SECOND EDITION

INTERNATIONAL SECONDARY SCIENCE

GRADE

7

TEACHER HANDBOOK

Pakistan Edition

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How to use your Teacher Handbook

Welcome to your **International Secondary Science** Teacher Handbook. This Teacher Handbook has been written to provide classroom support and teaching materials for PNC and Cambridge checkpoints.

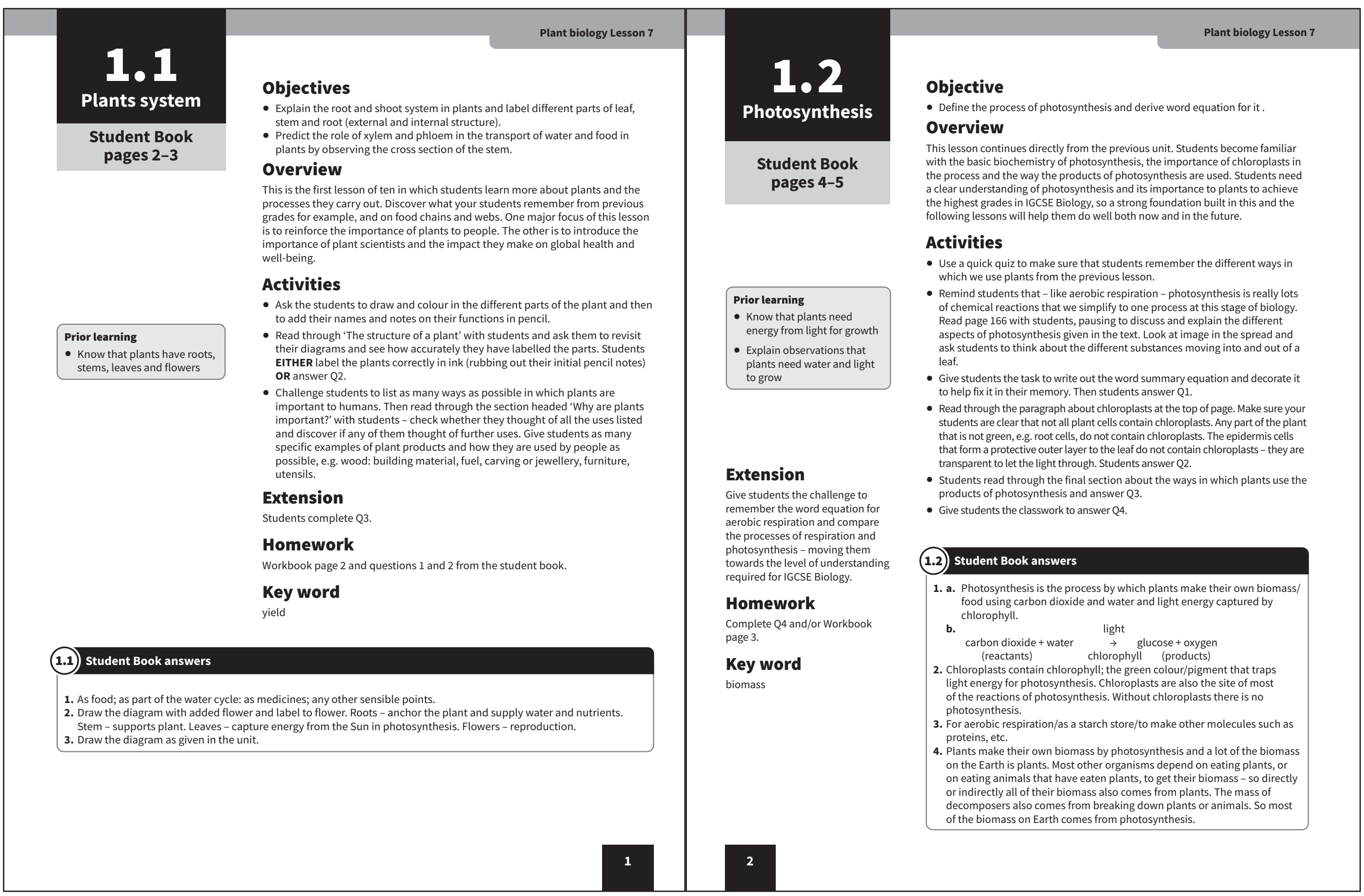
Your Teacher Handbook includes a book of lesson plans as well as answers to all of the Student Book questions for your reference at any time.

The answers to the workbook questions are provided at the end of the handbook for your ease of reference.

Using your book

This book contains suggested lesson plans and answers to all of the questions in the Student Book. There is also information about students' prior knowledge.

There is one lesson plan for every unit in the Student Book, including Thinking and Working Scientifically, Science in Context, as well as Extension for the topic. Each lesson plan suggests activities for use in the classroom linked to the topics covered on the Student Book spread.


Plant biology Lesson 7

1.1 Plants system

Student Book pages 2–3

Objectives
- Explain the root and shoot system in plants and label different parts of leaf, stem and root (external and internal structure).
- Predict the role of xylem and phloem in the transport of water and food in plants by observing the cross section of the stem.

Overview
This is the first lesson of ten in which students learn more about plants and the processes they carry out. Discover what your students remember from previous grades for example, and on food chains and webs. One major focus of this lesson is to reinforce the importance of plants to people. The other is to introduce the importance of plant scientists and the impact they make on global health and well-being.

Activities
- Ask the students to draw and colour in the different parts of the plant and then to add their names and notes on their functions in pencil.
- Read through 'The structure of a plant' with students and ask them to revisit their diagrams and see how accurately they have labelled the parts. Students EITHER label the plants correctly in ink (rubbing out their initial pencil notes) OR answer Q2.
- Challenge students to list as many ways as possible in which plants are important to humans. Then read through the section headed 'Why are plants important?' with students – check whether they thought of all the uses listed and discover if any of them thought of further uses. Give students as many specific examples of plant products and how they are used by people as possible, e.g. wood: building material, fuel, carving or jewellery, furniture, utensils.

Prior learning
- Know that plants have roots, stems, leaves and flowers

Extension
Students complete Q3.

Homework
Workbook page 2 and questions 1 and 2 from the student book.

Key word
yield

1.1 Student Book answers
1. As food; as part of the water cycle: as medicines; any other sensible points.
2. Draw the diagram with added flower and label to flower. Roots – anchor the plant and supply water and nutrients. Stem – supports plant. Leaves – capture energy from the Sun in photosynthesis. Flowers – reproduction.
3. Draw the diagram as given in the unit.

1

Plant biology Lesson 7

1.2 Photosynthesis

Student Book pages 4–5

Objective
- Define the process of photosynthesis and derive word equation for it .

Overview
This lesson continues directly from the previous unit. Students become familiar with the basic biochemistry of photosynthesis, the importance of chloroplasts in the process and the way the products of photosynthesis are used. Students need a clear understanding of photosynthesis and its importance to plants to achieve the highest grades in IGCSE Biology, so a strong foundation built in this and the following lessons will help them do well both now and in the future.

Activities
- Use a quick quiz to make sure that students remember the different ways in which we use plants from the previous lesson.
- Remind students that – like aerobic respiration – photosynthesis is really lots of chemical reactions that we simplify to one process at this stage of biology. Read page 166 with students, pausing to discuss and explain the different aspects of photosynthesis given in the text. Look at image in the spread and ask students to think about the different substances moving into and out of a leaf.
- Give students the task to write out the word summary equation and decorate it to help fix it in their memory. Then students answer Q1.
- Read through the paragraph about chloroplasts at the top of page. Make sure your students are clear that not all plant cells contain chloroplasts. Any part of the plant that is not green, e.g. root cells, do not contain chloroplasts. The epidermis cells that form a protective outer layer to the leaf do not contain chloroplasts – they are transparent to let the light through. Students answer Q2.
- Students read through the final section about the ways in which plants use the products of photosynthesis and answer Q3.
- Give students the classwork to answer Q4.

Prior learning
- Know that plants need energy from light for growth
- Explain observations that plants need water and light to grow

Extension
Give students the challenge to remember the word equation for aerobic respiration and compare the processes of respiration and photosynthesis – moving them towards the level of understanding required for IGCSE Biology.

Homework
Complete Q4 and/or Workbook page 3.

Key word
biomass

1.2 Student Book answers
1. a. Photosynthesis is the process by which plants make their own biomass/food using carbon dioxide and water and light energy captured by chlorophyll.
b. carbon dioxide + water (reactants) → (light, chlorophyll) glucose + oxygen (products)
2. Chloroplasts contain chlorophyll; the green colour/pigment that traps light energy for photosynthesis. Chloroplasts are also the site of most of the reactions of photosynthesis. Without chloroplasts there is no photosynthesis.
3. For aerobic respiration/as a starch store/to make other molecules such as proteins, etc.
4. Plants make their own biomass by photosynthesis and a lot of the biomass on the Earth is plants. Most other organisms depend on eating plants, or on eating animals that have eaten plants, to get their biomass – so directly or indirectly all of their biomass also comes from plants. The mass of decomposers also comes from breaking down plants or animals. So most of the biomass on Earth comes from photosynthesis.

2

Each lesson plan begins with a reference to the pages of the Student Book that it covers and a summary of their objectives.

The *Overview* section of the lesson plan reviews what the suggested activities will cover to fulfil the learning objectives. Here you will also find advice and tips about common misconceptions, what you may need to review from the Primary curriculum framework or previous lessons, and suggested questions for a class discussion.

The *Activities* section of the lesson plan lists several different activities that can be used in the classroom. These activities include fun and engaging demonstrations, interesting practical ideas, group work suggestions, reading and research activities, and ways to explore a novel topic using models, games, class discussions or Internet research.

Lesson plans that are matched to Thinking and Working Scientifically and Science in Context units include activities that encourage students to use the skills they are learning about by planning and carrying out their own investigations, analysing data, and drawing conclusions individually or as part of a group.

Most of the lessons have suggested *Extension* activities to stretch your strongest students and help prepare them for the step up to Cambridge IGCSE®. Some of these could be carried out in class, whilst others could be set as homework.

Every content unit in the Student Book is matched to a page in the Workbook. At the end of each lesson plan the corresponding workbook page is suggested as *Homework*.

Finishing each unit are the answers for all of the questions in the Student Book for quick reference in the classroom.

Contents

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1.1
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Student Book pages 2–3

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- Predict the role of xylem and phloem in the transport of water and food in plants by observing the cross section of the stem.

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Extension
Students complete Q3.

Homework
Workbook page 2 and questions 1 and 2 from the student book.

Key word
yield

1.1 Student Book answers
1. As food; as part of the water cycle: as medicines; any other sensible points.
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3. Draw the diagram as given in the unit.

1.2

Photosynthesis

Student Book pages 4–5

Prior learning

- Know that plants need energy from light for growth
- Explain observations that plants need water and light to grow

Objective

- Define the process of photosynthesis and derive word equation for it .

Overview

This lesson continues directly from the previous unit. Students become familiar with the basic biochemistry of photosynthesis, the importance of chloroplasts in the process and the way the products of photosynthesis are used. Students need a clear understanding of photosynthesis and its importance to plants to achieve the highest grades in IGCSE Biology, so a strong foundation built in this and the following lessons will help them do well both now and in the future.

Activities

- Use a quick quiz to make sure that students remember the different ways in which we use plants from the previous lesson.
- Remind students that – like aerobic respiration – photosynthesis is really lots of chemical reactions that we simplify to one process at this stage of biology. Read page 166 with students, pausing to discuss and explain the different aspects of photosynthesis given in the text. Look at image in the spread and ask students to think about the different substances moving into and out of a leaf.
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- Students read through the final section about the ways in which plants use the products of photosynthesis and answer Q3.
- Give students the classwork to answer Q4.

Extension

Give students the challenge to remember the word equation for aerobic respiration and compare the processes of respiration and photosynthesis – moving them towards the level of understanding required for IGCSE Biology.

Homework

Complete Q4 and/or Workbook page 3.

Key word

biomass

1.2 Student Book answers

1. a. Photosynthesis is the process by which plants make their own biomass/food using carbon dioxide and water and light energy captured by chlorophyll.

b.

$$\underset{\text{(reactants)}}{\text{carbon dioxide + water}} \xrightarrow[\text{chlorophyll}]{\text{light}} \underset{\text{(products)}}{\text{glucose + oxygen}}$$

2. Chloroplasts contain chlorophyll; the green colour/pigment that traps light energy for photosynthesis. Chloroplasts are also the site of most of the reactions of photosynthesis. Without chloroplasts there is no photosynthesis.

3. For aerobic respiration/as a starch store/to make other molecules such as proteins, etc.

4. Plants make their own biomass by photosynthesis and a lot of the biomass on the Earth is plants. Most other organisms depend on eating plants, or on eating animals that have eaten plants, to get their biomass – so directly or indirectly all of their biomass also comes from plants. The mass of decomposers also comes from breaking down plants or animals. So most of the biomass on Earth comes from photosynthesis.

1.3 Evidence for photosynthesis: testing for starch

TWS

Student Book pages 6–7

Prior learning

- Plants need energy from light for growth

Objectives

- Define the process of photosynthesis.
- Explain that the structure of a leaf is adapted for photosynthesis.

Overview

This lesson helps students develop to their skills in Thinking and working scientifically.

This is a good opportunity for students to carry out practical work themselves, as well as evaluating different practical methods described. Relatively little apparatus is needed if you provide your students with boiling water from a kettle rather than them boiling water using a Bunsen burner. An alternative is to demonstrate the basic technique of testing a leaf for starch. Forward planning is required to have one plant in a dark cupboard for at least 3 days before the lesson, and another plant in light for at least 12 hours before the lesson.

This is a valuable opportunity to demonstrate to students how different types of investigations give different evidence about the same process. It may also demonstrate the variability of living organisms.

Activities

- Begin the lesson with quick questions on what a plant needs to photosynthesise. Introduce the rest of the lesson as a practical session/evaluation of different practical techniques to investigate or demonstrate what is needed for photosynthesis.
- **EITHER** give students starch and let them carry out a practical technique themselves **OR** demonstrate the practical technique given to the class.
- Bring the class together and discuss how the basic technique – testing a leaf for the presence of starch as a sign that photosynthesis has taken place – can be used to demonstrate what a plant requires to photosynthesise successfully. Students answer Q1, producing a flow diagram of the practical technique.
- Students work through 'Investigating photosynthesis' and answer Q2 in full.
- Have a plenary session to go through the answers to Q2 and bring together ideas on the strengths and weaknesses of these techniques for demonstrating or investigating photosynthesis.

Extension

Students write a paragraph to explain why it is much harder to demonstrate that plants need carbon dioxide and water for photosynthesis than that they need light and chlorophyll. [You can remove carbon dioxide from the air around the leaf but can't stop the leaves making carbon dioxide as the cells respire, so they always have some carbon dioxide; plant cells contain lots of water and if a plant has no water input it will wilt and die, so you can't investigate the effect of removing water].

Homework

Workbook page 4 and the questions in the spread.

1.3 Student Book answers

1. Take a leaf from a test plant → place it in boiling water for up to a minute (to remove waterproof covering/break open cells) → turn off heat → remove leaf from boiling water → place leaf in test tube of ethanol → place test tube of ethanol in beaker of hot water (ethanol boils/removes green colour from leaf) → remove pale, stiff leaf from ethanol → dip leaf into hot water (to soften) → spread leaf on white tile → add a few drops of iodine solution (to test for starch) → if starch is present, turns blue-black.
2. **a.** Plants turn some of the glucose they make during photosynthesis into starch in their leaves to use when they are in the dark. It takes two to three days to use up these starch stores. By using plants that have been kept in the dark, students know that any starch they find in their tests is the result of photosynthesis during their investigation.

   b. Salma: **i.** Whether chlorophyll is needed for photosynthesis.

   ii. Chlorophyll is needed for photosynthesis.

   iii. Any two from these or any other sensible point: using a plant that has been kept in the dark, using a variegated leaf, leaving the plant in the light for 24 hours, using the iodine test for starch.

   iv. Use more than one leaf of each type; use green and white leaves instead of green and pink leaves; try several different types of variegated leaves; any other sensible point.

   Dina: **i.** Whether light is needed for photosynthesis.

   ii. Light is needed for photosynthesis.

   iii. Any two from these or any other sensible point: using a plant that has been kept in the dark, covering part of a leaf with foil/card so the light couldn't reach it, leaving the plant in the light for 24 hours, using the iodine test for starch.

   iv. Partly cover more than one leaf; completely cover some leaves; use more than one plant; any other sensible point.

   Abdul: **i.** Whether carbon dioxide is needed for photosynthesis.

   ii. CO_2 is needed for photosynthesis.

   iii. Any two from these or any other sensible point: using a plant that has been kept in the dark, removing the carbon dioxide from around one leaf, using the iodine test for starch.

   iv. Use more than one leaf of each type; use green and white leaves instead of green and pink leaves; try several different types of variegated leaves; any other sensible point.

1.4

Evidence for photosynthesis: oxygen bubbles

TWS

Student Book pages 8–9

Objective

- Define the process of photosynthesis and derive word equations for it.

Overview

This lesson helps students to develop their skills in Thinking and working scientifically. It is good opportunity for practical work with your students or a practical demonstration that requires very little apparatus. The Student Book provides a version of the practical and results for students to manipulate. Students already know that plants need light for photosynthesis. In this lesson, they investigate the link between light intensity and the rate of photosynthesis. This follows up on earlier work on the need for different techniques to investigate different aspects of the same process. It also introduces the limitations of the iodine test for starch as a way of assessing the rate of photosynthesis.

Activities

- Ask students whether they think a plant would photosynthesise faster in bright light or dim light. Ask what the term 'rate of photosynthesis' means. Encourage students to suggest ways in which the rate of photosynthesis might be measured.

Prior learning

- Plants need energy from light for growth

- Discuss problems using the iodine test for starch in measuring the rate of photosynthesis and point out its limitations – especially the fact that the plant leaves have to be killed before you can test them. Students then read the section headed 'Evidence for photosynthesis'
- Read through the section headed 'Does light intensity affect the rate of photosynthesis?' to the end of the method.
- **EITHER** give students a chance to create a table in their notebooks and fill in the sections headed Apparatus, Method and Prediction.

  Students carry out the practical as described and complete the results table. They use this data to plot a line graph, drawing conclusions and evaluating what they have done.
- **OR** give students a chance to discuss the practical and get them to consider the variables involved. Carry out the experiment as a Students use the data from your investigation or the data in the unit to complete their table, displaying the results on a line graph, drawing conclusions and evaluating what they have done.
- **OR** students read through the section headed 'Does light intensity affect the rate of photosynthesis?' to the end of page and complete the questions. In this option, make sure that students have the opportunity to see a sample of pond weed bubbling oxygen in a light source so they understand how the practical works.
- End with a brief plenary summarising the conclusions that can be drawn from the results and the limitations of these conclusions.

Homework

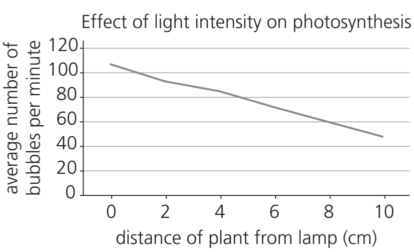
Workbook page 5 and question in the spread.

Key word

light intensity

1.4 Student Book answers

1.



2. The graph shows that the numbers of bubbles produced per minute by the plant decreases as the plant is moved further away from the lamp.

3. That light intensity affects the rate of photosynthesis, and the rate of photosynthesis increases as the light intensity increases.

4. To measure the temperature of the water in the beaker around the test tube containing the experimental pond weed. It is important because temperature might affect the rate of photosynthesis so it is a variable which must be controlled.

5. a. Any two from: Giving the plant time to adjust to the changes in light intensity; measuring the distance from the lamp accurately; controlling the temperature of the water so it stays the same throughout; any other sensible points.

b. Keep the pondweed in the dark before starting the experiment; control the amount of carbon dioxide available to the plant in the water; repeat the investigation more times/with different pieces of pond weed; any other sensible suggestions.

1.5

Aerobic respiration in animals and plants

Student Book pages 10–11

Prior learning

- Identify and describe the functions of mitochondria
- Describe the seven characteristics of living organisms

Objective

- Describe the process of respiration and write word equations for it. Compare and contrast the processes of photosynthesis and respiration.

Overview

In this lesson, you explore the process of aerobic respiration with students. This is an excellent opportunity to make sure that your students have remembered and understood work on the characteristics of living organisms and the functions of cell structures from previous grade. They apply and extend this knowledge and understanding as you explain the importance of the process of aerobic respiration in cells. Understanding cellular respiration is key both for understanding the need for gas exchange systems and for later study in IGCSE Biology.

Activities

- Look at the images in the Student Book. Ask students to name other examples of living organisms and ask for the seven characteristics of life.
- Explain to students that cells need energy to do work – from muscle cells contracting to building the chemicals needed for the body to function. Demonstrate burning sugar in air, using appropriate safety precautions, or show a video clip. This is uncontrolled energy release. Discuss with students the need for cells to release energy in a controlled way.
- Read through the section on aerobic respiration. Write the word summary on the board and talk about all of the substances with your students: glucose, oxygen, carbon dioxide and water. Make sure that students know what each of them is – a sugar, a gas from the air, etc., and where it comes from. They should also learn that carbon dioxide is toxic and must be removed from the cells.
- Explain to students that the substances involved in aerobic respiration move into and out of the cells by diffusion from the blood.
- Students produce a word summary of respiration. They should make this large and clear and decorate it in some way to make it easier to remember. They can stick this in their notebooks or you could make a wall display for the classroom.
- Ask students to name the part of a cell where aerobic respiration takes place – some will remember the mitochondria. Remind students that both animal and plant cells have mitochondria. Students read through the text and answer questions 1–4.

Extension

Students should show awareness of cells that use a lot of energy, e.g. muscle cells, heart muscle cells, cells in growing regions of bones or skin of young children, growing shoots of plants, forming fruits and tissues/cells with low energy demands, e.g. fat cells, starch storage cells in plant roots or stems, areas where little growth takes place, ageing tissue. Give extra credit where students include plant examples.

Homework

Workbook page 6.

Key words

oxygen, glucose, aerobic respiration, carbon dioxide, water

1.5 Student Book answers

1. Aerobic respiration.
2. Mitochondria
3. **a.** Glucose + oxygen --respiration--> carbon dioxide + Water + energy
   (reactants) (products)

   b. Sunlight
4. Carbon dioxide + water -------------> glucose + oxygen
   (reactants) chlorophyll (products)
5. Encourage students to recollect information from spread 1.2 and compare with the information of the current spread 1.5 and then collate information in tabular form.

1.6

The need for minerals

Student Book pages 12–13

Objective

- Know that plants require minerals to maintain healthy growth and life processes (limited to magnesium to make chlorophyll and nitrates to make protein).

Overview

This lesson introduces students to the mineral requirements of plants. It is a good opportunity to revisit the mineral requirements of people/animals to help students to understand that all living things face similar problems and often solve them in similar ways. This lesson is an opportunity for a practical exercise which requires at least two-weeks' observation – students can set it up in this lesson and revisit it before the end of the topic **OR** you can set it up at least two weeks before the lesson and demonstrate it on the day.

Activities

- Before the lesson, test students' knowledge and understanding of the importance of mineral salts in the human diet.
- Read through to the end of the section on 'The need for minerals'. Discuss the importance of nitrates and magnesium to plants. Challenge students to recognise the similarity between the need for iron in humans and the need for magnesium in plants. Students answer questions 1 and 2.
- Read through 'Mineral deficiencies in plants' with students. Look closely at the images in the table of mineral deficiencies and quiz students on how the symptoms of deficiency diseases in the plants are linked to the minerals they lack.
- **EITHER:** Students set up the practical and revisit their plants every lesson for the next two weeks or more. **OR:** Set up the practical two or three weeks before this lesson. During the lesson, demonstrate the experimental procedure/get students to set up the experimental procedure and then produce plants that have been growing in the different solutions for several weeks, so that students can observe the results and complete the worksheet in this lesson. They can also observe their own investigations over time.
- Work through the final section 'Where do plants get their minerals from?' with students. If possible, bring a leguminous plant into the lesson to demonstrate the root nodules. Students answer Q3.

- Draw the lesson together with a quick review of what has been learned and tell students that they will be using their knowledge and understanding from this lesson in the next one when they look at fertilisers.

Extension

Students research other mineral requirements of plants, e.g. phosphates, potassium.

Homework

Workbook page 7

Key words

minerals, nitrates, magnesium, mineral deficiency, legumes

1.6 Student Book answers

1. Water-soluble substances that cells can absorb and need to grow well.
2. Magnesium to make chlorophyll, the green colour needed to capture light energy for photosynthesis.
   Nitrates to make the proteins that control reactions in plant cells and are part of the cell structure.
3. a. Each year the plants take minerals/nitrates from the soil so there is less for the next crop. This year the plants are deficient in nitrates. Know this because symptoms of nitrate deficiency are poor growth and yellowing of the older leaves.
   b. Peas and beans are legumes so they make their own nitrates in root nodules full of bacteria. So they are not deficient in nitrates and they grow well.
   c. Grow other plants where the peas and beans grew this year as they add nitrates to the soil. If students puts compost/manure/fertiliser, give 1 mark.

1.7 The use of fertilisers

SIC

Student Book pages 14–15

Objective

- Plants need minerals to maintain healthy growth and life processes.

Overview

This lesson helps students to develop their understanding of Science in context.

It gives your students the opportunity to apply their knowledge and understanding of the mineral requirements of plants to the global use of fertilisers to improve crop yields. Draw on local experience of fertilizer use – which may be mainly artificial, mainly natural or a mixture of both – in your discussions. Help your students make connections between the chemistry about non-metals, gases, inert elements and chemical reactions and their biology, by introducing the Haber–Bosch reaction and its importance in making fertilisers from the nitrogen in the air. If students develop the ability to apply what they learn in each science to the other sciences they learn during their lower secondary course, they will have a big advantage when they tackle IGCSE science courses.

Activities

- Students discuss the difference between plants growing wild and farmed crop plants before reading the first two paragraphs of page 14.
- Read through with students the section headed 'What are fertilisers'. Make time for questions and discussion about any fertilisers students are familiar

Key words

natural fertilisers, manure, artificial fertilisers

with – on local farms, in gardens or for house plants. Take the opportunity to discover whether students have any information about compost and decomposers. Students answer questions 1 and 2.

- Read through the rest of pages with students. Stop to talk about each paragraph in turn, and make sure that students recognise the huge benefits fertilisers have brought to people. Ask questions such as:

  – Nitrogen is a relatively inert gas – what does this mean?

  – Nitrogen and hydrogen are both non-metals – what does this mean?

  – Nitrogen and hydrogen are gases – what does this tell you about their properties?

- Discuss the value of applying the science of Haber's reaction to the industrial process developed by Bosch, using the data in spread to support your case. Students answer Q3 and Q4.
- Remind the students to use their knowledge and understanding of the mineral requirements of plants and the importance of fertilisers and apply it to new information they are given.

Extension

Ask students to investigate the Haber–Bosch process and write a paragraph about how the process works.

Homework

Workbook page 8.

1.7 Student Book answers

1.a. A substance that replaces minerals such as nitrates in the soil.

b. Naturally plants take minerals from the soil when they grow, and the minerals are replaced when they die and decompose. Crop plants take minerals from the soil and when we harvest them, no minerals are replaced. Fertilisers are needed to replace the minerals so the crops grow well.

2.a. Advantages: two from, are cheap/easily available/improve the soil structure. Disadvantages: release minerals slowly, limited supply.

b. Advantages: two from, are always available, release minerals fast, farmers control the amount of minerals applied. Disadvantages: expensive, don't improve soil quality.

3. Scientists understood the way plants need minerals, and they developed a method of making ammonia from nitrogen in the air. Industry developed a way to use that reaction to make ammonia on an enormous scale, so artificial fertilisers were available and farmers could increase their crop yields, feeding more people.

4.a. i. No fertiliser → 1300 kg/hectare; with 45 kg fertiliser, yield 2500 kg/hectare → 2500 − 1300 = 1200 increase. 1200/1300 × 100 = 92.3%

ii. No fertiliser → 1300 kg/hectare; with 90 kg fertiliser, yield 3700 kg/hectare → 3700 − 1300 = 2400 increase. 2400/1300 × 100 = 184.6%

b.

kg nitrate fertiliser/ hectare	% increase in yield canola	% increase in yield wheat
45 kg	92.3	60
90 kg	184.6	85

1.8

Water and mineral transport in plants

Student Book pages 16–17

Prior learning

- Explain observations that plants need water to grow
- Know that water is taken in through the roots and transported through the stem

Objective

- Predict the role of xylem and phloem in the transport of water and food in plants by observing the cross section of the stem.

Overview

In this lesson, you will introduce your students to the basic processes in the movement of water from the soil to the leaves through the plant. This is the basic transpiration stream. Knowledge of the factors affecting transpiration are required in IGCSE. Here the focus is on the basic plant structures involved in the movement of water through the plant – root hairs, xylem and stomata – and their functions. Give students the opportunity to observe these different parts of the plant if possible. This requires preparation – setting up cress seeds to germinate, placing celery or other stems in water containing ink or food colouring several days before the lesson and painting the underside of leaves with nail varnish. If students develop a clear understanding of the basic principles of the movement of water and mineral salts through a plant, they will grasp more complex aspects of the transpiration stream more easily when they meet it in IGCSE Biology.

Activities

- Ask students why plants need water, and where they get the water from. Ask them about the mineral needs of plants too and how the minerals are transported.
- Read the first three paragraphs with your students, to the end of 'Getting water into the plant'. Ask students to recall specialised plant cells.
- Read through the section 'Transporting water and minerals around the plant' with your students. do the sectioning of the stems as a demonstration, showing students the dyed xylem tubes up the stem.
- Read through the section headed 'Leaving the plant' before carrying out the practical. Alternatively, demonstrate looking at the stomata on the varnish peel and project the microscope image for students to see.
- Students work through the Thinking and working scientifically box – ask them why the idea of dipping one of the celery stems in wax is so useful.
- Use the key points as a summary with students of the learning in this lesson. Students draw and annotate their own diagram and use any remaining time to answer some or all of questions 1–3.

Extension

Students complete questions 1–3 and then think about and answer Q4.

Homework

Workbook page 9.

Key words

transpiration stream, stomata

1.8 Student Book answers

1. Roots have root hair cells – microscopic hairs that increase the surface area for water to move in. Soil water moves into the root hair cells by diffusion into the xylem tubes in the root.
2. Mineral salts move into the roots dissolved in the soil water.
3. a. Holes found on the underside of leaves through which gas exchange takes place. They can be opened and closed by the guard cells.
   b. Water evaporates from the cells in the leaf and moves out by diffusion through the stomata.
4. Plants lose water through their leaves by transpiration. Water is pulled up through the plant from the soil in the transpiration stream. On cool days, the plant transpires and there is enough water in the soil to replace it. On hot days, more evaporation takes place so more transpiration takes place; there is not enough water in the soil to replace it. The cells of the plant do not get enough water and so they cannot support the plant and it wilts.

1.9 Factors affecting transpiration

Student Book pages 18–19

Prior learning

- understand the importance of transpiration in a plant.

Objectives

- Investigate the phenomena of transpiration and its importance in a plant.
- Explore natural raise of water based on the principle of transpiration.

Overview

This lesson is a continuation from the previous lesson on transpiration. In the lesson, you will guide the students towards a more in-depth understanding of factors affecting transpiration. Ensure they understand that the factors that increase the rate of evaporation or increase the rate of

photosynthesis will increase the rate of transpiration. These factors include wind (air flow), temperature, light and humidity, and they are strong enough to raise water above the ground level. Finally, students are introduced to the working and function of a potometer.

Activities

- Begin the lesson by reviewing the process of transpiration and its importance with the students. Elicit what they remember from the TWS experiment discussed in the book.
- Introduce (using the unit text) the factors that increase the rate of transpiration. Detail how these factors: wind (air flow), temperature, light, and humidity, are strong enough to raise water above ground level. You can encourage students to set up an experiment to visualise movement of water through xylem due to transpiration.
- In order to set up the experiment, ask the students how they can set up different conditions for air flow, tempurature, light and humidity, keeping other conditions constant or same. Once you have set up four such experimental stations, begin by taking cabbage or celery leaves (their ends should be intact) and place them in clear containers filled with water. Add a few drops of food coloring in the water and let the leaves sit for 8 hours or overnight. Observe how the veins of the leaves are colored, starting from the bottom to the top.
- Ask students to share their observations with the class. Discuss the role of xylem in water transportation in plants through this demonstration. Ensure that the students understand that factors that increase the rate of evaporation or increase the rate of photosynthesis will increase the rate of transpiration.

- Finally, if possible, show the students the working of a potometer. **Alternatively**, you can show them a video showing the function and use of a potometer. **Or** you can use the information in the students' book to discuss how a potometer doesn't actually measure the rate at which water evaporates from the leaves of a plant. Rather it measures the rate at which the plant takes up water. Ask the students why these two measurements are considered to be the same.

Homework

Questions from the student book spread and workbook page 10.

Key words

ground tissue, epidermis, xylem, phloem, vascular bundle stem, roots, leaves, root hair, stomata, cuticle, cortex, humidity, photosynthesis, respiration, transpiration.

1.9 Student Book answers

1. It is the loss of water vapour from the surface of a plant by evaporation.
2. **a.** Windy weather increases the rate of transpiration because it not only increases the rate of evaporation, but also removes water vapour from around the leaf, increasing the concentration gradient between the leaf and the air.
   b. On a hot, sunny day there is an increase in the rate of evaporation which causes an increase the rate of transpiration from the surface of a leaf.
   c. On a very humid day there is a lot of water vapour in the air, and so due to reduced difference in water vapour gradient between the inside of the leaf and the air around it, the transpiration slows down.
3. As the potometer measures the rate of uptake of water by the plant, it can be used to investigate the effect of wind on a plant shoot. By changing conditions i.e. Increasing or decreasing the speed of wind, we can measure how much water is taken up by the plant, versus when the wind speed is baseline.

Extension 1.10 Xylem, phloem and plant pests

Student Book pages 20–21

Objective

- Predict the role of the xylem and phloem in transport of food and water by observing the cross section of the stem.

Overview

In this extension lesson, students look in more detail at the transport tissues in plants, learning more about transport in the phloem vessels. This moves their basic studies towards the more detailed work on the xylem and phloem that are part of IGCSE Biology. Plant pests and diseases are the context for this lesson. This provides students with an interesting insight into why plant biology is so important. If possible, bring in a plant infected with aphids to show students as part of the lesson.

Activities

- Have a brief discussion with students about the problems of plant pests and plant diseases both locally and globally. Help them to understand both the loss of crop plants and the loss of ecosystems from plant diseases.

Prior learning

- Know that plants have roots, leaves, stems and flowers
- Explain observations that plants need water and light to grow
- Know that water is taken in through the roots and transported through the stem
- Know that plants need healthy roots, leaves and stems to grow well

- Remind students that they have mainly focused on the transport of water and mineral salts from the soil up through plants in the xylem. Help them to understand that plants need to move the glucose they make in photosynthesis to all parts of the plants to provide the fuel for cellular respiration. Read 'Sugar transport in plants' with.
- Depending on the abilities of your students and where you feel they need the most practice, give students **EITHER the task of drawing** diagrams of the different tissues **OR** a piece of free writing with diagrams describing the structure and functions of the two transport tissues in plants, discussing the similarities and differences between them.
- Introduce the idea that many plant pests attack the transport systems of plants, especially the phloem and ask students why. Read 'Targeting transport' down to the bottom of page. If you have a plant infected with aphids, let students look at it and see how the insects attack the plant.
- Students answer questions 1–4.
- Finally, students look at the section headed 'Unwelcome visitors' Work through it with students, emphasising the way in which plant pests often introduce plant pathogens into the structure of plants. Make clear: a) how plant diseases that block or damage the transport system of the plant will lead eventually to plant death; and b) the similarities between how these plant diseases and some human diseases are spread by insects penetrating the transport system.

Extension

Students carry out independent research and write a short report comparing the spread of plant diseases by pests such as aphids and human diseases such as malaria spread by mosquitoes.

Homework

Workbook page 11.

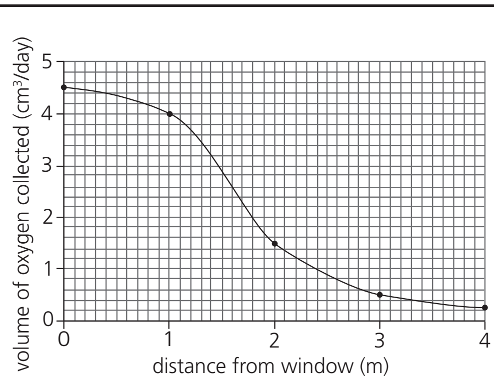
1.10 Student Book answers

1. Xylem is dead tissue, phloem is alive; xylem transports water and dissolved minerals, phloem transports water and dissolved food/sugars; xylem transports from the roots to the shoots/up the plant only, phloem transports all around the plant, transport in xylem doesn't use energy, transport in the phloem does.
2. a. An insect that feeds on the liquid in the phloem of living plants.
   b. Many aphids take a lot of the food from the plant by feeding on the contents of the phloem; the biting mouthparts of the aphids can carry pathogens into the plant, causing diseases.
3. Plants make sugars by photosynthesis and they are carried around the plant in the phloem. They are carried to the buds and provide the food needed to grow many healthy flowers. Aphids stick their stylets into the phloem and feed on the sugary liquid. A plant infected with many aphids will have less sugar reaching the buds, so it will have less food available and so will produce fewer, smaller flowers.
4. a. A tree carries out photosynthesis in the leaves. It needs a supply of water carried from the roots to the leaves in the xylem. The sugars made during photosynthesis are carried to all of the tissues of the tree, including the roots, in the phloem. If deer eat a complete ring of bark, both the xylem and the phloem are destroyed. Water cannot reach the leaves so they cannot photosynthesise and die. Sugars cannot reach the roots so the cells are starved and the roots die. These two things mean the whole tree dies.
   b. Covering the bark of young trees above the level that can be reached by deer, etc. – until the tree is older and the bark is too tough for the deer to eat it.

1.11 Review answers

Student Book pages 22–23

Student Book answers

1	**a**	Photosynthesis is the process by which plants make their own biomass/food using carbon dioxide and water and light energy captured by chlorophyll.	**[2]**
	b	light carbon dioxide + water → glucose + oxygen (reactants) chlorophyll (products)	**[3]**
	c	Carbon dioxide gets into the leaf from respiration in the cells and diffusion from the air through the stomata. Water enters the root hair cells by diffusion from soil water and is transported up the plant in the xylem to the photosynthesising cells in the leaves. Oxygen is used by the plant cells for aerobic respiration and the rest is lost through the stomata in the leaves by diffusion. Some of the glucose is used directly by the cells for aerobic respiration, some is converted to starch to store energy, some is used to build other molecules such as proteins, and some is transported around the plant to all of the other cells to use.	**[10]**
	d	**i.** No – root hair cells have no chloroplasts and they are not exposed to light. **ii.** Yes – the light needed for photosynthesis is captured by chlorophyll in the chloroplasts when there is plenty of light. **iii.** No – chloroplasts are still there but there is no light for them to capture	**[3]** **[2]**
2	**a**	The pond weed photosynthesised in the light. It absorbed carbon dioxide from the water and used it in photosynthesis. The concentration of carbon dioxide in the water fell so the indicator turned purple.	**[2]**
	d	The pondweed did not photosynthesise in the dark, so it did not remove any carbon dioxide from the water. It respires all the time, in the light and the dark, so in the dark it added carbon dioxide to the water from respiration and the indicator changed colour.	**[3]**
3	**a**	He collects the gas produced by the plant in a measuring cylinder.	**[1]**
	b		**[5]**

	c	The closer the plant is to the light of the window, the more oxygen is produced – indicating that more photosynthesis is happening. So the greater the light intensity, the more photosynthesis takes place.	**[3]**
	d	Any two sensible suggestions, e.g. temperature of water, amount of carbon dioxide in the water, the size of the piece of pondweed.	**[2]**
4	**a**	Does a plant need carbon dioxide to photosynthesise?	**[1]**
	b	To use up any starch it has stored in its leaves, so the presence of starch can be used to indicate photosynthesis has taken place in the investigation.	**[2]**
	c	Take the two experimental leaves from the plant and drop them into boiling water to remove the waterproof layer and break open the cells. • Turn off the heat. Take the leaves from the boiling water. • Place the leaves in a test tube of ethanol and put the test tube into the hot water. The ethanol will boil and the green colour will come out of the leaves. • Remove the white leaves from the ethanol and dip them into hot water to soften them. • Spread the leaves on a white tile and add a few drops of iodine solution to each.	**[6]**
	d	Leaf B (from the bag containing lots of carbon dioxide) will turn the iodine blue–black. It has been photosynthesising and contains starch. Leaf A (from the bag with no carbon dioxide) cannot photosynthesise so it has no starch in its leaves and has no effect on the iodine which stays yellow–brown.	**[5]**
5	**a**	The amount of minerals available to the plants.	**[1]**
	b	Minerals are absorbed into the roots of plants from the soil, dissolved in the soil water. They get into the plant through the root hair cells. They move into the xylem and are transported up the plant to all the cells in the transpiration stream.	**[4]**
	c	**i.** Magnesium is needed to make chlorophyll which is the green colour in plants. If a plant lacks magnesium, it can't make chlorophyll and this affects the colour of the leaves **ii.** Chlorophyll captures light energy for photosynthesis. If a plant lacks magnesium it cannot make the chlorophyll it needs, so it cannot capture as much light energy. Less photosynthesis takes place, so less food is made and so the plants do not grow as quickly as those that have plenty of magnesium.	**[5]** **[1]**
6	**a**	Xylem	**[1]**
	b	It is a dead tissue comprising tubes that go from the roots to the leaves and buds; it carries water (and dissolved minerals) up the plant from the roots to the leaves.	**[3]**
	c	It was put in plain water/it had the end sealed up, e.g. by wax, before it was put in the ink.	**[2]**
7		**a.** iii, **b.** i, **c.** iii, **d.** i.	**[4]**

2.1 Human Respiratory and Circulatory System

Student Book pages 24–25

Objective

- Explain that living organisms have a complex transport system for the transfer of various solids, liquids and gases across the body.

Overview

This spread prepares the ground for work on the respiratory system and gas exchange by introducing students to the concept of diffusion in the context of biology (they may have studied in chemistry so it is helpful to discuss this with their chemistry teacher). Diffusion is a key concept in many biological systems at IGCSE, so making sure that students have a basic understanding of the principles now is time well spent. It is important to avoid misconceptions about diffusion – for example, the movement of the particles is RANDOM – they do not deliberately move to areas of high concentration.

Activities

- Begin the lesson with an experiment. Stand in front of your class and tell students that you are going to squirt perfume/aftershave/air freshener somewhere in the class. Students should all close their eyes and raise their hand when they can smell the perfume. Once they have raised their hands, they can open their eyes and watch what happens with the rest of the class. This is a practical demonstration of diffusion.
- Question students to get an understanding of how well they understand diffusion from their chemistry lessons if appropriate.
- Set up an experiment on your desk – take a beaker of water and drop a crystal of potassium manganate (VII) into it. Leave it for diffusion to take place throughout the lesson. Look at it with students and discuss what it happening several times throughout the lesson.
- Read through page 88 with students and discuss the process. Emphasise that the movement of the particles is random but that the particles will always end up spreading out from where there are a lot of them to where there are fewer. Make sure that students understand that diffusion only takes place in fluids – liquids and gases.
- Read the rest of the unit with students who then answer questions 1–3.
- Students complete a Thinking and working scientifically activity – students draw diagrams to show the particles spreading by diffusion in the beaker of water and potassium manganate (VII). They then evaluate the model, discussing its strengths (e.g. it helps you to visualise what is happening when the particles are too small to see) and weaknesses (e.g. what fills the space between the particles/the particles are too big and there aren't enough of them, etc.).
- Students attempt Q4 and keep their answers for later in this series of lessons.

Extension

Students chose one example of diffusion in the natural world and explain how it works through a series of annotated diagrams.

Homework

Workbook page 12.

Key words

diffusion, net, concentration gradient

2.1 Student Book answers

1. Matter is made up of moving particles which are too small for us to see.
2. The net movement of particles down a concentration gradient, from a high concentration to a low concentration.
3. There is a high concentration of scent in the flowers. The scent particles spread through the air by diffusion. Eventually, some of the scent particles will reach your nose and you will smell them.
4. High concentration of oxygen in the air, low concentration of oxygen in your blood; oxygen moves by diffusion down the concentration gradient from the air to the blood.

2.2 Aerobic and anaerobic respiration

Student Book pages 26–27

Objective

- Differentiate between aerobic and anaerobic respiration.

Overview

In this lesson, you will be introducing students to the key principles about respiration that they will need to understand for IGCSE Biology. These include:

Defining *anaerobic respiration* as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism without using oxygen.

Stating the word equation for respiration in muscles during vigorous exercise (glucose → lactic acid).

Knowing that anaerobic respiration releases much less energy per glucose molecule than aerobic respiration.

Activities

- Begin by introducing students to the word summary equation for aerobic respiration. Explain to them that cells need plenty of oxygen to carry out aerobic respiration and ask students how the oxygen gets to the cells (in the blood).
- Students read through the section titled 'Respiration without oxygen'. Discuss the problems of respiring without oxygen and the production of lactic acid. Help students to understand that breaking down many glucose molecules provides the body with the energy it needs when there is not enough oxygen for aerobic respiration, but this is inefficient.
- Students work through a simple exercise, where students feel their muscles tire and ache a little as they are forced to respire anaerobically. Students use their results to draw a graph which demonstrates that the muscles continue to work for some time without oxygen, by respiring anaerobically, but eventually they will not contract any more.
- Students read about lactic acid. Explain how lactic acid builds up in the muscles during anaerobic respiration and how the body needs more oxygen once exercise stops to break down the lactic acid. Discuss the benefits of training in developing a better blood supply to the muscles – this delivers more oxygen so it takes longer for anaerobic respiration to be required, and it gives a faster recovery as more oxygen reaches muscles to break down lactic acid once exercise stops.
- Students answer questions 1–5.

Extension

Students investigate the different types of muscle cells, the respiration they carry out and their roles in the body.

Homework

Workbook page 13.

Key words

anaerobic respiration, lactic acid

2.2 Student Book answers

1. Anaerobic respiration
2. e.g.

Aerobic respiration	Anaerobic respiration
needs oxygen	does not need oxygen
waste product: carbon dioxide	waste product: lactic acid
a lot of energy per molecule of glucose	less energy per molecule of glucose
happens all the time	only happens for short bursts, e.g. when exercising hard

3. Sometimes cells do not have enough oxygen to carry out aerobic respiration but they still need energy. Anaerobic respiration makes it possible to release some energy from food even with very little or no oxygen.
4. When Amir is running, his muscles do not get enough oxygen and use anaerobic respiration. This causes a build-up of lactic acid. Lactic acid is the waste product of anaerobic respiration. When he stops running, his body needs extra oxygen to break down the lactic acid in his muscles. He keeps breathing faster for several minutes to supply the extra oxygen needed to break down the lactic acid which built up when he was running OR Once the lactic acid has been broken down, Amir's breathing returns to normal.

2.3 The lungs and gas exchange

Student Book pages 28–29

Prior learning

- Use scientific names and position of some of the major organs in the body
- Describe the main functions of some of the major organs and explain how they are essential

Objectives

- Describe the role and function of major organs in the human respiratory system including trachea, lungs and alveoli (air sacs).
- Trace the path of air in and out of the body, and how the oxygen it contains is used during the process of respiration.

Overview

In this lesson, you move your students away from aerobic and anaerobic respiration taking place in the cells and introduce the major organ system of the lungs. Students commonly get very confused by respiration and breathing. This isn't helped by the term 'human respiratory system'! It is helpful to talk about the **gas exchange system** instead. This lesson is a great opportunity to make sure that your students are clear about the difference. If you can avoid misconceptions and confusion during their current course, it will help students do well later in their IGCSE Biology.

Activities

- Begin by asking students what their cells need for aerobic respiration and what they produce during aerobic respiration. Then pose the problem that cells need oxygen but they are deep inside your body, and they produce lots of carbon dioxide which is poisonous – how do they get the oxygen they need and get rid of the poisonous carbon dioxide before it kills them?
- Look at the spread with your students. If possible, have a large version of human respiratory system on the board. Look at the diagram and read through the text about each of the areas of the gas exchange system. Explain to your students how the structure of each area is closely related to its function in the body.

- Students answer Q1. Then they **EITHER** answer Q2 **OR** do draw and label the diagram of the human respiratory system – they can also colour it in if they have time.
- Students answer Q3. This reinforces their knowledge and understanding of key biological terms and structures.

Homework

Workbook page 14.

Key words

respiratory system, gas exchange, gas exchange system, mouth, nose, trachea, bronchus (bronchi), alveolus (alveoli), pleura, diaphragm

2.3 Student Book answers

1. The exchange of gases in the lungs with oxygen from the air in the lungs moving into the blood and carbon dioxide moving from the blood into the air in the lungs.
2. Mouth and nose: make air warm and moist and remove microorganisms

   Trachea: tube though which air moves into and out of the lungs

   Bronchus/bronchi: tubes carrying air from the trachea to the lungs and from the lungs to the trachea

   Lung: organ where gas exchange takes place

   Alveolus/alveoli: air sac(s) where gas exchange takes place in the lungs

   Pleura: slippery membranes which allow lungs to move during breathing

   Diaphragm: muscle sheet dividing the body and involved in breathing.
3. The cells lining the bronchi are a good example of specialised cells. They make mucus which traps dust and dirt from the air. It also traps harmful microorganisms which might infect the lungs. These specialised cells are also covered in cilia, which are hair-like structures that move the mucus, dirt and microorganisms away from the lungs.

2.4 Investigating respiration

TWS

Student Book pages 30–31

Objective

- Differentiate between aerobic and anaerobic respiration.

Overview

This lesson helps students to develop their skills in Thinking and working scientifically.

It provides examples of three different investigations using the presence of carbon dioxide to demonstrate that aerobic respiration has taken place. Students are asked to evaluate the different methods, looking for strengths and weaknesses in the experimental designs.

Activities

- Begin by asking students to remember the equation for aerobic respiration. Talk to them about the use of indicators in science and explain that the change in colour of limewater indicates the presence of carbon dioxide. Discuss the important features to look for in investigations.
- Students read through to the end of investigation 1. Demonstrate this – breathe out gently through a straw to show students how limewater turns

from clear to cloudy. Comment on the hazard symbol on the bottle of limewater and remind students of the importance of safety in practical work. Alternatively, give students the opportunity to try this for themselves.

- You could also demonstrate that if you keep breathing through limewater it eventually turns clear again – one weakness in the investigation.
- Students read through investigations 2 and 3 before answering questions 1–3.
- Have a plenary session asking students for strengths and weaknesses of the different investigations that they have identified.
- Do a tally on which investigation students think is the most useful to a biology teacher, asking them for reasons. If more than one investigation gets votes, get students to draw a pie chart to show their conclusions with reasons given for each choice.
- If there is time, give students a challenge to either carry out an investigation into their own carbon dioxide production or asks them to explain how a piece of apparatus might be used to do that.

Extension

Students plan an investigation to show that people breathe out more carbon dioxide after exercise that they do at rest.

Homework

Workbook page 15

2.4 Student Book answers

1. Investigation 1: Whether people have carbon dioxide in the air they breathe out.
   Investigation 2: Whether the air people breathe out contains more carbon dioxide than the air they breathe in.
   Investigation 3: Whether germinating seeds respire and produce more carbon dioxide than seeds that are dormant.
2. Investigation 1: Good points: simple; easy to carry out; easy for students to see what happens.
   Problems: no control; no clear comparison; different amount of air from each person's lungs – limited in value; any other sensible points.
   Investigation 2: Good points: relatively simple and clear to carry out; good control; makes students think about the process which causes the difference between inhaled and exhaled air.
   Problems: the volume of air bubbled through the limewater is different both for each person and between the lungs and the air in a syringe or bottle; any other sensible point.
   Investigation 3: Good points: well thought out; valuable to reinforce the concept of respiration occurring in all living organisms; two controls – one with no seeds and one with seeds that are not growing – so students can see that it is not the presence of seeds that is affecting the limewater.
   Problems: It takes time to complete – at least a week. It does not show the students anything about respiration in humans; any other sensible point.
3. **EITHER** Investigation 2: Shows students the difference in the carbon dioxide concentration in inhaled and exhaled air; leading to discussion/understanding of the processes of respiration and gas exchange. Can be used for further investigations into the effect of exercise on the amount of carbon dioxide produced, etc. Any other sensible justification.
   OR Investigation 3: Shows students respiration in plants with clear demonstration that actively growing plants respire and produce more carbon dioxide than seeds which are not growing. Valuable for emphasising the importance of respiration in different types of organisms.
   OR both of these investigations for the reasons given above.

2.5
Breathing

Student Book pages 32–33

Prior learning

- Use scientific names and position of some of the major organs in the body
- Describe the main functions of some of the major organs and explain how they are essential

Key words

inhale, exhale, intercostal muscles

Objectives

- Differentiate between the processes of respiration and breathing.
- Trace the path of air in and out of the body and how the oxygen it contains is used during the process of respiration.

Overview

In this lesson, students learn the difference between breathing, aerobic respiration and gas exchange. Three common misconceptions are:

- We breathe in oxygen and breathe out carbon dioxide.
- The lungs suck air in and squeeze air out when we breathe.
- The lungs are like a pair of balloons.

Taking the time to get these concepts clearly differentiated and fully understood to give the students the ideal foundation for their IGCSE Biology studies. This lesson also gives you the opportunity to revisit TWS ideas on the use and evaluation of models.

Activities

- Begin by asking students for their ideas about what breathing is, why they breathe and what happens when they breathe. Note down their ideas.
- Do a class exercise to calculate resting mean breath rate, with you controlling the timing. Each student should end up with their own mean resting breathing rate.
- Read the paragraphs headed 'Why do we breathe?' and spend some time looking at the pie charts showing the composition of inhaled and exhaled air with students. Emphasise that both the air we breathe in and the air we breathe out are a mixture of gases. It is simply the proportions of the gases that change. Students could use the data from the pie charts to show the same information as bar charts to practise data manipulation. Students complete Q1.
- Now consider breathing. Look back at students' suggestions on breathing. Make sure students know that breathing is simply moving air in and out of the lungs. Emphasise that the lungs are completely passive. They cannot inflate themselves or deflate. Also emphasise that the lungs are not balloons – that they are made up of millions of alveoli – tiny air sacs.
- Students can feel their own rib cages rise and fall as they breathe in and out. Talk through the stages of inhaling and exhaling and let students relate the changes to the movements of their own rib cages as they breathe. Students make notes and draw diagrams.
- If possible, demonstrate the bell jar model of the lungs shown. If not, simply look at the images in the text. Point out that it allows them to see the effect of the movements of the diaphragm. Ask students for advantages and limitations of this model. Students answer Q2.
- Students to reinforce their knowledge of the structures of the respiratory system and how it works. They explore the strengths and weakness of the different diagrams and evaluate the strengths and weaknesses of the bell jar model of the chest and lungs.

Homework

Workbook page 16.

2.5 Student Book answers

1. **a.** Aerobic respiration uses oxygen to break down glucose into carbon dioxide and water, releasing energy in a controlled way to be used by the cells.
   Breathing moves air into and out of the lungs, bringing oxygen into the body for respiration and removing waste carbon dioxide.
   b. Oxygen content of inhaled air: 21% oxygen
   Oxygen content of exhaled air: 16%
   21 − 16 = 5%
2. **a.** Muscles between your ribs contract pulling your ribcage up and out → muscles of the diaphragm contract pulling it down and flat → volume of chest increases → pressure inside chest decreases → air forced into the lungs.
   b. Muscles between your ribs relax so your ribcage moves down and in → muscles of the diaphragm relax so it moves up and dome shaped → volume of chest decreases → pressure inside chest increases → air forced out of the lungs.
3. **a.** In the bell jar model, the balloons represent the lungs, the rubber sheet is the diaphragm and the bell jar is the chest.
   Breathing in: The rubber sheet is pulled down. The volume inside the bell jar increases, the pressure decreases and air is forced into the balloons so they inflate.
   Breathing out: The rubber sheet is pushed up, the volume inside the jar decreases, the pressure increases and air is forced out of the balloons.
   b. e.g. The lungs are not like balloons – they are like sponges. Each balloon is more like a single alveolus.
   The walls of the jar cannot move – the ribs are moved up and down by the muscles changing the volume of the chest.
   The diaphragm at rest is a domed structure – the rubber sheet is flat so the changes in volume are not as clear.
   The diaphragm is made of muscle which contracts – it does not have to be pulled down or pushed up.
   Any other sensible point.

2.6 The structure of the alveoli

Student Book pages 34–35

Objective

- Describe the role and function of major organs in the human respiratory system including trachea, lungs and alveoli (air sacs).

Overview

In this lesson, students focus on the process of gas exchange in the alveoli. You have built up their knowledge and understanding of diffusion, the structure of the respiratory system, the process of aerobic respiration and the mechanics of breathing. You have also thought about the use of scientific models. Now you bring all of these elements together to enable students to understand the key process in the respiratory system – gas exchange in the alveoli. Emphasise the relationship between structure and function, and the importance of a large surface area for diffusion – both key principles that students will need to grasp to do well in IGCSE Biology.

Activities

- Ask students to describe diffusion, aerobic respiration and breathing.
- Explain to students that they will now find out how oxygen gets from the lungs to the cells, and how waste carbon dioxide is transported from the cells and removed into the air. This is the function of the alveoli.
- Look at the first paragraph with your students, and discuss the structure of the lungs. If possible, bring in a kitchen or bath sponge cut open to show the many tiny air spaces. Ask students to consider the strengths and weaknesses of this model of the lung tissue.

- Read through the section on 'Gas exchange and the structure of the alveoli', Look at the diagrams with students, and talk about the relationships between the structure of the alveoli and their function. You could peel a large potato/yam and several small potatoes/yams to show students that the surface area (amount of peel) is much greater from several small 'spheres' than from one large one. This is a clear, physical demonstration of this important principle.
- Ask students how the structure of each alveolus is adapted to its function of gas exchange. They should use their Student Books to support this activity. Alternatively, students answer questions 1–3. This demands a good understanding of the sequence of events during gas exchange in the alveoli and how it links to events in the cells and breathing air in and out of the lungs.
- Read through the final paragraphs under 'COPD and the alveoli'. **Discuss this with sensitivity, as, with all health issues, some students will have family experience of these problems.** The key idea is that as the alveoli break down, there is less surface area for gas exchange and so the cells are short of oxygen and suffer a build up of carbon dioxide. Students answer Q4.

Homework

Workbook page 17.

Key words

capillaries

2.6 Student Book answers

1. One of the tiny air sacs which make up the structure of the lungs.
2. The right hand image of the single alveolus. Correctly labelled alveolus, thin walls, red blood cells, oxygenated blood, deoxygenated blood, air in and air out, and arrows showing movement of carbon dioxide from the blood to the air, and oxygen from the air to the blood.
3. Function: gas exchange – oxygen from air to blood, carbon dioxide from blood to air. How structure relates to function: rich blood supply – diffusion of gases and maintains steep concentration gradients. Thin walls of alveoli and blood vessels: allow easy diffusion of gases; large surface area – lots of space for gas diffusion to take place.
4. If the structure of the alveoli break down, then the air sacs get bigger. Bigger air sacs mean smaller surface area – so less gas exchange takes place. A person who is short of oxygen/has a build-up of carbon dioxide feels breathless when they do anything that needs more oxygen.

2.7 Asthma

SIC

Student Book pages 36–37

Objective

- Describe asthma, its causes and how it can be treated.

Overview

This lesson helps students to develop their understanding of Science in context. It gives you the opportunity to explore these ideas by looking at how our ideas on asthma and asthma treatment have developed over time and across societies. Asthma is a common condition affecting the respiratory system, especially in children, which is known about and treated around the world. Understanding asthma reinforces knowledge and understanding of the human respiratory system and how it functions. Considering how our knowledge of the condition has developed over time and the treatments developed enables students to see

Prior learning

- How the structure of the human respiratory system is related to gas exchange

the relevance of what they are learning. **As always when tackling health issues, this needs sensitive handling. Most classes will have at least one student with asthma or with family members affected by asthma. Check with your students before this lesson. You may have students with asthma who prefer others not to know. Or you may have students with asthma who would be happy to tell their classmates what an attack feels like, or how they use their inhalers.**

Activities

- Begin by introducing the concept of asthma to your class. Look up the names of well-known local sportsmen and women who are affected by asthma but who have achieved sporting success.
- Read the first section 'What is asthma?'. Discuss the problems of developing treatments for a condition if you don't understand how it affects the body. Ask students to consider the difference it makes now that we know that the lining of the tubes of the respiratory tract swells and the muscles contract and narrow the airways during an asthma attack.
- Ask students for suggestions about how the symptoms of asthma are linked to the changes in the airways.
- Students read about the different types of asthma treatment available and the challenge of getting drugs to the airways where they are needed. Talk through the ideas, emphasising how scientific knowledge has developed over time and the difference that better medicines have made to people and societies around the world.
- Students answer questions 1–4.
- Give students the task to design a poster to inform other students about asthma. They could make this full size for display in the classroom. Encourage them to include as much clear biology in their posters as possible. Students can complete this for homework.

Extension

Carry out some online research into the history of the scientific understanding of asthma and the development of the different treatments. Then write a report/ develop a timeline to inform others.

Homework

Complete poster or Workbook page 18.

Key words

inhaler, environmental triggers

2.7 Student Book answers

1. The muscles around the airways/bronchi/tubes to the lungs contract, narrowing the tubes and making it hard to move air into or out of the lungs. At the same time, the lining of the bronchi/tubes swells and produces a lot of extra mucus. This also makes the tubes narrower and so makes it harder to move air in and out. The person affected has a tight chest, wheezes, is short of breath, etc.
2. **a.** Any 3 from: pollen, pet hair, smoking, mould/spores, infections, food, medicines, dust mites, pollution, exercise, stress, cold air.
   b. 8 or 9
3. **a.** Relievers are used when someone has an asthma attack to make them feel better fast. Relievers relax the muscles around the bronchi. This opens up the airways quickly, making it easy to breathe again.
   Preventers reduce inflammation and so reduce the sensitivity of the airways, making asthma attacks less likely.
   b. After scientists understood the importance of muscles contracting in making the airways narrow in asthma, they made medicines to relax the muscles and relieve the symptoms. Scientists did not understand the importance of inflammation in asthma for another 100 years. They could not make medicines to reduce the sensitivity of the airways until they understood its cause.
4. **a.** Getting them into the right place in the airways.
   b. The development of inhalers which deliver the medicine into the respiratory system.

2.8

The human heart and circulatory system

Student Book pages 38–39

Prior learning

- Compare and draw connections between the transport systems in plants and humans.
- Know that many vertebrates have a circulatory system similar to humans.

Objectives

- Sketch and label the human circulatory system.
- Explain how blood circulates in the human body through a network of vessels (arteries, veins and capillaries) and transports gases, nutrients, wastes and heat.
- Describe the structure and function of the human heart.

Overview

This lesson is good opportunity to connect the concepts of multilevel organization in organisms, life processes, respiration and energy production, with importance of transport systems in animals.

Ensure that the students appreciate that the major difference between animals and plants, i.e. mobility, results in greater energy requirements and a complex transport system.

Activities

- Begin the lesson by reviewing with students the organisation of multicellular organisms - from single cells to systems. Remind them of the living processes and requirements of all cells, namely, food, water, oxygen, and production and removal of wastes. Ask them how a body can ensure the timely transport of these materials.
- Introduce the idea that, similar to plants, animals (such as humans) also have elaborated and complex transport system for transfer of various matter across the body. For example, all vertebrates (and also certain invertebrates) have a closed, unidirectional circulatory system for this purpose. A unidirectional circulatory system circulates blood in one direction, i.e. from the heart, around the body, and back to the heart. In mammals, this system is further evolved into a bidirectional, double circulatory system.
- Draw the double circulatory system on the board and explain that bi-directional means blood flows in two different directions and double circulatory means that the oxygenated and deoxygenated blood to flow separately from each other within the heart. This means that the blood from the heart travelling to the rest of body contains a high concentration of oxygen. This is an essential requirement due to the high energy requirements of mammals. High oxygen levels means that respiration and breakdown of food can occur easily in the rest of the body.
- Use **Either**, a poster of the internal structure of the human heart, **or** a video showing the movement of blood through the human heart to explain how the double circulation occurs through the heart, without mixing of the blood.

Homework

Q2a and 3 from the student book spread Workbook page 19.

Key words

heart, atrium, ventricle, valve, oxygenated blood, deoxygenated blood, red cells, white cells, platelets, plasma, haemoglobin.

2.8 Student Book answers

1. It is a special system to carry the nutrients and dissolved gases we need to the cells in a body, and to remove the waste substances produced by these same cells.
2. a. Students can reproduce the diagram in spread 2.8
   b. A double circulatory system carries gases, nutrients and wastes to and from all around the body. The movement of blood between the heart and the lungs is one part of the double circulatory system. The second part of the double circulatory system is the movement of blood between the heart and the rest of the body.
3. Encourage students to use the red- and blue-coloured pencils to indicate the paths of oxygenated and deoxygenated blood through the heart.

2.9

Arteries, veins and capillaries

Student Book pages 40–41

Prior learning

- Compare and draw connections between the transport systems in plants and humans.
- Know that many vertebrates have a circulatory system similar to humans

Objectives

- Explain how blood circulates in the human body through a network of vessels (arteries, veins and capillaries), and transports gases, nutrients, wastes and heat.
- Compare and contrast arteries, veins and capillaries.
- Hypothesize how exercises of varying intensity (from rest to high-intensity interval training) would impact their pulse rate. Test their hypothesis, calculate their pulse rate and record their findings.

Overview

This lesson is a continuation from the previous lesson on circulatory system. In this class, students are to be introduced to the so-called transport routes of the circulatory system. The terms arteries, veins and capillaries, their structural differences and functions are to be discussed in context of transport of gases, nutrients, wastes and heat in the body. Finally, the students can learn how pulse rates can be measured and use this process to measure the impact of exercises of varying intensity on their circulatory system.

Activities

- Begin by asking students to recall what they learned about the circulatory system and its functions.
- Use a poster or the images in the students' book to introduce arteries, veins, and capillaries. Explain their structural differences and functions in context of transport of gases, nutrients, wastes, and heat in the body. Ask students questions to elicit their understanding of transport routes with the class.
- Reinforce the information of the size and roles of blood vessels by asking students to prepare yarn models of capillaries, veins, and arteries. Take thick yarn in blue and red color to represent veins and arteries respectively. Thinner white colored yarn can be used to represent the capillaries.
- Explain the function of valves in the heart and veins, if possible, using a video. Explain how the valves are essential to the proper functioning of the heart.
- Divide students into groups for a practical investigation of blood vessels. Remind the students of the difference between veins and arteries. Begin by the investigating the presence of veins. If the students are not clear about the presence of veins on the backs of their hands, use a picture or video to show their location in an older person.

- Introduce the process of measuring pulse rates to students. Instruct them to measure their resting pulse rates and record their results. Next instruct them to perform exercises of varying intensity (e.g., jumping jacks, running in place) for a minute. Then after each exercise, remind the students to re-measure their pulse rates and record their results. Ask them to compare their pulse rates before and after exercise. Ask them to share their conclusions and their reasonings for it.

Homework

Questions from the student book spread and Workbook page 20.

Key words

heart, atrium, ventricle, valve, oxygenated blood, deoxygenated blood, red cells, white cells, platelets, plasma, haemoglobin.

2.9 Student Book answers

1. Arteries, Veins, Capillaries
2. **a.** Arteries carry blood away from the heart, veins carry blood to the heart, and capillaries join up to form a big network of tiny blood vessels which connect arteries to veins.
   b. Oxygen and nutrients pass from blood into cells, whereas cellular wastes pass from cells into blood.
3. Students can be encouraged to create posters as response to the question. Ensure they focus on the size of lumen versus the function of the vessel.

2.10 Transport in the blood

Student Book pages 42–43

Objective

- Describe the composition of the blood and the functions of red cells, white cells, platelets and plasma.

Overview

In this lesson, you will introduce your students to blood as a complex liquid that carries out many functions in the human body. It is an excellent opportunity for helping your students to develop an holistic view of the body, with all the different systems linked by the blood. This lesson reinforces the idea that the blood carries oxygen from the lungs to the tissues, and carries carbon dioxide away from the cells back to the lungs to be removed from the body. The worksheets give students the opportunity to analyse data and draw conclusions.

Activities

- Ask students what they know about blood and list their answers.
- Read through the first half of page with students. The key ideas are: 1) humans are large, multicellular organisms and so need a transport system to carry materials to and from the cells; 2) the blood is the main transport system; 3) the blood is made up of a number of different components. Have a micrograph slide of blood projected for reference.
- Students use the data in illustration to draw a pie chart to show the proportions of the different components of the blood. Ask them to annotate each section of the pie chart with the functions of that part of the blood.

- Remind students of the different materials that need transporting around the body in the blood – but also emphasise other functions of the blood such as defence against disease and clotting. Read with students the four sections under the heading ‘The structure and functions of the blood’. Take time after reading about each blood component to explain how it works and answer any questions the students have, before they make brief notes.
- Students answer questions 1 and 2.
- Encourage students to look at changes in the composition of the blood as it passes through different organs and are asked to describe and explain the patterns that they see. This activity pulls together the importance of the blood in supplying the food and oxygen needed by the cells and removing waste products.
- Finally, ask students to answer Q3, thinking about the major functions of the blood and its importance in the body.

Extension

Students can look at the blood profiles of three different patients to diagnose their diseases. (Patient 1 = haemophilia (low platelet count); patient 2 = infectious disease e.g. flu (high white cell count); patient 3 = anaemia (low red cell count).

Homework

Workbook page 21.

Key words

red blood cells, white blood cells, plasma, platelets, antibodies

2.10 Student Book answers

1. Order of column 1 does not matter

Component	% volume	Function
Plasma	55	Transports the blood cells and platelets, transports dissolved substances including nutrients, carbon dioxide and urea around the body.
Red blood cells	44	Transport oxygen to the body cells.
White blood cells	1	Protect against pathogens that cause disease.
Platelets	Less than 1	Makes the blood clot when you are injured so you don’t bleed to death. Help to produce scabs which protect the tissue and allow it to repair without infection.

2.

Substance	Part of the blood it is transported in	From	To
Oxygen	Red blood cells	Alveoli/lungs	Cells of the body
Carbon dioxide	Plasma	Cells of the body	Alveoli/lungs
Digested food	Plasma	Digestive system	Cells of the body
Urea	Plasma	Liver	Kidneys

3. Any four from:

- Blood transports the oxygen needed for respiration to all the cells of the body.
- Blood transports waste toxic carbon dioxide made in respiration away from the cells to the lungs to be removed from the body.
- Blood carries dissolved nutrients from the digestive system to the cells where they are needed for respiration, growth, etc.
- Blood removes the toxic urea made in the liver and transports it to the kidneys where it is removed from the body.
- Blood carries white blood cells to areas where pathogens have got into the body to prevent infectious diseases.
- Platelets make the blood clot if you have a cut so you don't lose a lot of blood.
- Platelets help your body make scabs which protect wounds and let the tissue repair itself.
- Any other sensible point.

2.11 The effect of exercise on the breathing rate

TWS

Student Book pages 44–45

Objective

- Hypothesize how exercises of varying intensity would impact the pulse rate, test the hypothesis, calculate the pulse rate and test the findings.

Overview

This lesson helps students to develop their skills in Thinking and working scientifically.

Students are given the results of a class investigation into the effects of exercise on breathing rates. This picks up on the exercise they did in lesson 5.6 calculating their own mean resting breathing rate, so they bring practical experience to the process. This gives you the opportunity to present your students with a considerable amount of data to analyse. There is a worksheet which enables students to carry out a variation of this investigation themselves.

Activities

There are several ways to approach this lesson:

- Work through the spread with your students. Discuss different aspects of the practical described, encouraging students to predict the outcome of the investigation based on their knowledge, look for trends in the results and make conclusions. They should also discuss limitations and answer questions 1–5.
- Work with your students. Discuss different aspects of the practical described, encouraging students to predict the outcome of the investigation based on their knowledge, look for trends in the results and make conclusions. Then ask

them to compare the method described in the Student Book with the method described on the worksheet, evaluate them and decide which is the better method. Students then carry out the investigation to observe the effect of exercise on their breathing rate.

SAFETY WARNING: Make sure that students who do not take part in PE lessons, for health reasons, do not do this practical – perhaps suggest they take charge of the timing instead. Check that students who usually use an asthma inhaler before exercising use their inhalers before taking part in this practical.

Students write up their investigation and results. You can combine the whole class results in a table and students can use their own data for the calculations.

- Tell students that they will be investigating the effect of exercise on their breathing rates. Ask them to predict what this will be using their knowledge of breathing and respiration. Apply the same safety precautions as described above.
- Once students have carried out the practical themselves, work through the Student Book with them. Discuss different aspects of the practical described, comparing it with the practical they have done themselves, evaluating the methods, and discussing the advantages and limitations of both. Students then answer questions 1–5, completing them as homework if necessary.

Extension

If doing the practical, complete questions 1–5 from the Student Book.

Homework

workbook page 41.

2.11 Student Book answers

1. a. Any movement uses energy and so increases the need for oxygen. This is likely to affect the breathing rate so it's important to be as still as possible before measuring the resting rate.
   b. They are investigating the effect of exercise on the resting breathing rate. It is important that they sit still after each exercise session to allow their breathing rate to return to its resting level or the results will not be valid.
2. Repeat measurements make the data more reliable – any single measurement may be anomalous.
3. a. Mean resting breathing rate per minute for the class: 280 ÷ 20 = 14 breaths/min; mean breathing rate per minute after exercise for the class: 380 ÷ 20 = 19 breaths/min.
   b Simple bar graph of the two mean figures calculated in **a** – check for labelled axes and labelled bars.
   c Individual students may make errors in counting/measuring time, etc. – but the more results that are combined, the less any individual errors will affect the pattern.
4. Resting breathing is affected by age, size, etc., so there will be variety in the class. It supplies the oxygen needed by the cells of the body at rest. When you exercise, the muscles need oxygen for respiration to provide the energy to contract – so the breathing rate must increase to supply the oxygen to be picked up by the haemoglobin in the red blood cells and carried to the cells of the body, especially the muscle cells. More carbon dioxide is produced as well, and increased breathing allows the body to remove this carbon dioxide through the lungs.
5. Limitations include: different students using different stopwatches – may not all measure the same time interval. Some students of different ages or sizes; some students exercise harder than others; some students may have a cold or something affecting their body; some students may miscount a breath or two – any sensible suggestions.

2.12 Review answers

Student Book, pages 46–47

Student Book answers

1	**a**	Aerobic respiration/cellular respiration	**[1]**
	b	glucose + oxygen → carbon dioxide + water + energy	**[2]**
	c	**i.** Microscopic structures in cells where aerobic respiration takes place. **ii.** The cell with few mitochondria is not very active and doesn't need much energy; the cell with many mitochondria is a very active cell requiring lots of energy; the cell containing chloroplasts and mitochondria is a plant cell; aerobic respiration takes place in both animal and plant cells.	**[1]** **[4]**
2	**a**	**a.** D **b.** C **c.** F **d.** A **e.** E **f.** B	**[5]**
3	**a**	alveolus/alveoli	**[1]**
	b	sbronchu	**[1]**
	c	diaphragm	**[1]**
4	**a**	Muscles between your ribs contract pulling your ribcage up and out → muscles of the diaphragm contract pulling it down and flat → volume of chest increases → pressure inside chest decreases → air forced into the lungs	**[5]**
	b	Muscles between your ribs relax so your ribcage moves down and in → muscles of the diaphragm relax so it moves up and dome shaped → volume of chest decreases → pressure inside chest increases → air forced out of the lungs	**[5]**
5	**a**	Trachea	**[1]**
	b	Diaphragm	**[1]**
	c	When the rubber sheet is pulled down the balloons inflate. Pulling the rubber sheet down increases the volume of the model chest. This lowers the pressure inside the jar, so air is forced into the balloons by the pressure of the air outside the jar.	**[2]**
	d	Any two from: In the real chest, the ribs move up and out as a result of muscles contracting. The walls of the bell jar are fixed. In the real chest, the diaphragm is domed up into the chest when it is relaxed and flattens when you breathe in. The muscles of the diaphragm contract to pull the diaphragm down and flat – it isn't done by hand. The lungs are not like balloons. They are sponge-like, made up of millions of tiny air sacs which each individually act a bit like these balloons. Any other well made point.	**[4]**
6	**a**	X = alveolus, Y = blood capillary	**[2]**
	b	Gas A is oxygen, gas B is carbon dioxide.	**[2]**
	c	Diffusion is the net/overall movement of particles from an area where there are lots of them (a high concentration) to an area where there are fewer of them (a lower concentration).	**[3]**

	d	There is only a short distance for the gases to travel so diffusion into or out of the blood happens easily.	**[1]**
	e	e.g. they have a large surface area – big area for gases to be exchanged; there is a rich blood supply bringing carbon dioxide to the lungs and picking up oxygen to take to the cells; there are steep concentration gradients between the blood and the air in the alveoli so diffusion happens as quicky as possible. Any other sensible points.	**[3]**
7	**a**	Students sketch using the spread.	**[1]**
	b	**i.** bring deoxygenated blood back to the heart **ii.** collects the deoxygenated blood and pumps it to the lungs **iii.** stop the blood flowing backwards through the heart - there are four sets of valves **iv.** keeps deoxygenated and oxygenated blood from mixing	**[1]** **[2]** **[2]**
8	**a**	**i.** Platelets **ii.** White blood cells **iii.** Red blood cells	**[3,1,1]**
	b	Plasma	**[1]**
	c	55%	**[1]**
	d	e.g. digested food, e.g. glucose; waste products/ urea; waste products/carbon dioxide; hormones; antibodies.	**[3]**
9		(see table below) The air breathed in/inhaled is relatively high in oxygen and low in carbon dioxide. In the lungs, gases are exchanged between the air in the alveoli and the blood. Oxygen moves into the blood by diffusion and is carried to the cells for aerobic respiration. Carbon dioxide, the waste product of respiration, is carried in the blood to the lungs. It diffuses into the air in the alveoli. As a result, the air breathed out/exhaled is lower in oxygen than the air breathed in, but it is higher in the waste product carbon dioxide.	**[8]**
10	**a**	Use data on table. Correct axes. Show different readings for each individual.	**[8]**
	b	E is least fit – highest resting breathing and biggest increase in breathing rate after exercise. D is fittest – lowest resting breathing rate and lowest increase in breathing rate after exercise.	**[2,2]**
	c	Resting = 14; Exercise = 20. Use data in table. Correct axes	**[2,2,3]**
	d	Individual mean – enables you to see differences between individuals/identify most or least fit. Group mean – increases reliability, enables you to see main trends	**[2]**

Gas	Inhaled air	Exhaled air
nitrogen	79%	79%
oxygen	21%	16%
carbon dioxide	0.04%	4%

3.1

Microorganisms

Student Book pages 48–49

Extension

Students complete Q3 calculating the magnification of bacterial cells.

Homework

Workbook page 22

Key words

microorganisms, single celled organisms, bacteria, fungi, viruses. culture, colonies, hyphae

Objective

- Identify the various types of pathogens that cause infectious diseases.

Overview

This is the first of several lessons introducing students to microorganisms. It is very important for future studies that students recognise the positive importance of microorganisms in the natural world (e.g. in the cycling of nutrients in nature, in decomposition, on the skin and in the digestive system). The role of microorganisms in infectious disease is, of course, also important, but the way you introduce and work with students at this stage should give them a balanced overview of these vitally important organisms.

Activities

- Give each student three coloured pieces of card, e.g. green, red and yellow. Each colour represents an answer: green = true, red = false, yellow = I don't know. Read the following statements to students and ask them to raise the coloured card which best represents their own knowledge. It doesn't matter what they answer – the value of this exercise is for you to gauge how much students know about microorganisms and what misconceptions they already have. Note down the responses to each statement. Do NOT give students any feedback on their answers – simply tell them that they are now going to learn more about microorganisms. Repeat this exercise at the end and see how the responses have changed. Suggested statements: *All microorganisms are so small you cannot see them. All diseases are caused by microorganisms. Microorganisms are bad for you. Microorganisms make food go bad. Some foods are made by microorganisms. Humans should aim to destroy all microorganisms.*
- Read through the content on bacteria with students. Discuss the features of bacteria and compare them with animal and plant cells that students are familiar with. Students can then answer Q2.
- Describe how quickly bacteria reproduce if they have everything they need. Ask students to suggest what bacteria might need to grow – food, water, right temperature. If you chose to culture bacteria on petri dishes with your students, observe how invisible microorganisms reproduce and form colonies,
- Give students the task to calculate the number of bacteria in a colony as it grows and then plot a graph of their data.
- Students read the rest of unit make notes on bacteria, fungi and viruses and answer questions 1, 4 and 5.

3.1 Student Book answers

1. Bacteria; fungi/yeasts; viruses.

2.

Feature	Animal cell	Plant cell	Bacterial cell
Size	(10–100) µm	(30–100) µm	(0.2–2.0) µm
Nucleus	Nucleus containing genetic material	Nucleus containing genetic material	No nucleus – single strand of genetic material
Cell wall	No cell wall	Cell wall made of cellulose	Cell wall but different structure to plants
Plasmids	No plasmids	No plasmids	Many bacteria have them

3. Actual length = measured length/magnification 7.4/74 000 = 0.0001 cm

4. Similarities: (one of) both are microorganisms; both are single cells; both have cell walls. Differences: (one of) yeast bigger than bacteria; different material in the cell walls; yeast have nuclei, bacteria do not.
5. plant cell: animal cell; bacterium; virus

3.2 Pathogens and infectious diseases

Student Book pages 50–51

Prior learning

- Define and describe main groups of microorganisms (bacteria, virus and fungi) and give examples of each.
- Recognize some common diseases of each group (bacteria, virus and fungi) caused by microorganisms.
- Recognize that microorganisms get transmitted into humans and spread infectious diseases.

Objective

- Identify the various types of pathogens that cause infectious diseases.

Overview

In this lesson, students are encouraged to find out more about the ways in which we the microorganisms impact our health, extending their studies towards the understanding they will need to succeed in IGCSE Biology. Begin with familiar materials such as bread, yoghurt, and cheese, and allow students to explore the role of microorganisms in our daily life, before considering the impact of microorganisms in other areas of our daily life, such as health.

Activities

- Begin by reviewing the role of microorganisms in our daily life. Ask the students if they remember the role of microorganisms play in our daily life. Elicit responses using familiar materials such as bread, yogurt, and cheese, and the processes of decomposition and fermentation as examples.
- Ask them if they can think of any other ways in which microorganisms impact our daily life. Elicit from them if they remember the difference between infectious and non-infectious diseases. Remind them that infectious diseases are a result of infections by pathogens. Describe the meaning of the word pathogen.
- Elaborate the concept of pathogens, such as bacteria and viruses, and how they can spread from one person to another. Discuss the modes of spread of infections including droplet infection, direct contact, contaminated food and drink, and by vectors. Direct contact occurs through skin-to-skin contact, whereas Indirect contact occurs due to contact between a person and a contaminated object. Droplet transmission occurs when droplets containing microorganisms create as a result of coughing, sneezing, or talking, are travel through the air and land on another person. Airborne transmission is said to occur when pathogens are carried by dust or droplet suspended in the air. Vector transmission occurs when another animal, usually an insect, transmits the infectious agent to a human host. Common vehicle transmission occurs when an object or item, such as food, water, or medication, is contaminated with the infectious agent, which then serves as the source of infection for multiple individuals.
- Ensure the students can classify the mode of transmission of major diseases. As a class activity, attempt question Q2 parts a and b. Encourage the students to prepare a KWL of the lesson.

Homework

Q1 and 3 from the student book spread and Workbook page 23.

Key words

Immune system, infectious diseases, non-infectious diseases, vaccine.

3.2 Student Book answers

1. Pathogens which are passed from one person to the other through various means.
2. a. Students can choose any one from droplets, direct contact, contamination of food/drink, or vectors.
   b. Students to write in their own words the mode of transmission. You may encourage them to research the mode of transmission in further detail and /or to present information in form of an infographic or a poster.
3. Students to write the answer in their own words, including the mode of admission of pathogen into body, behaviour of different pathogen inside body and cells, and body response.

3.3 Body defences against pathogens

Student Book pages 52–53

Prior learning

- Differentiate between contagious and non-contagious diseases and relate the transmission of common communicable diseases to human contact and explain some methods of preventing their transmission.

Objectives

- Explain the various lines of defences that the body has against pathogens.
- Describe the three types of immunity in humans – innate, adaptive and passive.
- Describe the parts of the immunity system and how they function to produce an immune response.

Overview

This lesson helps students to develop their understanding of some of the ways in which science affects us in our everyday lives. It shows how scientific understanding enables us to understand the role our body plays in protecting us against diseases that would otherwise result in the loss of life. This lesson also helps broaden the scope of understanding of the role different body systems (e.g., the circulatory system) play in protecting us during an infection

Activities

- Begin by discussing the role of the immune system in preventing pathogens from entering the body and destroying them in case they do. Describe the innate and adaptive immune systems and focus on the differences between them.
- Explain that the adaptive immune system, specifically identifies and destroys particular pathogens, and remembers them to protect us in the future. Discuss how this type of immunity is increased as we are exposed to diseases or get vaccinated.
- Explain the concept of the innate immune system, which is present from the time you are born and is not specific. Discuss how the innate immune system includes the skin, the clotting of the blood, the acid in the stomach, the mucous and cilia of the respiratory system, as well as the white blood cells responsible for phagocytosis. Explain the process of phagocytosis.
- Elaborate how the innate immune system is quick yet non-specific in its effectiveness. This means that it responds in the same way to all germs and foreign substances, which is why it is sometimes referred to as the “nonspecific” immune system.
- Explain how all the outer and inner surfaces of the human body all form key parts of the innate immune system. The closed surfaces of the skin and all the mucous membranes form a physical barrier against germs, to prevent them from entering the body. Additionally, chemical substances like acid, enzymes or mucus prevent them from settling in and growing inside the body.
- Review with students the possible points of entrance of pathogens in the human body.
- Ask them to review the major difference between innate and adaptive immunity.

Homework

Questions from the student book spread Workbook page 24.

Key words

Innate immunity, adaptive immunity, passive immunity, pathogens, immune system, virus, bacteria, antibodies, infectious diseases, non-infectious diseases, vaccine.

3.3 Student Book answers

1. All of the body openings, as well as any cuts and wounds.
2. **a.** the innate immune system is present from birth but is not specific, as it does not target particular pathogens. It has limited power over specific pathogens.
   b. the adaptive immune system is very specific and develops as per requirement. It identifies and destroys particular pathogens and remembers them to protect the body in the future.
3.

Part of the innate immune system	How it defends the body against pathogens
i. The skin **ii.** Digestive system **iii.** Respiratory system	**i.** Covers and protects the tissues of the body and stops pathogens getting in. In case of a cut, a scab forms to prevent infection. **ii.** The stomach acid kills off most of the infectious pathogens. **iii.** The nose hairs act as filters to trap pathogens, which get trapped in the mucus. The ciliated epithelial cells in the airways move this mucus with pathogen into the oesophagus, leading them to stomach where the acid destroys the pathogens.

3.4

The adaptive immune system

Student Book pages 54–55

Prior learning

- Know that the human body has a number of systems, each with its own function.

3.4 Student Book answers

1. Active adaptive immunity and Passive immunity.
2. **a.** antigens are special protein markers on the outside of cells of different organisms.

   b. an antibody is a special chemical made by white blood cells for each specific antigen. Antibodies target antigens which are different to the body's own antigen. Each type of pathogen requires different antibodies to destroy it.
3. Students to write the answer in their own words, starting from the need of the immune system to encounter a pathogen before an antibody can be produced against it. The mode of function of antibodies and how the body remembers the antigen should also be included in the answer.
4. In active adaptive immunity the body encounters an antigen and produces antibodies against it, and also remembers the antigen for future attack. In passive immunity the immune system does not produce its the antibodies, rather receives it from an external source, e.g. a baby from its mother.

Objectives

- Explain the various lines of defences that the body has against pathogens.
- Describe the three types of immunity in humans – innate, adaptive and passive.
- Describe the parts of the immunity system and how they function to produce an immune response.
- Illustrate how adaptive immunity develops over time.

Overview

This lesson provides a continuation of the previous topic on immunity. Here the students will gain a more in-depth look into how the adaptive immune system works in human beings, which has relevance both in their biology studies and in life. Students will have new terminology to cope with, as this lesson moves them towards their IGCSE Biology course, where they learn how an active immune system provide organisms with increased chances of survival and reproductive advantage.

Activities

- Begin by reviewing the previous lesson by questioning the students about types of immunity. Ensure they have a clear grasp of the difference between innate and adaptive immunity.
- Review the various lines of defenses that the body has against pathogens. Elaborate that the active adaptive immunity forms the second line of defense of our body. It provides us with immunity to a disease when the white blood cells learn to recognise the antigens on the surface of specific pathogens, and produce antibodies to destroy them.
- Explain the terms surface proteins, antigens, antibodies and antitoxins. Ensure the students understand the difference between these terms thoroughly.
- Explain how the processes of infection, illness and fever, recovery and long term immunity development are related to each other and part of the active adaptive immunity.
- Introduce the concept of a passive adaptive immunity in which a person does not make their own antibodies. Rather they receive antibodies from someone else to protect them from a disease e.g. when a baby receives passive immunity from its mother.
- Ensure the students understand clearly the difference between active adaptive immunity and passive immunity. You may choose to share an infogram with the students or prepare one in class with student participation.

Homework

Q3 from the student book spread and Workbook page 25.

Key words

Innate immunity, adaptive immunity, passive immunity, pathogens, immune system, leukocytes, lymphocytes, phagocytes, neutrophils, eosinophil, T-cells, B-cells, natural killer cells, virus, bacteria, antibodies, daily infection rate (/ R_o), infectious diseases, non-infectious diseases, vaccine.

3.5 Using science to prevent disease

SIC

Student Book pages 56–57

Objectives

- Visualize the ways to add additional layers of defense (such as wearing masks, using sanitizers etc).
- Suggest ways in which communities of people can safeguard against the spread of infectious diseases.

Overview

This lesson helps students to develop their understanding of Science in context. Any work relating to COVID-19 must be handled very sensitively as students may have been affected personally by the pandemic.

Pages of this spread present students with information about the spread of infectious diseases caused by microorganisms. They consider a chart on the spread of infectious diseases produced by students BEFORE the COVID-19 pandemic of 2019 onwards, and look at how such scientific knowledge can be applied. You then present your students with evidence from two studies looking at the impact of both mask-wearing and social distancing on deaths globally and cases of COVID-19 in two Italian towns. Throughout this work, emphasise how scientific evidence changes understanding and so changes actions across societies.

Activities

- Any work relating to COVID-19 must be handled very sensitively as students may have been affected personally by the pandemic.
- Quiz students on how diseases are spread to see what they have retained from the previous lesson.
- Read through the opening paragraphs and work through the display produced by the students. Make sure that students understand the different ways in which microorganisms can be passed from one person to another.
- Work through the section headed 'Using scientific knowledge' with students and encourage them to discuss the science behind the different instructions to prevent the spread of COVID-19. Students answer questions 1 and 2.
- The final section of page 69 challenges students to recognise that scientific theories must be backed by evidence. They are given two graphs to consider. students work through the rest of the page, using the graphs to answer questions 3 and 4.

Extension

Introduce the problem of people who have, or carry, a disease but have no symptoms themselves.

1. Students are asked to explain why asymptomatic disease is such a problem in controlling the COVID-19 pandemic.
2. If they have time, they are asked to investigate an historical case: Typhoid Mary, the story of Mary Mallon who is one of the first recorded cases of a symptomless person causing disease and even death in many other people.

Homework

Workbook page 26.

Key words

droplet infection, direct contact

3.5 Student Book answers

1. COVID-19 had not appeared when the students did this work.
2. - *Wash your hands often and well and use antiseptic hand gels*: Your hands touch surfaces and can pick up viruses which you then get in your mouth/nose. Washing your hands/using antiseptic hand gel removes viruses/kills viruses, reducing your risk of disease.
   - *Wear a face mask to cover your mouth and nose when you go out*: If you cough or sneeze, droplets containing viruses are caught in your mask – reduces the risk of passing viruses to other people. Mask may also reduce the chance of you breathing in viruses.
   - *Meet as few people as possible – avoid crowded places*: People carry COVID-19. The more people you meet, and the more crowded the place, the more likely you are to be in contact with someone with the disease or – if you are infected – to pass it on.
   - *Keep a distance between yourself and other people and meet outdoors if possible*: The further away you are, the less likely you are to breathe in viruses from someone else. In the open air viruses and droplets are moved away more quickly [sunlight can kill viruses].
   - *Cough or sneeze into a tissue or into your elbow*: Any viruses you may have are not sprayed out into the air to infect other people.
   - *Stay at home away from other people if you feel ill:* You are most infectious when you are ill – keep away from other people so they don't come into contact with the virus.
3. In countries where people were made to wear masks outdoors and in shops quickly (pink line), the death rates from COVID-19 were very low. In countries (blue line) where there was more of a delay in making mask wearing important, there were more deaths. Countries where it took months to introduce mask wearing (green line) had a very high death rate.
4. Answer must be justified. Jamal is correct – where businesses, etc., closed and people socially distanced/stayed at home, the number of people infected greatly reduced. That would in turn reduce the number of deaths. Where people carried on as normal [pink line] – the numbers infected just grew and grew.

3.6 Strengthening the immune system

Student Book pages 58–59

Objectives

- Illustrate how adaptive immunity develops over time.
- Visualise the ways to add additional layers of defense.
- Propose some common strategies for strengthening the immune system.
- Suggest ways in which communities of people can safeguard against the spread of infectious diseases.
- Describe the role of accines in immunity and explore some strategies on how vaccines can be created.

Overview

This lesson provides an interesting opportunity for the class to stretch the boundaries of teaching-learning process in a collaborative manner. The role of the teacher can be expanded from explaining to facilitating the learning journey of the students as they explore ways to prevent spread of infections and methods to strengthen the immune system. Although the topic further elaborates topics already introduced earlier, the real-world impact of these are explored, creating an opportunity for the students to understand how thinking and working scientifically occurs in a real world context.

Activities

- Begin the lesson by reviewing the role of and types of immunity found in human beings, by questioning the students. Invite them to share the information they

Prior learning

- Know that the human body has a number of systems, each with its own function.
- Relate the transmission of common communicable diseases to human contact and explain some methods of preventing their transmission.

remember, especially the differences between antigen, antitoxin, and antibody. Ask them to explain through an analogy how the surface proteins help in identification of pathogens.

- Introduce the word immunisation and explain that it is triggers a form of adaptive immunity. Remind them that immunisation can be form of a vaccine or oral drops, but they both function to ensure that the body is able to produce antibodies against the disease, ensuring that the numbers of people affected by the disease is lesser than before.
- Review the graph on page 59 and ask the students what they think is indicated in it. Elicit the role of immunisation in global disease reduction. You can introduce the idea of significant reduction of cases. This can be used as extension work demonstrating the use of statistical probability in scientific reporting and analysis.
- Introduce the concept of Artificial passive immunity and explain how it differs from active adaptive immunity. As a group, encourage students to answer question 2 given in the spread, giving their reasoning.

Homework

Q1, 3 and 4 from the student book spread and Workbook page 27.

Key words

Innate immunity, adaptive immunity, passive immunity, pathogens, immune system, leukocytes, lymphocytes, phagocytes, neutrophils, eosinophil, T-cells, B-cells, natural killer cells, virus, bacteria, antibodies, infectious diseases, non-infectious diseases, vaccine.

3.6 Student Book answers

1. Encourage students to present the information given in the spread in the form of a flow chart.
2. Encourage students to adapt the infographic in the spread in the form of a Venn diagram.
3. When entire (or maximum members of) populations are immunised against a disease, the numbers of people affected by the disease falls quickly.
4. Encourage students to adapt the infographic in the form of a triple Venn diagram.

3.7 Microorganisms and disease

TWS

Student Book pages 60–61

Objectives

- Identify the various types of pathogens that cause infectious diseases.
- Propose some common strategies for strengthening the immune system.

Overview

This lesson helps students to develop their skills in Thinking and working scientifically. Students are introduced to the world when we did not understand how infectious diseases are caused by microorganisms and had no effective treatments. They consider the work of Louis Pasteur, a global pioneer in germ theory and in vaccinations. Through the exciting story of Pasteur's anthrax trials, you allow students to make predictions of the outcome of the trials based on what they know, and help students understand how evidence is vital to support a scientific hypothesis, or to disprove it. This lesson gives you scope for setting project work on the life and work of Louis Pasteur.

Prior learning

- Suggest and evaluate explanations for predictions using scientific knowledge and understanding and communicate these clearly to others.
- Say if and how evidence supports any prediction made

Activities

- Find out from your students what they think causes infectious diseases and how they are spread. Then paint a picture of the 19th century CE, when no-one knew about the role of microorganisms in disease.
- Read the first paragraph with students and then give your students a brief summary of the old idea of spontaneous generation of organisms from mud or dust,
- Read though the spread with students – perhaps ask different students to read sections. At the end of each section, pause and question students – for example, ask them to discuss Pasteur's ideas; would they have agreed to Rossignol's challenge? Do they agree with Pasteur's prediction? How did the evidence confirm Pasteur's hypothesis? Raise some of the issues of Pasteur's techniques with students. Think about the ethics of using an untried treatment in this way.
- Students complete questions 1 and 2.
- Q 3 is an opportunity for students to carry out independent research into Pasteur's work on rabies. Students can simply answer the question OR you could ask them to use their research into this gripping story to write a report on Pasteur and rabies for a TV news item, or for a series of posts on social media, or as a story for other students to read and understand both what happened, then and why Pasteur's work would not be possible today.

Extension

Students research and produce a timeline for the life and research of Louis Pasteur, with analysis of some of his major discoveries and some of the most challenging ethical aspects of his work.

Homework

Workbook page 28.

Key words

germ theory of disease, vaccine

3.7 Student Book answers

1. Disease-causing germs are passed from one organism to another. In Pasteur's experiment, germs from infected animals were injected into his experimental animals. All of the unvaccinated animals developed the disease – confirming the idea of germs passed from one animal to another.

2. a. Using this account of Pasteur's famous experiment: e.g. he had a control group of animals which were not given the vaccine so he a comparison for his experimental group/he only changed one variable – whether the animals were vaccinated or not.

b. E.g. he had not finished testing his vaccine before giving it to animals/he carried out an experiment that killed over 30 animals and in public with associated risk to public health/he lied about the vaccine he used.

3. Look for evidence of good research and a clear account of the story, including his motivation for the work, the good science in developing the vaccine and the bad science of using an untested vaccine on children.

3.8 Infectious diseases: Hepatitis

Student Book pages 62–63

Prior learning

- Identify the various types of pathogens that cause infectious diseases.
- Propose some common strategies for strengthening the immune system.

Objective

- Explain how infectious disease such as hepatitis, is caused/contracted, how it is tested and diagnosed, and how it can be prevented.

Overview

This lesson provides an overview of the dangers and impact of Hepatitis in Pakistan. It is designed to cover many of the objectives of science in context. Students will be introduced to the common forms of the disease prevalent in Pakistan. They will also review the socio-economic reasons this prevalence and how they can play their part in reducing the number of Hepatitis affectees.

Activities

- Begin the lesson by asking students if they have ever heard of the disease known in Urdu as Verm-Jigar. Explain that this is the Urdu name for the disease Hepatitis, which is an infectious disease of the liver.
- Ask students to design and fill in a disease identification card as you share the information about Hepatitis. Explain that Hepatitis is caused by viruses which attack the liver and its functions and can even lead to cancer. The two common forms in Pakistan are hepatitis B (approximately 5 million people are affected) and hepatitis C (10 million people are affected).
- Hepatitis B and C primarily contracted through contaminated blood. Blood tests for the hepatitis viruses and antibodies against the different viruses are used to diagnose hepatitis. Explain how unhygienic and unlicensed medical and dental practitioners add to prevalence of the disease.
- Announce that government of Pakistan has an ambitious plan to eliminate viral hepatitis B and C infections in the country by 2030. The program will provide leadership and coordination to provincial programs in scaling up hepatitis prevention, testing and treatment services. List and elaborate the three proven methods of hepatitis prevention: Immunisation, Testing, and Stopping the spread through good hygiene in health care and screening blood transfusions.

Homework

Questions from the student book spread and Workbook page 29.

Key words

Innate immunity, adaptive immunity, passive immunity, pathogens, immune system, leukocytes, lymphocytes, phagocytes, neutrophils, eosinophil, T-cells, B-cells, natural killer cells, virus, bacteria, antibodies, infectious diseases, non-infectious diseases, vaccine.

3.8 Student Book answers

1. **a.** Hepatitis is an infectious disease of the liver. It is caused by viruses and contracted through contaminated blood.
   b. The two common forms in Pakistan are hepatitis B and hepatitis C. They both cause scarring and cancer of the liver and liver failure. However, Hepatitis B can be prevented by immunisation. Hepatitis C can be prevented from causing serious damage by early detection and treatment.
2. **a.** untreated blood transfusions and lack of hygiene.
   b. immunisation.
3. **a.** The symptoms of hepatitis C affect many different parts of the body and are similar to symptoms of many other diseases.
   b. The different types of hepatitis are diagnosed using blood tests that look for either the hepatitis virus or the antibodies which show that the adaptive immune system is fighting the hepatitis virus.

3.9 Infectious diseases: Covid-19

Student Book pages 64–65

Prior learning

- Identify the various types of pathogens that cause infectious diseases.
- Propose some common strategies for strengthening the immune system.

Objective

- Explain how infectious disease such as covid-19, is caused/contracted, how it is tested and diagnosed, and how it can be prevented.

Overview

In this lesson, your students will discover how a global pandemic affected millions in countries around the world. This is a sensitive topic as many students may have family members who succumbed to the Covid-19 virus. As the previous lesson, this lesson also covers many of the objectives of science in context as it looks at risk and the way scientific knowledge and human behaviour interact.

Activities

- As this lesson is related to the global pandemic, ask the students what they remember from that era. Collate their feedback and explain how it relates to the strategies suggested by the government of Pakistan.
- Take a step back and explain that covid is also a result of a viral infection. Review by asking students the modes of infection from person to person (review SiC unit 3.5).
- Explain the testing methods for diagnosing covid-19 infection. Discuss that though Covid-19 is prevented by immunisation, it still better to take precautions such as mask wearing, keeping your distance form others, and self-isolating if you are infected.
- Ask a class activity, facilitate a discussion on question 2 of the spread.

Homework

Q3 from the student book spread and Workbook page 30.

Key words

Innate immunity, adaptive immunity, passive immunity, pathogens, immune system, leukocytes, lymphocytes, phagocytes, neutrophils, eosinophil, T-cells, B-cells, natural killer cells, virus, bacteria, antibodies, infectious diseases, non-infectious diseases, vaccine.

3.9 Student Book answers

1. Virus

2. Encourage students to list and then discuss the statements.

3. Encourage students to search online for the latest data to calculate the answers for parts **a & b**. Use the formula 100 * (Infected population/total population).

c. encourage students to create the bar graphs themselves using their calculations.

d. possible differences between percentages of infected and dead, in different countries may lie in the precautions and self-isolation practiced.

3.10
Infectious diseases: Typhoid

Student Book pages 66–67

Prior learning
- Identify the various types of pathogens that cause infectious diseases.
- Propose some common strategies for strengthening the immune system.

Homework
Questions from the student book spread and Workbook page 31.

Key words
Innate immunity, adaptive immunity, passive immunity, pathogens, immune system, leukocytes, lymphocytes, phagocytes, neutrophils, eosinophil, T-cells, B-cells, natural killer cells, virus, bacteria, antibodies, daily infection rate infectious diseases, non-infectious diseases, vaccine.

Objective
- Explain how infectious disease such as typhoid, is caused/contracted, how it is tested and diagnosed, and how it can be prevented.

Overview
This lesson is similar to unit 3.8, as it reinforces how lifestyle and socio-economic conditions impact the prevalence of disease in Pakistan. In this lesson students will learn about Typhoid, its causal agent and health practices that impact its prevalence. They should be encouraged to discover how immunisation and hygiene practices go hand-in-hand towards creation of a disease-free society.

Activities
- Begin the lesson by sharing the statistic in the book: Pakistan has one of the highest rates of typhoid in the world, with 493.5 cases per 100,000 population, resulting in thousands of deaths each year, of which 70% are of children. Next share that the first vaccine dose against typhoid vaccine is generally given to children around 9 months to 15 months of age, with a second dose at 15 months to six years of age.
- Encourage the students to create and fill a disease-profile card with the information you are providing.
- Explain that typhoid is a disease caused due to a highly contagious bacterial infection, contracted by drinking water or eating food contaminated by infected human faeces. As a result, it can be contracted by anyone who takes in contaminated food or water. It can also be spread if an infected person prepares and serves raw or undercooked food. As a result, living areas with unhyginic living conditions are hotspots of infection. And it is is diagnosed by testing the faeces or the blood for the presence of typhoid bacteria.
- Detail that Typhoid outbreaks in Pakistan are particularly lethal as most cases are caused by antibiotic-resistant variants of the bacteria which cannot be treated using antibiotics. Ask the students, what may be the best preventive measure in such a situation. Elicit that under such circumstances, Immunisation is the best way to prevent typhoid.
- Facilitate a class discussion on what are the other ways to prevent typhoid. Ensure that students realize that the answer lies in personal as well as communal hygiene practices, which include Hand washing with soap, building pit latrines and using/providing clean water supplies.

3.10 Student Book answers

1. a. typhoid is a disease caused by bacterial infection contracted by drinking water or eating food contaminated by infected human faeces.

b. Low levels of hygiene and a prevalence of antibiotic resistant strain of typhoid bacteria are the main factors why typhoid is a problem in Pakistan.

2. a. Contamination of food and drink due to open defecation and a general lack of proper hygiene during food preparation help typhoid spread faster.

b. though immunisation is the best way to prevent typhoid, it only works if majority of the population is immunized.

c. the data in the graph demonstrates the incidence of typhoid in vaccinated versus unvaccinated children, over a period of time. It shows that the number of typhoid victims increase drastically among the unvaccinated as time passes. Among the vaccinated children the incidence of typhoid remains negligible.

3. Hand washing with soap, building clean public toilets and clean water supplies can help in preventing the spread of typhoid. Encourage the children to elaborate on these methods using the information in the spread and their general observations.

3.11 Infectious diseases: Dengue

Student Book pages 68–69

Prior learning

- Identify the various types of pathogens that cause infectious diseases.
- Propose some common strategies for strengthening the immune system.

Objective

- Explain how infectious disease such as dengue is caused/contracted, how it is tested and diagnosed, and how it can be prevented.

Overview

As with the last 3 lessons, this lesson also covers many of the objectives of science in context. Students will be encouraged to revisit how vectors can spread diseases. Sensitivity will be required by the teacher, as the class may include students who have themselves suffered from this disease or have lost a family member to it.

Activities

- Begin the lesson by askign the students if they know why the anti-dengue campaign is conducted annually. Ask them if they know the cause of dengue. Remind them that though dengue can be caused by any of the 4 viruses (DEN-1, DEN-2, DEN-3 and DEN-4) it is actually spread by a vector.
- Ask the student to remember how the spread of infection by vectors works. Explain that dengue viruses are spread primarily by the female Aedes aegypti mosquitos acting as unwitting vectors, during their reproductive cycle. Review the lifecycle of these mosquitos, and lead students to pinpoint that it's the 2 blood meals before egg-laying process that is responsible for spread of dengue.
- Move to the symptoms of dengue and ask students if they can recall the commonly advertised symptoms of the disease. Explain that mild dengue involves a fever, rashes and severe pain in the muscles and joints. However, severe dengue (haemorrhagic fever) causes internal bleeding and may cause death.
- Explain that dengue can be diagnosed by blood tests for the virus as well as, for antibodies against the virus. Elaborate that since there do not exist medicines or vaccines against dengue, it is best prevented by avoiding mosquito bites (e.g., using mosquito nets at night) and preventing mosquitos breeding.
- Ask the students to prepare a leaflet detailing best practices to prevent the Aedes aegypti mosquitos from breeding.

Homework

Questions from the student book spread and Workbook page 32.

Key words

Innate immunity, adaptive immunity, passive immunity, pathogens, immune system, leukocytes, lymphocytes, phagocytes, neutrophils, eosinophil, T-cells, B-cells, natural killer cells, virus, bacteria, antibodies, daily infection rate infectious diseases, non-infectious diseases, vaccine.

3.11 Student Book answers

1. Dengue is caused by four different viruses – DEN-1, DEN-2, DEN-3 and DEN-4.
2. Dengue can be mild or severe. Mild dengue includes a high fever, rashes and aching in the joints and muscles. Severe dengue (also called haemorrhagic fever) causes internal bleeding and shock leading to cardiovascular system failure.
3. It is because these methods help us avoid getting bitten by mosquitos. And if we do not get bitten by mosquitos, we will not catch dengue, since it cannot be caught directly from another person.

3.12

Review answers

Student Book pages 70–71

Student Book answers

<table>
<tr><td>1</td><td>a</td><td>any of the following: (i) they help us make food such as cheese and yoghurt, (ii) they decompose our waste and the bodies of dead organisms and fertilise the soil, (iii) they allow our sheep, cows and goats to digest their food and (iv) they make medicines such as penicillin.</td><td>[3]</td></tr>
<tr><td></td><td>b</td><td>a pathogen can be either bacteria, fungi or viruse which cause infectious diseases.</td><td>[1]</td></tr>
<tr><td></td><td>c</td><td>any infectious disease can be listed including Hepatitis, covid-19, typhoid, and dengue.</td><td>[3]</td></tr>
<tr><td></td><td>d</td><td>pathogens cause disease by attacking the cells of the body and causing disease symptoms.</td><td>[1]</td></tr>
<tr><td>2</td><td></td><td>Infectious diseases spread from one person to another by droplet infection, direct contact, contaminated food and drink, or by vectors.</td><td>[4]</td></tr>
<tr><td>3</td><td>a</td><td>antigens are special protein markers on the outside of cells of different organisms.</td><td>[2]</td></tr>
<tr><td></td><td>b</td><td>an antibody is a special chemical made by white blood cells for each specific antigen. Antibodies target antigens which are different to the body’s own antigen.</td><td>[2]</td></tr>
<tr><td></td><td>c</td><td>Each type of pathogen requires different antibodies to destroy it. The adaptive immune system requires an encounter with a pathogen before an antibody can be produced against it. Once an antibody against an antigen has been produced, the immune system remembers it and can re-produce them quickly in case of re-infection.</td><td>[5]</td></tr>
<tr><td>4</td><td></td><td>The two types of active immunity (innate and adaptive) work to prevent pathogens from entering the body and if they do enter, produce antibodies to destroy them. These are both active responses by the body itself. In passive immunity the body itself does not produce antibodies, rather it requires on antibodies produced by someone else to defend itself.</td><td>[5]</td></tr>
<tr><td>5</td><td>a</td><td>it covers and protects tissues of the body and stops pathogens getting in. In case there is a cut, the blood clots to form a scab to prevent pathogens gaining entry inside the body.</td><td>[2]</td></tr>
<tr><td></td><td>b</td><td>the acid in the stomach kills almost all of the microorganism in anything that is swallowed.</td><td>[1]</td></tr>
<tr><td></td><td>c</td><td>the nose hairs filter the air to trap pathogens. The respiratory system produces mucus which traps pathogens and dust. The airways have ciliated epithelial cells which move mucus out of the respiratory system to be swallowed. The acid in the stomach then destroys the pathogens trapped in the mucus.</td><td>[3]</td></tr>
<tr><td></td><td>d</td><td>students can refer to page 53 for the labelling.</td><td>[4]</td></tr>
<tr><td>6</td><td></td><td><table>
<tr><th>Innate immune system</th><th>Adaptive immune system</th></tr>
<tr><td>A- it is the first line of defense against pathogens.
B-the innate immune system is present from birth.
C- it is not specific and does not target particular pathogens.</td><td>A- it forms the second line of defense against pathogens.
B- the adaptive immune system is not present from birth but develops as the body encounters different pathogens.
C- it is very specific and can identify and destroy particular pathogens.</td></tr>
</table></td><td></td></tr>
</table>

Innate immune system	Adaptive immune system
D- It works to protect the body from all pathogens but has limited power over specific pathogens if they gain entry into the body.	D- it is able to remember particular pathogens by their antigens and produces targeted antibodies against these antigens. Sometimes it is also able to produce antitoxins.

7	**a**	Immunisation strengthens the immune system by teaching it to make the antibodies needed to protect against serious diseases. As a result of global immunisation, many diseases have been completely wiped out, resulting in millions of lives saved every year around the world due to vaccines.	**[5]**
	b	Ever since vaccination against measles began in 1985 in Pakistan, the number of measles cases has dropped drastically. This is due to reasons discussed above in part a, namely that immunisation strengthens the immune system by teaching it to make the antibodies needed to protect against serious diseases, such as measles.	**[4]**
8		(see table below)	**[8]**

	Hepatitis	**Covid-19**	**Typhoid**	**Dengue**
Caused by	Virus	Virus	Bacteria	Bacteria
Spread by	Contaminated blood	Droplet infection	Drinking water or eating food contaminated by infected human faeces	Mosquitos which act as vectors
How diagnosed	Blood tests	PCR and lateral flow tests	Testing the faeces or the blood for the presence of typhoid bacteria	Blood tests
How prevented	Use of good hygiene, screening blood transfusions, immunisation, early detection.	Immunisation and taking precautions including wearing a mask, social distancing, and self-isolation in case of infection.	Handwashing with soap, building accessible public toilets, and ensuring clean water supplies.	Avoiding mosquito bites and preventing mosquitos breeding.

9	**a**	Single	**[1]**
	b	Hyphae	**[1]**
	c	Vector	**[1]**
	d	Phagocytosis	**[1]**
	e	Passive	**[1]**
	f	Immunisation	**[1]**
	g	Hepatitis	**[1]**
	h	Typhoid	**[1]**

4.1

Structure of an Atom

Student Book pages 72–73

Objective

- Explain that the Periodic Table is a way to organise elements in a systematic order.

Overview

Students will understand that the Periodic Table is a systematic way to organize elements based on their properties. They will explore the layout and structure of the Periodic Table, learn about the significance of its arrangement, and understand how it helps predict the properties of elements.

Activities

- Begin the lesson by asking students what they know about the Periodic Table and its purpose.
- Explain that the Periodic Table is a fundamental tool in chemistry used to organize and categorize elements.
- Display a simplified version of the Periodic Table on the board or using visual aids.
- Explain that there are about 118 elements. The elements are listed in the Periodic Table. The Periodic Table groups together elements with similar properties. For example, the metals on the left of the stepped line are metals.
- The elements on the right of the stepped line are non-metals.
- Explain that the table is organized into rows called periods and columns called groups .
- Emphasize that elements within the same group have similar properties, while elements in the same period share the same number of electron shells.
- Introduce the concept of periodic trends, such as boiling point and melting point
- Explain that these trends vary in a predictable manner across the Periodic Table.
- Use examples and visual aids to illustrate how elements in a group or period exhibit similar trends. Activity: Periodic Table Scavenger Hunt Distribute handouts with simplified Periodic Tables to each student.
- Instruct students to work individually or in pairs to find specific elements .
- Encourage students to observe patterns and trends while completing the activity.
- Have students share their findings from the scavenger hunt and discuss the patterns they observed in the Periodic Table.

Extension:

To extend the lesson, students can research the properties of specific groups or periods on the Periodic Table, investigate the discovery and applications of new elements, or create a presentation on the historical development of the Periodic Table.

Homework:

Workbook page 33.

4.1 Student Book answers

1. The vertical columns are called groups while the horizontal rows of the Periodic Table are called periods.
2. aluminium Group 3, sulphur group 6, magnesium group 2
3. Phosphorus period 3, Zinc period 4, Xenon period 5.
4. The melting point increases from left to right for the first four elements. The others have low melting points.

4.2

The periodic table: Group 1

Student Book pages 74–75

Prior learning

- The periodic table lists all the elements, grouping together elements with similar properties.
- Metals conduct electricity, are shiny when freshly cut, and have high melting points and densities.

Extension

Students read Student Book which explains the melting point trend. They make a small poster to summarise the explanation.

Homework

Workbook page 34.

Key words

Group 1

Objectives

- Explain that the Periodic Table is a way to organize elements in a systematic order.
- Explain that the Periodic Table is a way to organize elements in a systematic order.
- Recognize periods and groups in the Periodic Table.

Overview

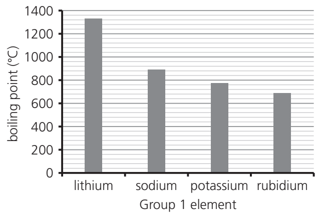
Having listened to the element song, students learn that the Group 1 elements are on the left of the periodic table. They then plot a bar chart of their melting points, describe the pattern shown, and consider the reasons for plotting a bar chart. The lesson concludes with a comparison of the Group 1 element properties to those of typical metal properties.

Activities

- Remind students that the periodic table lists all the elements, grouping together elements with similar properties.
- Tell students that this lesson is about the elements in Group 1, the column on the left of the periodic table. Point out that lithium, at the top of the group, is in great demand owing to its use in electric car batteries.
- Tell students that there are patterns in the physical and chemical properties of the Group 1 elements. This lesson is about their physical properties.
- Students plot a bar chart of the Group 1 element melting points. Elicit that the data are from a secondary source – students have not measured the values themselves. Ask students to explain why they should plot a bar chart, not a line graph (the independent variable – the element – is categoric). Students then describe the pattern in melting points.
- If there is time, students answer questions 1 and 4.
- Finish the lesson by eliciting properties of typical metals (shiny, conduct electricity, high melting points, high densities). Tell students that the Group 1 elements have some properties that are typical of all metals (shiny when freshly cut, conduct electricity), but that some of their properties are not typical of metals (relatively low melting points and densities).

4.2 Student Book answers

1. Lithium – Li; sodium – Na; potassium – K; rubidium – Rb; caesium – Cs
2. Group 1 elements have a giant metallic structure, with positively charged ions in fixed positions and negatively charged electrons moving around between the ions. From top to bottom of the group, the ions get bigger: electrostatic attractions between positive ions and negative electrons gets weaker and ions leave their fixed positions more easily, so melting points decrease.
3. **a.**



b. From top to bottom, boiling points decrease.

4.3
Inside atoms

Student Book pages 76–77

Prior learning
- An atom is the smallest part of an element that can exist.

Objectives
- Describe and draw the structure of an atom in terms of electrons, protons, and neutrons.
- Describe how an atom is electrically neutral.

Overview
This lesson introduces students to sub-atomic particles and the 1932 atomic structure model. Students learn the mass and charge of each sub-atomic particle, and its position in an atom. They then use dried beans to represent protons, neutrons, and electrons in different atoms, and evaluate the analogy. An extension activity supports students in considering the relative sizes of atoms, nuclei, and sub-atomic particles.

Activities
- Show students about ten small identical balls. Each one represents an atom of the element helium. Discuss how the balls can be used to explain changes of state. Point out that the balls are an analogy for the model of the atom used until the early 1900s, and that atoms are solid spheres. Tell students that an analogy is a comparison between one thing and another that helps to explain something.
- Tell students that the solid atom model cannot explain everything in chemistry, for example, chemical reactions. A new model is needed.
- Describe the 1932 atomic model, that atoms consist of tiny sub-atomic particles. Protons and neutrons make up the nucleus. Electrons move around outside the nucleus. Atoms are electrically neutral because the number of protons is equal to the number of electrons. This model can be used to explain chemical reactions, and how atoms join together.
- **Practical activity:** Explain that every atom of a certain element has the same number of protons. Student pairs use beans to represent atomic structures of given atoms. They do not arrange electrons in shells, but spread them out around the outside of the nucleus. Students draw their models. It includes a question in which students evaluate the bean analogy.

Homework
Workbook page 35.

Key words
sub-atomic particle, proton, neutron, electron, analogy

4.3 Student Book answers

1. Proton – charge +1, relative mass 1; neutron – no charge, relative mass 0; electron – charge -1, mass 1/2000
2. An electrostatic force between the positive nucleus and the negative electrons.
3. A football stadium – if an atom is the size of a football stadium, the nucleus is the size of a pea at its centre.
4. 4 protons and 5 neutrons in the nucleus, 4 electrons in 2 rings around the outside.
5. There are 4 positive protons and 4 negative electrons, so there is no net charge.

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4.4
Proton number and the periodic table

Student Book pages 78–79

Prior learning
- Atoms are made up of tiny sub-atomic particles.
- There are three types of sub-atomic particle – protons, neutrons, and electrons

Objectives
- Differentiate between atomic number and mass number.
- Describe and draw the structure of an atom in terms of electrons, protons and neutorns.

Overview
The lesson starts by considering MRI scans, making the point that scientists developed the technique using knowledge about sub-atomic particles. Next, students carry out activities to revise their knowledge about sub-atomic particles and atomic structure. Having been introduced to the term *proton number* and the fact that the periodic table gives the elements in order of proton number, students answer questions about proton number and make up quiz questions for each other.

Activities
- Display a picture of a brain MRI scan. Discuss why MRI scans are useful (they help doctors to diagnose tumours and other abnormalities). Point out that scientists developed the technique using knowledge about sub-atomic particles and their behaviour.
- Student pairs do a matching activity to revise their knowledge from chapter 7 about sub-atomic particles. Students also answer the questions on the same worksheet to revise their knowledge of atomic structure.
- Remind students that each element has a different number of protons in its atoms. Tell them that the number of protons in an atom of the element is its proton number, and that – in the periodic table – the elements are arranged in order of proton number. Students who carried out the activities in extension lesson 7.5 have already covered these ideas.
- You might wish to point out that, in Mendeleev's periodic table, the elements were arranged in atomic mass order, but element pairs were swapped so that only elements with similar properties were placed together in a group. On discovering protons, scientists arranged the elements in proton number order. This worked perfectly – all elements in a group then had similar properties.
- Students answer questions 1–4.
- To finish the lesson, students make up quiz questions for each other based on proton number and the periodic table. For example, which element's atoms have one more proton than vanadium atoms?

Homework
Workbook page 36.

Key words
proton number, atomic number

4.4 Student Book answers

1. Atomic number – the number of protons in an atom of an element.
2. A diagram with 5 purple circles and 6 green circles in a cluster.
3. **a.** 8 **b.** 17 **c.** 47
4. **a.** Vanadium, V
   b. Argon, Ar
   c. Iron, Fe
5. **a.** 22 **b.** 16 **c.** 20
6. **a.** sodium **b.** carbon

4.5
Mass number

Student Book pages 80–81

Objectives

- Differentiate between atomic number and mass number.
- Determine the atomic number and mass number of elements on the basis of the number of protons, electrons, and neutrons.

Overview

Students will understand the differences between atomic number and mass number and learn how to determine these values for elements based on the number of protons, electrons, and neutrons. They will explore the significance of these fundamental properties in identifying and categorizing elements.

Activities

- Begin the lesson by asking students what they know about atoms and their composition.
- Explain that atoms are the basic building blocks of all matter and that elements are made up of specific types of atoms.
- Introduce the concept of atomic number and mass number as fundamental properties of elements.
- Atomic Number and Mass Number Present the definitions of atomic number and mass number.
- Explain that the atomic number (Z) represents the number of protons in an atom, and it also defines the element's identity in the Periodic Table.
- Describe that the mass number (A) represents the total number of protons and neutrons in an atom's nucleus.
- Determining Atomic Number and Mass Number Use visual aids to illustrate the structure of an atom, with protons and neutrons in the nucleus and electrons in electron shells.
- Provide examples of different elements and guide students in determining their atomic numbers and mass numbers based on the number of protons, electrons, and neutrons.
- Clarify that in a neutral atom, the number of protons is equal to the number of electrons.

Activity: Building Atoms

- Distribute blank Periodic Tables handouts to each student.
- Instruct students to choose an element and construct a model of its atom, including the atomic number and mass number, along with the number of protons, electrons, and neutrons.
- Encourage them to use the Periodic Table and their knowledge of atomic structure.
- Have students share their models and findings with the class.
- Engage in a group discussion to reinforce the concepts of atomic number and mass number and address any questions or misconceptions.
- Reflect on the significance of these properties in understanding the identity and characteristics of elements.

Homework:

Workbook page 37.

Extension:

To extend the lesson, students can research and present on isotopes and their significance in atomic number and mass number determination, explore the role of atomic number in the arrangement of elements in the Periodic Table, or conduct experiments related to subatomic particles.

4.5 Student Book answers

1. The total number of protons and neutrons in an atom is its mass number.

2. Boron: Atomic No. = 5 Mass no. = 11

Lithium: Atomic No. = 3 Mass no. = 7

Carbon: Atomic No. = 6 Mass no. = 12

3. a. Mass Number = 119 , **b.** Tin

4. No. of Protons= 19 , No. of neutrons= 20

4.6 Electrons in atoms

Student Book pages 82–83

Prior learning

- There are three types of sub-atomic particle – protons, neutrons, and electrons.
- Electrons orbit outside the nucleus of an atom.

Objectives

- Show the arrangement of electrons in K, L and M shells of elements
- Draw the atomic structure of the first eighteen elements of the Periodic Table.
- Draw atomic structures of elements in the Periodic Table.

Overview

This lesson introduces electronic structure. Students use beans to show the electronic structures of atoms of different elements, and draw the electronic structures of these elements. They then draw the electronic structures of elements in the same group of the periodic table, and look for patterns in these structures. The lesson finishes with a true/false activity to check learning from the lesson.

Activities

- Remind students that the nucleus of an atom is made up of protons and neutrons, and that all atoms of an element have the same number of protons. This is the proton number of the element. In a neutral atom, the number of protons is equal to the number of electrons.
- **Practical activity:** Tell students that electrons whizz around an atom outside its nucleus. The atomic model we use states that the electrons move around in shells, and that each shell holds a maximum number of electrons. Students use beans to model the electron configurations of atoms. They draw the arrangements, and then write the electron configurations in the form 2,8,1.
- Students draw the electron configurations of atoms of the first three elements of Group 1. They repeat for Groups 2 and 18, and look for patterns.
- Read out statements about atomic structure and electron configurations. Students show thumbs up for true statements, thumbs down for false statements, and thumbs horizontal if they are not sure.

Extension

Students plan an illustrated talk to explain electron configurations to students in another class.

Homework

Workbook page 38.

Key words

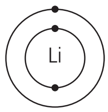
electron configuration

4.6 Student Book answers

1. Electron configuration – the arrangement of electrons in shells in an atom.

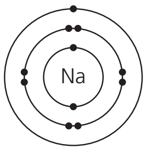
2. a. 7 **b.** 9 **c.** 13

3. a.



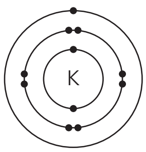
lithium

b.



sodium

c.



potassium

4. Similar – there is one electron in the outer shell, furthest from the nucleus; different – each has a different number of electron shells.

4.7 Review answers

Student Book pages 84–85

Student Book answers

<table>
<tr><td>1</td><td></td><td>from the top blank to last: electron, proton, nucleus</td><td>[3]</td></tr>
<tr><td>2</td><td></td><td>C</td><td>[1]</td></tr>
<tr><td>3</td><td></td><td>A</td><td>[1]</td></tr>
<tr><td>4</td><td></td><td>B</td><td>[1]</td></tr>
<tr><td>5</td><td></td><td>A</td><td>[1]</td></tr>
<tr><td>6</td><td></td><td><table>
<tr><th>Sub-atomic particle</th><th>Charge</th><th>Relative mass</th></tr>
<tr><td>Proton</td><td>+1</td><td>1</td></tr>
<tr><td>Neutron</td><td>0</td><td>1</td></tr>
<tr><td>electron</td><td>-1</td><td>1/1836</td></tr>
</table></td><td>[4]</td></tr>
<tr><td>7</td><td>a</td><td>nucleus</td><td>[1]</td></tr>
<tr><td></td><td>b</td><td>16</td><td>[1]</td></tr>
<tr><td></td><td>c</td><td>electrostatic</td><td>[1]</td></tr>
</table>

8	**a**	metal	**[1]**
	b	**i.** 200 **ii.** 80 **iii.** because there are equal numbers of electrons and protons.	**[2]** **[1]** **[1]**
9	**a**	7	**[1]**
	b	5	**[1]**
	c	Magnesium	**[1]**
	d	5	**[1]**
	e	4	**[1]**
	f	23	**[1]**
	g	24	**[1]**
10	**a**	11	**[1]**
	b	2	**[1]**
	c	K=2, L=1	**[3]**
	d	Magnesium	**[2]**
11	**a**	Group 6	**[1]**
	b	It can conduct electricity and belongs to group 1.	**[1]**
	c	Nucleus	**[1]**
	d	atomic number	**[1]**

5.1

Making ions

Student Book pages 86–87

Prior learning

- The electron configuration of an atom describes how its electrons are arranged.
- Each electron shell has a maximum number of electrons.

Objectives

- Define valency and explain the formation of ions.
- Draw dot and cross diagrams showing the formation of ionic compounds.

Overview

The lesson begins by considering an important ion, Na^+, and continues with a modelling activity in which students use dried beans to model atoms forming ions in chemical reactions. Students then learn why atoms form ions, before practising writing the formulae of some common ions. The lesson finishes with a true or false activity to check learning.

Activities

- Ask students if they have seen an animal licking salt, like the goat in the picture. Elicit that animals get sodium ions from salt. Animals (and humans) need sodium ions to make their heart and nerves work.
- Tell students that an ion is a particle with a positive or negative charge, and that an ion forms when an atom gains or loses electrons. Students use dried beans to model atoms forming ions in chemical reactions.
- Students read Student Book to learn why atoms form ions. Emphasise that an atom with a full outer shell is stable, and that ions form in order to achieve this stable structure. Students answer questions 1 and 2.
- Next, students practise writing the formulae of ions by answering question 3 Further examples are: fluorine ion, charge –1; lithium ion, charge +1; calcium ion, charge +2; sulfide ion, charge –2; nitride ion, charge –3; aluminium ion, charge +3.
- Finish the lesson by reading out the following statements. Students indicate which are true, and which are false:

  1. When an atom gains an electron, a negative ion forms. (True)

  2. A positive ion forms when an atom gains an electron. (False)

  3. An atom or ion is stable if its outer shell is full. (True)

  4. In the formation of sodium chloride from its elements, an electron moves from a chlorine atom to a sodium atom. (False)

Extension

Students work out the charges of the ions formed in the reaction of aluminium with nitrogen to make aluminium nitride.

Homework

Workbook page 39.

Key words

ion

5.1 Student Book answers

1. Ion – an atom that has gained one or more electrons to be negatively charged, or lost one or more electrons to be positively charged.

2. The outer electron shell is full, and the ion stable.

3. a. K^+

b. Mg^{2+}

c. Br^-

4. Charge on ion is −1, because gaining one electron gives a full outer shell, which is a stable arrangement.

5. Students should attempt this taking guidance from the student book page 86 and the teacher.

5.2 Inside ionic compounds

Student Book pages 88–89

Prior learning

- An ion is an atom that has gained one or more electrons to be negatively charged, or lost one or more electrons to be positively charged.

5.2 Student Book answers

1. Ionic bond – the electrostatic attraction between positive and negative ions that holds an ionic compound together; ionic compound – a compound made up of positive and negative ions; giant ionic structure – the three-dimensional pattern of oppositely charged ions in an ionic compound.
2. Electrostatic
3. Sodium chloride, calcium oxide, nickel chloride, and cobalt chloride.
4. **a.** The electrostatic attraction between oppositely charged ions is strong.
   b. If you drop a crystal of an ionic compound, it breaks between one row of ions and another.
5. Strengths – shows positions of ions, shows that the ions are held together strongly; limitations – does not show that ions vibrate on the spot, does not explain why ionic compounds are brittle.

Objective

- Recognize that a chemical bond results from the attraction between atoms in a compound and that the atoms' electrons are involved in this bonding.

Overview

The lesson begins by displaying ionic crystals and a model of the structure of sodium chloride. Following this, student groups make a model of the structure of sodium chloride, using modelling clay or grapes (or similar), and identify its strengths and limitations. Next, there is a demonstration of two of the properties of ionic compounds – their high melting points and their solubility in water. The lesson concludes with students composing and answering questions on the topic.

Activities

- If possible, display big crystals of a few ionic compounds, for example, copper sulfate and sodium chloride (salt). Point out that the crystals are made up of millions of positive and negative ions.
- Display a model of the structure of sodium chloride. Elicit that positive sodium ions and negative chloride ions are arranged alternately, in a regular pattern. This is a giant ionic structure. Tell students that electrostatic attraction between positive and negative ions holds the structure together. This is ionic bonding. Ionic bonds act in all directions.
- Student groups model the structure of sodium chloride, using modelling clay or grapes (or similar). They identify the strengths and limitations of their models.
- Demonstrate heating a small amount of sodium chloride, an ionic compound. It does not melt at the temperature of a Bunsen burner flame, so must have a high melting point. Tell students that all ionic compounds have high melting points, and that they are brittle. Elicit explanations for these properties, as given at the top of Student Book page 177.
- Demonstrate adding one spatula measure of three different ionic compounds (for example sodium chloride, copper sulfate, and cobalt chloride) to separate beakers of water. Stir. Elicit that these ionic compounds (and many others) are soluble in water.
- Finish the lesson by asking each student to make up one question about ionic compounds. Invite a few students to ask the class their questions.

Homework

Workbook page 40

Key words

ionic bonding, ionic compound, giant ionic structure

5.3 Covalent bond

Student Book pages 90–91

Prior learning

- The electron configuration of an atom describes how its electrons are arranged.
- Each electron shell has a maximum number of electrons.
- An atom with a full outer shell is stable.
- The chemical formula of a substance gives the relative number of atoms of each element in it.

Objectives

- Discuss types and formation of covalent bonds as a result of mutual sharing of electrons between atoms.
- Draw dot-and-cross diagrams showing the formation of covalent compounds.
- Name certain covalent compounds.
- Recognize that a chemical bond results from the attraction between atoms in a compound and that the atoms' electrons are involved in this bonding.

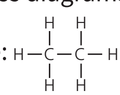
Overview

The lesson begins by considering the element ammonia, which is one of the products of digestion by fish. Students then use beans to model the formation of covalent bonds, before drawing dot-and-cross diagrams for elements and compounds that exist as simple molecules. The lesson ends by comparing covalent and ionic bonding.

Activities

- Display a picture of a fish. Student pairs speculate what the fish eats. Point out that fish digest their food, and that one of the waste products of fish digestion is ammonia gas. Ammonia has a bad smell, like rotting fish.
- Tell students that ammonia exists as molecules, and give its chemical formula, NH_3. Elicit that the formula shows that an ammonia molecule is made up of one nitrogen atom joined to three hydrogen atoms. Tell students that the atoms are joined together by covalent bonds, and that a covalent bond is a shared pair of electrons. Draw the electron configurations of nitrogen and hydrogen on the board, and show how electron pairs are shared to form covalent bonds. Students use dried beans to model atoms sharing electrons to form covalent bonds.
- Students practise drawing dot-and-cross diagrams for elements and compounds that exist as simple covalent molecules.
- Students to compare ionic and covalent bonding.

Extension

Challenge students to draw dot and cross diagrams for molecules made up of a larger number of atoms, such as ethane: 

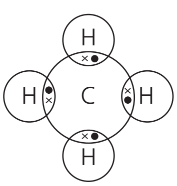
Homework

Workbook page 41.

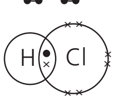
Key words

covalent bond

5.3 Student Book answers

1. Covalent bond – a shared pair of electrons that joins two atoms together.
2. **a.** any from: Methane, CH_4; Hydrogen, H_2; Chlorine, Cl_2; Nitrogen, N_2; Oxygen, O_2 .
   b. Hydrogen
   c. Nitrogen
3. 

4. 

5. 

5.4 Covalent structures

Student Book pages 92–93

Prior learning

- A covalent bond is a shared pair of electrons that joins two atoms together.

Objective

- Recognize that a chemical bond results from the attraction between atoms in a compound and that the atoms' electrons are involved in this bonding.

Overview

The lesson starts by observing that two substances with covalent bonding – nitrogen and diamond – have very different physical properties. Students then read about simple molecules and giant covalent structures, and create small posters to display their learning. Students then make conclusions about structure from melting point data. The lesson ends with students noting three things they have learnt.

Activities

- If possible, show students a sample of the element carbon (as graphite, charcoal, or diamond). Elicit some physical properties of the element. Point out that a neighbouring element in the periodic table, nitrogen, is an invisible gas. In both elements, the atoms are joined together by covalent bonds. In this lesson, students will learn why two substances with the same type of bonding have such different physical properties.
- In pairs, one student reads about simple molecules and the other reads about giant covalent structures They then tell each other what they have read about, and ask questions to check learning. Following this, student pairs create small posters to display their learning.
- Display the data in the Student Book. Elicit that the substances with low melting points (carbon monoxide and sulfur dioxide) have simple molecules, and that the substances with high melting points (diamond and silicon dioxide) have giant covalent structures. Point out that students have used secondary data – as well as scientific knowledge – to make conclusions.
- At the end of the lesson, students walk round the classroom to look at the posters created earlier. They consider how successfully each poster conveys the required information.

Extension

Ask students to compare the properties of a substance with a giant covalent structure, such as diamond, with the properties of a substance with a giant ionic structure, such as sodium chloride.

Homework

Workbook page 42.

Key words

giant covalent structure

5.4 Student Book answers

1. Giant covalent structure – a three-dimensional network of atoms that are joined together by covalent bonds.
2. Carbon in the form of diamond; Silicon dioxide.
3. **a.** Covalent
   b. To achieve a share in a fuller outer shell of electrons, so achieving a stable electronic configuration.
4. Simple molecules are attracted to each other only weakly, but in a giant covalent structure, the atoms are joined together in a three-dimensional network by strong covalent bonds.

5.5

Valency and chemical formulae

Student Book pages 94–95

Objectives

- Define valency.
- Write chemical formulae on the basis of valency of the constituent elements. such as H_2O, NaCl, NH_3, CO_2, CO, etc.

Overview

Students will understand the concept of valency and its significance in forming chemical compounds. They will learn how to write chemical formulas based on the valency of constituent elements for various compounds, such as H_2O, NaCl, NH_3, CO_2, and CO.

Activities

- Begin the lesson by asking students about chemical compounds and how they are formed.
- Introduce the concept of valency as the combining capacity of an atom to form chemical bonds with other atoms.
- Explain that valency determines the number of electrons an atom can gain, lose, or share to achieve a stable configuration.
- Use visual aids to illustrate that every element has a valency value, which is linked to the number of electrons in its outer shell. Elements in the same group of the Periodic Table have the same valency.
- Provide simple examples of chemical bonds and compounds formed by elements with specific valencies.

Writing Chemical Formulas

- Introduce the rules for writing chemical formulas based on the valency of the constituent elements.
- Provide examples of chemical formulas, such as H_2O, NaCl, NH3, CO_2, and CO, and explain how the valency of each element determines the number of atoms and their arrangement in the compound.
- Discuss the use of subscripts to indicate the number of atoms of each element in a compound.
- Explain that the valency method does not work for all compounds. E.g. You can find the formula of sulphur hexafluoride from its name. The prefix hexa- means that there are 6 fluorine atoms for every one sulphur atom, so the formula is SF_6.
- Introduce the prefixes mono,di ----
- Explain that if the name of a compound includes one of the prefixes , use the name to work out its formula – not the valency method.

Activity: Writing Chemical Formulas

- Distribute handouts with exercises on writing chemical formulas to each student.
- Instruct students to work individually or in pairs to complete the exercises, using the valency of the elements to form the correct chemical formulas.
- Encourage them to refer to the Periodic Table and their knowledge of valency.

Group Discussion and Review

- Have students share their answers and discuss any challenges they encountered in writing chemical formulas.

5.5 Student Book answers

1. Valency is the combining power of an element.

2. a. NO_2 **b.** PF_3 **c.** N_2O **d.** SF_4

3. a. NaCl

b. NaF

c. $CaBr_2$

d. K_2O

e. AL_2O

f. H_2O

g. NH_3

- Review the correct answers as a class and address any questions or misconceptions.

Extension:

To extend the lesson, students can research and present on polyvalent elements and their multiple valencies, or investigate the use of chemical formulas in various industrial processes.

Homework

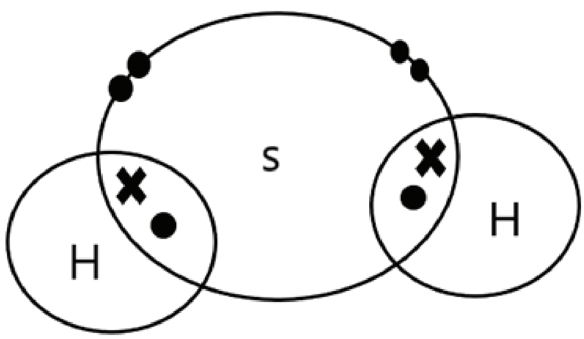
Workbook page 43.

5.6 Review answers

Student Book pages 96–97

Student Book answers

1	**a**	Neutron	**[5]**
	b	Electron configuration	
	c	Proton number	
	d	Positive	
	e	Negative	
2	**a**	9	**[1]**
	b	Diagram showing 9 protons and 10 neutrons, arranged in a cluster	**[1]**
	c	Refer spread for answer.	**[3]**
	d	Fluorine and chlorine	**[2]**
	e	They both have the same number of electrons (7) in their outer shells	**[2]**
3		Top row – B, 3 Second row – carbon, 6, 4 Third row – Li, 3 Fourth row – Mg, 12 Fifth row – sodium, 1	**[12]**
4	**a**	13	**[1]**
	b	2 electrons in shell nearest nucleus, 8 in next shell, 3 in outer shell	**[2]**
	c	One from: boron, gallium, indium, thallium	**[1]**
5	**a**	Li_+	**[5]**
	b	Ca_{2+}	

	c	d	
	d	Cl_{-}	
	e	$N3_{-}$	
6		2 (because it needs two more electrons to gain a full outer electron shell / gain a stable electron configuration)	**[2]**
7	**a**	Electrostatic	**[1]**
	b	The electrostatic attractions between the positive and negative ions are strong.	**[1]**
	c	Mg_{2+}	**[1]**
	d	I_{-}	**[1]**
	e	MgI_2	**[2]**
	f	If dropped or hit, it breaks between one row of ions and another.	**[1]**
8	**a**	F_2	**[1]**
	b	Covalent	**[1]**
	c	Fluorine molecules are attracted to each other only weakly	**[1]**
9	**a**	H_2S	**[1]**
	b	Gas	**[1]**
	c		**[1]**
10	**a**	Giant covalent structure	**[1]**
	b	Each carbon atom makes strong covalent bonds with four other carbon atoms.	**[1]**

6.1

Chemical and physical changes

Student Book pages 98–99

Objective

- Differentiate between physical and chemical changes while considering daily life examples.

Overview

Students will understand the difference between physical and chemical changes and recognize examples of each in their daily lives. They will explore the characteristics of these changes, identify the factors that distinguish them, and understand the significance of these concepts in the world around them.

Introduction

- Begin the lesson by asking students to define physical and chemical changes and if they have encountered any examples in their daily lives.
- Introduce the concept of physical changes as alterations that affect the appearance, shape, or state of matter without forming new substances.
- Explain that chemical changes involve the transformation of substances into new substances with different properties.
- **Characteristics and Examples of Physical Changes** Discuss the characteristics of physical changes, such as reversibility and no change in the composition of matter.
- Present visual aids and real-life examples of physical changes, such as melting ice, cutting paper, dissolving sugar in water, and crushing a can.
- Encourage students to identify other physical changes they encounter regularly.
- **Characteristics and Examples of Chemical Changes** Discuss the characteristics of chemical changes, such as the formation of new substances, energy changes, and irreversibility.
- Present visual aids and real-life examples of chemical changes, such as burning paper, rusting of iron, baking bread, and digestion of food.
- Encourage students to identify other chemical changes they encounter in their daily lives.
- **Activity: Identifying Changes** Divide the class into small groups and provide them with objects representing various examples of physical and chemical changes.
- Instruct each group to observe the objects and determine if the changes are physical or chemical.
- Have the groups present their findings to the class and explain the reasons behind their classifications.
- **Group Discussion and Review** Engage students in a discussion about the differences between physical and chemical changes based on the activity and examples discussed.
- Recap the main characteristics of each type of change and emphasize the importance of understanding these concepts in everyday life.
- Summarize the main points of the lesson, emphasizing the differences between physical and chemical changes.
- Encourage students to be observant of the changes they encounter in their daily lives and to think critically about whether they are physical or chemical.
- Discuss the significance of these concepts in various fields, such as cooking, construction, and environmental science.

Extension:

- To extend the lesson, students can research and present on reversible and irreversible changes, investigate the concept of conservation of mass in chemical changes, or conduct experiments to demonstrate physical and chemical changes in the laboratory.

Homework

Workbook page 44.

6.1 Student Book answers

1. Physical changes are changes that do not make new substances.
2. Physical change: dissolving sugar in water, melting ice, freezing water Chemical changes: rusting of iron, burning paper
3. Cooked food, Fire, Energy from digestion of food.
4. Encourage students to present their answers in form of an infographic.

6.2

Physical and chemical properties

Student Book pages 100–101

Objectives

- Distinguish between physical and chemical properties of matter.
- Relate uses of materials to their physical properties.
- Relate uses of materials to their chemical properties.

Overview

Students will distinguish between physical and chemical properties of matter, and relate the uses of materials to their respective properties. They will explore how these properties influence the choice of materials in various applications and understand the significance of these concepts in everyday life.

Activities

- Begin the lesson by asking students to define physical and chemical properties of matter and provide examples if they know any.
- Introduce the concept of physical properties as characteristics that can be observed or measured without changing the substance's identity.
- Explain that chemical properties are characteristics that describe how a substance reacts with other substances to form new substances.
- **Examples and Characteristics of Physical Properties** Present visual aids and real-life examples of physical properties, such as colour, texture, density, melting point, boiling point, and conductivity.
- Discuss the characteristics of physical properties, such as being observable and measurable without altering the substance's composition.
- Show samples of different materials and demonstrate how their physical properties influence their uses (e.g., metals for conductivity, wood for its texture and strength).
- **Examples and Characteristics of Chemical Properties** Present visual aids and real-life examples of chemical properties, such as flammability, pH, and combustion.
- Discuss the characteristics of chemical properties, such as describing how a substance interacts with other substances and undergoes chemical changes.
- Show samples of different materials and explain how their chemical properties determine their uses (e.g., plastic for its resistance to corrosion, iron for its rusting, magnesium oxide for high MP).
- Give use of penicillin and vegetable and fruit based on their solubility.
- **Identifying Properties and Uses** Divide the class into small groups and provide them with samples of different materials.
- Instruct each group to observe and identify the physical and chemical properties of the materials and discuss their potential uses based on these properties.
- Have the groups present their findings to the class, explaining how the properties influence the materials' applications.
- **Group Discussion and Review** Engage students in a discussion about the differences between physical and chemical properties and how they relate to the uses of materials.
- Recap the main characteristics of each type of property and emphasize the importance of understanding these concepts in choosing appropriate materials for different applications.

6.2 Student Book answers

1. Physical properties are properties that you can observe or measure without permanently changing the material. Chemical properties describe how substances change in chemical reactions
2. Physical properties: melting point, boiling point, mass of a substance, state of a substance
3. **a.** High melting point of magnesium oxide helps to make it suitable for fire-resistant building boards.
   b. Low melting point of ethanol helps to make it a suitable liquid for thermometers.

Homework

Workbook page 45.

- Summarize the main points of the lesson, emphasizing the distinction between physical and chemical properties and their relevance in material selection.
- Encourage students to be more observant of the materials they encounter in everyday life and think critically about their properties and uses.
- Discuss the significance of understanding these concepts in various fields, such as engineering, architecture, and product design.

Extension:

To extend the lesson, students can research and present on the properties and uses of specific materials, investigate how the properties of materials can be modified for specific applications, or conduct experiments to demonstrate the physical and chemical properties of different substances.

6.3

Using materials: Thermal conductivity

TWS

Student Book pages 102–103

Prior learning

- How to plan a fair.

6.3 Student Book answers

1. Scientific question – question that needs evidence in order to be answered; independent variable – the variable that you change; dependent variable – the variable that is observed or measured; control variable – variables that must be kept constant in order to do a fair.
2. Control variables
3. Iron, zinc, aluminium, copper

Objective

- Relate uses of materials to their physical properties: thermal conductivity.

Overview

This is a lesson that helps students develop their skills in Thinking and working scientifically.

The lesson starts with a discussion about computer heat sinks. Students then carry out a scientific enquiry to find out which of four metals is the best conductor of thermal energy. The lesson ends by referring back to the discussion about heat sinks – which of the metals used in the enquiry would make the best heat sink?

Activities

- If possible, show students a heat sink in a computer. Tell students that heat sinks are made from copper or aluminium. In this lesson, they will do an enquiry to find out why these metals are chosen.
- Students finish planning, carry out, and analyse an enquiry to find out which of four metals conducts heat quickest. Student Book page 64 shows one type of apparatus for the investigation, but your school may have a different type of apparatus.
- Finish the lesson by referring back to the discussion about heat sinks. Ask student pairs to discuss whether their results support the use of copper or aluminium for heat sinks.
- If time permits, students answer the questions in the Student Book.

Extension

Student suggest reasons for the shape of heat sinks.

Homework

Workbook page 46.

6.4

Using materials: Bicycles

SIC

Student Book pages 104–105

Prior learning
- The properties of materials make them suitable for their uses.

Objectives
- Evaluate some physical properties of materials.
- Evaluate Impact of combustion reaction on environment.

Overview
This is a lesson that helps students develop their understanding of Science in context.

The lesson begins by considering the properties that a bicycle frame must have, as well as an opportunity to look at some of the materials that are – or have been – used to make bicycle frames. Students then take the role of a company that makes bicycles, and chooses a material for the frame. They then make advertisements for their bicycle, and peer assess others' advertisements.

Activities
- Show a picture of some bicycles, and ask if any students have bicycles. Student pairs then discuss the properties that the material used for the frame must have.
- Tell students about materials that are, or have been, used to make bicycle frames (iron, steel, aluminium alloys, titanium alloys, carbon fibre reinforced polymer, bamboo) and display samples of some of these materials, if possible. Point out that, over the years, bicycle makers have worked with scientists to improve the performance of bicycles, in part by developing new materials for their frames.
- In pairs or groups of three, students take the role of a company that makes bicycles. They read Student Book and choose a material for the frame. They then make advertisements – for any media – for their bicycles.
- Finally, the class looks at some of the advertisements. They use two criteria to evaluate these – how clearly the science is conveyed, and its suitability for its audience.

Extension
Students create a graphic to compare the properties of the all the bicycle frame materials mentioned on Student Book.

Homework
Workbook page 47.

6.4 Student Book answers

1. Three from: bamboo is durable, strong, and makes bikes that are comfortable to ride. It is also sustainable.
2. Find the properties of different materials from secondary data or by testing first hand; make a small number of bikes from materials whose properties look promising; the bikes.
3. Paragraph including the points in the table which addresses one property at a time. For example, titanium alloy is approximately 10 times harder than the aluminium alloy in the table.
4. A well-reasoned answer.

6.5

Using materials: Rusting

Student Book pages 106–107

Homework

Workbook page 48.

Objectives

- Differentiate between physical and chemical changes while considering daily life examples .
- Recognise that oxygen is needed in rusting.
- Relate uses of materials to their chemical properties (tendency to rust and flammability).

Overview

Students will recognize the role of oxygen in rusting and relate the chemical properties of materials to their practical uses, specifically focusing on the tendency to rust and flammability. They will understand how chemical properties influence material selection and applications in various contexts Introduction to Rusting

Activities

- Begin the lesson by asking students what they know about rusting of materials.
- Introduce the concept of rusting as the process where metals, especially iron, combine with oxygen to form a reddish-brown compound called iron oxide.
- Present visual aids and real-life examples of rusting, highlighting the role of oxygen in the process.
- Discuss how water, oxygen, and iron react to form rust, emphasizing that oxygen is an essential component for rusting to occur.
- Use simple chemical equations to represent the rusting process.
- Show samples of different materials, including iron, copper, plastic, and wood.
- Discuss the chemical properties of each material, particularly focusing on their tendency to rust or not rust.
- Explain how the tendency to rust influences the use of materials in various applications (e.g., using stainless steel to avoid rusting in kitchen utensils and surgical tools.).
- Discuss that all almost all the iron we use is mixed with small amounts of carbon – and sometimes other metals – to make alloys. Iron alloys are called steels.
- Surgical tools are made from a special type of steel, called stainless steel. Stainless steel is an alloy of iron mixed with chromium. Stainless steel has different chemical properties from pure iron. Stainless steel does not rust.

Activity

- Divide the class into small groups and provide them with scenarios where materials are needed for specific applications (e.g., building a bridge, making a toy, constructing a home).
- Have the groups present their material selections and explain the reasoning behind their choices.

Extension:

To extend the lesson, students can research and present on other chemical properties that influence material selection, investigate the development of materials to address specific challenges (e.g., corrosion resistance).

6.5 Student Book answers

1. Reactants: iron and oxygen
   Product: water and hydrated iron oxide
2. Because rust forms due to a chemical reaction.
3. **a.** Bus **b.** Surgical tools

6.6

Preventing rusting

Student Book pages 108–109

Prior learning
- Oxygen is needed in rusting.
- materials are used according to their tendency to rust , especially during construction of buildings or tools.

Objective

- Explore methods of preventing rusting.

Overview:

This unit continues from the previous lesson on rusting. Students will be encouraged to use their thinking and working scientifically and science in context skills. They will learn that knowing that certain conditions are to be met for rusting to occur, we can use the same information to prevent or slow down the process of rusting. This is of great importance in industries.

Activities:

- Begin the lesson by reviewing with the students what they remember about rusting and which materials are more prone to rusting.
- Remind them of the role of water and oxygen in formation of rust, emphasizing that oxygen is an essential component for rusting to occur. Also remind that all almost all the iron we use is in the form of alloys, called steel.
- Discuss how most types of steel can also become rusty. You can protect steel objects by painting them, or covering them with oil or grease.
- Use the enquiry detailed in the textbook as a thought exercise for the class, by reading through and discussing the steps in details. Encourage students to share the steps they would add, change or ignore and to give their reasonings.
- Alternatively, set up the experiment using the details provided in the student book. Ask the students to make observations and note down results.
- Either way, facilitate the students through the conclusion making process. Do they reach the same conclusions as suggested in the unit?
- Encourage students to suggest improvements on their thought or actual experiment. If possible, repeat the experiment using their suggestions. Do the results differ?

Homework:

Workbook page 49 and questions from the student book.

6.6 Student Book answers

1. A hypothesis is a possible explanation that is based on evidence and that can be tested.
2. Paint, plastic, calcium chloride
3. Encourage the students to suggest the answer as part of the thought experiment suggested in the activity.

6.7

Using materials: Combustion

Student Book pages 110–111

Objectives

- Recognise that oxygen is needed in combustion.
- Relate uses of materials to their chemical properties (flammability).
- Evaluate the impact of combustion reactions on the environment.

Overview

Students will recognize the role of oxygen in combustion, relate the flammability of materials to their practical uses, and evaluate the impact of combustion reactions on the environment. They will understand the importance of oxygen in combustion reactions and become aware of the environmental consequences of these reactions.

6.7 Student Book answers

1. In a combustion reaction, a substance reacts with oxygen. Energy is transferred as heat and light.
2. methane + oxygen → carbon dioxide + water
3. Carbon dioxide
4. Climate change makes it harder to grow food. Climate change has made some plant and animal species extinct.
5. Encourage students to share reasoned answers.

Activities:

- Begin the lesson by asking students what they know about combustion and how it occurs.
- Introduce the concept of combustion as a chemical reaction that involves the rapid combination of a fuel with oxygen to produce heat, light, and new products.
- Explain that oxygen is essential for the combustion process to take place.
- Present visual aids and real-life examples of combustion reactions, highlighting the role of oxygen.
- Discuss how fuels (e.g., wood, gasoline, natural gas) react with oxygen to produce energy in the form of heat and light.
- Use simple chemical equations to represent combustion reactions.
- Show samples of different materials, including flammable and non-flammable substances.
- Discuss the chemical properties that make certain materials highly flammable and others less prone to catching fire.
- Explain how flammability influences the choice of materials for specific applications (e.g., using fire-resistant materials in construction, using fuels with specific combustion properties in engines).
- Methane gas catches fire easily. It is highly flammable. This makes methane suitable for cooking stoves.
- Brick and mud do not catch fire easily. They are not flammable. This makes brick and mud suitable for building houses.
- Present visual aids and real-life examples of combustion-related environmental impacts, such as air pollution and greenhouse gas emissions.
- Discuss how combustion reactions release various pollutants (e.g., carbon dioxide, nitrogen oxides, particulate matter) into the atmosphere.
- Explain the connection between these pollutants and environmental issues like global warming, acid rain, and respiratory problems.

Activity:

- Divide the class into small groups and provide them with scenarios related to combustion activities (e.g., burning of fossil fuels, forest fires).
- Instruct each group to discuss and evaluate the potential environmental impact of the combustion activity presented in their scenario.
- Have the groups present their findings to the class and discuss ways to mitigate the negative effects of combustion-related environmental impacts.

Extension:

To extend the lesson, students can research and present on alternative and renewable energy sources that produce fewer emissions than traditional combustion processes, investigate ways to promote energy efficiency and reduce fossil fuel consumption, or analyse real-world case studies of combustion-related environmental issues and solutions.

Homework:

Workbook page 50 and questions from the student book.

6.8 Review Answers

Student Book pages 112–113

Student Book answers

1	a	Physical	[5]
	b	Chemical	
	c	combustion	
	d	rusting	
	e	combustion	
2	a	physical	[9]
	b	conductor	
	c	malleable	
	d	ductile	
	e	independent	
	f	dependent	
	g	alloy	
	h	brittle	
	i	insulator	
3	a	good conductor of heat	[1]
	b	a good conductor of electricity	[1]
	c	sonorous	[1]
	d	strong	[1]
4	a	It melts at 1063°C	[1]
	b	It is a good conductor of electricity It is a good conductor of heat	[1]
	c	It is always shiny.	[1]
	d	It melts at 1063°C. It is a good conductor of electricity.	[1]
	e	Because it is very costly.	[1]
5	a	Oxygen and water	[2]
	b	Corrosion	[1]
	c	For example, paint the sign	[1]
6	a	combustion	[1]
	b	rusting	[1]
	c	combustion	[1]
7	a	Because bar graphs are useful for clearly comparing larger changes in data while line graphs are good for comparing continuous smaller changes.	[1]

<table>
<tr><td></td><td>b</td><td>42</td><td>[1]</td></tr>
<tr><td></td><td>c</td><td>58</td><td>[1]</td></tr>
<tr><td></td><td>d</td><td>Iron, Sodium, Aluminium, Gold, Copper</td><td>[2]</td></tr>
<tr><td></td><td>c</td><td>Because it is costly.</td><td>[1]</td></tr>
<tr><td>8</td><td></td><td>
<table>
<tr><th>Example</th><th>Physical/Chemical Change</th></tr>
<tr><td>Combustion</td><td>Chemical change</td></tr>
<tr><td>Condensation</td><td>Physical change</td></tr>
<tr><td>Melting</td><td>Physical change</td></tr>
<tr><td>Freezing</td><td>Physical change</td></tr>
<tr><td>Formation of sulphur dioxide</td><td>Chemical change</td></tr>
<tr><td>Rusting</td><td>Chemical change</td></tr>
<tr><td>Formation of ions</td><td>Chemical change</td></tr>
</table>
</td><td>[7]</td></tr>
</table>

7.1

Speeding up dissolving – 1

Student Book pages 114–115

Extension:

To extend the lesson, students can research and present on other solvents and their solubility characteristics, investigate the factors that influence solubility (e.g., temperature, pressure), or conduct experiments to explore the solubility of different solutes in various solvents.

Homework:

Workbook page 51 and questions from the student book.

7.1 Student Book answers

1. A solution is a mixture that forms when a substance dissolves in a liquid forming a uniform composition. Solute is the substance that dissolves. Solvent the liquid that the solute dissolves in
2. Sugar dissolves when sugar particles leave the surface of the grains and mix with water. This happens more quickly if you stir the mixture.
3. Dissolving speed increases with the increase in temperature.
4. Encourage students to provide a well reasoned answer based on their learning.

Objectives

- Demonstrate the process of solution formation (using water as universal solvent).
- Distinguish among solute, solvent and solution; saturated and unsaturated solution.
- Identify ways of accelerating the process of dissolving materials in a given amount of water and provide reasoning (i.e., increasing the temperature, stirring, and breaking the solid into smaller pieces increases the process of dissolving).

Overview

Students will demonstrate the process of solution formation using water as the universal solvent. They will learn to distinguish between solute, solvent, and solution, as well as recognize the differences between saturated and unsaturated solutions.

Activities

- Begin the lesson by asking students what they know about solutions and how they are formed.
- Introduce the concept of a solution as a homogenous mixture where one substance (solute) dissolves in another (solvent).
- Explain that water is a universal solvent because it can dissolve a wide range of substances.
- Set up a demonstration of solution formation using water as the solvent and different solutes (e.g., sugar, salt, food coloring).
- In separate clear containers, add water and a small amount of each solute, stirring to help the solutes dissolve.
- Observe the solute particles mixing uniformly with the solvent (water) to form solutions.
- Define solute as the substance that dissolves in a solvent to form a solution.
- Define solvent as the substance that dissolves the solute to form a solution.
- Use visual aids and examples from the demonstration to help students understand the differences between solute, solvent, and solution.
- Introduce the concept of saturation in solutions, explaining that a saturated solution contains the maximum amount of solute that can be dissolved in a given amount of solvent at a specific temperature.
- Discuss how adding more solute to a saturated solution will not dissolve, and any excess will remain undissolved at the bottom of the container.
- Present the concept of an unsaturated solution as one where more solute can still dissolve in the solvent at a given temperature.
- Use examples and visual aids to illustrate the differences between saturated and unsaturated solutions.

Activity: Classifying Solutions

- Divide the class into small groups and provide them with scenarios and descriptions of different solutions.
- Instruct each group to determine whether the solutions are saturated or unsaturated based on the information provided.
- Have the groups present their classifications and explain their reasoning.

- Summarize the main points of the lesson, emphasizing the process of solution formation using water as the universal solvent.
- Review the definitions of solute, solvent, and solution, as well as the differences between saturated and unsaturated solutions.
- Encourage students to observe and explore the formation of solutions in their daily lives and consider the factors that affect solubility.

7.2

Speeding up dissolving – 2

Student Book pages 116–117

Extension:

To extend the lesson, students can research and present on other factors that influence the dissolving process, investigate the impact of solute concentration on dissolving rates, or conduct experiments with different solvents to compare their dissolving capabilities.

Homework:

Workbook page 52 and questions from the student book.

Objective

- Identify ways of accelerating the process of dissolving materials in a given amount of water and provide reasoning (i.e., increasing the temperature, stirring, and breaking the solid into smaller pieces increases the process of dissolving).

Overview

Students will identify and understand ways of accelerating the process of dissolving materials in a given amount of water, including increasing the temperature, stirring, and breaking the solid into smaller pieces. They will explore the scientific reasoning behind these methods and recognize their practical applications in everyday life.

Activities

- Begin the lesson by asking students what they know about dissolving and how substances dissolve in water.
- Introduce the concept of dissolving as the process where a solid (solute) mixes uniformly with a liquid (solvent) to form a solution.
- Explain that dissolving is an essential process in various applications, such as cooking, cleaning, and medicine.
- Present visual aids and real-life examples to show how temperature, stirring, and surface area influence the dissolving process.
- Discuss how increasing the temperature of water can speed up the dissolving process
- Explain that stirring helps distribute the solute particles evenly in the solvent, facilitating faster dissolving.
- Show how breaking a solid into smaller pieces increases its surface area, leading to faster dissolving because more particles are exposed to the solvent.
- Divide the class into small groups and provide them with containers, water, and different solutes (e.g., sugar, salt).
- Instruct each group to set up three separate experiments using cold water, warm water, and hot water, and measure the time taken for each solute to dissolve.
- Have the groups stir one container while leaving the other unstirred to observe the difference in dissolving rates.
- Finally, provide solid sugar in different forms (e.g., sugar cubes and granulated sugar) and observe the dissolving rates for each form.

7.2 Student Book answers

1. **a.** Stirring **b.** temperature **c.** grain size of solute
2. Approximately 1 min 7 seconds
3. Using smaller pieces of solute speeds up dissolving.

Data Collection and Analysis :

- Have each group record their observations and time measurements in a table.
- Facilitate a class discussion where each group presents their findings and draws conclusions about the effects of temperature, stirring, and surface area on the dissolving process.
- Summarize the main points of the lesson, emphasizing the importance of temperature, stirring, and surface area in accelerating the dissolving process.
- Discuss practical applications of these methods in various situations, such as cooking, making beverages, and preparing medications.
- Encourage students to think critically about the dissolving process in their daily lives and consider how these factors can be used effectively.

7.3 Solutions and concentration

Student Book pages 118–119

Prior learning

- Define and use the terms solution, solute, and solvent

Objective

- Explain what is meant by concentrated and dilute solution.

Overview

The lesson begins by considering examples of everyday solutions, and revising key terms. Having been introduced to the terms *concentrated* and *dilute*, students then make and evaluate physical models to show the particles in dilute and concentrated solutions. The lesson finishes with a consideration of circumstances in which the concentration of a solution is changed for a specific purpose.

Activities

- Show students a bottle of vinegar. Elicit that vinegar is a solution. Ask student pairs to name as many other solutions as possible. Possible answers include fruit drinks, tea, coffee, cola, and seawater.
- Student pairs carry out the card matching activity to check that they can remember key words about solutions.
- Display dilute and concentrated tea (in transparent cups or glasses). Student pairs discuss the similarities and differences between the two cups of tea. Elicit that the paler-coloured tea is a dilute solution and that the darker colour tea is a more concentrated solution.
- Use the particle diagrams shown in the Student Book to explain the key difference between a dilute solution and a concentrated solution of the same substance.
- Student pairs to make physical models to show the particles in dilute and concentrated solutions. The worksheet guides them in evaluating the model.
- Finish the lesson by reading the *Science in context* box which describes how diluting a solution can reduce the risk of harm from the solution. Ask student pairs to think of other examples of situations in which it is useful to change the concentration of a solution.

Extension

Devise and evaluate a different physical model to explain dilute and

7.3 Student Book answers

1. A measure of the number of solute particles in a volume of a solution.
2. Diagram with more darker blue circles but with the same (or similar) number of circles in total.
3. It is easier to handle water safely, compared to an alkali. / The reaction of a concentrated acid with an alkali might be dangerous.
4. Hydrogen, sulfur, and oxygen

concentrated solutions.

Homework

Workbook page 53.

Key words

concentration, dilute, concentrated

7.4 How much salt is in the sea?

TWS

Student Book pages 120–121

Prior learning

- Seawater is a solution of salt in water.
- Salt may be obtained from seawater by evaporation.

Objective

- Recognize that the amount of solute which dissolves in a given solvent has an upper limit at a given temperature.

Overview

This is a lesson that helps students develop their skills in Thinking and working scientifically.

This lesson focuses on enquiry skills. Through part-planning and carrying out an investigation to find the percentage by mass of salt in seawater, students practise the skills of selecting ideas to, controlling risk, taking accurate measurements, using equipment correctly, making simple calculations, and making a conclusion.

If seawater is not available, make a substitute by dissolving about 35 g of sodium chloride in 1 dm^3 (one litre) of tap water. The investigation gives better results, and is safer, if the solution is heated to remove most water, but then left in a warm, dry place for the remaining water to evaporate slowly.

Activities

- Display some table salt (sodium chloride). Elicit that the salt is sodium chloride, NaCl. We obtain most of it from seawater or rock salt. Pairs discuss how salty the sea is – for example, how much salt is in a glassful of seawater? How could they find out how much salt is in all the seawater in the world?
- Ask how we could find the percentage by mass of salt in seawater. Elicit that we could take a known mass of seawater, evaporate the water, and find the mass of solute remaining. Most – but not all – the solute is sodium chloride.
- Students do an investigation to find the percentage by mass of salt in seawater, including writing a risk assessment and choosing apparatus.
- Gather results from all groups. Students speculate on reasons for differences, and suggest improvements to the investigation.

Extension

Students use the Internet to find out more about salts in the oceans, and their different total concentration in different regions.

Homework

Workbook page 54.

Key words

hazard, risk assessment

7.4 Student Book answers

1. Hazard – a possible source of danger; risk – the chance of injury from a hazard.
2. 19 cm^3
3. To make the results reliable and to calculate a mean, which is probably more accurate than a single result.
4. 35,000,000,000 kg/km^3 × 200,000 km^3 = 7,000,000,000,000,000 kg

7.5
Chlorine and water

SIC

Student Book pages 122–123

Prior learning

- Scientists carry out investigations, analyse the evidence, and make conclusions.

Objective

- Evaluate an issue that requires science understanding.

Overview

This is a lesson that helps students develop their understanding of Science in context.

Students read about a scientific study on the effects of chlorinating water. In groups of three, they create a radio programme to tell listeners about the study and its findings. Students then discuss how they can persuade people of the importance of drinking clean water.

Activities

- Ask students what may happen if they drink dirty water. Elicit that untreated water spreads diseases such as cholera, typhoid, and dysentery.
- Students read about the scientific study on the effects of chlorinating water described in the Student Book. In groups of three, they plan to create a radio programme or podcast to tell listeners about the study and its findings.
- Student groups perform or play their radio programmes or podcasts to at least one other group. The listening groups evaluate the programmes.
- Student pairs discuss how they can persuade people why it is important to drink clean water.

Extension

Use the Internet to research the chlorination of drinking water in more detail. Start by looking at the World Chlorine Council and navigating to resources.

Homework

Workbook page 55.

7.5 Student Book answers

1. Prevents diseases such as dysentery, diarrhoea, cholera, and typhoid.
2. THCs may form in the water. These may increase the risk of cancer.
3. It would have taken too long to collect the data.

7.6
Solubility

Student Book pages 124–125

Objectives

- Distinguish among solute, solvent and solution; saturated and unsaturated solution.
- Recognize that the amount of solute that dissolves in a given solvent has an upper limit at a given temperature.
- Define solubility.
- Identify the factors which affect the solubility of a solute in a solvent and recognize the importance of these factors in homes and industries.

Prior learning

- Define and use the terms solution, solute, and solvent.

Overview

The lesson begins with demonstrations of the amount of sugar in cola and the amount of sugar required to make a saturated solution in 100 g of water. Students then draw solubility bar charts, and make conclusions from these. Finally, there is a card matching activity to revise key words about solutions.

Activities

- Display a bottle of cola. Ask students to guess how many teaspoonfuls of sugar are in the drink. Then show the answer by measuring out the appropriate amount of sugar. [A 330 ml bottle of cola contains about 40 g of sugar, which is about 10 teaspoonfuls.] Elicit the health problems linked to consuming large amounts of sugar.
- Demonstrate adding sugar (sucrose) to 100 cm^3 of water, one spoonful at a time. Students guess how many spoonfuls will dissolve. At 25 °C, 200 g of sugar dissolves in 100 cm^3 of water. This is approximately 40 teaspoonfuls. Explain the terms *saturated solution* and *solubility*.
- Students draw solubility bar charts, using data from a secondary source. They make conclusions from this data.
- Students read about data from secondary sources on Student Book page 138. Elicit examples of trustworthy data sources.
- Finish the lesson with the card matching activity to revise key words.

Extension

Students answer question 4.

Homework

Workbook page 56.

Key words

solubility, saturated solution

7.6 Student Book answers

1. Solubility – the maximum mass of a substance that dissolves in 100 g of water; saturated solution – a solution that contains the maximum mass of solute that will dissolve.
2. a. Lithium chloride
   b. Sodium chloride
   c. 72 or 73 g/100 g of water
3. As temperature increases, solubility increases. The solubility more than doubles from 20 °C to 100 °C.
4. At 0 °C, their solubilities are similar (between 10 and 20 °C). Between 0 and 10 °C, the solubility of potassium nitrate increases greatly and the solubility of cerium(III) sulfate decreases greatly. From 20 °C upwards, the solubility of potassium nitrate continues to increase, but the solubility of cerium(III) sulfate changes little.

7.7 Investigating solubility and temperature – 1

TWS

Student Book pages 126–127

Prior learning
- Solubility is the mass of substance that dissolves in 100 g of water.

Objective
- Identify the factors that affect the solubility of a solute in a solvent.

Overview
This is a lesson that helps students develop their skills in Thinking and working scientifically.

The purposes of this lesson are to practise planning investigative work and to obtain evidence about the relationship between temperature and solubility for one solute. The lesson starts with a reminder that the solubility of sugar increases with temperature. Students then carry out these stages of an investigation: making a prediction, considering variables, choosing equipment, choosing apparatus, planning how to obtain data, recording data, and carrying out the investigation. The investigation continues the next lesson.

Activities
- Display hot and cold cups of tea. Elicit that more sugar dissolves in hot tea. This illustrates that the solubility of sugar increases with temperature. Point out that the relationship between solubility and temperature is different for different solutes.
- Student pairs plan an investigation on the effect of temperature on the solubility of a particular substance. It would be useful to display the apparatus. Suitable solutes include sodium hydrogencarbonate, potassium chloride, or ammonium chloride.
- Students carry out the investigation and record their data in a table. Tell students that they will analyse their data and make conclusions next lesson.

Homework
Workbook page 57.

7.7 Student Book answers
1. Independent variable – the variable to change; dependent variable – the variable to observe or measure.
2. Na_2CO_3
3. So that the investigation is a fair.
4. The measuring cylinder can measure smaller differences in volume.
5. Water temperature (°C) in left column; mass of sodium carbonate that dissolves (g) in right column.

7.8

Investigating solubility and temperature – 2

TWS

Student Book pages 128–129

Objective

- Identify the factors that affect the solubility of a solute in a solvent.

Overview

This is a lesson that helps students develop their skills in Thinking and working scientifically.

In this lesson, students continue the investigation they started in lesson 8.8. They decide whether to present their evidence in a line graph or bar chart, and then produce line graphs. Students then write a conclusion for the investigation, and discuss what to do about any results that do not fit into the pattern.

Activities

- Discuss the evidence obtained in previous lesson. Is it easy to make conclusions from the evidence presented in tables? Elicit that it would be better to present the evidence graphically.
- Student pairs discuss whether to draw bar charts or line graphs. Tell students that bar charts are suitable if the variable you change is discrete. Line graphs are suitable if the variable you change is continuous. In this investigation, line graphs should be drawn.
- Students draw line graphs and write conclusions for their investigations.
- Student pairs discuss any anomalous results, and possible reasons for these.
- Student pairs evaluate their investigations by discussing limitations and suggesting improvements.
- Tell students that they have drawn a solubility curve. Point out that every substance has its own solubility curve. There are examples of solubility curves in the Student Book. In turn, ask a few students to describe one solubility curve each.

Extension

Answer the questions in the spread.

Homework

Workbook page 58.

7.8 Student Book answers

1. A variable that can have any numerical value.
2. 42 g/100 g of water

7.9

Factors affecting solubility

Student Book pages 130–131

Objectives

- Identify the factors that affect the solubility of a solute in a solvent and recognize the importance of these factors in homes and industries.
- Make a rock candy with sugar using crystal seeding technique (STEAM).

Overview

Students will understand how temperature and pressure affect the solubility of gases in liquids. They will explore the scientific principles behind these effects, conduct experiments to observe gas solubility under different conditions, and apply their knowledge to real-world scenarios.

Extension:

To extend the lesson, students can research and present on the factors that affect gas solubility in specific liquids, investigate the solubility of different gases under varying conditions.

Homework

Workbook page 59.

7.9 Student Book answers

1. Solubility of solids increases with the increase in temperature.
2. Solubility of solute in gaseous state decreases as temperature increases.
3. Carbon dioxide is more soluble at 40 °C than at 60 °C
4. The solubility of a gas increases as pressure increases.

Introduction:

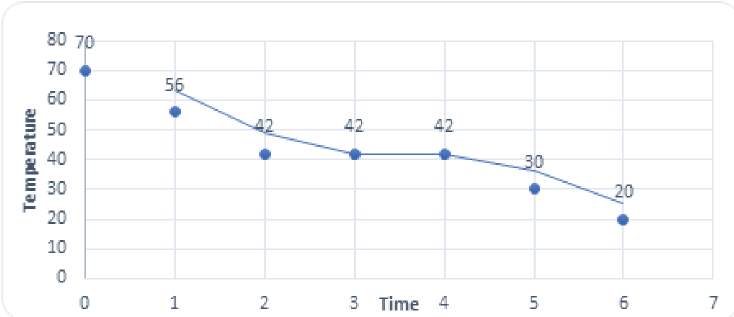
- Begin the lesson by asking students what they know about gas solubility and how gases dissolve in liquids.
- Introduce the concept of gas solubility as the ability of a gas to dissolve in a liquid to form a homogeneous mixture (solution).
- Explain that temperature and pressure are critical factors that influence the solubility of gases in liquids.
- Gases are different from liquids .If the solute is in the gas state, solubility decreases as temperature increases. So more gas dissolves at 10 °C than at 30 °C. Display graph showing the pattern for the gas in fizzy drinks, carbon dioxide.
- The pattern explains why, if a fizzy drink gets warm, more bubbles come out. If the drink is in a sealed bottle, the gas stays in the bottle, under the lid.
- The Effect of Pressure on Gas Solubility: Present visual aids and real-life examples to demonstrate the impact of pressure on gas solubility.
- Discuss how increasing pressure forces more gas particles into the liquid, leading to higher solubility.
- Show how decreasing pressure causes gas particles to escape from the liquid, resulting in lower gas solubility.
- Summarize the main points of the lesson, emphasizing how temperature and pressure influence gas solubility in liquids.

7.10 Review Answers

Student Book pages 132–133

Student Book answers

1	a	Pure	[6]
	b	Purity	
	c	Dilute	
	d	Concentrated	
	e	Concentration	
	f	Solubility	
2	a	Time	[1]
	b	Temperature	[1]

	c		[3]
	d	42 °C	[1]
	e	At first, the particles are moving from place to place, sliding over each other and their arrangements are random and changing. Then the movement of the particles slows down and the particles start vibrating on the spot in fixed positions.	[3]
3	a	Boiling	[1]
	b	The result at 1.5 minutes	[1]
	c	Any sensible suggestion	[1]
4	a	**i.** Temperature **ii.** Mass of potassium chloride that dissolves **iii.** Volume of water and amount of stirring	[1] [2] [1]
	b	The prediction is correct because the graph shows that, as temperature increases, the mass of potassium chloride that dissolves increases	[1]
	c	Both variables are continuous	[1]
5	a	Lithium bromide	[1]
	b	Copper sulphate	[1]
	c	72g	[2]
	d	16g	[2]
6	a	It has more water and less solute than a concentrated solution.	[1]
	b	stirring affects the speed of dissolving	[1]

8.1
Hot and cold

Student Book pages 134–135

Prior learning
- Investigate how materials change when they are heated and cooled

Workbook page 60.

Key words
heat, thermal energy, temperature, thermometer, degrees Celsius (°C), heat dissipation

Objectives
- Compare all three scales of temperature (including inter-conversion of temperature scales).
- Define the terms heat and temperature on the basis of Kinetic Molecular Theory.
- Differentiate between heat and temperature on the basis of particle theory.

Overview
In this lesson students learn the difference between thermal energy and temperature. They build on their experiences of heating and cooling materials. They start by learning how unreliable our skin is at detecting temperature, and hence the need for a thermometer. They learn that we measure temperature on the Celsius scale, and the temperatures that they might expect to find in everyday situations. In an experiment to heat water they learn that the temperature that water achieves depends not only on the length of time of heating, but on the mass of water being heated.

Activities
- Ask students to put one hand in hot water and the other in cold water for 1 minute, and then both in lukewarm water. This leads them to understand that feeling hot and cold is relative, so a better way of assessing the degree of hotness of an object is necessary. Ask for suggestions to do this. Show different types of thermometer. Mention the Celsius scale (°C). Get them to guess the temperature of each bowl. They will be surprised at the low temperature of the hot water.
- Students heat various masses of water and investigate how the temperature changes **Important:** Ensure that appropriate measures are taken make sure that there is a very low risk of injury. **(Safety: Ensure students wear goggles. The heating equipment and water will get hot. Ensure students allow all equipment to cool down before attempting to move it. For the extension activity, check the hazards involved in heating a different liquid.)**
- Students discuss the results and elicit the link between mass, temperature, and thermal energy. For extension students, discuss that the type of liquid is also a factor.
- Students can be guided to a conclusion that doubling the volume of water should halve the final temperature. This is unlikely to be the case, and is a good example of the dissipation of energy. Define dissipation and discuss how energy has been dissipated in this experiment.
- Students model the particles in a solid, liquid, and gas**. (Safety: Ensure students take care to keep the marbles in the tray.)**
- Demonstrate the movement of marbles in a tube with a piston (see the figure in the lesson plan for Unit 6.17 on page 67).
- Ask students to compare and contrast the two models**.**

Extension
Students heat a different liquid and suggest reasons for any differences.

Homework

8.1 Student Book answers
1. Temperature is a measure of how hot or cold something is. Thermal energy is related to how fast particles are moving or vibrating.
2. faster, gas, solid, hot, cold
3. **a.** 68°F.
   b. 263 kelvin.
   c. 5° C.
4. Because there are more particles in 1 kg of water so it takes more energy to get them moving faster.

8.2

Thermal expansion and contraction

Student Book pages 136–137

Prior learning

- Define the terms heat and temperature on the basis of Kinetic Molecular Theory.
- Differentiate between heat and temperature on the basis of particle theory.

8.2 Student Book answers

1. Expand, contracts, faster/ more, apart, slower/less close.
2. The forces between the particles in a liquid are less than in a solid. This means that as the particles are heated they can move further apart and so the substance expands more.
3. In the summer the cables have expanded ad so are longer this is why they hang lower OR In the winter the cables have contracted and so are shorter this is why they are tighter
4. The lid expands more than the glass in the hot water. This loosens the lid.

Objectives

- Describe the expansion of the three states of matter on heating, and contraction on cooling, in terms of particles.
- Identify the effects of thermal expansion and contraction with their applications in daily life.

Overview

This lesson helps students identify thermal expansion and contraction in daily life. They are introduced to the inference that generally, solids, liquids, and gases expand when heat energy is absorbed and contract when heat energy is given out. They are reminded of the particle theory of matter and encourage to make observations of the expansion or contraction of metals in their daily life.

Activities

- Begin by introducing the concept of heat and temperature to the students. Explain that heat is a form of energy that is transferred from one body to another as a result of a difference in temperature. Temperature, on the other hand, is a measure of the average kinetic energy of the particles in a substance.
- Use particle theory to remind them how heat causes the particles in a substance to move faster, increasing their kinetic energy and thus raising the temperature.
- Next, introduce the concept of thermal expansion. Explain that when a solid is heated, its particles gain kinetic energy and begin to vibrate more vigorously. This increased motion causes the particles to move slightly further apart, resulting in an overall expansion of the solid.
- Demonstrate the expansion of solids, using a metal ball and ring setup. Show the students how before heating, the metal ball is able to go through the ring. Ask them to predict what will happens when we heat the metal ball to high temperature. Remind them that heat gain causes expansion and heat loss causes contraction. Use a thermometer to measure the temperature change.
- After hearing their predictions, heat the metal ball and show that it expands and can no longer fit through the ring. Ask the students to relate this phenomenon to thermal expansion. Discuss how this phenomenon can have practical applications, such as in the design of bridges and other structures that must account for changes in temperature. You could also demonstrate how a thermometer works by showing how the liquid inside expands when heated, causing it to rise up the tube.

Homework

Workbook page 61.

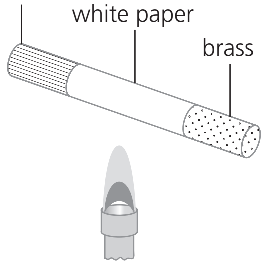
Key words

Conduction, convection, radiation, kinetic energy, convection current, thermometer, expansion, contraction, thermal, insulator, conductor, temperature, heat gain, heat loss, poor absorber/ reflector.

8.3

Energy transfer: Conduction

Student Book pages 138–139



Key words

conductor, insulator

8.3 Student Book answers

1. a. Thermal energy is transferred much more quickly in a conductor than in an insulator.
   b. Metals are conductors; plastics, wood, and trapped air are insulators.
2. It would take a very long time to heat the water.
3. a. The trapped layer of air is an insulator.
   b. Drysuits. Air will be a better insulator because the particles are farther apart.
4. It doesn't trap 'heat'. It traps air and air is not a very good conductor of thermal energy/is an insulator.

Objectives

- Construct the concept of heat conduction, convection and radiation by applying particle theory including daily life examples .
- Explain why metals are good thermal conductors and fluids are poor conductors of heat using the particle model.

Overview

This lesson introduces students to energy transfer by conduction. They discover that all good conductors are solid and that the best conductors are metals. The mechanism of conduction is to be linked to particle motion. The students learn many applications of good and bad thermal conductors and that air is a poor conductor. They will link the idea of particle motion to convection in the next lesson.

Activities

- Show that metal is a better conductor of heat than wood using a rod that is one half metal and the other wood, with paper wound tightly around the central area. Warm around the centre by rotating it above a *gentle* Bunsen flame. The paper will char a little but take care not to set it alight!
- Some students can be asked to feel either end of the rod and report what they notice. Ask students what they think is happening. Establish that thermal energy travels along metal more easily than along wood, so the paper wrapped around the metal is not scorched. Introduce the words *conductor* and *insulator*.
- Students write a list of places where it is important to have good insulators and a list of places where it is important to have good conductors. Elicit the fact that good conductors are usually metal.
- Discuss, in terms of particles, how energy is transferred from one end of the rod to the other. The students could make a model of a solid by standing in line. As one end is heated the particles vibrate more and this vibration is transferred along the rod. Ask students how they could demonstrate this in the way that they move. Bring out the link between electrical conductors and thermal conductors. Explain that electrons in metals transfer energy, and produce a current when they move.
- Pass around materials that are used to insulate (to keep hot things hot or cold things cold). Elicit the observation that they have pockets that trap air, and explain that air is a very poor conductor.
- Demonstrate that water is a poor conductor by taking a test tube of water containing some ice trapped at the bottom by a small piece of gauze, or similar, and heating it at the top. The water at the top boils but the ice does not melt.
- Students make a table of conductors and insulators and where they are used and why.
- Students learn that materials that feel warm are insulators because they do not transfer energy quickly. They investigate ice melting on conductors and insulators, which produces a counterintuitive result, Alternatively, this activity could be demonstrated.

Homework

Workbook page 62.

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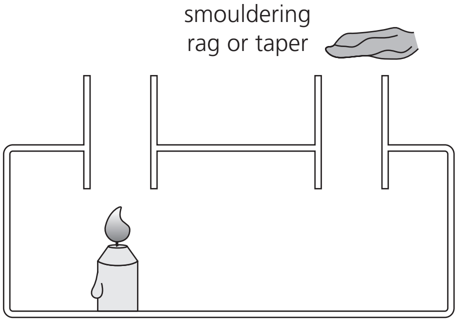
8.4

Energy transfer: Convection

Student Book pages 140–141



Objective

- Construct the concept of heat conduction, convection and radiation by applying particle theory including daily life examples .

Overview

The lesson introduces students to energy transfer by convection. They observe convection currents in liquids and gases, and discover that though liquids and gases do not transfer energy well by conduction they do transfer energy by convection. They explain convection in terms of density and the particle model. They consider some applications of convection and learn how convection currents are formed.

Activities

- Show short video clips of birds and gliders. Ask students to suggest how they do it. They may not come up with the correct answer, but it will get them thinking and you will return to this later in the lesson.
- Remind them that they saw energy transferred by conduction in solids last lesson, and they learned that liquids and gases are not good conductors. They do an experiment to find out what happens when they heat a liquid and to demonstrate that the same thing happens in air **(Safety: Ensure students wear goggles. The equipment will get hot – they should allow the equipment to cool down before moving it. Take care with hot water. Check hazards involved in handling potassium permanganate. Ensure students take care not to set fire to the paper.)**
- Demonstrate the same effect in air using a box containing a candle and some smouldering paper (see diagram on the left).
- Discuss the extent to which the two experiments show the same thing. Introduce the idea that the movement of the air/water is to do with density. Hold a cork underwater and let it go. Elicit that it moves up because it is less dense, so it floats up. This is what happens in a liquid. As the liquid gets hotter it becomes less dense, rises, then cools and sinks, and this makes a convection current.
- Demonstrate a convection current in water very clearly using a large glass bowl of water, a small bottle of coloured water, and some coloured ice cubes. You can find detailed instructions online, for example at https://www.thenakedscientists.com/get-naked/experiments/wind-bowlconvection.
- Students work through using the idea of density to explain convection.
- Students design a poster that explains how convection keeps a refrigerator cold.
- Return to the videos of the birds and gliders and ask students to explain what is happening.

Homework

Workbook page 63.

Key words

convection, convection current, thermal

8.4 Student Book answers

1. In conduction, thermal energy is transferred because particles in a solid are close to each other, so when the solid is heated the increased vibrations of the particles are transferred. In convection the gas or liquid moves when it is heated.
2. When you heat a gas the particles in it move further apart, so the gas becomes less dense and rises.
3. **a.** anticlockwise
   b. The air near the equator will rise because it is hotter. It will be replaced by cooler air drawn in from away from the equator.

8.5

Energy transfer: Radiation

Student Book pages 142–143

Objective

- Construct the concept of heat conduction, convection and radiation by applying particle theory including daily life examples .

Overview

This lesson introduces the idea of energy transfer by infrared radiation. Students look at thermal images and learn how they show temperature variation. They consider how thermal transfer is different from conduction and convection, and complete an investigation into which material absorbs infrared radiation fastest. They apply their knowledge to the Earth as a whole and explain what is happening in the greenhouse effect.

Activities

- Show some thermal imaging photographs and explain the colour coding. Remind them that thermal radiation is known as infrared radiation or infrared.
- Use an infrared thermometer, if available, to show that a hot object (kettle, person) produces infrared.
- Energy reaches us from the Sun by infrared. Discuss whether this transfer is like conduction or convection. Elicit that it must be different because there is a vacuum in space and the other methods require a medium. Set up a large plastic bottle filled with CO_2 (from e.g. antacid tablet and water, or a carbonate/bicarbonate of soda and vinegar), and another with the same amount of water. Put thermometers through corks to seal the bottles and set in the sun or near an infrared lamp.
- Students complete an investigation into how different materials absorb infrared **(Safety: Ensure students do not touch the lamp.)** There is an element of experimental design, but students could be directed to do a particular experiment, or the class split into groups who do the experiment in different ways. Compare the results of the class and elicit that darker materials absorb infrared better than lighter materials. Discuss reflection and absorption.
- If available, boil water on a solar oven. A simple solar oven can be made by using a concave shape in sand, covering with foil, and suspending a pan of water at the focus. Take care with positioning of students – they should not be able to look into it or get near the focus. Look up hazards and take appropriate precautions. Go to www.nasa.gov and search for 'Solar Oven'.
- Students read the Student Book about the greenhouse effect. Look at the temperatures of the bottles you set up at the start of the lesson. Discuss the differences. They research the greenhouse effect, climate change, and global warming, and produce a leaflet for other students that explains what climate change is and how it is linked to greenhouse gases and infrared radiation. Find, and check for scientific reliability, some suitable sources to suggest beforehand (e.g. www.nasa.gov, www.esa.int/esaKIDSen/Earth.html).

Homework

Workbook page 64.

Key words

infrared radiation, medium, vacuum, greenhouse effect

8.5 Student Book answers

1. carbon dioxide, methane, water vapour
2. a. The thermal imaging camera absorbs infrared, not visible light.
   b. The person is not hot enough to emit visible light.
3. If the Earth emitted more radiation than it receives.

8.6

Insulating homes

Student Book pages 144–145

Prior learning

- the concept of heat conduction, convection, and radiation by applying particle theory including daily life examples.

Objective

- State and explain the practical methods of thermal insulation used for constructing buildings.

Overview

Introduce the students to the concept of energy as an amount that we can track, spend and overspend. Elicit consideration of energy transfers as either 'useful' or 'wasted' energy. Remind them to make observations in their daily life, keeping in mind the law of conservation of energy, and how that applies to the energy transfers that they have been investigating.

Activities

- Begin by reviewing the concepts of energy transfer, conservation of energy and wastage of energy in daily life. Ask the students to share possible modes of energy wastage and whether they can be curtailed and how. Introduce the concepts of insulation and how it can help reduce energy consumption and save money on heating and cooling bills in houses. Elicit the importance of heat insulation in homes.
- Explain the different types of insulation materials and their properties, such as fiberglass, foam board, and cellulose. Divide the class into small groups. Encourage students to be creative and design their own unique house.
- Instruct students to incorporate heat insulation mechanisms into their model houses. Suggest possible insulation mechanisms, such as, to the walls and roof, double-paned windows, or weather stripping of doors and windows.
- Once the model houses are complete, with the the heat insulation mechanisms, encourage each group to present their model and discuss in class: students to ask questions and provide feedback.
- Ask what would be the impact of adding renewable energy sources (such as solar panels or wind turbines) to power their model houses. Encourage a class discussion on the importance of energy conservation and ways that students can reduce their own energy consumption at home.

Homework

Questions from the student book spread. Also Workbook page 65.

Key words

Conduction, convection, radiation, kinetic energy, convection current, thermometer, expansion, contraction, thermal, insulator, conductor, temperature, heat gain, heat loss, poor absorber/ reflector radiator/ absorber, emitter.

8.6 Student Book answers

1. Hot air rises and is replaced by cooler air coming in through any gaps.
2. White is a good reflector of radiation keeping the buildings cooler.
3. Conduction is the transfer of energy through the vibrations of the particles in the substance. If there is a vacuum, there are no particles. Conduction cannot take place.
4. The insulation reduces the rate of thermal energy transfer. Energy is transferred from hot to cold. When it is hot outside it reduces the energy transfer to the inside. When it is colder outside it reduces the energy transfer to the outside.

8.7 Cooling by evaporation

Student Book pages 146–147

Objective

- Predict the effects of heat gain and heat loss.

Overview

This lesson introduces the idea of cooling by evaporation. Students learn that people have been using evaporating liquids to produce a cooling effect for a long time and investigate the cooling effect. They consider how refrigerators and coolers work by evaporating a refrigerant or water, and how evaporation helps animals to keep cool.

Activities

- Ask how people used to keep their houses or food cool before electricity allowed us to use fans, air conditioning, or refrigeration. Get students to wet their hands or use a drop of a volatile liquid (check for allergies) on the back of their hands. They should feel that their hands get cooler. Discuss why.
- Recap that the temperature of a liquid depends on speed of the molecules, or their average speed. Work through the example on pages 206–207 of the Student Book to introduce the idea that the average speed of molecules decreases because faster molecules leave.
- Students brainstorm the factors that might affect the rate that a liquid evaporates. Elicit temperature of the air/liquid, type of liquid, surface area, and breeze/wind. Students can hold wet hands in front of a fan to feel that that is the case. Discuss why a breeze affects the rate of cooling. Set up a demonstration to investigate the effect of the factors that they have identified. Measure a set amount of water into a petri dish and into a small beaker, and then repeat with fans pointing at the surface. Students note the starting temperature of each and the volume of water in each.
- While the water is evaporating students investigate the evaporation of types of liquids. They consider the method and the types of variables and how they were controlled.
- Return to the demonstration and students write the temperatures and volumes in their table. Discuss what they have found out.
- Students read pages of the Student Book about how coolers and refrigerators work. Students make a model of a refrigerator using card/paper/packaging, etc. They present their model to the class and explain how it works.
- Show pictures of different animals and ask student to explain how they use evaporation to keep cool.

Homework

Workbook page 66.

Key words

evaporation, average speed, evaporative cooling, refrigerator, refrigerant

8.7 Student Book answers

1. The faster particles escape. The slower particles remain.
2. When your hands are wet the thermal energy from your skin is transferred to the water and it evaporates. If thermal energy is transferred from your body to another object then you feel cooler.
3. If the air around a liquid is warmer then more thermal energy will be transferred to the liquid, so more particles will be travelling fast enough to escape. So the liquid will evaporate faster.
4. You need electricity to blow the cool air around the house.

8.8 Review answers

Student Book pages 148–149

Student Book answers

1	a	temperature	[1]
	b	energy	[1]
	c	more	[1]
2	a	The type of material and amount of the material.	[1]
	b	**C**, **A**, **B**	[1]
3	a	Metals are good conductors of thermal energy.	[1]
	b	They absorb infrared radiation more quickly than white clothes.	[1]
	c	The hot air expands, becomes less dense, and floats up.	[1]
	d	The feathers trap air and keep the bird warm because air is a good insulator of thermal energy.	[1]
4		° C K °F 10 283 50 60 333 140 -173 100 -279.4	[1] each
5	a	The one covered with black paper.	[1]
	b	The black paper will absorb the thermal energy from the lamp and the foil will reflect it.	[1]
6	a	Thermal energy is conducted through the cup to the table. The temperature of the tea goes down.	[1]
	b	The air above the hot tea and around the sides of the cup gets warmer, expands, and rises. Cooler air flows in to replace it, more energy is transferred to the air from the tea, and that air too gets warmer, expands, and rises, and so on. The temperature of the tea goes down.	[1]
	c	All hot objects emit radiation. The hot cup will radiate thermal energy. The temperature of the tea goes down.	[1]
	d	The lid would reduce the thermal energy transfer by convection.	[1]
7		At least six from: The particles in the metal tray vibrate. The hotter the tray, the more they vibrate. When the tray goes into the oven the metal heats up. The particles on the outside of the tray vibrate more. They pass the vibrations on. The tray reaches the same temperature as the inside of the oven. The tray is in thermal equilibrium. When you take the tray out of the oven it cools down. The energy moves from the thermal store of the tray to the thermal store of the air. The air heats up. The tray reaches the same temperature as the air. The particles in the tray vibrate less.	[6]

9.1

Introducing waves

Student Book pages 150–152

Prior learning
- Energy and types of energy
- Transfer of energy

Objectives

- Define a wave.
- Compare the types of waves(mechanical and electromagnetic) with daily life examples.
- Distinguish between Longitudinal & Transverse waves.

Overview

This lesson introduces the relationship between movement and energy transfer through the medium of wave. It defines the wave as a disturbance that travels through a medium, transferring energy from one point to another. As this results in the movement of particles in the medium and the transfer of energy through the wave.

Activities

- Ask students to recall the names of the different types of waves that they have heard of earlier. Explain that a wave is a disturbance that results in transfer of energy from one point to another. Discuss the two main types of waves: mechanical and electromagnetic. List their characteristics and encourage students to identify and provide examples of each type of wave from daily life, such as sound waves (mechanical) and light waves (electromagnetic).
- Explain that electromagnetic waves are created by the vibrations of electric and magnetic fields. These vibrations result in transfer of energy that can travel through space and carry information over long distances.
- Relate waves to vibrations, to discuss the difference between longitudinal and transverse waves. Use the visual aids in the students' book to help students understand how the particles in the medium move in each type of wave.
- Lead the students in a hands-on activity to further explore transverse waves using a slinky or rope, or observe longitudinal waves using a tuning fork and water.

Homework

Create a fish bone diagram to differentiate between the different forms of waves. Also Workbook page 67.

Key words

energy, potential energy, mechanical energy, renewable, non-renewable, conservation, solar, geothermal, stores of energy, energy supplies, fossil fuel.

9.1 Student Book answers

1. A wave transfers energy without transferring matter

2. Mechanical: A, B and D Electromagnetic: Light, Radio

3. a. Mechanical

b. Transverse because the vibrations are perpendicular to the direction of the wave.

c. The building will sway/move from side to side.

4. Space is a vacuum with very few particles. Mechanical waves could not reach earth from the Sun therefore must be electromagnetic waves.

9.2

Describing waves

Student Book pages 152–153

Prior learning

- Energy and types of energy
- Transfer of energy

Key words

energy, potential energy, mechanical energy, renewable, non-renewable, conservation, solar, geothermal, stores of energy, energy supplies, fossil fuel.

Homework

Workbook page 68.

Objectives

- Define the terms: wavelength, frequency and time period of a wave.
- Construct the inverse relation between time, period and frequency.

Overview

In this lesson students will be introduced to certain important properties of waves. They will learn how a wave's wavelength, frequency, and time period, help us wave behaviour and ability to transfer energy from one place to another.

Students learn the definitions and then the relationship between these terms. They will discover how time period and frequency are inversely related.

Activities

- Begin by reviewing the previous lesson. Ask the students to recall what they remember about the different types of waves. Next introduce the idea that all wave types share certain common characteristics, namely, wavelength, frequency, and time period. Provide their brief overview and definitions.
- Draw a waveform on the board and indicate the above on it. Ensure the students understand that difference between a wavelength and the amplitude of a wave. Explain that wavelength is the distance between two consecutive points on a wave that are in phase, frequency is the number of waves that pass a point in one second, and time period is the time it takes for one complete wave to pass a point.
- Divide the class into small groups and provide each group with a slinky or rope. Instruct students to create transverse waves by moving one end of the slinky or rope up and down.
- Set up the wave creation in water activity (as discussed in the book). Have students measure the wavelength of the wave by measuring the distance between two consecutive points on the wave that are in phase. Suggest they calculate the frequency of the wave by counting the number of waves that pass a point in one second. Encourage the students to calculate the time period of the wave. Explain that this is because time period and frequency are inversely related - as one increases, the other decreases.
- Suggest students to experiment with creating waves of different frequencies and calculating their time-period and wavelength. At the end of the activity, have each group share their observations with the class and discuss how changing the frequency affected the wavelength and time period of the wave.

9.2 Student Book answers

1. A and 3, B and 4, C and 2, D and 1

2. Amplitude increases and the frequency decreases

3. Frequency= 1/(Time period)=1/0.1 = 10 Hz

4. Frequency= 1/(Time period)

0.5 =1/(time period)

Time period = 2 Hz

Or only 0.5 of a wave passes every second so the time period must be 2 seconds.

9.3 Sound waves and how they travel

Student Book pages 154–155

Prior learning

- Identify many sources of sound
- Know that we hear when sound enters our ear
- Recognise that as sound travels from a source it becomes fainter

Key words

source, detector, vibrate, medium, vacuum, sound wave, compression, rarefaction, longitudinal wave, transverse wave

Objectives

- Compare the types of waves (mechanical and electromagnetic) with daily life examples.
- Explain the factors affecting pitch and loudness of sound.

Overview

In this topic students build on what they have learned about sound in earlier grades.

In this lesson students learn that all sounds are made by vibrations, even though those vibrations may not be observable. They examine various ways of making sounds to find out what is vibrating, and look at a wave on a Slinky spring as a model of a sound wave. This work links to the particle model, which is needed to explain how sound travels and why it doesn't travel through a vacuum.

Activities

- Students make a list of five different sounds that they have heard that day, and what makes those sounds. Elicit the fact that the common feature is that something is vibrating. If they gently touch their throat while they are speaking they should feel vibration.
- Introduce the idea of sound waves travelling from a source to a detector. To model what is happening when a sound wave travels through the air, use a Slinky to show how a wave moves along a spring. Recap the particle model of gases, solids, and liquids. Introduce the vocabulary of compressions and rarefactions. Discuss whether sound would travel fastest in solids, liquids, or gases, and why. Explore what would happen if there was no material there at all.
- If the equipment is available, demonstrate that sound does not travel through a vacuum by removing the air from a bell jar containing a ringing bell. If the equipment is not available then show a video.
- Students to consolidate ideas about sound travelling through different materials.

Extension

Students use a Slinky to make longitudinal and transverse waves.

Homework

Workbook page 69.

9.3 Student Book answers

1. Three things that vibrate (e.g. guitar, drum, bell).
2. Sound needs a medium to travel through because a sound wave is a disturbance of the medium/a vacuum contains no particles that can vibrate back and forth so cannot carry a sound wave.
3. Light travels faster than sound so the light reaches you before the sound does.
4. Sound travels slower in air than water because the particles are further apart in air so the disturbance/vibration is passed on slower in air. (This is why it is hard to tell where a sound comes from under water – it reaches both ears at nearly the same time.)

9.4 Detecting sounds

Student Book pages 156–157

Objectives

- Describe how the ear detects sound.
- Explain how your hearing can be damaged.
- Describe how a microphone works.

Overview

The ear is one way of detecting a sound wave. In this lesson students learn about the structure of the ear and ways in which its structures can be damaged, resulting in loss of hearing.

Students learn about the similarities between the ear and the microphone, another detector of sound.

Activities

- Ask students how much of your ear can be seen, and how much of the ear is inside your head. Demonstrate the inside of the ear using a model of the ear if available. If not, use a suitable animation to show the different parts of the ear.
- Students label the diagram of the ear and colour-code it to show the inner, middle, and outer ear. Then students should work out the order in which a sound wave reaches parts of the ear.
- Students read about how hearing can become damaged. They show the different ways that your hearing can change. They could write the possible damage next to the part of the ear or they could make a table in the space below.
- Demonstrate using a microphone to record sound on a computer. Use sound software such as Audacity (available to download free). Record a student speaking and play it back. Discuss what is happening inside the microphone for this to happen.
- Students consolidate what they have learned.

Homework

Workbook page 70.

Key words

outer ear, pinna, auditory canal, auditory nerve, eardrum, middle ear, oval window, inner ear, semicircular canals, cochlea, perforate, transducer, electrical signal, microphone, loudspeaker

9.4 Student Book answers

1. **a.** You could perforate your eardrum.
b. the eardrum

2. **a.** Both convert sound to an electrical signal; the ear is made of living tissue, whereas the microphone has wire and a magnet.
b. the diaphragm

3. Yes, a microphone converts a sound wave to an electrical signal, while a loudspeaker converts an electrical signal to a sound wave.

9.5i

Loudness and amplitude

Student Book pages 158–159

Prior learning

- Investigate the way that high and low sounds can be loud or soft

Objectives

- Define and relate:

  a. Pitch and frequency.

  b. Amplitude and frequency.
- Explain the factors affecting pitch and loudness of sound.

Overview

Due to complexity, this lesson is divided into 2 lesson plans, to better aid students to clarify concepts. Students learn about the properties of waves and how they can be shown on an oscilloscope. They learn how to define wave properties, and link the change in loudness to a change in amplitude. They investigate what happens to the sound when they put a box under an elastic band. They link their experiment with the design of real musical instruments.

Activities

- Use a rope or Slinky to demonstrate transverse waves. Discuss how you can make different waves and what would be different about them. Elicit the properties of waves.
- Students act out a 'Mexican' (stadium) wave around the classroom to demonstrate the different properties.
- Use a signal generator, loudspeaker, and oscilloscope to show a sound wave on the screen of the oscilloscope and hear it at the same time. Change the volume of the sound and elicit that the amplitude has changed. Demonstrate that a tuning fork sounds a lot louder if you put its base on a table rather than holding it in the air. Show the wave produced by the tuning fork in both places.
- Students answer the questions to demonstrate what they have learned so far.
- Display some images of stringed instruments. Most have a box underneath them. Ask students why. They investigate the effect of putting a box underneath an elastic band. **(Safety: Ensure students do not flick elastic bands)**. Discuss the results. The box will amplify the sound, just like an amplifier that is used at a concert.
- Students make and play a simple game to demonstrate their understanding of the waveforms on an oscilloscope. Emphasise that the pairs should have the same number of waves, but different amplitudes.

Extension

Students explain the difference between the wave on the string, the wave on the screen of the oscilloscope, and a sound wave travelling through the air in terms of their properties.

Key words

property, wavelength, amplitude, frequency, oscilloscope, amplifier

9.5 Student Book answers

1. Loud, soft/quiet, frequency, shorter
2. 512 times each second
3. Sketch the answer as per below parameters:
   a. Long wavelength large amplitude
   b. Short wavelength small amplitude
4. To make louder sounds the vibrations of the voice box/vocal cords must be bigger. This increases the amplitudes of the vibrations of the air.

   To make higher pitched sound the frequency of the vibrations must be greater/ more vibrations per second.

9.5ii

Pitch and frequency

Student Book pages 158–159

Prior learning

- Investigate the way pitch describes how high or low a sound is and that high and low sounds can be loud or soft
- Explore how pitch can be changed in musical instruments in a range of ways

Objectives

- Describe what affects the pitch of a sound
- Draw and interpret waveforms showing differences in frequency

Overview

Continuing from the previous lesson plan for the same unit, this lesson will build on the knowledge gained so far. Students will know that some sounds are high and some are low; this lesson establishes the link between pitch and frequency. Students learn that changing the frequency is distinct from changing the amplitude of a sound. They explore the range of human hearing and the range of hearing of other animals. They learn why musical instruments sound distinctly different. They learn that sounds with a frequency higher than 20 000 Hz cannot be heard by humans and are called ultrasound.

Activities

- Discuss what is meant by 'high' and 'low' notes, and how this property – pitch – is different from loudness.
- Use a signal generator, loudspeaker, and oscilloscope to show a sound wave on the screen of the oscilloscope and hear it at the same time. Change the frequency of the sound and elicit the description that there are more waves on the screen, so the frequency has increased.
- Students investigate the link between frequency, wavelength, and pitch by making a set of musical instruments using everyday objects. If tuning forks and simple music are available, they could play a song by tuning their instruments.
- Demonstrate the range of human hearing. Use a signal generator and loudspeaker to make a sound that everyone can hear. Then increase the frequency until students cannot hear it. Introduce the idea of ultrasound. Discuss the range of hearing in humans and in other animals. Students compare the ranges of hearing in other animals. Discuss the fact that your hearing changes as you get older, due to changes to the hairs in the cochlea. The shorter hairs that detect high frequency sounds do not work so well. You can link the frequency and length of hairs to frequency and the length of overhang of the ruler.
- Play the same note on lots of different musical instruments, record each one and compare them. This is possible with a microphone and an oscilloscope but is easier to see when you can record it. Use Audacity (free software available to download) to show the timbre of different instruments. Discuss why different instruments sound so distinct. The same note will have the same 'fundamental' frequency, with higher frequencies that make up the quality, or timbre, that makes each one distinct.
- Students consolidate what they have learned about frequency, pitch, and how waves are represented on a screen.

Homework

Workbook page 71.

Key words

frequency, pitch, ultrasound, audible range, fundamental, harmonics, timbre

9.6

Hearing, decibels, and risk

SIC

Student Book pages 160–162

Science in context

- Describe how people develop and use scientific understanding, as individuals and through collaboration, for example through peer review.

Prior learning

- Investigate the way pitch describes how high or low a sound is and that high and low sounds can be loud or soft. Secondary sources can be used
- Explore how pitch can be changed in musical instruments in a range of ways

Objectives

- Name the unit of sound intensity, or loudness.
- Describe some of the risks of loud sounds and how to reduce the risks.

Overview

This lesson helps students develop their understanding of science in context. In this lesson students learn about the decibel scale of sound intensity or loudness, and what it means. They investigate the loudness of sounds in the world around them and collect data using a sound-level meter. They learn about how loud sounds can damage hearing and how to reduce the risk of that damage. This lesson links together what they have learned about the ear, amplitude, and how sound is displayed on an oscilloscope.

Students consider how people can use this scientific understanding to evaluate the risks to their hearing and take steps to reduce those risks.

Activities

- Ask the students to think of the loudest sound they have ever heard (or even ask them to make a very loud sound!). Bang a drum softly, and then loudly. Ask a student to measure the loudness of the sound with a sound meter. Introduce the decibel as the unit of sound intensity or loudness. Distinguish between sounds that we like and noise that we don't like. Students make a decibel scale.
- Students investigate the sound levels in and around the classroom or other area and interpret them. **(Safety: Remind students to follow road safety rules if they record traffic noise.)**
- Students may be surprised to know that listening to music on earphones can be damaging to their hearing. Studies have shown that the risk of hearing loss is considerably increased by listening with earphones. Use this example to introduce the idea of risk, and the link to probability and consequence.
- Students make a list of all the different ways that you can protect your hearing. Students test ear plugs and homemade or commercial ear defenders.
- Students analyse the results of their experiment. Ask groups to come up with two ways that they could improve the test and feed those ideas back to the class.

Homework

Workbook page 72.

9.6 Student Book answers

1. **a.** decibel
   b. 100 times more intense
2. Two from: reduce the volume, reduce the time, listen through a loudspeaker, not earphones.
3. **a.** Two jobs carried out near loud noise, e.g. construction worker, working near planes.
   b. The continuous road noise could damage their hearing.

9.7

Review answers

Student Book pages 162–163

Student Book answers

1	**a**	**f**, **h**	**[1]**
	b	**d**, **g**	**[1]**
	c	**e**, **h**	**[1]**
2		**1 – C**, **2 – D**, **3 – B**, **4 – A**	**[1] each**
3	**a**	false	**[1]**
	b	true	**[1]**
	c	false	**[1]**
4	**a**	closer together	**[1]**
	b	closer together	**[1]**
	c	less	**[1]**
5	**a**	**B**, **C**	**[1] each**
	b	**D**, **F**	**[1] each**
	c	**A**, **E**	**[1] each**
	d	**E** The speed is larger when the particles are closer together	**[1]** **[1]**
	e	**D**	**[1]**
6	**a**	distance = speed × time = 330 m/s × 4 seconds = 1320 m	 **[1]** **[1]**
	b	She assumes that the light took no time to travel to her. It arrives immediately.	**[1]**
7	**a**	wave with a bigger amplitude (taller) but same frequency	**[1]**
	b	wave with a higher frequency (peaks closer together) but same amplitude	**[1]** **[1]**
8	**a**	400	**[1]**
	b	200	**[1]**
9		(see table below)	**[1] each**

Arrow	Wavelength	Amplitude	neither
A		✓	
B			✓
C		✓	
D	✓		
E			✓
f	✓		

10	**a**	There are 1500 vibrations or waves per second.	**[1]**
	b	The pitch would be higher.	**[1]**
11		**1 – D** **2 – C** **3 – A** **4 – B**	**[1] each**

10.1

Introduction to forces

Student Book pages 164–165

Prior learning

- Explore, talk about and describe the movement of familiar things
- Recognise that both pushes and pulls are forces
- Know that pushes and pulls are examples of forces and that they can be measured with forcemeters

Objectives

- Define and state the SI unit of force.
- Give examples of contact forces and non-contact forces.

Overview

This lesson builds on the understanding of forces that students gained in previous grades. It will enable them to recall the different types of forces, such as gravity, air resistance, and friction.

The main idea is that forces enable us to explain what is happening to an object. To explain motion, students need to be able to identify the forces acting on an object and the direction in which they act. Because forces are invisible, students need to be able to represent the forces acting on an object with an arrow, and to be able to label those arrows correctly. Students will be familiar with using a spring balance, or forcemeter, to measure forces. They should be aware that forces are measured in newtons.

Activities

- Ask students to recall the names of the different types of force. They may not have learned about the electrostatic force. How do we know that there are forces acting? Explain that forces act on objects and we can represent them with arrows.
- Students revise what they know about forces.
- Students examine different situations where there are forces acting. For each one they identify the type of force and the direction in which it is acting and sketch diagrams to show those forces. **(Safety: Be careful not to drop object on fingers or feet. Do not let go of the elastic band.)**
- Demonstrate the use of a spring balance to measure force. Show lifting an object to measure weight and pulling an object to measure friction.
- Demonstrate how other forcemeters/bathroom scales can be used to measure force, for example, pushing bathroom scales against a wall.
- Students make a table showing the different types of forcemeter and where you might use them.

Extension

Individually or in pairs, identify the link between the size of forces and the motion of the object, and to identify whether the forces acting on the object are the same size or different sizes.

Homework

Workbook page 73.

Key words

force, gravitational force, weight, electrostatic force, attraction, repulsion, magnetic force, friction, air resistance, water resistance, drag, thrust, upthrust, tension, spring balance, newton

10.1 Student Book answers

1. a. Three from: friction, air resistance, water resistance, thrust, upthrust, normal force/reaction, and tension.

b. Weight/gravitational force, electrostatic force, magnetic force.

2. A magnet can exert a force of attraction = a pull or a force of repulsion on another magnet = a push.

3. Three from: friction, air resistance, weight, thrust.

4. Gravitational force acts on all objects and is directed towards the centre of the Earth.

10.2

Action and reaction pairs

Prior learning

- Types of forces

Key words

force, push, pull, stretch, turn, force arrow, interact, balance, direction, magnitude, pressure, area, force, atmospheric pressure.

10.2 Student Book answers

1. Gravitational, down/ downwards, gravitational, up/upwards
2. The force of 10 N applied by the wall to the ball acting westwards
3. The fire extinguisher exerts a force on the foam pushing it in one direction. The foam exerts and equal and opposite force on the extinguisher and you. If you did not brace you might be pushed off balance/fall over
4. When you push down on the earth, the earth exerts and equal and opposite upwards force on you. This causes you to move upwards. The Earth moves downwards but not by much as it is much more massive than you.

Objective

- Demonstrate that forces always work in action and reaction pairs (equal in magnitude, opposite in direction).

Overview

In this lesson students will explore the concept of forces and how they work in pairs. Introduce the terms action and reaction forces, and how they are always equal in magnitude but opposite in direction.

It may be a good idea to relate this idea to Newton's Third Law of Motion, which states that for every action, there is an equal and opposite reaction. This means that whenever an object exerts a force on another object, the second object exerts an equal and opposite force back on the first object.

Activities

- Indicate to the students that they will be exploring the concept of action and reaction forces through a series of activities. Review the concept that forces always act in action and reaction pairs, with each force being the same size but acting in the opposite direction. Explain that they will also see how the forces in an action-reaction pair act on different bodies, and how the effect of the force depends on the mass of the body.
- Divide the class into smaller groups and ensure there is plenty of space for the activities. Make sure the students observe safety. (Safety: Ensure that student do not stand anywhere hazardous such as on tables.)
- **Tug-of-War Demonstration:** engage the student groups in a game of tug-of-war using a rope or piece of cloth. Explain that when they pull on the rope, they are exerting a force on it, and in turn, the rope exerts an equal and opposite force back on them. This explains the tension felt in their arms when they pull on the rope. The forces in this action-reaction pair are acting on different bodies (the students and the rope) and are equal in magnitude but opposite in direction.
- **Rolling Marbles Experiment:** Provide each group of students with two marbles of different masses and a flat surface to roll them on. Instruct them to roll one marble towards the other so that they collide and make observations. Elicit that when the marbles collide, they exert forces on each other that are equal in magnitude but opposite in direction. As a result of this collision, marbles bounce off each other and change direction. Explain that the effect of these forces depends on the mass of each marble - the more massive marble will experience less acceleration than the less massive marble. You may provide detail that this is a result of Newton's Second Law of Motion (F=ma).
- **Balloon Experiment:** Provide each student or group of students with a balloon and have them blow up the balloon without tying it off. As they release the balloon, it will shoot along the string like a rocket. Explain that this is due to the action-reaction forces between the air escaping from the balloon and the balloon itself. The air escaping from the balloon exerts a force on the balloon in one direction, while the balloon exerts an equal and opposite force on the air in the other direction.

Homework

Workbook page 74.

8	**a**	Infrared radiation from the Sun heats up the can of soft drink.	**[1]**
	b	The water that he was pouring on the pot has evaporated. This has cooled the air inside the pot, and that has cooled the can of soft drink.	**[1]** **[1]**
	c	The water evaporates so he needs to keep pouring more water to keep cooling the can.	**[1]**
9	**a**	White surfaces reflect infrared radiation so the houses will absorb less and stay cooler.	**[1]**
	b	The fire emits infrared radiation, so the camera cannot distinguish between the infrared radiation from the people and the infrared radiation from the fire.	**[1]** **[1]**
10	**a**	Energy is transferred by conduction through the inner pane of glass/passed on by vibrations from the hot room. Air inside the gap heats up/conduction occurs very slowly through the air. There is very little convection as there is not much air inside the window. (Very little infrared gets through the glass.) Energy is transferred by conduction through the outer pane of glass/passed on by vibration to the cold air outside.	**[1]** **[1]** **[1]**
	b	The rate of transfer would decrease. There is no air to transfer the energy between the panes. Conduction and convection will not occur/energy would be transferred very slowly by radiation.	**[1]** **[1]** **[1]**
11	**a**	Heating the water creates convection currents and warmer, less dense water rises. The sugar cube dissolves. The convection currents carry the dissolved solid through the water, creating a purple current.	**[1]** **[1]** **[1]**
	b	Any three from: Water is heated by the Bunsen burner. The water molecules move faster. The water expands/becomes less dense. Hot water rises. This is replaced by cold water, forming a convection current.	**[3]**
	c	e.g. thermals, onshore/offshore breezes	**[1]**
12	**a**	Particles cannot move past each other so a group of particles cannot rise.	**[1]**
	b	Heat/thermal energy is transferred to you by radiation.	**[1]**
	c	Any one from: They can move/travel through a vacuum/space. They both travel at the speed of light. They are both waves.	**[1]**
13	**a**	the balloon would have a smaller volume	**[1]**
	b	The particles are moving more slowly and are closer together.	**[1]**

10.3
Air resistance

Student Book pages 168–169

Prior learning

- Recognise friction (including air resistance) as a force that can affect the speed at which objects move and that sometimes stops things moving

Objectives

- Describe how air resistance is produced.
- Describe where it causes a problem, and where it is useful.
- Describe what happens in a vacuum.

Overview

Students will be familiar with the idea of air resistance from their everyday experience. In this lesson the practical activities establish the link between air resistance and the area of an object, and air resistance and speed.

It is important for students to think about the mechanism by which the air is exerting a force, which is explained in terms of collisions with air particles. This will help them to explain the observations of the effect of changing area and speed on the force of air resistance.

Activities

- Demonstrate dropping sheets of paper in different ways:
  - two screwed-up pieces
  - one screwed-up and one flat piece
  - one held flat and one held vertically.

  Ask students why they fall at different rates, and establish the idea of air resistance.
- Discuss what exactly we mean by 'air resistance' and bring out the idea of collisions with air particles. Students draw diagrams of the second case above showing the air particles colliding with the paper. More collide with the flat piece than the screwed-up piece.
- Students make parachutes of different areas and test how long each one takes to reach the ground. This activity could be made into a competition to find the parachute that takes the longest time to travel a set distance. **(Safety: Do not allow students to stand on desks or tables. Ensure they use an appropriate environment for dropping the parachute.)**
- Show a video clip of the feather and hammer being dropped on the Moon or demonstrate in the classroom if a vacuum pump is available. There is no air resistance in a vacuum. See http://nssdc.gsfc.nasa.gov/planetary/lunar/apollo_15_feather_drop.html
- Discuss the difference between the Moon and the Earth in terms of gravitational field strength and atmosphere. Ensure that all students understand that there can still be gravity even if there is no atmosphere.

Homework

Workbook page 75.

Key words

air resistance, streamlining, terminal velocity

10.3 Student Book answers

1. **a.** Shaped to reduce the force of air resistance.

   b. The lorry travelling fast: air resistance depends on area – the lorry is bigger – and speed – the lorry is travelling faster.
2. The force of gravity (weight) acting on the cricket ball is bigger than the force of gravity acting on the tennis ball. This means that the acceleration of each ball will be the same. The area in contact with the air is about the same, so the air resistance acting on the balls will be about the same. So they will fall at the same rate.

10.4

Changing ideas about motion

SIC

Student Book pages 170–171

Objectives

- Describe how explanations about motion were developed.
- Explain why ideas take a long time to change.

Overview

This lesson helps students develop their understanding of Science in Context.

Students learn about how scientists can be very creative when they want to answer questions. They learn about how you can do 'thought' experiments as well as actual experiments, and how this can be very helpful when it is difficult or impossible to produce conditions that you are discussing. They do an actual experiment about falling objects and then think up a thought experiment that they could use to reach the same conclusion. They develop their understanding about why ideas can take a long time to develop and be accepted.

They plan a cartoon strip or picture book to explain to younger students that you do not need a force to keep something moving (at a steady speed). This is a misconception that many students (and adults!) have about moving objects. They consider why ideas take a long time to be developed.

Activities

- Ask students to imagine being a very, very long way away from Earth or any other planet. Ask them what has happened to their mass (nothing) and their weight. Elicit the idea that weight only has meaning if they are near a planet, a moon, or another massive body.
- Explain that this is a very simple example of a 'thought experiment'. Explain that they are going to answer the question 'do heavier things fall faster?' in two ways. First, they will do an experiment to see if they can answer the question – provide students with a range of balls including balls of similar size but different masses, e.g. cricket ball and tennis ball. **(Safety: Ensure that student do not stand anywhere hazardous such as on tables.)**
- If available, demonstrate two objects of different mass falling in a vacuum or show the video of the hammer and feather dropped on the Moon from the NASA website (search on http://www.nasa.gov/home/index.html for 'hammer and feather').
- Students work out a way of finding the answer to the question without doing the experiment.
- Students read about Galileo's thought experiment. They then design a cartoon strip to explain to students at Stage 6 how ideas about forces have changed.

Homework

Workbook page 76.

10.4 Student Book answers

1. Impossible activities: such as walking, running, writing, rolling over in bed, holding a straight mug by gripping its sides, riding a bicycle. Possible activities: such as lying still, sliding over the ground, falling, holding a mug by supporting it underneath or hooking fingers around the handle.
2. **a.** Water resistance is balancing the forward force of the engine.
   b. The boat would slow down and eventually stop.
2. No; if there is no friction and the only force acting on the ball is its weight, it will be accelerated downwards and then decelerated by the same amount of force as it rolls back upwards so only the height matters.

10.5

Planning fair tests: Streamlining

TWS

Student Book pages 172–173

Homework

Workbook page 77.

Key words

variable, evidence, plan, prediction, fair

10.5 Student Book answers

1.

Why Kiran needs it
To hold the water
To make the objects of different shapes
To measure the time
To measure the mass
To measure the volume of liquid

2. Independent variable: shape
   Dependent variable: time
   Control variables: mass, volume, temperature
3. The units. The second column should say 'Time (seconds)'.
4. You can see whether all the readings are close together or there are any that do not fit the pattern. If they are together your data are more likely to be close to the true value.

Objectives

- Describe how to plan an investigation to test an idea in science.
- Describe how to write a conclusion.
- Describe how to write an evaluation.

Overview

This lesson develops skills in Thinking and Working Scientifically.

In this lesson students plan an investigation into streamlining. They revise what they learned about air resistance and gravity, and apply it to dropping cones. They consider all the factors that might affect the fall, and then suggest what to investigate. Their plan should include:

- listing all the variables
- deciding how to make the investigation a fair test
- making a prediction
- choosing apparatus and making a plan
- collecting evidence to present in a table and on a graph
- writing a conclusion and an evaluation.

You may want the students to read pages of the Student Book before planning their investigation, or they could complete their investigation and then review what they have done once they have read the book.

Activities

- Show photographs of different vehicles and ask which is most streamlined.
- Remind the students of what they have learned about air resistance, and how it slows objects down.
- Demonstrate dropping a cone or coffee filter. Explain that the students are going to find out how the shape of the cone affects the air resistance.
- Discuss how to investigate the link between variables in an investigation. Explain what we mean by variables (independent, dependent, and control) and how scientists ensure that they are doing a fair test.
- Students plan an investigation. They may need help to ensure that they do not change more than one variable at a time. Students can make their own plan.
- Students carry out the investigation and record their results in a table.
- They plot a graph, write a conclusion, and evaluate the data. They can refer to the Thinking and Working Scientifically spreads in the Student Book. They write simple conclusions such as 'My data show that more streamlined shapes reach the ground in a shorter time', and evaluations such as 'My data are not reliable as it was difficult to measure the time accurately'.
- Students report to the class or make a poster that shows their plan, results, and findings. Other groups comment with one good thing and one thing to be improved.
- Students look at the points that need to be improved and make a checklist ready for their next investigation.

Extension

Students consider how other factors might be investigated or devise a more accurate method for measuring the time.

10.6
Speed

Student Book pages 174–175

Objectives

- State SI (System International) unit of speed.
- Calculate average speed.

Overview

In this lesson students are introduced to the equation for calculating speed. They also learn to consider the units used to measure speed. To appreciate the difference between (instantaneous) speed and average speed, they make a balloon rocket and measure the total time that it takes to travel a certain distance.

Activities

- Show pictures of animals and vehicles and ask students to discuss in pairs and rank them in terms of speed. Discuss the concept of a certain distance in a certain time. Introduce the equation and all the units that speed can be measured in. This is a good opportunity to discuss how best to set out calculations (as shown in the Student Book). Encourage students to develop good habits that will help them now and in examinations in the future.
- Discuss how the speed of a car or bicycle changes during a journey. Talk about the speed at a certain moment (like the number on the speedometer or phone app) know as the 'instantaneous' speed and the average speed. Define average speed and discuss how it is different from 'steady speed'.
- Introduce the balloon activity. You will need to suspend long pieces of string across the room for this activity, and assist students when they are putting their balloon racers on the string. Alternatively, ask students to time each other walking different distances and then calculate their average speeds.
- Students consolidate their learning by completing further calculations.

Homework

Workbook page 78.

Key words

speed, metres per second, kilometres per hour, steady speed, average speed

10.6 Student Book answers

1. Average speed is the total distance divided by the total time, and instantaneous speed is the speed at a given moment.
2. a. speed = distance/time = 150 km/2 h = 75 km/h
b. 5 m/s
3. Noreen. She travels the same distance in a shorter time.
4. To compare speeds they must be measured in the same unit.

10.7 Precision and accuracy: What's the difference?

TWS

Student Book pages 176–177

Objectives

- Calculate average speed.
- Describe the effect of force on changing the speed and direction of motion with time.

Overview

This lesson helps students develop their skills in Thinking and Working Scientifically.

The lesson introduces the ideas of precision and accuracy. Students learn that the precision of measurements made using a stop-clock are affected by reaction time. Students do an experiment to measure their reaction time. They learn that a higher level of precision is provided by timing gates or remote sensors that are linked to datalogging equipment. They compare measurements made in this way with measurements made with stop-clocks.

Activities

- Recap what by asking students the difference between speed, average speed, and instantaneous speed.
- Ask students how good they thought they were at timing their balloon in the previous lesson. Introduce the idea of reaction time and discuss how reaction time affects the measurements that they can take.
- Students complete an activity to measure their reaction time. They can compare their reaction times with others in the class and discuss what factors might affect reaction time (tiredness, age, distractions).
- Students measure the time it takes a ball to roll down a ramp manually and automatically.
- Students make a table comparing the pros and cons of using a stop-clock and timing gates.

Extension

Students research the technology that enables the sprint races in the Olympics to be timed to a thousandth of a second.

Homework

Workbook page 79.

Key words

precision, accuracy, reaction time, timing gate

10.7 Student Book answers

1. 1.348; it has the most significant figures.
2. The measurement of time does not include or depend on the reaction time of the person measuring it.
3. The competitors in a sprint will all reach the finish line at about the same time, so you need to measure the time to a high level of precision. In a marathon competitors will spread out and will not reach the finish line at similar times.
4. **a.** Less than 0.2 seconds.

   b. If the time was 0.2 seconds or more than 0.2 seconds then the competitor could be reacting to the gun. If it is less, then the competitor is probably not reacting to the sound of the starting gun. It is a false start.

10.8

Distance–time graphs

Student Book pages 178–179

Objectives

- Interpret a distance-time graph.
- Formulate the relationship between speed, distance, and time.

Overview

This lesson introduces the idea that a distance–time graph can be used to tell a story. Students learn that the total distance travelled in a certain time tells us the average speed, and it would be difficult to write down the speed at every moment of a journey, but a graph can convey that information simply.

Students complete an experiment to find the time it takes to travel different distances and use this to plot a graph. They work out how to draw distance–time graphs for different types of motion and how to interpret distance–time graphs in terms of relating the gradient of the graph to the speed of the object. Finally, they link this lesson back to what they know about calculating speed.

Activities

- Ask students to think about walking to school or going to see their friends after school. Ask them how they could describe that journey in terms of how far they went and how long it took them. Introduce the idea of showing those things on a distance–time graph.
- Students complete an activity that produces data from a ball rolling on a track that they have made, and use the data to draw a distance–time graph. They draw the graph and interpret it. This asks them to use the graph to work out where the ball is moving fastest and slowest.
- Discuss the shapes of the graphs and elicit that the slope of the graph tells you the speed.
- Discuss the need to take reaction time into account when measuring time. Elicit that repeating measurements improves accuracy be enabling you to remove outliers.

Homework

Workbook page 80.

Key words

distance–time graph, average speed

10.8 Student Book answers

1. The graph of a steady speed is a straight line and acceleration is a curved line.
2. Section E: the gradient is steepest (more distance in less time).
3. speed = (4500 m – 2400 m)/([45 – 35] × 60 s) = 3.5 m/s

10.9

Acceleration and speed–time graphs

Student Book pages 180–181

Objective

- Formulate the relationship between speed, distance , and time.

Overview

This lesson introduces the idea of acceleration as changing speed, and how to calculate it. Students learn the difference between positive and negative acceleration and how that links to the motion of the object. They learn how to interpret speed–time graphs and to make calculations from those graphs.

These are important skills that will link to work that students will do at IGCSE.

Activities

- Show pictures of a car, a motorcycle, and a plane, or find a suitable video online. Ask the students which one is the 'fastest'. Students discuss in pairs and report back. Elicit that there is a difference between speed and how fast the speed increases (acceleration). The motorcycle could accelerate more than the plane if both were on a runway, but the plane will end up travelling faster. You could show a video that demonstrates this.
- Introduce the equation for calculating acceleration and the units. Emphasise that the 'metres per second squared' is actually better thought of as '(metres per second) (per second)'.
- Students complete an investigation into the motion of a toy car on a ramp, using a motion sensor and a datalogger. They interpret the graph produced by the datalogger.
- If datalogging equipment is not available, students can to plot some graphs and answer questions relating to those graphs.

Key words

acceleration, deceleration

10.9 Student Book answers

1. Speed is the distance travelled in a certain time, acceleration is the increase in speed per second, deceleration is the decrease in speed per second.
2. The slope of a speed–time graph tells you the **acceleration**. If the line is **horizontal** the speed is not changing. This **is not** the same as a speed of zero.
3. **a.** acceleration = change in speed/time

   b. = (0 m/s – 10 m/s) ÷ 0.1 s = –100 m/s^2

   c. deceleration = 100 m/s^2
4. Car A: acceleration = change in speed/time
   = (30 m/s – 0 m/s) ÷ 2.5 s = 12 m/s^2
   Car B: acceleration = change in speed/time
   = (45 m/s – 0 m/s) ÷ 2.5 s
   = 18 m/s^2

10.10

Presenting data from racing

TWS

Student Book pages 182–183

Objectives

- Explain which type of graph to plot from different types of data.
- Apply ideas about distance–time graphs.

Overview

This lesson helps students develop their skills in Thinking and Working Scientifically.

The lesson looks at the presentation and analysis of data. Students consider pie charts, bar charts, and line or scatter graphs as ways of communicating. They learn that it is appropriate to use line graphs when the variables are continuous.

Activities

- Show some examples of bar charts and pie charts and demonstrate that we use bar charts to show information that is categoric (names, etc.) or discrete (can only have integer values).
- Students work with data from the Formula 1 2019 season to present it in the most appropriate way. They can decide on their own way of showing the data to structure their work. They present their charts to the rest of the class.
- Students develop their understanding of line or scatter graphs. Ask them what they think is important if you are going to be a successful Formula 1 driver. Elicit age and experience as possible factors. Give them more data about the drivers and ask them to plot line graphs to find out if there is a link. Discuss what is meant by anomalous results and what to do with anomalous results in experiments. Discuss how data can show that no relationship exists, as well as demonstrating a correlation.
- Consolidate with a list of examples of things to plot and ask students to decide whether to plot line graphs or bar charts.

Homework

Workbook page 81.

Key words

categoric, discrete, continuous, bar chart, pie chart, line graph, scatter graph, variable

10.10 Student Book answers

1. a. 1200 m

b. 6–7 seconds; then the line becomes a straight sloping line/the gradient becomes constant (meaning that distance is increasing by the same amount every second).

2. A bar chart or pie chart.

The number of races is a discrete variable.

3. a. A horizontal line at the distance to the pits.

b. A horizontal line at zero.

10.11 Review answers

Student Book pages 184–185

Student Book answers

1		**B**, **D**	**[2]**
2	a	buoyancy/upthrust/the force of the air on the balloon	**[1]**
	b	weight/the force of gravity on the balloon tension/the force of the string on the balloon	**[1]**
	c	contact – buoyancy, tension non-contact – weight	**[1]**
3	a	speed = distance/time $= \frac{1440\,km}{2\,h}$ = 720 km/h	**[1]** **[1]**
	b	deceleration/decelerating	**[1]**
	c	The average speed would be less. There is more air resistance/a force acts against the plane.	**[1]** **[1]**
4	a	3000 m or 3 km	**[1]**
	b	50 minutes	**[1]**
	c	from 30 to 40 minutes/the last 10 minutes of his journey out	**[1]**
	d	30 minutes = 30 × 60 = 1800 s speed = distance/time = 3000 m/1800 s = 1.7 m/s	**[1]** **[1]**
5	a	The slope of the graph increases.	**[1]**
	b	average speed = total distance/total time = 100 m/4.5 s = 22.2 m/s	 **[1]** **[1]**
	c	smaller	**[1]**
6		Either swimmer pushes back on water so water pushes forward with equal and opposite force Or gravitational force of attraction on swimmer from earth downward and equal upward force of gravitational attraction for Earth Or swimmer pushes down on the water and the water pushes back up on the swimmer (upthrust)	**[1]**
7	a	A streamlined object has a low surface area facing the flow of air/allows air to flow over it smoothly/has low air resistance when it moves.	**[1]**
	b	0.1 s (time 2 for shape **B**)	**[1]**
	c	1.9 s (time 2 is discarded)	**[1]**

	d	**A**, **B**, **C** The most streamlined will take the least time to fall.	**[1]** **[1]**
	e	Two from: the same tank/water/depth of water, mass of clay, temperature	**[2]**
	f	bar chart; the shapes are categoric	**[2]**
	g	The student may have used a different mass of clay/different liquid/different size of tank.	**[2]**
8		If it is streamlined then there is less air resistance. Fewer air particles collide with the car, producing less force opposing the motion of the car, so less thrust is needed to reach a given speed.	**[1]** **[1]** **[1]** **[1]**
9		A force pushes the bullet out of the gun in one direction. The bullet pushes back on the gun with an equal force in the opposite direction. This is why the gun recoils.	**[1]**
10		particles, force, vacuum, same	**[4]**
11		Any situation where a parachute is used.	**[1]**
12		Folding the wings reduces the area in contact with the air so reduces the air resistance (and water resistance/drag force) acting on the bird so it goes faster in the air (and the water).	**[1]** **[1]**
13		**a.** iv **b.** iii **c.** ii **d.** iii **e.** iv **f.** ii.	**[1] each**

11.1

Technology in Everyday life

Student Book pages 186–187

Prior learning
- Sound waves.
- Uses of preservation.
- Importance of water conservation.
- Importance of sanitizers.

Objectives

- Make a simple Stethoscope.
- Use different techniques of preserving foods like orange juice, apple jam and pickles.
- Design a model to demonstrate drip & sprinkler irrigation system for conservation of water.
- Make a sanitizer using suitable substances.

Overview

The Technology in Everyday Life chapters are designed to enhance the research and technology application skills of the students.

The aim is to have the students recognise importance of science and technology to solve everyday problems and integrate scientific concepts/ STEAM in daily life to improve the quality of their own life and lives of others. And finally, to understand how scientific concepts/ STEAM affect their life and society.

Activities

The activities added are as per the National Curriculum of Pakistan and detailed in the student book. The hands-on activities must ensure that the following scientific skills are practiced and encouraged during the class:

- use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions to challenges/ inquiry questions
- apply the process people follow to design new things (make a plan, make drawings of the design, choose the best available material, construct working models and test your design)
- describe the strengths and limitations of your model
- describe how science is applied across societies and industries

Key words

design, engineers, irrigation system, stethoscope, preservation, sanitiser, conservation, food sustainability.

Extension:

Workbook page 82.

Student Book answers

Spread	Question	Answer
11.1	1	waves; amplifies; ear.
	2	A2; B1; C3
	3	As metals are usually solids (with the exception of mercury), with tightly packed particles, the sound waves travel faster through them.

11.2	**1**	Food goes bad due to the action of non-beneficial microorganisms, which feed on food, break it down and make unpleasant compounds which smell and taste bad. Sometimes these compounds are harmful and make us ill.
	2	Cooling, heating, preserving.
	3	Removing or changing the ideal conditions for microorganisms to grow, which include warmth, oxygen, and pH levels.
11.3	**1**	The process of adding water to the soil.
	2	a. In a drip irrigation system, water is pumped through long tubes that stretch along the surface of the soil. Small holes in the tubes drip water onto the roots. b. In a sprinkler system, water is evenly distributed over large areas of the crop, using a pump and series of pipes with nozzles.
	3	a. Drip irrigation system is an efficient system as the water is delivered with little loss through evaporation and very little water pressure is needed. A disadvantage is that the pipe system set up can be expensive and difficult to maintain. b. Sprinkler irrigation system distributes water evenly over large areas of the crop. But the disadvantage is that a good pump is required to maintain water pressure for the system to work and wind can cause water to drift.
11.4	**1**	An alcohol, a gel, any nice smelling essential oil.
	2	Clean measuring cylinder, bowl, a mixing stick or a fork, (optional: dropper) and a funnel.
	3	It is the same everywhere in the mixture, i.e., with exactly the same substances, in exactly the same proportions.
	4	Students to research the difference between propan-1-ol and ethanol, focusing on the solubility difference. For extra credit they may also research and share the comparison between propan-1-ol and propan-2-ol.

12.1

The force of Gravity

Student Book pages 194–195

Prior learning

- Distinguish between mass measured in kilograms (kg) and weight measured in newtons (N), noting that kilograms are used to refer to weight in everyday life
- Recognise and use units of force, mass and weight and identify the direction in which forces act

Objective

- Differentiate between mass and weight, using examples of weightlessness experienced by astronauts on the surface of the Moon.

Overview

This lesson introduces ideas about weight and how it is different to mass. Students often find it difficult to distinguish between the two, so it is worth spending time talking about the use of the two words in everyday language to bring out the issue. The weight of an object is a measure of the gravitational force of the Earth on the object, and the mass is a measure of how difficult it is to move it, or the amount of 'stuff' there is in it.

Talking about the gravitational force *of the Earth* on objects naturally leads into the idea that weight will be different on different planets.

Activities

- Ask students to guess the weight of a bar of chocolate. They will usually give the answer in grams. It will even be printed in grams on the wrapper! Next, they write down as many ways of measuring the weight of something that they can think of, for example, bathroom scales, spring balance, etc. Ask what the weights would be, and again they will be in grams or kilograms.
- Establish that most weighing machines are effectively spring balances, so they are measuring a force, the *force* of the Earth on the object, and this is what we call weight, in newtons (N).
- Students find the weight of objects of different mass and work out the link between them. **(Safety: do not drop objects on fingers or feet.)**
- Prepare small boxes that are sealed and labelled with the names of the planets. In each box should be the amount of modelling clay that gives the weight as it would feel if you took an object of the same mass to each of the planets. Factors to use in calculating the appropriate weights relative to the Earth weight are: Mercury ×0.37; Venus ×0.89; Moon ×0.16; Mars ×0.37; Jupiter ×2.3; Saturn ×0.90; Uranus ×0.87; Neptune ×1.1. Hand around the boxes for students to feel the difference in the weight.
- Establish from the results that the link between weight and mass on Earth is the number 10. Emphasize that this is the link between weight and mass on *Earth*, and therefore their weight might be different elsewhere, such as other planets or the Moon. consolidate their understanding.

Extension

Students suggest reasons why weight is different on different planets.

Homework

Workbook page 83.

Key words

gravity, weight, newtons, mass, kilograms, grams, matter, gravitational field, gravitational field strength

12.1 Student Book answers

1. **a.** A force of attraction between objects with mass.
   b. The mass of the objects, the distance between them.
2. **a.** Weight is a force. It is the force of the Earth on an object.
   Mass is the amount of stuff (matter) in an object/mass is related to how hard it is to accelerate something when you apply a force to it.
   b. The same; your mass doesn't change, but your weight does.
3. The gravitational force and the magnetic force are both non-contact forces/the force of gravity pulls you down just like magnets pull other magnets. The force of gravity is to do with mass, not a magnet.
4. weight = mass × gravitational field strength
   = 4 kg × 10 N/kg
   = 40 N
5. weight = gravitational field strength × mass
   a. mass = weight/gravitational field strength
   = 370 N/3.7 N/kg
   = 100 kg
   b. weight = 100 kg × 10 N/kg
   = 1000 N

12.2 Orbits

Student Book pages 1196–197

Prior learning
- Gravitational force

Objective
- Recognize that the force of gravity keeps planets and moons in their orbit.

Overview
This lesson details how the concept of how gravitational force of the Earth on objects leads into the idea that gravity affects the motion of planets and moons. They will learn how the force of gravity keeps these celestial bodies in their orbits around the Sun or other planets.

It is important to ensure students are clear on the concept of Gravity as a force of attraction between any two objects with mass. The more massive an object is, the stronger its gravitational force.

Activities
- Begin by reviewing with students the concept of force of gravity. Elaborate how it keeps the planets in orbit around the Sun. Explain that since the Sun has a mass much greater than any of the planets, means that it has a stronger gravitational force. This force attracts the planets, which also exert their own gravitational force on the Sun. This action and reaction pair of the gravitational forces results in defining the orbits of planets around the Sun.
- Divide students into groups and instruct them to create models of the Solar system. Instruct them to use the skewers to connect the planets to the Sun and once completed, each group to demonstrate how the planets orbit around the Sun. Explain that the closer a planet is to the Sun, the stronger the gravitational force it experiences.

12.2 Student Book answers

1. Orbit, attract, mass
2. The station is in orbit so it is falling towards earth as the earth curves away. The astronauts are falling to earth too so experience weightlessness.
3. Tension provides the force to keep the balloon moving in a circle. When the balloon went faster more tension/force was needed. If it was too great the clip slipped off.
4. The stars have a similar mass, so the gravitational force has the same effect on both of them.

- Next, introduce the concept of weightlessness in space. Explain that weight is a measure of the force of gravity on an object, and that when an object is far from any large masses (such as planets or moons), it experiences very little gravitational force. This can cause objects to feel weightless, as if they are floating.
- As an extension activity, you could have students research and compare the masses of different planets and moons in our solar system. They could then discuss how these differences in mass affect their orbits and gravitational forces. You could also have students research and discuss real-life examples of weightlessness in space, such as astronauts on the International Space Station.
- Finally introduce the students to the concept of gravitational field strength and its calculation. Remind them that a force always has an associated ''field'' in which it has influence, and further away from the body exerting the force, the field becomes weaker.

Homework

Attempt the answers to the questions in the spread. Also Workbook page 84.

Key words

Force of Gravity, orbit, tides, annual revolution, axis, constellations, northern hemisphere, southern hemisphere.

12.3 How 'old' is gravity?

SIC

Student Book pages 198–199

Objectives

- Describe how scientific knowledge about gravity has developed over time.
- Describe some reasons why scientific explanations change.

Overview

This lesson helps students develop their understanding of Science in Context.

In this lesson students are introduced to the idea that scientific explanations have changed over time because of creative thought. They learn about how different scientists can give similar explanations for a phenomenon at different times in history, but how evidence from predictions is important in confirming that explanation. Students learn about the idea of gravity, as described by Bhaskaracharya and Newton, and use ideas about gravity to plot a journey to the Moon. They use creative thought to think about how the mission would work given the relative strengths of the gravitational fields of the Earth and the Moon.

Activities

- Students read through the Student Book pages to find out about Bhaskaracharya and Newton and their ideas about how the gravitational pull of the Earth keeps the Moon in orbit.
- Introduce the idea that gravity gets weaker as you move away from a planet or moon and that gravity is weaker on less massive planets or moons. Explain how the students are going to make a poster presentation about a journey to the Moon. They can use http://www.nasa.gov/mission_pages/apollo/missions/apollo11.html for information.

- Groups present their ‘Mission to the Moon’ to the class. Elicit the idea that the Earth’s gravity will slow the rocket as it leaves the Earth, but will accelerate as it approaches the Moon. The rocket will need to slow down to land safely.
- Students vote on which group has produced the best explanation for each of the questions on the worksheet.
- If available, show a video clip from the film ‘Apollo 13’ where the crew are returning to Earth and the astronauts say ‘Isaac Newton is in the driving seat now’.
- Students draw a table of similarities and differences between Bhaskaracharya and Newton’s ideas. Emphasise the role of evidence (the discovery of Neptune) as support for Newton’s ideas.

Extension

Scientists used Newton’s ideas to send astronauts to the Moon. Use the internet or books available to you to research the ideas of Edwin Hubble and Albert Einstein about gravity and its effects in the Universe.

Either:

- make a list of ways that their ideas differed from those of Newton and Bhaskaracharya

or:

- make a timeline that shows how ideas about gravity developed after Isaac Newton published his ideas.

Homework

Workbook page 85.

Key words

explanation, gravity, questions, Newton, Bhaskaracharya

12.3 Student Book answers

1. A force of attraction between the Earth and the Moon.
2. The Moon was changing direction, which needed a force.
3. Newton produced a mathematical model for gravity.
4. It correctly predicted that Neptune existed.
5. They could not feel the force/they might think that the Earth was not moving.
6. Sensible suggestion, for example: we cannot explain all observations with our current models.

12.4 The Moon

Student Book pages 200–201

Objective

- Recognize that tides are caused by the gravitational pull of the Moon.

Overview

In this lesson students learn about the Moon and its position in relation to the Earth. They are introduced to the different phases of the Moon and to eclipses, and model how phases and eclipses happen.

12.4 Student Book answers

1. **a.** 27.3 days/28 days
   b. h
2. In a solar eclipse the Moon is between the Earth and the Sun, in a lunar eclipse the Earth is between the Moon and the Sun.
3. One from: You would not see a full moon, there would be a lunar eclipse every month, there would be a solar eclipse every month.
4. All three happen when the Moon is between the Earth and the Sun.

Activities

- Ask students what they know about the Moon. They can refer to the diary of the night sky that they have been keeping. Elicit the idea that the Moon is Earth's satellite and takes 28 days to orbit the Earth. Then ask them to draw as many phases of the Moon as they can.
- Explain that we see the Moon because sunlight is reflected off its surface. We see it differently depending on where it is in its orbit: new Moon, waxing crescent, first quarter, waxing gibbous, full Moon, waning gibbous, last quarter, waning crescent, and new Moon. ('Waxing' is getting bigger, 'waning' smaller.)
- Students model the phases of the Moon using a half-black ping-pong ball. Talk about what the model represents (front wall = Sun, turning on the spot with the ball held out = the Moon's orbit around Earth, the view of the ball as it orbits = view of the Moon we get from Earth).
- Students consolidate ideas about the phases of the Moon. They write a short evaluation of the model, e.g. it is a good model because the ping-pong ball is round like the Moon and you can see the phases. It is not a good model because the Moon is not held out by a giant arm! The Earth (= person) does not spin on its axis the same way that the real Earth would. In reality the same part of the Moon is always facing the Earth and the shadow moves across the surface – in this model the shadow is fixed and it appears to move by turning the Moon. Students could suggest improvements to the model.
- Next, students consider how the model helps to understand how the tides form.
- Show a video clip of a solar eclipse from Earth and from space (e.g. from http://www.nasa.gov/, search for 'eclipse'). Ask students to try to explain what is happening.
- Students model solar and lunar eclipses with a lamp and two balls. **(Safety: Ensure students do not look directly at the lamp, and take care – the lamp will get hot.)** They draw diagrams to show how solar and lunar eclipses are formed. Discuss the diagrams and show a suitable animation (again, http://www.nasa.gov/ is an excellent source), showing the formation of solar and lunar eclipses. If one is available, show a photo or diagram of a solar eclipse as seen from space. Discuss the tilt of the Moon's orbit and how this relates to the frequency of eclipses. Discuss the difference between phases (different views of the fully lit Moon) and eclipses (shadows).
- Students consolidate what they have learned about phases, eclipses, and tides.

Homework

Workbook page 86.

Key words

phase, new Moon, first quarter, full moon, last quarter, gibbous, crescent, waxing, waning, solar eclipse, total eclipse, partial eclipse, umbra, penumbra, lunar eclipse, tide, spring tide, neap tide

12.5

Our planet: Day and night

Student Book pages 202–203

Prior learning

- Explore how the sun appears to move during the day and how shadows change
- Model how the Earth's spin leads to day and night, e.g. with different-sized balls and a torch
- Explore that the sun does not move; its apparent movement is caused by the Earth spinning on its axis
- Know that the Earth spins on its axis once in every 24 hours

12.5 Student Book answers

1. east, west, noon, 24
2. This cannot be true because when clouds cover the Sun during the day, night does not fall. You would need a lot of cloud to block out the Sun. These clouds would have to cover the Sun for the right amount of time each night. In fact, we have day and night because the Earth spins and only half the Earth is lit up by the Sun at any one time.
3. So that it would swing for a long time, long enough to show that the Earth was spinning.

Objective

- Describe the effects of the Earth's annual revolution around the Sun, given the tilt of its axis (e.g., different seasons, different constellations visible at different times of the year).

Overview

Students build on what they have learned about the direction of sunrise and sunset. They link this to the spinning Earth and the way that the Sun moves in the sky. They consider evidence for the spinning Earth. They extend this idea to a consideration of how stars look in the sky and how this depends on the direction in which you are looking.

Activities

- Ask students to list the observations that they have made about where the Sun is in the sky. Discuss how people thousands of years ago would have explained these observations.
- Use a model globe of the Earth with a model mountain stuck on it to show how scientists/astronomers argued that the Earth is round nearly 2000 years ago. Rotate the globe towards the students so that the mountain 'appears' over the horizon as if it is growing. Place the mountain on a flat surface to show that you would be able to see it all the time if the Earth were flat – it might just look smaller from a distance.
- Recap day and night using a globe and a light source to represent the Sun and the Earth.
- Discuss possible explanations for the observation that the Sun rises in the east and sets in the west. Revisit the demonstration of the Earth/Sun to explain. Remind students of the importance of physical models in science.
- Students investigate how the length of a shadow changes with the height of a lamp on the desk. **(Safety: Ensure that they can safely adjust the height of the lamp. Lamps can get very hot.)**
- Show an appropriate animation that shows how the Earth is spinning and how the Sun appears to move across the sky. Alternatively use Stellarium software, which can be downloaded free from www.stellarium.org, to highlight the changes in height of the Sun at different locations. Once loaded on a computer, press 1 (one) to see the menu. Set the location and the date (it might be useful to compare June to December). You can tilt the view by using the cursor keys, and so get more sky in view. Press play in the bottom right-hand corner of the screen, where you can speed up and slow down the time to watch the Sun rise and set and its progression across the sky.Discuss how (or whether) this apparent motion proves that the Earth is spinning on its axis.

Homework

Workbook page 87.

Key words

Earth, Sun, day, night, axis pole, year, shadow

12.6

Our planet: Seasons

Student Book pages 204–205

Prior learning

- Know that the Earth takes a year to orbit the Sun, spinning as it goes

Objective

- Describe how seasons in Earth's Northern and Southern Hemispheres are related to Earth's annual movement around the Sun.

Overview

Students build on what they have learned earlier to work out why there are seasons and why the seasons in some parts of the world are very different from the seasons in other parts of the world. They build on what they have learned about the tilt of the Earth's axis to explain the difference in day length, temperature, and the maximum height of the Sun in the sky.

Activities

- Discuss how temperature and day length changes during the year, and ask if the answer to the question would be different if they lived in a different country.
- Students model summer and winter in the different hemispheres **(Safety: Ensure that they can safely adjust the lamp. Lamps can get very hot.)** They demonstrate that when it is summer in the northern hemisphere that hemisphere receives more hours of sunlight than the southern hemisphere, and vice versa. They estimate the hours of daylight at different times in the year. Depending on your location, ask students to use their globes to find out one of the following: What is summer like at the South Pole? What is winter like at the North Pole? What are the day lengths in equatorial countries?
- Students feed back their answers and discuss explanations using their globes.
- Students show how seasons change as the Earth orbits the Sun. Students identify the seasons and fill in hours of daylight using information from the graph on the Student Book, then describe the temperatures (e.g. hot/cold, not actual temperatures). Alternatively a local publication or online source of meteorological data can be used to fill out the worksheet with information from the students' own area.
- If available, use strips of heat-sensitive tape attached to a globe together with a lamp to show how the temperature changes during different seasons in different parts of the world. Alternatively set up the practical shown in the extension question on page 29 of the Workbook. You will need two trays of sand, two long thermometers, and two desk lamps. If you vary the angle of the light from the lamp onto the sand you will see different temperatures on the thermometers. Discuss how the angle affects the temperature in the summer and the winter, as well as the hours of sunlight.
- Students write a story about what they would see around them during the year if they lived in a very different part of the world.

Homework

Workbook page 88.

Key words

Earth, year, season, pole, equator, northern hemisphere, southern hemisphere

12.6 Student Book answers

1. The shadow would be longer in winter because the sun is lower in the sky.
2. a. The Earth's axis is tilted relative to its orbit around the Sun. This makes the days shorter in the winter and longer in the summer.

   b. shortest – December

   longest – June
3. We would not have seasons. Day and night would be the same length all year round.

12.7 Using planetary data

TWS

Student Book pages 206–207

Objectives

- Describe the difference between primary and secondary sources of data.
- Name some secondary sources.
- Use information from secondary sources to answer questions.

Overview

In this lesson students learn the difference between primary and secondary sources of data. They interpret data about the planets of the Solar System. They compare the need to be able to repeat the results of an experiment, and for the results of an experiment to be reproduced by other people, to the need to confirm secondary data by looking at data from a range of sources.

Activities

- Ask students to recall an experiment that they have done this year where they collected data that they put in a table. Show them the cards with information about the planets of the Solar System and ask them where the data came from. Explain the difference between primary and secondary data.
- Students use the cards about the planets and investigate the link between distance from the Sun and temperature, and distance from the Sun and year length.
- Students read pages of the Student Book and discuss the conclusions that you can draw from the data shown. They answer questions 2 and 3.
- Students work out how you can ensure that your primary and secondary data are reliable. Groups present their ideas and the class votes on the best ideas.

Extension

Students find at least five websites that contain the information temperature, distance from the Sun, day length, year length, and diameter and draw a table comparing the data. Discuss any differences.

Students could plot graphs of the data collected on a graph paper and discuss how the graphs provide additional information about the links between the variables.

Key words

data, primary source, secondary source

12.7 Student Book answers

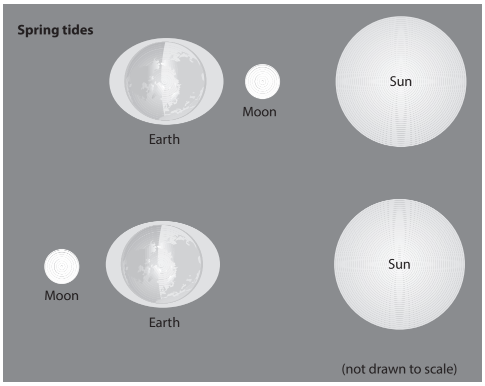
1. **a.** Mercury: its axis is not tilted.
   b. Mars, Saturn, Neptune: their axes are tilted by about the same angle as Earth's.
   c. Venus, Jupiter: the angle of tilt is very small.
   d. Uranus: the angle is nearly 90°.
2. No, there is no link between day length and year length. As the year length increases the day length does not steadily increase or decrease.
3. You need to look at more than one secondary source to check that the data are accurate.

12.8 Review answers

Student Book pages 208–209

Student Book answers

1		B, C	**[1]**
2		A, D	**[1]**
3		The gravitational field strength is smaller so it would go higher (and take longer to come down, so go further). There is no air, so there is no air resistance.	**[1]**
4	**a**	W = mg = 65 kg × 10 N/kg = 650 N	**[1]**
	b	Their mass will stay the same, because it is not affected by gravity. Their weight will be smaller (65 kg × 3.7 N/kg = 240 N) because the gravitational field strength on Mars is smaller.	**[1]**
5		Weight on Jupiter = mg u = 100 kg × 23 N/kg = 2300 N Weight on Io = mg Io = 100 kg × 1.8 N/kg = 180 N The astronaut will have a weight on Jupiter that is 2300 N/180 N = 12.8 times greater.	**[3]**
6	**a**	Arrow from the ball going straight down to the centre	**[1]**
	b	It would move at a tangent and then go downwards.	**[1]**
	c	gravity	**[1]**
	d	They would move off at a tangent to their orbits.	**[1]**
7		D	**[1]**
8	**a**	axis	**[1]**
	b	south, north, shorter, longer	**[1]**
	c	larger away from	**[1]**
9	**a**	3	**[1]**
	b	6	**[1]**
	c	9	**[1]**
	d	When the two are lined up together with the Sun, distance between them is 150 000 000 km – 60 000 000 km = 90 million km	**[2]**
	e	We only see stars at night when our side of the Earth is in shadow. The side of the Earth that is in shadow faces different directions at different times of the year as the Earth orbits the Sun.	**[1]**

10	**a**	one (or both) of: 	**[1]**
11	**b**	If Moon drawn between Earth and Sun in **a**: solar eclipse. If Earth drawn between Moon and Sun in **a**: lunar eclipse.	**[1]**
	c	The Moon's path around Earth is tilted (compared to the path of Earth around the Sun). Therefore, the Moon can be behind Earth and still get light from the Sun.	**[1]**
	c	If Moon drawn between Earth and Sun in **a**: new moon If Earth drawn between Moon and Sun in **a**: full moon	**[1]**
11		a- i, b- i, c- ii, d- i	**[1] each**

Answers

1.1 What do we know about plants?

1. **a.** A = roots, B = leaf/leaves; C = stem; D = flower.

   A: The roots anchor the plant in the ground and supply it with water and mineral nutrients from the soil.

   B: Leaves capture energy from the Sun using the green-coloured chlorophyll. They use this to make carbohydrates.

   C: Stems support the leaves, holding them out to capture the sunlight they need. They also support the flowers and fruit.

   D: Flowers are the reproductive structures of plants, and they form the seeds and fruit. They only appear at certain times in the life cycle of the plant.

2. Any three from: Plants are the producers for food chains and food webs all over the world. Plant crops are the source of most human food, both directly and as animal feed. Plants are part of the water cycle. Materials from plants are used for medicines, clothing, building, biofuels, and more.

Extension

Stems – swollen and fat to store a lot of water, green to capture sunlight to make food/photosynthesise.

Leaves – reduced to long sharp spines to stop animals eating them/reduced surface area reduces water loss from the plant.

1.2 Photosynthesis

1. **a.** Photosynthesis is the process by which plants make their own food using carbon dioxide from the air and water from the soil. They use energy from light. They produce glucose and oxygen.

   b.

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{glucose} + \text{oxygen}$$

2. **a.** A chloroplast is a structure found in many plant cells where the photosynthesis reactions take place.

   b. Chlorophyll.

   c. Not correct because not all plant cells contain chloroplasts. Only plant cells that are exposed to light contain chloroplasts and so are green. Structures such as the roots which are underground get no light so cannot photosynthesize and do not contain chloroplasts.

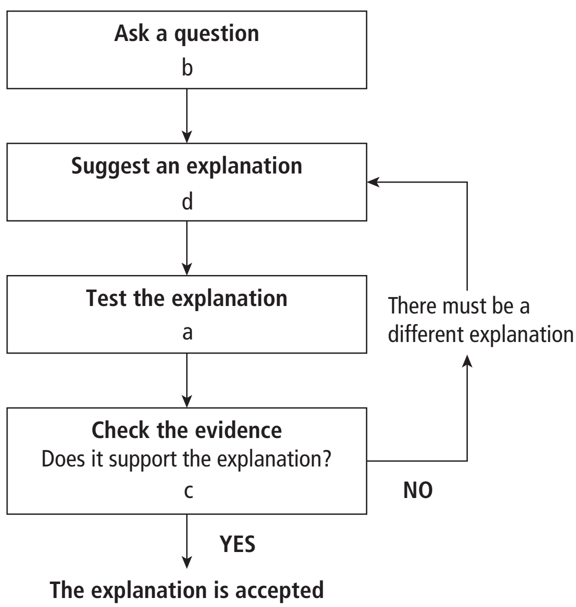
3. For aerobic respiration in the cells, making energy available for all the other reactions of life.

   To make starch as an energy store – glucose molecules are joined together to make large starch molecules which are stored in the leaves and in root and stem stores.

   To make all the other molecules needed in the plant such as cellulose for the cell walls.

1.3 Evidence of photosynthesis: testing for starch

1. The missing words are: variables; measured; changed; variable; repeat; reliable.

2. 

3. a. 1 Drop the leaf into boiling water to remove the waterproof outer layer, kill and break open cells. Turn off heat and remove leaf using forceps.

2 Place leaf in test tube of ethanol and put test tube in hot water. As the ethanol boils, the green colour comes out of the leaf.

3 Remove the stiff white leaf from the ethanol and dip it into the hot water to wash off the ethanol and soften it.

4 Spread the leaf on a white tile and add a few drops of yellow-brown iodine solution to test for the presence of starch.

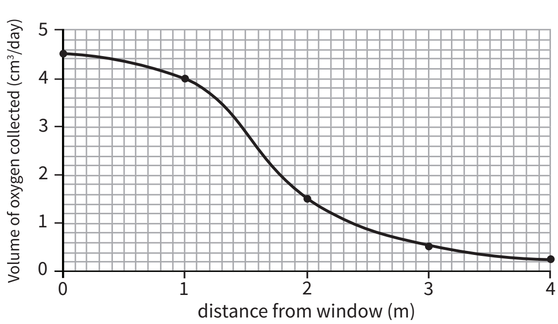
b. Blue-black.

Extension

When leaves photosynthesise, they use carbon dioxide and water with energy from light to make glucose and oxygen. The glucose molecules are joined together to make starch which is used as an energy store in the leaves and other parts of plants. So the presence of starch indicates that photosynthesis has been taking place. When plants are kept in the dark they use up their starch stores.

1.4 Evidence of photosynthesis: oxygen bubbles

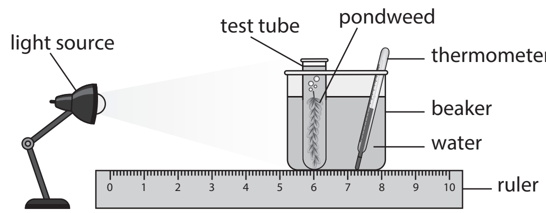
1. a. Prediction: light intensity will affect the rate of photosynthesis and the higher the light intensity, the more oxygen will be produced. Explanation: plants need light to photosynthesise, and the more light there is available, the more they can photosynthesise. Oxygen is produced as a waste product of photosynthesis and this is what Raheel is collecting and measuring, so the more light there is, the more gas he will collect.



b. Light intensity affects the volume of oxygen produced. The closer the pondweed is to the window, the higher the light intensity so more photosynthesis is carried out and more oxygen is produced.

Extension

a.



b. Prediction: rate of photosynthesis will increase as the carbon dioxide concentration of the water increases as plants need carbon dioxide as one of the raw materials for photosynthesis.

c. All the experimental beakers must be the same distance from the light source/window as light intensity also affects the rate of photosynthesis so they must all have the same light intensity.

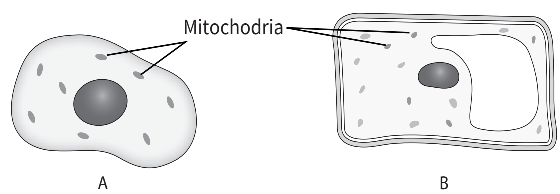
1.5 Respiration and photosynthesis

1. The missing words are: energy, aerobic, energy, glucose, controlled, oxygen, water, carbon dioxide.

2. glucose + oxygen carbon dioxide + water +(energy)

3. a. The irregularly shaped cell is the animal cell, whereas the rectangular looking cell is the plant cell.

b.



Extension

Since aerobic respiration takes place in mitochondria, increased number of mitochondria are found in those animal and plant cells where there is a need to release the energy stored in food molecules in a controlled way. These include the muscle cells in animals and the cells that produce seeds and fruits in plants, as they need to work or grow fast and so have a greater energy need. In contrast, cells such as storage cells, have very few mitochondria, as they do not have a great need for energy.

1.6 The need for minerals

1. **a.** Nitrate deficiency causes poor growth and the older leaves turn yellow. Magnesium deficient leaves are pale or yellow.
   b. Nitrates are needed to make the proteins in plant cells. Proteins control the reactions in the cells and are part of the structure of the plant.
   c. Magnesium is needed to make chlorophyll which is used in photosynthesis.
2. The missing words are: minerals; soil; minerals; water; soil; plant; roots; legumes; nitrates; soil; root nodules; bacteria; nitrates; nitrogen; Legumes; nitrates.

Extension

Your answer should include sensible points such as: setting up plants with their roots in solutions of minerals. One plant is in pure water; one plant has all the minerals; other plants are in solutions missing just one mineral, e.g. no nitrates, no magnesium. Controlled variables, e.g. light and temperature. Measure/observe the height or biomass or number of leaves or colour of leaves – any sensible measure. Expect plants with no minerals will do badly, plants missing a single mineral will show signs of mineral deficiency over time.

1.7 The use of fertilisers

1. A2; B6; C5; D3; E1; F4
2. **a.** About 100 years.
   b. They work fast and are always available.
   c. They are expensive and do not improve soil structure.
3. **a.** In the early 20th century, a German chemist called Fritz Haber developed a way of making a compound called ammonia from the nitrogen in the air. Ammonia acts as a nitrate-rich fertiliser. Haber's laboratory method only made small amounts of ammonia so it was no use as a fertiliser but it was the start of the process.
   b. A chemist and engineer called Carl Bosch applied Haber's scientific discovery and developed a way to carry out Haber's reaction to make ammonia from air on a big scale, so it could be produced industrially. The Haber–Bosch process is still used to make millions of tonnes of nitrate fertiliser every year.

1.8 Water and mineral transport in plants

1. The missing words are: water; photosynthesis; absorb; vacuoles; cell; support; wilts
2. **A** Water evaporates out into the air through stomata on the leaves. **B** Water moves up through xylem vessels. **C** Water is taken in through root hair cells and moves into the roots.
3. A2; B1; C4; D5; E3

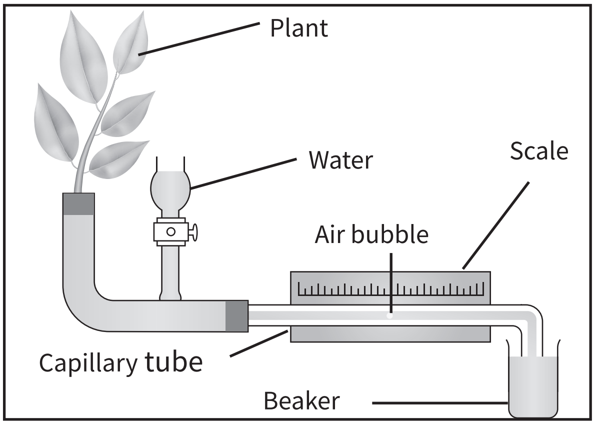
Extension

Petroleum jelly blocks the stomata on the underside of the leaf so water cannot be lost by evaporation. The plant with normal leaves loses water by transpiration from the leaves and so eventually it wilts as there is not enough water in the plant to maintain the cells. The plant with petroleum jelly does not wilt because it does not lose water by transpiration.

1.9 Factors affecting transpiration

1. The missing words are: evaporation, transpiration, quickly, wilt, overheat, transpiration, factors, light, humidity, heat.

2.



a. a Potometer

b. It measures the rate at which a plant takes up water.

c. Although a potometer does not measure transpiration, it is used to study the rate of transpiration, since it is similar to the rate at which a plant takes up water. To study the effects of wind on transpiration rate, we can set up the potometer apparatus attached to a plant near a fan. Another similar setup with same plant and conditions, apart from the fan, should be set up as control. Turn the fan on near the first potometer, and then begin noting observations on how fast the air bubble moves up the glass tube. The faster the movement, the more the plant is taking up water, due to losing water through transpiration. However, the humidity near the plant is lowered due to the movement of the wind, which increases the rate of transpiration.

3. This answer is provided in the student book unit. Encourage students to write the answers in their own words.

Extension

When a plant gets more sunlight, it opens tiny pores called stomata on its leaves. This allows gases to move in and out rapidly, leading to increased water evaporation and loss. More light results in greater photosynthesis, which, in turn, leads to higher water loss through transpiration.

1.10 Xylem, phloem and plant pests

1. a. Tissue A = phloem and tissue B = xylem.

   b. Tissue A/phloem contains sugars in solution moving from the leaves around the plant.

   The aphid feeds on these sugars; tissue B/xylem contains water which has no food value for the aphid.

   c. Tissue A/phloem is a living tissue which uses energy to move sugars around the plant. Tissue B/xylem is dead tissue, made up of tubes that carry water from the roots to the leaves.

   d. Tomato plants free of aphids grow normally and well. Tomato plants infected by aphids may be smaller, and produce fewer tomatoes, because the aphids are using lots of the food made by the plant so it is not available for growth or to make fruit. The plants infected by aphids are also more likely to be diseased, which will also affect the yield of fruit. The aphids pierce the phloem and can introduce pathogens into the plant phloem. They can then be carried all around the plant, causing disease.

2.1 Human Respiratory system

1. The missing words are: particles; diffusion; gases/liquids; liquids/gases; random; net; particles; high; lower; down; concentration gradient.

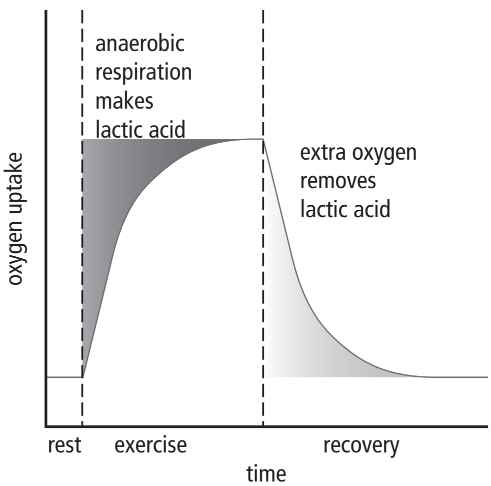
2. Any three, e.g. sense of smell relies on diffusion, pollinators finding flowers, gas exchange in the lungs, food moving from digestive system to the blood, sharks detecting prey, etc.

3. a. Dark particles should have spread out a bit further and be more mixed with light particles but there will still be an area which has only light particles.

   b. The whole volume of liquid has evenly spaced dark and light dots.

2.2 Aerobic and anaerobic respiration

1. **a.** Glucose + oxygen ➔ carbon dioxide + water
   b. Glucose ➔ lactic acid
2. **a.** T **b.** F **c.** T **d.** F **e.** F
   b. **Anaerobic** respiration provides only short bursts of energy <u>or</u> Aerobic respiration **provides a continuous supply of energy**.
   c. Anaerobic respiration releases **a smaller** percentage of the total energy in glucose **than** aerobic respiration.
   d. **Anaerobic** respiration is the main type used in **sprinting races**.
3. **a.** Labels should be added to the diagram as shown below.



   b. Anaerobic respiration can't be used all of the time because lactic acid is toxic.
   c. Anaerobic respiration can produce a sudden burst of energy because cells can use a lot of glucose molecules at once so, even though the anaerobic breakdown of each molecule only releases a small amount of energy, a lot of molecules are all used to give the energy needed.

2.3 The lungs and gas exchange

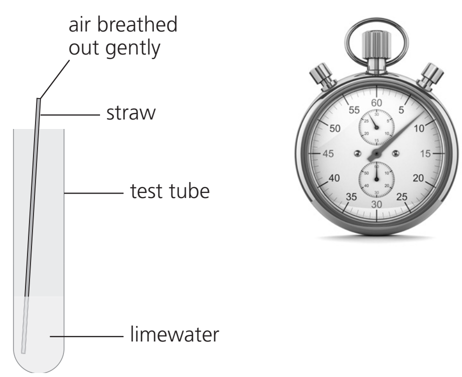
1. Clockwise from the top right the labels are: trachea, bronchus, small branch of bronchi, alveoli, diaphragm, lung, rib.
2. The missing words are: oxygen; aerobic; respiratory system; air; lungs; gas exchange; oxygen; carbon dioxide.
3. A5; B4; C1; D6; E3; F2

Extension

Specialised cells lining the bronchi make mucus that traps dust and dirt from the air that might irritate the lungs and harmful microorganisms that might cause lung infections. They are ciliated and the cilia beat to move the mucus, dirt and microorganisms away from the lungs.

2.4 Investigating respiration

1. **a.** They are hazard warning signs.
   b. **!** Harmful substance.
   c. Limewater is a clear, colourless liquid (a dilute solution of calcium hydroxide). It turns milky white in the presence of carbon dioxide. Carbon dioxide is a waste product of aerobic respiration so it is used to show living organisms are respiring and producing carbon dioxide.
2. **a.** That people who have been exercising will produce more carbon dioxide than people at rest.
   b.



   c. Controlled variables – resting or exercise, time of exercise, amount of limewater in test tube.

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Variables which are hard to control: differences between individuals, levels of fitness, etc.

d. Expected results: The limewater turns cloudy faster when people who have been exercising breathe through it.

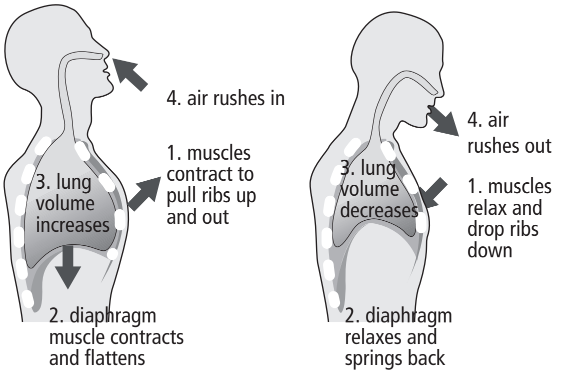
Explanation: When people exercise, they need more energy for their muscles to work. Their cells carry out more respiration to provide this energy and produce more carbon dioxide. So the air they breathe out through the limewater after exercise has a higher concentration of carbon dioxide than when they breathe out through limewater at rest. The limewater turns cloudy faster with the higher concentration of carbon dioxide.

Extension

a. Control – sealed tube containing limewater and an empty muslin bag.

b. Control – limewater stays the same as nothing is respiring so no carbon dioxide is being produced. Germinating seeds and worms – the limewater gradually turns cloudy, reacting with the carbon dioxide produced by respiration. The limewater would go cloudy faster in the tube with the worms as they are animals and move about and use more energy than germinating seeds, so they will produce more carbon dioxide, turning the limewater cloudy.

2.5 Breathing

1. The missing words are: blood; alveoli; energy; glucose; cells; exercise; exchange; oxygen.
2. Oxygen in air breathed out = 16, carbon dioxide = 4. Your answer should total close to 100% and show there is still plenty of oxygen in the air breathed out.
3. 

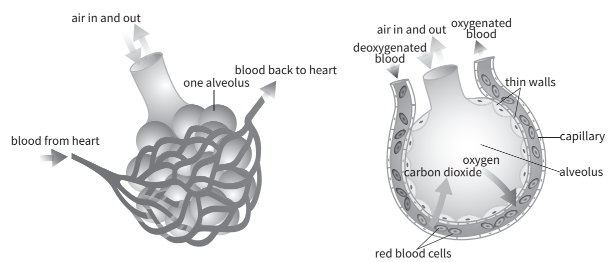
Extension

Lungs are not single sacs like balloons – lungs are made up of millions of tiny air sacs called alveoli so a sponge is a better model. A balloon could model a single alveolus.

Air is not blown into the lungs – changes in volume and pressure in the lungs mean air is forced into the lungs by external pressure.

Any other sensible points.

2.6 The structure of the alveoli

1. gas exchange; alveoli; adaptations; diffuses; air; blood; dioxide; capillaries; alveoli.
2. 

3. **a.** Many tiny air sacs give a very big surface area over which gas exchange takes place.

   b. Very short distances for the oxygen and carbon dioxide to diffuse.

Extension

a. The steep concentration gradient between oxygen in the air and the oxygen in the blood means oxygen diffuses quickly down the concentration gradient from the air in the alveoli to the blood in the capillary. The steep concentration gradient between the carbon dioxide in the blood and in the air in the alveoli means the waste gas diffuses out of the air into the blood as fast as possible.

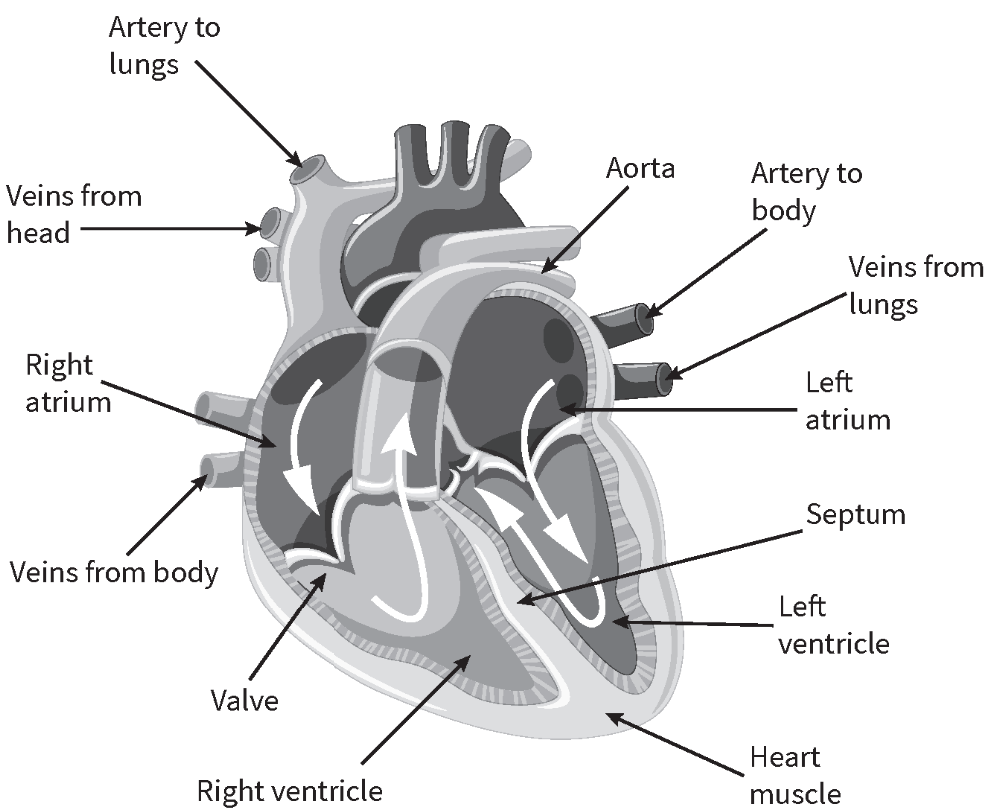
b. The rich blood supply helps maintain the steep concentration gradients needed for the rapid diffusion of oxygen into the blood and carbon dioxide out of it.

2.7 Asthma

1. a. The muscles around the airways to the lungs contract making the tubes narrower; the linings of the bronchi swell and make more mucus during an asthma attack.
   b. Both of these changes make the airways narrow and make it hard to move air into and out of the lungs. This means that the person affected does not get enough oxygen so they feel breathless.
2. a. Any two from the following: Lotanna breathes out a larger volume (or the reverse for Maryam); Lotanna breathes out faster (or the reverse for Maryam); Lotanna empties her lungs faster (or the reverse for Maryam).
   b. Maryam has asthma.
3. Scientists had to discover what happens in an asthma attack and what causes asthma before they could begin to develop medicines. Once they had developed medicines that stopped the muscles contracting and the tubes swelling, they needed to get the medicines into the respiratory system where it is needed. So they had to apply scientific principles from engineering to develop an inhaler to deliver the drug to where it is needed.

2.8 The human heart and circulatory system

1. The missing words are: circulatory, blood, blood vessels, oxygen, nutrients, carbon dioxide, urea, circulatory, efficient.
2.



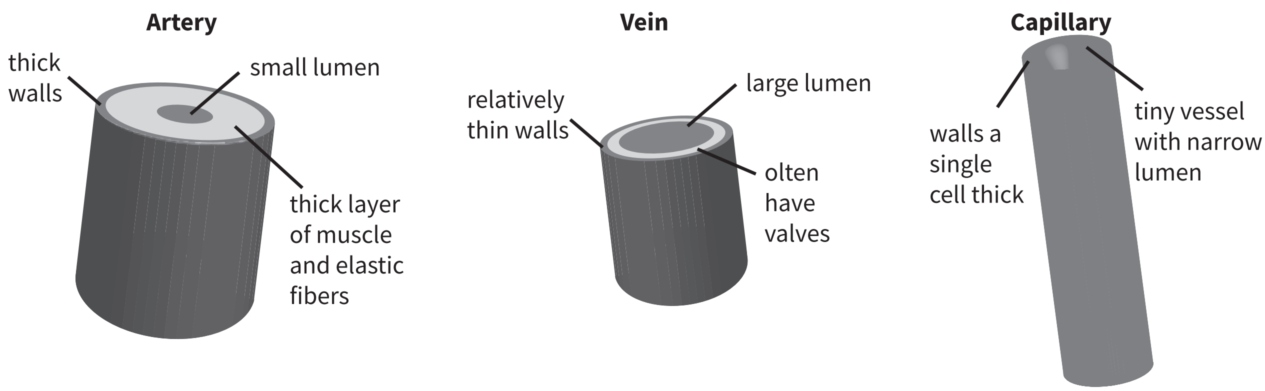
Extension

Generally, the left side of the heart deals with oxygenated blood, sending it to the body. Whereas, the right side handles deoxygenated blood, sending it to the lungs for oxygenation.

Left Side of the Heart	Right Side of the Heart
The **left atrium** receives **oxygenated blood** from the **lungs** via the **pulmonary veins.**	The **right atrium** receives **deoxygenated blood** from the **systemic circulation** via the **superior and inferior vena cava.**
This oxygen-rich blood then flows into the **left ventricle.**	This deoxygenated blood then flows into the **right ventricle.**
The **left ventricle** is responsible for pumping oxygenated blood to the **entire body** through the **aorta.**	The **right ventricle** pumps this blood to the **lungs** through the **pulmonary artery.**
The left ventricle has a **thicker muscular wall** as it needs to generate enough force to propel blood throughout the body.	In the lungs, the blood picks up oxygen and releases carbon dioxide during the process of **gas exchange.**

2.9 Arteries, veins and capillaries

1.



2.

Artery	Vein	Capillary
Arteries carry the blood away from your heart.	Veins carry blood back from the body to the heart.	Capillaries form a big network joining arteries to veins.
The blood they carry is usually oxygenated (rich in oxygen) and bright red in colour.	The blood they carry is usually deoxygenated - it has given up its oxygen to the cells of your body. It is purply-red in colour.	The blood moves quite slowly in the capillaries. Dissolved food and oxygen diffuse out of the blood into the cells. Carbon dioxide and urea diffuse out of the cells into the blood in the capillaries.

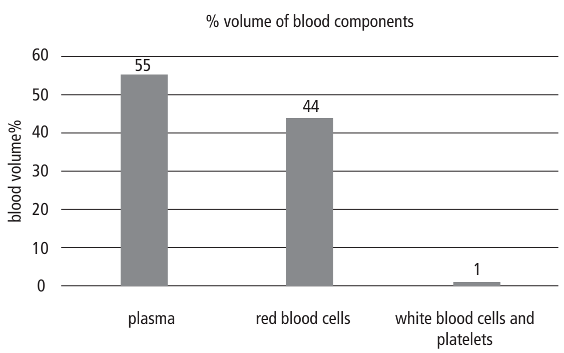
Arteries have a pulse due to heartbeat forcing the blood through the vessels.	Veins have no pulse.	As they connect arteries and veins, there is a slight pulse present.
Arteries have thick walls with lots of elastic tissue.	Veins have relatively thin walls, with valves to stop the blood flowing backwards away from the heart.	Capillaries have very thin, only one cell thick, walls.

Extension

The reason the artery carrying blood from the right side of the heart to the lungs, and the veins carrying blood from the lungs to the left side of the heart are different, is due to the blood they are carrying.

Generally, arteries carry oxygenated blood and veins carry deoxygenated blood. However, the artery carrying blood from heart to the lungs carries deoxygenated blood, so that it gets oxygenated in the lungs. On the other hand, veins transporting blood from lungs to heart carry oxygenated blood, which has had oxygen added to it in the lungs. This blood is sent back to the heart and from there to the rest of the body.

2.10 Transport in the blood

1. **a.** Platelets, red blood cells, plasma, white blood cells.
   b. Red blood cells are the most common – they are very small and need huge numbers to carry oxygen around the body.
2. **a.** Red blood cells. **b.** White blood cells. **c.** Red blood cells. **d.** White blood cells. **e.** Plasma. **f.** Plasma. **g.** Platelets. **h.** Red blood cell.
3. 

Extension

a. Red blood cells carry oxygen needed for cellular respiration to provide energy to carry out the processers of life. Lack of red blood cells means lack of oxygen so less energy which results in feeling tired.

b. Red blood cells contain haemoglobin which carries oxygen around the body. A patient with anaemia has fewer red blood cells than normal and so they will have less haemoglobin.

c. The body needs iron to make haemoglobin for the red blood cells. A lack of iron in the diet means less haemoglobin can be made so fewer red blood cells will be made, causing anaemia.

3.1 Microorganisms

1. The missing words are: single; bacteria/viruses; viruses/bacteria; fungi; microscope; culture.
2. **a.** fungus **b.** bacteria **c.** viruses **d.** yeast/s.
3. **a.** C
   b. F, plasmids.

c. i. Any two from: A cell membrane, B cytoplasm, C loop of genetic material, E cell wall.

ii. Corresponding two from: cell membrane – controls the movement of substances in and out of the bacterial cell; cytoplasm – site of most of the reactions that take place in the cell; loop of genetic material – carries information about making new bacteria; cell wall – gives the cell strength.

Extension

Your table should look something like this:

Feature	Bacteria	Fungi	Viruses
Size	0.2–2.0 µm	4.0 µm	0.01–0.1 µm
Genetic material	loop of genetic material + plasmids	nucleus	strand of genetic material
Cell wall	different to plant and fungal cell walls	present – made of chitin	no cell wall – protein coat
Cell contents	cytoplasm, cell membrane, loop of genetic material	cytoplasm, cell membrane, nucleus containing genetic material	genetic material

3.2 Pathogens and infectious diseases

1. a. Pathogens; b. Toxins; c. Viruses.

2. Any of the diseases listed in unit, such as covid-19, tuberculosis, hepatitis, typhoid,

Cholera, dengue, malaria.

3.

How disease-causing microorganisms spread from person to person	
Droplet infection:	many pathogens are spread through the air by droplet infection. Every time you cough, sneeze, or even talk, clouds of tiny droplets full of pathogens leave your breathing system. Other people breathe in these invisible droplets and become infected.
Direct contact:	some pathogens pass from one person to another by direct contact of the skin, or through contact with body fluids such as blood, or with objects covered in pathogens.
Contaminated food and drink:	we drink water contaminated with human waste or eat food washed in water containing pathogens, they are carried straight into our body and cause disease.
Vectors:	some pathogens are carried from person to person by another animal known as a vector. Vectors are often insects such as mosquitoes.

Extension

The spread of typhoid can be prevented by ensuring that the faeces do not contaminate the food and water taken in by people. This requires strictly observed personal and communal hygiene, such as washing hands with soap after using the toilet and before preparing food. Other important habits would be to drink boiled water, keep utensils clean and keep cooking area separate and away from the toilets. The community should also make sure not to defecate in public or near food storage.

Finally, the typhoid bacteria should be treated through use of antibiotics and the rest of population should be vaccinated against typhoid.

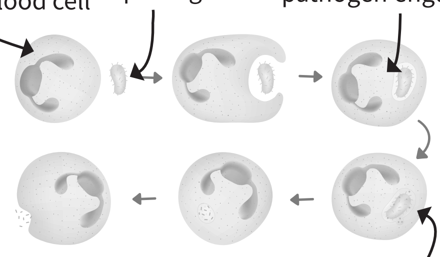
3.3 Body defences against pathogens

1. The missing words are: pathogens, immune, innate, specific, pathogens, adaptive immune system, different, remembers.

2.

Structure	Function
Skin	The skin covers and protects the tissues of the body and stops pathogens getting in. If there is a cut, the blood clots and forms a scab, to stop the bleeding, and prevent pathogens from getting in through the open cut.
The digestive system	Acid produced by the stomach kills almost all the microorganisms that get into this body system
Respiratory system	The nose hairs, mucus and epithelial cells work together to prevent pathogens from entering the lungs.

3.

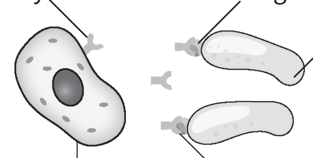


3.4 The adaptive immune system

1. a. The adaptive immunity offers targeted and memory-based protection against pathogens, while the innate immunity provides a rapid but non-specific defense. The innate immune system is present from birth and can be inherited but cannot remember any past pathogens it has encountered. The adaptive immune system is known as acquired immunity as it is acquired by the body as it encounters different pathogens. It can remember the pathogens it encounters and can provide a targeted response to them.

   b. The two elements of adaptive immunity are Antigens and Antibodies.

2. a.



   b. The cells of every different type of organism have special protein markers on the outside called antigens. A body can recognise pathogens because their antigens are different from its own.

   Some white blood cells make special chemicals called antibodies, which target antigens which are different to your own. Each type of pathogen needs different antibodies to destroy it and the adaptive immune system only adapts and learns to make the right antibodies once it meets the pathogen with its specific antigens.

The body 'remembers' the antigens from the surface of each type of pathogen, so it can make antibodies against it very fast if you meet it again. This makes a body immune to the disease

Extension

This is because being immune to a disease does not mean you have a high level of antibodies to a disease in your blood all the time. Jamils white blood cells remember the measles' antigens. This means that in case Jamil is ever infected with measles again, the white blood cells will make the right antibodies faster.

3.5 Using science to prevent disease

1

How disease-causing microorganisms spread from person to person
Droplet infection: Tiny droplets containing disease-causing microorganisms forced out of your nose and mouth when you breathe, talk, cough, or sneeze. Other people breathe in the droplets and take the microorganisms into their body.
Contact: Some microorganisms passed from one person to another by direct contact with skin or with other objects people have coughed/sneezed over, etc. You transfer the microorganisms to your mouth, eyes, etc. by touch.
Contaminated food and drink: Water contaminated by human waste or raw or undercooked food may be contaminated with disease-causing microorganisms. The microorganisms are taken directly into the body.
Break in the skin: Some microorganisms get straight into the blood stream through cuts or breaks in the skin, including animal bites and needle scratches.

1. a. Wear a face mask to protect your mouth and nose and prevent you breathing out/coughing out/sneezing microorganisms into the air for other people to take in; avoid crowded places so there are fewer microorganisms in the air; cough or sneeze into a tissue or your elbow to prevent a microorganism spray; meet outdoors where there is less build up of microorganisms in the air; any other sensible points.

b. Wash hands often/use antiseptic gel to prevent transfer of microorganisms from surfaces to mouth; don't shake hands; maintain distance from people so you don't touch them to transfer microorganisms; any other sensible points.

Extension

Any three from: improve sewage treatment so that drinking water is never contaminated with faeces carrying typhoid bacteria; make sure everyone can get clean drinking water so people are not forced to drink water that may be contaminated with typhoid bacteria; encourage people to wash their hands after using the toilet to make sure they don't transfer typhoid bacteria to surfaces, food, etc.; encourage people who sell or prepare food not to work when they feel ill to minimise risk of them passing on typhoid bacteria on their hands; any other sensible point with scientific explanation.

3.6 Strengthening the immune system

1. Some pathogens make you seriously ill; and may even kill you.

Examples of dangerous pathogens include; measles, typhoid, tetanus and COVID-19.

We can strengthen our immune system and protect ourselves against some serious diseases; by immunisation.

Immunisation teaches your adaptive immune system; to make the antibodies it needs to protect you against serious diseases.

Immunisation saves; millions of lives every year.

2. i. When you are given a vaccine against a serious infectious disease, it contains antigens from a specific type of pathogen. These antigens do not cause disease.

ii. When the white blood cells of your adaptive immune system meet the antigens in the vaccine, they recognise that they are different and react as if they were meeting the live pathogen. They learn to make the antibodies needed to protect you against this pathogen.

iii. Your adaptive immune system remembers the antigens in the vaccine. Your white blood cells can now make the right antibodies faster when you need them, if you come into contact with the live pathogen.

iv. Your body destroys the pathogen before it can make you feel seriously ill.

Extension

The data shows that as the uptake of polio vaccine increased in a population, the incidence of polio fell drastically and remained at minimal level.

3.7 Microorganisms and disease

1. The correct order is:

   2 Pasteur decides to grow anthrax germs, weaken them, and inject them into animals to protect them, against the disease and prove his germ theory.

   1 Pasteur has a hypothesis that infectious diseases like anthrax are caused by germs passed from one person or animal to another.

   7 Three days after the animals were infected with anthrax, there was a public inspection. All the vaccinated animals were alive and healthy. All the unvaccinated animals were dead or dying of anthrax.

   3 Hippolyte Rossignol does not believe in germ theory and challenges Pasteur to prove his theory with a public test.

   5 A few weeks later all the animals are infected with live anthrax from infected animals.

   6 Pasteur predicts that the vaccinated animals will survive and the unvaccinated animals will develop anthrax and die.

   8 Pasteur had clearly demonstrated both the germ theory of disease and the value of vaccination.

   4 Pasteur gives a group of healthy sheep, cows and goats his vaccine. He selects a similar group of animals that do not get the vaccine.

Extension

Says: When microorganisms land in liquids full of nutrients they grow and reproduce, and make the liquid cloudy – suggest an explanation.

Thinks: if I keep microorganisms out of a nutrient solution it will not go cloudy because it will not go bad – make a prediction.

Places nutrient solutions in flasks with S-shaped necks, and boils them to destroy any microorganisms present – test the explanation.

Notices that nutrient solutions do not go cloudy in flasks with S-shaped necks – review the evidence.

Breaks the neck of one of the flasks and observes that the nutrient solution begins to ferment and turn cloudy once microorganisms can get in – collect extra evidence.

3.8 Infectious diseases: hepatitis

1. a. The Hepatitis viruses are responsible for the cause of hepatitis infection in the liver.

   b. dark urine with pale poop; jaundice; hives, weakness, sleep disruption.

   c. 2 common ways of getting a hepatitis infection in Pakistan are:

      i. through untreated blood transfusions and in hospitals and dentists where good hygiene is not practised so surgical instruments and needles are not sterilised between one patient and the next.

      ii. through transfusion of infected blood.

2. Immunisation works against the spread of Hepatitis because there is a very good vaccine against hepatitis B. In Pakistan, many children are now given this vaccine when they are very young, protecting them for life.

Testing is essential especially when dealing with hepatitis C. In Pakistan there are some good, cheap medicines to treat hepatitis C, which can cure the disease in 3 months, but only if the medicines are used early in the infection, before the liver is permanently damaged. The only way to find out is to test people regularly, to identify and treat infections before they cause serious health problems.

Extension

The disadvantage of immunisation is that no vaccine is available for Hepatitis C. However, the advantage is that the vaccine for Hepatitis B is very good and cheap and when administered at a young age, can protect children from life.

The advantage of testing is that it is very effective for identifying Hepatitis C. However, the testing process can be expensive if not enough testing centres and health units are not available.

3.9 Infectious diseases: covid-19

1. The missing words are: virus; mutated; pandemic; millions; respiratory system; lungs; variants; covid-19; dengue; typhoid.

   Covid-19 is caused by a virus. It is very infectious and makes people very ill, so it is important to diagnose it correctly to avoid it spreading.

   The early symptoms of covid-19 are very similar to other illnesses, so we use lateral flow tests and PCR tests to diagnose it.

   There are two main ways to prevent covid-19 – immunisation and stopping the spread between people.

   We have effective vaccines against covid-19 and in Pakistan over 60% of the population is now fully immunised.

   For complete protection against covid-19 around 90% of a population need to be immunised.

   The way people behave also reduces the spread of covid-19. We need to wear masks in public places, avoid big crowds and stay at home away from others if we get covid-19.

Extension

The biggest difference between Lateral flow tests and PCR tests is the time between results. Since LFTs identify the antigens from covid-19 viruses, they can provide the results within minutes; however, the results are less sensitive and may give errors. The PCR tests identify the genetic material from the covid-19 viruses and so can take between one to three days for lab results. As a result, PCR tests are more reliable, but also more expensive.

3.10 Infectious diseases: typhoid

1. a. Typhoid is caused by an infection from Salmonelli typhi bacteria.

   b. The bacteria that cause the typhoid pass out of the body of an infected person in their faeces. Anyone who eats food or drinks water contaminated with infected faeces takes the bacteria into their body and becomes infected. Raw and undercooked food carry typhoid if the person preparing it had the bacteria on their hands.

   c. the graph clearly shows that the incidence of typhoid related deaths is very high among the unimmunised children in Pakistan. Comparatively, the rate of death due to typhoid among immunised children is very, very low.

2.

Personal hygiene practices	National and community hygiene practices
washing hands using soap every time we use the toilet, before cooking and before eating	religious leaders must encourage immunisation
boiling water before drinking or washing food in it	Local governments to provide latrines and toilets
cooking all food thoroughly	Local governments to give every community a clean water supply

do not defecate in the open – use a well-sited pit latrine or toilet	improved health infrastructure so typhoid is diagnosed and treated fast, and children are immunised in all areas of our country.

3.11 Infectious diseases: dengue

1. a. This name is given to dengue due to the severe pain experienced by its patients.
   b. Severe dengue is also called haemorrhagic fever because it makes the blood vessels leak, resulting in bleeding inside the bodies. This causes shock and failure of the cardiovascular system - 50% of people affected by severe dengue die.
2. a. The Aedes mosquitos lay their eggs in stored, open water. The eggs hatch to release larvae, which form a pupa and transform into adult mosquitos. These adult mosquitos can become infected with dengue viruses, which spreads from one person to another by the bite of infected mosquitoes. The female Aedes mosquito needs two blood meals before she lays her eggs. If the first person the mosquito bites is infected with dengue viruses, she carries them to the second person she feeds from, infecting them.
   b. i. 3 ways to avoid contact with dengue vectors is to: 1- Use mosquito nets on all beds. 2- Use mosquito repellents and wear clothing that covers most of your skin. 3- Have screens on doors and windows.
      ii. 3 ways to prevent dengue vectors from breeding include: 1- Fill in small ponds. 2- Store rubbish out of the rain. 3- Dispose of sewage properly – mosquitoes will breed in human waste. 4- Spray pesticides into the surface of ponds or rivers where mosquitoes breed. This kills the eggs and larvae, reducing the numbers of mosquitos to spread dengue and other diseases.

Extension

The early symptoms of dengue are similar to some other diseases such as malaria, which is why a diagnosis is not always easy. Dengue is diagnosed by blood tests which look for either:

- the dengue virus in your blood.
- antibodies which show your adaptive immune system is fighting the dengue virus. These antibody tests look rather like the covid-19 lateral flow test.

The reason it is important to diagnose dengue accurately is due to 50% mortality rate in severe dengue.

4.1 The Periodic Table

1. Encourage students to refer to the student book to mark out their answers.
2. a. i. A line graph is better able to show the increasing or decreasing trend.
      ii. Encourage students to draw bar and line graphs on a separate graph paper.
   b. Encourage a class discussion: students should be able to point out any anomaly they encounter and provide a reason for it.
   c. Improved conclusion: The size of atoms in the periods of the periodic table decreases gradually from left to right across the period except for silicon which does not follow this trend. Reasons: 1- The graph shows decreasing trend so it should be included in the conclusion statement. 2- It should be indicated in the statement that silicon does not follow the trend.

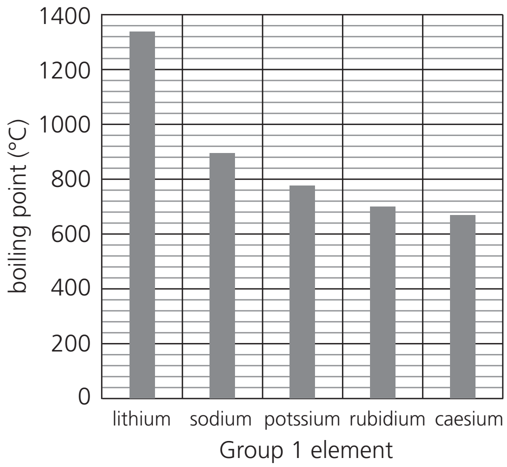
4.2 The periodic table: Group 1

1. a. **M**, **O**
   b. **M**, **O**
   c. **O**
   d. –
   e. –

f. –

g. O

2. a. i.



ii. From top to bottom of Group 1, boiling point decreases.

Extension

a. From top to bottom of Group 1, melting point decreases.

b. Group 1 elements have giant metallic structures. From top to bottom of the group, the ions get bigger. This means that electrostatic attractions between positive ions and negative electrons get weaker. As the attractions get weaker, ions leave their fixed positions more easily, so melting point decreases.

4.3 Inside atoms

1.

Phenomenon	The solid sphere model of atoms can explain this.	The solid sphere model of atoms cannot explain this.
condensing	✓	
chemical reactions		✓
melting	✓	

2. Left – nucleus; right, from top – electron, proton, neutron.

3. a. 5
   b. 19
   c. 28
   d. 33

4. Carbon – diagram showing 6 protons and 6 neutrons; beryllium – diagram showing 4 protons and 5 neutrons; fluorine – diagram showing 9 protons and 10 neutrons.

Extension

Like an atom – similar shape, includes small electrons/pips; unlike an atom – no nucleus, no parts represent protons and neutrons; overall usefulness – any well-argued answer.

4.4 Atomic number and the periodic table

1. True – **a**, **c**.
   False – **b**, **d**.
   Corrected versions of false statements:
   b. In the periodic table, the elements are arranged in order of proton/atomic number;
   d. A helium atom has 2 protons and 2 neutrons, so its proton number is 2.

2. a. i. 33
      ii. 36
      iii. 47
   b. i. Lithium.
      ii. Nitrogen.
      iii. Aluminium.
      iv. Potassium.
   c. i. 21
      ii. 17
      iii. 50
      iv. 79

3. Diagram showing 4 small circles in one colour (key – protons) and 5 small circles in another colour (key – neutrons).

Extension

Scientists did not know about protons.

4.5 Mass number

1. The missing words are: atomic; mass; atomic.

2. a: 7; b: 12; c: 19; d: 27; e: 119; f: 197; g: 201

3.

Atom of the element…	Atomic number	Mass number	Number of neutrons
Hydrogen	1	1	0
Helium	2	4	2
Beryllium	4	9	5
Nitrogen	7	14	7
Sodium	11	23	12
Sulphur	16	32	16
Titanium	22	48	26

4. a: 3; b: 4; c: silicon; d: Gallium (Ga) /Ytterbium (Yb); e: half; f: bromine.

4.6 Electrons in atoms

1. Neutrons, protons, 2, 8, chemical.

2.

Element	Number of electrons in one atom	Electron configuration
helium	2	2
lithium	3	2,1
boron	5	2,3
nitrogen	7	2,5
fluorine	9	2,7
magnesium	12	2,8,2
silicon	14	2,8,4
sulfur	16	2,8,6

3. Lithium – 2 electrons in first shell, 1 in second shell; beryllium – 2 in first shell, 2 in second shell; neon – 2 in first shell, 8 in second shell; sodium – 2 in first shell, 8 in second shell, 1 in third shell; magnesium – 2 in first shell, 8 in second shell, 2 in third shell; argon – 2 in first shell, 8 in second shell, 8 in third shell.

Extension

Lithium – 2,1; sodium – 2,8,1; potassium – 2,8,8,1.
They all have 1 electron in the outer shell.

5.1 Making ions

1. Ion, electrons, negatively, positively.

2.

Description of ion	Chemical formula of ion
A lithium ion, with a charge of +1	Li^{+}
A magnesium ion, with a charge of +2	Mg^{2+}
An aluminium ion, with a charge of +3	Al^{3+}
A fluoride ion, with a charge of –1	F^{-}
A sulfide ion, with a charge of –2	S^{2-}
A nitride ion, with a charge of –3	N^{3-}

3. **A** and **C**.

Extension

a. Electron moves from outer shell of sodium atom to outer shell of chlorine atom.

b. Results in formation of two stable ions, each with a full outer electron shell.

c. Sodium ion – 2 electrons in first shell, 8 in second shell; chloride ion – 2 electrons in first shell, 8 in second shell.

5.2 Inside ionic compounds

1. Ion – a particle with a positive or negative charge;
   ionic bonding – electrostatic attraction between positive and negative charges;
   giant ionic structure – the three-dimensional pattern of positive and negative charges;
   ionic compound – a substance that is made up of positive and negative ions.
2. **A**, **C**, **D**
3. Zareena.

Extension

Any suitable model, with clear labels.

5.3 Covalent bonding

1. True statements – **a**, **d**, **e**.
   False statements – **b**, **c**, **f**.
   Corrected versions of false statements:
   b. Each covalent bond holds two atoms together;
   c. Compounds of non-metals have covalent bonds;
   f. There are three covalent bonds in an ammonia molecule, NH_3.
2. **a.** From top – 4, 1, 8, 2.
   b. Their atoms have a share in the number of electrons needed for a full outer shell (8 for carbon and 2 for hydrogen).

Extension

B and **D**.

5.4 Covalent structures

1.

Statement	True for substances with simple molecules	True for substances with giant covalent structures	True for simple molecules and giant structures
There are shared pairs of electrons between the atoms.			✓
The atoms are joined by covalent bonds.			✓
There is a three-dimensional network of atoms.		✓	
The molecules are attracted to each other weakly.	✓		
They have low melting points.	✓		
They are in the solid state at room temperature.		✓	
They have high melting points.		✓	
Most are in the gas or liquid state at room temperature.	✓		

2. **a.** M
   b. G
   c. M
   d. M
   e. M
   f. G

3. In a substance with simple molecules, the molecules are attracted to each other only weakly, so little energy is needed to disrupt the structure when the solid melts; but in a substance with a giant covalent structure, atoms are joined together in a three-dimensional structure with strong covalent bonds, so large amounts of energy are needed to break all the covalent bonds when it melts.

Extension

a. W, Z
b. They have low melting points.

5.5 Valency and chemical formulae

1. the missing words in order are: valency; one; two; zero.

2. di- : 2; hexa- : 6; mon- : 1; penta- : 5; tetra- : 4; tri : 3

3.

Name	Chemical symbols	Valency	Swap and simplify	Answer
lithium fluoride	Li F	1 1	Li1 F1	LiF
calcium oxide	Ca O	2 2	Ca2 O2	CaO
magnesium bromide	Mg Br	2 1	Mg1 Br2	MgBr2
sodium sulfide	Na S	1 2	Na2 S1	Na2S
aluminium nitride	Al N	3 1	Al1 N3	AlN3
magnesium nitride	Mg N	2 1	Mg1 N2	MgN2
methane	C H	4 1	C1 H4	CH4

4. **a.** sulfur dioxide SO2
   b. sulfur trioxide SO3
   c. dinitrogen tetroxide N2O4
   d. phosphorus pentoxide PO5

6.1 Chemical and physical changes

1.

Statement	Is the statement true for chemical changes?	Is the statement true for physical changes?
These changes make new substances.	Yes	
The atoms rearrange and join together differently.	Yes	
The atom are joined together in the same particles before and after the change.		Yes
Many of these changes are easily reversible.		Yes
Energy may be transferred to the surroundings.	Yes	Yes
Most of these changes are not easily reversible	Yes	
Energy may be transferred to the surroundings.	Yes	Yes
The total mass is the same before and after the change.	Yes	Yes

2. C: c, d, f; P: a, b, e, g, h, i.

3. Encourage students to write in their own words.

Extension

Encourage students to provide any appropriate answer using scientific terms they have learned so

6.2 Physical and chemical properties

1. true: a, c, e, f, g, h, i; false: b, d.

   The corrected versions are:

   Boiling point is a physical property.

   Whether or not a substance reacts with oxygen is a chemical property.

2. **a.** Making furniture: does not catch fire easily; rigid (does not bend); does not take part in chemical reactions with water.

   Killing pathogens (germs) in water: soluble, or can mix with, water.

   Making hair brushes: does not take part in chemical reactions with water; does not catch fire easily.

   Making electrical wires: high melting point; good conductor of electricity; good conductor of thermal energy (heat); does not catch fire easily.

   Making water pipes: high melting point; does not take part in chemical reactions with water.

   Making frying pans: high melting point; rigid (does not bend); good conductor of thermal energy (heat); does not catch fire easily.

   Making jewellery: high melting point; does not take part in chemical reactions with water; does not catch fire easily.

   b. all are physical properties except for this: does not take part in chemical reactions with water.

Extension

Encourage students to provide any appropriate answer.

6.3 Using materials: Thermal conductivity

1. **a.** Independent – material the spoon is made of; dependent – time for butter to melt; control – size of spoon, amount of butter, temperature of water, distance from water to butter.

   b. The spoons are different sizes.

   c. The butter on the silver spoon melts quickest, showing that silver is the best conductor of thermal energy. The butter on the plastic spoon melts slowest, showing that plastic is the worst conductor of heat.

Extension

a. The metal elements in the table have higher thermal conductivity values, so are better conductors of thermal energy than non-metals.

b. Any suitable answer, for example: no, because carbon could just be a single exception; yes, because carbon is a non-metal and its thermal conductivity value is high, suggesting that it is not only metals that are good conductors of heat.

6.4 Using materials: bicycles

1. Low density, stiff, hard, shiny, strong, not damaged by air and water.

2. **a.** B

   b. Because it has the lowest density, and is hardest. It is also stiff and strong.

   c. It is renewable / can be obtained with minimal damage to the environment.

Extension

Encourage students to provide any appropriate answer.

6.5 Using materials: rusting

1. the correct word/phrase list: chemical; surface of; destroys; slowly. Oxygen; rust; exposes; can.
2. **a.** Water; oxygen
   b. iron: solid; water: liquid; oxygen: gas.
   c. rust or hydrated iron oxide, is a solid.
3. Cars: Paint them; Parts in a car engine: Cover them in grease; Surgical tools: Make them from stainless steel, which has different chemical properties from pure iron.

Extension

a. The constant exposure to water and the oxygen dissolved in it developed the rust.
b. The machine is used to remove/reduce the amount of water vapour in the air to prevent further development of rust.

6.6 Preventing rusting

1. **a.**

Variable	Change (independent variable)	Measure or observe (dependent variable)	Control
Volume of salt solution			●
Mass of salt dissolved in water	●		
Temperature of salt solution			●
The metal the nail is made out of		●	●
Amount of rust made after 1 week		●	
Size of nail			●

   b. Mass of salt dissolved in water
   c. The variable he changes is continuous and the variable he observes is continuous.

Extension

There are multiple reasons for the teacher to say this: 1- there are no hypothesis and conclusion statements; 2. An experiment needs to be repeated multiple times to get enough data for accuracy.

6.7 Using materials: combustion

1. Combustion reaction: A reaction in which a substance reacts quickly with oxygen, transferring energy as heat and light.

Greenhouse gas: A gas that absorbs heat.

Greenhouse effect: The overall transfer of energy from the Sun to the gases in the air.

Global heating: The increase in average air temperature.

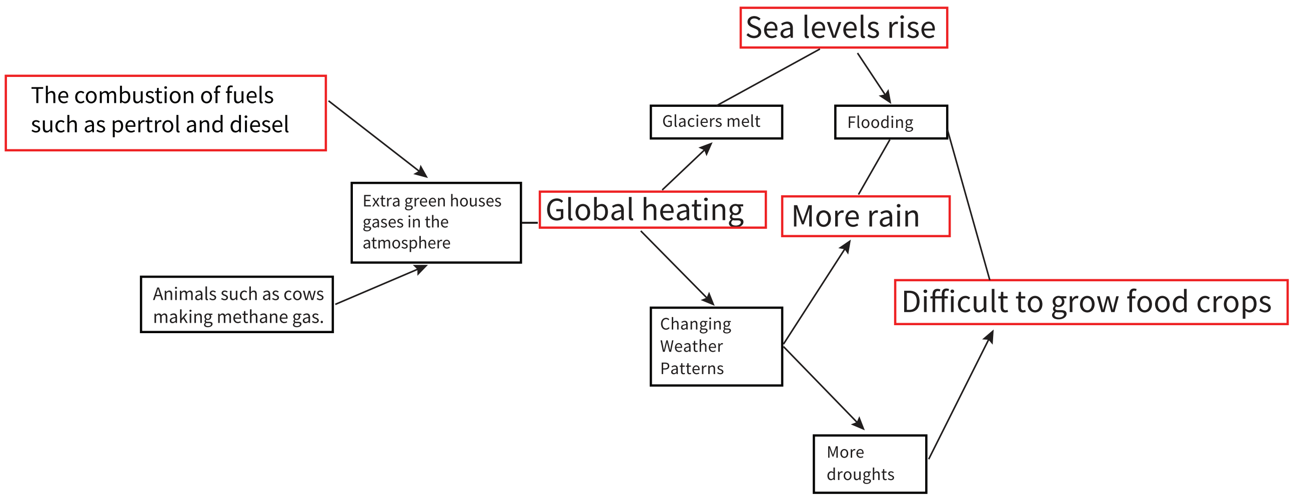
Climate change: Long-term changes to weather patterns.

Flammability: A chemical property that indicates how easily a substance catches fire.

2. Requires material of low flammability: Material for stuffing comfortable chairs; Material for making houses; Material for baby clothes.

Requires material of high flammability: Fuel for cooking stoves; Material for making pans for cooking; Material in a match head.

3.



7.1 Speeding up dissolving – 1

1. Solution: A mixture of a liquid with a solid or gas. All parts of the mixture are the same.

Solute: The substance that dissolves.

Solvent: The liquid in which a substance dissolves.

Dissolve: The mixing of a solute and solvent to make a solution.

2. a.

Variable	**This variable is the independent variable** (the variable the student changes)	**This variable is the dependent variable** (the variable the student measures)	**This is a control variable** (the variables the student keeps the same)
Time for sugar to dissolve		●	
Mass of sugar			●
Water temperature			●
Volume of water			●
Speed of stirring	●		

b. i. B; ii. The amount of water is not the same in all the beakers

7.2 Speeding up dissolving – 2

a.

Variable	**This variable is the independent variable** (the variable the student changes)	**This variable is the dependent variable** (the variable the student measures)	**This is a control variable** (the variables the student keeps the same)
Time for salt to dissolve		●	
Mass of salt			●
Water temperature			●
Volume of water			●
Speed of stirring	●		

b. the instruments in order from top to bottom are: stopwatch; balance; thermometer; measuring cylinder.

c. **i.** 28; **ii.** An increase in temperature reduces the time required to dissolve the salt in water; iii. To investigate whether the increase in temperature effect holds true for sugar as well.

7.3 Solutions and concentration

1. True – **a**, **b**, **c**.
   False – **d**, **e**, **f**.
   Corrected versions of false statements:
   d. To make a solution more concentrated, add more solute;
   e. To make a solution more dilute, add more solvent;
   f. The more solute particles in 100 cm^3 of solution, the more concentrated the solution
2. Beaker B.
3. Diagram the same as B, but with more black particles.

Extension

a. Y **b.** X **c.** Y **d.** Y **e.** X

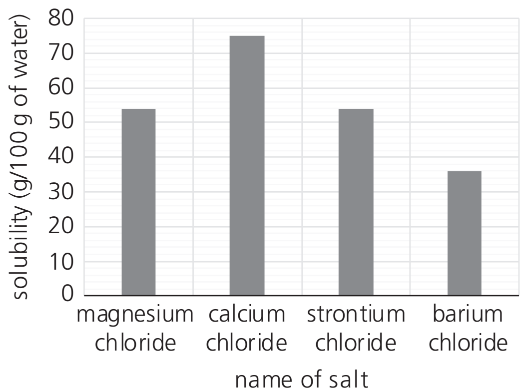
7.4 How much salt is in the sea?

1. **a.** Mass of empty beaker – 120 g; mass of beaker + rock salt – 125.8 g; mass of rock salt (125.8 – 120) = 5.8 g.
   b. **A**, **E**, **C**, **B**, **D**, **F**
   c. Hot apparatus – reduce chance of injury and damage by burning off Bunsen when water has evaporated, wait for the equipment to cool before touching, stand back while heating;
   salt spitting – burns to skin and damage to eyes; wear eye protection.
   d. Sample may contain less salt; some salt may have left the evaporating basin during the heating stage.

7.5 Chlorine and water

1. Larger samples make the results more reliable and reduce errors.
2. To compare the effect of fluoridation with no fluoridation.
3. 2007–2012 is a longer time frame so they could determine the effects of fluoridation over a longer time period.
4. In towns where the water was fluoridated, the number of 5–6 year olds with missing teeth (from decay) and the number of 12–13 year olds with surface decay decreased. However, the same effect on 5–6 year olds was seen in town D, which did not have fluoridated water. There does not appear to be a link between water fluoridation and the change in the number of 12–13 year olds with decayed, missing or filled teeth.
5. If the water did not contain adequate levels of fluorine, it is possible that the effects of the fluorine may have not been as significant as if the correct levels of fluorine were used.

7.6 Solubility

1. **A**, **C**, **E**
2. 

Extension

Any reasonable questions.

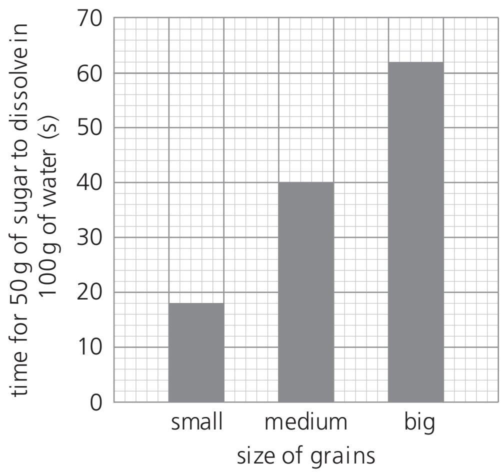
7.7 Investigating solubility and temperature –1

1. **a.** Independent – water temperature;
   dependent – mass of salt;
   control – water temperature.
   b. **i.** Measuring cylinder.
   ii. Lab thermometer (the longer one).
   c. 58
   d. **B.** heat the water to the required temperature;
   E. measure out 100 cm^3 of water and pour into a new beaker;

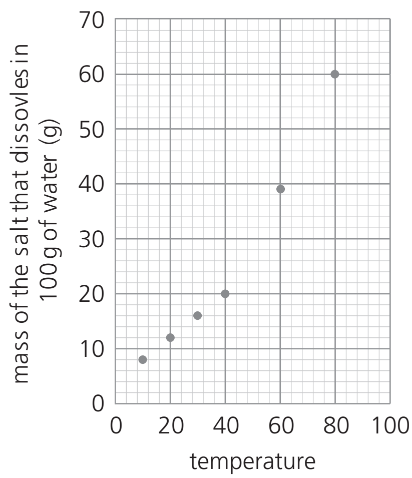
H. write down the mass of salt added when some remains undissolved.

7.8 Investigating solubility and temperature –2

1.



2. a.



b. D

Extension

Temperature (°C)	Mass of copper sulfate that dissolves in 100 g of water (g)	Mass of sodium carbonate that dissolves in 100 g of water (g)	Mass of potassium chloride that dissolves in 100 g of water (g)

7.9 Factors affecting solubility

1. the solubility of a substance in gaseous state decreases as the temperature increases.
2. a. Carbon Dioxide; b. Water; c. 0.1; d. 0.24; e. 15.

8.1 Hot and cold

1. Missing words in order: mass, temperature, longer, mass, energy, energy, mass, temperature, dissipation.
2. **a.** It takes longer to heat a cinema as more energy is needed to heat the greater mass of air than in a house.

b. It takes longer to boil a pan of water as more energy is need to heat the same mass of water to a higher temperature.

c. The temperature of the Sun is 6 million degrees C.

3.

	Thermal energy	Temperature
Measured in joules.	✓	
Does not depend on how much material there is.		✓
Measured in degrees Celsius		✓
Increases if you heat something for longer.	✓	✓

4. a. 8.4 kJ

b. 12.6 kJ

Extension

Statement c is true. Oil takes about half as much energy to raise its temperature by the same amount as water.

8.2 Thermal expansion and contraction

1. true: b, d; false: a, c.

The corrected versions are:

The particles do not expand they vibrate more and move further apart so the substance as a whole expands.

Bimetallic strips are made of two different metals welded together.

2. a. In hot weather the slabs expand, so the gaps stop them pushing against each other.

b. Glass is a poor conductor, so the inner surface of the glass is hotter than outer surface. The inner surface expands more, and this causes the glass to shatter.

c. Since the coolant expands when it is heated, it might break the car radiator.

3. The bimetallic strip bends to the right. This completes the circuit and lamp B lights up.

8.3 Energy transfer: Conduction

1. a. T b. F c. T d. F

b. F – Things that feel warm conduct thermal energy towards/into our hands.

d. F – The particles in a metal that is hot are vibrating more than the particles in a metal that is cold.

2. a. Foam.

b. Paper.

c. Air is a poor conductor of energy, so a material that contains pockets of air will be a good insulator.

3. a. The drawing pin drops off the rod that is the best conductor first.

b. If the rod was made of an insulator the drawing pin would not drop off.

c. Order of best to worst conductor: copper, aluminium, iron.

8.4 Energy transfer: Convection

1. Missing words in order: expands, decrease, upwards, colder, denser, convection current.

2. a. The purple crystal will have dissolved and the colour moved up across and back down.

b. Convection current.

c. The purple will have moved down to the bottom of the beaker and spread across the bottom.

d. No, there is no way that the purple will move up without heating.

3. a. Small amount of smoke beginning to be drawn down the tube.

b. Current of smoke down the tube along the bottom to the candle and up with the warm air from the candle.

c. The candle warms the air, which rises out of the enclosed space. This lowers the air pressure drawing cool air in from the other end, and the smoke with it.

Extension

a. The land heats up more quickly than the sea, so currents are onshore during the day, because the hot air above the land rises and is replaced by air from the sea. The sea stays warmer longer at night, so the air over the sea rises and is replaced with air from the land.

b. Cool air sinks, so the bottom of the refrigerator is the coldest part. The warmth from the bottle will warm the air around it, which will move up and take the energy away from the bottle.

c. Warm air rises, so the hottest part of the oven is at the top. The energy will be transferred to the food.

8.5 Energy transfer: Radiation

1. a. A video camera records light. A thermal imaging camera produces an image by detecting different temperatures.
   b. If parts of the building were burning there would be spots of a higher temperature that were fires rather than people, but you would not be able to tell using the thermal imaging camera.
   c. Yes, the metal door would conduct the heat and radiate it on the other side, but it might spread quickly across the whole door.
   d. You can detect people that you cannot see and tell whether they are alive.
2. a. Venus has a much denser atmosphere than Earth, so more energy is trapped as radiation and the atmosphere warms up more.
   b. Mercury has no atmosphere, so no energy is trapped as radiation. This means that when part of Mercury is not facing the Sun it will be a lot colder that the part facing the Sun.

Extension

a. microwave, infrared, ultraviolet, X-rays, gamma

b. They have a higher frequency so are higher energy, and this means they are more damaging to the body.

8.6 Insulating homes

1. the missing words are: hot, cold, conduction, convection, radiation, insulators
2. a. loft insulation/cavity wall insulation/draught excluders
   b. The fibre glass and foam contain trapped pockets of air. Air is a poor conductor/good insulator. So reduce thermal energy transfer by conduction.
   c. Conduction relies on particle transferring energy via vibrations. There are no particles in a vacuum so no energy is transferred by conduction.
3. Energy is transferred from regions of higher temperature to regions at colder temperature. The insulation reduces the rate of energy transfer

Extension

a. Energy transferred = 0.2 x (20 -5) x 1 = 3 W or = 0.2/2.5 × 37.5 = 3 W

b. Valuable energy resources are used to keep buildings at a constant temperature. To conserve resources buildings should be as well insulated as possible.

8.7 Cooling by evaporation

1. a. F – The average speed of molecules in a liquid is between the fastest and slowest.
   b. T
   c. F – If temperature decreases, so does the average speed of the molecules.
   d. F – Liquids evaporate at different rates.

2. **a.** The ethanol evaporates.
   b. Ethanol has a lower boiling temperature than water so its molecules can evaporate more quickly transferring energy away from your body more quickly.
3. **a.** The ether evaporates, transferring energy away from the water until it cools enough to freeze.
   b. In a refrigerator, coolant circulates transferring energy away from the air in the fridge cooling it and the contents.

Extension

a. Molecules at a lower temperature have a lower speed.
b. Higher.
c. Warm water evaporates faster than cold water because more molecules have enough energy to escape from the surface of the liquid.

9.1 Introducing waves

1. Mechanical: energy transferred through a medium.

   Electromagnetic: energy transferred without a medium.

   Longitudinal: vibrations are parallel to the direction of the wave.

   Transverse: vibrations are perpendicular to the direction of the wave.
2. **a.** By moving their hand up and down or side to side.
   b. The knot will move up and down (or side to side).
   c. Energy is transferred from the end to the other end of the rope.
3. **a.** sound/pressure wave/wave on a slinky when pushed back and forth.
   b. water/wave on a rope.
   c. light or any other electromagnetic wave.

9.2 Describing waves

1. **a.** The wavelength of a wave is the distance from one point of one wave to the same point of the next wave. For example, from the top of one wave to the top of the next wave.
   b. Time period is the time taken for one complete wave to a pass a point or time period = 1/frequency.
   c. The frequency of a wave is the number of waves per second.
   d. The amplitude of a wave is the distance from the centre of a wave to the highest or lowest point.
2. **a.** Amplitude = 15 cm
   b. time period = 20 seconds
   c. Frequency= 1/(Time period)=1/20 = 0.05 Hz
3. **a.** 4 waves in 8 cm, wavelength = 2 cm.
   b. 20 waves in 2 seconds so there must be 10 waves in 1 s. Frequency = 10 Hz
   c. time period = 0.1 s

9.3 Sound waves and how they travel

1. **a.** Missing words in order: vibrating, vacuum.
   b. Missing words in order: waves, compressions, rarefactions.
2. **a.** B; b. Gas; c. 10 times faster.
3. **a.** He hears the first sound directly and the second is a reflection/echo from the cliff.
   b. Distance = 330 × 1 = 330 m
   c. Distance = 330 × 1.5 = 495 m (total time = 3s but remember the sound has to travel there and back)
   d. Distance = 330 + 495 = 825 m (or 330 × 2.5s)

9.4 Detecting sounds

1. **a.** Missing words in order: auditory canal, eardrum, ossicles, middle ear, cochlea, inner ear, cochlea, oval window, auditory nerve.
   b. The pinna is not listed. Its function is to gather the sound wave and direct it into the ear.

2. **a.** G
   b. F
   c. C
   d. E, D, and C
   e. C

Extension

a. Underline: **converts a sound wave into an electrical signal.**

b. Singers use uni-directional microphones, so that the only noise that the microphone picks up is their voice. Any background voice would distort the signal.

c. It would be best to use an omni-directional microphone to measure sound levels in a classroom to ensure that all sounds are picked up.

9.5 Observing sound

1. the correct words are: frequency, higher, second, amplitude.

2. **a.** by the vibrations of the ruler.
   b. Pull the ruler down further to make larger vibrations; Wave should be drawn with greater amplitude but the same frequency.
   c. The wavelength would be shorter/there would be more waves visible.

3. **a.** This means the string vibrates 82 times each second.
   b. 6th string.
   c. 1st string.

Extension

a. Students should plot the data as a line graph and explain that it is because the data are continuous. The graph should show a negative relationship.

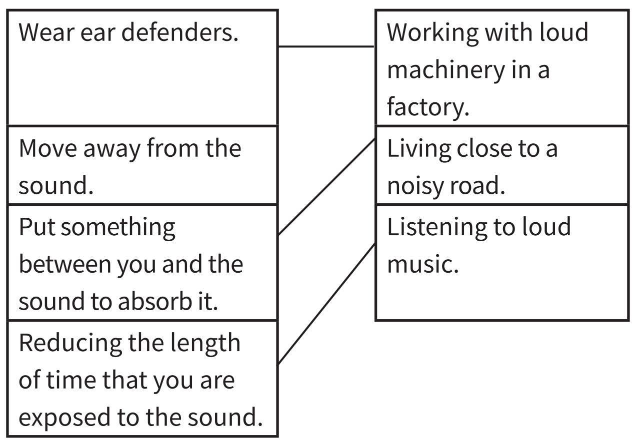
b. As the pipe length increases, the frequency decreases.

c. Yes, the frequency and wavelength are linked. A high frequency sound has a short wavelength, and a low frequency sound has a longer wavelength. Therefore, as the frequency of the noise is decreasing, the wavelength is getting longer.

9.6 Hearing, decibels, and risk

1. **a.** Ear defenders are better at reducing the sound as the student wearing ear defenders can only detect the sound when it is at 50 dB, but the student wearing ear plugs can hear it at a lower intensity, 30 dB.
   b. The experiment is not a fair test as the different students might have different hearing abilities. The same student should test all three options.
   c. The same student could test all three scenarios. The test should be repeated.

2.



Extension

a. As the sound level increases, the maximum recommended time of exposure decreases. The recommended maximum time of exposure halves each time the sound level increases 3 dB.

b. As sound level increases the maximum recommended time decreases significantly as ears are easily damaged by loud noises. The louder the noise, the quicker irreparable damage occurs.

c. i. The maximum recommended time of exposure would increase from 15 minutes to 2 hours.
   ii. The maximum recommended time of exposure would increase from 2 minutes to 30 minutes.

10.1 Introduction to forces

1. Correct answers in order: gravity, friction, air resistance, air resistance, gravity, upthrust.
2. The forces have been incorrectly labelled on the first diagram – drag is a combination of friction and air resistance that acts to slow down a moving object. Thrust is a force that acts in the direction that an object is moving, like a car.

   To correctly label the diagram the up arrow should be upthrust, and the down arrow should be gravity.

   a. Inside a spring balance is a spring. The extension of the spring is proportional to the size of the force applied. When a force is applied, the spring stretches and the display shows how much force has been applied dependent on the spring's extension.
   b. Tension.
   c. Weight is a measure of force, and is measured in newtons. The bananas have a mass of 1 kg.

Extension

a.

Contact forces	Non-contact forces
friction	weight
air resistance	electrostatic force
water resistance	magnetic force
thrust	
upthrust	
tension	

b. Any suitable answer: e.g. when something is dropped into water.
c. Any suitable answer: e.g. when a car drives from a road onto gravel.

10.2 Action and reaction pairs

1. We know that action and reaction force pairs do not act on the same body. As a result, all the statements are examples of action reaction pair.
2. a. the ball provides a force of 20 N to the right on the foot.
   b. the gases push upwards on the rocket with a force of 30 N
3. a. When the grasshopper pushes down on the earth the earth pushes back with an equal and opposite force. This force pushes the grasshopper upwards.
   b. The mass of the earth is so great the force has a very tiny/negligible effect on the earth.
4. If they throw the spanner backwards the spanner would exert and equal and opposite force of the astronaut forwards.

10.3 Air resistance

1. Missing words in order: friction/air resistance, air resistance/friction, faster, friction, streamlined.
2. G, C, A, D, E, F, B
3. a. Birds take on a streamlined shape to dive into water and catch fish, to reduce the water resistance acting on them.
   b. Large parachutes slow you down more than small parachutes because they have a larger surface area and so experience more air resistance.

Extension

a. Down arrow labelled gravity, up arrow labelled air resistance. On the Moon these arrows should be much smaller.
b. Objects fall at the same rate even if they are different masses. Any difference in speed on Earth is caused by air resistance, but on the Moon there is much less air resistance.

10.4 Changing ideas about motion

1. a. Any suitable answers, see below:

Why this doesn't happen in real life
Friction will slow the ball down on a horizontal slope.
The ball loses energy as it travels, meaning that it won't travel so far.
Friction will slow the ball down over time and it will stop when all of its energy has been lost.

2. a. Thought experiment.
   b. The heavy ball will fall faster than the light ball and hit the ground first.
   c. The heavy ball will fall faster until the string is taut. It has a greater force than the light ball so the light ball will speed up when the string is taut.
   d. The two balls cannot fall at different speeds if they are stuck together.
   e. This thought experiment shows that heavier objects don't fall faster because if the heavy and light balls were stuck together they must fall at the same rate OR if they are stuck together the heavy would speed up the light ball and the light ball would slow down the heavy ball. This is impossible.
   f. It is more convincing to see the experiment being done with equipment, as this shows what is possible and what will happen. It is possible to imagine things that are impossible.

Extension

a. From smallest to largest force: C, A, B, D.

b. Fiction/drag acts to slow objects down, therefore you need to apply a force to keep the forces balanced. Most people don't notice or realise friction/drag are acting on an object.

10.5 Planning fair tests: Streamlining

1. Any suitable answers: How does the size of the mass affect the deflection? Does the height of the books change the deflection?
2. I predict that the further apart the books are the greater the deflection will be.
3. Distance between the books, mass of object, type of card, height of books.
4. Equipment: books, cardboard, masses, ruler.
5. Plan of investigation: Set up equipment as in diagram, measure distance between books, measure deflection, repeat three times, change distance between books, and repeat.
6.

Distance between the books (cm) or (m)	**Deflection (cm)**

Extension

Any suitable answer: e.g. The student might have problems measuring the deflection accurately.

10.6 Speed

1. a. F
   b. T
   c. F
   d. F
2. a. speed $= \dfrac{\text{distance}}{\text{time}} = \dfrac{200\text{ m}}{16\text{ s}} = 12.5\text{ m/s}$
   b. Average speed. The average speed is the total distance travelled divided by the total time, the speed may have varied during this time.
3. a. 118 seconds
   b. average speed $= \dfrac{\text{distance}}{\text{time}} = \dfrac{800\text{ m}}{118\text{ s}} = 6.78\text{ m/s}$
   c. average speed $= \dfrac{\text{distance}}{\text{time}} = \dfrac{400\text{ m}}{48\text{ s}} = 8.33\text{ m/s}$
   d. time $= \dfrac{\text{distance}}{\text{speed}} = \dfrac{800\text{ m}}{8.33\text{ s}} = 96\text{ seconds}$

   = 1 minute 36 seconds

Extension

a. 88.89 seconds

b. 17.20 seconds

c. 1965 – The average speed more than doubled between 1964 and 1965.

10.7 Precision and accuracy: What's the difference?

1. **a.** Student 1 – his results are measure to a greater number of decimal places.
   b. Student 1 – using timing gates will increase the accuracy of his results, as student 2's reaction times will affect his results.
   c. 1.452, 1.45, 1.4, 1
2. **a.** It will be difficult for her to get an accurate reading of the winners time as her reaction times, and the time it takes to hear the gun will affect the results.
   b. It will be difficult to get a precise reading due to her reaction times.
3. **a.** The time interval between the two photos.
   b. You could be using the wrong time interval to make the calculation, or the second photo might not capture an image of the car.
   c. The one where the speed limit is 50 km/h will need a smaller time interval in order to take two images of a car in the same distance as the cars will be moving faster.

10.8 Distance–time graphs

1. **a.** $\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{20\text{ m}}{4\text{ s}} = 5\text{ m/s}$

   $\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{18\text{ m}}{6\text{ s}} = 3\text{ m/s}$

   $\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{16\text{ m}}{8\text{ s}} = 2\text{ m/s}$

   b. Graph A shows the fastest speed – the line is steepest meaning the same distance is travelled in less time.

2. **a.** 600 m
   b. 180 s
   c. $\text{average speed} = \frac{\text{distance}}{\text{time}} = \frac{600\text{ m}}{180\text{ s}}$

   $= 3.33\text{ m/s}$

Extension

a. 20 m

b. The graph gets steeper indicating that the speed is increasing.

c. The line should be below the other one, increasing more gradually.

d. The larger stone would fall at the same speed but it experiences more air resistance and so speeds up less quickly.

10.9 Presenting data from racing

1. **a.**

Student	Time (s)
Anyam	16
Ejiro	20
Mimi	17
Ikenna	17
Bayode	14
Iyo	22

   b. Students should draw a bar chart from their table.
   c. One of the variables, student, is categoric, so the data must be displayed as a bar chart.

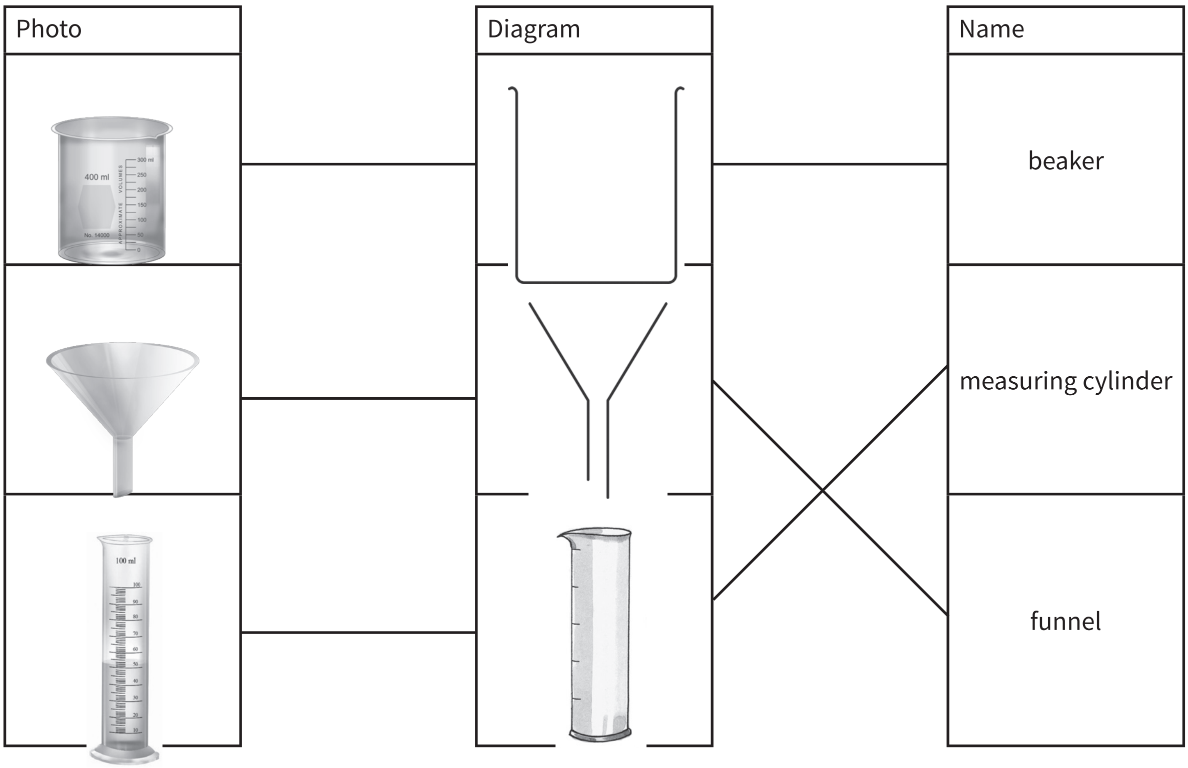
2. **a.**

Height (m)	Time (s)
1.35	7.2
1.23	8.4
1.10	9.1
1.00	9.5
1.40	8.1
1.45	7.1

   b. Students should draw a line graph from their table.
   c. Both of the variables are continuous so a line graph can be drawn.

3. **a.** Line graph, both volume and time are continuous variables.
   b. Line graph, both extension and weight are continuous variables.

11.1 Making hand sanitizer

- 

- To make the hand sanitizer smell good: lavender oil

  To kill bacteria and viruses: an alcohol

  To spread the hand sanitizer over the skin: aloe vera gel

Extension

Encourage students to prepare the advertisement in more than one format, eg a print format and a radio or podcast commercial.

Answers

12.1 The force of Gravity

1. Both arrows should start on the people and point towards the centre of the Earth.
2. a. N

   b. The third result is incorrect – the correct weight would be 2.0 N.
3. a. D b. D

Extension

a.

Mass of object on Earth	Weight on Earth (N)	Mass of object on the Moon	Weight on the Moon (N)	Mass of object on the planet	Weight on the planet (N)
50 g	0.5	50 g	0.08	50 g	2.5
500 g	5	500 g	0.8	500 g	25
2 kg	20	2 kg	3.2	2 kg	100
25 kg	250	25 kg	40	25 kg	1250

b. 50 N/kg

c. The gravitational field strength of the planet is greater than that of Earth, so it has a greater mass.

12.2 Orbits

1. the missing words are: gravity, Sun, mass, gravity, gravity, planets.
2. a. Astronauts experience weightlessness because they are falling towards the earth inside their space craft.

   b. Each orbit has a different speed.

   c. The Moon is in orbit about the earth.
3. a. The times are very short so hard to measure accurately because of reaction time.

   b. scatter graph plotted and a curved line of best fit drawn.

   c. as the radius increases the time to complete 10 loops increases.

12.3 How 'old' is gravity?

1. Missing words in order: questions, observations, explanations, proof, ideas, evidence, explanations.
2. a. Newton thought there was a force acting on the Moon because it was constantly changing direction. An object can only change direction if a force acts on it.

   b. i. C ii. B iii. question
3. a. F b. T c. T d. F

Extension

a. The Earth cannot be falling down as there is no down in space, but it is being pulled towards the Sun.

b. Bhāskara II and Newton both noticed that objects fall towards the Earth and that a force must be acting on them. That force would also be acting on objects like the Earth and the Moon.

c. Bhāskara II could not test his ideas or make predictions, but Newton was able to predict the existence of Neptune.

12.4 The Moon

1. a. F, A, B, G, H, E, C, D

   b. E and G

   c. H

d. We only see the area of the Moon that is lit up and facing us, other parts are lit up by the Sun at the same time. For example, in a new moon we see only a dark moon, the other side is lit by the Sun but we cannot see it.

2. a. From left to right: Sun, Earth, umbra, moon, penumbra.
   b. Lunar eclipse as the Moon is in darkness because the Earth is blocking the Sun's light.
   c. A diagram of a solar eclipse like the one in Unit 5.5, page 78, of the Student Book.

Extension

a. Earth, Mars, Jupiter, Saturn, Uranus , Neptune.
b. Yes, Mercury can block light from the Sun or no, Mercury is too far away.

12.5 Our planet: Day and night

1. Label the light side day, the dark side night, the central axis and north pole at the top, and the south pole at the bottom (as shown in the diagram in Unit 5.1 of the Student Book).

2. a. E b. B c. D/B d. F

3. a. Move, day.
   b. Spins, 24 hours, day.
   c. Day, night.
   d. Anticlockwise.

Extension

a. Junaid and Sarim can use this model to explain day and night because the torch represent the Sun. As Juniad turns anti clockwise you will see the path of the torch move around the map as the rays of the Sun would move on the Earth's surface.
b. Foucault's pendulum demonstrates that the Earth is spinning.

12.6 Our planet: Seasons

1. a. Orbit.
   b. The Sun and the Earth are similar sizes, but the Sun is really a lot bigger than the Earth.
   c.

Position	Southern hemisphere	Northern hemisphere
A	spring	autumn
B	summer	winter
C	autumn	spring
D	winter	summer

2. a. Summer, days, nights, high.
   b. Winter, nights, days, low.
   c. Warmer, longer, more, are not.

3. a. Southern.
   b. Sunrise is earlier in January than July, which means January must be summer, and this only happens in the southern hemisphere.

Extension

a. A
b. In the summer the Sun is directly overhead like in tray A, but in the winter its rays hit the Earth's surface at an angle like in tray B.

Notes