**Scheme of Work – Science Stage 9**

Cambridge Lower Secondary

**Introduction**

This document is a scheme of work created by Cambridge International as a suggested plan of delivery for Cambridge Lower Secondary Science stage 9. Learning objectives for the stage have been grouped into topic areas or ‘units’. These have then been arranged in a recommended teaching order but you are free to teach objectives in any order within a stage as your local requirements and resources dictate.

The scheme for Science has assumed a term length of ten weeks, with three terms per stage and three units per term. An overview of the sequence, number and title of each unit for stage 9 can be seen in the table below. The scheme has been based on the minimum length of a school year to allow flexibility. You should be able to add in more teaching time as necessary, to suit the pace of your learners and to fit the work comfortably into your own term times.

Scientific enquiry learning objectives are recurring, appearing in every unit. Activities and resources are suggested against the objectives to illustrate possible methods of delivery.

There is no obligation to follow the published Cambridge scheme of work in order to deliver Cambridge Lower Secondary. It has been created solely to provide an illustration of how delivery might be planned over the three stages. A step-by-step guide to creating your own scheme of work and implementing Cambridge Lower Secondary in your school can be found in the Cambridge Lower Secondary Teacher Guide available on the Cambridge Lower Secondary support site. Blank templates are also available on the Cambridge Lower Secondary support site for you to use if you wish.

**Overview**

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| **Term 1** | **Term 2** | **Term 3** |
| Unit 9.1 Photosynthesis and plant growth | Unit 9.4 Sexual reproduction in flowering plants | Unit 9.7 Ecology |
| Unit 9.2 The Periodic Table and preparing salts | Unit 9.5 Reactivity and rates of reaction | Unit 9.8 Chemicals and thermal energy |
| Unit 9.3 Electrostatics and electric currents | Unit 9.6 Moments, pressure and density | Unit 9.9 The energy crisis and human influences |

**Unit 9.1 Photosynthesis and plant growth**

It is recommended that this unit takes approximately **30% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of photosynthesis and water and the transport of water and minerals in flowering plants to develop their knowledge of:

* the process of photosynthesis, including the word equation
* the importance of water and mineral salts to plant growth.

Scientific enquiry work focuses on:

* making observations and measurements
* suggesting and using preliminary work to decide how to carry out an investigation
* deciding whether to use evidence from first hand experience or secondary sources
* explaining results using scientific knowledge and understanding; communicating this clearly to others.

Recommended vocabulary for this unit:

* photosynthesis, word equation, chlorophyll, chloroplasts, glucose, sugar, starch, biomass, cell, cytoplasm
* xylem, phloem, stomata, air space, cuticle
* wilt, turgid, flaccid, diffusion
* minerals, nitrogen, potassium, phosphorus, deficiency.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Bp1 | Define and describe photosynthesis, and use the word equation | Elicit what learners can remember from their previous study of photosynthesis.  In stage 8 they were introduced to the following word equation as a way of summarising the chemical reactions taking place:  carbon dioxide + water biomass + oxygen  Explain that in stage 9 learners should replace ‘biomass’ with ‘glucose’ in the word equation:  carbon dioxide + water glucose + oxygen  Explain that this word equation is a way of describing that light energy is transferred to chemical energy in glucose. This takes place in the green parts of plants. The glucose is made when carbon dioxide particles (from the air) are combined with water particles (from the soil). Most of the particles that make the plant grow come from the carbon dioxide in the air.  A subsequent chemical reaction converts the soluble glucose into insoluble starch. Plants can use glucose and starch as reactants to make a wide range of products (including cellulose, proteins, fats and oils).  Learners draw a diagram summarising the important solids (e.g. sugar and starch), liquids (water) and gases (carbon dioxide and oxygen) in photosynthesis. |  | Misconception alert: If learners have the misconception that plants grow by ‘eating’ nutrients from the soil then use the chemical reaction to explain to them why this is not the case. |
| 9Bp1  9Eo3 | Define and describe photosynthesis, and use the word equation  Make observations and measurements | If it emerges that learners need to revise and/or consolidate photosynthesis from stage 8, then this activity may be useful.  Chloroplasts as the site of photosynthesis  Learners draw a labelled diagram of a plant cell. They identify the structure of chloroplasts and their function. Explain that chloroplasts contain a green pigment called chlorophyll.  Learners observe plant cells from photosynthetic and non-photosynthetic tissues. This could be done with microscope samples (e.g. onion skin cells and pond weed). Alternatively, micrographs of cells from a range of plant tissues could be analysed (e.g. petal, leaves, bulb, root cells).  For each sample the learners should determine:   * + Is the sample from a green part of the plant?   + Do the cells contain chloroplasts?   + Would this cell be able to do photosynthesis?   Learners should design a table to display their results and draw a conclusion. | Microscopes, onion, pond weed, slides and coverslips.  Alternatively, micrographs of a range of plant cells. |  |
| 9Bp1  9Bp2 | Define and describe photosynthesis, and use the word equation  Understand the importance of water and mineral salts to plant growth | Show learners a diagram of a transverse section of a model leaf. Identify the vascular tissue (xylem and phloem), stomata and air spaces. Explain that gases can move through cell walls and membranes. They cannot move through the waxy cuticle.  Learners, in pairs, discuss a diagram of a transverse section of a leaf:   * + Where do the leaf cells get carbon dioxide from?   + What route can carbon dioxide use to get to the leaf cells?   + Where do the leaf cells get water from?   + How do leaf cells get rid of oxygen?   + What route can oxygen use to get away from the leaf cells?   + How is the sugar produced transported around the plant?   Take feedback. Elicit the idea that the gases move into and out of the leaf by diffusion, water travels in the xylem and sugar travels in the phloem.  **Extension activity:** Learners who require more challenge compare the structure of leaves from plants that are adapted for low water availability (e.g. marram grass). | Diagram of a transverse section of a model leaf. |  |
| 9Bp2  9Ec8 | Understand the importance of water and mineral salts to plant growth  Explain results using scientific knowledge and understanding. Communicate this clearly to others | Revise prior learning by asking learners to draw an annotated diagram of the route of water from the soil to the leaves. Reinforce the key vocabulary of root hairs and xylem.  Learners are likely to have experience of seeing plants that have wilted because of lack of water. Ask learners to try to explain why well-watered plants are firm and plants that are not watered wilt.  Give learners pre-prepared slides of turgid and flaccid cells to examine with a microscope. If the samples are of cells with a coloured cytoplasm (e.g. red onions) then learners can identify that in turgid cells the cytoplasm fills the cell (to the cell wall) and in the flaccid cell the cytoplasm takes up a much smaller volume.  Learners observe the slides and draw diagrams of the cells.  Learners then use their observations to explain why plants wilt. | Pictures, or samples, of normal and wilted plants.  Light microscopes, pre-prepared slides of turgid and flaccid cells (e.g. red onion cells).  Alternatively, pictures of turgid and flaccid plant cells. | Note: a simple way to prepare flaccid plants cells is to put the sample in a hypertonic solution. However, learners do not need to understand osmosis at this stage so the samples should be labelled ‘turgid’ and ‘flaccid’. |
| 9Bp2  9Ep6 | Understand the importance of water and mineral salts to plant growth  Decide whether to use evidence from first-hand experience or secondary sources | Show pictures of plants that are suffering from mineral deficiencies. Ask: *How do plants get the minerals they need?*  Provide learners with information sources (printed or online material). Learners need to find the answer to the questions:   * + Why do plants need nitrogen? What are the symptoms of nitrogen deficiency?   + Why do plants need phosphorus? What are the symptoms of phosphorus deficiency?   + Why do plants need potassium? What are the symptoms of potassium deficiency?   Conclude that minerals are needed by plants for healthy growth. Nitrogen is needed for healthy leaf growth, phosphorus is needed for root growth and flower and fruit development, and potassium is required for many functions throughout a plant. | Photographs of plants with mineral deficiencies.  Information sources for learners. |  |
| 9Bp2  9Ep5  9Ep6 | Understand the importance of water and mineral salts to plant growth  Suggest and use preliminary work to decide how to carry out an investigation  Decide whether to use evidence from first-hand experience or secondary sources | **Scientific enquiry activity**  How do different nutrients affect plant growth?  Show examples of duckweed growing and discuss ways it could be used to measure how well a plant grows. Ask: *How could this give an easy measure of how fast a plant grows? What would you have to count?*  Then show learners examples of duckweed which has been grown in different conditions. Discuss with learners how they can use the results from the preliminary work that you have set up, to inform their investigations.  Learners plan an investigation to answer the question ‘How does nutrient deficiency affect the growth of duckweed?’  They can plan their investigations in small groups. They should decide on their independent, dependent and control variables and the controls they will include.  Learners should also identify activity-related risks and hazards. They should decide the safety measures that they will take.   * + Learners set up dishes of duckweed in solutions with different combinations of nutrients. These should be labelled and kept for ongoing observations.   + Identify the key features that learners need to identify in the results from their investigation.   + Learners collect results of the duckweed growth in different nutrient conditions and create a table of their observations.   + Learners compare their results with those from other groups and identify any anomalous results. They should also compare their results with secondary data and identify any similarities or differences.   + Learners analyse and evaluate their investigation. Stimulate evaluation by asking questions such as: What went well? What could be improved upon? What were your results? Did those results agree with your prediction?   + Learners write a report of their investigation. They should describe their results and explain them using their understanding of the role of minerals in plant growth.   Conclude that minerals are needed by plants for healthy growth. Deficiencies can cause characteristic symptoms in plants. | Duckweed (*Lemna spp.)* grown in shallow dishes containing solutions with certain minerals omitted to observe the effects. A control should be included. Water should be prevented from leaving the containers by using an oil film.  Note: it can take several weeks for there to be an obvious difference in the growth of the duckweed under different conditions.  Small plastic dishes, test tubes or yoghurt pots, duckweed,  Sach’s culture solution (both a complete recipe and versions missing particular nutrients). The recipe can be found at: [www.nuffieldfoundation.org/practical-biology/investigating-effect-minerals-plant-growth](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-minerals-plant-growth)  Secondary data that learners can compare their results with (e.g. data from other species of plants). | Learners may need to be reminded of the importance of including controls (i.e. a plant grown with all the nutrients and a plant grown with no nutrients).  Water should be prevented from leaving the containers by an oil film.  Best results are obtained if plants are grown next to bright strip lights at 25° C. |

**Unit 9.2 The Periodic Table and preparing salts**

It is recommended that this unit takes approximately **35% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of the Periodic Table, particle theory and chemical reactions to develop their knowledge of:

* the structure of an atom
* the methods and discoveries of Rutherford and other scientists
* the structures of the first twenty elements of the Periodic Table
* trends in groups and periods
* preparing some common salts by the reactions of metals or metal carbonates with acid
* writing word equations to describe reactions of metals or metal carbonates with acids.

Scientific enquiry work focuses on:

* discussing and explaining the importance of questions, evidence and explanations, using historical and contemporary examples
* discussing the way that scientists work today and how they worked in the past, including reference to experimentation, evidence and creative thought
* suggesting and using preliminary work to decide how to carry out an investigation
* using appropriate sampling techniques where required
* deciding which measurements and observations are necessary and what equipment to use
* making sufficient observations and measurements to reduce error and make results more reliable
* explaining results using scientific knowledge and understanding.

Recommended vocabulary for this unit:

* nucleus, proton, neutron, electron, electron orbit, atomic (proton) number
* Periodic Table, group, period
* reactants, products, carbonates, sulfates, nitrates, chlorides, indicator, word equation
* neutralisation, filtration, crystallisation, evaporation, excess, saturated.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
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| 9Cp1  9Cp4  9Ep1  9Ep3 | Describe the structure of an atom and learn about the methods and discoveries of Rutherford  Talk about the contribution of scientists  Secondary sources can be used  Discuss and explain the importance of questions, evidence and explanations, using historical and contemporary examples  Discuss the way that scientists work today and how they worked in the past, including reference to experimentation, evidence and creative thought | Ask learners to draw a representation of an atom. Expect drawings similar to Dalton’s billiard ball model although some may show orbiting electrons.  Using secondary sources, learners research the history of the atom starting from ancient times (Democritus), through Dalton’s ‘billiard ball’ and Thomson’s ‘plum pudding model’ to Rutherford’s ‘planetary model’. Learners create a poster, presentation, video etc. describing the structure of the atom and how our understanding has changed over time. This can include how our idea of an atom is based on a model, and the strengths and weaknesses of the Rutherford model of an atom.  Introduce Rutherford’s experiment and how it demonstrated that most of the atom was empty space with a small, positively charged nucleus. A simulation can be used to help learners visualise why the plum pudding model and planetary model would give different results.  Learners make physical models of atoms to display in their classrooms. Make sure learners can identify the nucleus, protons, neutrons and electrons. | A useful website on the history of the atom  <http://thehistoryoftheatom.weebly.com/>  Simulation to visualise Rutherford scattering  <https://phet.colorado.edu/en/simulation/rutherford-scattering>  Materials for making models. |  |
| 9Cp2  9Ec1 | Compare the structures of the first twenty elements of the Periodic Table  Describe patterns (correlations) seen in results | Provide a range of activities that allow learners to practise recalling and using the symbols of the first 20 chemical elements and other common elements (e.g. common transition metals).  Possible activities include:   * + matching card game (using cards with either a name or symbol written on them)   + dominos (using cards with the name of one element and the symbol of another written on them)   + creating and solving crosswords and word searches   + matching the name of the element to the element in the Periodic Table containing only the symbols.   Give learners a copy of the Periodic Table. Show learners the information given for each element.  Use a range of activities to help learners become familiar with the information in the Periodic Table such as:   * + use the Periodic Table to find the atomic number of the first 20 elements. Do you see any patterns?   + use the Periodic Table to find the relative atomic mass of the first 20 elements. Do you see any patterns?   Explain that the atomic number is the number of protons and in an atom this is the same as the number of electrons. Provide cards with the atomic models (showing the electron shells) for hydrogen to sodium. Learners:   * + identify the atomic number of each element   + order the elements by atomic number   + compare the structures of hydrogen, lithium and sodium. Do you see any patterns?   + arrange the elements like a Periodic Table. Do you see any patterns?   Learners can then predict the atomic structures of magnesium to calcium. After each prediction they can check their answers and add the relevant card to their Periodic Table.  Learners practise drawing the atomic structures of the first 20 elements in a blank Periodic Table.  Demonstrate how to work out the number of protons, electrons and neutrons in an atom from the atomic number and relative atomic mass. Learners practise several examples.  Have atomic models of the first twenty elements of the Periodic Table and learners match them with the element name / symbol and Periodic Table information. Learners identify similarities and differences between the models. | Resources for these activities could be created by groups of learners and then swapped so another group tries the activity.  Periodic Table.  Set of cards with the atomic models for the first 20 elements.  Blank Periodic tables.  Worksheet (or similar) with atomic number and relative atomic mass for several elements. | Learners need to be able to remember the symbols of the first twenty elements of the Periodic Table and those of other familiar elements. These were introduced in Stage 8 but will probably need to be revised and reinforced.  Good activities can be saved to use again in future years. |
| 9Cp3 | Describe trends in groups and periods | Use demonstrations with elements so learners can observe elements which are in the same group and identify similarities in their physical and chemical properties. Examples include:   * + lithium and sodium (their state, appearance and reaction with water)   + magnesium and calcium (their state, appearance and reaction with dilute acid)   + chlorine, bromine and iodine (their state and appearance).   Learners make predictions about the next element in the group and compare the predictions with the actual properties of the element.  Learners recognise groups and periods by colouring in according to the properties of the elements e.g. metals and non-metals or solids, liquids and gases (at room temperature). | Periodic Tables.  Small pieces of lithium and sodium, magnesium, calcium, chlorine (in sealed vial), bromine (in sealed vial), iodine (in sealed vial), water bath, dilute acid (e.g. 0.1 mol dm-3 hydrochloric acid).  Videos of the elements can be found at: <http://www.rsc.org/periodic-table/video>  Periodic Tables. | Health and safety:   * These activities are for demonstration by the teacher only. * Safety goggles must be worn by learners and teacher and screens used for sodium and lithium. * Chlorine and bromine are highly toxic and should only be in classroom in sealed containers, made by trained technicians and disposed of safely. |
| 9Cc5  9Ep7  9Eo1  9Ec8 | Explain how to prepare some common salts by the reactions of metals and metal carbonates and be able to write word equations for these reactions  Decide which measurements and observations are necessary and what equipment to use  Make sufficient observations and measurements to reduce error and make results more reliable  Explain results using scientific knowledge and understanding. Communicate this clearly to others | **Scientific enquiry activity**  The preparation of salts from acids and insoluble metal carbonates  Demonstrate the preparation of a salt using a carbonate and an acid (e.g. calcium carbonate and dilute sulfuric acid):   * + add excess carbonate to dilute acid until no more dissolves   + remove the excess solid by filtration   + evaporate the solution until some solid appears   + allow the solution to cool   + filter the sample to obtain the crystals.   Before starting the practical activity, learners must assess the risks involved in the preparation and agree the safety measures required.   * + Learners, in groups, prepare an appropriate salt (e.g. calcium chloride, magnesium nitrate or copper sulfate) by reacting the metal carbonate with a dilute acid.   + Learners write word equations for the reaction (and symbol equations as an extension activity).   + Learners evaluate their preparation. They suggest how they could do it better if they were to do it again.   Conclude that when a metal carbonate reacts with an acid, a salt, water and carbon dioxide are formed. | For each group:  Solid metal carbonate (e.g. calcium carbonate, copper carbonate, magnesium carbonate) and dilute acid (e.g. hydrochloric acid, sulfuric acid, nitric acid), beaker, spatula, filter funnel, filter paper, evaporating basin, glass rod, heating apparatus. | Stage 9 learners should be able to use word equations to describe chemical reactions. It can be useful to begin to introduce symbol equations during this stage although this is optional. |
| 9Cc5  9Ep5  9Ep7  9Ep9  9Eo1  9Ec8 | Explain how to prepare some common salts by the reactions of metals and metal carbonates and be able to write word equations for these reactions  Suggest and use preliminary work to decide how to carry out an investigation  Decide which measurements and observations are necessary and what equipment to use  Use appropriate sampling techniques where required  Make sufficient observations and measurements to reduce error and make results more reliable  Explain results using scientific knowledge and understanding. Communicate this clearly to others | **Scientific enquiry activity**  The preparation of salts from acids and alkalis  Show the symbol equation for the reaction of hydrochloric acid and sodium hydroxide. Ask learners to write a word equation for the reaction. *How would you find out that the acid has been neutralised?*  Learners, in groups, prepare a salt using a soluble base and an acid (e.g. sodium hydroxide solution and dilute hydrochloric acid). They:   * + take a small volume of dilute acid and add a little indicator solution   + add a solution of hydroxide a drop at a time using a dropper or glass rod, mixing after each addition of alkali   + count the number of drops needed to create a neutral solution   + add charcoal to remove the indicator solution   + remove the charcoal by filtration   + evaporate the solution until some solid appears   + allow the solution to cool   + filter the sample to obtain the crystals.   Learners write word equations for the reaction (and symbol equations as an extension activity).  Ask learners to suggest how the technique could be improved (e.g. removing a drop of the solution to test with indicator rather than adding indicator to the whole sample). Explain that this is an example of a sampling technique.  Learners discuss how preliminary work would help them to improve their preparation because they would know approximately how much acid to add to the alkaline.  **Extension activity:** Learners who require more challenge can be shown the technique of titration.  Conclude that when a metal hydroxide reacts with an acid a salt and water are formed. A pH indicator can be used to determine when the reactants have been neutralised. | For each group:  Dilute hydrochloric acid, dilute sodium hydroxide, methyl orange (or plant indicator), beaker, spatula, filter funnel, filter paper, evaporating basin, glass rod, dropping pipette, heating apparatus. | Health and safety:   * + Safety goggles must be worn.   + Do not use the indicator phenolphthalein, this is not safe to use in school. |
| 9Cc5  9Ep7  9Eo1  9Ec8 | Explain how to prepare some common salts by the reactions of metals and metal carbonates and be able to write word equations for these reactions  Decide which measurements and observations are necessary and what equipment to use  Make sufficient observations and measurements to reduce error and make results more reliable  Explain results using scientific knowledge and understanding. Communicate this clearly to others | **Scientific enquiry activity**  The preparation of salts from metals and acids  Demonstrate the preparation of a salt using a metal and an acid (for example zinc powder and hydrochloric acid):   * + Put some acid (25 cm3) into a beaker. Add a spatula-full of zinc powder. What do you observe? What is happening?   + Keep adding zinc until no more dissolves. How do we know there is an excess? What does this mean? Why should an excess be added?   + How can the excess solid be separated? Filter off the excess.   + Evaporate (using a gentle heat source) until some solid appears. Explain that the remaining solution is a saturated solution. What does ‘saturated’ mean? What do you think will happen as the solution is cooled down?   + Leave to cool until the next lesson.   Learners draw and annotate diagrams describing the main steps of preparing a salt from a metal and an acid.  Learners write word equations for the reaction (and symbol equations as an extension activity).  Discuss which metal salts can be prepared in this way. Explain that some metals are too reactive (e.g. sodium) and others are too unreactive (e.g. copper).  Conclude that only some metals can be reacted directly with an acid. Others are either too dangerous or too unreactive. | Zinc powder, dilute hydrochloric acid, beaker, spatula, filter funnel, filter paper, evaporating basin, glass rod, heating apparatus. | Health and safety:  safety goggles must be worn. |

**Unit 9.3 Electrostatics and electric currents**

It is recommended that this unit takes approximately **35% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of different types of energy and energy transfers to develop their knowledge of:

* electrostatics and the concept of charge, including digital sensors
* simple series and parallel circuits
* how common types of component, including cells (batteries), affect current
* how current divides in parallel circuits
* measuring current and voltage
* measuring resistance.

Scientific enquiry work focuses on:

* testing explanations by using them to make predictions and then evaluating these against evidence
* selecting ideas and producing plans for testing based on previous knowledge, understanding and research
* deciding which apparatus to use and assessing any hazards in the laboratory, field or workplace
* making observations and measurements
* using a range of materials and equipment and controlling risks
* interpreting results using scientific knowledge and understanding
* drawing conclusions
* evaluating the methods used and refining for further investigations.

Recommended vocabulary for this unit:

* electrostatic, electron, electrical field, charge, positive, negative, neutral, attraction, repulsion
* circuit diagrams, series circuits, parallel circuits
* resistance, wire, cell, lamp, variable resistor
* current, ammeters, amps, voltmeters, voltage, volts.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Pm1  9Eo3  9Ec2 | Describe electrostatics and the concept of charge, including digital sensors  Make observations and measurements  Interpret results using scientific knowledge and understanding | Introduce the idea of electrostatics as the study of stationary electrical charges/fields.  Ask learners to rub inflated balloons on their clothing and investigate what happens when they bring the balloon near to different objects or materials. Take feedback.  Use a simulation to help learners visualise what happens when a balloon is rubbed against a jumper. Learners apply their knowledge from chemistry to identify the negative charges as electrons.  **Scientific enquiry activity**  Investigation on charging different materials by rubbing with a dry cloth   * + Learners suspend different rods from thin nylon thread so they are balanced and free to move. They try to charge these rods by rubbing them with dry fabrics.   + Initially, learners should test insulating materials (e.g. polythene, acetate, PVC). Then they should test conductors (steel, copper, aluminium etc.)   + Learners organise their observations in a table. They try to explain their observations using their understanding of charge and materials.   Elicit that, like magnetic and gravitational fields, charged objects do not need to be touching to have an effect on each other i.e. they involve ‘non-contact’ forces.  Conclude that electrostatic forces are invisible, weak and can act over small distances. Insulators can be charged by friction. | Balloons.  <https://phet.colorado.edu/en/simulation/legacy/balloons-and-static-electricity>  (Simulation is available in several languages.)  Thread, pieces of dry cloth e.g. duster/ t-shirt. Insulating rods (e.g. plastic rulers, plastic rods, acetate rods etc.) and conducting rods (e.g. steel, aluminium, copper etc.). |  |
| 9Pm1  9Eo3  9Ec2 | Describe electrostatics and the concept of charge, including digital sensors  Make observations and measurements  Interpret results using scientific knowledge and understanding | Use two charged polythene rods. Suspend one from thin nylon thread. Bring the other towards it. *What happens? Do they have the same charge?* Identify that like charges repel.  Use a polythene rod and an acetate rod. One is negative and the other is positive. *What happens? What can you say about charges that are different?* Identify that unlike charges attract.  Conclude that only negative charges (electrons) can move between objects. Objects with the same charge repel each other. Objects with opposite charges attract each other. | Thread, pieces of dry cloth e.g. duster/ t-shirt, two polythene rods.  Thread, pieces of dry cloth e.g. duster/ t-shirt, one polythene rod and one acetate rod. | Avoid and, if required, rectify misconceptions or confused use of language around positive and negative being the same as north and south poles. Make it clear that these terms refer to different phenomenon. |
| 9Pm1  9Eo3  9Ec2 | Describe electrostatics and the concept of charge, including digital sensors  Make observations and measurements  Interpret results using scientific knowledge and understanding | Introduce a more formal idea of charges. The key ideas are:   * + Materials have atoms.   + The centre of the atoms has a positive charge. The outside of the atoms are surrounded by electrons. These electrons are negative.   + When we rub objects we can move the negative electrons from one material to another.   + Materials are neutral when uncharged (equal numbers of positive and negative charges).   + If a neutral material loses some electrons it becomes less negative or more positive.   + If a neutral material gains negative electrons it becomes more negative.   + Materials can be neutral, negative or positive.   + When many electrons move quickly it can cause a spark.   Ideally, if one is available, electric charges can be demonstrated with a Van de Graaff generator. Explain that in the generator there is a belt that a motor spins. This allows the charge to build up to high levels. Use a Van de Graaff generator to demonstrate attraction, repulsion, sparks, etc.  If a Van de Graaff generator is unavailable there are many useful video clips that can be used. | Van de Graaff generator.  Possible videos:  <https://youtu.be/jZEFuCxD7BE>  <https://youtu.be/T0J5q43MSw8> | Health and safety:   * + The maker’s safety instructions must be followed.   + A Van de Graaff generator must not be used by someone with a heart condition or pacemaker.   + More information on safety: <http://practicalphysics.org/van-de-graaff-generator-safety.html> |
| 9Pm1 | Describe electrostatics and the concept of charge, including digital sensors | Elicit the idea of electrical discharges causing sparks. Explain that sparks are caused by high temperatures as electrons move during rapid discharge.  Provide sources of information (printed or online). Give learners a topic to research related to electrostatics (e.g. lightning, electrostatic precipitators or photocopiers). For their topic learners need to:   * + identify how a charge is established   + identify how the charge is used or what happens when the charge dissipates   + draw a diagram to explain the process.   Learners can feed back to the class.  Conclude that static electricity has practical uses (e.g. photocopiers and electrostatic precipitators). It can also be dangerous (e.g. lightning). | Secondary sources. |  |
| 9Pm2 | Interpret and draw simple parallel circuits | Show learners a circuit diagram for a series circuit with one switch, one lamp and one cell. Elicit whether learners need to revise the symbols used in circuit diagrams and the principles of how to make circuits. If necessary, revise these points.  Give learners circuit diagrams for series circuits with one switch, one cell and either one, two or three lamps. Learners use the circuit diagram to build the circuits. They should observe the brightness of the lamps in the three circuits.  Show learners a circuit diagram for a simple parallel circuit. Ask learners to identify how it is different to the circuits they have already made.  Demonstrate how to make a parallel circuit and then allow learners time to build their own.  Give learners a variety of circuit diagrams or circuits and they decide whether they are parallel or series circuits. | A simple circuit diagram and the equipment needed to make it (e.g. a non-rechargable cell, connecting wires, a switch, a 1,5 V lamp).  A range of circuit diagrams and the equipment needed to make them: low voltage power supplies (e.g. non-rechargeable cells), connecting wires, switches, lamps (1.5 V lamps, at least one per circuit). | Learners have previously studied conductors, insulators and simple circuits in stage 6. This is an opportunity to revise and consolidate previous learning on using circuit diagrams to build circuits.  Health and safety:   * + Mainselectricity should never be used directly for any of these investigations. If it is not being used for power packs, then it should ideally be switched off.   + Clear safety measures must be explained and followed.   + Rechargeable batteries should not be used.   A step-by-step approach is recommended to ensure all learners build a solid understanding. |
| 9Pm3  9Ep2 | Model and explain how common types of components, including cells (batteries), affect current  Test explanations by using them to make predictions and then evaluate these against evidence | **Scientific enquiry activity**  Investigating the flow of charge in a circuit  Emphasise that batteries produce charge which flows from one end to the other round a circuit. Learners suggest ways of increasing the rate of flow of charge (more batteries, easier path).  Learners test this explanation by using a variable resistor to dim/brighten a bulb. | Low voltage power supplies (e.g. non-rechargeable cells, at least two per circuit) connecting wires, switches, bulbs, variable resistor. | Health and safety:  mains electricity should never be used directly for any of these types of investigation. |
| 9Pm5  9Ep4  9Ep8  9Eo2  9Ec4  9Ec5 | Measure current using ammeters and voltage using voltmeters, including digital meters.  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which apparatus to use and assess any hazards in the laboratory, field or workplace  Use a range of materials and equipment and control risks  Draw conclusions  Evaluate the methods used and refine for further investigations | Series circuits  Ask learners to write a sentence that describes what an electric current is. Learners can draw a picture of an electric current.  Explain that current is a measure of how much electric charge flows through a circuit. Current is measured in units called amps (A).  **Scientific enquiry activity**  Measuring current in series circuits   * + Demonstrate how to add an ammeter to a circuit. Show a circuit diagram for the circuit.   + Show learners two circuit diagrams with one cell, one lamp and one ammeter. In one circuit the ammeter should be placed on the right of the lamp, and in the other circuit it should be on the left.   + Learners make the circuits and compare the current when measured at different places.   + They make a conclusion from their findings (i.e. the current is the same at each place in a series circuit).   + Ask learners to make series circuits containing one, two or three lamps. They should measure the current in each circuit. Before starting, the learners should predict their results.   + Learners compare their results with their predictions.   Simulations can be used to help learners visualise the current in a series circuit. | Ammeters, low voltage power supplies (e.g. non-rechargeable cells), connecting wires, switches, identical lamps (1.5 V lamps, at least three per circuit).  Low cost multimeters can be used as ammeters and be used in other activities.  DC circuit simulation, such as:  <https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-dc>  (Simulation is available in several languages.) | Health and safety:   * + Mains electricity should never be used directly for any of these investigations. If it is not being used for power packs, then it should ideally be switched off.   + Clear safety measures must be explained and followed.   + Rechargeable batteries should not be used.   Apparently identical bulbs will have different brightness so it is worth exchanging them or selecting matching ones. |
| 9Pm4  9Pm5  9Ep4  9Ep8  9Eo2  9Ec4  9Ec5 | Explain how current divides in parallel circuits.  Measure current using ammeters and voltage using voltmeters, including digital meters  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which apparatus to use and assess any hazards in the laboratory, field or workplace  Use a range of materials and equipment and control risks  Draw conclusions  Evaluate the methods used and refine for further investigations | Parallel circuits  **Scientific enquiry activity**  Measuring current in parallel circuits   * + Show learners circuit diagrams for parallel circuits with one cell, multiple lamps and one ammeter. The different circuits should have different numbers of branches, each with one lamp.   + Learners make the circuits. For each design of parallel circuit, learners should use an ammeter to take readings in different places.   + They compare the current when measured at different places.   + They make a conclusion from their findings about the brightness of the lamps and the size of the current in different branches of a parallel circuit.   Simulations can be used to help learners to visualise how current divides in parallel circuits.  Learners create a summary, such as a table, which compares and contrasts the current in series and parallel circuits. | Ammeters, low voltage power supplies (e.g. non-rechargeable cells), connecting wires, switches, identical lamps (1.5 V lamps, at least three per circuit).  Low cost multimeters can be used as ammeters and be used in other activities.  DC circuit simulation, such as:  <https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-dc>  (Simulation is available in several languages.) | Health and safety:   * + Mains electricity should never be used directly for any of these investigations. If it is not being used for power packs, then it should ideally be switched off.   + Clear safety measures must be explained and followed.   + Rechargeable batteries should not be used.   Apparently identical bulbs will have different brightness so it is worth exchanging them or selecting matching ones. |
| 9Pm5  9Pm3  9Ep4  9Ep8  9Eo2  9Ec4  9Ec5 | Measure current using ammeters and voltage using voltmeters, including digital meters  Model and explain how common types of components, including cells (batteries), affect current  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which apparatus to use and assess any hazards in the laboratory, field or workplace  Use a range of materials and equipment and control risks  Draw conclusions  Evaluate the methods used and refine for further investigations | Introduce the idea of resistance.  This can be modelled with a loop of rope:   * + one learner lightly holds the rope   + the teacher is the cell and makes the rope move by passing it between their hands.   + if the learner tightens their grip then the rope will move more slowly.   Other models and role play activities can also be used to explain resistance, e.g. circuits as: conveyor belts, milk or other delivery rounds, bicycle chains.  For each model, ask learners to compare it with their understanding of circuits, and critique the model:  *What does this model show well? What does this model not show well? Is it ‘good enough’ to explain the way both series and parallel circuits work?*  **Extension activity:** If multimeters are being used, demonstrate how to measure resistance with a resistance meter and introduce the unit ohms (Ω).  **Scientific enquiry activity**  How do different components affect the current in a circuit?  Learners plan and investigate how the current in a circuit is affected by including other components. Possible components include buzzers, motors and variable resistors.  Before learners begin their investigations emphasise that they should not have a circuit which contains only a power supply, ammeter and wires. The current would be very high and this would damage the ammeter.  It is anticipated that learners will make a simple series circuit including an ammeter and one component (e.g. a lamp). Once they have measured the current, they will replace the lamp with other components, remeasuring the current each time. | A loop of rope.  This demonstration can be used to revise the principle that the current starts to move in all parts of the circuit when the cell is working.  Multimeter which can measure resistance.  Ammeter (can be a multi-meter), connecting wires, variable resistors, lamps, buzzers, motors. | The rope model may have been previously used in stage 6.  Each model has advantages and disadvantages and these should be considered by the teacher. As before, it is important to avoid models that involve something being passed around a circuit.  Health and safety:  Mains electricity should never be used directly for any of these types of investigation.  Note: the action of variable resistors can be explained in terms of increasing the length of wire in the circuit.  Note: investigations into the factors affecting the resistance of a wire are commonly included in Upper Secondary Physics. |
| 9Pm5  9Ep4  9Ep8  9Eo2  9Ec4  9Ec5 | Measure current using ammeters and voltage using voltmeters, including digital meters  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which apparatus to use and assess any hazards in the laboratory, field or workplace  Use a range of materials and equipment and control risks  Draw conclusions  Evaluate the methods used and refine for further investigations | Explain that voltage is a way of measuring the energy transferred across a component. It is a measure of the energy that is transferred from the cell to the charges in a circuit or from the charges in a circuit to a component.  Demonstrate how to connect a voltmeter across a component. Explain that the circuit is made first and then the voltmeter added in parallel. A voltmeter measures voltage in volts (V).  **Scientific enquiry activity**  Measuring voltage   * + Learners practise making a simple series circuit and connecting a voltmeter across different components. Note: The voltmeter is best put on after the rest of the circuit is connected and is clearly working.   + They collect data to compare the voltage across the power supply and the voltage across the components in the circuit.   + Learners can then extend their enquiry using a simple circuit with more than one cell. They can start with two cells, then three cells, then three cells with one of the cells reversed.   + They make conclusion from their findings in order to answer questions like:   + How can you work out the voltage across the power supply (including if one of the cells is reversed)?   + How does the voltage across the power supply relate to the voltage across the components in a series circuit?   The voltage across a home-made cell can be detected using two different metals and a solution or simply a fruit. Learners investigate into the effect of different metals and different fruit/ vegetables. | Voltmeter (can be a multi-meter), low voltage power supplies (e.g. non-rechargeable cells), connecting wires, identical 1.5 V lamps (at least three per circuit).  Voltmeter (can be a multi-meter), pieces of metal, various fruit. |  |

**Unit 9.4 Sexual reproduction in flowering plants**

It is recommended that this unit takes approximately **35% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of reproduction and plant growth to develop their knowledge of:

* sexual reproduction in flowering plants
* the processes of pollination, fertilisation, seed formation and dispersal.

Scientific enquiry work focuses on:

* making observations and measurements
* interpreting results using scientific knowledge and understanding
* drawing conclusions
* looking critically at sources of secondary data
* using appropriate sampling techniques where required.

Recommended vocabulary for this unit:

* pollination, self-pollination, cross-pollination, fertilisation
* pollen, pollen grains, pollen tubes, anther, stamen
* stigma, style, ovary, ovule, egg, gamete
* fruit, seed, seed formation, dispersal, life cycle.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Bp3  9Eo3 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal  Make observations and measurements | To assess prior learning, ask learners to identify the different parts of a selection of locally occurring flowering plants. For each part they should give its name and function (parts of the flower should be included).  Briefly review the functions of each part and explain that the flower is the part where sexual reproduction takes place.  Learners draw and annotate diagrams of a typical flower showing the male and female reproductive parts. Include ovules and egg cells in the ovary and pollen in the anthers.  Discuss the difference between flowers from different plants. Learners identify and name the structures in a variety of flowers. | Selection of locally occurring flowering plants. Photographs may be used instead of specimens.  Selection of locally occurring flowering plants. Photographs may be used instead of specimens. | Revise previous knowledge of plant anatomy and functions. |
| 9Bp3  9Eo3 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal  Make observations and measurements | Elicit what learners can remember from their previous study of pollination and fertilisation. This could be in the form of a written description of each process.  Show learners images of a variety of pollen grains.  Identify pollen as the male sex cell and the ovule as the female sex cell. Introduce ‘gamete’ as the term for sex cell.  Learners observe pollen grains under a light microscope.  Learners draw and annotate diagrams of observed pollen grains. | Images of pollen grains.  Light microscopes, prepared slides of different pollen grains or equipment for learners to make their own slides (microscope slide, cover slip and pollen sample). | Health and safety:  some learners may have allergies to particular types of pollen. If so, then these should not be used in the activity. |
| 9Bp3 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal | Pollination  Ask learners: *What is meant by pollination? How can pollen travel from one flower to another?*  Explain that pollination is the transfer of pollen from anther to stigma. This can happen in the same plant (self-pollination) or between plants (cross-pollination). Animations can be used to illustrate these processes.  Discuss the advantages and disadvantages of self-pollination and cross-pollination. This can be done as a sorting activity.  Ask learners to suggest ways that cross-pollination occurs. Show pictures or samples of flowers that use wind pollination or are insect-pollinated.  Discuss the features of wind-pollinated and insect-pollinated flowers.  Investigate examples of wind- and insect-pollinated flowers (live, diagrams or photographs) and, if possible, a local flower showing the pollen and sticky stigma clearly.  Learners create a table summarising the similarities and differences between insect-pollinated and wind-pollinated flowers.  **Extension activity:** Learners who require more challenge research other types of pollination (e.g. bird pollination and bat pollination). | Animations at: [www.fs.fed.us/wildflowers/pollinators/What\_is\_Pollination/birdsandbees.shtml](http://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/birdsandbees.shtml)  Cards with advantages and disadvantages of self-pollination and cross-pollination. Include some statements that are not relevant, to encourage learners to think about and discuss each statement.  Pictures or samples of insect-pollinated and wind-pollinated flowers.  Selection of insect-pollinated and wind-pollinated flowers, hand lenses.  Video of pollen and pollinators:  [www.ted.com/talks/louie\_schwartzberg\_the\_hidden\_beauty\_of\_pollination](http://www.ted.com/talks/louie_schwartzberg_the_hidden_beauty_of_pollination)  (from 03:19–07:15) | Learners should use the correct terms for the male and female parts of the plant in their explanations. |
| 9Bp3  9Eo3  9Ec2 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal  Make observations and measurements  Interpret results using scientific knowledge and understanding | Fertilisation  Ask: *What happens after the pollen has landed on the stigma?* Show an animation that demonstrates pollen grains travelling down a pollen tube.  Explain fertilisation as the fusing of the nucleus from the pollen with the nucleus from an egg cell.  **Scientific enquiry activity**  Observe pollen tubes using a microscope.  Fresh pollen grains can be stimulated to produce pollen tubes in the presence of calcium, boron and sucrose. The resulting pollen tubes can be observed using a light microscope.  Alternatively, show pictures or a video clip of pollen grains germinating.  Learners draw and annotate diagrams to show that pollen tubes grow from the pollen on the stigma down the style and into the ovary. The pollen nucleus travels down the tube to fertilise the nucleus in the egg cell. | [www.brown.edu/Departments/Molecular\_Biology/pgl/KH's%20animation/Animation/Basic%20Animation/PollenAnimationBasic.html](http://www.brown.edu/Departments/Molecular_Biology/pgl/KH's%20animation/Animation/Basic%20Animation/PollenAnimationBasic.html) Note: the language of the animation is complex, but the animation can be used as a visual aid.  Microscopes, fresh pollen grains, 1.3 mol dm-3 sucrose solution, mineral salt solution, microscope slides and cover slips.  Full instructions on how to complete this practical are available at:  [www.saps.org.uk/secondary/teaching-resources/222-learner-sheet-4-pollen-tube-growth](http://www.saps.org.uk/secondary/teaching-resources/222-student-sheet-4-pollen-tube-growth)  Example pictures from activity:  [www.saps.org.uk/attachments/article/222/SAPS%20Sheet%204%20-%20Pollen%20Tube%20Growth%20Images.zip](http://www.saps.org.uk/attachments/article/222/SAPS%20Sheet%204%20-%20Pollen%20Tube%20Growth%20Images.zip) | Note: it is important that the pollen grains are fresh. The pollen from some plants works more reliably than others, and this can vary depending on the time of the year. |
| 9Bp3  9Eo3  9Ec2 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal  Make observations and measurements  Interpret results using scientific knowledge and understanding | Seed production  Show learners a range of seeds and fruits containing seeds. Ask learners: *Why are these familiar? What do humans use them for?*  Explain that after fertilisation, the ovule becomes a seed. Explain that seeds contain the embryo plant, a store of food and a seed coat. The ovary becomes the fruit.  **Scientific enquiry activity**   * + Learners cut a seed such as a large bean in half.   + They identify the parts (seed, embryo plant, store of food and seed coat) and use iodine solution to test for starch.   + With preparation, learners can compare beans that have been soaked for different lengths of time (and so have started to germinate).   Discuss the variety of seeds e.g. cherry stones, orange pips, tomato seeds, wheat ears, pea pods, maple tree seeds. For each example, learners identify the part that developed from the ovules and the part that developed from the ovary.  Consolidate learning by asking learners: *What is a fruit?*  Emphasise that the botanical term does not have the same meaning as in everyday language (e.g. *Is a tomato a fruit? Is a pea pod a fruit? Is a strawberry a fruit?)* | Seeds and fruits from different plants.  Apple cut in half.  Soaked broad bean seeds, hand lenses, iodine solution.  Seeds and fruits from different plants. | Note: it is possible to start broad beans germinating at different times before the lesson. This allows learners to identify the changes that take place during germination. |
| 9Bp3  9Eo3  9Ec2  9Ec4 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal  Make observations and measurements  Interpret results using scientific knowledge and understanding  Draw conclusions | Seed dispersal  Show a video clip on methods of seed dispersal (including mechanical, wind, water and animals).  Show learners examples of seeds. Ask them to predict the method of dispersal. Elicit the concept that the structures of seeds and fruit are adapted to their type of seed dispersal.  In pairs, learners play a ‘Yes/No’ game. One learner thinks of an example of a seed. The other learner asks questions that can only be answered with ‘Yes’ or ‘No’. The learner asking questions needs to work out how the seed is dispersed (they cannot ask direct questions e.g. *Is it dispersed by wind?*).  Learners discuss the advantages and disadvantages of each type of dispersal. They list these for each type of seed dispersal.  **Extension activity:** Investigate wind dispersal by making a paper model of a seed dispersed by wind (two or more wings and a weighted centre). By adjusting the wing size, total mass, shape etc. learners aim to make it stay in the air for the longest possible time, after dropping it from a certain height. | There is a useful video at: [www.bbc.co.uk/learningzone/clips/seed-dispersal/2258.html](http://www.bbc.co.uk/learningzone/clips/seed-dispersal/2258.html)  A range of fruits. Photographs may be substituted for live specimens.  Paper, scissors. |  |
| 9Bp3  9Ec3  9Ep9 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal  Look critically at sources of secondary data  Use appropriate sampling techniques where required | The reasons for seed dispersal  Discuss with learners why plants might need to spread their seeds as far as possible.  Show learners an example of plants grown in overcrowded conditions. For example, some shops sell herb plants that are over-crowded. Ask: *What do you think will happen to these plants? What are the problems for the plants of being overcrowded? How does seed dispersal reduce overcrowding? Will all seeds be able to grow into a plant?*  Learners research the answers using secondary data on plant growth at different densities.  Provide questions to support learners in analysing and interpreting the data. As part of their analysis they should evaluate the source of the data. This is a good opportunity to discuss how sampling is used to estimate the plant numbers over large areas.  Concludethat seeds are dispersed to avoid competition for valuable resources such as light, water and minerals.  **Extension activity:** Compare the growth of plants which are crowded with those with plenty of space. The same amount of water, light and nutrients should be supplied to, for example, cress seeds. | Live specimen of overcrowded plants or video: <https://youtu.be/Ic8rdQodSKA> (00:35–00:40)  Secondary data on plant growth at different densities. | This can include ideas of competition and also protection from local disasters. |
| 9Bp3 | Understand sexual reproduction in flowering plants, including pollination, fertilisation, seed formation and dispersal | Learners consolidate this topic by researching the life cycle of a flowering plant. They summarise their research with an annotated diagram which describes the processes taking place at each stage. | Secondary sources. |  |

**Unit 9.5 Reactivity and rates of reaction**

It is recommended that this unit takes approximately **35% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of chemical reactions to develop their knowledge of:

* the reactivity series of metals with oxygen, water and dilute acids
* displacement reactions
* the effects of concentration, particle size, temperature and catalysts on the rate of a reaction.

Scientific enquiry work focuses on:

* discussing and explaining the importance of questions, evidence and explanations, using historical and contemporary examples
* testing explanations by using them to make predictions and then evaluating these against evidence
* selecting ideas and producing plans for testing based upon previous knowledge, understanding and research
* deciding which measurements and observations are necessary and what equipment to use
* deciding whether to use evidence from first hand experience or secondary sources
* deciding which apparatus to use and assessing any hazards in the laboratory
* making sufficient observations and measurements to reduce error and make results more reliable
* using a range of materials and equipment and controlling risks
* making observations and measurements
* choosing the best way to present results
* describing patterns (correlations) seen in results
* interpreting results using scientific knowledge and understanding
* drawing conclusions
* comparing results and methods used by others
* looking critically at sources of secondary data
* evaluating the methods used and refining for further investigations
* explaining results using scientific knowledge and understanding; communicating this clearly to others.

Recommended vocabulary for this unit:

* metal, non-metal, acid, oxygen, oxide, hydroxide, salts
* reactivity series, oxidation, displacement reaction
* concentration, catalyst, reagent, reactant, product, rate of reaction.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Cc2  9Eo2  9Ec1 | Describe the reactivity of metals with oxygen, water and dilute acids  Use a range of materials and equipment and control risks  Describe patterns (correlations) seen in results | Reacting metals with oxygen  *What is formed when a metal reacts with oxygen?*  **Scientific enquiry activity**   * + Learners clean small samples of a range of metals and leave in air.   + They check them at intervals for signs of oxidation.   + They heat the same range of metals in air and place them in a gas jar of oxygen.   + For each example learners: * record their observations * write a word equation * write a symbol equation (extension).   Learners watch videos of reactions of different metals with oxygen or use a simulation. This allows reactions involving Group 1 metals to be observed.  Learners compare the rate of reaction of different metals with oxygen. They make a list from most reactive to least reactive.  *What do you think would happen if a non-metal reacted with oxygen?* Show videos of some examples.  Learners record observations and write word equations for the reactions (and symbol equations as an extension activity).  Conclude that when a metal or non-metal reacts with oxygen an oxide is formed. | Copper, iron, magnesium, zinc, oxygen, laboratory glassware and heating apparatus.  Simulation showing the reaction of Group 1 metals with oxygen:  [www.syngentaperiodictable.co.uk/reaction-zone.php](http://www.syngentaperiodictable.co.uk/reaction-zone.php)  Sulfur burning in oxygen:  <https://youtu.be/V1sQO91UvFI> | Health and safety: safety goggles must be used. |
| 9Cc2  9Cc6  9Eo2  9Ec1 | Describe the reactivity of metals with oxygen, water and dilute acids  Give an explanation of the effects of concentration, particle size, temperature and catalysts on the rate of a reaction  Use a range of materials and equipment and control risks  Describe patterns (correlations) seen in results | Reacting metals with water  Ask learners to recall examples of reactions of metals with water that they have already tested or observed. *What happens when a metal reacts with water?*  Show learners the word equation:  lithium + water → lithium hydroxide + hydrogen  Ask learners to suggest the word equation for the reaction of different metals with water, e.g. calcium, potassium and zinc.  **Scientific enquiry activity**   * + Learners clean small samples of a range of metals and leave in water.   + They observe changes over the next few days. (Some may only react when heated in steam; some will not react at all.)   + For each example learners: * record their observations * write a word equation * write a symbol equation (extension).   Learners watch videos of reactions of different metals with water or use a simulation. This allows reactions involving Group 1 metals to be observed.  Learners compare the rates of reaction of some metals with water and make a list.  Conclude that when a metal reacts with water, metal hydroxide and hydrogen are formed. | Reaction of lithium and water  <https://youtu.be/tAr6Lbb_qvQ>  Copper, iron, magnesium, zinc, laboratory glassware and heating apparatus.  Simulation showing the reaction of Group 1 metals and other metals with water:  [www.syngentaperiodictable.co.uk/reaction-zone.php](http://www.syngentaperiodictable.co.uk/reaction-zone.php) | Health and safety: safety goggles must be used. |
| 9Cc2  9Eo2  9Ec1 | Describe the reactivity of metals with oxygen, water and dilute acids  Use a range of materials and equipment and control risks  Describe patterns (correlations) seen in results | Reacting metals with acids  Ask learners to complete the following word equation:  magnesium + hydrochloric acid → magnesium chloride + …  Ask learners to identify the salt in the reaction and suggest a method that could be used to measure the rate of reaction of magnesium with hydrochloric acid.  **Scientific enquiry activity**  Learners investigate the reaction of three different metals (e.g. magnesium, iron and zinc) reacting with dilute acid. They:   * + put equal volumes of dilute acid into three conical flasks   + put equal masses of each metal (as a powder) into three balloons   + fit the balloons carefully over the mouth of the conical flask without spilling metal powder   + empty balloons at the same time   + observe the rate of hydrogen gas production.   Learners compare the rates of reaction they observe with the list of reactivity they created in the previous lessons.  Provide learners with the names and formulae of the main laboratory acids. Learners complete word equations for the reaction of each acid with a series of metals. This can be extended to include symbol equations.  Conclude that when a metal reacts with an acid, a salt and hydrogen are produced. | Per group:  Three conical flasks, three balloons, dilute hydrochloric acid, powdered magnesium, iron and zinc.  Alternatively, a video or a simulation can be used:  [www.syngentaperiodictable.co.uk/reaction-zone.php](http://www.syngentaperiodictable.co.uk/reaction-zone.php)  Worksheet of reactions of different metals and acids to complete. | Health and safety: safety goggles must be used. |
| 9Cc2  9Ec3  9Ep6 | Describe the reactivity of metals with oxygen, water and dilute acids  Look critically at sources of secondary data  Decide whether to use evidence from first-hand experience or secondary sources | Constructing a reactivity series  Provide a description of results, for example of league football matches, horse racing or running. Learners sort out the order from the winner to the last place.  Explain to learners that chemicals can be listed in a similar way. They look at reactions between different chemicals to make an order of reactivity.  Learners review their results from earlier in the unit to compare the rates of reaction of some metals with oxygen. Learners use their notes or watch a quick video or use simulations to remind them about the reactions studied. They summarise the results in a table.  Similarly, learners compare the rates of reaction of some metals with water and with dilute acids. They add their results to their summary table.  Learners analyse their table of results and suggest an order of reactivity. This can be enhanced with research or supplied information about metals which have not been observed.  Give learners the correct reactivity series of metals.  Conclude that metals can be put in order of their reactivity based on observations made in different chemical reactions. | A worksheet describing the results of football league matches, horse racing, running etc. (e.g. A finished before B but was beaten by C and D).  [www.syngentaperiodictable.co.uk/reaction-zone.php](http://www.syngentaperiodictable.co.uk/reaction-zone.php)  Information about the reactivity of metals that have not previously been studied. |  |
| 9Cc3  9Ec3  9Ep6  9Ep4  9Ep7  9Ep8  9Eo1  9Eo2  9Eo3  9Eo4  9Ec1  9Ec2  9Ec4  9Ec5  9Ec8 | Explore and understand the reactivity series  Look critically at sources of secondary data  Decide whether to use evidence from first-hand experience or secondary sources  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which measurements and observations are necessary and what equipment to use  Decide which apparatus to use and assess any hazards in the laboratory, field or workplace  Make sufficient observations and measurements to reduce error and make results more reliable  Use a range of materials and equipment and control risks  Make observations and measurements  Choose the best way to present results  Describe patterns (correlations) seen in results  Interpret results using scientific knowledge and understanding  Draw conclusions  Evaluate the methods used and refine for further investigations  Explain results using scientific knowledge and understanding. Communicate this clearly to others | Investigating the reactivity series  Start with a sorting cards activity to put metals into a correct order based on their reactivity*. Do you think the order is the same at all times? Does it depend on the reagent used? How could we find out?*  **Scientific enquiry activity**  Learners investigate whether the reactivity series is the same with different acids.  Learners should plan their own investigations including a basic risk assessment and decide whether to use primary data and/or secondary data.  If learners decide to use secondary data, they should evaluate the data they select.  If learners decide to use primary data, then they should plan their investigation. This should include details about:   * + the measurements or observations they will make   + whether they will need equipment to make the measurements (e.g. stopwatches)   + the apparatus they will use   + their assessment of any risks, hazards and precautionary measures   + how many repeated measurements will be taken and an explanation of how this will reduce the error in the investigation.   Learners conduct their investigations and record their results in an organised way (for example a table).  Learners analyse their results and conclude whether the reactivity series is the same when different acids are used.  Conclude that the reactivity of metals is the same with different acids as long as the acids used are at the same concentration. | Sorting cards of metals in the reactivity series.  Copper, iron, magnesium, zinc, dilute acids of the same concentration (sulfuric, nitric, ethanoic), laboratory glassware.  Information sources for learners (printed or online). | Health and safety: safety goggles must be used. |
| 9Cc4  9Ep2 | Give examples of displacement reactions  Test explanations by using them to make predictions and then evaluate these against evidence | Displacement reactions  Demonstrate a displacement reaction by putting an iron nail into copper sulfate solution and a copper coin or strip into iron sulfate solution.  Alternatively, show a video of one or more displacement reactions.  Explain that the more reactive metal will displace a less reactive one out of its salt. Learners identify which of the chemicals in the demonstration are more reactive – link back to the reactivity series concept.  Learners write a word equation for the reaction of iron and copper sulfate. They annotate to identify the salt, the more reactive metal and the less reactive metal.  **Scientific enquiry activity**  Learners make predictions about displacement reactions involving a selection of metals, using the reactivity series.  Learners confirm their predictions by carrying out reactions. Alternatively, they can watch a video or use a simulation.  Conclude that in a displacement reaction the more reactive metal will displace the less reactive metal from its salt. | Iron nail, copper strip iron sulfate solution, copper sulfate solution.  [www.youtube.com/watch?v=2MawIDT5DFU](https://www.youtube.com/watch?v=2MawIDT5DFU) (0.30 onwards. Contains several examples of displacement reactions.)  A selection of metals and solutions of their salts (e.g. magnesium, iron, zinc, lead, copper), spotting tiles, pipettes.  [www.youtube.com/watch?v=2MawIDT5DFU](https://www.youtube.com/watch?v=2MawIDT5DFU) (0.30 onwards)  <http://intro.chem.okstate.edu/1515F01/Laboratory/ActivityofMetals/home.html> | Very small quantities can be used by carrying out the tests on a spotting tile.  Health and safety: safety goggles must be used. |
| 9Cc3  9Ep1 | Explore and understand the reactivity series  Discuss and explain the importance of questions, evidence and explanations, using historical and contemporary examples | The reactivity series and extraction methods  Tell learners that Louis Napoleon (Napoleon III) had a state dinner service and ceremonial helmet made in one of the most expensive metals available when he was Emperor of France (1848–1870). *What metal do you think he chose?*  Most learners will assume that the metal was gold, silver or platinum. Instead it was aluminium. Tell learners that by the end of the lesson you want them to be able to explain why aluminium was so expensive.  Provide learners with information sources (printed or online material). Learners answer these questions:   * + When were gold and silver discovered?   + What do they look like when they are extracted from the ground?   + Where are they in the reactivity series?   + How can zinc, iron, lead and copper be extracted from their ores? Where are they in the reactivity series?   + How can scrap iron be used to purify copper?   + How is aluminium purified from its ore?   + Where is it in the reactivity series?   + Why was aluminium so expensive when Napoleon was alive?   Discuss that for the metals in the middle of the reactivity series displacement reactions can be used, but for the most reactive metals different methods of extraction are needed. The more difficult metals to extract were typically discovered later.  Conclude that the more reactive metals were discovered later as new methods of extracting metals were introduced. | Information sources for learners.  [www.rsc.org/periodic-table/history](http://www.rsc.org/periodic-table/history)  The Periodic Table (which is also available as an app) can be used to find out the years of discovery. |  |
| 9Cc6  9Eo1  9Eo3  9Ec6 | Give an explanation of the effects of concentration, particle size, temperature and catalysts on the rate of a reaction  Make sufficient observations and measurements to reduce error and make results more reliable  Make observations and measurements  Compare results and methods used by others | Effect of concentration  Ask learners to predict how increasing the concentration of the reactants will affect the rate of a reaction.  Learners who require more support understanding concentration may find it useful to compare the colour of drinks made with different concentrations of a coloured squash. They then draw particle diagrams showing the concentration of the ‘squash particles’ in each drink.  **Scientific enquiry activity**  Learners carry out an investigation into the time taken for a 3 cm length of magnesium ribbon to completely react in 25 cm3 of hydrochloric acid of different concentrations.  They make a table to record their results. They then compare their results and methods against their peers to discuss variation in data and to build a larger data set to ensure accuracy of the experiment.  They analyse their results to write a conclusion describing how increasing the concentration of the reactants affects the rate of reaction.  Learners write a word equation for the reaction (and symbol equation as an extension activity).  Conclude that increased concentration increases reaction rate. | Coloured squash, water, glass.  Magnesium ribbon in 3 cm strips, hydrochloric acid (at a range of concentrations: 0.10, 0.25, 0.5, 1.0 mol dm-3), boiling tube (or other glassware with a capacity of greater than 25 cm3), measuring cylinder (50 cm3 or 100 cm3), stopwatch (or other means of timing the reaction). | Health and safety: safety goggles must be used.  Different groups of learners can be given different concentrations of acid to use. All of the data can be gathered as a class set. |
| 9Cc6  9Eo1  9Eo3 | Give an explanation of the effects of concentration, particle size, temperature and catalysts on the rate of a reaction  Make sufficient observations and measurements to reduce error and make results more reliable  Make observations and measurements | Effect of particle size  **Scientific enquiry activity**  Learners carry out independent investigations, e.g.   * + comparing the time taken for the same mass of magnesium powder and magnesium ribbon to completely react with dilute hydrochloric acid   + comparing the time taken for the same mass of marble chips of different sizes to completely react with hydrochloric acid   + comparing the time taken for an indigestion tablet used as a whole, broken in half, broken into quarters, and powdered to completely dissolve.   They make a table to record their results.  They analyse their results to write a conclusion describing how increasing the particle size of the reactants affects the rate of reaction.  Learners write a word equation for the reaction (and symbol equation as an extension activity).  Conclude that the smaller the particle size, the faster the reaction. | Magnesium ribbon in 3 cm strips and magnesium powder, dilute hydrochloric acid.  Marble chips of different sizes, dilute hydrochloric acid  Ingestion tablets, water. | Health and safety: safety goggles must be used. |
| 9Cc6  9Eo3 | Give an explanation of the effects of concentration, particle size, temperature and catalysts on the rate of a reaction  Make observations and measurements | Effect of a catalyst  Ask learners if they have heard the term ‘catalyst’ before. *What is a catalyst?*  Show learners the word equation for the decomposition of hydrogen peroxide. *What would you see if the reaction was happening quickly?*  Make sure that learners know that hydrogen peroxide decomposes (slowly) all the time. Show learners the vent in the lid of a laboratory bottle of hydrogen peroxide. Explain that this is to let the gas escape. It is important that learners understand that the catalyst changes the rate of the reaction and is not a reagent.  Add a small amount of manganese (IV) oxide. Learners observe the difference in the rate of reaction before and after the addition of the catalyst.  Conclude that catalysts speed up chemical reactions without being used up. They are not a reagent in the reaction. | Hydrogen peroxide solution, manganese (IV) oxide, laboratory glassware. | Health and safety: safety goggles must be used. |
| 9Cc6 | Give an explanation of the effects of concentration, particle size, temperature and catalysts on the rate of a reaction | Use the kinetic theory to explain effects on rates of reaction.  Through diagrams, use ideas about particle theory to explain the effects of the different variables on the speed of reactions, i.e. concentration increases the number of particles, temperature increases their speed and increased lump size decreases the area for particles to approach one another. |  | A good context is found in recipes where cooking times vary for, e.g., potatoes depending on area exposed. |
| 9Cc6  9Eo3 | Give an explanation of the effects of concentration, particle size, temperature and catalysts on the rate of a reaction  Make observations and measurements | Investigating the effect of temperature on rate of reaction  Depending on resources available, learners investigate the effect of temperature on the reactions between:   * + sodium thiosulfate and hydrochloric acid (measuring the time it takes for a cross to disappear)   + sodium hydrogen carbonate solution and calcium chloride solution (measuring the time it takes for a cross to disappear)   + an indigestion tablet and water (measuring the time it takes for the tablet to dissolve).   Conclude that increasing the temperature of a reaction increases the rate of collisions and the energy of the collisions. This increases the chance of a successful collision so the rate of reaction is increased. | Resources dependent on the chosen investigation. | Health and safety: safety goggles must be used. |

**Unit 9.6 Moments, pressure and density**

It is recommended that this unit takes approximately **30% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of forces and movement to develop their knowledge of:

* objects turning on a pivot and the principle of moments
* pressure as caused by the action of force on an area
* pressures in gases and liquids (qualitative only)
* the densities of solids, liquids and gases.

Scientific enquiry work focuses on:

* selecting ideas and producing plans for testing based upon previous knowledge, understanding and research
* deciding which measurements and observations are necessary and what equipment to use
* making observations and measurements
* choosing the best way to present results
* describing trends and patterns (correlations) seen in results
* interpreting results using scientific knowledge and understanding
* drawing conclusions
* explaining results using scientific knowledge and understanding; communicating this clearly to others.

Recommended vocabulary for this unit:

* lever, pivot, load, force, distance, moment, clockwise moment, anticlockwise moment
* volume, mass, density
* force, surface area, pressure.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Pf4 | Know that forces can cause objects to turn on a pivot and understand the principle of moments | Introducing levers  Show the class some tasks that are hard to do with their bare hands. For example: undoing a tight-fitting lid, undoing a bolt, cracking a nut or removing a nail from a piece of wood. Ask learners to discuss why the tasks are so difficult to do with bare hands. *What tools could you use to help you?*  Show simple tools or machines that could be used (e.g. screwdriver or lever, spanner, nutcracker or pliers, hammer). *Why do these make the jobs easier?* Discuss learners’ ideas.  Demonstrate how to open a tin with a tight-fitting lid. Describe the lever as a simple machine which uses a pivot. Identify the pivot, load and force applied. The ‘lever’ itself is the whole setup, not just the long object involved.  Demonstrate the other tools or machines that use leverage. Ask learners to identify the pivot, load and force applied in each example.  Show a video clip on using levers. Learners write down any levers they see in the video. | Examples of everyday levers, e.g. nut and nutcracker, spanner and bolt, can with tight-fitting lid.  Tin (e.g. paint can) with tight- fitting lid, screwdriver.  Suggested link:  <https://youtu.be/QejD6z69trg> | The aim is for learners to realise that the turning effect of the lever increases with the distance from the force and the pivot and with the size of the force. |
| 9Pf4  9Eo3  9Ec1  9Ec2  9Ec4 | Know that forces can cause objects to turn on a pivot and understand the principle of moments  Make observations and measurements  Describe patterns (correlations) seen in results  Interpret results using scientific knowledge and understanding  Draw conclusions | Introducing moments  Show learners a picture of a spanner being used to loosen a nut. *Where is the pivot?* Ask learners to suggest two things that they could change that would alter the turning force on the nut.  Elicit the two key variables: (1) the size of the force applied on the spanner; and (2) the distance along the handle of the spanner that the force is applied.  **Scientific enquiry activity**  The forces in a lever  Learners investigate the forces in a simple lever. They change the distance between the pivot and the force applied and measure the size of the force needed to lift the load. If the lever is a ruler, then it is straightforward to measure the distance from the pivot to where the force is applied. The size of the effort can be measured with a forcemeter. The size of the load should be kept constant.  Learners produce a table of their results and use this to draw a line graph. They should identify the trend and write a conclusion.  Introduce how to calculate a moment using the formula:  moment = distance from pivot x force  Learners suggest suitable units for the moment (Nm). Correct any mistaken references to N/m, or to N/m2.  Learners calculate the moments from the investigation. Ideally all their results should give the same moment. *Is this what you found? Where there any problems with your investigation? How would you improve it if you were to do it again?* | Picture of spanner being used to loosen a nut.  Rulers, forcemeters and small loads.  load  pivot  force applied   (measured with a forcemeter)  Calculators (optional). |  |
| 9Pf4  9Ep4  9Ep7  9Eo3  9Eo4  9Ec1  9Ec2  9Ec4 | Know that forces can cause objects to turn on a pivot and understand the principle of moments  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which measurements and observations are necessary and what equipment to use  Make observations and measurements  Choose the best way to present results  Describe patterns (correlations) seen in results  Interpret results using scientific knowledge and understanding  Draw conclusions | Show learners a seesaw balance. Ask them to identify the pivot. Apply some masses to one side of the seesaw and ask learners to calculate the moment.  **Scientific enquiry activity**  The forces in a seesaw balance  Provide groups of learners with seesaw balances. They find as many ways as possible to balance two masses placed 6 cm from the pivot.  Learners record their findings in a table.  Learners calculate the moment of two masses placed 6 cm from the pivot. Check answers.    Then learners calculate the moments of all the combinations they found which balanced the seesaw. Learners should be able to identify a pattern and determine the principle that a seesaw is balanced when:  clockwise moment = anticlockwise moment  Conclude that moments can be measured, calculated and predicted. A seesaw will balance if the clockwise and anticlockwise moments are equal.  Learners perform simple calculations involving two weights either side of a pivot. | Seesaw balance, pivot, weights /counters of equal masses (e.g. 10 g = 0.1 N), metre ruler.  Seesaw balances, suitable pivots, weights/counters of equal masses (e.g. 10 g =  0.1 N), metre rulers.  Calculations for practice. |  |
| 9Pf2 | Determine densities of solids, liquids and gases | Determining the density of regular-shaped objects  Show a video clip of a rubber object being thrown at people, which they think is heavier than it actually is.  Discuss the clip. *Why did people run away from the object? Are large objects always heavier?*  Density can be explained as the amount of ‘stuff’/matter of different materials in the same size/volume.  **Scientific enquiry activity**  Learners investigate the masses of equal-sized volumes of different materials.  Learners find the mass of each material and put their results in a table (provide a table with space to calculate the density).  Demonstrate how to calculate the density of one sample. Learners complete the table with the densities of all the samples. Learners suggest possible units for density.  Ask learners to suggest why objects have different densities. To help, show learners three identical boxes or cases (all with different masses). Ask: *Why do the boxes have different masses?* Elicit the idea that the boxes contain different numbers of items and the items have different masses.  Link this to the idea that atoms have different masses and sizes and can be packed together in different ways. | Suggested link:  <https://youtu.be/fE67XeUeaHY>  Equal-sized blocks (e.g. 1cm3 cubes) of different materials: e.g. steel, wood, aluminium, zinc, polystyrene, lead, slate, marble, stone, porcelain, etc. |  |
| 9Pf2  9Ep7  9Eo3  9Ec2  9Ec4 | Determine densities of solids, liquids and gases  Decide which measurements and observations are necessary and what equipment to use  Make observations and measurements  Interpret results using scientific knowledge and understanding  Draw conclusions | Determining the density of irregular-shaped objects.  Demonstrate how to determine the volume of irregular solids by immersing them in liquids. By measuring the volume of water displaced learners can determine the volume of any objects (including irregular objects).  **Scientific enquiry activity**  Learners determine the volume of irregularly-shaped objects using the displacement of water. They then calculate the density of each object.  Learners collect and interpret their results. They compare their results with the results from others in the class. Ask if any learners have anomalous results (ones that do not fit the pattern). Ask: *Why are the results not the same? Should we take a mean of all of the results?* | Irregular-shaped objects, water, measuring cylinders, displacement cans or beakers (or equivalent), mass balance (to at least ± 0.5 g).  Irregular-shaped objects, water, measuring cylinders, displacement cans or beakers (or equivalent).  Mass balance (at least to ± 0.5 g). |  |
| 9Pf2  9Ep4  9Ep7  9Eo3  9Ec4 | Determine densities of solids, liquids and gases  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which measurements and observations are necessary and what equipment to use  Make observations and measurements  Draw conclusions | Density of a liquid  Ask learners it if is possible to determine the density of liquids. *How can we measure the volume of a liquid? How can we measure the mass of a liquid?*  **Scientific enquiry activity**  Learners measure the densities of different liquids, for example water, olive oil and ethanol.  Calculated values can be checked in data tables for accuracy. | Measuring cylinders, a mass balance (at least to ± 0.5 g), various liquids to test.  Practical procedure:  <http://practicalphysics.org/measuring-density-liquids.html> | Health and safety: if ethanol is used, be aware of the risk of fire. |
| 9Pf2  9Ep7  9Eo3  9Ec4 | Determine densities of solids, liquids and gases  Decide which measurements and observations are necessary and what equipment to use  Make observations and measurements  Draw conclusions | Density of a gas  Ask learners it if is possible to determine the density of gases. *How can we measure the volume of a gas? Do gases have mass? How could we measure the mass of a gas?*  Demonstrate a simple approach to measuring the mass and volume of a gas:   * + Put some sticky tape on a mass balance and zero the balance.   + Place an empty balloon on the mass balance to find its mass.   + Breathe into the balloon. Use the tape to keep the balloon on the mass balance (so it does not fall off).   + Take the mass of the balloon plus air. Calculate the mass of the gas.   + Calculate the volume of the balloon by assuming it is a sphere (volume = ). Alternatively, measure its volume by the displacement of water in a large bucket.   Learners collect the gas from the reaction when an anti-acid tablet is put in water. They do the reaction in a conical flask and collect the gas produced in a balloon. They experimentally determine the density of the gas.  Provide a data sheet with densities of different gases. Learners try to identify the gas from its density. *Why do different gases have different masses?* | Balloon, sticky tape, mass balance (at least to ± 0.01 g).  An alternative method to determine the density of a gas using syringes is:  <https://youtu.be/6V6f8P_WlQ4>  Possible method:  <http://practicalphysics.org/measuring-density-air-1.html>  Balloon, sticky tape, anti-acid tablets, conical flasks, mass balance (at least to ± 0.01 g).  List of densities of common gases, e.g. <http://wiki.gekgasifier.com/w/page/6123697/Densities%20of%20Common%20Gasses> | Many learners struggle to believe that gases have mass. It is important to identify and challenge this misconception. |
| 9Pf1  9Eo3  9Ec1  9Ec4 | Explain that pressure is caused by the action of a force on an area  Make observations and measurements  Describe patterns (correlations) seen in results  Draw conclusions | Introducing pressure  Display this information:  ‘Children use small plastic bricks and leave them on the floor. When a small child stands on them in bare feet it does not hurt them. But when an adult stands on them with bare feet it really hurts them!’  Ask learners to discuss this statement in pairs. *Do you agree? Why might there be a difference in pain?*    Show a video clip of a men lying on a bed of nails. *Why are they not injured?*  **Scientific enquiry activity**  What affects pressure?  Give learners masses and moulding putty.  First they place the mass directly on a piece of moulding putty. Then they place the mass on a small (1 cm3) block on a piece of moulding putty. Learners compare the marks left on the putty.  Discuss that the deeper marks in the second example are due to the increased pressure.  Learners then compare the marks left in the putty when a mass is balanced on 12 blocks. They then try balancing the mass on 8, 6, 4, 2 and 1 block(s) and compare the results.  *How does area affect pressure?*  Learners repeat the investigation but this time keep the area the same and increase the mass. *How does force affect the pressure?*  Learners use ideas about force and area to explain:   * + Why the bed of nails does not hurt too much?   + Why standing on small plastic bricks hurts adults more than children?   Demonstrate a very sharp knife or show a few seconds of a video clip. Ask learners to apply their learning to explain what makes the knife so effective.  Ask: *How does a drawing pin work?* Elicit the idea that one part has a large area (force is spread over a larger area on finger). The other side is a point so the same force is concentrated on a small area.  Remind learners of putting masses on blocks. Help learners to formalise the idea of pressure:  24 N on 4 x 1 cm2 blocks = 6 N on each block  24 N on 8 x 1 cm2 blocks = 3 N on each block  Introduce pressure = (measured in N / cm2 )  Provide learners with data to practise calculating pressure, force or area. Examples could include the pressure exerted by a person if they wore snowshoes, trainers or stilettos. Learners trace around a foot and use their own weight to calculate pressure.  Provide learners with information sources (printed or online material). They research ways that force can be spread or concentrated to alter the pressure, for example, wide tyres on off-road vehicles, tracks on tanks, raft foundations for buildings, shape of drill bits. | Suggested link: <https://youtu.be/QfdBwkOxCe4>  Per group: several masses (e.g. 100–500g), moulding putty, 1cm3 blocks  Suggested link:  <https://youtu.be/Kry8tD-bz7I>  Drawing pin.  Data for learners.  Information sources. | Other units are possible (e.g. N / m2 or kN / m2) but it is useful to start with simple examples. |
| 9Pf3  9Ec8 | Explain pressures in gases and liquids (qualitative only)  Explain results using scientific knowledge and understanding. Communicate this clearly to others | Pressure in liquids  Use an empty plastic bottle (filled with air and with the top on). Learners suggest what would happen, with an explanation of the outcome, if:   * it was cooled * it was warmed * it was placed in water * it was placed deep under water.   Show a video clip of a plastic bottle at a depth of 22 m (75 feet). Use this to introduce the idea of water pressure.  Demonstrate pressure in a liquid. Use a tall plastic bottle which has holes in the sides at different heights. When filled, water is forced out sideways. The lower the hole, the greater the pressure.  Learners explain the pressure of a liquid in terms of the particle model or in terms of the weight of the liquid above the surface.  Conclude that the pressure in a liquid is caused by moving particles colliding. Pressure in a liquid increases with the depth of the liquid. | Empty plastic bottle with an airtight top.  Suggested video link (can be shown without sound):  <https://youtu.be/cHf9eWRd_bc>  Tall plastic bottle with three holes in the side at different heights, water. | Reference can be made to dams and deep sea divers. |
| 9Pf3  9Ec8 | Explain pressures in gases and liquids (qualitative only)  Explain results using scientific knowledge and understanding. Communicate this clearly to others | Pressure in gases  Show learners two balloons inflated to the same volume. (They should be about 80 per cent full.) Put one in a freezer and leave the other in the room.  In pairs, learners predict what will happen and use scientific ideas to explain why. Remove the balloon from the freezer after at least 30 minutes. Learners compare the result with their predictions.  Learners use the particle model to explain the observations and predict what will happen to the balloon as it slowly warms up.  Demonstrate to learners how gases behave in different temperatures. Use a small conical flask (containing air) with a deflated balloon secured on the top. Heat the flask and the balloon will expand. Let it cool and it will deflate. Ask learners to offer explanations for these observations.  Introduce the ideas:   * air particles move * air particles move faster when heated * air particles move slower when cooled.   Use a simulation to help learners visualise the movement of liquid and gas molecules in a container.  A variety of demonstrations can be used to show some of the effects of air pressure. For example:   * A container of at least three litres is connected to a vacuum or suction pump and compressed by the pressure of the atmosphere. * Alternatively, a heat-proof container containing a little water can be heated and then have the top screwed on tightly causing the same effect as it cools.   Blowing up balloons or tyres or heating tins with a lid on causes an increase of pressure which learners should explain using the particle model. | Two identical balloons inflated to the same volume, a freezer or other cold place.  Balloons, Bunsen burner, safety glasses and a conical flask.  <https://phet.colorado.edu/en/simulation/legacy/states-of-matter>  (Simulation is available in several languages.)  Container (at least 3 litres), vacuum or suction pump.  Heat-proof container, water, heating apparatus.  Balloon and tyre, pump  Heat-proof container with lid, water, heating apparatus. | Air pressure is a relatively large force so good demonstrations are possible.  Health and safety: for either method, safety screens and safety goggles should be used. |

**Unit 9.7 Ecology**

It is recommended that this unit takes approximately **30% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of organisms in their environment to develop their knowledge of:

* constructing keys to identify plants and animals
* food chains, food webs and energy flow including the role of decomposers
* how living things are adapted to their habitats
* how characteristics are inherited
* selective breeding
* the work of Darwin on natural selection and other scientists studying the natural world.

Scientific enquiry work focuses on:

* discussing and explaining the importance of questions, evidence and explanations, using historical and contemporary examples
* discussing the way that scientists work today and how they worked in the past, including reference to experimentation and evidence.

Recommended vocabulary for this unit:

* biological key, species,
* food chain, food web, consumer, producer, trophic level, primary, secondary, tertiary, herbivore, carnivore, omnivore, detritivore
* inherit, genetic, characteristics
* adaptation, variation, habitat.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Bv1 | Use and construct keys to identify plants and animals | Ask learners about things that need sorting in the home, e.g. cutlery drawer, TV channels, CDs/DVDs. Ask learners how they think it is best to sort them.  *What questions could you ask to sort a cutlery set?*  Repeat the previous activity using images of dog breeds. Provide facts for each example (e.g. height, coat colour).   * Demonstrate how to divide the dogs into groups by asking a question to which there is a ‘Yes’ or **‘**No’ answer e.g. ‘Is the dog large (above 65cm)?’ * Ask learners: *What question could be used to divide the large dogs down into further groups?* * Next divide each group down into further subdivisions by asking another question to which there is a Yes’ or **‘**No’ answer e.g. ‘Does the dog have a brown and black coat?’ * Finally, divide the groups down into individual dogs which could name the actual dog breed, e.g. ‘Does the dog have curly hair?’   Explain that by asking questions that subdivide the dogs a key can be produced. To save space, biologists list the questions and give instructions at the end as to which question to go to next, for example:  1. Is the dog over 65cm tall?  If yes, go to question 2  If no, go to question 5  2. Does the dog have brown or black hair?  If yes, go to question 3  If no, go to question 4  3. Does the dog have a woolly coat?  If yes, then Airedale Terrier  If no, then Rottweiler.  Learners copy down the key and then complete it to classify the rest of the dogs.  Summarise that biological keys are written using a set of ‘Yes/No’ questions that keep dividing large groups into two. Eventually a single species or breed can be identified.  Show learners a short dichotomous key and some pictures. Ask them to identify the objects in the pictures.  Provide learners with examples of keys and questions (e.g. for plants or aquatic animals). These can be of progressive difficulty to reinforce how dichotomous keys work and are used.  Ask learners questions so that they become familiar with the keys. The questions could include identifying species from photographs or pictures. | Use a worksheet with photos of a range of dogs that will be familiar to learners. It is important that learners understand that these are all the same species. Therefore, the key they are producing will be to subdivide the species into breeds of dog.  Example of a dichotomous key and pictures of the species mentioned in the key.  Keys for common aquatic animals that would be found in a local pond or river or keys for common plants that would be found in the school grounds.  Pictures or photographs of local aquatic animals or local plants. | Note: these breeds can be replaced with examples that would be familiar to the learners |
| 9Be3 | Explain and model food chains, food webs and energy flow | Learners produce a set of cards for a chosen ecosystem. Each card should have written on it one of the following things:   * name of a living organism and what it eats * consumer, producer or decomposer * herbivore, carnivore, omnivore or detritivore * an arrow.   These cards should be designed so that they can make several complete food chains.  Learners make and discuss (using the technical terms) a variety of food chains.  Provide learners with an example food web and ask them to think about what would happen if abiotic or biotic factors changed so that the numbers of one organism declined dramatically. Include the effect of humans on food chains.  Introduce the idea of energy flowing along the food chain and so flowing through the food web.  Learners investigate a simulation of what happens when changes are made to the populations of living things in a food web. | White or coloured card (cut up into roughly playing card-sized pieces) and coloured pens.  Example food web.  Food web simulation:  [www.learner.org/courses/envsci/interactives/ecology/ecology.html?initLesson=1](http://www.learner.org/courses/envsci/interactives/ecology/ecology.html?initLesson=1)  Food web game:  [www.brainpop.com/games/foodfight/](https://www.brainpop.com/games/foodfight/) | This is an opportunity to revise the key terms associated with food chains learned in stage 7 (e.g. producer, consumer, herbivore, carnivore)  Introduce the term ‘trophic level’. |
| 9Be4 | Explain the role of decomposers | Discuss the place of decomposers in a food chain and food web.  Discuss the importance of decomposers in food webs, in terms of recycling material such as minerals and atoms.  Explain to learners that energy flows through a food web and materials cycle in a food web.  Demonstrate the breakdown of bread (or fruit) as moulds are allowed to grow on it in a sealed container.  Conclude that decomposers break down dead and decaying material and need warm, moist conditions with plenty of oxygen. | Prepared sample of mouldy bread (or fruit) in a sealed, transparent container. | Health and safety:   * + These samples must be carefully sealed to prevent any escape of microbes. Learners must be very careful not to damage the container.   + The container must be disposed of appropriately by either sterilising or incineration. |
| 9Be1 | Explain the ways in which living things are adapted to their habitats. Secondary sources can be used | Learners choose (from a list) an animal and a plant, and research and report on how each is adapted to its habitat.  Topics to consider include adaptations to:   * promote photosynthesis (plants) or find food sources (animals) * avoid being eaten * the abiotic factors in their environment. | Secondary sources. |  |
| 9Bv2 | Understand that organisms inherit characteristics from their parents through genetic material that is carried in cell nuclei | Inheriting characteristics  Discuss inherited characteristics by showing learners some images of families and by giving examples of similarities and differences between parents and offspring.  Explain that characteristics are passed on in genes and the genetic material is stored in the nucleus of the cell. Discuss how this genetic material is passed on from one generation to another. | Photographs of families. | A simple knowledge of genetic materials being located in the nucleus of most cells and being joined with other genes during fertilisation is all that is required. |
| 9Bv3  9Be2  9Ep3 | Describe how selective breeding can lead to new varieties  Research the work of scientists studying the natural world. Secondary sources can be used  Discuss the way that scientists work today and how they worked in the past, including reference to experimentation, evidence and creative thought | Learners research selective breeding using secondary sources to write an account of how to selectively breed a certain characteristic in an organism e.g.   * a flower grower trying to achieve a flower of a certain colour * a fruit grower trying to get a sweet citrus fruit that is easy to peel * a dairy farmer trying to breed cows that produce more milk * a chicken farmer trying to breed chickens that lay more eggs.   If time allows, learners present their findings as posters/presentations to the rest of the class. | Secondary sources. |  |
| 9Bv4  9Be2  9Ep1  9Ep3 | Discuss the work of Darwin in developing the scientific theory of natural selection  Research the work of scientists studying the natural world Secondary sources can be used  Discuss and explain the importance of questions, evidence and explanations, using historical and contemporary examples  Discuss the way that scientists work today and how they worked in the past, including reference to experimentation, evidence and creative thought | Show learners a video or photographs of finches from the Galapagos Islands. Ask: *Do you think these differences are due to artificial selection?*  Learners investigate Darwin’s work on finches and how he used evidence to develop his theory of natural selection, from secondary sources.  Explain that the theory of natural selection proposes that individuals with the adaptations most suitable for their environment are most likely to survive and breed. These individuals are likely to have offspring that inherit their adaptations. Over many generations a species can evolve.  Use simulations to explore the theory of natural selection. In this example the coat colour and teeth length of rabbits can be changed and it can be investigated how this affects rabbits’ survival when predated by wolves or in situations of food shortage. | Video on Darwin’s finches:  <https://youtu.be/l25MBq8T77w>  Secondary sources.  <https://phet.colorado.edu/en/simulation/legacy/natural-selection>  (Simulation is available in several languages.) |  |

**Unit 9.8 Chemicals and thermal energy**

It is recommended that this unit takes approximately **40% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of chemical reactions and energy transfers to develop their knowledge of:

* exothermic and endothermic reactions and processes
* the thermal (heat) energy transfer processes of conduction, convection and radiation
* cooling by evaporation.

Scientific enquiry work focuses on:

* selecting ideas and producing plans for testing based upon previous knowledge, understanding and research
* suggesting and using preliminary work to decide how to carry out an investigation
* deciding which measurements and observations are necessary and what equipment to use
* deciding which apparatus to use and assessing any hazards in the laboratory
* making sufficient observations and measurements to reduce error and make results more reliable
* using a range of materials and equipment and controlling risks
* making observations and measurements
* choosing the best way to present results
* describing patterns (correlations) seen in results
* interpreting results using scientific knowledge and understanding
* drawing conclusions
* evaluating the methods used and refining for further investigations
* explaining results using scientific knowledge and understanding; communicating this clearly to others.

Recommended vocabulary for this unit:

* reaction, reactant, product
* exothermic, endothermic, thermal (heat) energy transfer
* conduction, convection, radiation, evaporation, condensation
* respiration, photosynthesis.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Cc1  9Eo1  9Eo2  9Eo3  9Eo4  9Ec1  9Ec2  9Ec4 | Explore and explain the idea of endothermic processes and exothermic reactions e.g. melting of ice, and exothermic reactions, e.g. burning, oxidation  Make sufficient observations and measurements to reduce error and make results more reliable  Use a range of materials and equipment and control risks  Make observations and measurements  Choose the best way to present results  Describe patterns (correlations) seen in results  Interpret results using scientific knowledge and understanding  Draw conclusions | Exothermic or endothermic?  Ask learners: *How can we know whether heat has been released by a reaction or has been taken in?*  Introduce the terms ‘exothermic’ and ‘endothermic’. Explain that in exothermic reactions the temperature of the surroundings will go up and in endothermic reactions the temperature of the surroundings will go down.  **Scientific enquiry activity**  Learners investigate the reactions of an acid with:   * + magnesium   + sodium hydroxide solution   + potassium hydrogen carbonate   + sodium hydrogen carbonate   For each reaction they measure the temperature of the dilute acid before and after adding the test substance. They should design a table to record their results.  Learners classify each reaction as exothermic or endothermic on the basis of the temperature change.  Learners compare their results with those of others in the class. They identify where their results are similar or different to other groups. Learners discuss the methods they used to see if they can find a reason for differences in their results.  Learners write word equations for the reactions investigated (and symbol equations as an extension activity). | Magnesium, sodium hydroxide solution, potassium hydrogen carbonate, sodium hydrogen carbonate, dilute acid, laboratory glassware, thermometers | ‘Heat’ was referred to as ‘thermal energy’ in stage 7.  Spend time on discussing the planning process to develop skills of independent working as preparation for Upper Secondary study.  Health and safety: safety goggles must be used. |
| 9Cc1  9Ep5  9Eo1  9Eo2  9Eo3  9Eo4  9Ec1  9Ec2  9Ec4  9Ec7  9Ec8 | Explore and explain the idea of endothermic processes and exothermic reactions e.g. melting of ice, and exothermic reactions, e.g. burning, oxidation  Suggest and use preliminary work to decide how to carry out an investigation  Make sufficient observations and measurements to reduce error and make results more reliable  Use a range of materials and equipment and control risks  Make observations and measurements  Choose the best way to present results  Describe patterns (correlations) seen in results  Interpret results using scientific knowledge and understanding  Draw conclusions  Present conclusions and evaluation of working methods in different ways  Explain results using scientific knowledge and understanding. Communicate this clearly to others | Burning – an exothermic reaction  Light a candle. *What processes are happening as the candle burns? Is it an exothermic or endothermic process? How can you decide? Why are burning reactions useful?*  Give the word equation for burning a candle as:  paraffin + oxygen carbon dioxide + water  Show learners the word equations for burning some other fuels (e.g. ethanol, wood, coal) so that they can see the similarities.  Discuss how the thermal energy released by a reaction can be measured. Explain that equal masses of fuels can be used to heat equal volumes of water.  **Scientific enquiry activity**  Are all fuels equally efficient?  Learners can plan their investigations to answer this question in pairs or small groups. They should decide on their independent, dependent and control variables and write a method for the investigation. Their methods should include information about how many times they will repeat their measurements. Ask learners to remember the feedback they received on their previous plans. They should use that feedback to make this plan better.  As part of their plans, learners should identify whether they will need to do any preliminary work before they conduct their investigation e.g. to decide the mass of fuel or the volume of water to use.  Learners should also identify activity-related risks and hazards. They should decide the precautionary measures that they will take.  Learners peer assess their methods with a different group. Learners should give each other feedback on whether the plan is detailed. Does the plan clearly show:   * + What is the independent variable?   + How will the independent variable be changed?   + What is the dependent variable?   + How will the dependent variable be measured?   + What are the control variables?   + How will these variables be controlled?   + How many repeats will you take of your results?   + What are the precautionary measures?   Learners carry out the investigation, make a conclusion and evaluate the methods they used in their investigation.  Learners then present their conclusions and evaluation to the rest of the class. Each pair or group can decide how best to communicate their ideas to the class.  Another activity that could be done related to this, would be the collection of the products and test for carbon dioxide and water. | Candle, matches.  A range of fuels (e.g. ethanol, candle wax, snack foods), heatproof containers, water, thermometers (or similar).  Activity details for testing products of combustion:  [www.rsc.org/learn-chemistry/resource/res00000707/identifying-the-products-of-combustion?cmpid=CMP00005148](http://www.rsc.org/learn-chemistry/resource/res00000707/identifying-the-products-of-combustion?cmpid=CMP00005148)  Candle, funnel, boiling tubes, bungs, glass tubing, plastic tubing, filtering pump, cobalt chloride, limewater. | Note: learners should be able to apply their learning from physics to create an energy transfer diagram for a burning candle.  Chemical energy → light energy + thermal energy  Health and safety:   * If learners follow their own method then it must be checked by the teacher in advance. * Risks associated with heating should be discussed and controlled * The fuels available to learners should be restricted to short chain alcohols, wax and foods. Highly volatile fuels like petrol, diesel and hexane must not be used. |
| 9Cc1  9Eo2 | Explore and explain the idea of endothermic processes and exothermic reactions e.g. melting of ice, and exothermic reactions, e.g. burning, oxidation  Use a range of materials and equipment and control risks | The Fire Triangle  By discussion, identify the need for heat, fuel and oxygen to start /maintain a fire.  Learners should use this information to suggest ways of stopping different types of fire.  Learners produce a poster on fire prevention in the home  and/or work environment. | [www.youtube.com/watch?v=Yrd5HAGQqi8](https://www.youtube.com/watch?v=Yrd5HAGQqi8)  Secondary sources. |  |
| 9Cc1  9Ep4  9Ep7  9Ep8  9Eo1  9Eo2  9Eo3  9Eo4  9Ec1  9Ec2  9Ec4  9Ec5  9Ec7 | Explore and explain the idea of endothermic processes and exothermic reactions e.g. melting of ice, and exothermic reactions, e.g. burning, oxidation  Select ideas and produce plans for testing based on previous knowledge, understanding and research  Decide which measurements and observations are necessary and what equipment to use  Decide which apparatus to use and assess any hazards in the laboratory, field or workplace  Make sufficient observations and measurements to reduce error and make results more reliable  Use a range of materials and equipment and control risks  Make observations and measurements  Choose the best way to present results  Describe patterns (correlations) seen in results  Interpret results using scientific knowledge and understanding  Draw conclusions  Evaluate the methods used and refine for further investigations  Present conclusions and evaluation of working methods in different ways | Investigating endothermic processes  Revise previous learning by asking learners to write a definition of the terms ‘exothermic’ and ‘endothermic’.  Demonstrate that dissolving ammonium chloride (or ammonium sulfate) is an endothermic process.  Ask learners to predict what will happen if more ammonium chloride is dissolved or if less water is used.  Learners carry out the investigation to collect data to test their prediction. They can use a similar method as described on pages 66-67.  Alternatively, provide learners with secondary data to analyse.  Learners draw simple conclusions.  Conclude that the amount of a substance or water will affect the temperature change observed. | Ammonium chloride or ammonium sulfate, water, thermometers, polystyrene cups or beakers.  Equipment for groups of learners or secondary data to analyse. | Health and safety: safety goggles must be worn.  Note: 0.5 g to 3.0 g of ammonium chloride in 10 cm3 of water provides a suitable temperature decrease. |
| 9Cc1 | Explore and explain the idea of endothermic processes and exothermic reactions e.g. melting of ice, and exothermic reactions, e.g. burning, oxidation | Respiration and photosynthesis  Ask learners to create a mind map of what they have learned about photosynthesis from biology.  Provide learners with information sources (printed or online material) on some of the scientists who researched the chemistry of photosynthesis. They should answer the questions:   * + What investigation did Joseph Priestley do with a mint plant and a candle?   + Describe the result.   + Explain what the result meant.   + What investigation did Jan Ingenhousz do by putting leaves in water?   + Describe the result.   + Explain what the result meant.   Learners identify that these researchers used experiments to provide evidence that oxygen is a product of photosynthesis.  Learners write equations for photosynthesis. *Is photosynthesis an endothermic or exothermic reaction? How do you know?*  **Extension activity:** Learners who require more challenge write balanced symbol equations for the reactions.  Discuss that respiration is the ‘reverse’ of photosynthesis. Write word (and symbol) equations. *Would you expect it to be an exothermic or an endothermic process?*  Conclude that photosynthesis is an example of an endothermic reaction and respiration is an example of an exothermic reaction. | Information sources for learners. | Respiration can be represented by the word equation:  glucose + oxygen → carbon dioxide + water  Photosynthesis can be represented by the word equation:  carbon dioxide + water → glucose + oxygen |
| 9Cc1  9Pe3 | Explore and explain the idea of endothermic processes and exothermic reactions e.g. melting of ice, and exothermic reactions, e.g. burning, oxidation  Explain cooling by evaporation | Endothermic phase changes  In pairs, learners try to explain: *Why do you feel cold when you get out of the swimming pool on a hot day?*  Discuss why melting ice and evaporation are endothermic processes. Learners write their own explanations using particle diagrams of solids, liquids and gases.  Ask learners to predict whether freezing and condensation are exothermic or endothermic. Support learners in applying the law of conservation of energy to this example. They can add their conclusions to their particle diagrams. *How could you test your prediction?*  Learners name other examples of cooling by evaporation that they have encountered in biology and physics.  Conclude that evaporation and melting are endothermic processes, as the energy is needed to allow particles to spread out and to move faster. Condensation and freezing are exothermic processes, as the particles slow down and the kinetic energy which the particles had is released by the material.  **Extension activity:**  Investigate which conditions aid the rate of evaporation using dampened tissues or small pieces of cloth. Factors which can be tested are temperature and moving air. | Small pieces of cloth (or tissues), timers. | Ask learners to give a particle explanation of the processes wherever they can.  The law of conservation of energy was covered in stage 7. |
| 9Pe2  9Ep8  9Eo3  9Ec2 | Identify and explain the thermal (heat) energy transfer processes of conduction, convection and radiation  Decide which apparatus to use and assess any hazards in the laboratory, field or workplace  Make observations and measurements  Interpret results using scientific knowledge and understanding | Heat on the move – conduction  Discuss with learners that there are three main methods of heat transfer: conduction, convection and radiation.  Show learners three blocks made of metal, polystyrene and wood.   * Pass them around and ask for adjectives to describe what they are like, e.g. cold, warm, smooth, shiny. * Ask learners to predict what will happen over time if you put a piece of ice on each of the blocks. Choose two groups with conflicting ideas to try to persuade each other, using reasons. * Place three identical pieces of ice on the three surfaces. Observe the results (the one on metal should melt fastest). * Ask if anyone can explain what is happening and why.   (The metal is a good conductor of heat. It conducts the heat from the surrounding air to the ice cube. Although the metal feels cold when we touch it, this is because it conducts the heat away from our fingers. Metal will conduct heat from the hotter object to the colder object. The wood and polystyrene are poor conductors of heat so the ice cubes do not melt.)  Learners use rods of different materials to test how quickly heat conducts through them. A blob of wax which holds a drawing pin on the end can be used as an indicator of temperature. Heat the rods at one end (e.g. by placing in hot water) and time how long it takes for the wax to melt for each rod.  Ask: *What happens to the thermal energy when you put a coat on?* *What happens to the thermal energy when you put a coat on a snowman?* Ask them to explain both in terms of conduction.  Discuss the results with the class. Ask learners to recall what happens to the particles when materials get warmer. (This is an opportunity to revise the particle model.)  Learners try to model the conduction of heat through solids as transferred by the passing on of vibrations from particle to particle. Learners then develop this model to explain that metals are good conductors of heat because they have closely packed particles and electrons that can move easily in the solid.  Conclude that conduction takes place when particles collide. Conduction transfers thermal energy from a hotter area to a cooler area. Solids conduct heat much better than liquids and gases. Metals are the best conductors because they have electrons that can move through the metal. | A video of this demonstration is available:  <https://youtu.be/SNY8o3s5KL0>  Metal and non-metal rods of different materials, candle wax or petroleum jelly, drawing pins, hot water, beaker or suitable container.  See example on page 6 of the following link: [www.ocr.org.uk/Images/177366-heat-transfer-activity-teacher-instructions.pdf](http://www.ocr.org.uk/Images/177366-heat-transfer-activity-teacher-instructions.pdf)  This video includes animations showing the conduction of heat in glass and metal:  <https://youtu.be/9joLYfayee8> | Distinguish between heat and temperature.  Ask learners to give a particle explanation of the processes wherever they can.  Health and safety:safety goggles must be worn. |
| 9Pe2 | Identify and explain the thermal (heat) energy transfer processes of conduction, convection and radiation | Heat on the move – convection  Ask learners why heat cannot move through liquids and gases by conduction.  Teacher demonstration of convection. Prepare:   * a small conical flask of warmed water which is coloured with food colouring; this should have a bung added with a small tube inserted * a large transparent container of cold water.   Place the conical flask at the bottom of the container of cold water. The warm coloured water escapes through the small hole at the top showing convection currents.  Make it clear to learners that the colour is only there so that the movement of the water can be seen.  Take suggestions from learners about what is happening at each part of the convection current. Explain the results in terms of density. Learners may already know that hot air rises; use this to make the more general point that less dense objects float.  Learners write a summary of the movement in a convection current. The key points they should include are:   * warmer water has particles that move faster so they spread out * warmer water becomes less dense and more buoyant so rises * cooler water sinks because it is less dense * warm and cold water is passed around in convection currents.   Ask learners to take it in turns to describe the convection currents in different scenarios (e.g. a room with a heater, a fish tank with a heater, a refrigerator with a cooling coil).  Conclude that convection can happen where particles are fluid, i.e. in liquids and gases. Convection currents only form where there is space so the fluid can move. | Large transparent container,  50ml conical flask with bung and small tube inserted, food colouring, Bunsen burner.  Instructions on how to do this demonstration can be seen as demonstration 1 at: <https://youtu.be/WEDUtS0IMws> | Note: the concept of density is important for understanding convection and may need to be revised and/or reinforced.  Learners may have previously been able to see convection currents in a bathroom (where the water droplets make the movement above a hot bath visible). |
| 9Pe2  9Eo3  9Ec2  9Ec4 | Identify and explain the thermal (heat) energy transfer processes of conduction, convection and radiation  Make observations and measurements  Interpret results using scientific knowledge and understanding  Draw conclusions | Heat on the move – radiation  Show a black pan of hot water. Ask learners to suggest ways they could prove it was hot. Discuss their ideas and ask them to identify the heat transfer processes involved:   * hand over the top – sense heat by convection * touch the side – sense heat by conduction * hand near the side – elicit the idea that this could not be sensed by conduction or convection.   Introduce the idea of heat transfer by radiation. Explain that infrared radiation is emitted by hot objects in all directions. Explain infrared as being similar to visible light, and having similar (though not identical) properties.  Show a shiny pan alongside the black pan. Have hot water in both. *Can you feel the radiation from the sides of the pan (without actually touching it)?* *Does one seem hotter than the other?* Ask learners to suggest reasons.  **Scientific enquiry activity**  Investigation of cooling by radiation  Learners investigate how radiation can cool things down.   * + They use boiling tubes of hot water which are allowed to cool down. The boiling tubes have different surfaces, e.g. one with shiny aluminium foil, one with aluminium foil that has been blackened (see note).   + They measure the temperature changes and compare the outcomes.   Describe the trends in the results: *Which one cools the least?*  *Which one cools the most?*  Learners research which colours are best for absorbing and emitting infrared radiation. They use this to discuss the colour used for solar panels, the colour used for the top and bottom sides of the space shuttle, and the colour traditionally used for houses in warm climates.  Conclude that hot objects emit infrared radiation in all directions. Black matt surfaces are better for absorbing and emitting infrared radiation than shiny, light surfaces. | Black pan (or other black metal container), hot water.  Black pan (or other black metal container), shiny stainless steel pan (or other shiny metal container), hot water.  Boiling tubes, shiny (aluminium) foil, a means of blackening foil, thermometers, stopwatches, hot water. | Explain that the heat is not carried by particles in this case but by a type of ray similar to light which can travel through space.  Note: many activities using blackened glassware do not produce convincing results. The most effective method is to use soot (but this is messy). Aquadag works but is expensive. Black paint normally does not work well. |
| 9Pe2 | Identify and explain the thermal (heat) energy transfer processes of conduction, convection and radiation | Show learners a vacuum flask containing very hot water. Also display an image of a cross-section of a vacuum flask. Ask learners to suggest how it keeps things hot. The key points are:   * vacuum reduces heat by conduction and convection (no particles) * shiny surfaces reflect radiated heat back into the hot liquid * the lid reduces heat loss by convection (and evaporation).   Learners study different approaches used to keep things hot or cold. For each one they should identify the types of heat transfer involved. Possibilities include:   * cold transport for vaccines * clothes and sleeping bags for arctic conditions * passive cooling of houses (e.g. malqafs, reflective roofs, shutters). | Vacuum flask and image of cross-section of a vacuum flask.  An alternative is to show a real vacuum flask that has been cut. | Note: learners often have difficulty in distinguishing the different heat transfer processes so try to provide a lot of practice. |

**Unit 9.9 The energy crisis and human influences**

It is recommended that this unit takes approximately **30% of the teaching time for this term**.

In this unit, learners build on their previous knowledge of energy and the environment to develop their knowledge of:

* factors affecting the size of populations
* some effects of human influences on the environment
* the world’s energy needs.

Scientific enquiry work focuses on:

* describing patterns (correlations) seen in results
* interpreting results using scientific knowledge and understanding
* looking critically at sources of secondary data.

Recommended vocabulary for this unit:

* population, birth rate, death rate, survival, habitat, food source, predators, disease
* insecticides, pesticides, monocultures, introduced species, deforestation, pollution
* population curve, lag phase, exponential phase, stationary phase, death phase, endangered, extinction
* energy source, power station, turbine, generator
* fossil fuel, renewable, non-renewable, carbon dioxide, nuclear, solar, hydroelectric, geothermal.

| **Framework Code** | **Learning Objective** | **Suggested activities to choose from** | **Resources** | **Comments** |
| --- | --- | --- | --- | --- |
| 9Be5  9Ec3 | Describe factors affecting the size of populations  Look critically at sources of secondary data | Ask: *What factors affect the size of the human population?* Elicit that the same two factors apply to all organisms, specifically, rate of birth and rate of death.  Give learners data on world population size. Discuss what scale to use for the *y*-axis.  Learners plot a graph of the data. Discuss the shape of the data and identify that it requires a smooth line of best fit.  Discuss whether all populations do grow in this manner. *If so, what might the consequences be? And, if not, what factors might come into play to reduce the rate of population growth?*  Show a model graph that shows the first three phases of population growth (lag, exponential and stationary phases). Learners identify the phases that are evident in the human population data.  Ask learners to name an animal that no longer exists on the planet. Expect answers such as dinosaurs, dodo etc. Explain that species that are very close to being extinct are classed as ‘endangered’. Ask learners to suggest the growth curve for an organism that has become endangered or extinct.  Conclude that population growth occurs in stages. This includes lag, exponential, stationary and death phases. At the moment the global human population is showing exponential growth. | World population growth data:  <http://geography.about.com/od/obtainpopulationdata/a/worldpopulation.htm> |  |
| 9Be5  9Ec1  9Ec3 | Describe factors affecting the size of populations  Describe patterns (correlations) seen in results  Look critically at sources of secondary data | Build on learners’ previous understanding of food chains by giving them population data for a predator and prey relationship.  Learners plot the population/time graph.  In pairs they describe what happens when:   * the population of prey increases * the population of predators increases * the population of prey decreases * the population of predators decreases.   Elicit that the graph shows a repeating curve for each of predator and prey; the line for the prey has higher peaks and reaches its highest point before that for the predator. | Population data for a predator and prey (e.g. lion and antelope, fox and rabbit, shark and fish, lynx and hare). |  |
| 9Be5  9Be6 | Describe factors affecting the size of populations  Describe and investigate some effects of human influences on the environment | Learners create a mind map, or similar, which shows the factors that can influence the birth rate and/or survival rate. For each factor, they give examples. Possible factors include:   * food supply * clean water supply * predators * space/suitable habitat * light (for plants) * disease.   Groups of learners investigate examples of how human activities can influence these factors. Possible activities include:   * use of insecticides, pesticides, monocultures * hunting, fishing, introduced (non-indigenous) species * deforestation, habitat clearance * pollution of land, air, water (e.g. marine plastics, water acidification).   Learners present their research and all learners make notes on a range of human influences on the environment. |  | This is a good opportunity to consolidate prior learning on living things in their environment. |
| 9Pe1  9Be6  9Ec1  9Ec2 | Use knowledge of energy sources including fossil fuels and renewable energy resources to consider the world’s energy needs, including research from secondary sources  Describe and investigate some effects of human influences on the environment  Describe patterns (correlations) seen in results  Interpret results using scientific knowledge and understanding | Show learners diagrams of a range of electricity generators. For each one, learners identify the turbine, generator and the system used to make the turbine spin.  Learners classify the energy sources in different ways such as:   * need to be burned / do not need to be burned * renewable / non-renewable * fossil fuel / non-fossil fuel * emits carbon dioxide / does not emit carbon dioxide * original source of the energy is the Sun / original source of energy is not the Sun.   Discuss and clarify any misconceptions raised by this activity.  Learners contrast electricity production that uses turbines with photovoltaic cells.  Provide learners with data about the world’s energy consumption. Learners draw a graph of the data and describe the trend. They then discuss explanations for this trend (e.g. human population, more technology, more heating / air conditioning etc.).  Learners analyse the current annual output of different types of power station and discuss:   * Is there a global energy crisis? * How can the world’s energy needs be supplied?   Support learners in using data to support their conclusions and claims.  If feasible, arrange a visit to a local power station.  Learners study energy needs in their local area and evaluate which type(s) of power station would be most suitable.  **Extension activity:** Learners who require more challenge can research the use of former oil and gas reservoirs for carbon dioxide storage. | Simple diagrams of a range of power stations including those using gas, coal, wood, nuclear, geothermal, wave, wind, or hydroelectric sources of energy.  Data of the world’s energy consumption by year.  Data about the current annual output of different types of power station. | Learners have previously studied the basic idea of moving a conductor in a magnetic field to produce a current in Stage 7  A careful definition of renewable is necessary i.e. a source that can be replaced in a shorter time than it is used.  Renewable energy sources should include solar, waves, rivers, tides and wind.  Distinguish between energy sources (used to meet the needs of human populations) and types of energy that can be stored. |