Science Knowledge Organisers

Year 11 PC1 (September 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

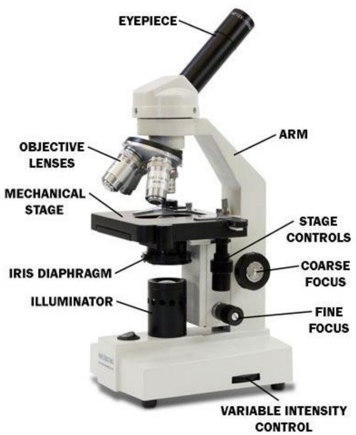
Once you have memorised some of the information, or have made a good start, it's a good idea to start trying to **use that knowledge**. Websites like **Seneca** and **Educake** provide great banks of questions for this.

B1: Biology key concepts

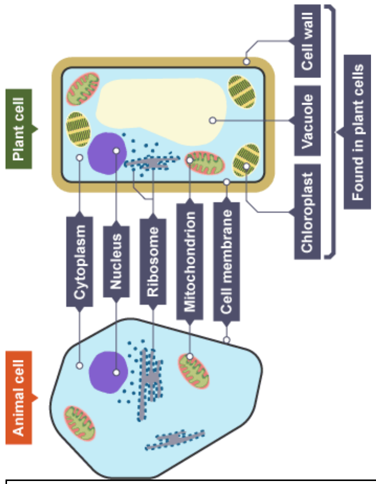
Lesson sequence

1. Microscopes
2. Plant and animal cells
3. Measuring cells
4. Core practical: using microscopes
5. Specialised cells
6. Bacterial cells
7. Digestive enzymes
8. How enzymes work
9. Factors affecting enzymes
10. Core practical: enzymes and pH
11. Cell transport
12. Core practical: osmosis in potatoes

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.



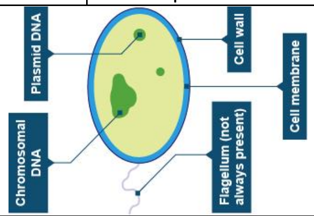
3. Measuring cells	
***Micrograph**	A picture produced by a microscope.
***Light microscope**	A microscope that uses light, can magnify up to 1500 times.
****Electron microscope**	A microscope that uses electrons to produce an image, can magnify up to 1,000,000 times.
****Actual size of a cell**	Actual 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.

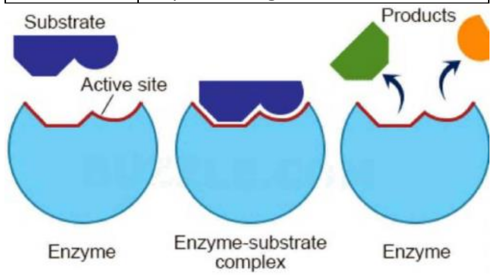


7. Digestive enzymes

*Digestion	Breaking large food molecules down into ones small enough to absorbed by the small intestine.
*Catalyst	A substance that speeds up a chemical reaction without being used up.
*Enzyme	A protein that works as a catalyst to speed up the reactions in our cells.
*Digestive enzymes	Enzymes that break large food molecules down into smaller ones.
**Amylase	**Where found:** saliva, small intestine **What it does:** breaks down starch into simple sugars such as maltose
**Lipase	**Where found:** small intestine **What it does:** breaks down fats into fatty acids and glycerol
**Protease	**Where found:** stomach (pepsin), small intestine (trypsin) **What it does:** breaks down proteins into amino acids

8. How enzymes work

*Substrate	The chemical(s) that an enzyme works on.
*Active site	An area of an enzyme with the same shape as the substrate.
**Lock and key mechanism	The substrate moves into the active site and reacts to form the products. The products leave the active site so another substrate can then enter and so on.
**Specificity	Each enzyme can only work on one substrate because the shape of the active site has to match.
*Denature	When the shape of the active site changes shape so the enzyme stops working.



9. Factor affecting enzymes

*Optimum temperature	The temperature when an enzyme works fastest (about 37^{o} for human enzymes).
**Changing the temperature	**Increasing to optimum**: rate increases because particles move faster **Increasing past optimum:** rate decreases as enzyme denatures
*Optimum pH	The pH when enzymes work fastest (around pH 6-8 for most human enzymes)
**Changing pH	Rate decreases as you move away from the optimum because the enzyme denatures.
**Increasing substrate concentration	At first the rate increases, but then it levels out as the enzyme is working as fast as possible.

10. Core practical – enzymes and pH (CP2)

*CP2 – key question	How does the rate that amylase works change as you change the pH?
*CP2 – Prepare your reactants	Place starch solution, amylase solution and pH 7 buffer into separate test tubes and warm them in a water bath at 40°C
*CP2 – Prepare your dropping tile	Place a few drops of iodine solution into each well of a spotting tile.
*CP2 – Start the reaction	Mix reactants together, start the stop watch and keep the mixture warm in the water bath.
*CP2 – Test for starch	Remove a small amount of mixture and place in a well on the spotting tile.
*CP2 – Record your results	Repeat the test until the mixture does not go black (no starch). Record the time.
*CP2 – Vary the pH	Repeat with different pH buffers from pH 3 to pH 10
*CP2 – Results	The amylase works fastest around pH 7 and more slowly at pH high or lower than this.

11. Cell transport

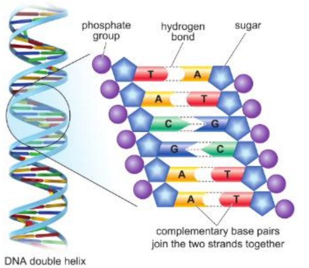
*Concentration	The number of particles in a given volume (the strength of a solution).
**Concentration gradient	The difference in concentration between two neighbouring areas.
*Diffusion	The movement of particles from high to low concentration (down a concentration gradient).
*Diffusion examples	**Lungs:** oxygen into blood, carbon dioxide out of blood **Leaf:** carbon dioxide into leaf, oxygen out of leaf.
**Partially permeable membrane	A membrane that allows some molecules but not others to pass through it (like a cell membrane).
**Osmosis	The movement of water across a partially permeable membrane from high water/low solute conc to low water/high solute conc.
**Osmosis examples	Water into plant roots, water in/out of any cells.
*Active transport	Using energy to move substances from low to high concentration (up a concentration gradient).
*Active transport examples	Minerals being absorbed into plant roots.

12. Core practical – osmosis in potatoes (CP3)

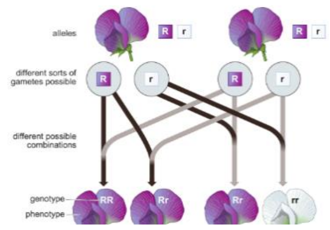
*CP3 – Prepare potatoes	Cut six similar pieces of potato, blot them dry and weigh them.
*CP3 – Run the experiment	Place each potato piece in a test tube with sucrose (sugar) solutions with concentrations from 0% to 50%
*CP3 – Record results	Blot each potato piece dry and re-weigh it.
*CP3 – Calculate percentage mass change	% change = (final value – starting value) / starting value x 100
*CP3 – Results	Potato in weaker sucrose solutions gain mass because water enters potatoes by osmosis, those in stronger solutions lose mass as water leaves by osmosis.

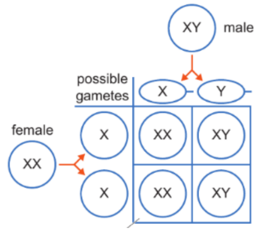
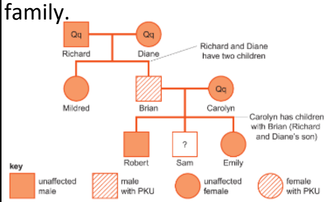
B3: Genetics

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.

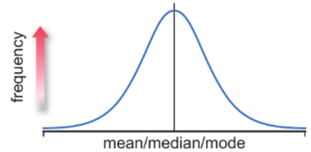
2. DNA	
Chromosome	Large DNA molecule made into a small package by tightly coiling DNA around a protein.
DNA Structure	Two strands, double helix, complementary base pairs, sugar-phosphate backbone 
DNA Bases	Adenine, A; thymine, T; cytosine, C; guanine, G
Complementary Base Pairs	A pairs with T C pairs 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 10cm^3 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 $\text{BMI} = \dfrac{(\text{weight in kilograms})}{\text{height in meters}^2}$ 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

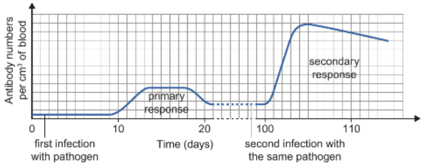
Chemical Defences	Kill pathogens or make them inactive before they can infect us.
Lysozyme	Enzyme found in mucus, tears and sweat that kills some bacteria.
Hydrochloric Acid	Found in the stomach, reducing pH to 2, killing most pathogens.
Physical Barrier	Block or trap pathogens so they cannot enter the 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.

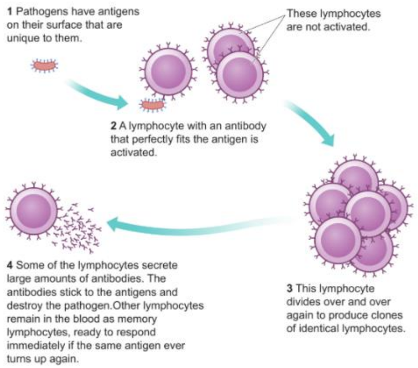
Lymphocyte	White blood cells that produce antibodies. Each lymphocyte produces a different antibody.
Antibodies	Molecules with a specific shape that can attach to a specific antigen on a pathogen and kill it.
Activated Lymphocyte	When an antigen sticks to an antibody, it activates the lymphocyte causing 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



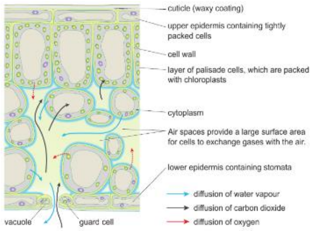
8. Antibiotics

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	

B6: Plant Structures and their Functions

1. Photosynthesis

Photosynthesis	How plants produce glucose using the energy from light.
Photosynthesis equation	Carbon dioxide + water → glucose + oxygen
Chloroplast	Part of a plant cell where photosynthesis happens.
Chlorophyll	A green pigment that enables photosynthesis by trapping the energy in light.
Glucose	Sugar formed by photosynthesis.
Starch	As soon as they are made, glucose molecules are joined together into long chains to form starch.
Sucrose	Starch is be broken down into sucrose to be transported around the plant.
Uses of sucrose	Sucrose is converted into: - Glucose for respiration - Starch for storage - Other molecules for growth
Endothermic	Reactions where the products have more energy than the reactants. Photosynthesis is an exothermic reaction.
Leaf adaptations	To do more photosynthesis, leaves have: a large surface area, a waxy cuticle, palisade cells, a spongy layer, stomata.
Large surface area	Allows the leaf to absorb more light.
Waxy cuticle	A waxy coating that stops water evaporating from the leaf.
Palisade cells	Tall cells in a leaf with many chloroplasts for lots of photosynthesis.
Stomata (singular = stoma)	Microscopic pores in the bottom of the leaf that allow carbon dioxide in and oxygen and water vapour out.
Stomata structure	Each stoma is surrounded by two guard cells that can swell to open it or shrink to close it.
How stomata work	During the day, the stomata open to allow gas exchange. At night the stomata close. Stomata also close during dry spells to stop water loss.
Leaf Structure	

2. Factors That Affect Photosynthesis

Limiting factor	A factor that holds back the rate of photosynthesis when in short supply. Carbon dioxide concentration, light intensity and temperature
Carbon Dioxide and Photosynthesis	To start with, increasing CO_2 levels will increase the rate of photosynthesis. Eventually further increases have no effect because they are no longer the limiting factor.
Light Intensity and Photosynthesis	To start with, increasing light intensity will increase the rate of photosynthesis because they. Eventually increasing it further has no effect as they are no longer limiting.
Temperature and photosynthesis	Increasing temperature towards the optimum increases the rate as particles move faster and collide more. Increasing past the optimum decreases rate as enzymes denature.
Inverse square law	$$I_{new} = \frac{I_{orig} \times d_{orig}^2}{d_{new}^2}$$
Linear Relationship	A relationship between two variables shown by a straight line on a graph.
Direct Proportion	A linear relationship in which a change in a variable occurs with an equal percentage change in another variable.

3. Core Practical

Key Question	How does light intensity affect the rate of photosynthesis?
Method	Measure the pH of solutions with algal balls in at different distances away from a light source.
Dependent Variable	Change in pH/hour (rate of photosynthesis)
Independent Variable	Distance of algal balls from light source.
Control Variables	Number/size of algal balls, volume of indicator solution, temperature (tank of water is placed between light source and jars with algal balls to absorb heat).
Results	The closer to the light source the greater the rate of photosynthesis (and greater final pH).
Explanation	The closer to the light source the algal balls are, the greater the light intensity and the greater the level of photosynthesis.

4. Absorbing Water and Mineral Ions

Water	In plants, used for carrying dissolved mineral ions, keeping cells rigid, cooling leaves and photosynthesis.
Root hair cells	**Role:** To quickly absorb water and minerals from soil **Adaptations:** A long hair which increases their surface area & thin cell wall for fast water absorption.
Diffusion	Movement from a high concentration to low until equilibrium is reached.
Osmosis	Movement of a solvent from high to low concentrations across as semi-permeable membrane.
Diffusion in roots	Water diffuses along the cell walls around the outside of each cell until it reaches the xylem.
Osmosis in roots	Water travels from cell to cell across cell membranes by osmosis until it reaches the xylem.
Minerals in the soil	Plants absorb minerals from soil such as nitrates, phosphates and potassium.
Absorbing minerals	Plants absorb minerals by active transport because their concentration is low.

5. Transpiration and Translocation

Transpiration	The movement of water into a plant's roots, up its stem and evaporating out of the leaves.
Xylem	Hollow tubes that carry water from the roots, up the stem to the leaves.
Xylem Adaptations	Hollow dead cells to let water pass, no walls between neighbours to allow water through, rings of lignin to make them strong.
Factors increasing transpiration	Air movement (wind), dryer air (low humidity), higher temperatures
Potometer	Equipment used to measure rate of transpiration.
Translocation	The movement of sucrose (sugar) around a plant through the phloem.
Phloem	Tissue that transports sucrose around plants, made of sieve tubes and companion cells.
Sieve tubes	Cells in phloem with a large channel running through them to carry sucrose solution.
Companion cells	Cells in phloem that sit next to the sieve tubes and pump sucrose into the sieve tubes- lots of mitochondria for active transport

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.

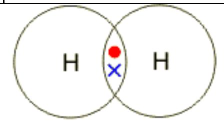
****Forming ionic bonds**	Electrons are transferred from a metal atom to a non-metal atom to form a positive metal cation and a negative metal anion. The oppositely charged ions are attracted to each other.

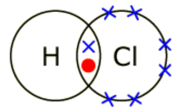
2. Ionic compounds	
***Chemical formula**	Shows the number of atoms of each element present in one 'unit' of a compound.
***Writing formulae**	- Each chemical symbol starts with a capital letter. - The number of each atom present is shown with a subscript number after the symbol. E.g. H_2SO_4.
****Determining 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.

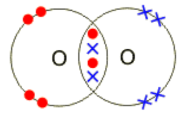
3. Properties of ionic compounds	
****Melting point of ionic compounds**	High because melting needs a lot of energy to break strong ionic bonds.
***Solubility of ionic compounds**	Many ionic compounds dissolve in water.
****Electrical conductivity of ionic compounds**	Solid: Do not conduct because ions 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).

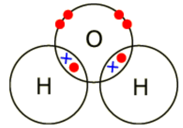
4. Covalent bonding	
***Covalent bond**	An electrostatic attraction between two atoms and a share pair of electrons.
****Double bond**	A covalent bond involving two shared pairs of electrons.
***Dot and cross diagram**	A bonding diagram showing the electrons in the outer shell of each atom, with electrons 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.

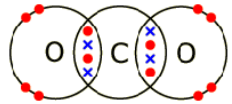
****Valency**	The number of covalent bonds an atom can form.
****Valency and groups**	Group 4 = 4 (4 electrons needed) Group 5 = 3 (3 electrons needed) Group 6 = 2 (2 electrons needed) Group 7 = 1 (1 electron needed)
****Working out molecular formulae**	Find the lowest common multiple of the valency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

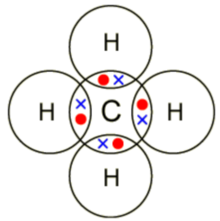








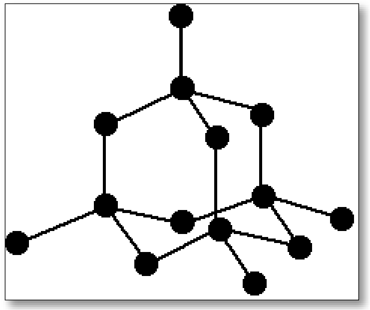


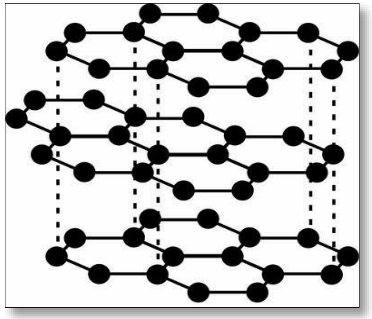


5. Covalent structures	
***Molecule**	A particle made from two or more atoms bonded together.
***Simple molecular structure**	A structure made of small molecules in which a few atoms join together to form a small particle.
****Structure of molecular substances**	Atoms in a molecule are held together 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.

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	

C14 Rates of Reaction

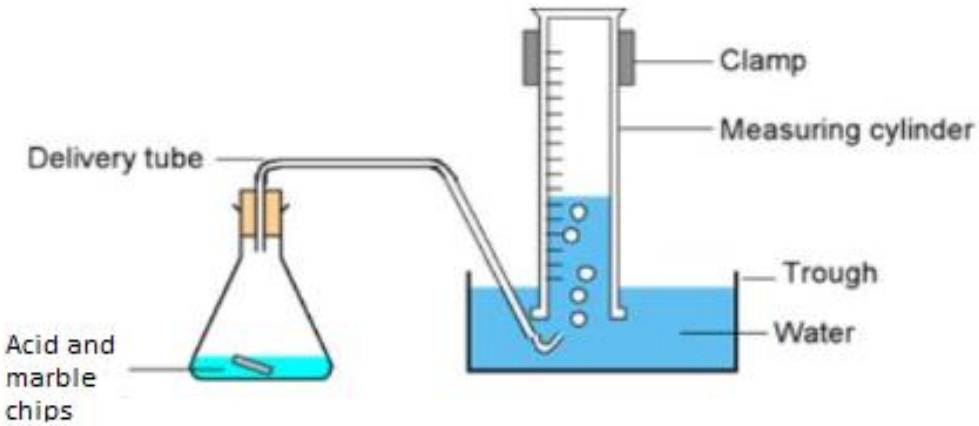
Lesson sequence

21. Rates of reaction
22. Collision theory
23. Core practical – rates of reaction (CP11)
24. Catalysts

1. Rates of reaction	
***Rate of reaction**	The rate at which reactants are used up or products are made.
***Reactants vs time graph**	Starts high and curves downward, decreasing rapidly at first and then more gently. Steeper line = faster rate.
***Products vs time graph**	Starts low and curves upwards, increasing rapidly at first and then more gently. Steeper line = faster rate.
****Measuring rates – reactions that produce gas**	- Collect gas in a gas syringe and measure the volume every 30 secs. - Collect gas over water (up-turned measuring cylinder full of water) and measure volume every 30 secs. - Do reaction on a balance and record the change in mass every 30 secs.
****Measuring rates – reactions that go cloudy**	Do the reaction in a beaker placed on piece of paper with a cross marked on it. Looking down through the beaker, time how it takes for the cross to disappear.

2. Collision theory	
***Collision theory**	States that for two particles to react they must: - Collide with each other - Collide with enough energy to react
***Activation energy**	The minimum energy that two particles must have when they collide in order to react.

****Effect of concentration on rate**	• Increased concentration means that there are more particles **in the same volume** • So there are more collisions **per second**. • So a faster reaction
****Effect of surface area on rate**	• Increased surface area means that there are more particles **at the surface able to collide** • So there are more collisions **per second**. • So a faster reaction
****Effect of pressure on rate**	• Increased gas pressure means that there are more particles **in the same volume** • So there are more collisions **per second**. • So a faster reaction
****Effect of temperature on rate**	• Increased temperature means that that particles have a higher kinetic energy and **move faster** • So there are more collisions **per second**. • But these collisions **also are at higher energy** so more collisions result in reactions • So a faster reaction



3. Core practical – rates of reaction (CP11)

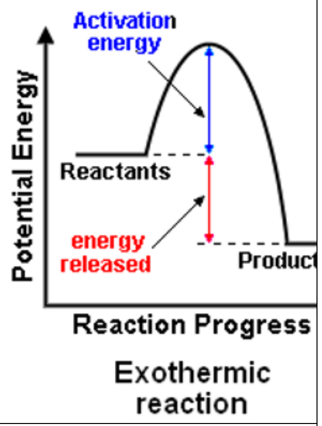
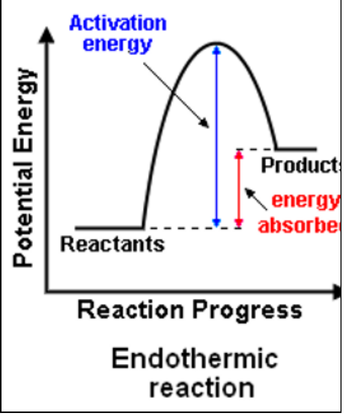
***CP11 – Aim**	To explore how particle size and concentration affect the rate of reaction
***CP11 – Gas collection – setup**	See diagram
***CP11 – Gas collection – measurements**	Record the volume of gas collected few seconds until it stops.
***CP11 – Gas collection – independent variable**	Repeat with a different size of marble chips.
***CP11 – Gas collection – results**	The amount of gas collected increases quickly at first and then more slowly. The smaller marble chips produce gas more quickly, but the same amount in total.
***CP11 – similar experiments**	You could keep the chip size the same and use different temperatures, or different concentrations
***CP11 – common problems**	Gas escaping, so the reaction looks slower than it really is
***CP11 – improvements**	Use a gas syringe (CO_2 dissolves in water so you don't get a perfect reading)
***CP11 – Colour change – setup**	Draw a cross on a piece of paper and place a beaker on it. Measure out 50 cm^3 of sodium thiosulfate solution and 5 cm^3 of hydrochloric acid into two test tubes and leave to warm in a water bath at 30^{O}C.
***CP11 – Colour change – run the experiment**	Quickly pour both test tubes into the beaker, mix and start the stopwatch. Looking down through the beaker, stop when you can no longer see the cross.
***CP11 – Colour change – independent variable**	Repeat with water baths set to 35^{O}C, 40^{O}C, 45^{O}C and 50^{O}C.
***CP11 – Colour change – results**	The cross disappears most quickly at 50^{O}C and least quickly at 30^{O}C.

4. Catalyst	
***Catalyst**	A substance that speeds up a chemical reaction without being used up.
****Effect of catalysts on rate**	Catalysts increase the rate of reaction by reducing the activation energy so that a greater proportion of collisions lead to reactions.
****Reaction profile**	A graph that shows the changes in energy during a reaction. Starts with large 'hump' that represents the activation energy.
****Effect of catalysts on reaction profiles**	The 'hump' representing the activation energy is smaller.
***Enzyme**	A protein that works as a catalyst to speed up the reactions in our cells.
***Enzymes in alcohol production**	Alcoholic drinks are produced using enzymes found in yeast which catalyse a reaction that turns glucose into ethanol.

CC15: Groups, rates and heat changes

Lesson sequence

25. Exothermic and endothermic reactions
26. Explaining energy changes

1. Endothermic and exothermic reactions	
***Exothermic reaction**	A reaction that transfers energy to the surroundings (gets hotter, temperature **up**).
***Endothermic reaction**	A reaction that absorbs energy from the surroundings (gets colder, temperature **down**)
****Exothermic reaction profile**	
****Endothermic reaction profile**	

****Measuring energy changes**	-Sit a polystyrene beaker inside a glass beaker (insulation) - Measure the starting temperature of the reactants. - Mix the reactants in the polystyrene beaker - Cover with lid fitted with a thermometer - Monitor and record the peak temperature change.
**** Most common problem**	Heat escaping. Solution is more insulation.

2. Explaining energy changes	
****Chemical bonds in reactions**	During chemical reactions, old chemical bonds are broken and new ones are formed.
****Breaking bonds**	**Endothermic.** Breaking bonds absorbs energy, breaking stronger bonds absorbs more energy.
****Making bonds**	**Exothermic.** Making bonds releases energy, making stronger bonds releases more energy.

****Energy changes and bond formation**	The energy change in a reaction is the difference between the energy required to break the old bonds and the energy released by making the new ones.
****Exothermic reactions and bonds**	Exothermic reactions break weaker bonds and make stronger ones.
****Endothermic reactions and bonds**	Endothermic reactions break stronger bonds and make weaker ones.
*****Bond strength**	The energy required to break one mole of a particular covalent bond in kJ/mol.
*****Calculating energy changes from bond strengths**	Add up the total strength of old bonds broken and subtract the total strength of new bonds made. A negative answer is exothermic.

CP3 Conservation of Energy

Lesson sequence

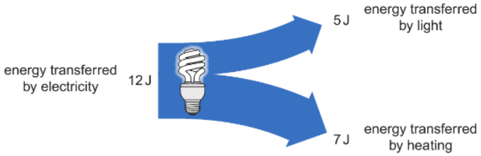
27. Energy stores and transfers
28. Energy efficiency
29. Keeping warm
30. Stored energies
31. Non-renewable energy resources
32. Renewable energy resources

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.

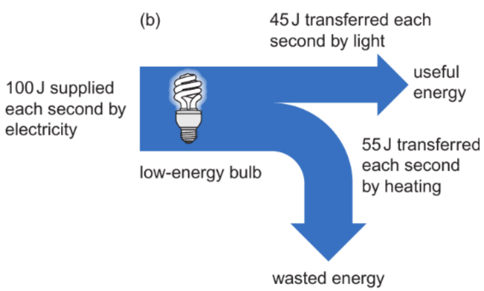
energy stored in moving car (kinetic energy) → energy transferred by forces during braking → energy stored in hot brakes (thermal energy)

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

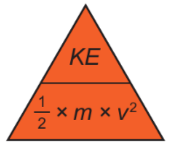


3. Keeping warm

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)	

P5 Light and the Electromagnetic waves

1. Electromagnetic waves

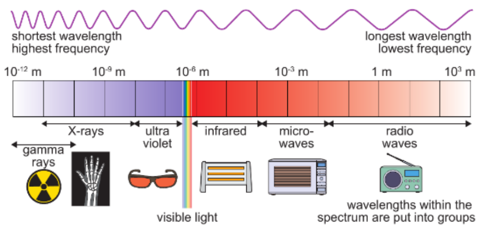
Electromagnetic waves	A group of waves that all travel at the same speed (speed of light) in a vacuum, and are all transverse.
Speed of light	300,000,000 m/s (3 x 10^8 m/s)
Frequency	The number of waves that pass a point every second. One hertz (Hz) is one wave per second.
Wavelength	The distance between 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

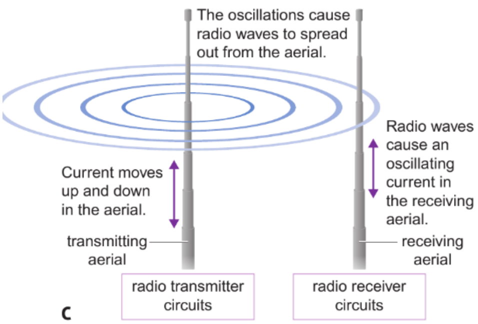
EM spectrum mnemonic	Rubbish Memories Include Visiting Ur X Girlfriend
EM spectrum – lowest to highest frequency or energy	Radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays.
EM spectrum – lowest to highest wavelength	Gamma rays, X-rays, ultraviolet, visible light, infrared, 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.

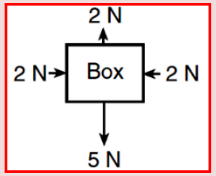
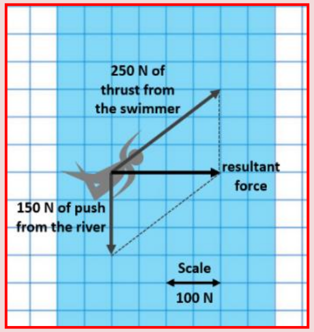
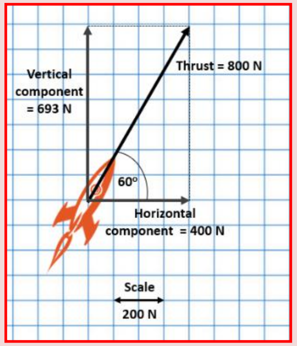
Lesson	Memorised?
1. Electromagnetic waves	
2. Core practical – Investigating refraction	
3. The electromagnetic spectrum	
4. Using the long wavelengths	
5. Using the short wavelengths	
6. EM radiation dangers	

P7/8 Energy and Forces and their Effects

Kettering Science Academy

1. Work and Power	
Energy	Needed to make things happen or change.
Joules	The units of energy, symbol = J.
Kilojoules	1000 J, symbol = kJ.
Work Done	The energy transferred by a force.
Calculating Work Done	Work done = force x distance E = F x d Work done = joules Force = newtons Distance = metres
Power	The rate of energy transfer.
Watts, W	The unit of power: 1 W = 1 joule per second
Calculating Power	Power = work done / time P = E / t Power = watts Work done = joules Time = seconds

2. Contact & Non-Contact Forces	
Contact Force	A force that acts when two objects touch.
Contact Force Examples	Normal contact force, friction, upthrust, air resistance.
Normal Contact Force	Force that acts at right angles to a surface as a reaction to a force on that surface.
Non-contact Force	A force that acts at a distance.
Non-contact Force Examples	Gravity, magnetism, electrostatic force.
Action-Reaction Forces	If, A applies an action force to B, B applies a reaction force of same size and opposite direction to A.
Force Field	The area around an object where its force can affect other objects.
Magnetic Field	The area of magnetic force around a magnet.
Magnet	Attracts magnetic materials (iron, nickel, cobalt) and attracts or repels other magnets.
Electric Field	The area of electrostatic force around an object charged with static electricity.
Vectors	Arrows that show size and direction.

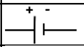
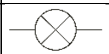
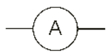
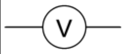
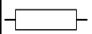
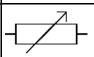
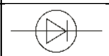
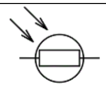
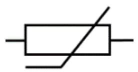
3. Vector Diagrams (HIGHER ONLY)	
Free Body Diagram	A diagram showing all the forces on an object. 
Vector Diagram Arrows	Arrows showing the size and direction of a force – must be drawn to scale.
Scale Diagram	Diagram drawn on graph paper to find the size of forces.
Resultant Force	The force left over when forces acting in opposite directions are cancelled out.
Resultant Force Diagram	Draw correct arrows for two forces, add lines to make a parallelogram. Resultant force = the diagonal of the parallelogram.
Resultant Force Diagram	
Resolving Forces	Breaking a force up into its horizontal and vertical components.
Component Forces	The vertical and horizontal forces that a diagonal force is made from.
Resolving Forces Diagram	Draw a correct force arrow, add arrows for vertical and horizontal component forces.
Resolving Forces Diagram	

Lesson	Memorised?
1. Work and Power	
2. Contact & Non-Contact Forces	
3. Vector Diagrams	

CP9 Electricity and Circuits

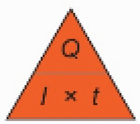
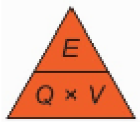
Lesson sequence

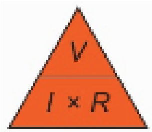
33. Electrical circuits
34. Current and potential difference
35. Current, charge and energy
36. Current, resistance and potential difference
37. More about resistance
38. Core practical – investigating resistance (CP15)
39. Transferring energy
40. Electrical power
41. Using electricity
42. Electrical safety

Circuit symbols	
Switch	
Cell	
Battery	
Lamp	
Ammeter	
Voltmeter	
Resistor	
Variable resistor	
Diode	
LDR	
****Thermistor**	

1. Electrical circuits	
Delocalised electrons	Electrons that are free to move between many different atoms.
Conventional current	The flow of positive charge from the positive terminal towards the negative terminal (goes in the opposite direction to electrons).
Electron flow	Electrons flow from the negative terminal towards the positive terminal.
Series circuit	A circuit in which there is only one path for the current to flow.
Parallel circuit	A circuit with multiple paths for the current to flow.

2. Current and Potential Difference	
Amperes, A	The unit of measurement for current. Amps for short.
Ammeter	Used for measuring current. Connected in **series** to measure the current **passing through** a component or circuit.
Potential difference	Also called voltage. This is what pushes electrons around a circuit.
Volts, V	The unit of measurement for potential difference.
Voltmeter	Used for measuring potential difference. Connected in **parallel** to measure the potential difference **across** a component or circuit.
Current in series circuits	The **same** at all points in the circuit.
Current in parallel circuits	**Less** on the branches than at the battery. Current on branches adds up to that at the battery.
Potential difference in series circuits	Potential difference is **shared** between the components on a circuit. It adds up to be the same as the battery.
Potential difference in parallel circuits	Potential difference is the **same** across each branch as it is across the battery.

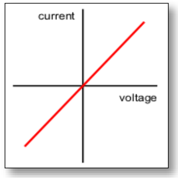
3. Current, charge and energy	
Charge	The amount electricity that has flowed through a circuit.
Coulombs, C	The unit of measurement for charge.
Current, I	The number of coulombs of charge that flows past a point each second. 1 amp = 1 coulomb per second
Calculating charge	Charge = current x time Q = I x t Q is charge (C) I is current (A) T is time = (s) 
Voltage, V	The amount of energy transferred by each coulomb of charge. One volt = 1 joule per coulomb.
Calculating energy	Energy = charge x potential difference E = Q x V E is energy (J) Q is charge (C) V is potential difference (V) 

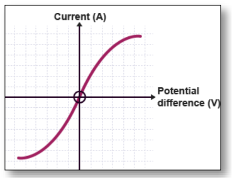
4. Current, resistance and potential difference	
Resistance	The difficulty with which current passes through materials.
Ohms, Ω	The unit of measurement for resistance.
High/low resistance	Higher resistance → better insulator→ lower current Lower resistance →better conductor→ higher current
Changing current	Higher voltage → higher current Higher resistance → lower current
Calculating resistance 	Current = potential difference / resistance I = V / R I is current (A) V is potential difference (V) R Is resistance (Ω) Note: This equation is normally written as V = IR.

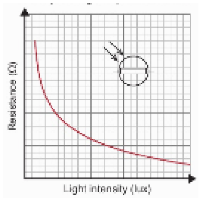
Resistors	Circuit components with differing resistance to control how much current flows to parts of a circuit.
Resistors in series	Total resistance is the sum of all of the resistors.
Voltage and resistors in series	Voltage is shared in proportion to the resistance. The resistor with more resistance takes more of the voltage. Calculate this using V=IR.
Resistors in parallel	Think about each branch of the circuit as a different series circuit. Resistors on different branches do not affect each other. The total resistance of resistors in parallel will always be **less** than resistors in series.

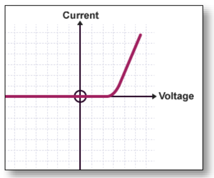
5. More about resistance

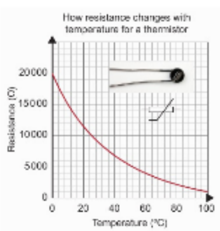
LDR	Light-dependent resistor. High resistance in dark, low resistance in light.
Thermistor	High resistance when cold, low resistance when hot.
Diode	High resistance in one direction, low resistance in the other.
Filament lamp	High resistance causes the filament to heat up, producing light.
Resistor graph	Current increases in direct proportion to voltage (straight line going through the origin (0,0)).
Filament lamp graph	Current increases as voltage increases, but levels out eventually as resistance increases with temperature.
Diode graph	Graph slopes up with a positive voltage but stays at 0 with a negative voltage.











6. Core practical CP15 Investigating resistance

CP15 - Aim	To explore how resistance changes in different circuits.
CP15 - Investigating resistance	Set up a circuit with an ammeter, resistor and voltmeter across the resistor. Vary the voltage and record voltage and current.
CP15 - Investigating series circuits	Set up a series circuit with an ammeter, two bulbs and voltmeters across each bulb and the power supply. Vary the voltage and record all readings
CP15 - Investigating parallel circuits	Set up a parallel circuit with two bulbs and ammeters on each branch and by the power supply, and voltmeters across each bulb and the powers supply. Vary voltage, record all readings.
CP15 - Results	Resistor – doubling voltage doubles current Series circuit – voltage at bulbs half of that at power supply Parallel circuit – voltage at bulbs equal to power supply, current half that at power supply

7. Transferring energy

Calculating energy transfer	Energy = current x potential difference x time E = I x V x t Energy (J) Current (A) Potential difference (V) Time (s)
Resistance and energy transfer	Electrons flowing through wires collide with atoms and lose energy. This energy is transferred to heat.

Electrical energy dissipation	When electrical energy is transferred to the surroundings as wasted heat energy by resistance.
How to reduce resistance	Use thicker wires, use shorter wires, use lower-resistance metals, reduce the temperature.

8. Electrical power

Power	The rate of energy transfer.
Watts, W	The unit of power: 1 W = 1 joule per second
Power and work done	$P = \frac{E}{t}$ P is power (W) E is work done (J) t is time (s)
Power, current and voltage	$P = I \times V$ P is power (W) I is current (A) V is the potential difference (V)
Power, current and resistance	$P = I^2 \times R$ P is power (W) I is current (A) R is resistance (Ω)

9. Using electricity

Mains electricity	The electricity supplied from wall sockets.
National grid	The systems of power lines and sub-stations that distributes electricity from power stations to homes and businesses.
Heaters	Transfer energy from electrical to thermal.
Motors	Transfer energy from electrical to kinetic.
Direct current	Current that flows in one direction.
Alternating current	Current that switches direction many times each second.
Frequency of mains current	Mains current alternates (switches direction) 50 times each second. The frequency is 50 Hz.

10. Electrical safety

Live wire	Brown, bottom right, 230 V, connects the appliance to the power station.
Neutral wire	Blue, bottom left, 0 V, completes the circuit.
Earth wire	Green and yellow, top, 0 V. Connects the appliance to the ground so current can flow there in the event of a short circuit.
Fuse	A thin metal wire that melts and breaks the circuit if there is too much current.
Circuit breaker	Breaks the circuit if too much current flows.
Advantages of circuit breakers	Quicker than fuses, just need switching - not replacing.

Lesson	Memorised?
Circuit symbols	
1.Electrical circuits	
2. Current and potential difference	
3. Current, charge and energy	
4. Current, resistance & potential difference	
5. More about resistance	
6. Core practical CP15 investigating resistance	
7. Transferring energy	
8. Electrical power	
9. Using electricity	
10. Electrical safety	

Reducing resistance (HIGHER AND TRIPLE ONLY)

Reducing resistance	Use a low resistance metal for the wires. Make the wire thicker. Cool the wires so ions do not vibrate as much.