Investigation skills

Lesson	Knowledge
1. Prediction	1. Hypothesis - A proposal intended to explain certain facts or observations.
	2. Prediction - A prediction is a statement suggesting what will happen in the future, based on observation, experience or a hypothesis.
2. Variables	1. Variable - These are physical, chemical or biological quantities or characteristics.
	2. Independent variable - Independent variable is the variable for which values are changed or selected by the investigator. Plot on the x-axis.
	3. Dependent variable - The variable of which the value is measured for each and every change in the independent variable. Plot on the y-axis.
	4. Control variable - Control variable is one which may, in addition to the independent variable, affect the outcome of the investigation and therefore has to be kept constant or at least monitored.
	5. Fair test - A fair test is one in which only the independent variable has been allowed to affect the dependent variable.
	6. Calibration - Marking a scale on a measuring instrument. This involves establishing the relationship between indications of a measuring instrument and standard or reference quantity values, which must be applied. For example, placing a thermometer in melting ice to see whether it reads zero, in order to check if it has been calibrated correctly.
3. Method	1. Resolution - This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.
	2. Reproducible - A measurement is reproducible if the investigation is repeated by another person, or by using different equipment or techniques, and the same results are obtained. Previously known as reliable.
	3. Method – A set of instructions to follow to carry out an investigation.
	4. Resolution - This is the smallest change in the quantity being measured (input) of a measuring instrument that gives a perceptible change in the reading.
4. Bar Graphs	1. Data - Information, either qualitative or quantitative, that has been collected.
	2. Categoric variable - Categoric variables have values that are labels, eg names of plants or types of material.
5. Line Graphs	1. Anomaly - These are values in a set of results which are judged not to be part of the variation caused by random uncertainty.
	2. Interval - The quantity between readings, eg a set of 11 readings equally spaced over a distance of 1 metre would give an interval of 10 centimetres.
	3. Range - The maximum and minimum values of the independent or dependent variables; important in ensuring that any pattern is detected. For example a range of distances may be quoted as either: 'From 10 cm to 50 cm' or 'From 50 cm to 10 cm'.
	4. Precision - Precise measurements are ones in which there is very little spread about the mean value. Precision depends only on the extent of random errors – it gives no indication of how close results are to the true value.

	5. Continuous variable - Continuous variables can have values (called a quantity) that can be given a magnitude either by counting (as in the case of the number of shrimp) or by measurement (eg light intensity, flow rate etc). Previously known as discrete variable.
6. Results	1. Accuracy - A measurement result is considered accurate if it is judged to be close to the true value.
	2. Measurement error - The difference between a measured value and the true value.
	3. Random error - These cause readings to be spread about the true value, due to results varying in an unpredictable way from one measurement to the next. Random errors are present when any measurement is made, and cannot be corrected. The effect of random errors can be reduced by making more measurements and calculating a new mean.
	4. Systematic error - These cause readings to differ from the true value by a consistent amount each time a measurement is made. Sources of systematic error can include the environment, methods of observation or instruments used. Systematic errors cannot be dealt with by simple repeats. If a systematic error is suspected, the data collection should be repeated using a different technique or a different set of equipment, and the results compared.
	5. Zero error - Any indication that a measuring system gives a false reading when the true value of a measured quantity is zero, eg the needle on an ammeter failing to return to zero when no current flows. A zero error may result in a systematic uncertainty.
	6. True value - This is the value that would be obtained in an ideal measurement.
7. Conclusion & Evaluation	1. Validity - Suitability of the investigative procedure to answer the question being asked. For example, an investigation to find out if the rate of a chemical reaction depended upon the concentration of one of the reactants would not be a valid procedure if the temperature of the reactants was not controlled.
	2. Valid conclusion - A conclusion supported by valid data, obtained from an appropriate experimental design and based on sound reasoning.
	3. Evidence - Data which has been shown to be valid.

Physics 1: Energy and Forces

Lesson	Knowledge
1. What is Energy?	1. No-one knows what energy is. It is a mathematical concept.
	2. A system is an object or series of object that interact.
	3. Energy gives a system the ability to do work.
	4. There are 8 energy stores: Chemical, kinetic, thermal, nuclear, gravitational, electrostatic, elastic & magnetic.
	5. Energy is transferred between stores by 4 energy pathways: Mechanical, heating, radiation and electrical.
2. Conservation of Energy	1. The unit of energy is the Joule (J).
	2. Conservation of energy = energy cannot be created or destroyed, just transferred between stores.
	3. In a closed system, all of the energy in the starting store will be transferred to the final store.
	4. In an open system, some energy will be dissipated (lost).
	5. When energy is dissipated (lost) it is transferred to the thermal energy store of the surroundings.
3. Particle Model	1. Matter is the name we give to any substance that has mass or takes up space.
	2. Matter comes in four fundamental forms: Solid, liquid gas and plasma.
	3. In solids the atoms are in a fixed shape, are arranged in rows and columns and vibrate around a fixed position.
	4. In liquids the atoms are randomly arranged but are all touching, are free to flow and take the shape of a container.
	5. In gases the atoms are randomly arranged with many gaps, are free to move and take the shape of a container.
4. Temperature and Heat	1. Thermometers are used to measure temperature.
	2. The unit of temperature is degrees Celsius (°C).
	3. Temperature and thermal energy are not the same thing.
	4. Temperature is a measure of the average kinetic energy of particles.
	5. The higher the temperature of a substance, the greater average kinetic energy of particles in the substance.
5. Making a Temperature Scale	1. Temperature scales need to have 2 fixed points.
	2. The Celsius (°C) scale has 2 fixed points: 0°C the point at which ice melts and 100°C the point at which water boils.
	3. Absolute zero is the point at which all atoms have no kinetic energy so are stationary.
	4. The Kelvin temperature scale starts at absolute zero. 0 K (Kelvin) = +273.15 °C (Celsius).
	5. Kelvin and Celsius have the same scale (i.e. a 1 K increase = 1°C increase).
6. Contact and Non-contact Forces	1. A force is a push or pull acting on an object.
	2. The unit of force is the Newton (N).
	3. A contact force is a force that occurs when 2 object touch.
	4. A non- contact force is a force that occurs without 2 objects touching.
	5. Air resistance and friction are examples of contact forces; Weight and magnetism are examples of non-contact forces.

7. Vectors and Scalars	1. Scalars have magnitude (a size) only.
	2. Examples of scalars include: Mass, distance and speed.
	3. Vectors have magnitude (a size) and one given direction.
	4. Examples of scalars include: Weight, displacement and velocity.
	5. Vectors can be represented by free-body diagrams.
8. Weight and Mass	1. Mass (in kilograms, Kg) is a measure of an objects resistance to acceleration when a resultant force is applied.
	2. Inertia = a stationary needs a force to move it. The bigger the mass, the bigger the force needed.
	3. All objects with mass have a gravitational field.
	4. Weight (in Newton's, N) is a force felt by a mass when placed into the gravitational field of another object.
	5. The equation for calculating weight is: Weight (N) = mass (Kg) x gravitational field strength (N/Kg)
9. Balanced and Unbalanced Forces	1. Resultant force = overall force acting on an object found by adding all of the forces acting on the object together.
	2. If the resultant force acting on an object = 0N, then the forces are balanced.
	3. If an object is stationary (not moving), the result force = 0N (the forces acting on the object are balanced).
	4. If an object is moving at a constant velocity the result force = 0N (the forces acting on the object are balanced).
	5. If the resultant force acting on an object is not 0N, then the forces are unbalanced.
10. Pressure	1. Pressure is a measure of the force being applied to an area.
	2. The equation for calculating pressure is: Pressure (Pa) = force (N) ÷ area (m^2)
	3. The unit of pressure is the Pascal (Pa).
	4. Increasing the force to an area increases the pressure.
	5. Increasing the area that a force is applied to decreases the pressure.

Physics 2: Fields and Materials

Lesson	Knowledge
1. Static Charge	1. Atoms are made of positive protons, neutral neutrons and negative electrons.
	2. Protons have a relative mass of 1, neutrons have a relative mass of 1 and electrons have a relative mass of 0.0005.
	3. When a polythene rod is rubbed with a cloth, electrons transfer from the cloth to the rod making it more negative.
	4. Conductors allow charge to flow through them. Insulators do not allow charge to flow through them.
	5. When electrons are rubbed onto an insulator, the electrons do not move. A static charge has been created.
2. Electric Fields	1. An electric field is the region (area) around an electric charge where a force can be felt
	2. Electric fields are non-contact forces.
	3. When 2 electric fields of the same charge come together they repel.
	4. When 2 electric fields of opposite charge come together they repel.
	5. Field lines always point towards a negative charge and away from a positive charge.
3. Electric Charge and Current	1. There are two types of electric charge positive (+) and negative (-).
	2. The unit of charge is the Coulomb (C)
	3. 1 Coulomb is equal to the charge on about 6 million million million electrons.
	4. Current (symbol, *I*) is the rate of flow of charge.
	5. Current is measured in amperes (A).
4. Magnets and Magnetism	1. There are 3 magnetic elements: Iron, cobalt and nickel. Steel is a magnetic alloy (made of more than 1 metal).
	2. Magnets have a north and south pole.
	3. Same poles (e.g. north and north) repel.
	4. Opposite poles (e.g. north and south) attract.
	5. Bar magnets have magnetic fields that go out from the north pole and into the south pole.
5. Series Circuits	1. Components in circuits can be drawn using circuits symbols, e.g. a lamp can be drawn as an "X" within a circle.
	2. In circuit diagrams, connecting wires are always drawn as straight lines using a ruler.
	3. In order for a current to flow around a circuit, the circuit needs a source of potential difference, e.g. a cell or battery.
	4. Potential difference (measure in volts, V) is a measure of the amount of energy per coulomb of charge.
	5. In a series circuit, the current has the same value all the way round the circuit.
6. Density	1. Density is a measure of the mass of a substance per unit volume.
	2. The equation for calculating density is: Density (Kg/m^3) = mass (Kg) ÷ volume (m^3)
	3. A solid mass will have a higher density than the same mass as a gas due its atoms being more tightly packed together.
	4. If an object has a greater density than water, it will sink on water.
	5. If an object has a smaller or equal density than water, it will float on water.
	1. When a substance is heated it expands (increases is size).

7. Expansion and Contraction	2. When a substance expands the size of the particles stay the same, but the spaces between the particles increase.
	3. A substance expands when heated as its particles will vibrate more and move faster so they take up more space.
	4. When a substance is cooled it contracts (decreases is size).
	5. When a substance contracts the size of the particles stay the same, but the spaces between the particles decrease.
8. Evaporation and Melting	1. Melting is when a solid changes state from a solid to a liquid.
	2. Freezing is when a liquid changes state from a liquid to a solid.
	3. Evaporation is when a liquid changes state from liquid to gas at its boiling point.
	4. Condensation is when a gas changes state from a gas to liquid.
	5. Solids can change state to a gas by a process called sublimation, but it takes a lot of energy.

Physics 3: Energy and Electricity

Lesson	Knowledge
1. Conduction and Convection	1. The unit of energy is the Joule (J).
	2. Temperature is a measure of the average energy in the kinetic store of the particles in the material.
	3. Density (kg/m^3) = mass (kg) ÷ volume (m^3)
	4. In convection, the fluid becomes less dense and rises.
	5. In thermal conduction, vibrating particles pass the thermal energy along the rows of particles.
2. Radiation and Insulation	1. Space is mostly a vacuum. There are no particles in space.
	2. Heat is transferred from the Sun to Earth by heat radiation. The heat is radiated by waves called infra-red waves.
	3. The best emitter (gives out) and best absorber (takes in) is black.
	4. Silver is the worst 5 emitter and absorber of heat.
	5. Insulation is used to reduce conduction, convection and radiation.
3. State Changes	1. A vapour is a gas given off by a liquid, even when the liquid is not boiling.
	2. A substance can be described as a fluid when each part of it – no matter how small – can change shape easily.
	3. The melting point is the temperature above which a solid changes to a liquid.
	4. The boiling point is the temperature above which a liquid changes to a gas
	5. When changing state, the temperature of the substance remains constant.
4. Work	1. Work is done whenever a force makes an object move through a distance.
	2. The equation for work done is: Work done = force x distance moved in the direction of the force
	3. The unit for work done is the Joule (J): The same as energy.
	4. 1 joule of work is done when a force of 1 newton (N) moves an object 1 metre is the direction of the force.
	5. To convert joules to kilojoules, divide the number of joules by 1000.
5. Charge Flow	1. Atoms are made of positive protons, neutral neutrons and negative electrons.
	2. Electric current is the movement of electric charges. This is in most cases the movement of electrons.
	3. A circuit is a loop through which the electrons can flow.
	4. All circuits require a power source to provide energy to the electrons.
	5. The equation for charge flow is: Charge flow = current x time
6. Ohm's Law and Resistance	1. Resistance is the opposition to the flow of electrons (current).
	2. Resistance is measured in Ohm's (Ω).
	3. Ohm's law states that the current through a conductor points is directly proportional to the potential difference.
	4. The equation for Ohm's law is: Potential difference = current x resistance.
	5. Plotting potential difference against current for a resistor will produce a straight-line graph that passes through the origin.

7. Parallel Circuits	1. In series circuits, electrons can only flow through one path.
	2. In a parallel circuit there is more than one possible path that the current can flow through.
	3. The rule for current in a parallel circuit is the total current in the circuit is the sum of the current in each branch.
	4. The rule for potential difference in a parallel circuit is the potential difference in each branch is equal to the cell.
	5. In a parallel circuit with 2 branches, with a lamp on each branch, if one lamp breaks the other lamp will remain on.
8. Magnetic Effect of a Current	1. When opposite pole of a magnet come together they attract. When the same poles of a magnet come together they repel.
	2. Electromagnet = When an electric current flow through a coil of wire a magnetic field is induced in the wire.
	3. To increase the strength of the electromagnet, a soft iron core can be placed in the middle of the coil of wire.
	4. Electromagnets used soft iron cores so that they lose their magnetism when there is no current flowing.
	5. Electromagnets can be increased in strength by increasing the current in the wire or the number of coils in the wire.

Chemistry 1: Discovering the Atom and Atomic Interactions

Lesson	Knowledge
1. Naming Elements and their Symbols 1	1. All substances are made of atoms.
	2. An atom is the smallest part of an element that can exist.
	3. Elements are made of one type of atom.
	4. Each element is represented by a chemical symbol, e.g. "O" for Oxygen.
	5. In chemical symbols, the first letter is always a capital letter. If there is a second letter, it is always lower case.
2. Naming Elements and their Symbols 2	1. There are 118 elements on the periodic table.
	2. The elements of the periodic table are arranged into rows called periods, and columns called groups.
	3. Elements in the periodic table are arranged by atomic number.
	4. The periodic table has eight groups. From left to right they are groups: 1, 2, 3, 4, 5, 6, 7 and 0.
	5. The periodic table is split into two sections: metals (on the left) and non-metals (on the right).
3. Properties of Elements	1. An elements properties is the way it looks, feels, behaves, etc.
	2. Metals (usually) conduct electricity, conduct heat, are shiny, hard and have high boiling points.
	3. Non-metals (usually) do not conduct electricity, do not conduct heat, are dull, brittle and have low boiling points.
	4. Group 1 elements are more reactive down the group.
	5. Group 8 elements (noble gases) are unreactive.
4. Discovery of the Periodic Table	1. John Newlands developed a periodic table in 1864.
	2. When ordered by atomic mass, Newlands identified a pattern in chemical properties every octave (8 elements).
	3. The modern periodic table was formulated by a scientist called Dmitri Mendeleev in 1869.
	4. Mendeleev originally arranged his table by atomic mass (but this was later changed).
	5. Mendeleev predicted that other elements would be discovered, so left gaps so they could be included in the table.
5. Discovery of the Atom	1. John Dalton (1803) believed that atoms were just tiny spheres with no smaller parts.
	2. J. J Thompson (1893) discovered the electron and proposed the plum pudding model.
	3. Ernest Rutherford (1911) discovered the nucleus.
	4. Neils Bohr (1922) developed the atomic model to show that electrons orbited around the nucleus at specific distances.
	5. James Chadwick (1931) discovered the neutron.
6. Structure of the Atom	1. Atoms are the smallest building block of matter.
	2. All atoms are made of the same sub-atomic particles: protons, neutrons and electrons.
	3. Protons have a positive charge, neutrons have a neutral charge and electrons have a negative charge.
	4. Protons have a relative mass of 1, neutrons have a relative mass of 1 and electrons have a relative mass of 0.0005.
	5. In the centre of an atom is a nucleus made of protons and neutrons.

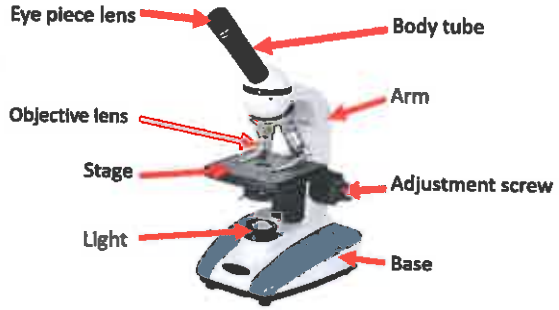
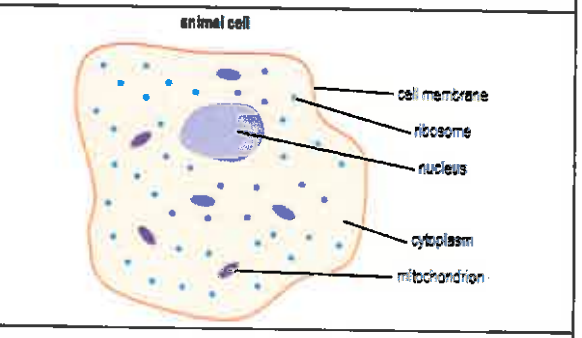
7. Structure of the Atom 2	1. The nucleus has a positive charge, because it is made of positive protons and neutral neutrons.
	2. The negative electrons are attracted to the central positive nucleus by electrostatic forces.
	3. An atom is neutral because the number of positive protons and negative electrons is the same so cancel out.
	4. An atom with the same number of protons but a different number of neutrons is called an isotope.
	5. The electrons orbit (go around) the nucleus at specific distances called energy levels (shells).
8. Electronic Structure of the Atom	1. The energy levels (shells) are filled up with electrons from the inner energy level to the outer energy level.
	2. The first energy level can hold a maximum of 2 electrons (because there are 2 elements in period 1).
	3. The second energy level can hold a maximum of 8 electrons (because there are 8 elements in period 2).
	4. The third energy level can hold a maximum of 8 electrons (because there are 8 elements in period 3).
	5. When an atom loses or gains electrons to have a full outer shell, it is then called an ion.

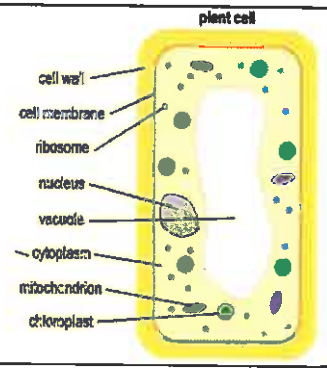
Chemistry 2: Compounds

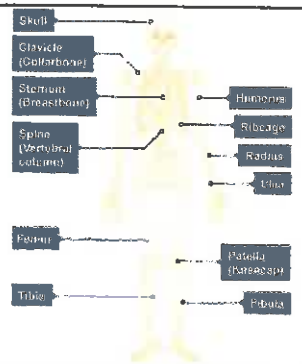
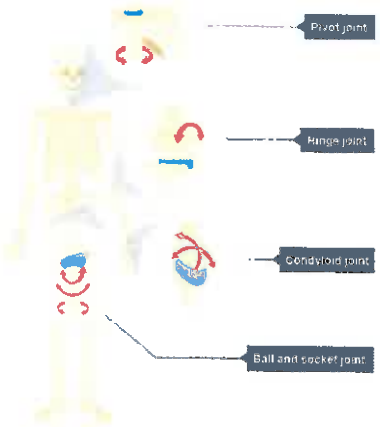
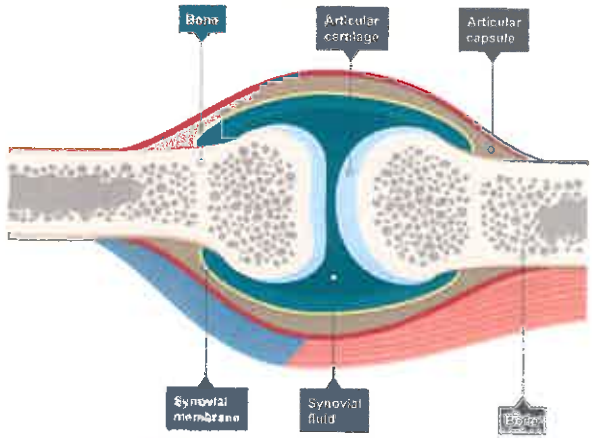
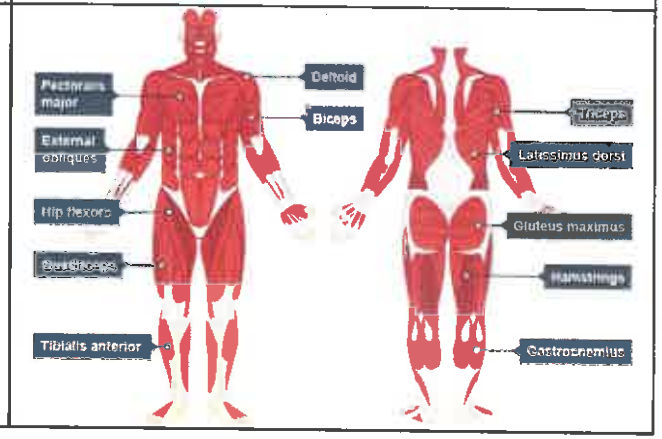
Lesson	Knowledge
1. States of Matter	1. Matter is the name we give to any substance that has mass or takes up space.
	2. Matter comes in four fundamental forms: Solid, liquid gas and plasma.
	3. In solids the atoms are in a fixed shape, are arranged in rows and columns and vibrate around a fixed position.
	4. In liquids the atoms are randomly arranged but are all touching, are free to flow and take the shape of a container.
	5. In gases the atoms are randomly arranged with many gaps, are free to move and take the shape of a container.
2. Unstable Atoms	1. All atoms, apart from Noble gases in group 0, are reactive because their outer shell is incomplete (not full of electrons).
	2. Atoms can share electrons with other atoms to try and fill up their outer shells and become stable (unreactive).
	3. Metal atoms lose all the electrons in their outer shell, leaving the full shell below to become stable.
	4. Non-metal atoms gain electrons to fill up their outer shell to become stable.
	5. The electrons in the outer shell are called valence electrons.
3. Forming Ions	1. When an atom loses or gains electrons to have a full outer shell, it is then called an ion.
	2. Metals lose electrons forming ions with a positive charge. Losing 1 electron gives an ion with a +1 charge.
	3. When a metal loses 1 electron it gives an ion with a +1 charge.
	4. Non-metals gain electrons forming ions with a negative charge.
	5. When a non-metal gains 2 electrons it gives an ion with a -2 charge.
4. Naming Compounds	1. A compound is when two or more different elements chemically combine.
	2. When a metal binds with a non-metal it is called an ionic bond.
	3. Compounds can be easily identified because they do not exist on the periodic table (which only shows elements).
	4. Ionic compounds are formed between metals and non-metals.
	5. When naming an ionic compound we use the name of the metal ion first, then the name of the non-metal ion second.
5. Writing Ionic Equations	1. The attractive force between the oppositely charged ions is called an electrostatic force.
	2. The ionic compound sodium chloride is also known as salt (that you put on food).
	3. Sodium chloride is neutrally charged because it has the same number of sodium (+) and chlorine (-) ions.
	4. When molten or in a solution, ionic compounds (such as sodium chloride) conducts electricity.
	5. Ionic compounds (such as sodium chloride) have high melting and boiling points.
6. Writing Chemical Equations	1. During a chemical reaction, the bonds within a substance are broken and reformed to make a new substance.
	2. In a reaction, the chemicals at the start of the reaction are called the reactants.
	3. In a reaction, the chemicals formed at the end of the reaction are called the products.
	4. A chemical reaction can be shown by the equation: Reaction → Products.
	5. The arrow (→) means "reacts to form" not equals as products are completely different to the reactants.

7. Making compounds MgO	1. Magnesium has the chemical symbol Mg.
	2. Magnesium + Oxygen → Magnesium Oxide
	3. Oxygen (O_2) is diatomic – 2 oxygen atoms are bonded to each other.
	4. The test for oxygen is when a glowing splint is placed into a test tube of oxygen it re-lights.
	5. Magnesium reacts with oxygen to produce magnesium oxide.
8. Making compounds $MgCl_2$	1. Chlorine has the chemical symbol Cl.
	2. Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen
	3. Hydrogen is the most flammable element in the universe.
	4. The test for hydrogen is when a lit splint is placed into a test tube of hydrogen it ignites (squeaky pop test).
	5. Magnesium reacts with chlorine to produce magnesium chloride.
9. Making compounds FeS	1. Iron is a transition metal.
	2. A mixture is 2 or more different elements not chemically combined.
	3. Mixtures can be separated by physical processes, e.g. chromatography, distillation, filtration and crystallisation.
	4. Iron a sulphur is a mixture from which the iron can be separated by a bar magnet.
	5. Iron reacts with sulphur to make iron sulphide.

Biology 1: Organisation

Lesson	Knowledge	
1. Microscopes	1. Magnification = How big something appears, compared to its actual size.	
	Resolution – The ability to distinguish between two objects that are very close together.	
	2. Magnification = Eye piece lens magnification X Objective lens magnification.	
	3. Hold the microscope by the arm and support the base when carrying it around the lab.	
	4. Eye piece lens – The part you look through. This usually has a magnification power of X10.	
	5. Objective lens – Usually the light microscope has three of these and they can be used to observe the slide at different magnifications.	
	6. Coarse adjustment screw – this adjusts the height of the stage, to help focus the image.	
	7. Fine adjustment screw – this adjusts the height of the stage very slightly, to help focus the image.	
	8. Stage – the part of the light microscope where the slide is placed.	
	9. Cover slip – a small glass square, placed on top of the specimen on the microscope slide.	
2. Animal cells	1. Cell membrane – Controls entry and exit into and out of the cell.	
	2. Nucleus – Contains the genetic material.	
	3. Cytoplasm – A jelly-like substance, where the cell chemical reactions take place.	
	4. Mitochondria – Aerobic respiration takes place here.	
	5. Ribosomes – Where proteins are made.	
3. Plant cells	1. Cell wall – in plant cells and bacteria cells. This gives the cell structure.	
	2. Permanent vacuole – in plant cells only; this contains cell sap.	
	3. Chloroplasts – this is where photosynthesis takes place.	
	4. Chlorophyll is the green chemical in chloroplasts that absorbs light energy.	

	5. The three organelles that a plant cell has, but an animal cell does not are: Cell wall, Chloroplasts and Permanent Vacuole.	
4. Unicellular organisms	1. Unicellular organism = An organism made up from one single cell.	
	2. Euglena and amoeba are both examples of unicellular organisms.	
	3. Flagella: 'tail-like' structures that enable the cell to move through liquid.	
	4. Pili: Allow bacterial cells to transfer genetic material.	
	5. Slime capsule: Protects the bacterium from drying out and from poisonous substances. It helps the bacterium to stick to smooth surfaces.	
	6. Plasmid: Circular piece of DNA, used to store extra genes that aren't always in use e.g. antibiotic resistant genes.	
6. Diffusion	1. Diffusion: The passive movement of particles from an area of high concentration to an area of low concentration.	
7. Osmosis	1. Osmosis – The passive movement of water from an area of high water concentration to low water concentration, across a partially permeable membrane.	
8. Animal Organs & Tissues	1. Cell – the basic unit of a living organism.	
	2. Tissue – Similar cells working together to perform a function.	
	3. Organ – Tissues working together to perform a function e.g. the heart.	
	4. Organ system – Organs working together to perform functions e.g. the digestive system.	
	5. Heart – Pumps blood around the body.	
	6. Stomach – churns food and mixes food with acid, to kill bacteria.	
	7. Brain – Part of your central nervous system. It controls your personality, memory and learning and other unconscious processes e.g. heart rate and body temperature.	
	8. Kidneys – Filter the blood and reabsorb necessary particles e.g. water and glucose.	
	9. Pancreas – helps control blood sugar levels and produces chemicals needed for digestion.	
	10. Spleen – Used to recycle old blood cells and helps fight bacterial infections.	
9. Plant Organs & Tissues	1. Palisade cell – a basic plant cell, found in leaves, that has a regular shape and lots of chloroplasts.	
	2. Xylem – tubes in a plant that carry water from the roots to the leaves.	
	3. Phloem – tubes in a plant that carry nutrients up and down.	
	4. Stomata – tiny holes in the base of leaves.	

10. Skeletal system	1. Skeleton – bones in your body, give the body structure, protect vital organs and produce blood.	
11. Synovial joints	1. Ligaments – connective tissue attaching bone to bone. 2. Tendon – Connective tissue attaching muscle to bone. 3. Synovial fluid – Lubricates the joint so it can move smoothly. 4. Synovial membrane – produces synovial fluid. 5. Cartilage – Covers the end of the bones at the joint, acting as a shock absorber and prevents friction.	 
12. Muscular system	1. Antagonistic muscle action – when muscles work in pairs to control movement across a joint – as one contracts and shortens, the other relaxes and lengthens.	

Biology 2: Nutrition & Digestion

Lesson	Knowledge
1. Food groups	1. Carbohydrates – Energy
	2. Fats – Energy and insulation
	3. Protein – Growth and repair
	4. Vitamins – there are different types and they all have slightly different functions, to keep the body healthy.
	5. Minerals – there are different types and they all have slightly different function, to keep the body healthy.
	6. Fibre – makes the digestive system work hard, to push digesting food through the system. This keeps the digestive system healthy.
	7. Water – Use for many functions in the cells.
2. Food tests	1. Orange/brown iodine turns blue/black with starch.
	2. Blue biuret solution turns purple with proteins.
	3. Blue Benedict's solution turns green→orange→red with sugars.
	4. Ethanol and water turn cloudy with fats.
	5. The four food tests described above are objective (opinion based), depending on the colour changes.
3. Energy requirements	1. Macronutrients – Carbohydrates, protein and fats, which are needed in larger amounts in our diet.
	2. Micronutrients – Vitamins, minerals and fibre, which are needed in smaller amounts in our diet.
	3. BER – Basic Energy Requirement
	4. BER (KJ/day) = 5.4 X 24 (hours) X Body Mass (Kg)
4. Unbalanced diet 1: Malnutrition & Deficiency diseases	1. Malnutrition (The refix mal – meaning badly and the Latin root nutrire to feed) is literally defined as "bad diet" and can occur as a result of too much food, too little food or too much or too little of a particular nutrient group
	2. Anorexia - a serious mental health condition. It's an eating disorder where a person keeps their body weight as low as possible.
	3. Kwashiorkor - a severe form of malnutrition. It is most common in developing countries where children have diets lacking in protein. Tissues in the body begin to hold too much fluid, swelling up.
	4. Night blindness - People with night blindness struggle to see in the dark, or may be completely blind in darkness. It is caused by a lack of Vitamin A in the diet.
	5. Scurvy - a condition that can develop if you don't have enough Vitamin C in your diet.
	6. Rickets - a condition that causes the bones to become soft and weak, due to a lack of Vitamin D.
5. Unbalanced diet 2: Excess diseases	1. Obesity – when a person has a high excess of body fat.
	2. An obese person is at a greater risk of type-2 diabetes, heart disease and some types of cancer.
	3. Coronary artery – blood vessels around the heart that supply the heart muscle with glucose and oxygen.
	4. Type 2 diabetes – a disease where your body cannot control (regulate) the amount of glucose in the blood.
	1. Digestion – The process of breaking down large insoluble food molecules into small, soluble ones.

6. The digestive system	2. Oesophagus – the pipe connecting the mouth to the stomach.
	3. One function of stomach acid is to kill the microbes on the food that has been eaten.
	4. The liver produces bile and the gall bladder stores it.
	5. The pancreas produces 'pancreatic juice', which is sent to the small intestine to help digest food.
	6. The two functions of bile are to neutralise the food leaving the stomach and emulsify (break down) fats.
	7. The large intestine is where most water is absorbed into the blood.
	8. Enzymes are known as 'biological catalysts' and they help speed up the breakdown of food.

Biology 3: Reproduction

Lesson	Knowledge
1. Plant reproduction	1. Stamen - made up from the anther and the filament.
	2. Carpel - made up from the stigma, style and ovary.
	3. Anther – the top part of the stamen, this contains pollen grains.
	4. Filament – Acts in the same way as the stem, holding up the anther.
	5. Stigma – top of the female part of the flower, which collects pollen grains.
	6. Style – Tube that connects the stigma and ovary.
	7. Ovary – Produces the female sex cells (ovules).
	8. Sepal – Protects the unopened flower.
	9. Pollination - the process of getting the pollen from the anther to the stigma.
	10. Fertilisation - when the pollen reaches the eggs in the ovary, the DNA from both combine; this process is known as fertilisation
2. Seed dispersal	1. Four types of seed dispersal are: Wind, animal, water and explosive.
3. Puberty	1. Hormone – chemical messenger, release from glands, travels through the blood and acts on target cells.
	2. Primary sexual characteristics – Characteristics we are born with e.g. a penis or a vagina.
	3. Secondary sexual characteristics – these develop during puberty e.g. production of sperm in males and release of egg in females.
	4. The menstrual cycle is (on average) 28 days long.
	5. Ovulation – the name of the process of the egg being released half way through (on average day 14) of the menstrual cycle.
4. Sexual reproduction	1. Ovary – Contains and release eggs and hormones during the menstrual cycle.
	2. Oviduct – (Fallopian tube) connects the ovary to the uterus.
	3. Uterus – A muscular bag where the foetus (unborn baby) will develop.
	4. Cervix – A ring of muscle which keeps the foetus (unborn baby) in place before birth.
	5. Vagina – Muscular tube leading from the cervix to the outside of the woman's body.
	6. Testes – Produce sperm.
	7. Penis – Passes urine and sperm out of the man's body.
	8. Urethra – Tube (in both male and female) that carries urine out of the body.
	9. Gamete – a cell that contains half the usual amount of DNA e.g. egg cell in female and sperm cell in male.
5. Foetal development & Birth	1. Gestation – the time during which a fertilised egg develops into a baby ready to be born.
	2. Amniotic fluid – fluid in the sac, that acts as a shock absorber to the unborn baby.
	3. Foetus – An unborn baby, usually eight weeks after conception.
	4. Placenta - The organ in the uterus of pregnant mammals that allows the transfer of nutrients and waste products between the mother and the foetus through the umbilical cord.
	5. Umbilical cord – Cord connecting the foetus to the placenta.
	6. The mother and unborn baby's blood do not mix.

Biology 4: Ecology

Lesson	Knowledge
1. Classification	1. Classification – putting things into groups.
	2. Five kingdoms – Animal, plant, fungi, protist and bacteria.
	3. Vertebrate – Animals that have backbone
	4. Invertebrate – Animals that don't have a backbone.
	5. Arthropod – Type of invertebrate that has jointed legs.
	6. Insect – Arthropods with six legs and often have wings.
	7. Linnaean system – Kingdom, Phylum, Class, Order, Family, Genus and Species.
	8. 3 Domain system – Eukaryota, Eubacteria and Archaea.
	9. Binomial system – Used to name animals using their Genus and Species.
2. Food chains & Food webs	1. Arrows in a food chain represent the flow of energy through the chain.
	2. Plants and some bacteria are known as 'producers', as they start the food chain e.g. the plants use the light energy from the sun and convert it into chemical energy in the form of glucose that we can use.
	3. Carnivore – eats other animals only.
	4. Herbivore – eats plants only.
	5. Omnivore – eats animals and plants.
3. Competition	1. Plants compete for light, space, nutrients and water.
	2. Animals compete for shelter, water, food and mates.
	3. Intraspecific competition – competition between the same species.
	4. Interspecific competition – competition between organisms of different species.
4. Adaptations	1. Adaptation – a feature or behaviour that allows the organism to survive in its habitat.
	2. The three types of adaptations are: structural, functional and behavioural.
	3. Structural adaptation – physical features e.g. camouflage.
	4. Behavioural adaptation – something the organism does e.g. penguins huddling to keep warm or reptiles moving into the shade to cool down.
	5. Functional adaptation – bodily function e.g. camel kidneys are adapted for retaining more water so it loses less in the urine.
5. Sampling techniques	1. Pooter – Use to capture small insects.
	2. Quadrat – used to randomly sample areas in an ecosystem.
	3. Pitfall trap – an area, which is camouflaged over, so small organisms will fall into the trap, enabling them to be counted.
	4. Swoop net – Used to capture flying organism e.g. flies.
	5. Transect – a line across a habitat or part of a habitat. It can be as simple as a string or rope placed in a line on the ground. The number of organisms of each species along a transect can be observed and recorded at regular intervals.

6. Decomposition	1. Detritus – dead material which detritivores feed on.
	2. Decomposer – bacteria or fungi which release enzymes, that breakdown dead material and take up the nutrients they require.
	3. Detritivore – Small organisms e.g. worms and maggots, that feed on dead material, increasing their surface area for decomposers to act on.
	4. Decomposition is important for breaking down dead material, to release nutrients back into the ecosystem for other organisms to use.

Physics 4: Fields and Forces

Lesson	Knowledge
1. Distance-time Graphs	1. Speed is how fast something is travelling regardless of direction. It is a scalar quantity.
	2. Speed can be calculated by the equations: Speed = distance ÷ time
	3. The unit for speed is m/s.
	4. Velocity is how fast something is travelling in a given direction. It is a vector quantity.
	5. On a distance-time graph, a horizontal line represents that the object is stationary.
2. Resultant Force	1. The unit of force is the Newton (N).
	2. When a number of forces are acting on an object, the resultant force shows the overall force acting on the object.
	3. Two forces acting on an object in opposite directions can be represented using a vector diagram.
	4. If the resultant force = 0, the object is stationary or moving at a constant velocity.
	5. Newton's 1st law states that an object will remain at constant velocity or stationary unless another force acts upon it.
3. Acceleration	1. Acceleration is the rate of change of velocity of an object.
	2. If an object is accelerating it is getting faster. If it is decelerating it is getting slower.
	3. The equation for acceleration is: Acceleration = change in velocity ÷ change in time
	4. The unit for acceleration in m/s^2
	5. The acceleration due to gravity on Earth is 9.81 m/s^2.
4. Friction and Streamlining	1. Friction is the forces which opposes motion.
	2. Friction can be cause by molecular adhesion - when two surfaces are very close together there molecules attract.
	3. Friction can be caused by the roughness of surfaces. The rougher the surface, the greater the friction.
	4. Friction between surfaces can be reduced by putting lubrication between the surfaces.
	5. Friction can occur between a solid surface and a fluid (liquid or gas). Therefore air resistance is an example of friction.
5. Moments	1. The turning effect of a force is called a moment.
	2. The equation for calculating a moment is: Moment = force x distance.
	3. The unit for moment is Nm.
	4. To increase the moment, the distance from the pivot and/or the force applied can be increased.
	5. The force applied acts perpendicular (at 90°) to the line of action (object turning).
6. Waves	1. A wave is an oscillation that transfers energy without transferring matter.
	2. There are 2 types of wave: Transverse and Longitudinal.
	3. Transverse waves have peaks and troughs. Energy travels along the wave perpendicular to the direction of the wave.
	4. Longitudinal waves have compressions and rarefactions. Energy travels parallel to the direction of the wave.
	5. The wavelength of a wave is the distance between identical points on adjacent (next to each other) waves.

7. Sound	1. Sound waves are examples of a longitudinal wave.
	2. Sound is a vibration that travels through the air or other substances (media) to our ear.
	3. If there are no air particles (or other media) there is nothing to vibrate so the sound cannot be transmitted.
	4. The human ear can detect a wide range of sounds, of different frequencies from 20 Hz to 20kHz.
	5. Sound travels faster through denser materials. Therefore, sound will travel faster through a solid than a gas.
8. Reflection and Pinhole Camera	1. We can see objects because the light is reflected off the surface of the object.
	2. Diffuse reflection = when light is reflected in all directions because a surface is uneven. An image cannot be seen.
	3. Specular reflection = when light is reflected at the same angle because a surface is even. An image can be seen.
	4. The angle that the ray of light hits a surface is called the angle of incidence.
	5. The angle that the ray of light is reflected from a surface is called the angle of reflection.
9. Colour	1. White light is made up of all the other colours put together.
	2. A prism can split white light into a spectrum of seven colours: red, orange, yellow, green, blue, indigo and violet.
	3. Red, green and blue are the three primary colours.
	4. Yellow, magenta and cyan are 7 the secondary colours.
	5. A red surface appears red because it reflects red light. All the other colours are absorbed by the surface.
10. The Earth	1. A day is the length of time it takes the Earth to complete one rotation on its axis. On Earth this takes 24 hours.
	2. A year is the amount of time it takes the Earth to orbit the Sun. This is approximately 365 days.
	3. The Earth rotates at an angle of 23.5° to the orbital plane.
	4. In summer in the northern hemisphere the Earth is tilted towards the Sun, so will spend more time in the daylight.
	5. A solar eclipse is caused by the moon moving between the Sun and the Earth.
11. Space Physics	1. The solar system consists of one star called the Sun and various objects which orbit the Sun.
	2. The solar system has 8 planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.
	3. Moons are bodies which orbit planets (all but 2 planets have moons, Jupiter has 79 moons).
	4. Our solar system is part of the Milky way galaxy.

Chemistry 3: Chemical Interactions

Lesson	Knowledge
1. Covalent Bonding	1. Covalent bonding occurs between non-metals.
	2. Outer shell electrons are shared between atoms so each atom achieves a full outer shell.
	3. When one electron from each atom is shared, a single bond is formed.
	4. When two electrons from each atom are shared, a double bond is formed.
	5. Covalent bonds are very strong.
2. Molecules	1. A molecule is 2 or more atoms bonded together.
	2. Elements are made of 1 type of atom.
	3. Oxygen (O_2) is an element as it is made of 1 type of atom and a molecule as well as it is made of 2 atoms bonded together.
	4. Small molecules are those that are made of 8 atoms or less, e.g. O_2, CO_2 and H_2O.
	5. Most small molecules exist as gases or liquids at room temperature (20°C).
3. Molecular Forces	1. Most small molecules are gas or liquid at room temperature because their intermolecular forces are weak.
	2. Intermolecular forces are really weak compared to covalent bonds.
	3. If molecules are heated, they will have weaker intermolecular forces because they have more kinetic energy.
	4. Solids have the strongest intermolecular forces.
	5. Gases have the weakest intermolecular forces.
4. Water Molecules	1. Water (H_2O) is made of 2 hydrogen atoms covalently bonded to 1 oxygen atoms.
	2. Water can also be called dihydrogen oxide.
	3. Water is polar because it has a positively charged end (with the hydrogens) and negatively charged end (with the oxygen).
	4. Weak intermolecular forces form between the hydrogen atom of one water molecule and the oxygen atom of another.
	5. Liquid water is less dense than solid water (ice), therefore ice floats on water.
5. Properties of Water	1. Cohesion = attraction of one molecule to the same type of molecule.
	2. Adhesion = attraction of one molecule to another kind of molecule.
	3. As water is polar, it means that it will be attracted to other molecules that have positive or negative charges.
	4. Water is very important for life processes. Animals and plants rely on water for: transport, food, digestion and movement.
	5. Water can be used as a solvent – substances can dissolve in it.
6. Dissolving	1. Ionic compounds are made from positive or negative ions that are bonded together.
	2. Ionic compounds can be separated when placed in water so they dissolve.
	3. Soluble means that substances can dissolve in a solvent.
	4. Insoluble means substances that cannot dissolve in a solvent.
	5. Stirring or heating a substance and solvent can speed up the rate at which substances dissolves.

7. Mixtures	1. Mixtures are more than one different type of substance (atom/molecule) in the same space but not chemically bonded.
	2. Mixtures can be separated by physical processes such as: Chromatography, filtration, distillation and crystallisation.
	3. Filtration can used to separate sand and water.
	4. Chromatography can be used to separate different inks.
	5. To calculate the R_f value of ink from chromatography: R_f = distance travelled by ink / distance travelled by solvent.
8. Separating Mixtures	1. In chromatography, the paper is the stationary phase and the paper is the mobile phase.
	2. Distillation can be used to separate ethanol and water because they have different boiling points.
	3. The boiling point of water is 100°C. The boiling point of ethanol is 78°C. So ethanol will evaporate first.
	4. During distillation, a condenser is used to condense the evaporated gas back into a liquid so it can be collected.
	5. During crystallisation, a solution is left for liquid to evaporate leaving solid crystals.

Biology 5: Key Processes

Lesson	Knowledge
1. Respiration	1. Aerobic respiration takes place in the mitochondria of the cell.
	2. Aerobic respiration in humans: Glucose + Oxygen → Carbon dioxide + Water
	3. Chemical formula for glucose: $C_6H_{12}O_6$
	4. Anaerobic respiration in humans: Glucose → Lactic Acid
	5. Respiration is an exothermic reaction.
2. Respiratory system	1. Trachea – windpipe.
	2. Bronchi – the two pipes, which the trachea splits into, towards the lungs.
	3. Bronchioles – all of the small tubes that your bronchi divide into, which spread throughout the lungs.
	4. Alveoli – Tiny air sacs, which 'expand' and 'recoil' as air enters and leaves the lungs. This is where oxygen diffuses into the blood and carbon dioxide diffuses out of the blood.
3. Diffusion & Gas exchange	1. Alveoli are adapted for gas exchange with: A large surface area, good blood supply and thin wall for a short diffusion distance.
	2. Diffusion – the passive (without energy) movement of particles from an area of high concentration to an area of low concentration.
	3. About 21% of the atmosphere is oxygen, however only 16% of the air you breathe out is oxygen, as your body uses some of it for aerobic respiration.
	4. About 0.04% of the atmosphere is carbon dioxide, however about 4% of the air you breathe out is carbon dioxide because your body produces it during aerobic respiration.
4. Blood and blood vessels	1. Red blood cells carry oxygen around the body.
	2. White blood cells help the body fight infectious diseases, by producing antibodies and antitoxins and engulfing microbes.
	3. Platelets clot the blood.
	4. Plasma transports substances in the blood e.g. carbon dioxide, urea, glucose and hormones.
	5. Arteries carry blood away from the heart at high pressure.
	6. Veins carry blood back to the heart at low pressure.
	7. Valves – Stop the back flow of blood in veins and in the heart.
	8. Capillaries carry blood between the arteries and veins. This is where substances from the blood are exchanged with surrounding cells.
6. Heart & Circulatory system	1. Right and left atrium – the top two chambers of the heart.
	2. Right and left ventricle – the bottom two chambers of the heart.
	3. Humans have a double circulatory system, as the right side of the heart pumps blood to the lungs to pick up oxygen and the left side of the heart pumps blood around the body, to deliver the oxygen.
	4. Vena Cava – the main vein leading into the right side of the heart.

	5. Aorta – the main artery, carrying blood at high pressure from the left side of the heart.
7. Smoking	1. The four man damaging components of cigarettes are: Carbon monoxide, nicotine, tar and particulates.
	2. Carbon monoxide – binds to red blood cells irreversibly, stopping them from carrying oxygen.
	3. Nicotine – makes smoking addictive.
	4. Particulates and tar – damage the air ways and alveoli in the lungs, making it hard for gas exchange.
	5. Goblet cells – cells that line the trachea and produce mucous, to trap any microbes entering the airways.
	6. Ciliated epithelial cells – cells with 'tiny hairs' that help 'waft' the mucous up and out of the trachea.
8. Alcohol	1. Liver – organ in the body that performs around 1500 functions, including breaking down any alcohol in the body.
	2. Depressant – a type of drug that acts on the nervous system, slowing down impulses (messages).
	3. Cirrhosis – Scarring of the liver, which can be caused by alcoholism or hepatitis.
9. Photosynthesis	1. Carbon Dioxide + Water → Oxygen + Glucose
	2. Glucose that the plant has made is either used by the plant for respiration, converted into another molecule, or stored as an insoluble molecule called starch.
	3. Photosynthesis takes place in the chloroplasts in plant cells.
	4. Photosynthesis is an endothermic reaction.
	5. The tiny holes in the bottom of the leaf are called stoma (stomata plural).
	6. Carbon dioxide enters the leaf and oxygen and water exit the leaf via the stomata.