

Cambridge Lower Secondary Science 0893 Stage 7

This Cambridge Scheme of Work is for use with the Cambridge Lower Secondary Science Curriculum Framework published in September 2020 for first teaching in September 2021.



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Introduction

This document is a scheme of work created by Cambridge Assessment International Education for Cambridge Lower Secondary Science Stage 7.

It contains:

- suggested units showing how the learning objectives in the curriculum framework can be grouped and ordered
- at least one suggested teaching activity for each learning objective
- a list of subject-specific language that will be useful for your learners
- some possible models and representations that are relevant to the learning objectives
- some possible misconceptions learners may have, or develop
- sample lesson plans.

You do not need to use the ideas in this scheme of work to teach Cambridge Primary Lower Secondary Stage 7. This scheme of work is designed to indicate the types of activities you might use, and the intended depth and breadth of each learning objective. These activities are not designed to fill all of the teaching time for this stage. You should use other activities with a similar level of difficulty, including those from endorsed resources.

The accompanying teacher guide for Cambridge Lower Secondary Science will support you to plan and deliver lessons using effective teaching and learning approaches. You can use this scheme of work as a starting point for your planning, adapting it to suit the requirements of your school and needs of your learners.

Long-term plan

This long-term plan shows the units in this scheme of work and a suggestion of how long to spend teaching each one. The suggested teaching time is based on 90 total hours of teaching for Science Stage 7 at 3 hours a week. The actual number of teaching hours may vary according to your context.

Unit and suggested order	Suggested teaching time	Unit and suggested order	Suggested teaching time	Unit and suggested order	Suggested teaching time
Unit 7.1 Cells	11% (10 hours)	Unit 7.4 Classifying life	11% (10 hours)	Unit 7.7 Environment and ecosystems	13% (12 hours)
Unit 7.2 Classifying matter	13% (12 hours)	Unit 7.5 Explaining properties of matter	9.5% (8 hours)	Unit 7.8 Chemical changes and reactions	11% (10 hours)
Unit 7.3 Forces in space	11% (10 hours)	Unit 7.6 Energy and sound	11% (10 hours)	Unit 7.9 Electricity	9.5% (8 hours)

Sample lesson plans

You will find two sample lesson plans at the end of this scheme of work. They are designed to illustrate how the suggested activities in this document can be turned into lessons. They are written in more detail than you would use for your own lesson plans. The Cambridge Lower Secondary Science Teacher Guide has information on creating lesson plans.

Other support for teaching Cambridge Lower Secondary Science Stage 7

Cambridge Lower Secondary centres receive access to a range of resources when they register. The Cambridge Lower Secondary support site at **<https://lowersecondary.cambridgeinternational.org>** is a password-protected website that is the source of the majority of Cambridge-produced resources for the programme. Ask the Cambridge Coordinator or Exams Officer in your school if you do not already have a log-in for this support site.

Included on this support site are:

- the Cambridge Lower Secondary Science Curriculum Framework, which contains the learning objectives that provide a structure for your teaching and learning
- grids showing the progression of learning objectives across stages
- the Cambridge Lower Secondary Science Teacher Guide, which will help you to implement Cambridge Lower Secondary Science in your school
- templates for planning
- worksheets for short teacher training activities that link to the teacher guide
- assessments provided by Cambridge
- a list of endorsed resources, which have been through a detailed quality assurance process to make sure they are suitable for schools teaching Cambridge Lower Secondary Science worldwide
- links to online communities of Cambridge Lower Secondary teachers.

Resources for the activities in this scheme of work

We have assumed that you will have access to these resources:

- paper, graph paper, pens, pencils, rulers and calculators for learners to use
- clean water
- the internet.

Other suggested resources for individual units and/or activities are described in the rest of this document. You can swap these for other resources that are available in your school.

The Cambridge Lower Secondary Science Equipment List provides a list of recommended scientific equipment that your school should have access to in order to teach all stages of Cambridge Lower Secondary Science. It is available on the support site.

Websites

There are many excellent online resources suitable for teaching Cambridge Lower Secondary Science. Since these are updated frequently, and many are only available in some countries, we recommend that you and your colleagues identify and share resources that you have found to be effective for your learners.

Approaches to teaching Cambridge Lower Secondary Science Stage 7

There are three components to the Cambridge Lower Secondary Science Curriculum:

- four content strands (Biology, Chemistry, Physics, and Earth and Space)
- one skills strand (Thinking and Working Scientifically)
- one context strand (Science in Context).

When planning lessons, the three components should work together to enable you to provide deep, and rich, learning experiences for your learners.

We recommend you start your planning with a learning objective from one of the four content strands. This determine the focus of the lesson. Once there is a content learning objective lesson focus you can consider what Thinking and Working Scientifically learning objectives can be integrated into your teaching, so learners are developing their scientific skills alongside their knowledge and understanding of science.

This approach is exemplified in this scheme of work by providing activities that cover the content learning objectives while also developing selected Thinking and Working Scientifically learning objectives. Some Thinking and Working Scientifically learning objectives are covered multiple times over the scheme of work which reflects the need for learners to have several opportunities to develop skills.

The selection, and frequency, of Thinking and Working Scientifically learning objectives in this scheme of work may match the needs of your learners. However, the selection of Thinking and Working Scientifically learning objectives needs suit the requirements of your school and needs of your learners. Any changes to what Thinking and Working Scientifically learning objectives are selected to be developed when teaching the content learning objectives will require activities to be reviewed and edited.

Once you are confident with the combination of content and Thinking and Working Scientifically learning objectives, you then have the option to integrate context into your lessons to show how the learning objectives and/or skills relate to the world the learners know and experience. The Science in Context learning objectives provide guidance on doing this. As including context is dependent on your learners and your context, the scheme of work does not give contextual links to an activity. Possible ways to contextualise units are provided in the unit introductions, aligned to the relevant Science in Context objectives.

Further support about integrating Thinking and Working Scientifically and Science in Context into lessons can be found in the Cambridge Lower Secondary Science Teacher Guide.

Models and representations

Scientists use models and representations to represent objects, systems and processes. They help scientists explain and think about scientific ideas that are not visible or are abstract. Scientists can then use their models and representations to make predictions or to explain observations. Cambridge Lower Secondary Science includes learning objectives about models and representations because they are central to learners' understanding of science. They also prepare learners for the science they will encounter later in their education.

To support the integration of models and representations into your teaching, for each learning objective we have suggested possible models you may wish to use.

Misconceptions

Scientific misconceptions are commonly held beliefs, or preconceived ideas, which are not supported by available scientific evidence. Scientific misconceptions usually arise from a learner's current understanding of the world. These ideas will be informed by their own experiences rather than evidence. To support you in addressing misconceptions, for each learning objective in each unit we have suggested, where relevant, possible misconceptions to be aware of.

Due to the range of misconceptions that learners can hold not all misconceptions have been provided and you may encounter learners with misconceptions not presented in this scheme of work.

Misconceptions may be brought to the lesson by the learners, reinforced in the lesson, or created during a lesson. It is important that you are aware of misconceptions that learners may exhibit so that you can address them appropriately.

It is important to note that not all misconceptions are inappropriate based on the conceptual understanding learners are expected to have at different stages of their education. Therefore, some misconceptions may be validly held by learners at certain stages of their learning. A misconception of this type is known as an age-appropriate concept. Trying to move learners away from age-appropriate concepts too soon may give rise to other, more significant, misconceptions or barriers to their understanding of science. Over time age-appropriate concepts can become misconceptions when they start to interfere with the expected level of understanding learners need to have.

The misconceptions flagged in this scheme of work are considered to be either inappropriate concepts for a learner at this stage of understanding science or important age-appropriate concepts to be aware of, so they are not challenged too early.

Health and safety

An essential part of this curriculum is that learners develop skills in scientific enquiry. This includes collecting primary data by experiment. Scientific experiments are engaging and provide opportunities for first-hand exploration of phenomena. However, they must, at all times, be conducted with the utmost respect for safety, specifically:

- It is the responsibility of the teacher in charge to adhere and conform to any national, regional and school regulation in place with respect to safety of scientific experimentation.
- It is the responsibility of the teacher in charge to make a risk assessment of the hazards involved with any particular class or individual when undertaking a scientific experiment that conforms to these regulations.

Cambridge International takes no responsibility for the management of safety for individual published experiments or for the management of safety for the undertaking of practical experiments in any given location. Cambridge International only endorses support material in relation to curriculum content and is not responsible for the safety of activities contained within it. The responsibility for the safety of all activities and experiments remains with the school.

The welfare of living things

Throughout biology, learners study a variety of living things, including animals. As part of the University of Cambridge, Cambridge International shares the approach that good animal welfare and good science work together.

Learners should have opportunities to observe animals in their natural environment. This should be done responsibly and not in a way that could cause distress or harm to the animals or damage to the environment.

If living animals are brought into schools then the teacher must ensure that any national, regional and school regulations are followed regarding animal welfare. In all circumstances, the teacher responsible must ensure all animals have:

- a suitable environment, including being housed with, or apart from, other animals (as required for the species)
- a suitable diet
- the opportunity to exhibit normal behaviour patterns
- protection from pain, injury, suffering and disease.

There is no requirement for learners to participate in, or observe, animal dissections for Cambridge Lower Secondary. Although dissection can provide a valuable learning opportunity, some learners decide not to continue studying biology because they dislike animal dissection. Several alternatives are available to dissection (such as models and diagrams) which you should consider during your planning.

If you decide to include animal dissection then animal material should be obtained from premises licensed to sell them for human or pet consumption, or from a reputable biological supplier. This approach helps to ensure animal welfare standards and also decreases the risk from pathogens being present in the material. Neither you nor your learners should kill animals for dissection.

When used, fresh material should be kept at 5 °C or below until just before use. Frozen material should be defrosted slowly (at 5 °C) without direct heat. All fresh or defrosted material should be used within 2 days. Preserved animal materials should only be handled when wearing gloves and in a well-ventilated room. The responsibility for ensuring the welfare of all animals studied in science remains with the school.

Unit 7.1 Cells

Unit 7.1 Cells

Outline of unit:

This unit introduces cells as the basic unit of all living organisms and microorganisms are considered as examples of single-celled organisms. Learners identify and describe the functions of some cell structures; they learn how the structures of some specialised cells are related to their function. Learners then study the similarities and differences between the structures of plant and animal cells and learn that cells can be grouped together to form tissues, organs and organ systems.

Learners will have opportunities to select equipment, plan how to make slides of plant and animal cells safely and use microscopes. If microscopes are not available, then videos could be used as an alternative. Learners will also evaluate models of cells, make measurements of cells and interpret the data.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- knowing plants get their energy from light while animals get their energy from eating plants or other animals
- identifying, and describing, the link between the structure of some organs and their functions (e.g. ears, eyes, teeth).

Suggested examples for teaching Science in Context:

7SIC.01 Discuss how scientific knowledge is developed through collective understanding and scrutiny over time.

Learners can discuss how scientific understanding about cells has changed over time as microscopes have been developed and improved.

7SIC.02 Describe how science is applied across societies and industries, and in research.

Learners can use their knowledge of cells, tissues and organs to consider current issues (e.g. stem cells, tissue matching and organ transplants).

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Bs.01 Understand that all organisms are made of cells and microorganisms are typically single celled.	Organism, cell, microorganism	<p>An animation that shows that living organisms are made up of cells.</p> <p>Anatomical models or diagrams of:</p> <ul style="list-style-type: none"> organs that show their cellular structure (e.g. a cross-section through a leaf) microorganisms. 	<p>Some learners may be confused about the biological use of the term 'cell' and the use of electrochemical 'cells' that make up batteries. Explain that the terms are very different with biological cells found in living organisms whereas electrochemical cells are not part of the biological basis of living things. The scale is also very different: biological cells are mostly microscopic; electrochemical cells can, normally, be seen by eye.</p> <p>Learners may not understand that microorganisms are typically single celled when other organisms are made up of many cells. Explain this by using drawings (or models) of microorganisms that show that they are typically made of a single cell.</p>
7Bs.02 Identify and describe the functions of cell structures (limited to cell membrane, cytoplasm, nucleus, cell wall, chloroplasts, mitochondria and sap vacuole).	Cell structure, cell membrane, cytoplasm, nucleus, cell wall, chloroplasts, mitochondria, sap vacuole	<p>Diagrams of generalised cells are models that show the structures identified in the learning objective.</p> <p>Learners can create physical models of cells to show the structures identified in the learning objective.</p>	<p>Learners may struggle to appreciate the scale of cells and their structures and may think that cell structures are smaller cells. Clearly explain that cells are the basic units of living things and that the structures are the components of the cells. Show some size comparisons (or charts) to help sort out the scale of the cells and structures.</p> <p>The idea of a 'cell wall' may conjure up a picture of a solid wall. Explain that the cell wall is more like scaffolding around the cell with many holes and it does not act as a barrier to substances moving in or out of the cell. Clarifying this may prevent misunderstanding later on when learners study the movement of substances in and out of cells.</p> <p>In diagrams, the cell wall is usually shown as a double line and the cell membrane appears to be labelled as the inner wall; this can confuse learners. Point out that the cell membrane is actually pressed up against the inner cell wall.</p>

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
			It might be useful for future learning, to tell learners that membranes are also found around the mitochondria, chloroplasts, nucleus and sap vacuole.
7Bs.03 Explain how the structures of some specialised cells are related to their functions (including red blood cells, neurones, ciliated cells, root hair cells and palisade cells).	Specialised cells, red blood cells, neurones, ciliated cells, root hair cells, palisade cells, adaptation	<p>Learners can examine, make and/or use physical models of different types of cell to demonstrate how their structure is related to their function.</p> <p>Learners can create a pictorial list of different types of cells, including microorganisms, and use this to highlight adaptations by adding labels and/or descriptions.</p>	<p>In some resources, specialised cells are not shown to scale, so learners may think that all cells are a similar size.</p> <p>This can be addressed by showing learners where different cells fit on a size scale. For example, Learners could compare the approximate diameters of red blood cells (7 micrometres), some palisade cells (100 micrometres) and some neurones (1 000 000 micrometres).</p>
7Bs.04 Describe the similarities and differences between the structures of plant and animal cells.	Plant cells, animal cells, cell structures, cell membrane, cytoplasm, nucleus, cell wall, chloroplasts, mitochondria, sap vacuole	<p>Learners can use diagrams and/or physical models of plant and animal cells to compare cells.</p> <p>Learners can create physical models of both an animal cell and a plant cell to help identify their key similarities and differences.</p>	Some learners may think that all plant cells have chloroplasts. Remind learners of the function of chloroplasts; ask them how chloroplasts in cells in parts of plants below ground could carry out their function.
7Bs.05 Understand that cells can be grouped together to form tissues, organs and organ systems.	Cells, tissues, organs, organ systems	A flow chart that uses arrows to show that cells make up tissues, tissues make up organs and organs make up organ systems can be used.	<p>Learners may believe that all living organisms show every layer of organisation described in the learning objective. Explain that only multicellular organisms can form tissues and only more complex living organisms form organs and have organ systems.</p> <p>Organ systems may be seen by some learners as 'stand alone' systems. Explain that not only do organ systems interact with each other, but their functions may also overlap. For example, the human circulatory system plays a role in transporting oxygen provided by the gas exchange (respiratory) system.</p>

Unit 7.1 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7Bs.01 Understand that all organisms are made of cells and microorganisms are typically single celled.</p>	<p>7TWSc.02 Decide what equipment is required to carry out an investigation or experiment and use it appropriately.</p> <p>7TWSc.05 Carry out practical work safely.</p> <p>7TWSp.05 Know the meaning of hazard symbols and consider them when planning practical work.</p> <p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p>Using light microscopes to observe and compare cells (requires additional resources)</p> <p>Explain to learners that they are going to look at their own cheek cells. Ask them to work in pairs to list what equipment they might need. Suggest the use of a nuclear stain (e.g. methylene blue) to make the nuclei easier to see. Before any practical work is started, discuss the health and safety aspects of working with human saliva and cheek cells; ensure that learners are aware of any hazards associated with the use of the chosen stain.</p> <p>Learners, working individually, make preparations of their own cheek cells using sterile cotton buds on microscope slides, and a nuclear stain. Choose a good preparation and attach a camera to a monocular light microscope to show learners what they are looking for. Ask learners to make a labelled drawing of one or two cells. Encourage them to add a scale (or magnification) to their drawing. Introduce the formula:</p> $\text{total microscope magnification} = \text{magnifying power of eyepiece} \times \text{magnifying power of objective lens}$ <p>Learners work in pairs, or small groups, to make preparations of plant cells (e.g. red onion cells) on microscope slides; alternatively, provide learners with prepared microscope slides that show plant cells clearly. Show learners what they are looking for with the microscope. Ask learners to make a labelled drawing of one or two cells, calculate total microscope magnification and add this to their drawing.</p> <p>Then provide learners with living specimens of non-pathogenic, single-celled organisms (e.g. <i>Amoeba</i> or <i>Paramecium</i>). These are best viewed using binocular microscopes, if available, or under low power using monocular microscopes and cavity slides. Ask learners to calculate the total microscope magnification at which the organisms can be seen most clearly.</p> <p>Give learners pictures (or photographs) of microorganisms, such as bacteria, that include information about how much the microorganisms have been magnified. Learners measure the sizes of the microorganisms in the pictures and then calculate the actual size of the microorganisms, using the formula:</p> $\text{actual size} = \text{size in picture} / \text{magnification}$ <p>Ensure learners use the same units for both actual size and picture size.</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>Based on their research, learners can draw, and describe cells, from an animal, a plant and a microorganism. They can present their understanding of cells in a poster; encourage them to cover the key points (i.e. definition of a cell, all organisms are made of cells, microorganisms typically being single celled).</p> <p>For health and safety reasons, learners should use clean cotton buds, only use their own cells and put used cotton buds and microscope slides with coverslips straight into disinfectant. Ensure that learners are aware of any hazards associated with the use of the chosen stain.</p> <p>Resources: light microscopes (monocular or binocular), microscope slides (including cavity slides), coverslips, cotton buds, mounted needles for lowering coverslips, nuclear stain, disinfectant, red onion, pictures of microorganisms</p>
	<p>7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys.</p> <p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p>Using micrographs to observe and compare cells</p> <p>Provide learners with a range of high-quality photomicrographs of human cheek cells, red onion cells, single-celled organisms (e.g. <i>Amoeba</i>, <i>Paramecium</i>) and microorganisms (e.g. bacteria). Explain how the images were produced; include the use of stains and how microscope slides are made.</p> <p>Learners observe the photomicrographs, identify the cells and make labelled diagrams of one or two cells from each image. Give learners information about the eyepieces and objective lenses used. Ask them to calculate total microscope magnification and add this to their drawing. Introduce the formulae, explaining that learners need to use the same units for both actual size and picture size:</p> $\text{total microscope magnification} = \text{magnifying power of eyepiece} \times \text{magnifying power of objective lens}$ <p>By measuring the sizes of the cells in the pictures, learners can calculate the actual size of the microorganisms, using</p> $\text{actual size} = \text{size in picture} / \text{magnification}.$ <p>Based on their research, learners can draw, and describe cells, from an animal, a plant and a microorganism. They can present their understanding of cells in a poster; encourage them to cover the key points (i.e. definition of a cell, all organisms are made of cells, microorganisms typically being single celled).</p> <p>Resources: Photomicrographs (with the magnification data) of human cheek cells, red onion cells, single-celled organisms and microorganisms.</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7Bs.02 Identify and describe the functions of cell structures (limited to cell membrane, cytoplasm, nucleus, cell wall, chloroplasts, mitochondria and sap vacuole).</p>	<p>7TWSm.01 Describe the strengths and limitations of a model.</p>	<p>Functions of cell structures</p> <p>Introduce the structure and function of the following cell structures: cell membrane, cytoplasm, nucleus, cell wall, chloroplasts, mitochondria and sap vacuole. Learners, working in pairs, create models of cells that show these structures. The models are then passed to other pairs of learners who label the structures they can see before the model is finally returned to the creators to make any modifications needed to ensure all cell structures are included and are clear. Ask learners:</p> <p><i>How is the cell wall shown in the model the same as / different to the cell wall in a living cell?</i></p> <p><i>How many mitochondria are in the model cell that they made and how many might be in a living cell?</i></p> <p><i>What proportion of the model cell is taken up by the sap vacuole and how might this differ in a living plant cell?</i></p> <p>Provide small groups of learners with photomicrographs and/or electron micrographs that clearly show some (or all) of the following cell structures: cell membrane, cytoplasm, nucleus, cell wall, chloroplasts, mitochondria and sap vacuole. Ask learners to use their physical models to help them identify each cell structure in the micrographs; they annotate the micrographs with the name and function of each cell structure.</p> <p>Learners can then describe the strengths and limitations of their physical cell models by comparing their models to the images of cells.</p> <p>This activity can be extended by telling learners the actual sizes of different cell structures shown in the micrographs and asking them to calculate the magnification of the cell structures in the micrographs they have been given. Make it clear which dimension is being compared (i.e. length, width, diameter). Additionally, give learners the magnification of their micrograph and ask them to calculate the actual size of a cell structure that they can identify. Compare results for the same cell structure from different learners and discuss why differences may occur.</p> <p>Resources: modelling materials, micrographs of cells</p>
<p>7Bs.03 Explain how the structures of some specialised cells are related to their functions (including red blood cells, neurones, ciliated cells,</p>	<p>7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information,</p>	<p>The structure and function of specialised cells</p> <p>Learners, working in pairs or small groups, research the structure and function of a different specialised cell to include: red blood cells, neurones, ciliated cells, root hair cells and palisade cells. Each group makes a poster about their specialised cell; the poster includes a drawing of the cell structure and written information about how the cell is specialised for its function. Groups then visit the different posters,</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
root hair cells and palisade cells).	and making and using keys.	<p>learners make drawings and take notes. Ensure that, by the end of the activity, all learners know about all of the cells.</p> <p>Alternatively, set up five stations, each with information about one of the different specialised cells: red blood cells, neurones, ciliated cells, root hair cells and palisade cells. Learners visit each station, in pairs or small groups, to take notes. If possible, give learners the opportunity to view some specialised cells (e.g. root hair cells and palisade cells) using microscopes and prepared slides.</p> <p>After learners have made drawings and taken notes about specialised cells, ask questions such as: <i>What adaptations have you noticed that red blood cells possess?</i> <i>What cells can you name that have a large surface area relative to their size?</i> <i>What do ciliated cells use their cilia for?</i> <i>Why do root hair cells not have chloroplasts?</i></p> <p>Ask learners, working in pairs, to sort the different specialised cells into groups and justify their inclusion in a particular group. For example, 'with a nucleus' or 'without a nucleus'; 'plant cell' or 'animal cell'.</p> <p>Resources: Secondary information sources, light microscopes and prepared slides of root hair cells and palisade cells (optional)</p>
7Bs.04 Describe the similarities and differences between the structures of plant and animal cells.	7TWSm.01 Describe the strengths and limitations of a model. 7TWSa.03 Make conclusions by interpreting results and explain the limitations of the conclusions.	<p>Plant and animal cells</p> <p>Provide learners with images of plant and animal cells; ask learners to describe the cells. Explain these images can be used to base a physical model on.</p> <p>Learners, in small groups, then build a physical model of a named plant cell and a named animal cell; the models should show the inside of the cells so that cell structures are also modelled. Provide learners with modelling materials (e.g. small plastic balls for nuclei, empty boxes for cells walls, clear plastic bags for cell membranes and other scraps for cell structures).</p> <p>Hold a class discussion on how well the models represent the cells that they are intended to show. <i>What are the strengths of your model?</i> <i>What are the limitations of your model?</i></p> <p>Ask learners, using evidence from the models of plant and animal cells, to make a summary table of the similarities and differences between the structures of plant and animal cells.</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>Ask learners questions that make them think about the evidence that they have seen when looking at cells. <i>How many explanations can you think of that explain why you might not see chloroplasts in a cell that you are looking at?</i> <i>If you look at a cell and it does not have a cell wall, can you be sure that the cell has come from an animal?</i></p> <p>Resources: Images of plant and animal cells, modelling materials</p>
<p>7Bs.05 Understand that cells can be grouped together to form tissues, organs and organ systems.</p>	<p>7TWSm.01 Describe the strengths and limitations of a model.</p>	<p>Levels of organisation within organisms</p> <p>Demonstrate how to create a flow chart using an example of cells that make up a tissue, tissues that make up part of an organ, and organs that are part of an organ system e.g.</p> <div data-bbox="891 699 2033 821"> <pre> graph LR A[muscle cells] --> B[muscle tissue] B --> C[heart] C --> D[circulatory system] </pre> </div> <p>Allocate learners, working in pairs, different cells as starting points and they construct their own flow charts; some pairs receive an organ system as the starting point with the learners working 'backwards' to the cell.</p> <p>Explain that flow charts, like other types of diagram, are modelling the real situation. Using the flow charts created by learners, discuss the strengths and limitations of the learners' flow charts as models. Strengths could include: simplicity, showing the levels of organisation clearly, allowing many different examples. Limitations could include: not showing the whole picture (e.g. many different tissues make up one organ not just one type of tissue; many organs make up an organ system, not just one); flow charts do not work for single celled organisms that do not have tissues or simple organisms that do not have organs.</p> <p>Ask learners to illustrate their flow charts with appropriate drawings of the cells, tissues, organs and organ systems. Ask learners if adding illustrations to their flow charts makes their model more effective.</p> <p>Resources: Images of cells</p>

Unit 7.2 Classifying matter

Unit 7.2 Classifying matter

Outline of unit:

This unit covers atoms and elements as the building blocks of matter. The Periodic Table is introduced as a system of ordering the elements with metals and non-metals making up the two main groupings of the elements. Learners study the differences between metals and non-metals, and compounds and mixtures, including alloys. Learners also study the arrangement, separation and motion of particles in the three main states of matter. They explore the idea of a vacuum being a space devoid of matter and the lack of air resistance on movement in a vacuum.

Learners will have many opportunities in this unit to become familiar with chemical symbols and simple word equations. Learners will also develop using models to show their understanding of elements, compounds and mixtures and to become more familiar with particle diagrams. Learners will identify patterns and trends in the Periodic Table by watching demonstrations and they plan, carry out and evaluate practical work.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- using the particle model to describe solid, liquids and gases and to explain the properties of solids and liquids
- describing the processes of solidification/freezing, melting, evaporation and condensation, using the particle model and relating the processes to changes in temperature
- knowing gases have properties, including mass
- identifying the main properties of water and knowing that water acts differently from many other substances
- knowing electrical conductivity and thermal conductivity are properties of a substance
- knowing chemical reactions involve substances, called reactants, interacting to form new substances, called products
- describing the effect of different forces on an object at rest and in motion
- exploring a range of forces including air resistance.

Suggested examples for teaching Science in Context:

7SIC.01 Discuss how scientific knowledge is developed through collective understanding and scrutiny over time.

Learners can explore how the Periodic Table has developed over time, including the discovery of elements that had been predicted to exist.

7SIC.05 Discuss how the uses of science can have a global environmental impact.

Learners can discuss how the different properties of solids, liquids and gases have an impact on how waste materials are treated. The environmental impact of sending waste to landfill (or recycling) can be explored at a local, national or global level.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Cm.01 Understand that all matter is made of atoms, with each different type of atom being a different element.	Matter, atom, elements	<p>The idea that the chemical symbols represent elements can be formally introduced to learners.</p> <p>Learners can use kits (or modelling clay) to create some simple models showing different elements, each made from one type of atom.</p>	<p>Learners may not appreciate how very small atoms are. Provide a scale of sizes that shows where atoms fit compared to other objects. Give some comparisons (e.g. one atom's diameter is to a millimetre as the thickness of a sheet of paper is to the height of the Empire State Building).</p> <p>Learners may have heard that human bodies contain different elements (e.g. calcium in teeth, iron in blood). Explain that these are present in our bodies in a physically and chemically different form from the pure elements. Clarification on this could be given when learners are in Stage 9 and are learning about ions as part of Cambridge Lower Secondary Science.</p> <p>Learners may think that atoms have the same properties as the element that they make up. Provide examples that show that this is not so (e.g. individual copper atoms have no colour, but billions of them joined together make a shiny orange metal).</p> <p>At this level, it is acceptable to teach that all matter is made of atoms but explain that this is an incomplete model. Learners will learn, at a later stage, that most substances are made from combinations of atoms called molecules.</p>
7Cm.02 Know that the Periodic Table presents the known elements in an order.	Periodic Table, elements	Learners can examine the Periodic Table as a representation of the elements that we know about.	Some learners may believe that elements were invented rather than discovered. Explain that, over time, scientists have discovered 94 naturally occurring elements and synthesised 24 more (as of September 2020). This can be explored by looking at the history of elements.
7Cm.03 Know metals and non-metals as the two main groupings of elements.	Metals, non-metals, elements	Learners can identify the metals and non-metals in the Periodic Table which is an organisational tool and representation of the discovered elements. .	Some learners may think that all metals are solids. Explain that mercury is both a metal and liquid; show a video of mercury behaving as a liquid. For health and safety reasons, mercury should not be used in class as it is highly toxic.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
			At this stage of learning, the idea that some elements (i.e. metalloids) are neither metals nor non-metals, is not required.
7Cp.05 Describe common differences between metals and non-metals, referring to their physical properties.	Metals, non-metals, physical properties, appearance, thermal conductivity, electrical conductivity, magnetism, malleability, ductility, flexibility, density	<p>Animations (or videos) can be shown to illustrate some of the common differences between metals and non-metals.</p> <p>Use of the Periodic Table will allow learners to locate the metals and non-metals and to use their chemical symbols (and atomic numbers) when comparing differences.</p> <p>Particle diagrams can be used to explain ideas about conductivity (thermal and electrical) and density.</p>	<p>Some learners may think that the different physical properties between metals and non-metals are only true for the solid state. Explain to learners that metals and non-metals can exist in different states; some metals in the liquid state retain their metallic properties.</p> <p>Some learners may think that all metals are elements. Provide examples, that only the metals and non-metals found on the Periodic Table are elements; all other metals and non-metals are mixtures (including alloys) or compounds (i.e. bronze and steel are not elements).</p>
7Cm.04 Describe the differences between elements, compounds and mixtures, including alloys as an example of a mixture.	Elements, compounds, mixtures, alloys, particle, particle model, substance	<p>Learners can use a range of diagrams to represent elements, compounds and mixtures; atoms of different elements can be distinguished by colour and/or size.</p> <p>Learners can use materials (e.g. small coloured sweets, different colours of modelling clay or molecular modelling kits) to construct physical models of elements, compounds and mixtures.</p>	<p>Learners may be confused with some of the terminology in this learning objective and how elements, compounds and mixtures relate to 'particles' and 'substance'. Provide plenty of opportunities for learners to practise and use the terms in correct contexts.</p> <p>Some learners may think that alloys and metals are the same thing. Explain that a metal is made of a single element, but an alloy is composed of two or more elements where at least one element is a metal. It can be useful to note that the only alloy that can be found naturally is electrum; it is an alloy of gold and silver.</p>
7Cm.07 Use the particle model to represent elements, compounds and mixtures.			
7Cm.06 Describe the three states of matter as solid, liquid and gas in terms of the arrangement, separation and motion of particles.	States of matter, solid, liquid, gas, particles, volume, compressibility, rigid, flow	<p>Particle diagrams of solids, liquids and gases can be used to model the arrangement and separation of particles in the different states of matter.</p> <p>Learners can take part in a physical model by role-playing particles at different temperatures and states. For health and safety reasons, this should be in a large enough space that learners can be fast, high-energy gas particles; learners can tap each other on the</p>	<p>Learners may believe that the size of a particle increases as it gains energy. Explain that particles have a fixed size and, when drawing changes of state, take care that particles remain the same size. Providing a template (e.g. small coin, paper with a hole punched in it) for drawing the particles may help to reinforce this idea.</p>

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
		shoulder (or give each other a 'high five') to represent a collision.	<p>Learners may think that water is the only substance that can exist in all three states; as it is the example is used most often when teaching states of matter. Seek to provide examples of other substances (e.g. iron as solid and liquid, nitrogen as liquid and gas), as well as water.</p> <p>Some learners can be confused between the scientific term 'particle' and the everyday use of the same word (i.e. small, visible bits of matter, such as specks of dust). Make it clear that the scientific term 'particle' refers to atoms or combinations made from atoms.</p>
7Cm.05 Describe a vacuum as a space devoid of matter.	Vacuum, matter, devoid	<p>Learners can use diagrams to represent what a vacuum is.</p> <p>Learners can model the effects of a vacuum. They create a partial vacuum by putting a marshmallow into a syringe, with a blocked nozzle, and pulling on the plunger.</p>	<p>Some learners may confuse the everyday use of the word 'vacuum', in reference to the household appliance (vacuum cleaner), with the scientific use of the term. Explain that a vacuum is a scientific term for a space that is devoid of matter.</p> <p>At this learning stage, it is appropriate to consider a vacuum as a space devoid of all matter. In reality, this can never occur; some particles are always present in a vacuum but far fewer than outside a vacuum.</p> <p>Learners may believe that space is a good example of a vacuum; they may think there is nothing between the planets and the stars. Explain that space, although it does not contain much, does contain atoms (e.g. hydrogen, helium).</p> <p>Learners may believe that the space between particles is filled with the same (or a different substance). For example, in a diagram modelling hydrogen gas, learners may think that the space between hydrogen particles is filled with hydrogen (or air). Use the particle model to emphasise that the particles are all that is there.</p>

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Pf.04 Understand that there is no air resistance to oppose movement in a vacuum.	Air resistance, vacuum	Learners can take part in a physical model of air resistance. Some learners play the role of particles moving through air and other learners play the role of the particles in air that obstruct their movement. The activity is repeated for a vacuum where the movement of the particles is not opposed. If the activities are timed, it provides a useful model of how air resistance can slow down movement. Ensure learners take care to not exert too much force when obstructing.	Some learners may think that only solids and liquids offer resistance to movement, particularly as they may have seen (or carried out) investigations about friction. Explain clearly that the particles present in air provide resistance to movement; remind learners of examples of air resistance (e.g. parachutes).

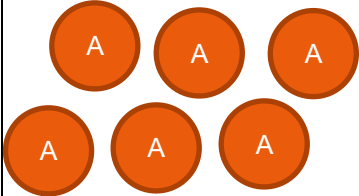
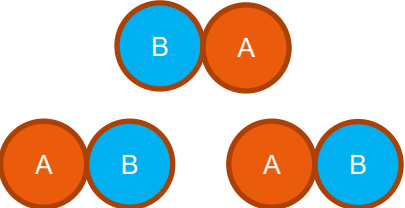
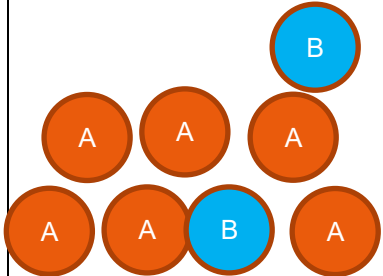
Unit 7.2 Suggested activities

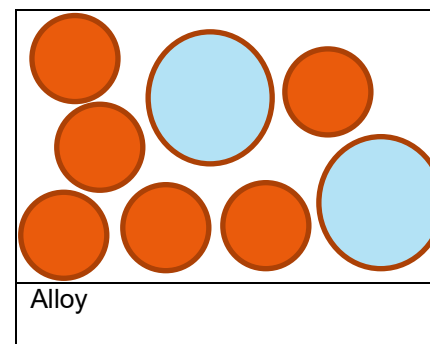
Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
7Cm.01 Understand that all matter is made of atoms, with each different type of atom being a different element.	7TWSm.01 Describe the strengths and limitations of a model.	<p>Modelling atoms and elements</p> <p>Define elements as the simplest chemical substances. Explain that each element is made of atoms and the atoms in each element are all of the same kind.</p> <p>Provide learners with building blocks of different colours to model an element. <i>Can you model an element using those blocks?</i> <i>Which blocks would you use for sulfur? Why?</i> (Expect answers to include using blocks of just one colour because sulfur is an element; elements are only made of one type of atom. The blocks represent sulfur atoms.)</p> <p>Build a 'wall' of one colour; the wall represents an element where only one type of atom (i.e. one colour of block) is used to make a substance.</p> <p>Show learners, with the blocks, a construction with one block a different colour, then another with several colours used. <i>Are these still representing elements?</i> <i>What needs to happen to the model for it to represent an element?</i></p> <p>Discuss with learners the strengths and limitations of using blocks to represent atoms and 'make elements'.</p> <p>Resources: Building blocks of different colours</p>
7Cm.02 Know that the Periodic Table presents the known elements in an order.	<p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p> <p>7TWSp.02 Describe how scientific hypotheses can be supported or contradicted by evidence from an enquiry.</p>	<p>Changing ideas about the Periodic Table</p> <p>Introduce the Periodic Table to the learners. <i>What does this table show us?</i> <i>What do the symbols mean?</i></p> <p>Explain how the Periodic Table represents all the known elements (i.e. types of atoms) and that the version we use was first constructed in 1869 by Dmitri Mendeleev with around 60 known elements at the time (compared to the 118 we know as of September 2020).</p>

		<p>Explain how each symbol in the Periodic Table represents an element. Have learners identify common elements they may already know of (e.g. oxygen, carbon, iron, hydrogen, gold, silver, tin).</p> <p>Have learners examine the Periodic Table and see if they can identify any rules (or patterns) for the order of elements within it.</p> <p><i>What do you notice about the order of the elements?</i></p> <p><i>Apart from being metals, what have the following elements got in common?</i></p> <ul style="list-style-type: none"> • Zinc, cadmium, mercury • Platinum, gold, mercury? <p><i>What happens to the atomic weight of elements as you go across the Periodic Table horizontally?</i></p> <p>Describe how Mendeleev originally arranged the Periodic Table by placing the elements in order of atomic weight and this information can be seen in the Periodic Table. (Stage 7 learners do not need to understand what causes atomic weight; they need to know that it exists and that different elements have different atomic weights.) A story about Mendeleev, including references to other scientists who tried to order the elements before him, could be told to learners.</p> <p>Explain how Mendeleev left gaps in his Periodic Table that have now been filled. Describe how Mendeleev predicted that these gaps would be filled and how the discoveries of new elements have proven Mendeleev's Periodic Table to be an accurate representation of the order of known elements. Point out that Mendeleev, when he created the Periodic Table, only had a hypothesis about the order of elements; the later discoveries of the predicted elements provided the evidence to support the hypothesis.</p> <p>This activity can be extended by learners exploring how some elements have been known for much longer than others. Online resources about the history of the elements can be found and used. Learners can investigate, and research, the history of elements including considering why sodium has the symbol Na, potassium has the symbol K, gold has the symbol Au and others. Learners can then write a fact file entry about an element.</p> <p>Resources: Printouts of the Periodic Table</p>
<p>7Cm.03 Know metals and non-metals as the two main groupings of elements.</p> <p>7Cp.05 Describe common differences between metals and non-metals, referring to their physical properties.</p>	<p>7TWSp.03 Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding.</p> <p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p>	<p>Properties of metals and non-metals (requires additional resources)</p> <p>Explain that all elements are made of metals or non-metals. Ask learners to name as many metals and non-metals as they can and to describe some of their properties. Collect their answers; summarise the key differences between metals and non-metals, correcting any misconceptions or inaccuracies they have.</p> <p>Ask learners to suggest how unknown elements might be tested to find out whether they possess the properties of a metal or non-metal.</p> <p>Demonstrate testing metals and non-metals for thermal conductivity. Ask learners, working in pairs or small groups, to plan a range of other tests (e.g. electrical conductivity, magnetism, malleability, ductility,</p>

	<p>7TWSc.02 Decide what equipment is required to carry out an investigation or experiment and use it appropriately.</p> <p>7TWSc.05 Carry out practical work safely.</p> <p>7TWSc.07 Collect and record sufficient observations and/or measurements in an appropriate form.</p>	<p>flexibility, density, appearance) to sort different elements into metals and non-metals. Provide a range of equipment which learners select from. Learners could use help sheets, with more information, to help them plan.</p> <p>After learners have planned testing different elements check their plans, including safety precautions. Ask learners to carry out one (or more) of the investigations on suitable elements (e.g. copper, tin, carbon, sulfur); this will result in a range of investigations might be carried out across the class. Ask learners to present their findings clearly.</p> <p>Ask learners to prepare a poster that summarises the properties of metal elements and non-metal elements. They should include examples of metals and non-metals, important properties, how these properties are related to the uses of the elements, the chemical symbols of the elements and where they are found on the Periodic Table.</p> <p>Resources: Printouts of the Periodic Table; specimens of some common metals and non-metals; magnets; apparatus and equipment for testing thermal and electrical conductivity, malleability, ductility, flexibility and density</p>
	<p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p> <p>7TWSa.03 Make conclusions by interpreting results and explain the limitations of the conclusions.</p>	<p>Mystery elements: Metal or non-metal</p> <p>Explain that all elements are metals or non-metals. Ask learners to name as many metals and non-metals as they can and to describe some of their properties. Collect their answers; summarise the key differences between metals and non-metals, correcting any misconceptions or inaccuracies they have. <i>What evidence is needed to decide whether an element is a metal or a non-metal?</i> <i>Where do you find a) metals and b) non-metals on the Periodic Table? Is there a pattern?</i> <i>How do the number of metals and non-metals in the Periodic Table compare?</i></p> <p>Explain to learners that they will be given information about a set of 'mystery elements' that they can use to decide whether each element is a metal or a non-metal. Demonstrate how this is done using an element the learners are familiar with (e.g. oxygen, hydrogen, gold, iron) before learners attempt it independently. Provide learners with information about the properties (e.g. electrical conductivity, appearance, flexibility, durability) of a set of 'mystery elements' (i.e. where they haven't been given the name). Ask them if the mystery elements are metal or non-metal; they then use the information to present conclusions about which element each 'mystery element' is.</p> <p>Discuss if their conclusions are limited in any way; discuss if having the information from investigative work is as good as carrying out the work themselves.</p> <p>Ask learners to prepare a poster that summarises the properties of metal elements and non-metal elements. They should include examples of metals and non-metals, important properties, how these properties are related to the uses of the elements, the chemical symbols of the elements and where they are found on the Periodic Table.</p>

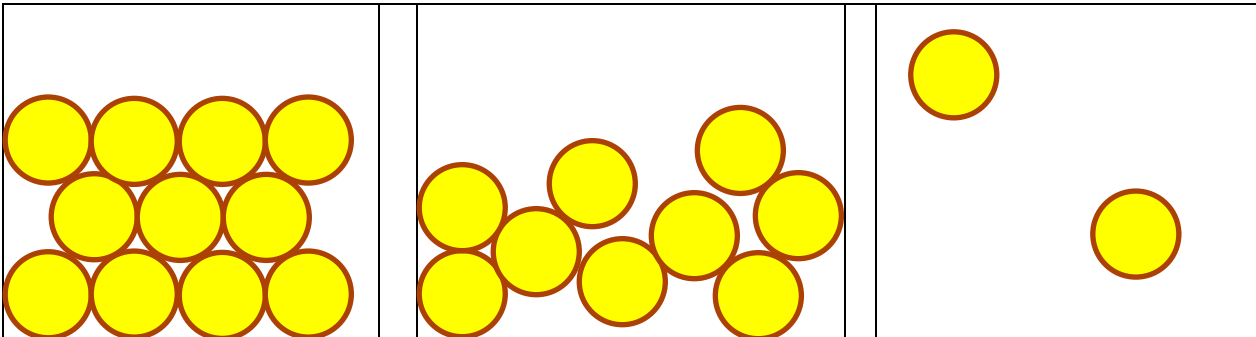
<p>7Cm.04 Describe the differences between elements, compounds and mixtures, including alloys as an example of a mixture.</p> <p>7Cm.07 Use the particle model to represent elements, compounds and mixtures.</p>	<p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p> <p>7TWSm.01 Describe the strengths and limitations of a model.</p>	<p>Resources: Printouts of the Periodic Table, 'mystery elements' factsheets</p> <p>Modelling elements, compounds and mixtures</p> <p>Describe how an element is made of only one type of atom. Provide an example using coloured blocks of five blocks in a row and touching that are all the same colour.</p> <p>Show three blocks touching; the central block is one colour and the outer two are of a different colour.</p> <p><i>What is this model representing?</i></p> <p>Describe how this is called a compound; a compound is a substance where the constituent atoms are of two or more different types and are joined together.</p> <p><i>What happens when I have two substances, where the atoms within the substances are not joined together?</i> (Describe how this is a mixture.)</p> <p>Show learners three blocks on one colour that are touching against a set of three blocks of a different colour. Explain how the two colours are not joined together and show two substances physically near each other, which is what happens in a mixture.</p> <p>Learners will have previously used the particle model, but this is an opportunity to expand its use where each 'particle' represents an atom. When discussing the particle model, describe the strengths and limitations of the particle model; point out that there are no gaps between the atoms in a solid but leaving gaps in the model makes it easier to show two substances mixing.</p> <p>Introduce the concept of an alloy though talking about a real example (i.e. steel). Show learners a video of how steel is made from iron and additives; explain that steel is a mixture which we call an alloy.</p> <p>Give examples of compounds, mixtures and alloys; use both names and simple formulae to show how compounds are made of several types of atoms. Use particle models to support your examples.</p> <p>Learners, working in pairs, create models of elements, compounds and mixtures (including alloys) using small, coloured sweets (or modelling clay). Ask learners to name their modelled substances; they can use a help sheet, if needed, to give the symbols of the elements and simple formulae for the compounds.</p> <p>Ask learners to create their own particle diagrams to show how the particles are arranged in their modelled elements, compounds and mixtures. Suggest that learners use colour, and a key, to help make their diagrams clearer.</p> <p><i>What do you notice about the endings of the names of compounds made from just two elements?</i></p> <p><i>If a substance contains the atoms of three different elements, what possibilities are there about what might the substance be?</i></p> <p>(There are three possibilities: a mixture of three elements; a compound made up of three different elements; a mixture made up of an element and a compound containing two elements).</p>
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Element	Compound	Mixture of an element and a compound



Learners can be extended by demonstrating and discussing the reaction, between the two elements, iron and sulfur, to form the compound iron sulfide. For the teacher demonstration the following resources are needed: a borosilicate glass test tube (for example 'Pyrex'), iron powder (potential irritant, note that iron powder is needed, not iron filings), finely powdered sulfur, safety glasses, balance to 1 or 2 d.p; burner, such as a Bunsen burner, heat resistant mat, clamp stand and clamp, spatulas, small magnet, watch glass, filter paper, mineral wool to plug the mouth of the test tube. The mixture in the tubes should be in the ratio of 7:4, iron: sulfur, well mixed and the mixture should not fill more than a third of the test tube.

This reaction usefully illustrates elements, mixtures and compounds. Talk through the appropriate safety precautions with learners, including the use of a well ventilated room and suitable glassware. Learners can test the properties of the reactants separately and when mixed together and compare these with the properties of the product, iron sulfide. Learners should observe that the properties of the product are different from the properties of its constituent elements. Reinforce the idea that no substance disappeared in the reaction by asking learners to draw coloured particle diagrams to represent the reactants and

		<p>product of the reaction. Ask learners to add the names and symbols for the elements shown in the particle diagrams.</p> <p>Resources: Coloured sweets (or modelling clay); particle diagrams of elements, mixtures, alloys and compounds.</p>			
<p>7Cm.06 Describe the three states of matter as solid, liquid and gas in terms of the arrangement, separation and motion of particles.</p>	<p>7TWSc.04 Take appropriately accurate and precise measurements, explaining why accuracy and precision are important.</p> <p>7TWSa.03 Make conclusions by interpreting results and explain the limitations of the conclusions.</p> <p>7TWSp.01 Identify whether a given hypothesis is testable.</p>	<p>The arrangement of particles</p> <p>Show learners an animation (or video) of a substance in its three different states. Ask learners how we can represent the different states of matter for this substance on paper.</p> <p>Present learners with the particle model for solids, liquids and gases; in this case the particle represents an element or compound (rather than a single atom).</p> <div data-bbox="831 603 2083 978">  <table border="1" data-bbox="831 941 2083 978"> <tr> <td>Solid</td> <td>Liquid</td> <td>Gas</td> </tr> </table> </div> <p>Discuss with learners how the solid has a rigid structure; the particles are moving (i.e. vibrating) but they are in a consistent and secure position. The particles in a liquid still touch each other (if one is not touching it is in the gas phase) but are in a less rigid structure than when in a solid and can flow. In a gas, the particles are 'free' from each other so they can move more readily which makes the gas compressible.</p> <p>The particle model can be described while you (or the learners) physically handle samples of the three different states of matter (e.g. a safe solid, liquid water in a container, and gaseous air (within a sealed syringe)). This will illustrate that solids are rigid and hold their shape; liquids can flow and hold the shape of a container but cannot be compressed; gases have no defined shape, they can flow and be compressed. In addition, learners can create fact files about substances they unlikely to know much about, e.g. platinum, mercury, nitrogen, methane, galena (i.e. lead sulfide). They include the state of matter at room temperature for each substance and what the particle model for each substance will be.</p> <p>Resources: Solid sample, container, syringe</p>	Solid	Liquid	Gas
Solid	Liquid	Gas			

<p>7Cm.05 Describe a vacuum as a space devoid of matter.</p>	<p>7TWSa.05 Present and interpret observations and measurements appropriately.</p> <p>7TWSa.04 Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes.</p>	<p>Creating a partial vacuum</p> <p>Demonstrate the ‘collapsing can’ activity. Boil less than 15 ml of water inside an otherwise empty can (e.g. 350 ml aluminium drinks can). Use tongs to invert the open end of the can into a container filled with cold water; explain both the hazards and the precautions taken to learners. This demonstration gives opportunities to reinforce the science behind the learners’ observations by asking lots of questions. Make sure that learners understand that:</p> <ul style="list-style-type: none"> • The small quantity of boiling water inside the can produces water vapour. • The water vapour mixes with the air to form steam. • The steam displaces the air from inside the can. • When the can is inverted in cold water, the water vapour condenses rapidly and forms a partial vacuum. • The air pressure is now greater than the pressure inside the can, so the can collapses. <p>If this demonstration cannot be conducted, show learners a video of the ‘collapsing can’ activity and provide a commentary if required.</p> <p>Ask questions: <i>What was happening during this demonstration? Give reasons for your explanation.</i> <i>What differences might be observed if:</i></p> <ol style="list-style-type: none"> <i>the can opening was not inverted first?</i> <i>the heated can was put in warm water?</i> <i>the can was not heated?</i> <i>a different size can was used?</i> <i>a different volume of water was heated inside the can?</i> <i>a non-metal container was used?</i> <p>If time allows, the modifications to the demonstration suggested in the questions could be tested.</p> <p>Ask learners to draw a particle diagram that shows the contents of the can before heating, during heating and after immersion in the cold water. Explain that the last diagram should still show some particles as only a partial vacuum was created. Make sure that learners can describe a vacuum as a space totally devoid of matter.</p> <p>Resources: aluminium can, tongs, container</p>
<p>7Pf.04 Understand that there is no air resistance to oppose movement in a vacuum.</p>	<p>7TWSp.02 Describe how scientific hypotheses can be supported or contradicted by evidence from an enquiry.</p>	<p>No air resistance in a vacuum</p> <p>Remind learners that air resistance is due to particles in air getting in the way of objects passing through. Use a demonstration (or video) of a parachute to reinforce this. Give learners the hypothesis to test: when there are no particles in the air, as in a vacuum, then there cannot be any resistance to movement.</p>

	<p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p><i>What kind of investigation could you do to find out if this hypothesis was true or false? (Remind learners that living organisms cannot survive in a vacuum)</i> <i>What equipment might you need?</i> <i>How could you measure the speed of movement?</i></p> <p>Learners then peer review each other's plans discussing what is good about them and what could be improved.</p> <p>Show learners videos of experiments which compare movement in air and in a vacuum (searching on the internet for a video of objects falling in a vacuum may help locate a video). Ask learners to write a short explanation of their observations using the terms: air resistance, vacuum, movement. They can also compare their own investigation plans to what was observed in the video.</p> <p>Resources: Videos of experiments showing movement in air and in a vacuum, model parachute</p>
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Unit 7.3 Forces in space

Unit 7.3 Forces in space

Outline of unit:

This unit covers gravity as a force of attraction between any two objects and how the size of gravity is related to the masses of the objects.

Learners apply their understanding of gravity to consider how planets are formed from dust and gas, and how gravity is the force that holds components of the Solar System in orbit around the Sun. This unit concludes with explanations of how solar and lunar eclipses happen.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- knowing the difference between mass and weight
- describing the effect of gravity and knowing that when gravity changes, the weight of an object changes but the mass does not
- using force diagrams to show the name, size and direction of forces acting on an object
- knowing gases have properties, including mass
- describing orbit of the Earth around the Sun
- describing the relative position and movement of the planets, the Moon and the Sun in the Solar System
- knowing Solar Systems can contain stars, planets, asteroids and comets
- describing the changes in the appearance of the Moon over its monthly cycle.

Suggested examples for teaching Science in Context:

7SIC.01 Discuss how scientific knowledge is developed through collective understanding and scrutiny over time.

Learners can consider how our understanding about the formation of planets (or solar and lunar eclipses) has changed over time through the collection and scrutiny of scientific evidence (through observation). Learners could look at previous models for how planets have formed and compare them to current models discussing why the previous models were valid at the time based on the evidence available.

7SIC.03 Evaluate issues which involve and/or require scientific understanding.

Building on their understanding of how gravity keeps bodies in orbit, learners can consider the generation of 'space junk' and the issue this presents to the space industry and to people living on Earth. For example, the risk of satellites colliding with space junk and affecting our communications networks.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Pf.03 Describe gravity as a force of attraction between any two objects and describe how the size of the force is related to the masses of the objects.	Gravity, force, force arrows, attraction, mass, weight	<p>The action of forces (e.g. gravity) on objects can be represented using diagrams; force arrows show the size and direction of the forces.</p> <p>Animations and simulations of the effect of gravity between any two objects can show learners how the size of a force is related to the masses of the objects.</p>	<p>Learners may think that gravity is only related to how close an object is to the Earth; this is because many examples discuss gravity in relation to the attraction between an object and the Earth. Make it clear that gravity is a force of attraction between any two objects.</p> <p>Learners may believe that heavy objects fall faster than light objects. Remind learners that all objects fall at the same rate in a vacuum but, in air, light objects (e.g. feathers) are greatly affected by air resistance.</p> <p>Learners can confuse the terms ‘mass’ and ‘weight’ as they are used interchangeably in everyday life. Check learners’ understanding by asking for definitions of mass and weight and the units that are used to measure them. Help learners to think about situations where weight would be different but mass the same.</p>
7ESs.01 Describe how planets form from dust and gas, which are pulled together by gravity.	Planets, dust, gas, gravity, space	<p>Learners can sort, label and annotate a series of sequential diagrams that represent the formation of planets from dust and gas, pulled together by gravity.</p> <p>Learners can be introduced to a simple outline of the solar nebular hypothesis.</p>	Learners may believe that there is no gravity in space. Explain that there is gravity in space; the force is much weaker than on Earth. Astronauts in orbit ‘feel’ weightless because they are in free-fall and not experiencing any contact forces. Gravity is still acting upon their body.
7ESs.02 Know that gravity is the force that holds components of the Solar System in orbit around the Sun.	Gravity, force, Solar System, orbit, Sun, galaxy	Learners can spin a ball (attached to a string) overhead to model how gravity holds components of the Solar System in orbit around the Sun. The learner represents the Sun, the ball represents a component of the Solar System (e.g. planet) and the string represents the pull of gravity preventing the component from moving off into space.	Some learners may believe that gravity causes the planets to orbit the Sun. Explain that gravity is a force of attraction. Planets orbit the Sun now because they were circling the Sun as gas and dust when they were formed; gravity just keeps the planets in orbit and there are minimal resistant forces in space to slow them down.
7ESs.04 Explain how solar and lunar eclipses happen.	Solar eclipse, lunar eclipse, orrery	Diagrams can be used to represent the position of the Earth, Sun and Moon during eclipses; ray diagrams can show learners how light from the Sun is affected by the position of the Earth and Moon.	<p>Some learners may have believe a folk story about eclipses, such as:</p> <ul style="list-style-type: none"> “Total solar eclipses produce harmful rays that can cause blindness”. Looking at the Sun just before an eclipse may cause retinal damage, but eclipses do not produce any harmful rays.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
		<p>Learners can watch animations that model how solar and lunar eclipses happen or role-play being the Earth, Sun and Moon during solar and lunar eclipses.</p> <p>The simplest orreries, or tellurions, are models that only include the Earth, Sun and Moon.</p>	<ul style="list-style-type: none"> “Eclipses suggest that something bad is about to happen”. This idea is based on coincidence and non-scientific belief; humans have a confirmation bias whereby a cause-and-effect link is ‘proved’ by only considering bad events that occur just after eclipses. <p>Some learners may think that lunar eclipses happen every month. Explain that the Moon is relatively far from the Earth and the special conditions of precise alignment only happen a few times each year.</p>

Unit 7.3 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7Pf.03 Describe gravity as a force of attraction between any two objects and describe how the size of the force is related to the masses of the objects.</p>	<p>7TWSa.03 Make conclusions by interpreting results and explain the limitations of the conclusions.</p> <p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p> <p>7TWSa.02 Describe trends and patterns in results, including identifying any anomalous results.</p>	<p>The link between mass and gravity</p> <p>Explain that the force that acts on an object, due to gravity, is called weight; since weight is a force, it is measured in newtons. Check that learners understand the term 'mass' and provide some historical background. For example, describe how Newton realised that any object which has mass produces a force that attracts other objects with mass. The size of that force increases as the object's mass increases.</p> <p>Show learners a simple table that shows the mass of different planets and their gravity. Look at the data, supporting learners to identify the pattern: as mass increases the force of gravity from the mass increases. Ask the learners to play 'higher or lower' by providing an object (e.g. a different planet, an astronomical object) and asking if the gravity from the object is higher or lower than one of the provided planets.</p> <p>Explain to learners that gravity is a weak force compared to other forces; this is why very large masses are required to create significant gravity. Learners, working in pairs, can see this for themselves by comparing the force of magnetism and the force of gravity acting on paperclips. They use paper clips attached by string to a ruler, placed under another ruler, to which magnets have been attached and which is suspended at a height just greater than the string holding the paper clips. Before the paperclips are placed under the magnets, the force of gravity causes them to rest on a surface; when under the magnets, the force due to gravity is less than that due to magnetism, so the paper clips move towards the magnets.</p> <p>Ask learners, working in pairs, to explain why they are not pulled towards their desks by the force of gravity acting between them and their desks. Suggest that they make a list of all the other forces acting on them that are stronger than the force of gravity.</p> <p>This activity can be extended by learners challenging the assumption that a larger object always has a greater mass than a smaller object. They can study data tables covering the mass and gravitational strengths of planets, to identify high-density objects (e.g. neutron stars or black holes) that have high gravitational strength despite being smaller than other astronomical objects.</p> <p>Resources: Magnets, paperclips, string</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7ESs.01 Describe how planets form from dust and gas, which are pulled together by gravity.</p>	<p>7TWSp.02 Describe how scientific hypotheses can be supported or contradicted by evidence from an enquiry.</p> <p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p>Forming planets</p> <p>Ask learners what ideas they already have about how the planets might have been formed.</p> <p>Describe some of the different hypotheses that have been put forward by the scientific community in the past about how planets formed; this could be done by showing a video. Hypotheses could include:</p> <ul style="list-style-type: none"> • Descartes swirling condensation idea • Dirk Ter Haar's accretion model • Leclerc's idea that the planets were formed when a comet collided with the Sun <p>Briefly outline evidence for and against these hypotheses.</p> <p>Show learners an animation (with a commentary) of a planet forming from dust and gas. Tell learners that they are going to write their own commentary for the animation; provide key terms (e.g. planet, dust, gas, gravity) that should be included in the commentary. Show the animation, without the commentary, as many times as needed while learners, working in pairs, write a commentary in their own words. Ask pairs of learners to form small groups to decide which commentary is best; show the animation again, with the chosen commentaries. This provides the opportunity to address any misconceptions or errors.</p> <p>Alternatively, ask learners to work in small groups to create a cartoon strip showing the formation of a planet. Each frame should have at least one sentence explaining what is happening.</p> <p>Discuss how the formation of the Solar System and planets must have taken a long time. The process must have started slowly, as gravity is such a weak force with objects of small mass; it sped up as the objects that became the planets become bigger over time.</p> <p>Resources: Animation of the formation of a planet</p>
<p>7ESs.02 Know that gravity is the force that holds components of the Solar System in orbit around the Sun.</p>	<p>7TWSm.01 Describe the strengths and limitations of a model.</p>	<p>A model of gravity in the Solar System</p> <p>Explain to learners that there are different ways to model our understanding about gravity.</p> <p>A classical way to consider gravity is as a force of attraction. This can be modelled by a person (representing the Sun), a ball (representing a planet) and string (representing gravity that is acting between them). In a clear space, a volunteer spins a tennis ball (firmly attached on a piece of string) around their head.</p> <p><i>If the ball represents a planet, what does the volunteer represent?</i></p> <p><i>What does the string represent?</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p><i>What is the name for the route that the 'planet' takes?</i> <i>What stops planets orbiting the Sun from hurtling off into space?</i> <i>What other objects, apart from a planet, could be represented by the ball?</i> <i>What are the limitations of this model?</i></p> <p>Discuss with learners the answers to these questions and use the answers to discuss if the model is a good one or not.</p> <p>Resources: Ball attached to string</p>
7ESs.04 Explain how solar and lunar eclipses happen.	7TWSm.01 Describe the strengths and limitations of a model.	<p>Modelling solar eclipses</p> <p>Show learners an animation that explains how solar eclipses occur. Ask learners to place physical models of the Earth, Sun and Moon on a surface; they model the movements that occur during a solar eclipse. Do this as a whole class exercise, on as large a scale as possible, so that everyone can see it clearly. Ask for feedback on how the model works well and where the model works less well.</p> <p>Ask learners to work in small groups to create a physical model of the Earth, Sun and Moon just before, during and after a solar eclipse. Learners draw, or photograph, each stage of the Earth and Moon moving into, and out of, the positions that will result in a solar eclipse. Learners can then sequence their images to show the process of a solar eclipse.</p> <p>Provide learners with a partially-completed diagram showing the arrangements of the Earth, Sun and Moon during a solar eclipse. Ask learners to complete the diagram; this could involve labelling or adding light rays.</p> <p>Resources: Animation of a solar eclipse, spheres to model the planets diagram of a solar eclipse</p>
	7TWSm.01 Describe the strengths and limitations of a model.	<p>Modelling lunar eclipses</p> <p>Show learners an animation that explains how lunar eclipses occur. Ask learners to place physical models of the Earth, Sun and Moon on a surface; they model the movements that occur during a lunar eclipse. Do this as a whole class exercise, on as large a scale as possible, so that everyone can see it clearly. Ask for feedback on how the model works well and where the model works less well.</p> <p>Learners can use a tennis ball (i.e. the Moon) on a stick, held at arm's length from their head (the Earth); they stand in a beam from a light source (i.e. the Sun). This model is often used to demonstrate the phases of the Moon as learners rotate, keeping their arm outstretched and look at the 'Moon'. To</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>demonstrate a lunar eclipse, the learners should let the 'Moon' drop a little so that it moves into the shadow of their head.</p> <p>Provide learners with a partially-completed diagram showing the arrangements of the Earth, Sun and Moon during a lunar eclipse. Ask learners to complete the diagram; this could involve labelling or adding light rays</p> <p>Resources: Animation of a lunar eclipse, spheres to model the planets, partially-completed diagrams of a lunar eclipse</p>

Unit 7.4 Classifying life

Unit 7.4 Classifying life

Outline of unit:

This unit covers the characteristics of living organisms; it leads on to the concept, and definition, of species as groups of organisms that can reproduce to produce fertile offspring. Learners then use, and create, dichotomous keys to classify species and groups of related organisms.

Viruses are studied. Learners discuss the classification of viruses and discuss whether they can be considered as living organisms.

Learners will have opportunities to research a variety of organisms, to consider whether a given hypothesis is testable and to evaluate models of viruses.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- knowing life processes common to plants and animals include nutrition, growth, movement and reproduction
- knowing animals, including humans, produce offspring that have a combination of features from their parents
- explaining how flowering plants reproduce
- distinguishing features of different groups of animals, including fish, reptiles, mammals, birds, amphibians and insects
- understanding that some diseases can be caused by infection with viruses
- identifying the differences between things that are living, that were once alive and that have never lived.

Suggested examples for teaching Science in Context:

7SIC.03 *Evaluate issues which involve and/or require scientific understanding.*

Learners can use scientific knowledge and understanding to debate whether viruses should be considered as living or non-living. For example, learners can examine how regular discoveries of new species create opportunities for research and, in some circumstances, for re-evaluating evolutionary relationships. Based on their understanding of what a species, learners can discuss concerns about the loss of biodiversity as well as historic (and potential future) mass extinctions.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Bp.01 Describe the seven characteristics of living organisms.	Characteristics, movement, respiration, sensitivity, growth, reproduction, excretion, nutrition, organism	<p>Learners can use annotated diagrams of different living organisms and identify any physical features associated with each characteristic (e.g. legs for movement, eyes for sensitivity, digestive system for nutrition).</p> <p>Animations that show the seven characteristics of life for living organisms can be used to support learners. Check the suitability of these online animations before showing to learners.</p>	<p>Some learners may think that the seven characteristics of living organisms apply only to animals. Make it clear, by giving lots of examples, that these characteristics apply to all living organisms.</p> <p>Some learners may think that having just one or two of the characteristics makes something alive. Explain that all seven characteristics are usually required if anything is to be considered as living.</p>
7Bp.03 Describe a species as a group of organisms that can reproduce to produce fertile offspring.	Species, organism, reproduce, fertile, offspring	Learners can create physical models using modelling clay (and other materials) of imaginary species; this can also be done using computer software. They can choose 'parents' and model what the offspring might look like. Then the 'offspring' can be used as 'parents' and their 'offspring' modelled.	<p>Some learners may think that 'species' is only a plural word. Explain that 'species' is both singular and plural (like 'sheep').</p> <p>Some learners may think that all members of a species will look alike. Showing learners pictures of a range of dog breeds will help to address this.</p>
7Bp.04 Use and construct dichotomous keys to classify species and groups of related organisms.	Dichotomous, key, classify, species, organisms	<p>A dichotomous key is a model to sort and classify organisms.</p> <p>Learners can use biscuits or sweets to use as model organisms when they are practising making and using a key.</p>	<p>Learners may think that a 'dichotomous' key means a complicated key. Explain that the term just means 'divided into two' so that, at each stage of the key, you choose between two routes.</p> <p>Learners may think that a new key has to be constructed every time they want to use one; show them examples of ready-made identification keys.</p>
7Bp.02 Discuss reasons for classifying viruses as living or non-living.	Classification, virus, living, non-living	<p>Diagrams and models of viruses can be used to help learners visualise their structure.</p> <p>Animations of viruses can highlight the current understanding of what viruses can and cannot do.</p>	<p>Some learners may believe that a virus is a kind of cell. Show them diagrams showing the structure of a virus; explain that viruses do not have the structure of cells (e.g. they have no cell membrane).</p> <p>Learners may think that bacteria and viruses are a similar size. Explain that most viruses are about a thousand times smaller than most bacteria.</p>

Unit 7.4 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
7Bp.01 Describe the seven characteristics of living organisms.	7TWSa.05 Present and interpret observations and measurements appropriately.	<p>Defining the seven characteristics of living organisms</p> <p>Check learners' prior knowledge by asking what life processes are common to plants and animals. Add to their correct responses, if necessary, so that they have a list of the seven characteristics.</p> <p>Gather specimens (living or dead) of a range of organisms so that the class, as a whole, can study more than just plants and animals. (Note: this activity would also work with models, or pictures, of the organisms). Put learners into small groups and give each group a different organism to research; ask the groups to try and find out how 'their' organism moves, respire, senses its environment, grows, reproduces, excretes and obtains nutrients. Learners can use secondary sources of information, observations of the specimens and videos of the specimens in their natural environment. Groups can then present their findings to the rest of the class. (Note: some movement cannot be seen by the naked eye over a short space of time).</p> <p>Ask questions: <i>If an organism appears to show only six of the seven characteristics of living organisms, is it alive?</i> <i>How could you explain the seven characteristics of living organisms for a cactus, mushroom or bacterium?</i></p> <p>This activity could be extended by asking learners to consider if there might be further characteristics that define living organisms. Scientists have suggested other characteristics (e.g. being composed of cells, having a finite lifespan). Ask learners to research these ideas using secondary information sources and to produce a short report, recommending or otherwise, the adoption of additional, or alternative, characteristics that describe living organisms.</p> <p>Resources: Specimens of different organisms, secondary sources of information</p>
7Bp.03 Describe a species as a group of organisms that can reproduce to produce fertile offspring.	<p>7TWSp.01 Identify whether a given hypothesis is testable.</p> <p>7TWSc.06 Evaluate a range of secondary information sources for</p>	<p>Exploring the concept of species</p> <p>Give learners a hypothesis: 'a species is a group of organisms that can reproduce to produce fertile offspring'. Ask learners to work in small groups to test this hypothesis; give the groups specific categories of organisms to research so that they do not focus only on animals. Learners, using secondary information sources, search for examples of organisms that reproduce to produce fertile offspring. Ensure learners</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
	<p>their relevance and know that some sources may be biased.</p>	<p>justify their use of any texts through considering their relevance to the task. Discuss whether having many examples is sufficient to test a hypothesis.</p> <p>Provide learners with examples of family trees. These could be for humans (e.g. a royal family) or another animal (e.g. horse). Ask learners, working in pairs, to use the chart to create a single line of inheritance. They should start by identifying one descendent, then one parent, then one grandparent, then one great grandparent etc. They should label offspring and parents on their inheritance chart. This is a relatively simple exercise but involves extracting information from a more complex chart and reinforces the idea of organisms reproducing to produce offspring, who in turn reproduce to produce further offspring; this could only happen if the organisms were fertile.</p> <p>Ask the question: <i>Zebras and horses are two different species, yet they have been known to produce offspring together. How does this fit with the definition of species? (The offspring are not fertile).</i></p> <p>As an extension learners can research other hybrid offspring and how they fit with the definition of species for animals (e.g. mule, liger, jaglion) and plants (coffea arabica)</p> <p>Resources: Secondary information sources, family trees</p>
<p>7Bp.04 Use and construct dichotomous keys to classify species and groups of related organisms.</p>	<p>7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys.</p>	<p>Using dichotomous keys</p> <p>Tell learners that they will be using and creating dichotomous keys; check what prior knowledge they have of keys. Give learners the definition of a dichotomous key and explain that the term 'dichotomous' means 'in two parts'.</p> <p>Demonstrate a simple dichotomous key (e.g. a real key based on four different leaves). Alternatively, create an invented 'alien key' to describe four aliens: choose the alien names and create a key that would help you differentiate between them (e.g. how many heads they have, what colour they are, what shape they are, how many appendages they have). Show learners the key and challenge them to draw one of the named aliens. (Examples of 'alien keys' can be found online).</p> <p>Provide learners with a simple dichotomous key for real species (e.g. using beaks as identification choices for birds, using leaves as identification choices for plant species). Alternatively, learners can use an online, interactive, dichotomous key to identify organisms (e.g. freshwater fish).</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>Ask pairs of learners to use the key to identify a given specimen. This would work well as a 'circus' activity so that learners can practise on a range of organisms and use different dichotomous keys. Explain to learners that it is important that they go through each stage of the key, even if they think they know what the answer is going to be, as some species are very similar.</p> <p>Ask learners to 'think-pair-share' to discuss how they might start to construct a dichotomous key. Once learners are clear how to start, ask them to work in pairs to construct a simple dichotomous key for a specimen (or picture) that they are given. Pairs should test their keys by asking another pair to use their key to identify their specimen, and modify their key if necessary, in the light of constructive feedback.</p> <p>Resources: Examples of simple dichotomous keys, specimens of organisms</p>
<p>7Bp.02 Discuss reasons for classifying viruses as living or non-living.</p>	<p>7TWSm.01 Describe the strengths and limitations of a model.</p> <p>7TWSc.06 Evaluate a range of secondary information sources for their relevance and know that some sources may be biased.</p>	<p>What are viruses?</p> <p>Hold a class discussion to find out what learners already know about viruses.</p> <p>Provide learners, working in small groups, with models of different viruses. Ask the groups to research 'their' virus and to make a list of how their model is similar to the actual virus and how it is different from the actual virus. Discuss with the class the strengths and limitations of the virus models.</p> <p>Divide the class into two. Ask one half to research and present arguments for viruses being classified as 'living'. Ask the other half to research and present evidence for viruses being classified as 'non-living'. Hold a debate to discuss the reasons for classifying viruses as living or non-living. Ask learners to justify the use of their secondary information sources in terms of their reliability and any possible bias from the authors.</p> <p>Give learners a labelled diagram of a virus. Ask them to annotate the diagram with any features that match the characteristics of living organisms in one colour (e.g. the ability of viruses to make more viruses) and any features that do not match the characteristics of a living organism in another colour (e.g. the absence of any mechanism to carry out movement).</p> <p>Ask questions: <i>The majority of scientists consider that viruses are non-living. What are their reasons?</i> <i>A few scientists consider that viruses should be regarded as living organisms. What are their reasons?</i> <i>What do you think? What are your reasons?</i></p> <p>Resources: Models of viruses, secondary information sources, labelled diagram of a virus</p>

Unit 7.5 Explaining properties of matter

Unit 7.5 Explaining properties of matter

Outline of unit:

This unit covers the chemical and physical properties of substances. Learners will understand that acidity and alkalinity are chemical properties of substances and that these can be measured by pH. The use of indicators to distinguish between acidic, alkaline and neutral solutions is explored.

Learners study the chemical and physical properties of alloys and their constituents; they use the particle model to explain differences in their properties.

During this unit, learners have opportunities for individual and group work, planning investigative work and constructing appropriate tables for results. During practical work with dilute acids and alkalis, they will consolidate their understanding of hazard symbols and safe practice.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- understanding a property can be described as a characteristic of a material and that materials can have more than one property
- testing materials to determine their properties
- knowing electrical conductivity and thermal conductivity are properties of a substance
- knowing the temperature at which a substance changes state is a property of the substance
- using the particle model to describe solid, liquids and gases
- knowing that the change of state of a substance is a physical process
- knowing alloys are examples of mixtures.

Suggested examples for teaching Science in Context:

7SIC.04 *Describe how people develop and use scientific understanding, as individuals and through collaboration, e.g. through peer-review.*

Learners can explore the range and types of dental alloys used by dentists. If possible, a dentist could be invited in to describe how dental alloys have been developed and the research required (including scientific publication and peer review) before new materials are used on patients.

Learners can explore the story of the discovery of graphene and the research of its chemical and physical properties; this involved many groups of scientists, publications and peer reviews (and resulted in a Nobel prize).

7SIC.05 *Discuss how the uses of science can have a global environmental impact.*

The increasing demand for some metals for industrial use as alloys (e.g. tin in solder for the computer industry) has an impact on the global environment as new sources of metals are sought and more land is used for quarries and mining. Learners can explore this part of the life cycle of a computer and understand how the human search for metals and alloys can affect the environment.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Cp.01 Understand that all substances have chemical properties and physical properties.	Chemical properties, physical properties, appearance, thermal conductivity, electrical conductivity, magnetism, malleability, ductility, flexibility, density, hardness, lustre, chemical reaction	<p>Animations and videos can be used to illustrate the chemical and physical properties of substances, and the differences between chemical and physical properties.</p> <p>Flow charts can guide learners to ask useful questions in order to decide whether a physical or a chemical property is being described in relation to a substance.</p> <p>Interactive Periodic Tables can be used to search for the chemical and physical properties of different elements.</p>	Chemical property may be confused with chemical change; similarly, physical property may be confused with physical change. Give definitions, examples and plenty of opportunities for learners to practise using these terms to help them understand the differences.
7Cp.02 Understand that the acidity or alkalinity of a substance is a chemical property and is measured by pH.	Acid, alkaline, neutral, acidity, alkalinity, chemical property, pH	<p>pH indicator charts provide colourful representations of the acidity, alkalinity or neutrality of substances.</p> <p>Animations can be used to illustrate the range of pH of different substances.</p>	<p>Some learners may believe that an acidic substance is the same as an acid; this may lead on to thinking that all acidic substances are dangerous (i.e. they can 'burn' and 'eat' material away as well as damage skin). Explain (and/or demonstrate) that many substances are naturally acidic (e.g. lemon juice; secretions from human skin; rain not just acid rain).</p> <p>Learners may not understand that alkalis can be corrosive; they have more awareness of the corrosive properties of acids and view alkalis as substances that neutralise acids. Show learners videos of the corrosive nature of some alkalis, such as caustic soda solution (i.e. sodium hydroxide solution); explain that 'caustic' means to burn or corrode.</p>
7Cp.03 Use indicators (including Universal Indicator and litmus) to distinguish between acidic, alkaline and neutral solutions.	Indicator, Universal Indicator, litmus, acid, alkali, pH, acidic, alkaline, neutral, solution	<p>pH indicator charts for Universal Indicator provide colourful representations of the acidity, alkalinity or neutrality of substances.</p> <p>Simple colour charts that show the colours that litmus turns when used to test substances provide a representation of the acidity or alkalinity of a substance.</p>	<p>Learners may think that all indicators appear 'red' for acidic substances and 'blue' for alkaline substances. Show learners that litmus exists in red and blue forms and let them see that it is the change in colour when substances are tested that gives the information about acidity or alkalinity.</p> <p>Learners may think that Universal Indicator and litmus are the only indicators that distinguish between acidic, alkaline and neutral solutions. Explain to learners that</p>

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
		Animations showing the use of Universal Indicator and litmus can help learners understand the range of colours and what they mean for each type of indicator.	<p>these are two common indicators; there are many more indicators, including ones that can be made from red cabbage. It might be helpful to explain that Universal Indicator is a mixture of a number of other indicators; litmus is also a mixture, but of different dyes extracted from lichens.</p> <p>As this learning objective only distinguishes between acidic, alkaline and neutral solutions, it is not necessary to talk about 'strong' acids and alkalis. Should they be mentioned, guide learners in the use of correct terminology; discourage them from using 'strong' and 'concentrated' to mean the same thing.</p>
7Cp.06 Understand that alloys are mixtures that have different chemical and physical properties from the constituent substances.	Alloy, mixture, chemical property, physical property, constituent, tensile strength	<p>Particle diagrams can be useful to show the composition of alloys and the composition of constituent substances; different colours and sizes can be used to represent the different constituents.</p> <p>Animations can be used to show the different chemical and physical properties of alloys and their constituent substances.</p>	Some learners may think that alloys are made from two or more metals. Explain that alloys are made from at least one metal and the other constituents may be metals or non-metals. Steel is a useful example of an alloy as there are many different types of steel; they are all based on iron mixed with different metals and/or non-metals.
7Cp.07 Use the particle model to explain the difference in hardness between pure metals and their alloys.	Particle model, hardness, pure metals, alloys	Show learners particle diagrams representing a pure metal with a very regular structure and an alloy with a distorted layer structure due to some of the particles being a different size.	Some learners may be confused about what a 'pure metal' means as the word 'pure' can be used differently in everyday language. For example, 'pure' spring water can refer to a bottle of a dilute solution containing minerals. Explain that a chemically 'pure' metal consists of a single element; it only has one type of atom in it. Provide examples of some common pure metals (e.g. aluminium, copper, iron and lead).

Unit 7.5 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
7Cp.01 Understand that all substances have chemical properties and physical properties.	7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys.	<p>Chemical and physical properties</p> <p>Define what is meant by a chemical property and a physical property, give examples:</p> <ul style="list-style-type: none"> A chemical property is any property that describes the potential of a substance to undergo a chemical change or reaction due to its composition (e.g. hydrogen has the potential to ignite and explode given the right conditions; the reaction of a substance with air, water, acid or other chemicals). A physical property is a property that can be observed or measured without the substance undergoing any chemical change (e.g. density, hardness, colour, conductivity, malleability, lustre, melting and boiling points, solubility, elasticity). <p>Ask learners, working in pairs, to sort a given list of properties into either chemical properties or physical properties. Pairs check their lists with other pairs; they discuss any differences in their lists and the reasons for the choices they made. Some learners may find a 'decision' flowchart useful to help them make choices.</p> <p>Provide learners with 'chemical property' and 'physical property' cards they can hold up. Read learners a short description of an interesting substance (e.g. the element, gallium) including several chemical properties and physical properties (e.g. gallium melts in your hand, it can form an alloy with aluminium). Ask learners to hold up the correct card each time a property is mentioned in the description, they choose to show either 'chemical property' or 'physical property'. Challenge a few learners to explain their choice of property.</p> <p>Resources: List of chemical and physical properties, description of a substance including its chemical and physical properties, 'chemical property' and 'physical property' cards</p>
7Cp.02 Understand that the acidity or alkalinity of a substance is a chemical property and is measured by pH.	7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys.	<p>Using pH as a measure of the acidity or alkalinity of substances</p> <p>Explain that the acidity or alkalinity of a substance is a chemical property. Explain that pH is a useful way to measure how strong an acid or alkali is; it gives a number on a scale that is internationally recognised. Learners may wonder what 'pH' stands for; there is no need for Stage 7 learners to know more than it stands for the 'power of hydrogen' and relates to how acidic or alkaline a substance is.</p> <p>Show learners an animation that illustrates the range of pH of different substances.</p>

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		<p>Give learners a copy of a pH chart with a 1-14 scale and blank spaces next to the numbers, for them to add examples of substances with the matching pH. Provide learners with information about a range of substances and their pH; alternatively, learners use secondary information sources to find at least one example for each pH.</p> <p>Give pairs of learners a set of 'concept cartoons' on the topic of pH (or acid and alkalines). Ask each pair to discuss the cartoons and decide which are true statements, which are false statements, and which need further discussion. If concept cartoons are not available, you can make your own or prepare a set of 'true or false' questions for learners to discuss and answer.</p> <p>Resources: Animation about pH, pH chart worksheets, information sheets about substance, concept cartoons</p>
<p>7Cp.03 Use indicators (including Universal Indicator and litmus) to distinguish between acidic, alkaline and neutral solutions.</p>	<p>7TWSp.04 Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests.</p> <p>7TWSp.05 Know the meaning of hazard symbols and consider them when planning practical work.</p> <p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p>Using indicators (requires additional resources)</p> <p>Demonstrate the use of Universal Indicator, red litmus paper and blue litmus paper; learners will become familiar with the range of colours that represent the acidic, alkaline and neutral solutions.</p> <p>A particularly effective way to show the use of Universal Indicator is to demonstrate acids and alkalis on filter paper. Add 0.1M hydrochloric acid to one half of a piece of filter paper sitting in a petri dish; 0.1M sodium hydroxide solution to the other half of the filter paper, so that the whole filter paper is just damp. Add a few drops of Universal Indicator solution to the middle of the filter paper. Observe the different colours forming as the indicator spreads out. If possible, photograph the liquids as they spread out and the colours of the pH scale develop; this can make an interesting record that learners can annotate.</p> <p>Alternatively, learners can carry out the following activity themselves. Explain the appropriate safety precautions to be taken when working with dilute acids and dilute alkalis (i.e. wear safety glasses, do not eat or drink, mop up spills immediately, wash splashes from hands immediately). Show, and discuss, hazard symbols to learners and explain why it is important to pay attention to them. Ask learners which hazard symbols may apply when testing the acidity and alkalinity of solutions.</p> <p>Provide learners with a selection of common substances that represent a wide range of pH values (e.g. lemon juice; salad cream; mouthwash; yoghurt; rainwater; tap water; egg white; baking soda in water; milk of magnesia; washing powder in water: dilute household ammonia product; and dilute bleach) Ensure if using any ammonia products, bleach or other harmful chemicals learners are aware of how to handle them safely. Learners, working in pairs, plan an investigation to find the pH of the substances using both Universal Indicator paper and red and blue litmus paper. Remind learners to note any hazard symbols on</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>the substances they are going to test (e.g. on a bottle of bleach) and to consider these when planning their investigation. Ensure learners discuss what investigation type they have planned and why they choose that type.</p> <p>Before starting to test substances, ask learners to prepare a results table (that includes headings for any colour change and the pH) and a separate table to sort the substances into acidic, alkaline and neutral solutions. Learners then test the substances.</p> <p>Ask questions: <i>Did Universal Indicator and litmus give any different results? If so, why was this?</i> <i>Are there any advantages and disadvantages of using a) Universal Indicator and b) litmus?</i> <i>Are there any advantages and disadvantages of using a) Universal Indicator solution and b) Universal Indicator paper?</i> <i>Were there any pH values that were not found when testing household substances? If so, why might that be?</i></p> <p>This activity can be extended by challenging learners to create a 'rainbow' of colours using Universal Indicator, 0.1M hydrochloric acid, 0.1M sodium hydroxide and water. Spotting tiles and dropping pipettes can be used to make this activity small scale. Remind learners of the safety issues for handling dilute acids and alkalis. Ask them to plan what they are going to do; they should consider the potential hazards and take appropriate safety precautions. Encourage learners to photograph their final array of colours; some of these could be printed and given to learners to label with the pH number that the colour represents.</p> <p>Resources: Universal Indicator paper, Universal Indicator solution in small dropper bottles, red and blue litmus paper, circles of filter paper, dilute sodium hydroxide, dilute hydrochloric acid, dropping pipettes, spotting tiles, cameras, common substances that represent a wide range of pH values.</p>
	<p>7TWSp.04 Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests.</p>	<p>Using indicators</p> <p>Show learners an animation (or video) that demonstrates the use of Universal Indicator, red litmus paper and blue litmus paper; learners will become familiar with the range of colours that represent the acidic, alkaline and neutral solutions.</p> <p>Show, and discuss, hazard symbols to learners and explain why it is important to pay attention to them. Ask learners which hazard symbols may apply when testing the acidity and alkalinity of solutions.</p>

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	<p>7TWSp.05 Know the meaning of hazard symbols and consider them when planning practical work.</p> <p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p>Provide learners with pictures of common substances with a range of pH (e.g. lemon juice, salad cream, mouthwash, yoghurt, rain water, tap water, egg white, baking soda, milk of magnesia, washing powder, dilute household ammonia product and dilute bleach). Ensure if using any ammonia products, bleach or other harmful chemicals learners are aware of how to handle them safely. Learners, working in pairs, use secondary information sources to find out the pH, and any hazard symbols, for one of two of the substances. Ask learners to create a poster that summarizes their findings for their substance: name, picture, pH, the colour it would turn with Universal Indicator, the colour it would turn with litmus solution and any hazard symbols. Learners then share their posters and discuss their findings. Create a class pH scale using their findings so learners can see all of the findings on one scale.</p> <p>Ask learners to write a short plan to show how the products on their poster could be tested using Universal Indicator and litmus, including any precautions they would take when using substances that are potential hazards (e.g. bleach). Their plan should also include a table for results. Learners can peer review each other's plans and provide constructive criticism. Ensure learners discuss what investigation type they have planned and why they choose that type.</p> <p>Ask questions: <i>Would you expect Universal Indicator and litmus to give any different results? If so, why?</i> <i>Are there any advantages and disadvantages of using a) Universal Indicator and b) litmus?</i> <i>Are there any advantages and disadvantages of using a) Universal Indicator solution and b) Universal Indicator paper?</i> <i>Were there any pH values that were not found when researching household substances? If so, why might that be?</i></p> <p>This activity can be extended by showing learners a video of the 'rainbow colours' that can be created by using Universal Indicator, a dilute acid, a dilute alkali and water. If the video has a sound track or commentary show it with the sound off. Ask learners, working in pairs, to write their own script. Play the video as many times as needed, then show it while learners read some of their scripts.</p> <p>Resources: Animation of the use of Universal Indicator and red and blue litmus paper, pictures of common substances with a wide range of pH values, secondary information sources, a video of 'rainbow colours'</p>
<p>7Cp.06 Understand that alloys are mixtures that have different chemical and physical properties</p>	<p>7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing,</p>	<p>Differences between alloys and their constituent substances</p> <p>Check learners' understanding of what an alloy is; give them a list of definitions of an alloy, where only one definition is correct, and ask them to find the correct definition (i.e. an alloy is a mixture of two or more elements, including at least one metal element).</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
from the constituent substances.	observation, using secondary information, and making and using keys.	<p>Explain that converting pure metals into alloys often increases the strength of the product. For example, brass is an alloy of copper and zinc; brass is stronger than copper or zinc alone. Ask learners to try to bend thin sheets of brass, copper and zinc; alternatively, show them a short video. Explain that 'tensile strength' is another way of measuring strength; this is how easy it is to break a substance by pulling on it.</p> <p><i>Why are alloys classed as mixtures and not as compounds?</i> <i>If zinc has a tensile strength of 139 MPa and copper has a tensile strength of 220 MPa, would you expect the tensile strength of brass to be less than 139, about 180 (a rounded up mean of 139 & 220) or more than 220 MPa? (the actual tensile strength of brass is 350 MPa).</i> <i>Is 'strength' a physical or chemical property?</i></p> <p>Ask learners if they have come across stainless steel and, if so, what it was being used for. If necessary, prompt learners by showing pictures of items that are made of stainless steel (e.g. washing drums, cutlery, cooking utensils, saucepans, stoves, sinks, refrigerators, nuts, bolts, screws, pipes and containers for large-scale food and drink processing). The commonest type of stainless steel is made from iron with added chromium (18%) and nickel (8%). Ask learners to find these three elements on the Periodic Table and to draw a particle diagram using three different colours showing the composition of stainless steel with roughly the right proportions of each constituent.</p> <p>Learners can then research using secondary information sources the individual properties of the constituent elements of stainless steel and compare these properties with those of stainless steel. <i>Why might a ship that used iron nails to hold its outer shell together be an insurance risk?</i> <i>Why is it better to use stainless steel nails than chromium nails?</i> <i>Why is stainless steel called 'stainless'?</i></p> <p>Make sure that all learners are clear that alloys are mixtures that have different chemical and physical properties from their constituent substances by putting learners into teams and holding a quick quiz.</p> <p>Resources: True/false definitions of an alloy; thin sheets of brass, copper and zinc; Periodic Table; secondary information sources; quiz questions.</p>
7Cp.07 Use the particle model to explain the difference in hardness between pure metals and their alloys.	<p>7TWSm.01 Describe the strengths and limitations of a model.</p> <p>7TWSm.02 Use symbols and formulae to</p>	<p>Using particle models to explain the differences in hardness between brass, zinc and copper.</p> <p>Show learners a range of alloys (e.g. different types of steel, brass, bronze, duralumin, pewter and solder) and information about each of them and the pure metals they are composed of. Ideally this is arranged as a 'circus' activity, with pairs (or small groups) visiting each 'alloy station'. They extract information to complete a table on a worksheet: name of alloy; composition (i.e. chemical formulae); particle diagrams to show the</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
	represent scientific ideas.	<p>composition of each alloy (using different colours and sizes for different substances) and the uses of the alloy. It may be helpful to have the first row filled in with an example. If alloys are not available, show learners an animation (or video) that explains the different properties of alloys and their constituent substances.</p> <p><i>Why can thin sheets of copper and thin sheets of zinc be bent easily but not thin sheets of brass?</i></p> <p>Explain, using particle models, why brass is harder than the pure metals it is made from. Learners then explain the difference in hardness between pure metals and their alloys using their own particle model.</p> <p>Resources: Range of alloys, information sheet for alloys and pure metals, alloys Worksheet, Periodic Table</p>

Unit 7.6 Energy and sound

Unit 7.6 Energy and sound

Outline of unit:

This unit covers the changes in energy that are a result of an event or process; it will introduce the idea that energy tends to dissipate and in doing so it becomes less useful. Learners will also learn that particles vibrate in a sound wave and be able to explain why sound does not travel in a vacuum.

Learners will have opportunities to present and interpret observations and to evaluate some secondary sources of information. They will make predictions based on their scientific knowledge and understanding. Learners will use formulae to investigate how echoes can be used to calculate distances and how these calculations can be made more reliable by improving the experimental design.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- knowing energy is present in all matter and in sound, light and heat
- knowing energy cannot be made, lost, used up or destroyed but it can be transferred, stored and dissipated
- understanding energy is required for any movement or action to happen
- understanding not all energy is transferred from one object to another, but often some energy during a process can be dissipated to the surrounding environment and this can be detected as sound, light or a temperature increase
- identifying sounds are made by vibrating sources
- describing sounds in terms of high or low pitch and loud or quiet volume
- knowing there are different sources of sound
- knowing as sound travels from a source it becomes quieter.

Suggested examples for teaching Science in Context:

7SIC.03 Evaluate issues which involve and/or require scientific understanding.

Learners can consider the advantages and disadvantages of single glazing, double glazing and triple glazing for windows, with a focus on how they are reducing the amount of dissipated energy.

7SIC.05 Discuss how the uses of science can have a global environmental impact.

Learners can discuss the need for long-lasting mobile phone batteries and the factors that might extend the life of batteries. The impact on the environment of the manufacture of mobile phone batteries and the disposal of old batteries can be explored.

The use of echoes by fishermen to locate, and catch, large shoals of fish (e.g. in echo location or sonar) can be discussed; learners can try to answer the question; Is this technology having a global impact on fish populations?

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Pf.01 Describe changes in energy that are a result of an event or process.	Energy, stores, transfers, conservation, thermal, chemical, kinetic, gravitational, potential, elastic, nuclear	<p>There are various models of energy. The simplest is to consider energy as being of different 'types', for example: 'chemical energy', 'thermal energy' and 'kinetic energy'. This model of energy allows learners to consider how energy can be transferred from one type of energy into a different type of energy. Alternative models of energy exist (e.g. the stores and pathways model). More information about this model can be found online. If you decide to use this model, then you will need to significantly alter the activities in this unit accordingly.</p> <p>Toy construction bricks can be used to represent small packets of energy. This model sets a limit on how much energy can be transferred (i.e. all the bricks remain, whatever combinations and shapes they are made into).</p> <p>Money can also be used to represent energy; a limit can be set by having only a certain amount of money (energy) available. Money (energy) can be transferred from one form into another; such as from a savings account (e.g. chemical energy) into a different currency (e.g. thermal energy).</p>	<p>'Energy' is an abstract idea and hard to define. Learners often hear and use the word in ways that are not scientifically accurate (e.g. energy is made or produced; energy is 'used up' or 'runs out'). Once it has been explained that energy is neither created nor destroyed but transferred from one type of energy to another type of energy, ensure that the correct terms are used when talking about energy.</p> <p>A common misconception about energy is that the terms 'energy' and 'force' are interchangeable. Be alert to any misuse of the term 'energy' such as 'energy causes changes' or 'energy makes things happen' and correct these when necessary.</p> <p>Some learners may think that energy is a fuel. Explain that fuels have chemical energy; this energy can be transferred to thermal energy in the surroundings when fuel is burned.</p> <p>Some learners may think that an object at rest 'has no energy' or 'has run out of energy' and/or that only moving objects are 'full of energy'. Explain that energy is always present, just as different types. When a disposable battery is said to 'have run out of energy' it has actually transferred all of its chemical energy to another type of energy. When someone says: 'I've run out of energy', they will still be converting chemical energy into useful energy.</p>
7Pf.02 Know that energy tends to dissipate and in doing so it becomes less useful.	Energy, dissipation, useful energy, non-useful energy	The 'money' model can be used to illustrate dissipation of energy. Each coin represents an amount of energy. When coins are distributed between many people, no-one has much to spend and the money (energy) becomes less useful.	Learners sometimes confuse sources of energy (e.g. fuels, wind, solar) with types of energy (e.g. chemical, kinetic). It is worth spending time clarifying the differences between sources and types of energy.
7Ps.01 Describe the vibration of particles in a sound wave and	Vibration, particles, energy, sound, sound wave, vacuum	The Slinky model uses a 'slinky' toy (i.e. a compressed helical spring toy) to model how a sound wave travels; each coil represents an air molecule and each wave of	Some learners may think that sound waves can travel through space because light waves can. Explain that

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
explain why sound does not travel in a vacuum.		<p>compression represents a sound wave. Sound travels through the air (the wave moves), but the air (the coil) does not travel with the sound; like the coils, the air particles just vibrate.</p> <p>The particle model can be used to help explain why sound does not travel in a vacuum. Compare the particle arrangement of a gas and a vacuum: gas particles are spaced apart from each other but can vibrate and interact, but a vacuum has no particles to vibrate or interact with.</p>	<p>light waves move in a different way and do not need particles to move, unlike sound.</p> <p>Learners may think that sound travels through an empty space (a vacuum); this is a likely misconception as a number of science fiction films imply sound can travel in space. This misconception will be addressed in this unit.</p>
7Ps.02 Explain echoes in terms of the reflection of sound waves.	Echoes, sound, sound waves, reflection	<p>Drawings of waves can illustrate how sound waves travel or change, including their reflection.</p> <p>Diagrams and oscilloscope images can show representations of sound waves.</p>	Some learners may think that the process of reflection only involves light. This unit will address this misconception and show learners that sound can also be reflected.

Unit 7.6 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
7Pf.01 Describe changes in energy that are a result of an event or process.	7TWSa.05 Present and interpret observations and measurements appropriately.	<p>Types of energy</p> <p>Introduce the different types of energy as: thermal (i.e. heat), chemical, nuclear, electrical, light, sound, mechanical, elastic and gravitational. Explain that 'kinetic energy' is the energy of a moving object and 'potential energy' is energy that is stored in an object or substance. Introduce the idea that some of these types of energy can be stored (e.g. potential energy, chemical energy).</p> <p>Set up a 'circus' of several events (or processes) involving different types of energy and energy transfers. These might include real events (e.g. a candle burning) or pictures of processes (e.g. a battery-powered motor lifting a stack of bricks). At each 'station' learners, working in pairs, identify which types of energy and energy transfers are being shown. Further examples are:</p> <ul style="list-style-type: none"> • bread being toasted in an electric toaster • a light bulb being switched on • music playing from a radio • a hair dryer operating • a cricketer hitting a cricket ball • a stone being dropped down a well • a safety match being struck so that it lights • a candle burning • a speedboat travelling on water • a solar cell on the roof of a house. <p>Select the examples most relevant to your learners and, if beneficial, add in your own examples.</p> <p><i>Was it difficult to identify the types of energy and energy transfers involved in any of the examples? (If so, discuss)</i></p> <p><i>Can you think of any more examples and what types of energy / energy transfers would be involved?</i></p> <p>Resources: Examples of events involving different types of energy and energy transfers.</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7Pf.02 Know that energy tends to dissipate and in doing so it becomes less useful.</p>	<p>7TWSc.06 Evaluate a range of secondary information sources for their relevance and know that some sources may be biased.</p>	<p>Dissipation of energy</p> <p>Discuss learners' ideas about the conservation of energy. Make sure they understand that the total amount of energy in the universe is always the same, but it can be transferred from one energy store to another during an event or process.</p> <p>Show learners a selection of messages (e.g. signs, headlines) that encourage people to 'save energy' (e.g. 'a list of top energy-saving tips', 'save electricity'). Ask learners: <i>What is wrong with these messages?</i> <i>If energy is always conserved, it 'saves itself', so why do people need to save it?</i> <i>What actually gets 'used up' that we should be trying to conserve? (fuels)</i></p> <p>Explain to learners that energy can become less useful (or be wasted) when it is transferred to thermal stores in the environment e.g. increases the air temperature. Such energy is referred to as 'dissipated'. An example is burning a candle. The energy that was in the chemical store spreads out amongst other stores, most of which will be thermal stores of energy, as the surroundings are heated up. It is very difficult to do anything useful with these dissipated stores of energy.</p> <p>An efficient system transfers most of its energy in a useful form (i.e. not much is dissipated). Explain that mechanical devices can be made more efficient by using grease to reduce the friction between moving parts of the machine and increasing the amount of useful energy transferred. Provide learners, working in small groups, with examples of energy transfers (e.g. eating a chocolate bar, swinging a pendulum, bouncing a ball) and ask them to suggest how the amount of energy dissipated could be reduced. Hold a class discussion using learners' ideas.</p> <p>Show learners a picture of a light switch with a notice next to it that reads 'switch the light off when you leave to save electricity' or similar. Learners, working in pairs, try to write a scientifically accurate notice (e.g. switch the light off when you leave to avoid adding to the non-useful thermal store of energy in the environment and to save the fuels needed to put energy into a chemical store that can then be transferred to electrical energy.)</p> <p>Resources: Selection of 'save energy' messages; examples of energy transfers, picture of a light switch</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7Ps.01 Describe the vibration of particles in a sound wave and explain why sound does not travel in a vacuum.</p>	<p>7TWSp.03 Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding.</p> <p>7TWSa.02 Describe trends and patterns in results, including identifying any anomalous results.</p>	<p>Sound does not travel through a vacuum (requires additional resources)</p> <p>Show learners a video (or animation) that uses the particle model to explain sound waves. Then, ask learners, working in pairs, to write an account in their own words. Make sure that they include the following ideas:</p> <ul style="list-style-type: none"> • When a wave travels through a substance, particles move to and fro (i.e. they vibrate). • Energy is transferred in the direction of movement of the wave. • Bigger or faster waves transfer more energy. • The wave moves in one direction, but the material it travels through does not. • Vibrations of particles transport energy from place to place without transporting matter. • Our ears can pick up these ‘particle-vibrations’ as sound. <p>If possible, demonstrate the actions of a ‘slinky’ toy (a compressed helical coil). Explain that a sound wave is like a slinky wave because:</p> <ul style="list-style-type: none"> • the wave is transported from one location to another • the wave travels through a medium (air for the slinky; particles for the sound wave) • there is a vibrating source (the first bit of the slinky; the vibrating part of a guitar or vocal cord of a person) • there are interacting parts (coils of the slinky; interacting, vibrating particles of a sound wave – as one air particle is displaced it exerts a push/ pull on its nearest particles causing them to be displaced and these, in turn, cause their neighbouring particles to be displaced). <p>Ask learners to draw particle diagrams of air and of a vacuum (no particles). Set up a battery-powered buzzer (or other object that can make sound in a bell jar (or similar apparatus) that can have the air evacuated using a vacuum pump.</p> <p>Before the activity, check that the bell jar is free from cracks and chips; the outside should be covered in transparent adhesive film in case of implosion. Safety screens should be placed between learners, operator and the bell jar; the operator should wear safety glasses. Make sure that learners can hear the sound of the buzzer when the air is inside the jar.</p> <p>Ask learners to use their particle diagrams, and their scientific understanding, to predict what will happen to the sound if no air is present. Remove air from the bell jar; stop at several stages, to allow learners to listen to what happens to the sound of the buzzer as the air content reduces. Finally, remove as much air as possible from the bell jar and, again, allow learners to listen carefully for any sound of the buzzer. To</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>show that the buzzer is still operating, allow air back into the jar so that learners hear the increase in sound. Discuss this demonstration with learners and ask questions.</p> <p>Alternatively, show learners a video of the bell jar, buzzer and vacuum pump demonstration. Pause the video before the vacuum pump is started; give learners time to write down their prediction of what will happen to the sound. Restart the video and allow learners to check their predictions.</p> <p><i>Were your predictions correct? (If not, why not? Could they have been worded differently?)</i></p> <p><i>What trend can you describe, in terms of the volume of sound, as the air content was reduced?</i></p> <p><i>When the bell jar had as much air removed as possible, could you still hear any sound from the buzzer? If so, how might this result be explained?</i></p> <p><i>Would it make a difference if two buzzers were in the jar? If not, why not?</i></p> <p><i>The speed of sound in air is about 340 ms^{-1}; this is a million times slower than the speed of light. What is it about the way that sound travels that makes it relatively slow?</i></p> <p>This activity can be extended by asking learners to compile a list of science fiction films that have errors (e.g. screams and noises of explosions in space) that ignore the science of sound transmission in space. There are online sources for information about scientifically inaccurate films. Ask learners to identify the scientific errors and then suggest alternative scenes that would be correct; these can be written as a short scene (or as a letter to the film director explaining the issues and how they could be addressed).</p> <p>Resources: Video to explain sound waves, 'slinky' toy, bell jar, transparent adhesive film, safety screen, buzzer, vacuum pump, safety glasses</p>
<p>7Ps.02 Explain echoes in terms of the reflection of sound waves.</p>	<p>7TWSa.04 Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes.</p> <p>7TWSc.06 Evaluate a range of secondary information sources for their relevance and know that some sources may be biased.</p>	<p>Echoes are reflections of sound waves.</p> <p>Provide learners with a definition of an echo (i.e. a reflection of sound waves from a surface back to the listener). Show an animation of sound waves being reflected off a surface to make sure learners are clear about what is meant by reflection.</p> <p>Ask learners to work in a safe space, with few trip hazards. One learner should wear a blindfold (or keep their eyes closed). Ask this learner to walk around making a noise (e.g. clicking their fingers) to see if they can tell when they are close to a wall, another person, or a door. Several non-blindfolded learners and/or adults should monitor the blindfolded learner to ensure no accidents occur.</p> <p><i>Did this activity work?</i></p> <p><i>If so, what is the science behind the activity?</i></p> <p><i>If not, what might have prevented it working? How could the activity be improved? If it had worked, explain the science behind the activity.</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p><i>Can you think of any examples of animals using reflected sound? If so, what do they use it for?</i></p> <p>Show videos of some famous echoes (e.g. Grand Central Terminal's Whispering Gallery in New York City). Ask learners, working in small groups, to use secondary information sources to research other places that are known for their echoes. (e.g. Grand Canyon in the USA, Temple of Heaven in China) While doing so, learners should note the sources of their information and consider whether some sources (e.g. tourist information websites) might be biased in their claims. Hold a class discussion, using the found examples, for learners to suggest what makes these places so good for echoes. Ensure that learners understand that echoes are clearest when they have hard, reflecting surfaces rather than soft, absorbing surfaces. Explain that echoes are also affected by the size and shape of a space.</p> <p><i>How accurate might the information from secondary information sources be?</i> <i>Why might bias appear in some secondary information sources, such as tourist information websites?</i></p> <p>Resources: Animation of sound waves being reflected, blindfold, videos of echoes, secondary information sources</p>

Unit 7.7 Environment and ecosystems

Unit 7.7 Environment and ecosystems

Outline of unit:

This unit covers a wide range of topics that link to different aspects of environments and ecosystems. Learners start by considering the Earth at a geological level by studying plate tectonics, earthquakes, volcanoes and fold mountains. Learners investigate what causes tides and study the water cycle on Earth. Learners then learn about the composition of the atmosphere and the effect of pollutants.

The unit ends by considering living things on Earth and how they co-exist in ecosystems. As part of this, learners study the important role that microorganisms play in ecosystems and food webs.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- describing the relative position and movement of the planets, the Moon and the Sun in the Solar System
- describing the effect of gravity
- describing the model of the structure of the Earth which includes a core, a mantle and a crust
- identifying and describing common features of volcanoes and that they are found at breaks in the Earth's crust
- knowing that the Earth's crust moves and when parts move suddenly this is called an earthquake
- describing food webs and knowing they are made of producers and consumers
- identifying the energy source of a food chain/web and describing how energy is transferred through a food chain/web
- knowing that the water cycle involves evaporation, condensation and precipitation
- understanding that pollution is the introduction of substances by humans that harm the environment
- knowing that the Earth is surrounded by a layer of air called the atmosphere, which is a mixture of different gases
- knowing that the common gases at room temperature are oxygen, carbon dioxide, water (vapour), nitrogen and hydrogen.

Suggested examples for teaching Science in Context:

7SIC.02 Describe how science is applied across societies and industries, and in research.

Learners can research and discuss, the potential impact of climate change on the water cycle and the consequences for society and industries (e.g. fishing, farming and forestry). They can identify who is responsible for finding out and communicating such impacts (i.e. the scientists who study climate change or the scientists who research water cycles).

7SIC.05 Discuss how the uses of science can have a global environmental impact.

Technologies have been developed to harness the energy from tidal forces as electricity (e.g. tidal turbines, barrages). Learners can discuss the advantages and disadvantages of increasing the use of 'wave power' around the world; they can consider aesthetic, economic, ecological and environmental issues.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7ESp.01 Describe the model of plate tectonics, in which a solid outer layer (made up of the crust and uppermost mantle) moves because of flow lower in the mantle.	Plate tectonics, crust, mantle, flow	<p>Of the many models that can be used to represent the Earth's structure, the two models that are relevant to Stage 7 learners are:</p> <ul style="list-style-type: none"> A chemical model is based on chemical composition and subdivides the Earth into crust, mantle and core. A physical model which considers physical properties in terms of layers that can flow or not-flow. The outermost solid layer that cannot flow is broken into tectonic plates. These float on a layer that can flow. (Note: Learners do not need to know the technical terms lithosphere and asthenosphere at this stage.) <p>When using models of the Earth that show layers, be careful to distinguish between the chemical and physical models.</p> <p>Animations can show the movement of the different layers of the Earth in relation to each other.</p>	Learners may be confused about where the Earth's tectonic plates are located (e.g. somewhere below the surface, at the Earth's core, in the atmosphere). They may also think that tectonic plates are made up of crust only, rather than a thicker layer made up of both crust and some solid mantle. When teaching about tectonic plates, explain to your learners that they are on a tectonic plate.
7ESp.02 Describe how earthquakes, volcanoes and fold mountains occur near the boundaries of tectonic plates.	Earthquake, volcano, fold mountain, boundary, tectonic plate	<p>Animations can show the causes of earthquakes and volcanoes.</p> <p>Sequential diagrams are useful to show how fold mountains occur.</p> <p>Plate tectonic jigsaws can be used to illustrate the boundaries of different plates. From an online geological survey website, a map can be found that has the outlines of continents and the plates to make them. If the plates are cut out along their boundaries and stuck onto pieces of card, a plate jigsaw can be created for a class to use; it can also be demonstrated if a visualiser is available.</p>	<p>Learners may believe that earthquakes only happen in hot countries and they are always directly related to volcanic activities. These misconceptions can be addressed by giving examples that occur in both hot and cold countries and mapping the distribution of earthquakes and volcanoes.</p> <p>Learners may also think that earthquakes never occur in certain countries (e.g. the UK) or in certain areas (e.g. Chicago). The focus of this learning objective is on those earthquakes that occur near the boundaries of tectonic plates, but you may also like to give a wider range of examples. You could briefly explain that earthquakes can occur in other places (especially at faults in the Earth's outer solid layer) with the boundaries of tectonic plates being the largest examples of faults (and so are the sites of the largest earthquakes).</p>

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
			<p>Other misconceptions about the causes of earthquakes include the influence of weather, people and animals, gas pressure, gravity, the rotation of the Earth and processes in the Earth's core, 'exploding soil' and the expanding Earth. When teaching about earthquakes, be clear that none of these ideas are viable alternatives to the tectonic plate boundary idea.</p> <p>Learners may think that the magma within a volcano and the lava that spills out, come from the hot molten core of the Earth. Instead they are from the upper portion of the mantle and crust. Once at the surface, they are no longer under high pressure so flow freely.</p>
7ESs.03 Describe tidal forces on Earth as a consequence of the gravitational attraction between the Earth, Moon and Sun.	Tidal forces, tides, gravitational attraction, Earth, Moon, Sun	<p>A series of diagrams (or an animation) could be used to show the effects of lunar tidal forces on Earth. Correct diagrams will show bulges of water on the side of the Earth nearest the Moon, and also on the side furthest away from the Moon, so that the water 'shell' of the Earth looks like an oval, rather than a sphere.</p> <p>A series of diagrams (or an animation) could be used to show the effects of solar tidal forces on Earth and the effects of both lunar and solar tidal forces when the Moon and the Sun are aligned.</p>	<p>Learners may believe that tides are dependent on the rotation of the Earth–Moon system, and that this rotation causes the tides. Explain that the tidal 'bulges' are not due to rotation but instead the gravitational field of the Moon.</p> <p>Some learners may think that tidal forces affect all bodies of water, even water inside their bodies. Explain that tides arise because of tiny differences in the lunar gravitational pull at different points on the Earth. The large bodies of water that make up the oceans have different pulls on them in different places, causing the tides. Small bodies of water (e.g. inside someone's body, in an outside pool) will not have tides as all of the water in the contained spaces will be the same distance from the Moon.</p>
7ESp.03 Know that clean, dry air contains 78% nitrogen, 21% oxygen and small amounts of carbon dioxide and other gases, and this composition can change because of	Air, atmosphere, nitrogen, oxygen, carbon dioxide, pollution, natural emissions	Pie charts and bar charts can be useful representations of the proportions of different gases in the air. They can be used to illustrate the impact of pollutants on the composition.	<p>Some learners may not be aware that the air around them is mostly nitrogen gas. Raise their awareness by speaking about nitrogen when oxygen and carbon dioxide are mentioned.</p> <p>Some learners may not appreciate that when pollutants (or natural emissions) are added to air, this will alter the percentage composition of the other components of air. Remind learners that percentages</p>

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
pollution and natural emissions.			mean 'parts of 100' and that all the component parts have to add up to 100%; if something is added, and nothing taken away, then the percentages of other components must fall, if only by a small amount.
7ESc.01 Describe the water cycle (limited to evaporation, condensation, precipitation, water run-off, open water and groundwater).	Water cycle, evaporation, condensation, precipitation, run-off, sources, groundwater	Diagrams and animations are useful to show the water cycle.	<p>Some learners may think that the water cycle is confined to water evaporating, condensing and then evaporating again. Introduce learners to a water cycle diagram that shows evaporation, condensation, precipitation, water run-off, open water and groundwater.</p> <p>Some learners have difficulty in differentiating between water vapour and air. Explain that water vapour is the gaseous form of water and is usually present in different amounts in air (0.2 – 4%).</p> <p>Some learners believe that water vapour is visible as clouds. Explain that clouds are made of drops of liquid water, or ice crystals, floating in the sky whereas water vapour is a colourless gas.</p>
7Be.01 Know and describe the ecological role some microorganisms have as decomposers.	Ecology, ecological role, microorganism, decomposer, decomposition	Learners can be presented with a model of dead organic matter (e.g. layers of fabric where each layer, or different fabric, represents different tissue or organic matter). They use scissors, representing microorganisms, to cut the organic matter up. This represents the process of decomposition. The 'cut up' organic matter is used by the microorganism as an energy and nutrient source; it is then returned to the food web as nutrients for plants or via organisms that feed on the microorganisms.	Some learners believe that when plants and animals decay, they turn into microorganisms that produce carbon dioxide when they respire. (Note: this idea may come from a misunderstanding of the carbon cycle, so might not be met in Stage 7 learners). Be ready to clearly explain what microorganisms are and what happens to organisms when they decompose.
7Be.02 Construct and interpret food chains and webs which include microorganisms as decomposers.	Food chain, food web, microorganism, decomposer	Diagrams of food chains (and food webs) can be used to show the decomposer role of some microorganisms.	Some learners have difficulty in getting the arrows in food chains and food webs pointing in the correct direction. Explain that the arrows indicate the flow of energy, so arrows always move from the Sun, to producers, to primary consumers etc. When adding decomposers to food chains or webs, suggest that learners think about where the energy is moved to, when organisms die and decompose.

Unit 7.7 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7ESp.01 Describe the model of plate tectonics, in which a solid outer layer (made up of the crust and uppermost mantle) moves because of flow lower in the mantle.</p>	<p>7TWSm.01 Describe the strengths and limitations of a model.</p>	<p>The Earth's layers and tectonic plates.</p> <p>Ask learners, working in pairs, to describe what is below their feet. Encourage them to go as deep as they can; It is likely that learners will answer in terms of the crust, mantle and core. Bring ideas together in a discussion; show a model of the layers of the Earth, based on current evidence.</p> <p>Ready-made (or hand-made) models can be useful to illustrate the different layers (e.g. a 3D model showing a section through the whole Earth). An unpeeled apple can be used to model the very thin layer of the Earth's crust (represented by the peel). Explain that these models are 'chemical models' because they focus on the chemical composition of the Earth's structure. Other models exist that focus on the physical properties of the different parts of the Earth (e.g. whether or not a part can flow).</p> <p>Provide learners with diagrams of the layers of the Earth. Make sure that learners understand (and label in their diagrams) that the crust and the upper part of the mantle form, together, the solid parts called 'tectonic plates'. Explain the meaning of the term 'tectonic' with reference to the structure of the Earth's crust and the large-scale processes which take place within it.</p> <p><i>What do you notice about the Earth's crust?</i></p> <p>Explain that the plates are not a solid seal around the Earth but have gaps in various places. Explain that the edges where the plates fit together are called 'boundaries' and that the plates can move relative to each other at these boundaries.</p> <p><i>Because of these gaps, how do the tectonic plates behave? Are they static or moving?</i></p> <p>Demonstrate a 'moving tectonic plate' model using hard digestive biscuits and syrup. Fill a 2 litre container approximately one third full, with golden syrup (or another viscous liquid). Cool the syrup (for example in a fridge) for several hours before the lesson to increase the viscosity. Place a flat digestive biscuit, which has been broken in several places, on the surface of the liquid. Using appropriate safety precautions, heat the liquid gently from below, so that it warms up to a maximum of 50°C. Ask learners to note the starting position of the digestive biscuit pieces and watch what happens; the pieces will move apart. Ask learners to draw two diagrams (showing the position of the syrup and the digestive biscuit pieces) before and after the syrup is warmed.</p>

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		<p>Show learners an animation that illustrates how tectonic plates move; ask them to compare the biscuit model with the animation: <i>What did the digestive biscuit pieces represent in the model? Have you labelled this in your diagram?</i> <i>What did the syrup represent in the model? Have you labelled this in your diagram?</i> <i>Why did the digestive biscuit piece move? (because the syrup underneath moved)</i> <i>What are the strengths of the physical model?</i> <i>What are the limitations of the physical model?</i> <i>What are the strengths and limitations of the animation showing tectonic plate movement?</i></p> <p>Note: learners will revisit this model in Stage 9 when they will learn about convection currents. Learners at Stage 7 do not need to learn about convection currents.</p> <p>Resources: Model of the Earth, diagrams of the Earth, container, golden syrup, digestive biscuits, animation showing tectonic plate movement.</p>
<p>7ESp.02 Describe how earthquakes, volcanoes and fold mountains occur near the boundaries of tectonic plates.</p>	<p>7TWSm.01 Describe the strengths and limitations of a model.</p>	<p>Earthquakes, volcanoes, fold mountains and tectonic plate boundaries.</p> <p>Introduce the idea of fold mountains: they are formed by the folding of layers within the upper part of the Earth's crust when two tectonic plates move towards each other at a plate boundary. When tectonic plates (and the continents riding on them) collide, layers of rock may crumple and fold like a tablecloth that is pushed across a table. As a result of the way they form, fold mountains are usually long and narrow mountain ranges. Provide learners with fabric (e.g. tablecloths, t-shirts, curtains) and ask them, in pairs, to model fold mountains being formed.</p> <p>Give some examples of fold mountains (e.g. the Jura mountains in France and Switzerland, the Zagros mountains in Iran, the Akwapim-Togo ranges in Ghana, the Appalachians in the USA). Provide learners with a map which shows the plate boundaries and ask learners to find these mountains on the map and mark them in some way. <i>Where else may you expect to find fold mountain?</i></p> <p>Explain it depends on how the tectonic plates are moving relative to one another. Other fold mountains that could be located include: the Himalayas, Andes, Urals, Caucasus and Atlas mountain ranges.</p> <p>Introduce the terms 'earthquake' and 'volcano'. <i>What do you think an earthquake is?</i> <i>What do you think a volcano is?</i></p>

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		<p>Show learners a video of an earthquake. Explain that an earthquake is when two tectonic plates which are moving against each other, or one plate moving against another, do not move smoothly due to friction but eventually will move once the force to move becomes too great. This sudden movement causes an earthquake. Learners can model this using fabric by having one piece of fabric over another and then moving it while pressing down. It may not move to start with but eventually it will move and suddenly. Earthquake zones are places on Earth where earthquakes are common. <i>Where would you expect to find earthquakes happening?</i></p> <p>Provide learners with some key earthquake zones such as the Pacific ring of fire. Learners mark this on their map. <i>As well as earthquakes, why do you think this zone is called a ring of fire?</i></p> <p>Explain that when plates are moving away from each other this creates a gap in the crust which fills in quickly, but it is weaker. The pressure from the mantle will force magma up through the crust and cause it to erupt as volcanoes. Learners pierce a hole in the middle of a piece of card and attach a tube under it, so the tube exists where it has been pieced. Learners fill a syringe with water and attach it to the free end of the tube. When they apply pressure to the syringe the water will erupt out of the card. If syringes and tubing is not available, animations of volcanoes can be used. <i>Where would you expect to find volcanoes happening?</i></p> <p>As well as the ring of fire, provide some examples of volcanoes such as Mt Vesuvius, Mt Etna, Mt St. Helens, Kilauea in Hawaii.</p> <p>Recap the models used with learners. <i>Were the models used effective?</i> <i>What were the strengths of each model?</i> <i>What were the limitations of each model?</i> <i>Did the models help us in our thinking?</i></p> <p>Resources: Fabric, world map with plate boundaries marked, videos of an earthquake and a volcano, card, syringe, tubing</p>
7ESs.03 Describe tidal forces on Earth as a consequence of the gravitational attraction	7TWSm.01 Describe the strengths and limitations of a model.	<p>Tidal forces</p> <p>Explain the differences between tides and tidal forces. Use an animation to show how tides form. Show a time-lapse video of actual tides, so that learners appreciate that most coastal places on Earth experience two tides every day.</p>

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between the Earth, Moon and Sun.		<p>Give learners, working in small groups, a sequence of diagrams showing tides at various times of the day (i.e. as the Earth rotates during a full Moon). The diagrams must show the Earth, the Moon, the Sun, as well as arrows showing gravitational attraction. Ask learners to write questions, based on the diagrams they have been given, about anything that they want further clarity on. Use these questions to hold a class discussion.</p> <p><i>What force keeps water on the surface of the Earth?</i> <i>What force causes tides?</i> <i>What happens to the water in the oceans when the Moon is directly overhead?</i> <i>What causes the bulge on the opposite side of the Earth?</i> <i>What would happen to tidal forces if:</i></p> <ul style="list-style-type: none"> • <i>the Moon was less massive</i> • <i>the Moon was closer to the Earth</i> • <i>the Sun and the Moon were aligned (e.g. at the time of a full Moon)?</i> (tidal forces would be greater, so that high and low tides are much larger than usual; these are called spring tides.) • <i>the Sun and the Moon are at right angles relative to the Earth?</i> (tidal forces would be smaller as the gravitational force of the Sun partially cancels out that of the Moon; the resulting smaller tides are called neap tides.) <p><i>In what ways do the diagrams correctly model the tidal forces of the Moon?</i> <i>In what ways do the diagrams incorrectly model the tidal forces of the Moon?</i></p> <p>Resources: Animation showing how tides form; time-lapse video of actual tides; sequence of diagrams showing tides at various times of the day.</p>
<p>7ESp.03 Know that clean, dry air contains 78% nitrogen, 21% oxygen and small amounts of carbon dioxide and other gases, and this composition can change because of pollution and natural emissions.</p>	<p>7TWSa.01 Describe the accuracy of predictions, based on results, and suggest why they were or were not accurate.</p> <p>7TWSa.05 Present and interpret observations and measurements appropriately.</p> <p>7TWSc.06 Evaluate a range of secondary information sources for</p>	<p>The composition of air and factors that change it</p> <p>Give learners a list, with numerical percentages, of the composition of clean, dry air. <i>What does this data tell you?</i> <i>How can we best represent this data?</i></p> <p>Working in pairs, they choose the most appropriate and visual way to present the data. Encourage creativity (e.g. 'people charts') and, if appropriate, suggest pie charts or bar charts. Share the resulting visual presentations with the class and discuss the strengths and limitations of each.</p> <p>Tell learners they will look at an example of atmospheric pollutions. <i>What is the impact of putting more carbon dioxide into the atmosphere?</i> <i>What is the impact of putting more sulfur dioxide into the atmosphere?</i> <i>How does the composition of the atmosphere change with emissions?</i></p>

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	<p>their relevance and know that some sources may be biased.</p>	<p>Learners produce predictions basing their prediction on their scientific understanding.</p> <p>Learners, working in small groups, then use secondary information sources to carry out research. One half of the class investigate gases resulting from pollution and the other half research gases resulting from natural emissions. Ask all the 'researchers' to note the sources of their information and to look out for possible bias (e.g. information about air pollution from a car manufacturer). After a suitable time, the groups share their information with 'their' half of the class and, together, create one presentation to give to the other half of the class.</p> <p><i>What could be the impact of bias in your sources?</i> <i>Why may sources be biased on this subject?</i></p> <p>Show learners a video of the formation of acid rain. Ideally, find a demonstration of a burning fuel (e.g. burning match) that shows the formation of acid gases, the capture of acid gases by water droplets in cotton wool clouds, and the use of Universal Indicator solution to show the acidity of 'rain' produced by such 'clouds'. Discuss with learners:</p> <p><i>What pH is the 'rain' originally?</i> <i>What pH does the 'rain' change to?</i> <i>What conclusions can be drawn about:</i></p> <ul style="list-style-type: none"> <i>a) what the burning matches produced?</i> <i>b) what happened to the 'atmosphere' in the beaker?</i> <i>c) how the 'rainwater' was different from the water in the 'ocean'</i> <p><i>What limitations are there in the conclusions drawn from this demonstration?</i></p> <p>Discuss with learners if, based on the video and their findings from their research, if their predictions were accurate or not.</p> <p>Ask learners to go back to working in their original pairs to create new visual presentations of data; this time, they illustrate how pollution and/or natural emissions can change the composition of air. These, along with the previously drawn charts, could be used to make a display on a classroom wall.</p> <p>Resources: Data about the composition of air, secondary information sources, video of the formation of acid rain</p>
<p>7ESc.01 Describe the water cycle (limited to evaporation, condensation,</p>	<p>7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through</p>	<p>The water cycle</p> <p>Divide the class into six groups; give each group one of the key terms from the water cycle (i.e. evaporation, condensation, precipitation, water run-off, open water sources, groundwater). The groups,</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
precipitation, water run-off, open water and groundwater).	testing, observation, using secondary information, and making and using keys.	<p>using secondary information sources, prepare an interesting explanation of ‘their’ term to present to the rest of the class. Set a time limit for the presentations (e.g. one minute per group) and encourage learners to include definitions and examples.</p> <p>Give learners, working in pairs, cards with the key terms from the water cycle (i.e. evaporation, condensation, precipitation, water run-off, open water sources, groundwater). They arrange the cards into a cycle, adding arrows between the cards. Once this has been checked, ask each learner to write a description of the water cycle in their own words.</p> <p><i>Where does the water cycle start? (there is no start as it is a cycle.)</i> <i>How might the water cycle change:</i> a) <i>when the weather is very hot?</i> b) <i>when there is a lot of rainfall?</i> <i>How does the water cycle work in some parts of the Earth (e.g. the Atacama Desert) where it may not rain for a year?</i> <i>How does the water cycle work in some parts of the Earth where the water is permanently frozen (e.g. at the South Pole)?</i></p> <p>Ask learners to research bodies of water by looking at local maps; if the region has no bodies of water, then choose another region to investigate. If possible, invite a guest speaker (e.g. geography teacher, geologist or water professional) to talk about open water sources, groundwater and water run-off in the local area. Based on their research, learners can create a diagram of the water cycle that includes specific names of water sources.</p> <p>Resources: Secondary information sources, water cycle cards, maps showing bodies of water.</p>
7Be.01 Know and describe the ecological role some microorganisms have as decomposers.	7TWSc.03 Evaluate whether measurements and observations have been repeated sufficiently to be reliable.	<p>Microorganisms as decomposers</p> <p>Elicit what learners already understand by the term ‘microorganism’ and ask them to give examples of microorganisms.</p> <p>Define what is meant by the terms ‘ecological role’ and ‘decomposer’. Give some examples of microbial decomposers (e.g. bacteria, fungi, protozoa) and explain what they do (i.e. break down dead organic material to water, carbon dioxide, minerals and other simple chemicals which are then recycled by plants and/or microorganisms).</p>

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		<p>Give learners data from an investigation into the role that microorganisms have as decomposers; ask questions about the part the microorganisms play in the decomposition process and the reliability of the data. One example is:</p> <p>An investigation into decomposition was carried out in a tropical rainforest. An equal mass of dead leaves was put into several net bags and left for up to nine months. At several timepoints, the mass of leaves in each bag was recorded. After one month, the mean mass of the leaves had decreased by 20%; after three months, the mean mass had decreased by 45% and, after nine months, the mean mass had decreased by 70%.</p> <p><i>Why were 'net' bags used in the investigation?</i> <i>How would 'mean mass' have been calculated?</i> <i>Why does the mass of the leaves in the bags decrease with time? What is happening to the leaves?</i> <i>What microorganisms might have been present?</i> <i>What organisms, other than microorganisms, might be responsible for decomposition?</i> (Annelid worms, arthropods such as woodlice.) <i>Is there any information missing from the description of the investigation?</i> (Possible answers could include: total number of bags; types of leaves; position of bags; the actual masses of the leaves; the range of results, rather than just the mean.) <i>If the bags of leaves were left longer than nine months, would you expect the mass to decrease to 0%?</i> (No, there would be the mass of the microorganisms to consider, the mass of the broken-down material and the mass of any material that was hard to break down, e.g. woody leaf stems.) <i>Are there enough results from this study to be considered reliable?</i> <i>What could be improved in the study?</i></p> <p>Resources: Data from an investigation into the role that microorganisms have as decomposers.</p>
<p>7Be.02 Construct and interpret food chains and webs which include microorganisms as decomposers.</p>	<p>7TWSc.01 Sort, group and classify phenomena, objects, materials and organisms through testing, observation, using secondary information, and making and using keys.</p>	<p>Decomposer microorganisms and their place in food chains and food webs</p> <p>Provide learners with a food web that includes decomposers and ask them to identify and draw as many food chains as possible. Ask learners to work in pairs to check each other's work and make sure that the arrows are pointing in the correct direction to show the flow of energy. Encourage learners to add a key that explains what the arrows on their food chains represent.</p> <p>Provide information about another habitat and the organisms (including the microorganisms which are decomposers) present in the habitat. Ask learners, working in pairs, to collect information about each organism present, including the decomposers; they record key information (e.g. what each organism eats, their mode of nutrition) onto a blank card. Provide learners with another set of cards that have arrows on. Learners use their information cards, and the arrow cards, to construct a food web; they use all of the</p>

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		<p>organisms, including the decomposers. Once learners have completed this activity, and it has been checked, they could photograph (or draw) the food web.</p> <p>Ask learners to use the food webs they have created, and their own knowledge, to answer questions such as: <i>What do microorganisms that are decomposers feed on? Give examples from your food web.</i> <i>What might feed on microorganisms? Give examples from your food web.</i></p> <p>Organisms in a food chain/web are usually organised at different levels, with producers being on the first level, primary consumers (e.g. herbivores) on the next level and so on. <i>Where do microorganisms, that are also decomposers, fit into these levels of organisation?</i> (They don't fit into any one level as they will feed from dead organisms at any level. In a sense, the decomposer level can be thought of as running parallel to the 'standard' levels in food chains and food webs.)</p> <p>Resources: Food web containing decomposers, information about organisms in a habitat, blank cards, arrow cards</p>

Unit 7.8 Chemical changes and reactions

Unit 7.8 Chemical changes and reactions

Outline of unit:

This unit covers how to identify when a chemical reaction has taken place. Learners will be able to use the particle model to describe chemical reactions and why precipitates form. They will study neutralisation reactions in terms of change of pH and learn the tests to identify hydrogen, carbon dioxide and oxygen gases.

The many opportunities for practical work in this unit. These include allowing learners to: make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding, carry out practical work safely, and make conclusions by interpreting results. Learners will also have opportunities to use symbols and formulae to represent scientific ideas.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- knowing some substances will react with another substance to produce one or more new substances and this is called a chemical reaction
- knowing chemical reactions involve substances, called reactants, interacting to form new substances, called products
- identifying that a chemical reaction has taken place through observing evidence such as a gas being produced, colour change and change in temperature
- testing materials to determine their properties
- using the particle model to describe solid, liquids (including solutions) and gases
- knowing that pH can be used to show the acidity or alkalinity of substances.

Suggested examples for teaching Science in Context:

7SIC.03 Evaluate issues which involve and/or require scientific understanding.

The reaction of soluble substances to form insoluble precipitates contributes to freshwater and marine pollution. Learners can discuss the impact of insoluble precipitates on wastewater treatment and evaluate how this type of pollution could be tackled. They can compare treatment options for reducing the build-up of insoluble deposits in the domestic water supply in areas of 'hard' water; these deposits reduce the efficiency of kettles and cause pipes to become partially or fully blocked.

7SIC.04 Describe how people develop and use scientific understanding, as individuals and through collaboration, e.g. through peer-review.

Neutralisation reactions are important in medicine. Over time, various indigestion and 'heartburn' remedies based in folklore have developed into scientifically-based and tested remedies; this has been based on an understanding of the acidity of gastric contents and the use of effective and safe neutralising agents or anti-acids. A pharmacist could be invited to discuss the development of common remedies that rely on neutralisation; alternatively, learners could undertake a short study of medicines that are based on neutralisation reactions to understand how they work.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Cc.01 Identify whether a chemical reaction has taken place through observations of the loss of reactants and/or the formation of products which have different properties to the reactants (including evolving a gas, formation of a precipitate or change of colour).	Chemical reaction, reactant, product, properties, gas, evolving, precipitate, soluble, insoluble	<p>A physical model can be used to describe chemical reactions where the atoms and molecules (represented by different colour balls) in reactants are rearranged to make the products; this demonstrates that the total number of atoms is conserved. This can also be done with molecular modelling kits.</p> <p>Drawings, with atomic representations of reactants and products, can be used to show that no matter is lost during chemical reactions.</p> <p>Animations can be useful to show chemical reactions in which a colourless gas is evolved; it is often much clearer to see compared to an actual reaction.</p> <p>Animations (and time-lapse videos) are useful to 'speed up' very slow reactions (e.g. rusting) and 'slow down' very fast reactions (e.g. the small explosion produced when a flame is put into a test tube of hydrogen).</p>	<p>Many learners confuse chemical reactions with physical changes such as change of state, dissolving and diluting. To help learners get a clear understanding of the idea of a 'chemical reaction' show learners a range of chemical and physical changes that encourages learners to ask questions and work towards an understanding of the differences. These misconceptions will be addressed through this unit.</p> <p>Some learners may think that a chemical reaction is what is observed during the reaction, for example, fizzing or bubbling, not the production of a new substance. Make it clear that what is observed is part of the reaction happening, but that chemical reaction is defined by the loss of reactants and the formation of products with different properties to the reactants.</p> <p>Some learner may confuse the use of the word evolving with the biological term. Explain that in chemistry (and sometimes physics) evolving relates to something being produced or given off and is commonly associated with the production of gaseous products.</p>
7Cc.03 Use the particle model to describe chemical reactions.	Particle model, chemical reactions	<p>There are many ways that the rearrangement of particles during a chemical reaction can be modelled:</p> <ul style="list-style-type: none"> • Molecular modelling kits • Small wrapped sweets of different colours • Small toy construction bricks of different colours • Stiff pieces of card, shaped differently for different elements so they fit together in different arrangements • Animations and/or computer software • Diagrams 	<p>Some learners may think that particles are destroyed when a substance is burned, so it loses mass. Explain that no particles are lost during chemical reactions, just rearranged.</p> <p>Some learners may think that, when two substances react together, the atoms from the reactants are changed into new atoms to form the products. Explain that atoms always remain the same during chemical reactions, they move around and form new combinations leading to new substances. The use of the models suggested will help reinforce this point.</p>
7Cc.02 Explain why a precipitate forms, in	Precipitate, chemical reaction, soluble,	Animations can be used to show how precipitates form during a reaction.	Some learners may struggle with the terminology needed to meet this learning objective due to previous

terms of a chemical reaction between soluble reactants forming at least one insoluble product.	insoluble, reactant, product		learning e.g. being taught about precipitation as part of the water cycle. When teaching, take time to check understanding of terms they have met before (e.g. soluble, insoluble) and new terms (e.g. precipitate). Consolidate what is meant by 'chemical reaction' and 'reactant'.
7Cc.04 Describe neutralisation reactions in terms of change of pH.	Neutralisation, reactions, pH, neutral, acid, alkaline	pH colour scales are useful representations of actual pH values.	Some learners may think that a neutralisation reaction always produces a neutral product; this idea is reinforced because most neutralisation reactions shown to Stage 7 learners produce a neutral product. A neutral product is not always produced (e.g. when salts are made from weak acids and/or weak bases). Help learners to focus on the idea that neutralisation reactions use equivalent amounts of acid and base to react with each other.
7Cp.04 Use tests to identify hydrogen, carbon dioxide and oxygen gases.	Hydrogen, carbon dioxide, oxygen, gas	Animations can be used to illustrate the tests for hydrogen, carbon dioxide and oxygen gases.	<p>Learners may get the gas tests and/or the results mixed up. When teaching, treat each test separately and revisit them frequently; for example, whenever one of the gases is mentioned, refer to the corresponding test for that gas.</p> <p>The reagent, calcium hydroxide, used for testing for the presence of carbon dioxide, is often called 'limewater' and may be confused with lime juice (or lime cordial). The term 'lime' in this context has nothing to do with the fruit; it refers to the alkaline mineral.</p>

Unit 7.8 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
7Cc.01 Identify whether a chemical reaction has taken place through observations of the loss of reactants and/or the formation of products which have different properties to the reactants (including evolving a gas, formation of a precipitate or change of colour).	7TWSa.05 Present and interpret observations and measurements appropriately.	<p>Chemical reactions: Loss of reactants</p> <p>Explain that chemical reactions are processes where one or more new substances are formed, as shown by: reactants → products. The original reactants will all, or partly, be changed into at least one or more new products.</p> <p>Check learners understanding by burning a piece of paper over a heat-resistant mat; ask learners to look out for any smoke and show them the ashes.</p> <p><i>What are the reactants?</i> <i>What are the products?</i> <i>How can you tell a chemical reaction has taken place?</i></p> <p>Learners identify the reactant (i.e. paper) and the products (i.e. ash, 'smoke' or carbon particles, carbon dioxide and water vapour) of the chemical reaction.</p> <p>Show learners a video of a forest fire that shows what the forest floor looks like after the fire has gone out; prompt learners to look out for any smoke during the fire and what remains after the fire.</p> <p><i>What are the reactants?</i> <i>What are the products?</i> <i>How can you tell a chemical reaction has taken place?</i></p> <p>Learners identify the reactant (i.e. wood or trees) and all the products (i.e. ash, 'smoke' or carbon particles, carbon dioxide and water vapour) of the chemical reaction.</p> <p>Discuss with learners the chemical reactions observed: <i>Will the mass of the ash be the same as the mass of the reactant?</i> (For the paper burning If accurate and sensitive balances are available, this could be checked). <i>Where has the rest of the mass of the reactant gone?</i> <i>How are the products different from the reactant? Are they in the same state of matter?</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>Learners, working in pairs, write a brief description of what they saw when the reactant burned and explains why it was a chemical reaction.</p> <p>Resources: Heat-resistant mat, safety matches, video of a forest fire</p>
	<p>7TWSa.03 Make conclusions by interpreting results and explain the limitations of the conclusions.</p>	<p>Chemical reactions: Evolving a gas</p> <p>Explain to learners that they are going to carry out a chemical reaction that will demonstrate that a colourless or invisible gas has been made (i.e. evolved).</p> <p>Ask learners to work in pairs and wear safety glasses. They line up four tealights (or short candles) on a heat resistant mat and light them. They add 20 g of sodium hydrogen carbonate (commonly known as sodium bicarbonate or baking soda) to a 250 ml measuring cylinder and carefully add 150 ml of white vinegar (or 0.1M ethanoic acid).</p> <p><i>What do you observe that indicates a reaction is occurring?</i></p> <p>Explain that the bubbles mean a gas is being produced. After allowing the bubbles to settle ask learners: <i>Where has the gas gone?</i> (Many will say it has entered the room/air/atmosphere)</p> <p>Learners then 'pour' the invisible gas over the flames of the tealights, one by one, and watch them go out. They should hold the mouth of the measuring cylinder a few centimetres above the flame, taking care to not pour out any of the liquid.</p> <p>Alternatively, this experiment can be shown as a demonstration where you place tealights in a slopped piece of open guttering and 'pour' the carbon dioxide in from the top. As the carbon dioxide travels down the guttering the tealights will go out one by one. This reinforces the concept that gases have mass as well as being a demonstration that a reaction can produce a gas.</p> <p>Give learners two facts: Fact 1: Carbon dioxide was one of the products made. Fact 2: Tealights need oxygen from the air to continue burning.</p> <p>Now, ask learners the following questions and discuss the answers. <i>What were the reactants in this chemical reaction?</i> <i>What do you think was inside the bubbles?</i> <i>Why do you think the tealights went out?</i> <i>Is carbon dioxide gas heavier or lighter than air?</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>Provide learners with the equation for the reaction: sodium hydrogen carbonate + vinegar / ethanoic acid → sodium ethanoate + water + carbon dioxide <i>What were the other products, apart from carbon dioxide?</i> <i>Where happened to these other products?</i></p> <p>Resources: Tealights, safety matches, sodium hydrogen carbonate, white vinegar, heat resistant mats, measuring cylinders</p>
	<p>7TWSc.05 Carry out practical work safely.</p> <p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p>	<p>Chemical reactions: Formation of a precipitate (required additional resources)</p> <p>Explain to learners that they are going to carry out practical work that will show the formation of a precipitate in a chemical reaction. Explain that a precipitate is an insoluble solid, formed from two solutions. <i>What do you expect to see when this reaction happens?</i></p> <p>Discuss how they should see a solid form within the reaction mixture.</p> <p>Give each pair of learners: 25 ml of 0.5M magnesium sulfate solution and 25 ml of 0.5M sodium carbonate solution (in labelled containers), two 100 ml conical flasks, a filter funnel (polyethylene or glass) and filter paper. Ensure that everyone is wearing eye protection.</p> <p>Give each pair a set of instructions as a list; include a column for ticks to be added when each stage is completed. Learners should:</p> <ul style="list-style-type: none"> Mix 25 ml of magnesium sulfate solution and 25 ml of sodium carbonate solution in a conical flask. <i>What did you see happen in the flask when you mixed the solutions?</i> Ask learners to judge if a solid, a precipitate, has been produced. They will isolate the precipitate. Use a pencil to write your initials around the edge of a piece of filter paper. Fold the filter paper and place it in the filter funnel. Place the filter funnel, containing folded filter paper, in the neck of another conical flask. Swirl the reaction mixture gently and pour a little at a time into the filter paper in the funnel. Do not let the level rise too close to the top of the filter paper. Continue pouring, until all the reaction mixture has passed through the filter paper into the second flask. Remove the wet filter paper and carefully open it over a paper towel, taking care not to spill any contents.

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<ul style="list-style-type: none"> • Leave the filter paper to dry for a few hours (this may require this activity to be taught over several lessons). • Inspect the dry filter paper for any precipitate. This will be a white powder. <p>While the filter paper is drying, give each small group of learners two sets of the same four cards (each card has a single word written on it: 'magnesium', 'sulfate', 'sodium' or 'carbonate'). Tell them that chemical reactions not only produce new substances, but they often do this by swapping chemical 'partners'. Ask them to arrange the cards to show the reactants (i.e. magnesium sulfate and sodium carbonate) and then to arrange the remaining cards to suggest the names of the new substances formed. They may need a hint (i.e. the name of the metal element always comes first in a chemical compound). Once learners have got the equation:</p> $\text{magnesium sulfate} + \text{sodium carbonate} \rightarrow \text{magnesium carbonate} + \text{sodium sulfate}$ <p>ask them to copy it out to add information to later.</p> <p>Once the filter paper is dry and learners have identified the precipitate, hold a class discussion and ask questions:</p> <p><i>Magnesium carbonate is the insoluble product left on the filter paper. What is the term for an insoluble product made from two solutions?</i></p> <p><i>What can you tell about the properties of sodium sulfate? (it must be soluble as it did not form a precipitate).</i></p> <p><i>What evidence is there that this was a chemical reaction?</i></p> <p>Ask learners to add descriptions of the reactants and products to their copied equation, using the terms: soluble/insoluble and solution/precipitate.</p> <p>Resources: 0.5M magnesium sulfate solution, 0.5M sodium carbonate solution, 100 ml conical flasks, filter funnels, filter paper, word cards for the equation</p>
	7TWSm.02 Use symbols and formulae to represent scientific ideas.	<p>Chemical reactions: Formation of a precipitate</p> <p>Explain to learners that they are going to watch a video that shows the formation of a magnesium carbonate precipitate in a chemical reaction. Explain that a precipitate is an insoluble solid, formed from two solutions. Learners watch the video and are then go into small groups.</p> <p>Before watching the video, give each group two sets of the same four cards (each card has a single word written on it: 'magnesium', 'sulfate', 'sodium' or 'carbonate'). Explain that chemical reactions not only produce new substances, but they often do this by swapping chemical 'partners'. Ask learners to arrange</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>the cards to show the reactants (i.e. magnesium sulfate and sodium carbonate) and then arrange the remaining cards to suggest the names of the new substances formed. They may need a hint (i.e. the name of the metal element always comes first in a chemical compound). Once learners have got the word equation:</p> $\text{magnesium sulfate} + \text{sodium carbonate} \rightarrow \text{magnesium carbonate} + \text{sodium sulfate}$ <p>ask them to copy it to add information to later.</p> <p>Watch the video and discuss as a class: <i>What did you see happen in the flask when the solutions were being mixed?</i> <i>Magnesium carbonate was the insoluble product left on the filter paper. What is the term for an insoluble product made from two solutions?</i> <i>What can you tell about the properties of sodium sulfate? (it must be soluble as it did not form a precipitate).</i> <i>What evidence is there that this was a chemical reaction?</i></p> <p>Ask learners to add descriptions of the reactants and products to their copied equation, using the terms: soluble/insoluble and solution/precipitate.</p> <p>Resources: Video of the formation of a magnesium carbonate precipitate, word cards for the equation</p>
	<p>7TWSa.04 Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes.</p>	<p>Chemical reactions: Change of colour (requires additional resources)</p> <p>Remind learners that chemical reactions are processes where one or more new substances are formed. One piece of evidence that a new substance has been formed is to observe a change of colour.</p> <p>Give each pair of learners 25 ml of 1M copper sulfate solution (in a 100 ml beakers) and 25 ml 1M sodium carbonate solution (in a 100 ml beaker). They record the colours of the two solutions. Wearing safety glasses, they mix the solutions together, stirring with a glass rod. Any splashes on skin should be immediately washed off. After allowing time for the precipitate to form, learners note any colour changes. To help with observations, the mixture can be filtered, the precipitate collected on filter paper and then allowed to dry.</p> <p>Discuss what has been observed and ask questions: <i>What changes did you observe?</i> <i>Where did the precipitate come from?</i> <i>What evidence is there that a chemical reaction occurred? (formation of a new substance, as seen by the appearance of a different colour.)</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p><i>How could the experiment be improved?</i> (using a different reaction that produced a more colourful product, using a hand lens to inspect the products, repeating the experiment with fresh reactants to check the results)</p> <p>Resources: copper sulfate solution, sodium carbonate solution, beakers, glass rods, filter funnels, filter paper</p>
<p>7Cc.03 Use the particle model to describe chemical reactions.</p>	<p>7TWSa.04 Evaluate experiments and investigations, and suggest improvements, explaining any proposed changes.</p> <p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p> <p>7TWSm.01 Describe the strengths and limitations of a model.</p>	<p>Chemical reactions: Change of colour</p> <p>Remind learners that chemical reactions are processes where one or more new substances are formed. One piece of evidence that a new substance has been formed is to observe a change of colour.</p> <p>Show learners a video that demonstrates a chemical reaction that forms a product of a different colour to the reactants (e.g. the reaction between potassium iodide and lead nitrate, the reaction between copper sulfate solution and sodium carbonate, the rusting of iron, the starch and iodine solution reaction, the weathering reactions of the copper of the Statue of Liberty in New York). Take care to choose an example that is due to a chemical reaction and not just colours mixing (e.g. combining two different food colourings).</p> <p>Discuss what has been observed and ask questions (the following questions are based on the potassium iodide and lead nitrate reaction; if a different chemical reaction is shown, the questions need adapting appropriately):</p> <p><i>What changes did you observe?</i></p> <p><i>Where did the precipitate come from?</i></p> <p><i>What evidence is there that a chemical reaction occurred? (formation of a new substance, as seen by the appearance of a different colour.)</i></p> <p>Resources: Video showing a chemical reaction that produces a colour change</p> <p>The particle model and chemical reactions</p> <p>Start this activity by demonstrating the chemical reaction for sodium metal and water either using the following instructions or by showing a video.</p> <p>For health and safety reasons, the demonstrator should wear safety glasses with side protection and disposable gloves; learners should wear safety glasses and be kept a few metres away from the demonstration (as corrosive oxides are given off if the sodium catches fire) and safety screens should be set up both between the demonstrator and the reaction and between the learners and the reaction. Ensure</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>that conditions are dry for cutting the sodium (i.e. dry tile, dry forceps, dry scalpel blade); use a very small piece of sodium metal (i.e. no larger than a grain of rice) and do not touch the metal with fingers (use dry forceps); remove oil from the cut piece; return any large pieces to their original bottle where they are stored under oil and place any used equipment (e.g. forceps, scalpels, tiles) into the trough of water at the end of the demonstration in case there are any residual traces of sodium.</p> <p>To carry out the reaction, use a glass trough about half full with water. Add a drop of detergent as this helps to stop the sodium from sticking to the side of the trough. Alternatively, show a video of the chemical reaction</p> <p><i>What happened?</i> <i>What evidence do we have for a chemical reaction?</i> <i>What were the reactants?</i> <i>What do we think the products are?</i></p> <p>Give learners the word equation for the chemical reaction they have been shown: sodium + water → sodium hydroxide + hydrogen</p> <p>Ask learners to add the symbols for sodium and hydrogen to the equation (they can use a Periodic Table) and the formula for water; introduce learners to the formula, if necessary, explaining that the '2' in H₂O indicates two hydrogen atoms for every oxygen atom.</p> <p>Now they should have:</p> $\text{Na} + \text{H}_2\text{O} \rightarrow ?? + \text{H}$ <p>At this stage, do not expect a balanced equation and 'H' is acceptable to represent the hydrogen gas. Ask learners to work out what the missing product is by rearranging the symbols for the reactants, taking away an 'H', and putting the name of the metal first (the convention for compounds that contain metals). Acceptable answers will be NaOH and NaHO. Explain that it is conventional to put OH (but HO is not wrong) and that the name of the product is sodium hydroxide.</p> <p>Explain that, during a chemical reaction, atoms swap places in a limited number of set ways. Give each group of learners a different way to model the chemical reaction they have seen: molecular modelling kits (if available); small wrapped sweets of different colours; small modelling bricks of different colours, 'element cards' (i.e. cards cut differently for each element and made to fit with the other elements; templates for 'element cards' can be found online) or paper and coloured pens to draw a particle model of the chemical reaction.</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>Once the models have been completed, ask each group to make a 'flip book' to show the reaction as a step-by-step process; this will give a moving image representation of the rearrangement of particles during the chemical reaction. Templates for flip books can be found online; they may need cutting up and stapling together to work well.</p> <p>Finally, show the whole class an animation illustrating a particle model of the reaction (or a similar reaction). Hold a class discussion about the merits, and any limitations, of each type of model. Ask learners to complete a table to compare the strengths and limitations of the models that they have investigated.</p> <p>Resources: materials and equipment to demonstrate a chemical reaction such as sodium and water (rice grain size pieces of sodium metal, dry forceps, dry scalpel or knife and dry tile for cutting, trough of water, detergent, protection screens, full safety glasses with side protection, disposable gloves), video of the sodium in water reaction (if required), Periodic Table; a range of equipment to model a chemical reaction, template for flicker book, animation showing a chemical reaction using the particle model, table to compare models.</p>
<p>7Cc.02 Explain why a precipitate forms, in terms of a chemical reaction between soluble reactants forming at least one insoluble product.</p>	<p>7TWSp.02 Describe how scientific hypotheses can be supported or contradicted by evidence from an enquiry.</p>	<p>The formation of precipitates</p> <p>Ask learners to recall what evidence is needed to show that a chemical reaction has happened. If necessary, prompt them to remember watching an insoluble product (e.g. magnesium carbonate) being formed from two soluble reactants.</p> <p>Suggest the hypothesis that when soluble reactants form one or more insoluble products, the insoluble product (or products) can be seen as precipitates, either immediately or by separating them from any other products.</p> <p>Show learners several short videos that demonstrate various chemical reactions that involve the formation of an insoluble product from soluble reactants (e.g. Benedict's test for reducing sugars, the reaction between calcium chloride solution and sodium carbonate solution, the test for sulfate ions using barium chloride solution in the presence of dilute hydrochloric acid). Ask learners to consider the hypothesis for each reaction and look out for any precipitate being formed</p> <p><i>What have you observed from these reactions?</i> <i>Why can a produce form a precipitate?</i></p> <p>Discuss with learners the difference between soluble and insoluble and how a soluble substance is able to mix with a solvent so well it forms a solution.</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p><i>If a product from a chemical reaction was not able to mix well with the solvent the reaction was taking place in, what would happen?</i></p> <p>Explain that the now insoluble product would be seen as a precipitate as it can no longer remain part of the solution, so it forms as a solid (if a precipitate forms quickly, chemists say 'the product crashes out')</p> <p>Resources: Short videos showing the production of precipitates</p>
<p>7Cc.04 Describe neutralisation reactions in terms of change of pH.</p>	<p>7TWSp.03 Make predictions of likely outcomes for a scientific enquiry based on scientific knowledge and understanding.</p> <p>7TWSc.05 Carry out practical work safely.</p>	<p>Neutralisation reactions</p> <p>Remind learners about the pH scale and the use of indicators to measure pH. Remind learners that acidic and alkaline substances have different pH values.</p> <p>A particularly effective way to show neutralisation reactions is to use 'neutralisation circles'. Remind learners about the appropriate safety precautions required when working with acids and alkalis, particularly eye protection.</p> <p>Provide clearly-labelled dropper bottles containing small volumes of 0.1M sodium hydroxide solution, 0.1M hydrochloric acid and Universal Indicator solution. Tell learners that they are going to investigate what happens when an acidic solution reacts with an alkaline solution; they will use Universal Indicator solution to show any changes in pH. Ask learners to use their scientific knowledge and understanding to predict the likely pH values of each sample. Also ask learners to predict what colours Universal Indicator solution might give for each sample.</p> <p>Ask learners to work in pairs. Each pair needs a white tile and a circle of filter paper. Ask each pair to add just a few drops of dilute acid and alkali to filter paper on a tile, putting the drops close to each other, so that they will meet and react as they spread out. Then add a few drops of Universal Indicator solution where the acid and alkali meet and a few drops at the outer edges of the reactants.</p> <p>Alternatively, learners can be shown a video that demonstrates 'neutralisation circles':</p> <p>Discuss with learners: <i>What colour and pH was unreacted hydrochloric acid with Universal Indicator?</i> <i>What colour and pH was unreacted sodium hydroxide with Universal Indicator?</i> <i>What colour was seen where the acid and sodium hydroxide met? What pH does this represent?</i> <i>Did your predictions match the results that you observed?</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p>Explain that learners have carried out a 'neutralisation' reaction. The acidic and alkaline solutions have neutralised each other and where they met and reacted, the pH of the products was different.</p> <p>This activity can be extended by asking learners to research local folklore about neutralising stings. Examples include: treating bee sting venom with a mild alkali (e.g. dilute sodium hydrogen carbonate solution; treating wasp sting venom with a mildly acidic solution (e.g. dilute sodium ethanoate solution, vinegar).</p> <p>Resources: Universal Indicator solution, filter paper, dropper bottles, sodium hydroxide solution, hydrochloric acid, white tiles, video of a 'neutralisation circle' (if required)</p>
<p>7Cp.04 Use tests to identify hydrogen, carbon dioxide and oxygen gases.</p>	<p>7TWSc.05 Carry out practical work safely.</p> <p>7TWSc.07 Collect and record sufficient observations and/or measurements in an appropriate form.</p> <p>7TWSc.03 Evaluate whether measurements and observations have been repeated sufficiently to be reliable.</p>	<p>Testing for hydrogen, carbon dioxide and oxygen</p> <p>Explain to learners that it is often useful to know what gases are present (e.g. to find out what products are made in a reaction). Tell learners that they are going to work in pairs and are going to carry out tests for hydrogen, carbon dioxide, oxygen and one unknown gas. Provide learners with a partially-completed table for their results; this could include the instructions for each test, a column for safety precautions and a column for observations. Talk learners through the different tests and give them time to discuss, and write down, the appropriate safety precautions before they start. Eye protection is needed at all times during the practical work.</p> <p>Suitable instructions (and safety precautions) might include:</p> <p>Testing for hydrogen:</p> <ul style="list-style-type: none"> Put a stoppered tube of gas into a test tube rack. (Do not hold tubes in hands). Light a splint so that there is a small flame. (Make sure the splint is at least 15 cm long to avoid any danger of getting burned). Remove the rubber bung of the tube of gas and immediately put the burning splint just above the mouth of the open tube. (Do not look directly down into the tube). <p>Testing for carbon dioxide:</p> <ul style="list-style-type: none"> Put a stoppered tube of gas into a test tube rack. (Do not hold tubes in hands). Collect a bottle of fresh, clear calcium hydroxide solution (also known as 'limewater') and a dropper. (Clarify with learners if you use the name 'limewater' that the solution has nothing to do with limes and is not safe to drink). Remove the rubber bung of the tube of gas, immediately add a few drops of calcium hydroxide solution and replace the bung. (Do not put the used dropper on the table; put the top back on the bottle).

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<ul style="list-style-type: none"> Shake the test tube and observe any changes to the solution. (Use a 'chemist's shake', a sideways shake of the tube, rather than an up and down shake, which could cause the bung to come off.) <p>Testing for oxygen:</p> <ul style="list-style-type: none"> Put a stoppered tube of gas into a test tube rack. (Do not hold tubes in hands). Light a wooden splint so that there is a small flame and then blow it out gently so that the wooden splint is just glowing. (Make sure the wooden splint is at least 15 cm long to avoid any danger of getting burned). Remove the rubber bung of the tube of gas and immediately put the glowing wooden splint into the mouth of the open tube. (Do not look directly down into the tube). <p>Discuss with learners that they should repeat the tests several time. <i>Why should they be repeated?</i> Discuss with learners how to judge when they have reliable results and highlight how all scientists have to consider this when planning and carry out practical and investigative work.</p> <p>If the resources for carrying out these tests are unavailable, then videos showing the tests can be used. If using videos ask learners to note the experimental procedures and the outcome of each test through written notes, creating a table or drawing diagrams.</p> <p>Play a 'What Am I?' game with learners to consolidate their knowledge of the tests for the three gases in the learning objective. <i>What am I if:</i> <i>I squeak when a flame comes near me?</i> <i>I turn calcium hydroxide solution cloudy?</i> <i>I can relight a glowing splint?</i> <i>I put out a flame?</i> (This was not directly tested but could be worked out by the process of elimination)</p> <p>Resources: Labelled test tubes with rubber bungs containing hydrogen, carbon dioxide or oxygen gas; test tubes labelled as 'unknown' gas (filled with oxygen); long wooden splints; test tube racks; calcium hydroxide solution; droppers; 'Tests for gases' worksheets.</p>

Unit 7.9 Electricity

Unit 7.9 Electricity

Outline of unit:

This unit introduces a simple model to describe electricity as a flow of electrons around a circuit. Learners describe electrical conductors as substances that allow electron flow and electrical insulators as substances that inhibit electron flow. Learners measure the current in series circuits and describe how adding components into a series circuit affects the current. By the end of this unit, learners will be familiar with the use of diagrams and conventional symbols to represent, make and compare circuits that include cells, switches, lamps, buzzers and ammeters.

There are opportunities throughout this unit for learners to practise their circuit-making skills, although online alternatives are suggested. Learners will plan a range of investigations involving circuits and recognise that not all investigations can be fair tests. They will have opportunities to decide what equipment is required to carry out an investigation, to collect and record sufficient observations (and/or measurements) in a suitable form and they will present and interpret their data.

Recommended prior knowledge or previous learning required for the unit:

Learners will benefit from previous experience of:

- using diagrams and conventional symbols to represent, make and compare circuits that include cells, wires, switches, lamps and buzzers
- making simple circuits and comparing the brightness of lamps in series and parallel circuits
- understanding electrical devices will not work if there is a break in the circuit
- explaining how a simple switch is used to open and close a circuit
- describing how changing the number or type of components in a series circuit can make a lamp brighter or dimmer
- knowing some materials are good electrical conductors, especially metals, and some are good electrical insulators.

Suggested examples for teaching Science in Context:

7SIC.01 Discuss how scientific knowledge is developed through collective understanding and scrutiny over time.

Early ideas about electricity can be discussed; the actual nature of electricity has been debated for hundreds of years and has prompted many investigations and scientific papers (e.g. Einstein's paper suggesting that energy is carried in 'packets'). Much of our current scientific knowledge about the nature of electricity stems from discoveries about the atomic and sub-atomic nature of matter.

7SIC.05 Discuss how the uses of science can have a global environmental impact.

With an increasing human population, there is an ever-increasing need for electricity around the world. As electrical technology has improved, it has become easier and cheaper to produce electrical goods. Learners can discuss the global environmental impacts of this increasing need. These could include environmental destruction (e.g. deforestation to mine for minerals needed to construct electrical items; creation of more landfill sites to bury discarded electrical items) and environmental pollution (e.g. light pollution of the night skies due to increasing numbers of electric lights).

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Pe.01 Use a simple model to describe electricity as a flow of electrons around a circuit.	Electricity, flow, electrons, circuit	<p>Learners can be introduced to the speckled rope model. Two learners hold a loop (about 3m) of speckled rope; one learner represents an electrical lamp and holds the rope loosely so it can slip through their hands. The second learner represents an electrical cell and makes the rope circulate; this provides the 'potential difference'. The 'speckles' on the rope represent electrons. The model shows that electricity is everywhere in a live circuit, that electricity flows at the same rate around all parts of a circuit and that no time is needed for energy to get to components of the circuit.</p> <p>The water model of electricity describes the flow of electricity as being like the flow of water in pipes. One of the limitations of this model is that it doesn't accurately describe what happens when a parallel branch is added to a circuit: <i>the original water</i> (current) splits which is incorrect. When you add a parallel branch to a circuit, <i>additional</i> current flows and it is this new, greater current that splits at junctions in parallel circuits.</p> <p>Donation / carrier models for electricity can also be introduced (e.g. the teacher hands out sweets (energy) to learners (charge) who walk around the class, dropping off sweets (energy) at lamps). This model does not explain what happens to the energy when the circuit is broken, or how the 'charges' know how much energy to 'drop off' at each lamp. It suggests, incorrectly, that it is possible to have energy in one half of a circuit but not in the other half.</p>	<p>Some learners may think that an electric current is the flow of electrons through wires that are 'empty' until the current reaches them. Explain that the electrons are already present in wires in a circuit.</p> <p>Stage 7 Learners will not be familiar with electrons; they will not be introduced to atomic structure until Stage 8. Explain that substances contain electrons and that electrons can move. Electricity can be described as a flow of electrons (or electrons passing energy between each other). Some substances enable the flow of electrons better than others and this makes them electrical conductors.</p>
7Pe.02 Describe electrical conductors as substances that allow electron flow and electrical insulators as	Electrical conductor, electron, electron flow, electrical insulator, inhibition	<p>Animations and simulations can be useful to show the flow of electricity through electrical conductors but not through electrical insulators.</p> <p>The rope model could be used to compare electrical conductors and electrical insulators. This model works</p>	Some learners may confuse electrical conductors and electrical insulators with thermal conductors and thermal insulators. Help avoid confusion by using 'electrical' in front of conductors and insulators throughout this unit.

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
substances that inhibit electron flow.		by using a long (approximately 3m) loop of speckled rope, passed between the hands of two people to show the flow of electrons (i.e. the speckles) in a circuit. When the speckled rope is replaced by a plain, non-speckled rope, but all the other components remain the same, no flow of electrons (i.e. speckles) occurs. Substances that are electrical insulators do contain electrons, just not any which are free to move.	
7Pe.03 Know how to measure the current in series circuits.	Current, series circuits, ammeter	<p>The speckled rope model may be used to show the rate of flow of free electrons (i.e. the current). Moving the rope faster models the effect of increasing the current (i.e. increasing the flow rate of the free electrons). Asking another learner to join in by holding something that the rope can pass through (e.g. a hoop) can model the addition of an ammeter. Passing through the 'ammeter' does not slow the flow of electrons, but it allows the current to be measured.</p> <p>Simple circuit diagrams can be used to model a series circuit with an ammeter.</p> <p>Online simulators may be used to show how current may be measured in a series circuit.</p>	<p>Some learners may have the idea that current and electricity are the same thing. Explain that electricity is one way that energy may be transferred but current is the flow of free electrons (i.e. the speckles on the rope model).</p> <p>Some learners may believe that current reduces as it passes through components of an electrical circuit. Remind learners of the speckled rope model; the number of speckles on the rope (i.e. number of free electrons) does not depend on the number of people holding the rope in their hands (i.e. number of components). However, with more components to pass through, the speed of the flow of electrons can decrease due to extra resistance.</p>
7Pe.04 Describe how adding components into a series circuit can affect the current (limited to addition of cells and lamps).	Components, series circuit, current, electrical cells, ammeter	<p>Circuit diagrams can model how electrical circuits are arranged.</p> <p>Online simulators may be used to show how current may be measured in a series circuit.</p>	<p>Some learners may think that electrical cells contain electricity. Explain that electrical cells provide the push (as in moving the speckled rope in the rope model). Energy can be transferred from the cell to movement of electrons and to thermal energy as components heat up.</p> <p>Some learners may use the non-scientific term 'batteries' for cells. Encourage learners to use 'cell' if singular, but more than one cell in a circuit may be called a 'battery'.</p>

Learning objective	Key vocabulary	Possible models and representations	Possible misconceptions
7Pe.05 Use diagrams and conventional symbols to represent, make and compare circuits that include cells, switches, lamps, buzzers and ammeters.	Conventional symbols, circuits, cells, switches, lamps, buzzers, ammeters	<p>Learners can use conventional electrical circuit symbols and circuit diagrams to represent the components of electrical circuits and compare electrical circuits.</p> <p>Online circuit builder simulators can be used to represent, make and compare electrical circuits.</p>	Some electric circuit symbols may be misunderstood, misinterpreted or drawn wrongly by learners. Be very clear when you introduce each symbol that it is a conventional symbol and recognised internationally; it has to be drawn correctly or it may mean something else. (See Appendix of the Cambridge Lower Secondary Curriculum Framework which shows the range of circuit symbols learners are expected to know.)

Unit 7.9 Suggested activities

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7Pe.01 Use a simple model to describe electricity as a flow of electrons around a circuit.</p>	<p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p>The speckled rope model to show the flow of electrons in a circuit.</p> <p>Demonstrate the speckled rope model to learners; it represents electricity as a flow of electrons around an electrical circuit. Introduce the model by explaining that electrons are in all substances and can move. Some electrons can move freely ('free electrons'). In some substances (i.e. electrical conductors) the electrons move more freely than in other substances (i.e. electrical insulators). Tell learners that they will find out more about electrons in Stage 8, when they study atomic structure.</p> <p>Add speckles to 3 m of plain rope (using a permanent marker) and knot it together to form a loop. Ask one learner to hold the rope lightly so that it passes through their hand(s) easily; they represent an electric lamp. Face the learner, hold the rope loop and make the rope move; explain that this represents an electrical cell.</p> <p>Explain that the rope is speckled to show that free electrons are already present in the circuit. <i>When the rope started to move (the current started to flow), where did the rope (the current) start flowing first? (everywhere at the same time).</i> <i>Which speckles on the rope (free electrons) started to move first? (all the free electrons started to move at the same time).</i> <i>Which speckles (free electrons) moved fastest? (they all moved at the same speed everywhere around the loop (circuit)).</i> <i>What does this tell you about the rate of flow of electricity in different parts of an electric circuit? (it is the same everywhere).</i> <i>What is happening to the 'lamp's' hand? (It is getting hotter, showing that energy transfer is happening; this represents a transfer of chemical energy from the cell to thermal energy in the lamp, as well as to kinetic energy in all the free electrons).</i> <i>How long did it take from the rope starting to move (the current being switched on) for the free electrons to reach the lamp? (No time at all. As soon as the rope started moving, energy was transferred by the motion of the system as a whole).</i></p> <p>Ask learners to write a brief description of how the rope model shows the flow of electrons around a circuit; encourage them to use diagrams. Alternatively, learners could complete the gaps (picking from a list of terms) of a 'Speckled rope model' worksheet.</p> <p>Resources: 3 m of speckled rope</p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
<p>7Pe.02 Describe electrical conductors as substances that allow electron flow and electrical insulators as substances that inhibit electron flow.</p>	<p>7TWSp.04 Plan a range of investigations of different types, while considering variables appropriately, and recognise that not all investigations can be fair tests.</p> <p>7TWSc.02 Decide what equipment is required to carry out an investigation or experiment and use it appropriately.</p> <p>7TWSa.01 Describe the accuracy of predictions, based on results, and suggest why they were or were not accurate.</p>	<p>Electrical conductors and electrical insulators</p> <p>Check that learners are confident using the terms ‘electrical conductor’ and ‘electrical insulator’. If necessary, explain that:</p> <ul style="list-style-type: none"> • an electrical conductor is a material that allows electrons to flow through it easily • an electrical insulator does not allow electricity to flow through it as it inhibits electron flow. <p>Explain to that learners are going to work in small groups to investigate if different materials are electrical conductors or electrical insulators by inserting them into a simple circuit. Ask the groups to plan what equipment they will need to make a circuit to test the materials; provide an appropriate range of electrical components of circuits from which learners can select equipment and design circuits. A demonstration of how to build a circuit and test a material may be helpful.</p> <p>Discuss with learners what the variables are in this investigation. <i>What is the independent variable?</i> <i>What is the dependent variable?</i> <i>What are the control variable?</i></p> <p>Challenge their responses by discussing how important the control variable really are to this investigation and if managing variables to ensure a fair test is the most appropriate thing to do. Discuss that they do not have to conduct a fair tests they could experiment without controlling variables and make observations. Discuss the strengths and limitations of that approach and together as a class decide what sort of investigation they should be planning.</p> <p>Encourage learners to include a switch in their circuits. Provide learners with a range of electrical insulators and electrical conductors; include some materials (e.g. graphite) that may challenge learners when they make their predictions. Ask learners to produce a table with the column headings: the name of the material, whether it is a metal or a non-metal, predicted result, actual result. They record their predictions in their table before they test each material.</p> <p>Learners then carry out their investigation and complete their tables. Afterwards, have a class discussion about the results:</p> <p><i>Give an example of a substance that you found to be an electrical conductor.</i> <i>What happens to electrons within an electrical conductor when a circuit is ‘live’? (Electrons can flow through).</i> <i>Give an example of a substance that you found to be an electrical insulator.</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p><i>What happens to electrons within an electrical insulator when a circuit is switched on? (Electrons cannot flow through).</i></p> <p><i>Were there any materials for which your predictions did not match your results? Which materials? Why might this have been?</i></p> <p><i>Were there any patterns that you noticed in which materials did (or did not) conduct electricity? (Metals are all conductors; non-metals are mostly, but not all, electrical insulators).</i></p> <p>Resources: Components of a simple electrical circuit (cell, wires, lamp, switch); range of materials to test</p>
<p>7Pe.03 Know how to measure the current in series circuits.</p> <p>7Pe.04 Describe how adding components into a series circuit can affect the current (limited to addition of cells and lamps).</p>	<p>7TWSc.04 Take appropriately accurate and precise measurements, explaining why accuracy and precision are important.</p> <p>7TWSc.07 Collect and record sufficient observations and/or measurements in an appropriate form.</p> <p>7TWSc.03 Evaluate whether measurements and observations have been repeated sufficiently to be reliable.</p>	<p>Measuring current</p> <p>Explain to learners that electric current is measured in amperes (A) by a piece of equipment called an ammeter. Show an electrical circuit diagram, in series, with an ammeter, switch, lamp and one cell. Provide learners with equipment for building simple electrical circuits (i.e. cells, switches, lamps, wires, connectors). Learners, working in small groups, construct the circuit as shown in the diagram. Tell them that they are going to measure the current in the series circuit when:</p> <ol style="list-style-type: none"> the ammeter is moved to different places around the circuit more lamps are added more cells are added. <p>Before they start the practical work, ask learners to construct a table to put the readings from the ammeter in. Encourage learners to put units (A) in the column heading and not keep repeating the unit in the body of the table. Explain that this makes the changes in the important information (i.e. the numbers of A) clearer to read. Also encourage learners to think about adding space in their table of results to record repeated results. It is important to check that learners can read the ammeter output correctly; can they see where the decimal point is in the digital reading; can they read the analogue scale accurately and precisely.</p> <p>After learners have completed their current measurements, hold a class question and answer session:</p> <p><i>What exactly was the ammeter measuring?</i></p> <p><i>Did it make any difference where the ammeter was placed in the circuit, in relation to other components?</i></p> <p><i>What does this mean about the current in different places around the circuit?</i></p> <p><i>What happened to the current when you added a) more lamps and b) more cells?</i></p> <p><i>How can you explain the changes in current when you added a) more lamps and b) more cells?</i></p> <p><i>Did you get any anomalous results? Can you explain why you might have got some anomalous results?</i></p> <p><i>If you repeated any results, were they the same or different? Why do you think that might be?</i></p> <p><i>Did the ammeter always give the same reading when you repeated the reading without changing the circuit?</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p><i>Might different ammeters have given different readings?</i> (This could be a chance to introduce the idea of systematic errors if you felt that was appropriate for your learners).</p> <p>This activity can be extended by learners carrying out research to identify examples of the practical uses of series circuits (e.g. torches, domestic water heaters, Christmas tree lights, dimmer switch circuits). Ask learners to note any advantages and disadvantages of series circuits; this can be done without reference to parallel circuits. Learners can present their findings as an oral presentation or poster.</p> <p>Resources: Electric circuit diagram, components to build simple electrical circuits, ammeters</p>
<p>7Pe.05 Use diagrams and conventional symbols to represent, make and compare circuits that include cells, switches, lamps, buzzers and ammeters.</p>	<p>7TWSa.05 Present and interpret observations and measurements appropriately.</p>	<p>Representing, making and comparing circuits</p> <p>Introduce and explain the use of conventional symbols for cells, switches, lamps, buzzers and ammeters. Give examples of how the symbols are used in circuit diagrams.</p> <p>Ask learners to work in small groups. Their task is to design a range of series circuits (built from cells, switches, lamps, buzzers and ammeters) and draw them using conventional symbols. It may be necessary to remind learners how to build a series circuit so that learners do not stray into making parallel circuits. Ask learners to start with some simple circuit diagrams, then build up to more complex ones that have more lamps, cells and/or other components. Each circuit diagram should be drawn on a separate bit of paper and numbered in order of perceived difficulty.</p> <p>Once groups have completed at least six circuit diagrams, ask each group to pair up with another group. Groups swap circuit diagrams and, starting with the simplest circuits, construct the circuits according to the circuit diagrams. If any circuit does not work, because of errors in the diagram, the diagrams are returned to the original group, with notes about the error, to make corrections.</p> <p>Ask groups to make a copy of each circuit diagram as they build it; they record what happens when the circuit is complete (e.g. how bright the lamp is, the current recorded by the ammeter).</p> <p>When all the circuits have been built, tested and the observations recorded, ask the groups to look for patterns so that they can contribute to a class discussion: <i>What happened to the brightness of lamps when more cells were added? How can this be explained?</i> <i>What happened to the loudness of the buzzer when more cells were added? How can this be explained?</i> <i>What happened to the readings on the ammeter when a) more lamps b) more buzzers c) more cells were added? How can this be explained?</i></p>

Learning objective	Thinking and Working Scientifically opportunities	Suggested teaching activities and resources
		<p><i>If more ammeters were added, did they all read the same or did they have different readings? How can this be explained?</i></p> <p>Resources: Components for making electrical circuits (including ammeters)</p>

Sample Lesson 1

CLASS:	
DATE:	
Learning objectives	<p>7Bs.01 Understand that all organisms are made of cells and microorganisms are typically single celled.</p> <p>7TWSc.02 Decide what equipment is required to carry out an investigation or experiment and use it appropriately.</p> <p>7TWSc.05 Carry out practical work safely.</p> <p>7TWSa.05 Present and interpret observations and/or measurements appropriately.</p>
Lesson focus / success criteria	<p>I can explain that all organisms are made from cells, including microorganisms.</p> <p>I can describe cells using observational evidence</p> <p>I can make simple drawings of cells</p> <p>I can complete calculations of magnification.</p>
Prior knowledge / Previous learning	<p>Learners should have considering how living things can be grouped in different ways and how living things are interconnected</p> <p>Some experience of using a range of scientific equipment, especially microscopes, will be beneficial. Learners with this experience can peer support others who have not used microscopes before.</p>

Plan

Lesson	Planned activities	Notes
Introduction	<p>Grab learners' attention by setting up the classroom like a professional laboratory (i.e. microscopes already set out, clean paper towels next to the microscopes with microscope slides, cover slips, mounted needles and wrapped cotton buds on top). This should provide a 'wow' factor as learners arrive. Providing laboratory coats (if available) can add to the atmosphere and a projection of some interesting cells can add visual interest.</p> <p>Establish the context of the lesson/learning by explaining to learners that they are going to do what they may have seen on television, take mouth cotton buds.</p> <p><i>Why is this normally done?</i></p> <p>Discuss how looking at a small part of an organism (DNA) gives us information about the whole organism. Instead of DNA analysis, they are going to look for their own cells.</p> <p><i>What is a cell?</i></p> <p>Learners discuss in pairs and provide answers.</p> <p>Explain that cells are the building blocks of all living organisms; humans have around 37.2 trillion cells (on average). Cells are where DNA is found and understanding cells helps us understand how, and why, organisms behave the way they do.</p>	<p>Microscopes, microscope slides, mounted needles, wrapped cotton buds, paper towel.</p> <p>Laboratory coats or aprons should be worn (if available).</p>
Main activities	<p>Before learners start to look at cells, explain the health and safety issues associated with working with human saliva and the safety precautions they must take (i.e. using a clean cotton bud, disposing of the used cotton bud, microscope slide and coverslip in a strong disinfectant, or bleach, and not swapping cotton buds with anyone else). Also, demonstrate how to add an appropriate amount of nuclear stain to the smear of cells on the microscope slide.</p>	<p>Microscopes (monocular and/or binocular), microscope slides, cavity slides, coverslips, mounted needles, wrapped cotton buds, paper towel.</p>

Lesson	Planned activities	Notes
	<p>Learners work individually to make preparations of their own cheek cells using sterile cotton buds on microscope slides. A suitable stain (e.g. methylene blue solution) can be used to make the nuclei easier to see. Choose a good preparation and attach a camera to a microscope to show learners what they are looking for. Ask learners to make a labelled drawing of just one or two cells. Encourage them to add a scale or magnification to their drawing. Introduce the formula: $\text{total microscope magnification} = \text{magnifying power of eyepiece} \times \text{magnifying power of objective lens}$</p> <p>Learners work in pairs, or small groups, to make preparations of plant cells (e.g. red onion cells) on microscope slides. Choose a good preparation (or a prepared slide) to show learners what they are looking for. Ask learners to make a labelled drawing of one or two cells and to calculate total microscope magnification and add this to their drawing.</p> <p>Alternatively, learners may be given prepared microscope slides that show plant cells clearly.</p> <p>Without telling learners the specimen of the next slide, provide learners with living specimens of non-pathogenic, single-celled organisms (e.g. <i>Amoeba</i> or <i>Paramecium</i>). These are best viewed using binocular microscopes, if available, or under low power using monocular microscopes and cavity slides. Ask learners to calculate the total microscope magnification at which the organisms can be seen most clearly. <i>What can you see with the final specimen?</i></p> <p>Discuss how this specimen is a single cell but is living independently. This means it is a microorganism.</p> <p>Give learners pictures, or photographs, of microorganisms (e.g. bacteria) that include information about how much the microorganisms have been magnified. By measuring the sizes of the microorganisms in the pictures, learners can calculate the actual size of the microorganisms, using the formula: $\text{actual size} = \text{size in picture} / \text{magnification}$</p> <p>Remind learners to use the same units for both actual size and picture size.</p> <p>Using the information collected, learners can draw and describe cells from an animal, a plant and a microorganism. They can present their understanding of cells in a poster, including a definition and an understanding that all organisms are made of cells with microorganisms typically being single celled.</p>	<p>Laboratory coats or aprons should be worn (if available).</p> <p>Nuclear stain (e.g. methylene blue) in small dropper bottles. Bleach (or strong disinfectant) to dispose of used cotton buds.</p> <p>Plant material (e.g. red onion).</p> <p>Living specimens of a single-celled organism such as <i>Amoeba</i> or <i>Paramecium</i>.</p> <p>Pictures (or photomicrographs) of microorganisms (e.g. bacteria) with information about how much the microorganisms have been magnified.</p>
End/Close/Reflection/Summary	<p>Ask learners to evaluate their work, and others' work, by exchanging cell drawings with a partner and providing constructive feedback on each other's drawings and calculations.</p> <p>Complete a class sentence on the board about organisms being made of cells and defining what a microorganism is.</p>	

Reflection**Use the space below to reflect on your lesson. Answer the most relevant questions for your lesson.***Were the learning objectives and lesson focus realistic? What did the learners learn today?**What was the learning atmosphere like?**What changes did I make from my plan and why?**If I taught this again, what would I change?**What two things went really well (consider both teaching and learning)?**What two things would have improved the lesson (consider both teaching and learning)?**What have I learned from this lesson about the class or individuals that will inform my next lesson?***Next steps****What will I teach next, based on learners' understanding of this lesson?**

Sample Lesson 2

CLASS:	
DATE:	
Learning objectives	<p>7Cc.01 Identify whether a chemical reaction has taken place through observations of the loss of reactants and/or the formation of products which have different properties to the reactants (including evolving a gas, formation of a precipitate or change of colour). <i>This lesson is focused on the formation of a precipitate.</i></p> <p>7TWSc.05 Carry out practical work safely.</p> <p>7TWSm.02 Use symbols and formulae to represent scientific ideas.</p>
Lesson focus / success criteria	<p>I can carry out and observe a chemical reaction safely</p> <p>I can identify a precipitate</p> <p>I can explain why a precipitate is a sign a chemical reaction has occurred</p>
Prior knowledge / Previous learning	<p>Learners need to know a chemical reaction involves reactants forming new products. Previous experience of observing chemical reactions is beneficial as these can be discussed during the lesson.</p>

Plan

Lesson	Planned activities	Notes
Introduction	<p>Recap learners prior knowledge of reactions by demonstrating some reactions; only cover reactions that do not form a precipitate.</p> <p><i>How do you know a reaction is occurring? What are the signs?</i></p> <p>Discuss the tell-tale signs of a reaction (e.g. change of colour, evolving a gas, combustion)</p> <p>There is another sign that a reaction is occurring or has occurred: precipitation.</p> <p><i>What do you think this word means?</i></p> <p>Learners may refer to weather and precipitation (e.g. rain, snow). Explain that, in chemistry, it is a related idea. Precipitation is when an insoluble solid separate from a solution. In a reaction, an insoluble solid may be formed from mixed solvents or mixed soluble solids; this creates a visible solid as the new 'insoluble solid' appears'.</p>	<p>Resources as required for demonstrating a range of non-precipitation reactions</p> <p>If in a hard water area, the issue of limescale can be discussed as an example of chemical precipitation.</p>
Main activities	<p>Give each pair of learners: 25 ml of magnesium sulfate solution and 25 ml of sodium carbonate solution (in separate, labelled containers), two 100 ml conical flasks, a filter funnel (polyethylene or glass) and filter paper. Ensure that everyone is wearing eye protection.</p> <p>Give each pair a set of instructions as a list; include a column for ticks to be added when each stage is completed. Ask learners after the first step to share their observations and if they believe a precipitate has been formed or not.</p> <ul style="list-style-type: none"> Mix 25 ml of 0.5M magnesium sulfate solution and 25 ml of 0.5M sodium carbonate solution in a conical flask. Use a pencil to write your initials around the edge of a piece of filter paper. Fold the filter paper and place it in the filter funnel. 	<p>0.5M magnesium sulfate solution, 0.5M sodium carbonate solution, 100 ml conical flasks, filter funnels, filter paper.</p>

Lesson	Planned activities	Notes
	<ul style="list-style-type: none"> Place the filter funnel, containing folded filter paper, in the neck of another conical flask. Swirl the reaction mixture gently and pour a little at a time into the filter paper in the funnel. Do not let the level rise too close to the top of the filter paper. Continue pouring, until all the reaction mixture has passed through the filter paper into the second flask. Remove the wet filter paper and carefully open it over a paper towel, taking care not to spill any contents. Leave the filter paper to dry for a few hours. Inspect the dry filter paper for any precipitate. This will be a white powder. (This can be done at the start of the next lesson) <p>While the filter paper is drying, give each small group of learners two sets of the same four cards (each card has a single word written on it: 'magnesium', 'sulfate', 'sodium' or 'carbonate'). Tell them that chemical reactions not only produce new substances, but they often do this by swapping chemical 'partners'. Ask them to arrange the cards to show the reactants (i.e. magnesium sulfate and sodium carbonate) and arrange the remaining cards to suggest the names of the new substances formed. They may need a hint (i.e. the name of the metal element always comes first in a chemical compound). Once learners have got the equation:</p> $ \begin{array}{ccc} \text{magnesium sulfate} & & \text{magnesium carbonate} \\ + & \rightarrow & + \\ \text{sodium carbonate} & & \text{sodium sulfate} \end{array} $ <p>Ask them to copy it out to add information to later.</p> <p>Hold a class discussion and ask questions: <i>What did you see happen in the flask when you mixed the solutions?</i> <i>Magnesium carbonate is the insoluble product that is drying on the filter paper. What is the term for an insoluble product made from two solutions?</i> <i>What can you tell about the properties of sodium sulfate? (it must be soluble as it did not form a precipitate).</i> <i>What evidence is there, and will be available, that this was a chemical reaction?</i></p> <p>Ask learners to add descriptions of the reactants and products to their copied equation, using the terms: soluble/insoluble and solution/precipitate.</p>	
End/Close/Reflection/Summary	<p>Discuss with learners where precipitation may be useful. Identify examples together and suggest other examples if learner's struggle e.g. making pigments, removing salt from water in water treatment.</p>	

Reflection**Use the space below to reflect on your lesson. Answer the most relevant questions for your lesson.***Were the learning objectives and lesson focus realistic? What did the learners learn today?**What was the learning atmosphere like?**What changes did I make from my plan and why?**If I taught this again, what would I change?**What two things went really well (consider both teaching and learning)?**What two things would have improved the lesson (consider both teaching and learning)?**What have I learned from this lesson about the class or individuals that will inform my next lesson?***Next steps****What will I teach next, based on learners' understanding of this lesson?**

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