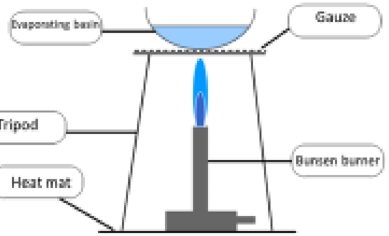
Lesson 4 Filtration and crystallisation

Filtration can be use to separate an insoluble solid from a liquid or from a solution



Filtration works because the large particles of the residue can not pass through the small gaps in the filter paper

Crystallisation can be used to separate a soluble solid from a solution of that solid

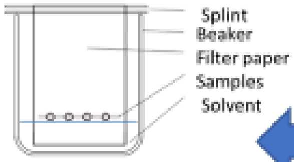


In crystallisation of a solution the **solvent** is **evaporated** from a **solution** to leave the **solute**

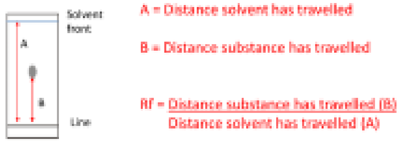
Lesson 5 Chromatography

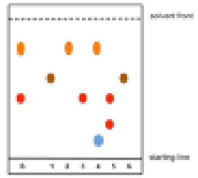
Chromatography is used to separate a mixture of substances. E.g. a mixture of different dyes in an ink.

The mixture separates because some dyes like the solvent more and some like the paper more.



Calculating Rf values

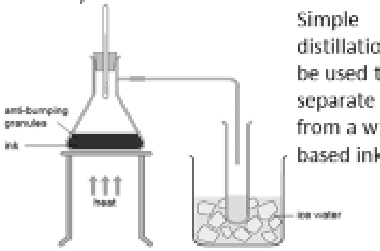




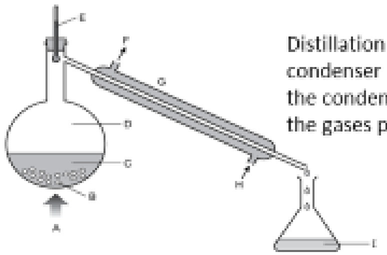
You can compare how far inks have travelled (Rf values) to analyse the dyes in an unknown mixture

Lesson 6 Distillation

Distillation is used to separate a solvent from a solution or from a mixture of solvent (fractional distillation)



Simple distillation – can be used to separate water from a water based ink



Distillation with a condenser is better as the condenser cools the gases produced

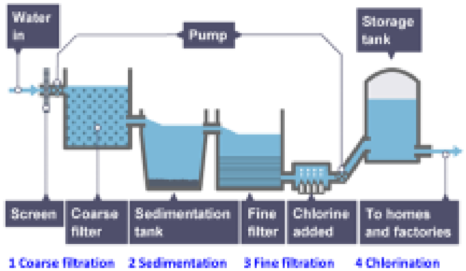
State changes involved in distillation - boiling/evaporation and condensation

Risk Assessment
Hazard – what is dangerous e.g. Bunsen Burner
Risk – the hard it could do e.g. Hair could catch fire
Control measure – How you make it safe e.g. tie your hair back

Lesson 7 Purifying water

Water is used for many things around the home and comes from a variety of sources

Water is purified to remove impurities (silt and mud, chemicals, dissolved salts)



Course filtration – filtered to remove twigs etc.
Sedimentation – a chemical is added which makes particles sink to bottom
Fine filtration – filtered through sand
Chlorination – to kill bacteria

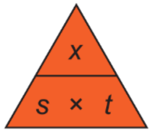
Distilled water is pure water and contains no dissolved salts. It is used for laboratory tests.
Sea water contains dissolved sodium chloride
Mineral water contains many dissolved salts
We do not use distillation to make drinking water as it uses a lot of energy and would be expensive

CP1/SP1 Motion

1. Vectors and Scalars

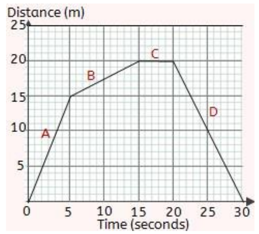
Magnitude	The size of something, such as the size of a force or the measurement of a distance.
Scalar quantity	A quantity that has a magnitude (size) only, but not a direction.
Scalar examples	Distance – 10 m Speed – 25 m/s Mass – 50 kg Energy – 300 J
Vector quantity	A quantity that has both a magnitude (size) and a direction.
Vector examples	Displacement – 10 m north Velocity – 25 m/s east Force – 30 N left Acceleration – 3 m/s^2 south Momentum – 400 N m/s right Weight – 600N down
Vector arrows	Vectors can be represented by arrows, with the length of the arrow representing the magnitude.
Displacement	The distance travelled in a particular direction.
Velocity	The speed of an object in a particular direction.

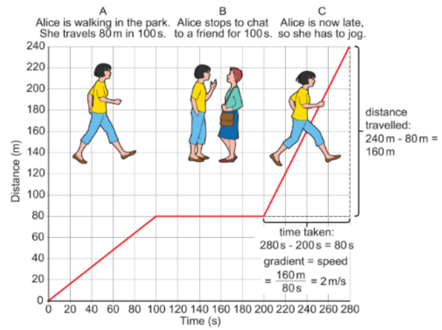
2. Speed

Speed	A measure of the distance an object travels in a given time.
Units of speed	Metres per second (m/s)
Some typical speeds	Walking – 1.4 m/s Cycling – 6 m/s Speed limit in towns – 10.5 m/s Ferry 18 m/s Motorway speed limit – 31 m/s Commuter train – 55 m/s High speed train – 90 m/s Airliner – 250 m/s
Speed – word equation	Speed = distance / time Speed (m/s) Distance (m) Time (s) 
Speed – symbol equation	v = x/t v = speed x = distance t = time
Instantaneous speed	The speed at one particular moment in a journey.
Average speed	The speed worked out from the total distance travelled divided by the total time taken for a journey. v = x/t.
Calculating distance travelled – word equation	Distance = average speed x time x = v x t Distance (m) Average speed (m/s) Time (s)
Measuring speed	Measure the distance between two points and time how long an object takes to pass, then calculate using v = x/t.
Light gates	A piece of apparatus containing an infrared beam that is transmitted from a source onto a detector. If the beam is cut, the light gate measures how long it is cut for, giving a reading for time.

3. Distance-Time Graphs

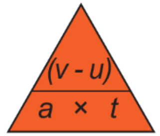
Distance-time graph	A graph showing the distance travelled against time for a moving object. Time is on the x-axis and distance on the y-axis.
Distance-time graphs – stationary	Horizontal line **C** on diagram below
Distance-time graphs – constant speed	Forwards – line sloping up **A and B** on diagram below Backwards – line sloping down **D** on diagram below
Distance-time graphs – line gradient	A measurement describing the steepness of the line on a graph. Steeper line = faster, so **A** is faster than **B** below
Calculating speed from the gradient of a distance-time graph	Speed = change in distance/ change in time =gradient gradient = change in y / change in x





D The gradient of a distance/time graph gives the speed.

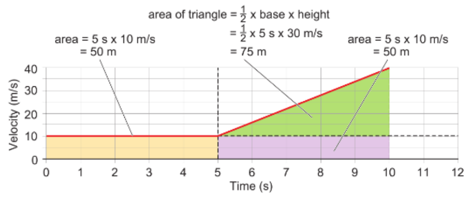
4. Acceleration

Acceleration	A measure of how quickly the velocity of something is changing. Rate of change of velocity. It is positive if an object is speeding up and negative if it is slowing down. A vector quantity.
An object accelerates when it…	- Speeds up - Slows down - Changes direction
Units of acceleration	Metres per second squared (m/s^2)
Positive and negative acceleration	Positive acceleration = speeding up Negative acceleration = slowing down
Deceleration	Slowing down, negative acceleration.
Acceleration – word equation	Acceleration = change in velocity / time Acceleration (m/s^2) Change in velocity (m/s) Time (s)
Acceleration – symbol equation	a = (v – u)/ t  a = acceleration v = final velocity u = initial velocity t = time
Linking acceleration and distance travelled	Use the equation: $v^2 - u^2 = 2ax$ to find distance $x = (v^2 - u^2) / 2a$ x = distance travelled a = acceleration v = final speed u = initial speed
Acceleration due to gravity (free fall)	10 m/s^2

5. Velocity-Time Graphs

Velocity-time graph	A graph of velocity against time for a moving object. Time is on the x-axis, velocity is on the y-axis.
Velocity-time graphs – constant speed	Horizontal line

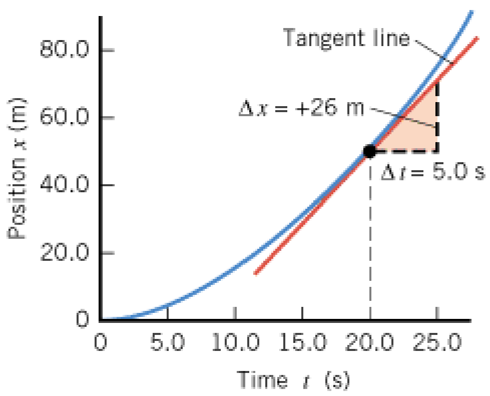
Velocity-time graphs – acceleration	Speeding up – line sloping up Slowing down – line sloping down
Velocity-time graphs – stationary	Horizontal line on the x-axis
Velocity-time graphs – line gradient	Steeper line = greater acceleration
Calculating acceleration on a velocity-time graph	Acceleration = change in velocity / change in time = gradient gradient = change in y / change in x
Calculating distance travelled from a velocity-time graph	Distance = area under the graph. Divide the graph into rectangles and triangles, find the area of each and add them together.



The total distance travelled by the object in graph D is the sum of all the areas.

total distance travelled = 50 m + 50 m + 75 m = 175 m

6. Calculating instantaneous speed (HIGHER ONLY)	
Instantaneous speed	Draw a tangent to the curve of the graph at the time you want to calculate the instantaneous speed for. Find the gradient of the tangent line by calculating the change in distance on the y axis and the change in time on the x axis. Instantaneous speed = gradient of tangent = change in distance / change in time



Lesson	Memorised?
1. Vectors and Scalars	
2. Speed	
3. Distance-Time Graphs	
4. Acceleration	
5. Velocity Time Graphs	
6. Calculating instantaneous speed (HIGHER ONLY)	

CP3 Conservation of Energy

Kettering Science Academy

Lesson sequence

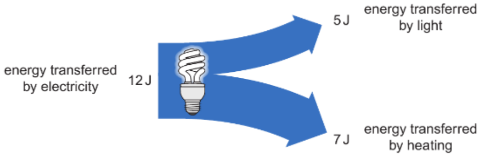
1. Energy stores and transfers
2. Energy efficiency
3. Keeping warm
4. Stored energies
5. Non-renewable energy resources
6. Renewable energy resources

1. Energy stores and transfers

Energy	The capacity to do work.
Joules	The units of energy, symbol = J
Kilojoules	1000 J, symbol = kJ
Thermal energy	Energy stored in hot objects.
Kinetic energy	Energy stored in moving objects.
Chemical energy	Energy stored in chemicals such as fuels.
Nuclear energy	Energy stored in the nucleus of atoms. Also called atomic energy.
Gravitational potential energy	Energy stored in objects based on how high they are.
Elastic potential energy	Also called strain energy. Energy stored in bent or stretched objects.
Energy stores examples	Light, thermal(heat), sound, electrical, kinetic (movement)
Law of conservation of energy	Energy cannot be created or destroyed, just transferred from one energy store to another.
Energy transfers	Say from what store the energy starts as *and* what its new store is.

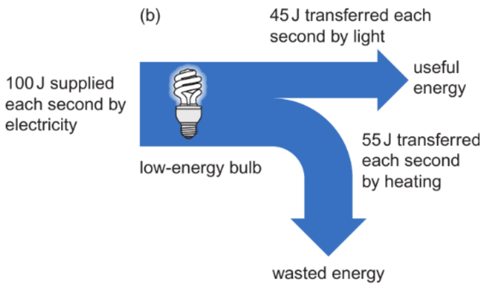
energy stored in moving car (kinetic energy) → energy transferred by forces during braking → energy stored in hot brakes (thermal energy)

Sankey diagram	Shows energy transfers. The thickness of the arrow relates to the amount of energy.



2. Energy efficiency

Dissipation	The way energy spreads out into the surroundings, becoming less useful as it does.
Wasted energy	Energy that is transferred into stores that aren't useful.
Friction	Causes thermal energy loss as heat when two surfaces rub together.
Lubrication	Allows surfaces to move smoothly, reduces energy loss from friction.
Electrical resistance	Causes wires to heat up, wasting electrical energy.
Calculating efficiency	$\text{efficiency} = \frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$ Efficiency is expressed as a decimal.
Energy efficiency numbers	Efficiency is between 0 and 1. 1 = no energy wasted 0 = all energy wasted

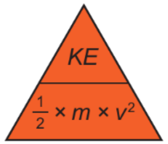


3. Keeping warm

Convection	Heat transfer caused when hot fluids (gas or liquid) rise because they are less dense.
Conduction	Heat transfer through solids caused by vibrating particles bumping into each other.
Radiation	Heat transfer by infrared radiation which heats objects up when they absorb it.
Radiation and surfaces	Infrared radiation is absorbed (taken in) and emitted (given out) easily by dull, dark surfaces. Radiation is absorbed and emitted poorly by shiny, light surfaces.
Insulation	Materials that contain lots of tiny air pockets that prevent heat loss by conduction.
Thermal conductivity	A measure of how well a material conducts heat.
Reducing the rate of energy transfer	Increase thickness of material Decrease thermal conductivity Decrease temperature difference

4. Stored energies

Gravitational field strength g	The strength of gravity. Different on different planets. On Earth g = 10 N/kg.
Calculating gravitational potential energy	$GPE = mg\Delta h$  GPE is gravitational potential energy (J) m is mass (kg) g is gravitational field strength (N/kg) Δh is height change (m)

Calculating kinetic energy	$KE = \frac{1}{2}mv^2$  KE is kinetic energy (J) m is mass (kg) v is velocity (m/s)
Calculating v from KE	$v = \sqrt{\frac{2KE}{m}}$

5. Non-renewable energy resources

Non-renewable resource	A resource that will one day run out because it is being used faster than it is being made.
Fossil fuels	Coal, oil, natural gas. All are non-renewable.
Harm from burning fossil fuels	Carbon dioxide gas is released which causes global warming. Sulfur dioxide is released which causes acid rain.
Nuclear power	Electricity generated from non-renewable nuclear fuels such as uranium.
Nuclear power pros and cons	😊 Lasts a long time, releases no carbon dioxide ☹ Produces very harmful waste, expensive to decommission, although rare, accidents are very dangerous.
Climate change	Changes that happen to global weather patterns as a result of global warming.

6. Renewable energy resources	
Renewable resource	A resource will not run out.
Wind power	Large turbines spun by the wind turn kinetic energy into electrical energy. 😊No CO_2 ☹Lots needed, ugly?, no wind no power
Solar power	Solar cells turn light energy from the Sun into electrical energy. 😊No CO_2 ☹No sun no power, need lots of space, not suitable for all countries
Tidal power	Uses kinetic energy from water movement from tides to spin turbines and produce electrical energy.
Tidal barrage	A damn built across an estuary that fills up when tide goes in. When stored water is released its kinetic energy produces electrical energy. 😊Huge amounts of energy, no CO_2 ☹Destroys important mudflat habitats
Hydroelectricity	A damn is built across a river valley, water released from the damn spins turbine and its kinetic energy produces electrical energy. 😊Lots of energy, no CO_2 ☹Destroys habitat by flooding
Biofuels	Fuels made from recently plant or animal matter, often waste, are a store of chemical energy. 😊Carbon neutral ☹Needs a lot of land, increases food prices

Carbon neutral	When burning a fuel releases the same CO_2 it absorbed when it was growing, so there is no CO_2 increase.

7. Reducing energy losses (HIGHER ONLY)	
Reducing energy losses	Increases the efficiency of a device or process, e.g. engines. This can be by reducing friction; by making sure all fuel is burned; or by using energy that would otherwise be wasted.

Lesson	Memorised?
1. Energy stores and transfers	
2. Energy efficiency	
3. Keeping warm	
4. Stored energies	
5. Non-renewable energy resources	
6. Renewable energy resources	
7. Reducing energy losses (HIGHER ONLY)	

B2: Cells and Control

1. Mitosis

Cell cycle	The life of a cell comprising of interphase and mitosis.
Interphase	Preparation for mitosis in which extra cell parts are made and DNA chromosomes are replicated (copied).
Mitosis	When one cell divides into two genetically identical daughter cells.
Prophase	The membrane of the nucleus breaks down and spindle fibres start to form.
Metaphase	Spindle fibres fully form and chromosomes line up across the **m**iddle of the cell.
Anaphase	Chromosome copies get pulled **a**part and move to each end of the cell.
Telophase	A new membrane forms around each set of chromosomes to form **t**wo nuclei.
Cytokinesis	The two new cells fully separate.
Diploid	The type of cells produced by mitosis which have two sets of chromosomes (23 pairs in humans).
Asexual	Type of reproduction with just one parent producing a clone of itself through mitosis.
Cancer	When mitosis happens out of control forming large lumps of cells called tumours.

2. Animal Growth

Growth	Increase in size due to increased numbers of cells.
Percentile	A measure of the growth of a child that compares them to other children of the same age.
90th percentile	90% of children will have a mass below this percentile on a percentile growth curve.
50th percentile	Average for height/mass for the age.
Differentiation	The process by which an unspecialised cell becomes specialised.
Specialised cell	A cell with special features designed for a specific job.
Red blood cell	Specialised cell with no nucleus (more room for haemoglobin) and a large surface area (allowing for quicker diffusion).
Fat cell	Specialised cell with large fat droplets in the cytoplasm which is stored until energy is needed.
Muscle Cell	Specialised cell with contractile proteins than can shorten the cell.

3. Plant Growth

Plant growth	Cell division creates more cells, elongation makes these cells get bigger.
Meristems	Areas in the tips of roots and shoots where cell division and differentiation happens.
Xylem	Specialised cells which form a hollow tube of dead cells to allow water to pass through.
Root hair cell	Specialised cell with a large surface area to allow roots to take in more water / mineral ions.
Percentage change	% change = (final value – starting value) / starting value x 100

4. Stem Cells

Stem cell	An unspecialised cell that can undergo cell division and differentiation to form specialised cells.
Embryonic stem cell	A stem cell that can become any kind of cell. Found in developing embryos.
Adult stem cell	A stem cell that can only become limited types of cell. Found in animals after birth.
Stem cells in medicine	It is hoped they can be used to replace damaged cells in diseases like type 1 diabetes or leukaemia, or to grow new organs for transplant.
Problems with stem cells	They may potentially cause cancer, stem cells may be rejected if used in other people than where they were taken from.

5. The Nervous System

Nervous system	Organ system made up of the CNS and nerves. Allows all parts of the body to work together to gather information, make decisions and control responses.
CNS	Central nervous system- The brain and spinal cord – controls the body.
Stimulus	Anything your body is sensitive to (e.g. changes inside or outside the body).
Sense organ	Contain receptor cells that detect stimuli (e.g. eyes, ears, skin).
Neurone	A nerve cell
Impulse	Electrical message carried by a neuron.
Response	The action that the nervous system makes happen.
Sensory Neurone	Nerve cell that carries impulses from sense organs to the CNS.
Cell body	The central part of a nerve cell containing its nucleus.
Dendron and axon	The long parts of a nerve cell carrying impulses towards the cell body (dendron) and away from it (axon)
Dendrites	Branches at the beginning of a dendron that connect to receptor cells or another neuron.
Axon terminals	Branches at the end of an axon that connect to a muscle or another neuron.
Myelin sheath	A fatty layer around the axon and dendron that insulates it to prevent the impulse from losing energy and speeds the impulse up.
Voluntary Response	Stimulus detected by receptor → impulse sent along sensory neurone → brain makes decision → impulse sent along motor neurone → effector carries out response.

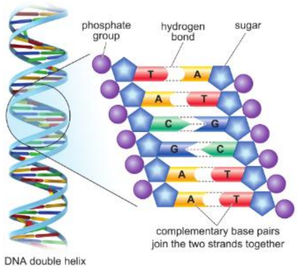
6. Neurotransmission Speeds

Neuro-transmission	The travelling of an impulse along a neuron and into another.
Effector	The body part that produces the response, often a muscle.
Synapse	Small gap between two neurons where the axon terminals of one meet the dendrites of another.
Neuro-transmitter	Chemicals released by axon terminals that diffuse across the synapse to trigger a new impulse the dendrite of another neuron.
Relay neuron	Nerve cell in the CNS that links sensory and motor neurones.
Motor neuron	Nerve cell that carries impulses from the CNS to effectors. Dendrites join onto cell body, long axon.
Reflexes	Automatic responses that happen very quickly without conscious thought to keep the body safe.
Reflex arc	Neurone pathway that bypasses the brain. Stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector

Lesson	Memorised?
1. Mitosis	
2. Animal Growth	
3. Plant Growth	
4. Stem Cells	
5. The Nervous System	
6. Neurotransmission Speeds	

B3: Genetics

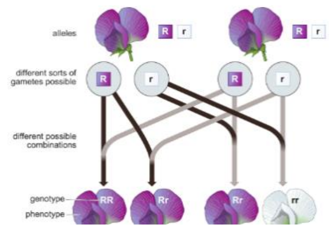
1. Meiosis	
Gametes	Sex cells- egg and sperm
Fertilisation	Sperm cell fuses with egg cell and nuclei combine.
Zygote	A fertilised egg cell
Gene	Length of DNA coding for a protein. Controls your characteristics
Genome	All the DNA and genes in an organism
Diploid	A cell that has 2 sets of chromosomes- 23 pairs of chromosomes in humans
Haploid	A cell with 1 set of chromosomes- 23 single chromosomes in humans
Meiosis	Cell division that makes gametes
Stages of Meiosis	DNA replicates, cell divides into 2 diploid cells, these divide into 4 haploid daughters.
Meiosis Daughter Cells	One division by meiosis creates 4, haploid, non-identical daughter cells.

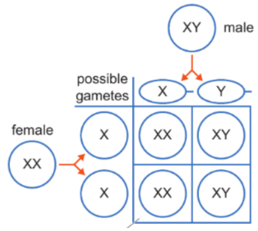
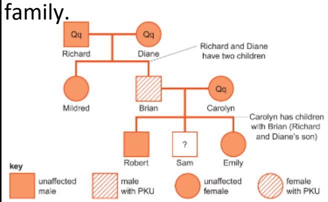
2. DNA	
Chromosome	Large DNA molecule made into a small package by tightly coiling DNA around a protein.
DNA Structure	Two strands, double helix, complementary base pairs, sugar-phosphate backbone 

DNA Bases	Adenine, A; thymine, T; cytosine, C; guanine, G
Complementary Base Pairs	A pairs with T C pairs with G
Hydrogen Bonds	Weak force holding the two strands of DNA together. C and G form 3 bonds A and T form 2 bonds
DNA Analysis	Uses small differences in DNA to determine family relationships or link people to crimes.

3. DNA Extraction Method	
Mix water, salt and detergent	Salt makes DNA clump together, detergent breaks down cell membranes to release DNA.
Mash fruit/veg and add solution	Mash to increase the surface area.
Leave in water bath at 60°c	Heat makes it react quicker.
Filter the mixture and collect filtrate	Removes unwanted lumps.
Measure out 10cm³ of filtrate and add two drops of protease	Protease breaks down proteins around the DNA
Gently add ice cold ethanol	DNA is insoluble in ethanol so precipitates.
Leave for several minutes	So a white DNA layer forms.

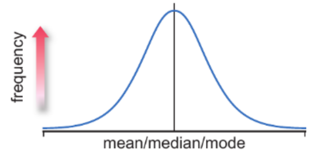
4. Alleles	
Allele	Different version of the same gene. We have two alleles of each gene.
Homozygous	Two copies of the same allele
Heterozygous	Two different copies of an allele
Dominant Allele	One copy needed for characteristic to show. Written as a capital.
Recessive Allele	Two copies for the characteristic to show. Written as lowercase.
Genotype	The combination of alleles in an organism.

Phenotype	The characteristics produced by the alleles.
Genetic Diagram	Shows the likelihood of offspring produced by parents with certain genotypes. 

5. Inheritance	
Sex Chromosomes	Female: XX Males: XY
Punnet Squares	Uses the genotypes of male and female gametes to predict the genotypes of the offspring.
Inheriting Sex	
Cystic Fibrosis	Illness that affects the lungs and digestive system caused by inheriting two copies of a faulty recessive allele.
Family Pedigree Chart	Chart showing how genotypes are inherited down through a family. 

6. Gene Mutation	
Mutation	A change to the bases in a gene.
Effects of Mutations	Sometimes harmless, can be harmful, very rarely beneficial

Cause of Mutations	Mistakes copying DNA during cell division, DNA damage from chemicals or radiation
Human Genome Project	(HGP) Project involving many scientists from many countries to find the order of bases in human DNA. Allows us to tailor drugs to genes to design better drugs.

7. Variation	
Variation	Natural differences between members of a species that affect the chance of survival.
Genetic Variation	Variation caused by genes.
Environmental Variation	Caused by interaction with the surroundings.
Acquired Characteristics	Characteristics caused only by the environment.
Continuous Variation	Data can be any value in a range (height, weight, etc.)
Discontinuous Variation	Data can be a limited set of values (blood group, eye colour, etc.)
Normal Distribution	Bell-shaped curve formed by continuous data with more in the middle and fewer either side. 

Lesson	Memorised?
1. Meiosis	
2. DNA	
3. DNA Extraction	
4. Alleles	
5. Inheritance	
6. Gene Mutation	
7. Variation	

B5: Health, Disease & the Development of Medicines

1. Health and Disease

Health	A state of complete physical, social and mental wellbeing.
Physical Health	Being free from disease, active, fit, sleeping well and no substance abuse.
Mental Health	How you feel about yourself.
Social Health	Having healthy relationships and how your surroundings affect you.
Disease	An illness that prevents the body from functioning normally.
Communicable Disease	Diseases caused by pathogens, can be spread from one person to another.
Non-Communicable Disease	Diseases caused by genes or lifestyle. Cannot be spread from one person to another.
Correlated Diseases	Getting one disease increases your chance of another due to diseases weakening organ systems, damaged immune system, and weaker defences.
Pathogen	A microorganisms that causes disease.

2. Non-Communicable Diseases

Genetic Disorders	Diseases caused by inheriting faulty genes from parents.
Malnutrition	Getting too little or too much of a particular nutrient.
Deficiency Disease	Disease caused by the lack of a certain nutrient.
Anaemia	Lack of iron. Causes fewer and smaller red blood cells and low energy.
Kwashiorkor	Lack of protein. Swollen belly, small muscles, stunted growth.
Rickets	Lack of calcium or vitamin D. Causes weak bones leading to bowed legs.
Scurvy	Lack of vitamin C. Swollen bleeding gums, muscle and joint pain, lack of energy.
Drug	Chemical that changes the way the body works.
Cirrhosis	Fatal liver disease caused by drinking too much alcohol over a long period of time.
Impact of Liver Disease / Alcohol	Fifth largest causes of death in the UK, increasing 450% in the last 30 years. Costs £500 million each year to treat.

3. Cardiovascular Disease

Obesity	A condition in which someone is overweight for their height and large amounts of fat builds up around major organs.
Cardiovascular Disease	Disease in which the heart or circulatory system is affected.
Heart Attack	When the heart stops pumping due to a lack of oxygen reaching it.
BMI	Body mass Index $BMI = \frac{(\text{weight in kilograms})}{\text{height in meters}^2}$ BMI over 30 is obese
Waist:hip Ratio	Waist measurement ÷ hip measurement Better method of measuring abdominal fat which is linked with cardiovascular disease.
Smoking	Harmful substances from smoke can damage blood vessels, increase blood pressure, make blood vessels narrower and increase risk of blood clots.
Stent	A small mesh tube that is inserted into a narrowed artery and opened up to widen it.
Treating Heart Disease with Lifestyle	More exercise and a better diet can treat cardiovascular disease and giving up smoking.

4. Pathogens

Types of Pathogen	Bacteria, virus, protist, fungi.
Tuberculosis	Bacteria. Damages lungs causing bloody cough, fever and weight loss.
Cholera	Bacteria. Sever life-threatening diarrhoea.
Chalara Ash Dieback	Fungi. Kills the leaves of ash trees, killing the tree.
Malaria	Protist. Multiplies inside red blood cells and liver cells and causes fever and weakness.
Haemorrhagic Fever	Virus, e.g. Ebola. Liver and kidney damage, internal bleeding and fever.
HIV	Human immunodeficiency virus attacks white blood cells, causing AIDS.
AIDS	Acquired Immunodeficiency Syndrome. Weakened immune system making simple infections deadly. Caused by HIV.
Hidden Pathogens	Many types of bacteria live in our bodies. Some are essential for health, others may not affect us most of the time. *Helicobacter pylori* can cause stomach ulcers some of the time.

5. Spreading Pathogens

Airborne	Spread through the air. Colds/flus/TB by infected droplets in saliva being passed into the air by coughing or sneezing. Chalara ash dieback by fungal spores carried by wind.
Waterborne	Spread through contaminated water. Cholera
Oral Route	Pathogen enters body through the mouth by eating/drinking.
Vectors	Organisms that carry a pathogen from one person to the next. Mosquitos are vectors for malaria.
Bodily Fluids	Spreading through contact with bodily fluids such as blood or semen. HIV
Hygiene	Keeping things clean to remove or kill pathogens.
Epidemic	When many people over a large area are infected with the same pathogen at the same time.

6. Physical & Chemical Barriers

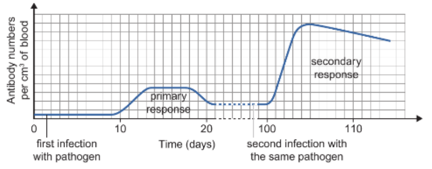
Chemical Defences	Kill pathogens or make them inactive before they can infect us.
Lysozyme	Enzyme found in mucus, tears and sweat that kills some bacteria.
Hydrochloric Acid	Found in the stomach, reducing pH to 2, killing most pathogens.
Physical Barrier	Block or trap pathogens so they cannot enter the body.
Mucus	Sticky secretion that traps pathogens- found in most body openings (nose, mouth, etc.).
Ciliated Cells	Specialised cells with hair like cells that sweep mucus out of the body.
Skin	Blocks pathogens from entering the body.
STIs	Sexually transmitted infections – pathogens spread via sexual activity.
Preventing STIs	Use barrier contraception (such as condoms) to prevent mixing of fluids.
Screening	Large scale testing of people to check if they have an STI so they can be treated. This helps to reduce the spread of STIs.

7. The Immune System

Immune System	Destroys pathogens that manage to infect us.
Antigens	Chemical markers on the surface of pathogens that identify them as a pathogen. Unique to each pathogen.

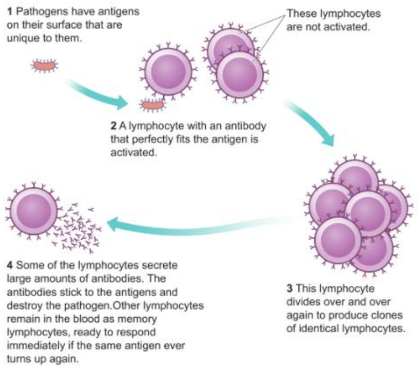
Lymphocyte	White blood cells that produce antibodies. Each lymphocyte produces a different antibody.
Antibodies	Molecules with a specific shape that can attach to a specific antigen on a pathogen and kill it.
Activated Lymphocyte	When an antigen sticks to an antibody, it activates the lymphocyte causing it to make many copies of itself that make the same antibodies.
Memory Lymphocyte	Lymphocytes left over after an infection that retain the ability to fight the pathogen.
Immune	The body has memory lymphocytes to fight the pathogen if it returns so it can’t be harmed by it.

Primary Response vs. Secondary Response



Vaccine	A weakened or inactive version of a pathogen.
How vaccines work	Vaccines are harmless versions of pathogen that still have the antibodies on them, so the immune response is triggered without any risk of disease.

How the Immune System Attacks Pathogens



8. Antibiotics	
Antibiotics	Substances that kill bacteria or inhibit their processes without harming human cells.
Penicillin	The first antibiotic discovered by Alexander Fleming. Produced by a mould.
Resistance	Widespread use of antibiotics has led to resistance, meaning many antibiotics don’t work as well as they once did.
Drug Development	Developing new medicines involves many stages that take a lot time and money.
Discovery Phase	Developing new chemicals that might work as medicines.
Pre-Clinical Phase	Testing on cells grown in the lab, or on animals, to see if the chemical has any useful effect.
Small Clinical Trial	Testing on a few healthy people to check for safety.
Large Clinical Trial	Testing on many patients to discover how effective the drug is and determine the dose.
Side Effects	Unwanted effects of the medication that can be quite harmful.
Dose	The correct amount of the medicine that needs to be given to the patient.

Lesson	Memorised?
1. Health and Disease	
2. Non-Communicable Diseases	
3. Cardiovascular Disease	
4. Pathogens	
5. Spreading Pathogens	
6. Physical & Chemical Barriers	
7. The Immune System	
8. Antibiotics	

CC13: Groups in the Periodic Table

1. Group 1

Alkali metals	The name we give to group 1 – lithium, sodium, potassium and so on.
Group 1 symbols	Li – lithium Na – sodium K – potassium
Properties of alkali metals	- soft - relatively low melting points
Reaction of alkali metals with water	Metal + water → metal hydroxide + hydrogen E.g: sodium + water → sodium hydroxide + hydrogen $2Na + 2H_2O \rightarrow 2NaOH + H_2$
Lithium and water	Floats. Bubbles (of hydrogen). Moves slowly.
Sodium and water	Floats. Melts. Bubbles (of hydrogen). Moves more quickly
Potassium and water	Floats. Melts. Bubbles (of hydrogen) **catch fire (lilac flame)**. Moves very quickly
Group 1 reactivity	Reactivity increases as you move down the group.
Explaining group 1 reactivity	When metals react they **lose** their outer electrons. Further down the group there are: - **more** shells of electrons - so the outer electrons are **further** from the nucleus - so outer electrons are **less attracted** to the nucleus - so outer electrons are **easier to remove.** OPPOSITE PATTERN TO GROUP 7

2. Group 7

Halogens	The name given to group 7 – fluorine, chlorine, bromine and iodine.
Chlorine	Cl_2. A pale green gas.
Bromine	Br_2. A red-brown liquid.
Iodine	I_2. A shiny purple-black solid.
Reaction of halogens with metals	Halogen + metal → metal halide E.g: Bromine + sodium → sodium bromide $Br_2 + 2Na \rightarrow 2NaBr$
Reaction of halogens with hydrogen	Halogen + hydrogen → hydrogen halide E.g: Chlorine + hydrogen → hydrogen chloride $Cl_2 + H_2 \rightarrow 2HCl$
Hydrogen halides	Hydrogen halides dissolve in water to form acids, for example hydrogen chloride makes hydrochloric acid.
Chlorine test	Chlorine gas turns **damp blue litmus red** then quickly bleaches it **white**.

3. Reactivity of halogens

Group 7 reactivity	Reactivity increases as you go up the group.
Explaining group 7 reactivity	When non-metals react they complete their outer shells. Going up the group there are: - **less** shells of electrons - so the outer electrons are **closer** to the nucleus - so outer electrons are **more attracted** to the nucleus - so **more able to hold** an extra outer electron OPPOSITE PATTERN TO GROUP 1
Displacement reactions	Reactions in which a more reactive metal displaces a less reactive metal from a salt eg: *copper sulfate + zinc → zinc sulfate + copper* Does not work backwards as copper is less reactive than zinc.
Displacement reactions of halogens	A **more** reactive halogen displaces a **less** reactive halide ion by taking its electrons. E.g: bromine + sodium iodide → iodine + sodium bromide $Br_2 + 2NaI \rightarrow I_2 + 2NaBr$ [bromine more reactive]
Redox reactions of halogens	Displacement reactions are REDOX because the more reactive halogen **oxidises** the less reactive halide by **taking its electrons**. The more reactive halogen is reduced. E.g: $Br_2 + 2I^- \rightarrow 2Br^- + I_2$
OIL RIG	**O**xidation **I**s **L**oss (of electrons) **R**eduction **I**s **G**ain (of electrons)

4. Group 0

Noble gases	The name given to group 0 – helium, neon, argon, krypton and xenon.
Melting point of noble gases	They are all gases at room temperature but the melting and boiling point increase down the group.
Reactivity of group 0	The noble gases do not (easily) do any reactions – they are inert.
Explaining reactivity of group 0	When elements react they try to complete their outer shells. Because group 0's outer shells are already complete, they do not react.
Uses of noble gases	-Helium is used in airships because it is inert and has low density - Argon is used in fire extinguishers because it is inert and denser than air. - Neon is used in lighting because it glows red when electricity is passed through it.

Lesson	Memorised?
1. Group 1	
2. Group 7	
3. Reactivity of halogens	
4. Group 0	

C3 & 4: Atoms and the periodic table

Lesson sequence

7. Structure of atoms
8. Detailed structure of atoms
9. Isotopes
10. Mendeleev's periodic table
11. The modern periodic table
12. Electron configuration

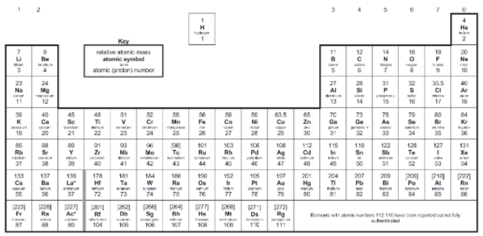
1. Structure of atoms	
***Particle**	The tiny pieces that all matter is made from.
***Atom**	The smallest independent particle. Everything is made of atoms.
****Size of atoms**	About 1 x 10^{-10} m in diameter.
****Dalton's model of atoms**	- Tiny hard spheres - Can't be broken down - Can't be created or destroyed - Atoms of an element are identical - Different elements have different atoms
***Subatomic particles**	Smaller particles that atoms are made from.
***Proton**	Mass = 1 Charge = +1 Location = nucleus
***Neutron**	Mass = 1 Charge = 0 Location = nucleus
***Electron**	Mass = 1/1835 (negligible) Charge = -1 Location = shells orbiting nucleus
***Nucleus**	Central part of an atom, 100,000 times smaller than the overall atom

2. Detailed structure of atoms	
****Alpha particle**	Small positively charged particle made of two protons and two neutrons.
****Scattering**	When particles bounce back or change direction.
****Rutherford's experiment**	Fired alpha particles at gold leaf, used a phosphor-coated screen to track where they went.
****Rutherford's results**	Most alpha particles went through, some scattered (changed direction).
****Rutherford's explanation**	Scattered particles hit a solid nucleus. Most did not hit it, therefore nucleus is small
***Atomic number**	The bottom number on the periodic table, gives the number of protons and electrons.
***Atomic mass**	The top number on the periodic table, gives the total protons and neutrons together.
***Number of protons**	The atomic number.
***Number of electrons**	The atomic number.
***Number of neutrons**	Atomic mass minus atomic number.
***Number of protons and electrons**	Equal, because each negative electron is attracted to a positive proton in the nucleus.

3. Isotopes	
****Isotopes**	Atoms with the same number of protons but different number of neutrons.
****Describing isotopes**	Mass after the name (e.g. boron-10) or superscript mass before the symbol (^{10}B).
***Nuclear fission**	Large unstable atoms break into two smaller stable ones.
****Uses of fission**	Nuclear power, nuclear weapons.
****Relative atomic mass, A_r**	The weighted average of the masses of all of the isotopes of an element.
*****Isotopic abundance**	The percentage of an element that is made of a particular isotope.
*****Calculating A_r**	- Multiply each mass by the decimal % - Add these up **Note:** (decimal % = %/100)

4. Mendeleev's periodic table	
***Dmitri Mendeleev**	Russian chemist, developed the periodic table.
***Mendeleev's periodic table**	Ordered by increasing A_r, some elements switched according to their properties.
***Chemical properties**	Includes reaction with acid and formula of oxide.
***Physical properties**	Includes melting point and density.
****Gaps in Mendeleev's periodic table**	Mendeleev left gaps where no known element fitted and predicted these would be filled with newly discovered elements.
****Eka-aluminium**	An element that Mendeleev thought would fill a gap. He predicted its properties, which matched gallium when discovered.

5. The modern periodic table	
***Noble gases**	Gases that do not react: He, Ne, Ar, Kr.
****Moseley's experiment**	Fired electrons at samples of elements and measured X-rays produced.
****Moseley's results**	Energy of x-rays produced proportional to the positive charge of the element.
****Conc. from Moseley's work**	The atomic number must be the number of protons in the atoms.



****Pair reversals**	Elements (like Ar and K) that are not in order of increasing mass.
****Explaining pair reversals**	It means elements should be order elements by increasing atomic number instead.

6. Electron configuration	
***Shells**	Electrons orbit atoms in shells.
***First shell**	Holds up to two electrons.
***Second shell**	Holds up to eight electrons.
***Third shell**	Holds up to eight electrons.
***Number of electrons**	Given by the atomic number.
***Filling shells**	Fill shells from the first shell out. Move up a shell when current one is full.
***Electron configuration**	The number of electrons in each shell (e.g. Al is 2.8.3).
***Outer shell**	The last shell with any electrons in it.
****Groups**	Columns in the periodic table, tell you the number of electrons in the outer shell.
****Periods**	Rows in the periodic table, tell you the number of electron shells.

C5-7: Bonding

Lesson sequence

13. Ionic bonding
14. Ionic compounds
15. Properties of ionic compounds
16. Covalent bonding
17. Covalent structures
18. Allotropes of carbon
19. Metallic bonding
20. Classifying materials

1. Ionic bonding

***Bond**	An attraction between two atoms that holds them together.
***Ion**	An atom that has gained a charge by gaining or losing electrons.
***Charge**	Whether an ion is positive or negative.
***Cation**	Positive ion formed by losing electrons. Formed by metal atoms.
***Anion**	Negative ion formed by gaining electrons. Formed by non-metal atoms.
****Size of charge**	The number of electrons transferred affects the size of charge: losing two electrons makes a 2+ charge, gaining three electrons makes a 3- charge.
****How many electrons are gained or lost?**	**Metals:** however many electrons are in the outer shell **Non-metals:** however many electrons are needed to fill the outer shell.
***Electrostatic force**	A force of attraction between a positive and negative particle.
***Ionic bond**	When two oppositely charged ions are held together by an electrostatic force.
****Forming ionic bonds**	Electrons are transferred from a metal atom to a non-metal atom to form a positive metal cation and a negative metal anion. The oppositely charged ions are attracted to each other.

2. Ionic compounds

***Chemical formula**	Shows the number of atoms of each element present in one ‘unit’ of a compound.
***Writing formulae**	- Each chemical symbol starts with a capital letter. - The number of each atom present is shown with a subscript number after the symbol. E.g. H_2SO_4.
****Determining ionic formulae**	- Ensure the total number of positive and negative charges balance. - Change the number of each ion present by changing the subscript numbers.
***Compound ions**	An ion made from two or more atoms that share a charge.
***Common compound ions**	Hydroxide: OH^- Nitrate: NO_3^- Sulfate: SO_4^{2-} Sulfite: SO_3^{2-} Carbonate: CO_3^{2-} Ammonium: NH_4^+
****Including compound ions in formulae**	If you need more than one, put brackets around it. E.g. $Mg(OH)_2$
***Ionic lattice**	The structure of ionic compounds: a repeating 3D pattern of alternating positive and negative ions.
****Crystal**	A piece of material with a regular shape and straight edges formed by the regular pattern of ions in an ionic lattice.

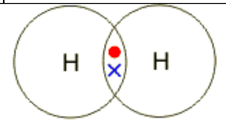
3. Properties of ionic compounds

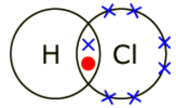
****Melting point of ionic compounds**	High because melting needs a lot of energy to break strong ionic bonds.
***Solubility of ionic compounds**	Many ionic compounds dissolve in water.
****Electrical conductivity of ionic compounds**	Solid: Do not conduct because ions can’t move. Liquid (molten or solution): Do conduct because ions can move.
****How ionic compounds conduct electricity**	When they are in a liquid form, the positive cations move to the negative electrode (cathode) and the negative anions move the positive electrode (anode).

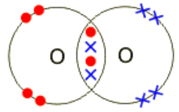
4. Covalent bonding

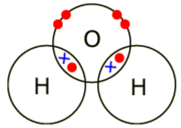
***Covalent bond**	An electrostatic attraction between two atoms and a share pair of electrons.
****Double bond**	A covalent bond involving two shared pairs of electrons.
***Dot and cross diagram**	A bonding diagram showing the electrons in the outer shell of each atom, with electrons drawn as dots or crosses.
***Hydrogen, H_2**	Two overlapping circles both labelled H. One pair in the overlap.
****Hydrogen chloride, HCl**	Two overlapping circles labelled H and Cl. One pair in the overlap, 6 electrons around Cl.
****Oxygen, O_2**	Two overlapping circles both labelled O. Two pairs in the overlap, 4 electrons around each O.
****Water, H_2O**	Three overlapping circles in a line labelled H, O, H. A pair in each overlap, 4 electrons around O.
****Carbon dioxide, CO_2**	Three overlapping circles in a line labelled O, C, O. Two pairs in each overlap, 4 electrons around each O.
****Methane, CH_4**	Five circles with one in the centre labelled C and 4 labelled H around it. A pair in each overlap.

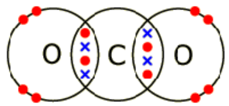
****Valency**	The number of covalent bonds an atom can form.
****Valency and groups**	Group 4 = 4 (4 electrons needed) Group 5 = 3 (3 electrons needed) Group 6 = 2 (2 electrons needed) Group 7 = 1 (1 electron needed)
****Working out molecular formulae**	Find the lowest common multiple of the valency of each atom. Use the number of an atom required to reach the LCM.

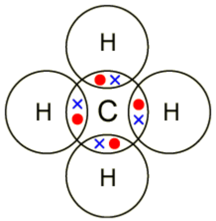








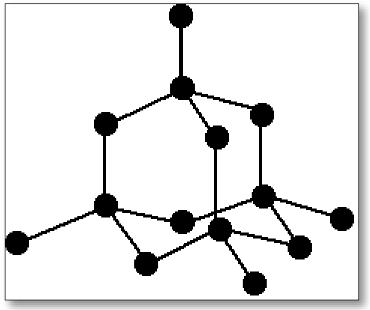




5. Covalent structures	
*Molecule	A particle made from two or more atoms bonded together.
*Simple molecular structure	A structure made of small molecules in which a few atoms join together to form a small particle.
**Structure of molecular substances	Atoms in a molecule are held together by strong covalent bonds. Neighbouring molecules are held close by weak intermolecular forces.
**Intermolecular force	A weak electrostatic force that holds two neighbouring molecules together.
**Melting point of simple molecular compounds	Low because melting only needs a little energy to break weak intermolecular forces.
**Electrical conductivity of simple molecular compounds	Do not conduct because there are no electrons that are free to move.
*Examples of simple molecular substances	Hydrogen gas, oxygen gas, water, carbon dioxide, methane.
*Giant molecular structure	A structure made of a repeating pattern of atoms covalently bonded together.
**Melting point of giant molecular compounds	High because melting requires breaking strong covalent bonds.
**Electrical conductivity of simple molecular compounds	Do not conduct (except graphite) because there are no electrons free to move.
*Examples of simple molecular substances	Silicon dioxide (silica), diamond, graphite.
*Polymer	A large molecule made of a small unit repeated many times.
*Monomer	A small molecule that can be joined together many times to form a polymer.

6. Allotropes of carbon	
*Allotrope	A different structural form of an element made of the same atoms just bonded together differently.
*Carbon's allotropes	Graphite, diamond, graphene, fullerenes
**Graphite	**Structure:** stacked sheets of carbon in a honeycomb pattern with delocalised electrons between them. **Properties:** sheets slide apart easily, excellent conductor **Uses:** lubricants
**Diamond	**Structure:** Repeating pattern of 4 atoms bonded to 4 others. **Properties:** Extremely hard. **Uses:** Cutting tools and drills
**Graphene	**Structure:** A single layer of atoms in a honeycomb pattern. **Properties:** Very strong, excellent conductor. **Uses:** None yet, but potentially many.
**Buckminster fullerene	**Structure:** Ball-shaped molecules of C_{60}. **Properties:** Low melting point **Uses:** None
**Carbon nanotubes	**Structure:** Cylinders made of carbons bonded in a honeycomb pattern. **Properties:** Very strong, excellent conductors **Uses:** Strong and flexible materials, electronics.

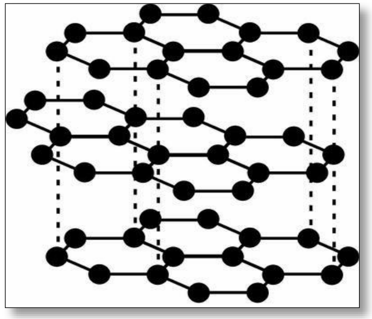
7. Metallic bonding	
*Structure of metals	A lattice of positive metal ions surrounded by a cloud of delocalised electrons.
**Delocalised electrons	Electrons that are not bound to a single atom but move freely around many.
**Metallic bonding	The electrostatic attraction between the lattice of positive metal ions and the cloud of delocalised electrons.



**Electrical conductivity of metals	Metals are good conductors because the electrons are free to move.
**Comparing the conductivity of metals	Metals with more electrons in the outer shell – such as Al – are better conductors than those with fewer – such as Li – because there are more delocalised electrons that are able to move.
*Malleable	When a substance dents when it is hit instead of shattering.
**Malleability of metals	Metals are malleable because the atoms are arranged in regular sheets and these sheets can easily slide over each other when hit.
**Melting point of metals	High because melting them requires breaking the strong force of attraction between the lattice of metal ions and the cloud of delocalised electrons.

8. Bonding models	
**Classifying materials	The properties of a material can be used to determine the type of bonding in it.
**Properties of ionic compounds	High melting point, often soluble in water, solid does not conduct electricity, liquid/solution does.
**Properties of simple molecular compounds	Low melting point, does not conduct electricity, sometimes soluble in water.

**Properties of giant molecular compounds	High melting point, does not conduct electricity (except graphite), insoluble in water.
**Properties of metallic compounds	High melting point, does conduct electricity, insoluble in water.
**Bonding models	The ideas and drawings that we use to explain the bonding of atoms.
**Problems with bonding models	- Dot and cross diagrams make electrons seem different, they are not - Atoms appear stationary but are actually vibrating - Atoms don't appear to be touching when they actually are.



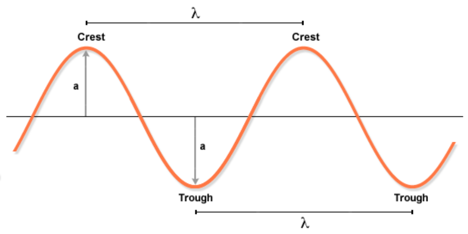
P4 Waves

Kettering Science Academy

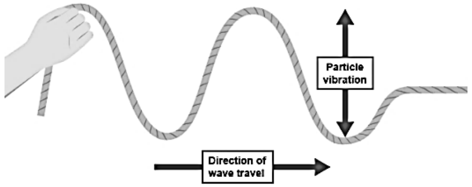
1. Describing waves

Waves	Transfer energy without transferring matter.
Oscillate	When particles vibrate backwards and forwards or up and down.
Transverse waves	Waves in which particles oscillate at right angles to the direction of energy movement. E.g., waves on the surface of the water, some seismic waves and light waves (all electromagnetic waves).
Longitudinal waves	Waves in which particles oscillate parallel to the direction of energy movement. E.g., sound waves and some seismic waves.
Medium	The material that waves travel through. Light (all electromagnetic waves) waves are the only waves that have no medium.
Seismic waves	Waves of vibrating rock caused by earthquakes.
Frequency, f	The number of waves that pass a point every second.
Hertz, Hz	The unit of frequency. 1 Hz = 1 wave per second.
Period, T	The length of time it takes for a single wave to pass.
Wavelength, λ	The distance in m from the top of one wave to the top of the next.
Amplitude, a or A	The maximum distance a particle vibrates away from its resting point,
Velocity, v	The speed of a wave in m/s.

Transverse wave



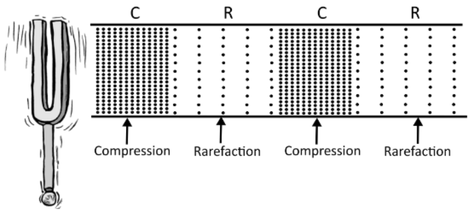
Transverse wave



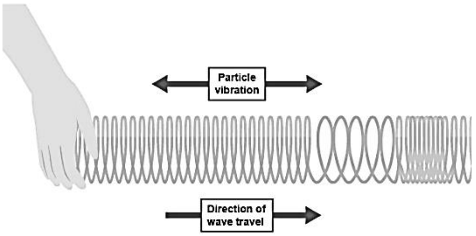
Longitudinal wave

teachoo.com

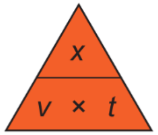
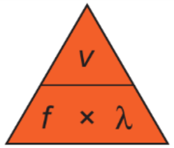
Compression and rarefactions of a longitudinal wave



Longitudinal wave



2. Wave speeds

Speed, distance and time	$wave\ speed\ (m/s) = \frac{distance\ (m)}{time\ (s)}$  Wave speed = v Distance = x Time = t
Speed, frequency and wavelength	$wave\ speed\ \left(\frac{m}{s}\right) = frequency\ (Hz) \times wavelength\ (m)$  Wave speed = v Frequency = f Wavelength = λ
Measuring wave speed	Time how long they take to travel a certain distance. (stopwatch) Distance between two points.(tape measure)
Changing speed	Waves travel at a different speed in a different medium. Light is slower in water than air.

3. Core practical – Investigating waves

CP4 - Aim	To measure the speed of waves in a liquid and a solid.
CP4 – Water waves 1	1. Count the number of waves in 10 s and use this to find the frequency. 2. Measure the wavelength with a ruler Wave speed = frequency x wavelength
CP4 – Water waves 2	1. Time how long a wave takes to pass two points, 0.3 m apart. Wave speed = dist / time
CP4 - Waves in a solid	1. Hit suspended metal bar with hammer and measure the frequency using an app. Measure the metal bar – double the length gives the wavelength

4. Refraction

Refraction	Bending of waves when they enter a new medium at an angle.
Interface	The boundary between two media (mediums) such as air and water.
Normal	An imaginary line drawn at 90° to where light hits an interface (boundary).
Angle of incidence	The angle between an incoming light ray and the normal.
Angle of refraction	The angle between the normal and a ray of light that has been refracted.
Travelling from air to glass or water	Light bends towards the normal
Travelling from glass or air to water	Light bends away from the normal.
Explaining refraction	Light waves slow down as they go from air to water. The 'bottom' of the wave hits the water and slows down first, causing refraction.

Lesson	Memorised?
1. Describing waves	
2. Wave speeds	
3. Core practical – Investigating waves	
4. Refraction	

P5 Light and the Electromagnetic waves

1. Electromagnetic waves

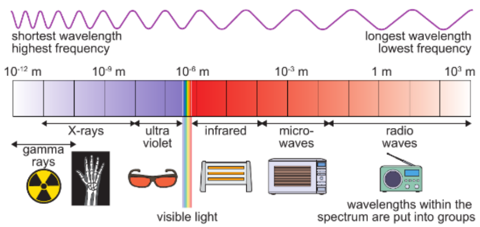
Electromagnetic waves	A group of waves that all travel at the same speed (speed of light) in a vacuum, and are all transverse.
Speed of light	300,000,000 m/s (3 x 10^8 m/s)
Frequency	The number of waves that pass a point every second. One hertz (Hz) is one wave per second.
Wavelength	The distance between a point on one wave and the same point on the next wave.
EM wave similarities	All are transverse, all travel at the speed of light.
EM wave differences	Different frequencies, different wavelengths.
Visible light	The only type of EM radiation that our eyes can detect.
Interface	The boundary between two different materials.
Refraction and wave speed	Light travels at different speeds in different materials causing it to refract when hitting the interface at an angle.
Prisms and the colour spectrum	Different wavelengths slow down by different amounts when they hit glass causing each colour to refract differently.
Infrared discovery	Light split into a spectrum. Thermometer placed on every colour plus next to red. Red was hot, next to red was hottest.

2. Core practical – Investigating refraction

Normal	A line at right angles to the interface.
Angle of incidence	Angle between the incident ray and the normal.
Angle of refraction	Angle between the refracted ray and the normal.
CP5 – Aim	To explore how changing the angle of incidence changes the angle of refraction.
CP5 - Setup	Place a glass block on a sheet of paper, point a beam of light from a ray box at it, trace around the block and draw in the light ray.
CP5 - Measurement	Use a protractor to draw a normal, then measure the angles of incidence and refraction.
CP5 - Variations	Repeat 5 times, from 5 different angles, including head-on.
CP5 - Results	The greater the angle of incidence, the greater the angle of refraction.

3. The electromagnetic spectrum

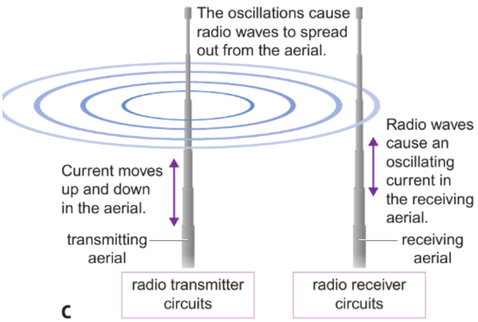
EM spectrum mnemonic	**R**ubbish **M**emories **I**nclude **V**isiting **U**r **X** **G**irlfriend
EM spectrum – lowest to highest frequency or energy	Radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays.
EM spectrum – lowest to highest wavelength	Gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves, radio waves.
EM spectrum	The full range of types of EM waves.
EM Radiation and the atmosphere	Some EM radiation (visible light, radio waves) passes through the atmosphere, most is absorbed.
Space telescopes	For radiation absorbed by the atmosphere, a telescope must be placed in space.



Electromagnetic spectrum

4. Using the long wavelengths

Visible light uses	Illumination, photography
Infrared uses	Short-range communications (TV remotes), fibre optics, cooking (grills and toasters), security cameras, thermal images.
Microwave uses	Microwave ovens, mobile phone and satellite communications.
Radio wave uses	Radio and TV signals, communications between controllers and spacecraft, satellite communications.
Producing radio waves	Oscillating electricity in a metal rod produces radio waves.
Receiving radio waves	Radio waves absorbed by a metal rod cause electrical oscillations.



Producing radio waves

5. Using the short wavelengths

Fluorescence	Absorbing ultraviolet and re-emitting it as visible light.
Ultraviolet uses	Security marking, fluorescent lamps, detecting forged bank notes and disinfecting water.
X-ray uses	Observing the internal structure of objects, airport security scanners and medical X-rays.
Gamma ray uses	Sterilising food and medical equipment, and the detection of cancer and its treatment.

6. EM radiation dangers

Infrared dangers	Surface heating causing skin burns.
Microwave dangers	Absorbed by water causing it to heat up → internal heating of body cells.
Ionisation	High-energy radiation causes ions to form in our cells, damaging DNA and causing cancer.
Ultraviolet dangers	Damage to surface cells and eyes leading to skin cancer and eye conditions.
X-ray dangers	Cancer, mutation or damage to cells in the body.
Gamma ray dangers	Cancer, mutation or damage to cells in the body.

Lesson	Memorised?
1. Electromagnetic waves	
2. Core practical – Investigating refraction	
3. The electromagnetic spectrum	
4. Using the long wavelengths	
5. Using the short wavelengths	
6. EM radiation dangers	