Science Knowledge Organisers

Year 10 Internal Assessment(March 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

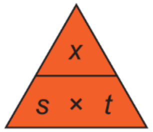
Once you have memorised some of the information, or have made a good start, it's a good idea to start trying to **use that knowledge**. Websites like **Seneca** and **Educake** provide great banks of questions for this.

CP1/SP1 Motion

1. Vectors and Scalars

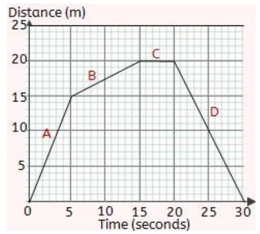
Magnitude	The size of something, such as the size of a force or the measurement of a distance.
Scalar quantity	A quantity that has a magnitude (size) only, but not a direction.
Scalar examples	Distance – 10 m Speed – 25 m/s Mass – 50 kg Energy – 300 J
Vector quantity	A quantity that has both a magnitude (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.

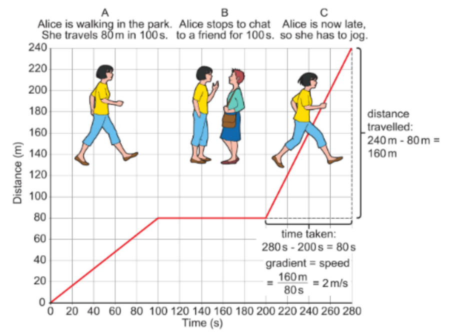
2. Speed

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

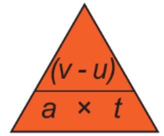
Distance-time graph	A graph showing the distance travelled against time for a moving object. Time is on the x-axis and distance on the y-axis.
Distance-time graphs – stationary	Horizontal line **C** on diagram below
Distance-time graphs – constant speed	Forwards – line sloping up **A and B** on diagram 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.

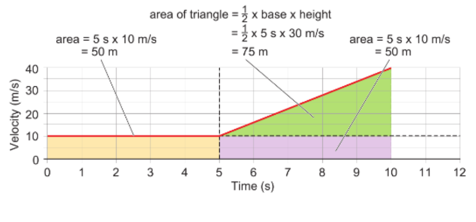
4. Acceleration

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

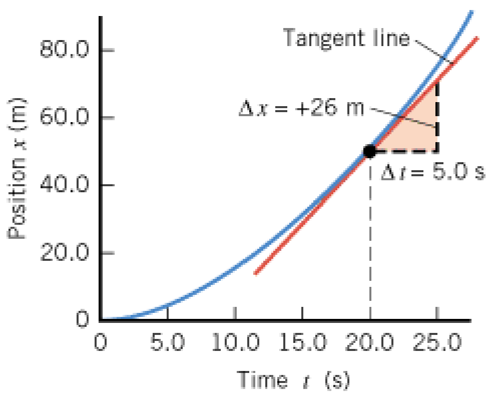
Velocity-time graphs – acceleration	Speeding up – line sloping up Slowing down – line sloping down
Velocity-time graphs – stationary	Horizontal line on the x-axis
Velocity-time graphs – line gradient	Steeper line = greater acceleration
Calculating acceleration on a velocity-time graph	Acceleration = 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)	

CP2/SP2 Forces and Motion

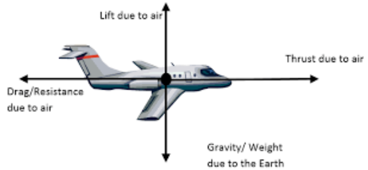
Kettering Science Academy

<u>**Lesson sequence**</u>

1. Resultant forces
2. Newton's first law
3. Mass and weight
4. Newton's second law
5. Core practical – investigating acceleration (CP12)
6. Newton's third law
7. Momentum (HT ONLY)
8. Stopping distances
9. Car safety
10. Braking distance and energy (TRIPLE ONLY)

1.Resultant forces

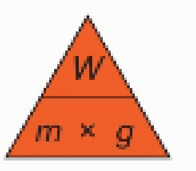
Scalar quantity	A quantity with magnitude (but no direction).
Vector quantity	A quantity with magnitude and direction.
Force arrows	Arrows can be used to represent forces: - Direction = direction of force - Length = size of force
Resultant force	The force left over when forces acting in opposite directions are cancelled out.
Calculating resultant force	Subtract the total force in one direction from the total force in the other direction.
Balanced forces	When the resultant force is zero (because forces acting in opposite directions are the same size).
Unbalanced forces	When the resultant force is non-zero (because there is more force in one direction than another).



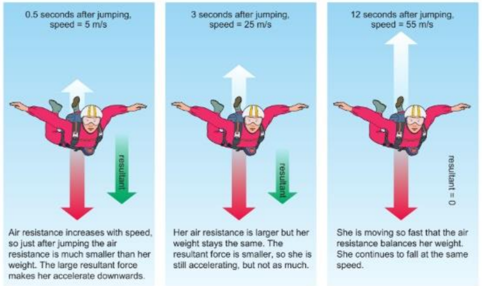
2. Newton's first law

Newton's first law of motion	An object will move at the same speed and direction unless it experiences a resultant force.
The effect of resultant forces	Resultant forces cause acceleration: speeding up, slowing down or changing direction
The effect of forces on motion	Forces make you start moving, stop moving or change direction, they are not needed to keep you moving!

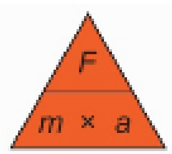
3. Mass and weight

Mass	The quantity of matter in an object is made of. Units = kilograms (kg)
Weight	A force caused by gravity pulling downward on an object. Units = newtons (N)
Force meter	An instrument for measuring forces. They usually have a spring that stretches more the greater the force applied.
Gravitational field strength	The strength of gravity, which is different on different planets. Units = newtons per kilogram (N/kg)
Gravitational field strength on Earth	10 N/kg
Calculating weight	Weight = mass x gravitational field strength W = m x g  Weight (N) Mass (kg) Gravitational field strength (N/kg)

Air resistance	A force caused by the air pushing against you as you move. Faster movement → greater air resistance.
Motion whilst falling	Falling objects accelerate until the air resistance is equal to the weight; now there is no resultant force so speed stays constant (**terminal velocity**).

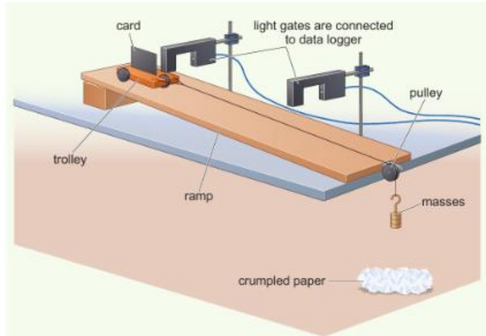


4. Newton's second law

Newton's second law of motion	Force = mass x acceleration
Acceleration is greater when…	- The force is greater - The mass is smaller
Calculating forces	Force = mass x acceleration F = m x a  Force (N) Mass (kg) Acceleration (m/s²)
Calculating acceleration	Acceleration = mass / force a = F / m Force = N Mass = kg Acceleration = m/s²

5. Core practical – investigating acceleration (CP12)

CP12 - Aim	To investigate how changing force changes acceleration.
CP12 - Setup	A trolley on a ramp with 9 x 10g masses. 10 g mass hanger attached to trolley via a string over a pulley.
CP12 – Data collection	Release the trolley, use light gates to measure the acceleration.
CP12 – Variations	Move 10 g of mass from the trolley to the mass hanger each time.
CP12 – Independent variable	The force: each 10 g mass = 0.1 N force
CP12 – Control variables	Move the 10 g masses from the trolley to the mass hanger to keep the total mass in the system the same. Raise the ramp slightly until the car only just starts to move freely to eliminate the effects of friction.
CP12 - Results	More mass pulling on the string → more force → greater acceleration.

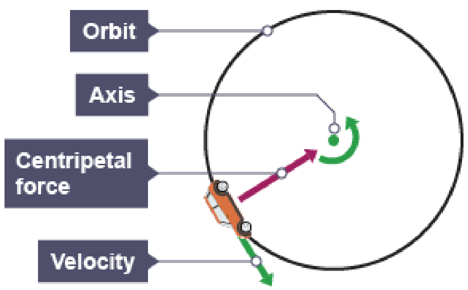


6. Newton's third law	
Newton's third law	For every action force there is an equal but opposite reaction force.
Action force	The force you push or pull with.
Reaction force	A force of the same size but opposite direction to an action force.
Action-reaction forces	If, A applies an action force to B, B applies a reaction force of same size and opposite direction to A.
Action-reaction vs balanced forces	Similarities: same sizes, opposite directions Differences: balanced forces act on one object, action-reaction act on two different objects

8. Stopping distances	
Stopping distance	The total distance travelled from when a hazard is seen to when you fully stop.
Thinking distance	The distance travelled from when a hazard is seen to when you brake.
Braking distance	The distance travelled from when you brake to when you fully stop.
Calculating stopping distance	Stopping distance = thinking distance + braking distance
Thinking distance and reaction time	Slower reactions = greater thinking distance
Thinking distance increased by…	Higher speed, tiredness, illness, drugs, distractions, old age
Braking distance increased by	Higher speed, poor brakes, poor tyres, wet/icy/gravelly road, downhill, heavier load

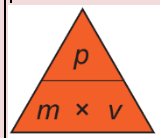
9. Car safety	
Crash danger	Crashes involve large decelerations, creating large forces which can injure you.
How car safety features work	Increase the time a collision takes, reducing deceleration and forces.
Three car safety features	Crumple zones, (stretchy) seat belts, air bags

2. Circular motion (HIGHER AND TRIPLE ONLY)	
Circular motion	Moving in a circle is a type of acceleration because you are changing velocity (your direction changes even if your speed does not).
Centripetal force	A force acting towards the centre of a circle that enables objects to move in a circle.
Sources of centripetal force	Gravity – keeps the Earth orbiting the Sun Tension – lets a bucket swing in circles on a rope Friction – keeps cars turning round a roundabout



4. Inertial mass (HIGHER AND TRIPLE ONLY)	
Inertial mass	The mass calculated by measuring the acceleration produced by force, using the equation m = F / a
The point of inertial mass	Inertial mass is the same as mass measured with a mass balance, but it gives us a way to measure mass where there is no gravity, such as in space.

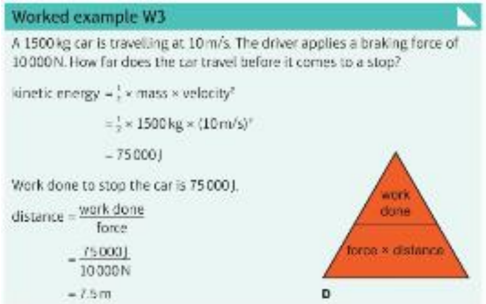
6. Collisions (HIGHER AND TRIPLE ONLY)	
Action-reaction forces in collisions	E.g. kicking a ball: the foot pushes the ball, the ball pushes back on the foot.

7. Momentum (HIGHER AND TRIPLE ONLY)	
Momentum	The tendency of an object to keep moving.
Calculating momentum	Momentum = mass x velocity p = m x v  Momentum (kg m/s) Mass (kg) velocity (m/s)
Momentum and force calculations	Force = change in momentum / time F = (mv – mu)/t Force (N) Mass (kg) Velocity (m/s) Time (s)
Conservation of momentum	Total momentum before and after a collision is the same.

9. Collision forces (HIGHER AND TRIPLE ONLY)	
Collision forces	Greater momentum change → greater force
Calculating collision forces	Force = change in momentum / time F = (mv – mu)/t Force (N) Mass (kg) Velocity (m/s) Time (s)

Lesson	Memorised?
1. Resultant forces	
2. Newton's first law	
3. Mass and weight	
4. Newton's second law	
5. Core practical – investigating acceleration (CP12)	
6. Newton's third law	
8. Stopping distances	
9.Car safety	
(HIGHER AND TRIPLE ONLY)	
2. Circular motion	
4. Inertial mass	
6. Collisions	
7. Momentum	
9.Collision forces	
10. (TRIPLE ONLY) Braking distance and energy	

10. Braking distance and energy (TRIPLE ONLY)	
Work done	The energy transferred by a force acting over a distance is called work done. Measured in joules (J)
Calculating work done	Work done = force x distance moved in the direction of the force  Work done (J) Force (N) distance (m)
Kinetic energy	Energy stored in a moving object Measured in joules (j)
Calculating kinetic energy	kinetic energy = $\frac{1}{2}$ × mass × $(\text{speed})^2$ Kinetic energy (J) Mass (kg) $(\text{Speed})^2$ $(\text{m/s})^2$
Estimating stopping distance using mass, braking force and speed	See worked example below. Remember that work done and energy transferred are the same.



Worked example W3

A 1500 kg car is travelling at 10 m/s. The driver applies a braking force of 10 000 N. How far does the car travel before it comes to a stop?

kinetic energy = $\frac{1}{2}$ × mass × velocity^2

= $\frac{1}{2}$ × 1500 kg × $(10\text{ m/s})^2$

= 75 000 J

Work done to stop the car is 75 000 J.

distance = $\frac{\text{work done}}{\text{force}}$

= $\frac{75\,000\text{ J}}{10\,000\text{ N}}$

= 7.5 m

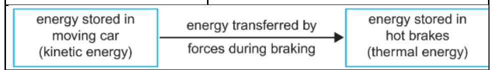
CP3 Conservation of Energy

Lesson sequence

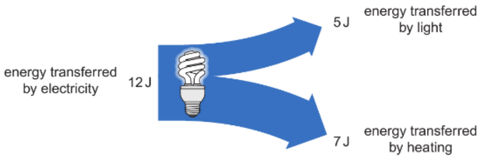
11. Energy stores and transfers
12. Energy efficiency
13. Keeping warm
14. Stored energies
15. Non-renewable energy resources
16. Renewable energy resources

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.

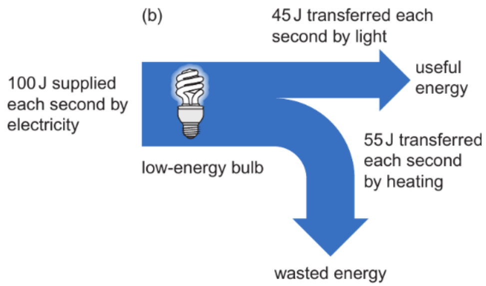


Sankey diagram	Shows energy transfers. The thickness of the arrow relates to the amount of energy.



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

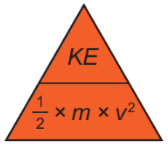


3. Keeping warm

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.

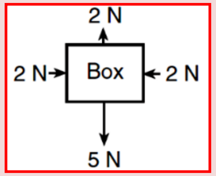
Lesson	Memorised?
1. Energy stores and transfers	
2. Energy efficiency	
3. Keeping warm	
4. Stored energies	
5. Non-renewable energy resources	
6. Renewable energy resources	
7. Reducing energy losses (HIGHER ONLY)	

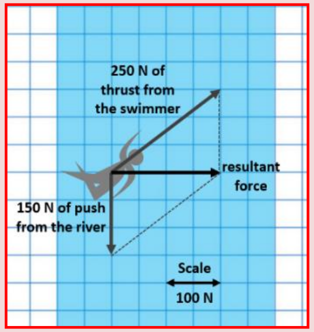
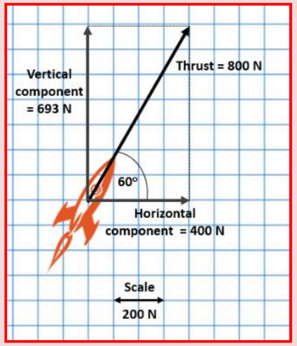
P7/8 Energy and Forces and their Effects

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	

CC9: Quantitative chemistry

Kettering Science Academy

1. Relative Formula masses

Molecular formula	Gives the number of atoms of each element present in a molecule.
Empirical formula	The **simplest ratio** of the atoms of each element present in a compound.
Converting molecular to empirical formulae	Divide the number of each atom by the highest common factor of all of the atoms.
Molecular to empirical formula examples	C_4H_8 ← write the formula 4 : 8 ← write as a ratio $\frac{4}{4}:\frac{8}{4}$ ←divide by small number 1 : 2 ← simplest ratio CH_2 ← write as formula
Relative atomic mass, Ar	The mass of an atom relative to 1/12th the mass of carbon-12. No units.
Relative formula mass, Mr	The mass of one unit of a formula, found by adding the relative atomic masses of all of the atoms in it.

2. Calculating empirical formulae

Steps to calculate empirical formulae from experimental data	1) Write each element's symbol with a ratio (:) symbol between 2) Write out the amount of each element from the questions 3) Divide each amount by the $\mathbf{A_r}$ of the element 4) Divide each answer by the **smallest number** to get a ratio 5) Write the empirical formula

To find a molecular formula from an empirical formula	1) Calculate M_r for the empirical formula 2) Divide the M_r of the molecular formula by this number 3) Multiply the empirical formula by your answer

Empirical formula example
A compound contains 14.3% hydrogen by mass and 85.7% carbon. Determine its empirical formula.

Symbols:	C	:	H
Amounts:	85.7%		14.3%
by A_r:	85.7 ÷ 12 = 7.14		14.3 ÷ 1 = 14.3
÷ by smallest:	7.14 ÷ 7.14 = 1		14.3 ÷ 7.14 = 2
Write formula:	CH_2		

The relative formula mass of the compound is 28, determine its molecular formula.

M_r of empirical: $M_r(CH_2)$ = 12 x 1 + 1 x 2 = 14
÷ molecular M_r by empirical M_r: 28 ÷ 14 = 2
Multiply empirical formula: CH_2 x 2 = C_2H_4

3. Magnesium Oxide Experiment

Equipment	Crucible (small pot capable of withstanding high heat) Clay triangle (to put the crucible on because a gauze would melt)
Method	1) Weigh small amount of magnesium ribbon 2) Heat in a **crucible** to react with air 3) Reweigh once cool to find new mass.
Results	It gets heavier because the oxygen has been added to the solid
Analysis	Find the mass of oxygen added by doing **new mass – old mass.** **Then do the empirical formula calculation**
Magnesium Oxide	Is MgO

3. Conservation of mass

Conservation of mass	The total mass of products must equal the total mass of reactants.
Precipitation reaction	A reaction that produces An insoluble solid precipitate by mixing two solutions.
Closed system	A system in which no chemicals can enter or leave, such as a sealed test tube.
Open system	A system in which chemicals can enter or leave – such as an open test tube.
Conservation of mass in a closed system	No atoms are able to enter or leave - total mass stays the same. Example: precipitation in a closed flask.
Conservation of mass in an open system	Atoms can leave – total mass appears to change. Example: a carbonate reacting with acid producing CO_2 bubbles: the mass appears to decrease because you can't weigh the gas that goes into the air, however it is still there.

4. Calculating reacting masses

Excess reactant	Any reactant which is not used up completely in a reaction because there is more of it than needed.
Limiting reactant	Any reactant which is completely used up in a reaction. The limiting reactant determines how much product is made because it will run out of this then stop.
Stoichiometry	Means the balancing of an equation. Use the **limiting reactant** to work out how much is made from balancing.
Calculating reacting masses	1) Write out the balanced equation 2) Calculate the RFMs 3) Write the RFMs as a **ratio** 4) Divide both sides of the ratio by the RFM of the chemical you know the mass of 5) Scale up or down

Calculate concentration	Concentration = $\frac{\text{mass in g}}{\text{volume in dm}^3}$
Convert cm^3 to dm^3	$\frac{cm^3}{1000} = dm^3$

Reacting masses example
What mass of iron can be produced from 50 g of iron oxide (Fe_2O_3)?

$2Fe_2O_3 + 3C$ →		$4Fe + 3CO_2$
320	:	224
$\frac{320}{320}$	:	$\frac{224}{320}$
1	:	0.7
1 × 50	:	0.7 × 50
50g	:	**35g**

RFM calcs: **2 Fe_2O_3:** 2 x (2 x 56 + 3 x 16) = 320
4 Fe: 4 x 56 = 224

5. Moles (HIGHER ONLY)

Moles	Measures **amount of substance** – one mole of any chemical is the same amount.
One mole is…	The Avogadro number of particles (atoms, ions or molecules)
One mole is also…	The mass in grams of its relative formula mass.
Avogadro's constant	6.02×10^{23}: the number of atoms/molecules present in one mole of a substance.
Calculating moles from mass	moles = $\frac{\text{mass}}{\text{relative formula mass}}$
Calculating moles from a number of particles	Quantity in moles = $\frac{\text{no.particles}}{6.02 \times 10^{23}}$
Calculating the number of particles from moles	No. particles = moles x 6.02×10^{23}

Lesson	Memorised?
1. Relative Formula Masses	
2. Calculating Empirical Formulae	
3. Conservation of mass	
4. Reacting masses	
5. Moles	

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 $\text{BMI} = \frac{(\text{weight in kilograms})}{\text{height in meters}^2}$ 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.
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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.
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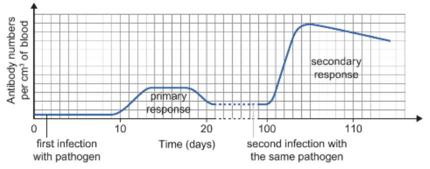
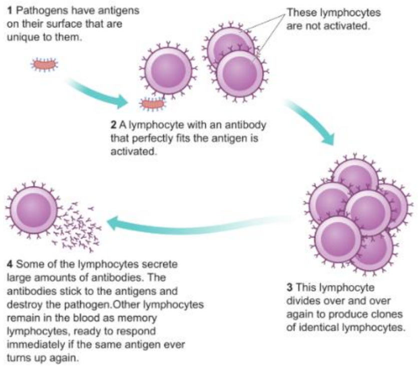
Primary Response vs. Secondary Response



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.
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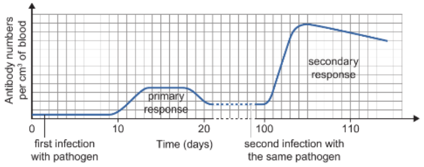

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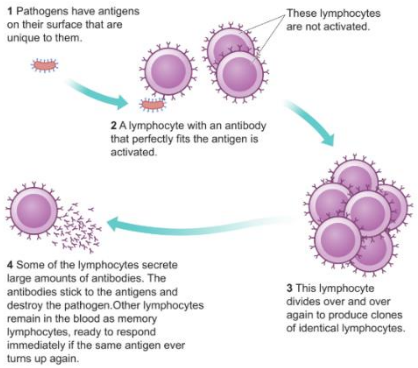

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7. The Immune System	
8. Antibiotics	

B8: Exchange and Transport in Animals

1. Efficient Exchange & Transport

Substances Needed	Oxygen, glucose and nutrients are needed by the body.
Waste Products	Carbon dioxide, urea.
Transport	Moving substances around the body.
Exchange	Moving substances in and out of our cells.
Diffusion	The way substances move in and out of cells – they diffuse from high to low concentration.
Increasing Diffusion	High surface area, thin surfaces
Surface Area: Volume Ratio	Surface area ÷ volume A higher ratio means there is more surface area, so substances can diffuse in and out of cells more quickly.
Alveoli	**Role:** Air sacs in lungs where CO_2 and O_2 are exchanged **Adaptations:** millions of them gives a high surface area, good blood supply maintains a high concentration gradient, thin walls increases diffusion

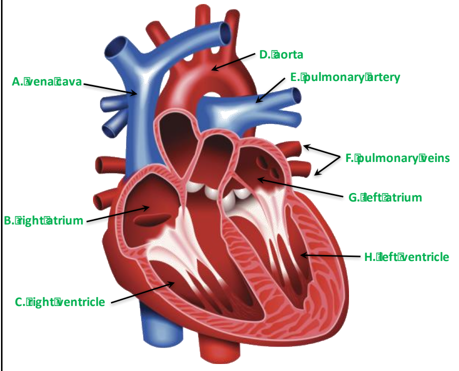
2. Circulatory System

Circulatory System	Your heart, arteries, capillaries and veins which work together to pump blood around the body.
The Role of Blood	To carry oxygen and nutrients to our cells and take waste products away.
Arteries	**Role:** Carry blood away from the heart **Adaptations:** Thick muscle walls to withstand the high pressure, elastic fibres to stretch as pressure increases during a pulse.
Capillaries	**Role:** To exchange nutrients and waste between the blood and cells. **Adaptations:** Thin walls to increase diffusion, many of them to give a high surface area.
Veins	**Role:** To carry blood towards the heart **Adaptations:** Thin walls because pressure is low, wide because blood is moving slowly, valves so blood flows right way.
Components of Blood	Plasma, red blood cells, white blood cells, platelets.
Plasma	A straw-coloured liquid that carries the blood cells and dissolved substances such as urea, carbon dioxide and glucose.
Red Blood Cells	Erythrocytes Contain haemoglobin to carry oxygen around the body.
White Blood Cells	Fight pathogens. **Phagocytes** – engulf ('eat') pathogens. **Lymphocytes** – produce antibodies to attack pathogens.
Platelets	Small fragments of cells that help the blood to clot when you are cut.

3. The Heart

Heart	A double pump that pumps blood: **Right side**: to lungs **Left side**: around the whole body
Atria (Atriums)	The two chambers at the top of the heart. Right: receives blood from body Left: receives blood from lungs
Ventricles	The two chambers at the bottom of the heart Right: pumps blood to lungs Left: pumps blood to body
Valves	Prevent blood from flowing from the ventricles back to the atria
Vena Cava	Carries blood from the body into the right atrium.
Pulmonary Artery	Carries blood from the right ventricle to the lungs.
Pulmonary Vein	Carries blood from the lungs to the left atrium.
Aorta	Carries blood from the left ventricle to the body.
Cardiac Output	Cardiac output = stroke volume x heart rate
Increasing Cardiac Output	Stronger heart beats (higher stroke volume), higher heat rate.

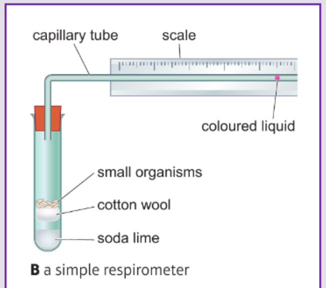
Structure of the Heart



4. Respiration

Respiration	An exothermic reaction carried out in all living cells to release energy from food molecules such as glucose.
Aerobic Respiration	The main type of respiration, which takes place in mitochondria and uses oxygen.
Aerobic Equation	glucose + oxygen → carbon dioxide + water
Anaerobic Respiration	A form of respiration that releases less energy but extremely quickly. Takes place in the cytoplasm.
Anaerobic Equation	Glucose → lactic acid
Role of Anaerobic Respiration	To provide an energy boost during intense exercise when aerobic respiration alone isn't enough.
Lactic Acid	A poison that builds up in muscles during anaerobic respiration leading to muscle tiredness and cramp.
Excess Post Exercise Oxygen Consumption	We continue to breathe heavily and have a high heart rate after exercise to get lots of oxygen to the muscles to oxidise harmful lactic acid to CO_2 and H_2O.

5. Core Practical

Key Question	How does temperature affect the rate of respiration in small animals?
Method	Place some soda lime (absorbs CO_2) into the test tube put a protective layer of cotton wool over it, add ten maggots, insert in bung with capillary tube and put in water bath to adjust for 5 mins. Dab open end of capillary tube into red dye and start timing.
Equipment	 **B** a simple respirometer
Record Results	Every five minutes for fifteen minutes, measure the distance travelled by the food colouring.
Vary the Temperature	Repeat the experiment in water baths set to different temperatures.
Results	The higher the temperature, the faster the animals respire.

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)

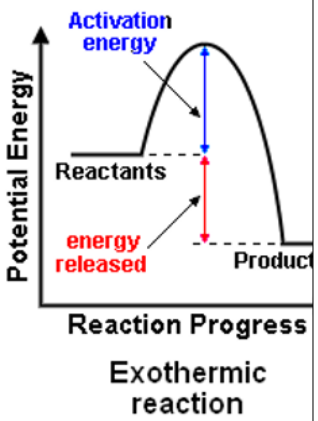
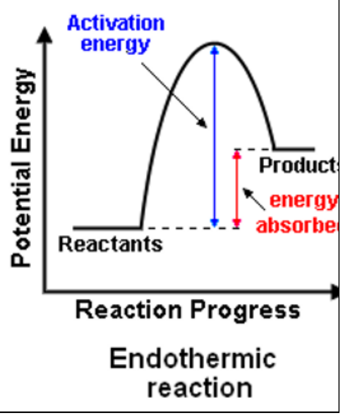
4. Group 0

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	

CC15: Groups, rates and heat changes

Lesson sequence
17. Exothermic and endothermic reactions 18. 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.

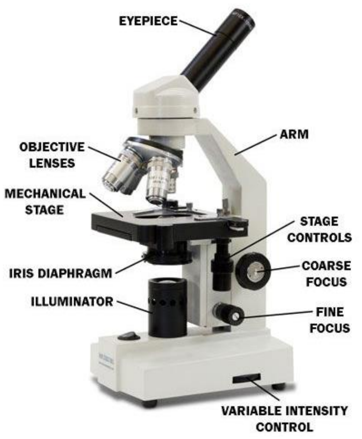
****Energy changes and bond formation**	The energy change in a reaction is the difference between the energy required to break the old bonds and the energy released by making the new ones.
****Exothermic reactions and bonds**	Exothermic reactions break weaker bonds and make stronger ones.
****Endothermic 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.

B1: Biology key concepts

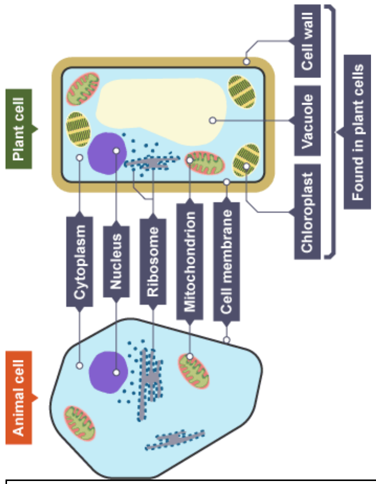
Lesson sequence

19. Microscopes
20. Plant and animal cells
21. Measuring cells
22. Core practical: using microscopes
23. Specialised cells
24. Bacterial cells
25. Digestive enzymes
26. How enzymes work
27. Factors affecting enzymes
28. Core practical: enzymes and pH
29. Cell transport
30. 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.



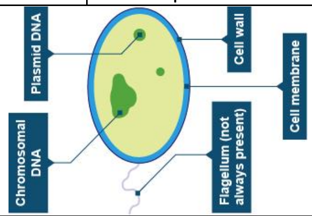
3. Measuring cells	
***Micrograph**	A picture produced by a microscope.
***Light microscope**	A microscope that uses light, can magnify up to 1500 times.
****Electron microscope**	A microscope that uses electrons to produce an image, can magnify up to 1,000,000 times.
****Actual size of a cell**	Actual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

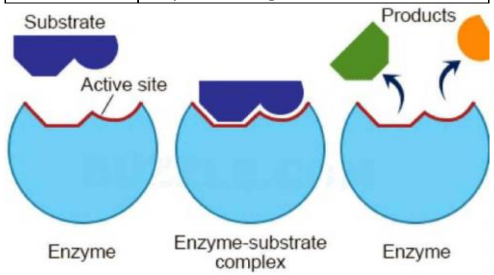


7. Digestive enzymes

*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 37ºC 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 40ºC
*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.

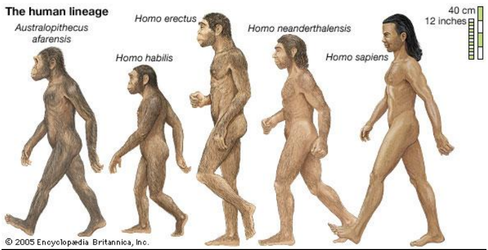
B4: Evolution

Lesson sequence

31. Human evolution
32. The theory of evolution
33. Resistance
34. Classification
35. How to modify species
36. Problems with modifying species
37. Genetic engineering of bacteria (HT)

1. Human evolution

***Binomial naming**	Two-part names, first part = genus, second part = species. Written in italics.
Homo sapiens	Our species. Evolved about 200,000 years ago. Skull volume 1450 cm^3.
****Ardipithecus ramidus***	Aka 'Ardi'. 4.4 million years ago, walked upright and climbed trees, 350 cm^3 skull volume.
****Australopithecus afarensis***	Aka Lucy. 3.2 million years ago, walked upright, skull volume 400 cm^3.
****Homo habilis***	2.4-1.4 million years ago, walked upright, skull volume 5-600 cm^3.
8Homo erectus	1.8 to 0.5 million years ago, walked upright, skull volume 850 cm^3.
***Fossil evidence**	Many fossils have been found showing a gradual transition from 'ape-like' to 'human-like'.
****Stone tool evidence**	Older stone tools are simpler requiring less intelligence to make, younger stone tools are more complex requiring more intelligence to make.
****The Leakeys**	Mary and Louis discovered *Homo habilis*, their son Richard worked on *Homo erectus*.



2. The theory of evolution

***Charles Darwin**	Develop the theory of evolution.
***Evolution**	The way that species develop by gradual changes over many generations due to natural selection.
***Variation**	Natural differences between members of a species that affect the chance of survival.
****Mutations and evolution**	Changes in DNA cause variation.
****Environmental change**	Change to factors such as food supply, climate or predators.
***Competition**	The fight to eat, survive and breed.
***Natural selection**	Organisms with the best genes and characteristics are more likely to survive, breed and pass on their better genes.
***Inheritance**	Gaining your genes from your parents.
****Well adapted**	An organism has features that make it better able to survive and breed.
****Evolution and the individual**	An individual does not evolve during its lifetime, populations of organisms evolve over many lifetimes.
****Human evolution**	Humans did not evolve from chimpanzees, we both evolved from a common ancestor.

3. Resistance

***Resistance**	The natural ability of some members of a species to survive poisons that would kill the other members.
***Evolution of resistance**	Evolution of organisms that stops them from being affected by poisons.
****Rats and warfarin resistance**	Warfarin is used to kill rats. Some rats were naturally resistant, survived the warfarin, bred and passed on their resistance genes.
****Antibiotic resistance**	Antibiotics are used to kill bacteria. Some bacteria were naturally resistant, survived the antibiotics, bred and passed on their resistance genes.
****The problems of resistance**	Antibiotic resistance means that many infections that used to be simple to treat may become too resistant to treat, causing major health problems.

4. Classification

***Carl Linnaeus**	Developed the modern system of classification.
***How to classify**	Based on similarities, group things into smaller and smaller groups with fewer and fewer similarities.
***Problems with classification**	Sometimes organisms that look similar are not actually related.
***Kingdoms**	Old idea, classifying living things into five kingdoms (including plants, animals and fungi)
****Carl Woese**	Developed the modern system of classification with three domains.
***Domains**	Modern idea of classifying living things into three main groups: bacteria, Archae, Eukarya.
****Bacteria**	Single-celled organisms with no nucleus and no unused sections of DNA.
****Archae**	Single-celled organisms with no nucleus but with unused sections of DNA.
****Eukarya**	(Often) multi-cellular organisms with a nucleus and unused sections of DNA. Includes plants, animals, fungi and protists.

5. How to modify species

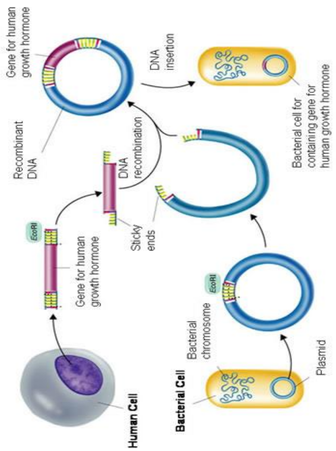
***Artificial selection**	When humans (normally farmers) select the animals/plants to breed with the best characteristics.
***Selective breeding**	Developing new breeds of plants or animals with better characteristics by selective breeding over many generations.
****Selective breeding in practice**	Choose parents with the best characteristics, breed them together, choose from their offspring with the best characteristics, breed them together, repeat for many generations.
***Genetic engineering**	Changing the characteristics of organisms by giving them genes from another organism.
***GMO**	Genetically modified organism: an organism that has had its genes changed.
****Bt corn**	Corn containing a gene from *Bacillus thuringiensis* that makes it produce a substance called Bt which kills insects.
***Medical GMOs**	GM bacteria are used to make insulin (for diabetes) and some antibiotics.
****Pros and cons of GM**	Quicker than selective breeding and can introduce more different characteristics but is expensive.

6. Problems with modifying species

Over-selection	Farmers focussing too much on breeding for one characteristic (such as chicken breast size), don't spot problems with other characteristics (such as weak leg bones) causing suffering.

Gene leakage	The concern GMOs could breed with wild relatives, enabling the modified genes to escape into the wild. This could have ecological impacts.
Resistance	The concern that in areas growing Bt corn, insects simply evolve resistance to Bt.
Insulin	Insulin made by GM bacteria is not identical to human insulin, and some people suffer bad reactions to it.

7. Genetic engineering of bacteria (HT)	
****Plasmid DNA**	Small loops of DNA containing a few genes.
*****Restriction enzyme**	Enzymes that cut DNA, leaving sticky ends at each end of the piece of DNA.
*****Sticky end**	A short sequence of unpaired bases at the end of a piece of DNA.
*****Ligase**	An enzyme that joins two pieces of DNA by matching up the bases on their sticky ends.
*****Recombinant DNA**	DNA produced by combining together two of more pieces of DNA.
*****How to genetically engineer bacteria**	Cut out gene using restriction enzymes, remove plasmids from bacteria and open with restriction enzymes, use ligase to join gene and plasmid together, return plasmids to bacteria.



C3 & 4: Atoms and the periodic table

Lesson sequence

38. Structure of atoms
39. Detailed structure of atoms
40. Isotopes
41. Mendeleev's periodic table
42. The modern periodic table
43. Electron configuration

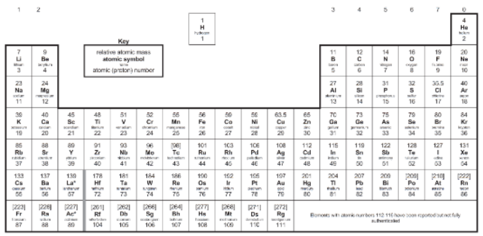
1. Structure of atoms	
***Particle**	The tiny pieces that all matter is made from.
***Atom**	The smallest independent particle. Everything is made of atoms.
****Size of atoms**	About 1 x 10^{-10} m in diameter.
****Dalton's model of atoms**	- Tiny hard spheres - Can't be broken down - Can't be created 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

44. Ionic bonding
45. Ionic compounds
46. Properties of ionic compounds
47. Covalent bonding
48. Covalent structures
49. Allotropes of carbon
50. Metallic bonding
51. 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.

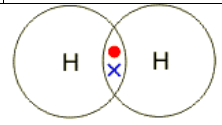
****Forming ionic bonds**	Electrons are transferred from a metal atom to a non-metal atom to form a positive metal cation and a negative metal anion. The oppositely charged ions are attracted to each other.

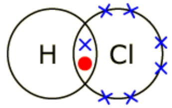
2. Ionic compounds	
***Chemical formula**	Shows the number of atoms of each element present in one ‘unit’ of a compound.
***Writing formulae**	- Each chemical symbol starts with a capital letter. - The number of each atom present is shown with a subscript number after the symbol. E.g. H_2SO_4.
****Determining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

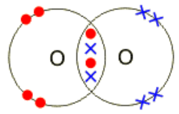
3. Properties of ionic compounds	
****Melting point of ionic compounds**	High because melting needs a lot of energy to break strong ionic bonds.
***Solubility of ionic compounds**	Many ionic compounds dissolve in water.
****Electrical conductivity of ionic compounds**	Solid: Do not conduct because ions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

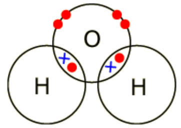
4. Covalent bonding	
***Covalent bond**	An electrostatic attraction between two atoms and a share pair of electrons.
****Double bond**	A covalent bond involving two shared pairs of electrons.
***Dot and cross diagram**	A bonding diagram showing the electrons in the outer shell of each atom, with electrons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

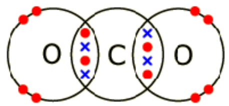
****Valency**	The number of covalent bonds an atom can form.
****Valency and groups**	Group 4 = 4 (4 electrons needed) Group 5 = 3 (3 electrons needed) Group 6 = 2 (2 electrons needed) Group 7 = 1 (1 electron needed)
****Working out molecular formulae**	Find the lowest common multiple of the valency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

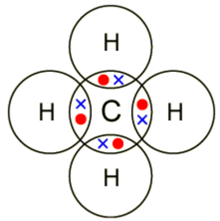








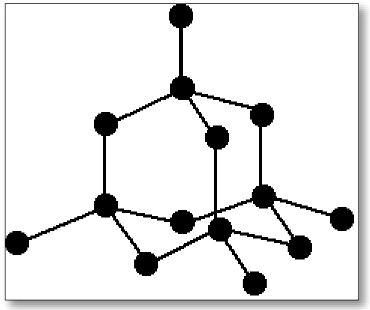




5. Covalent structures	
***Molecule**	A particle made from two or more atoms bonded together.
***Simple molecular structure**	A structure made of small molecules in which a few atoms join together to form a small particle.
****Structure of molecular substances**	Atoms in a molecule are held together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