INTERNATIONAL SECONDARY SCIENCE 3
TEACHER PACK

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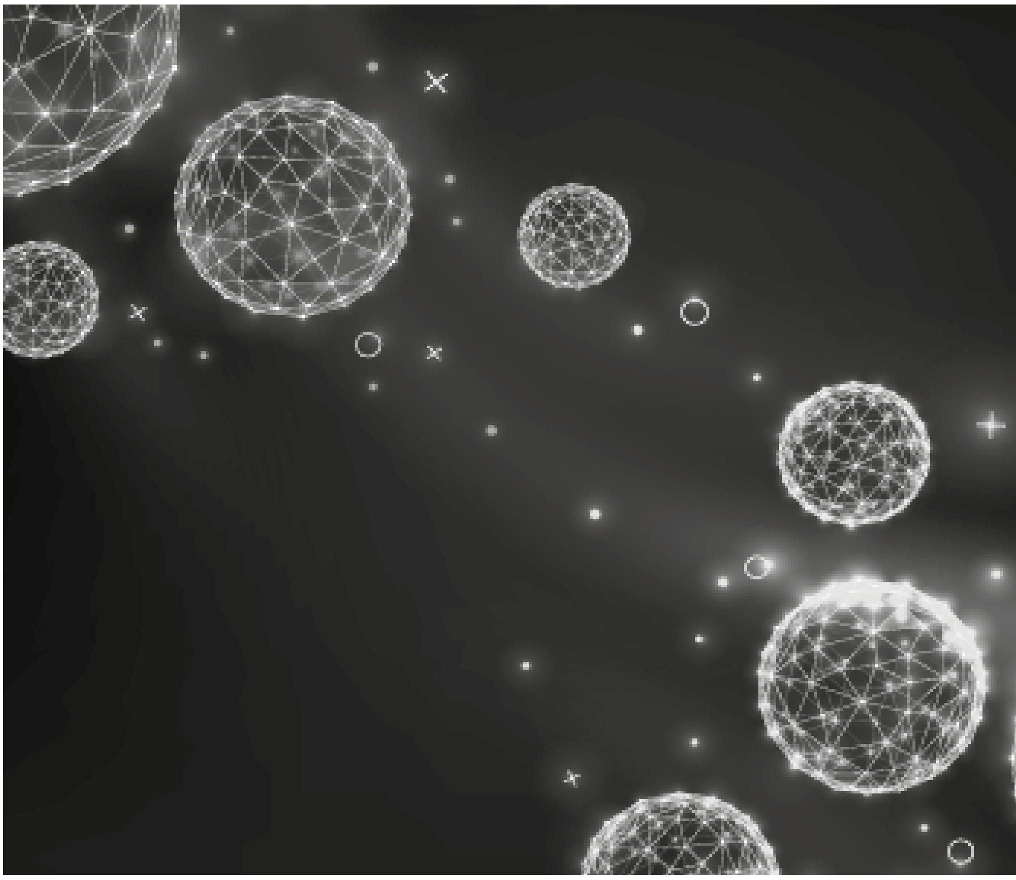

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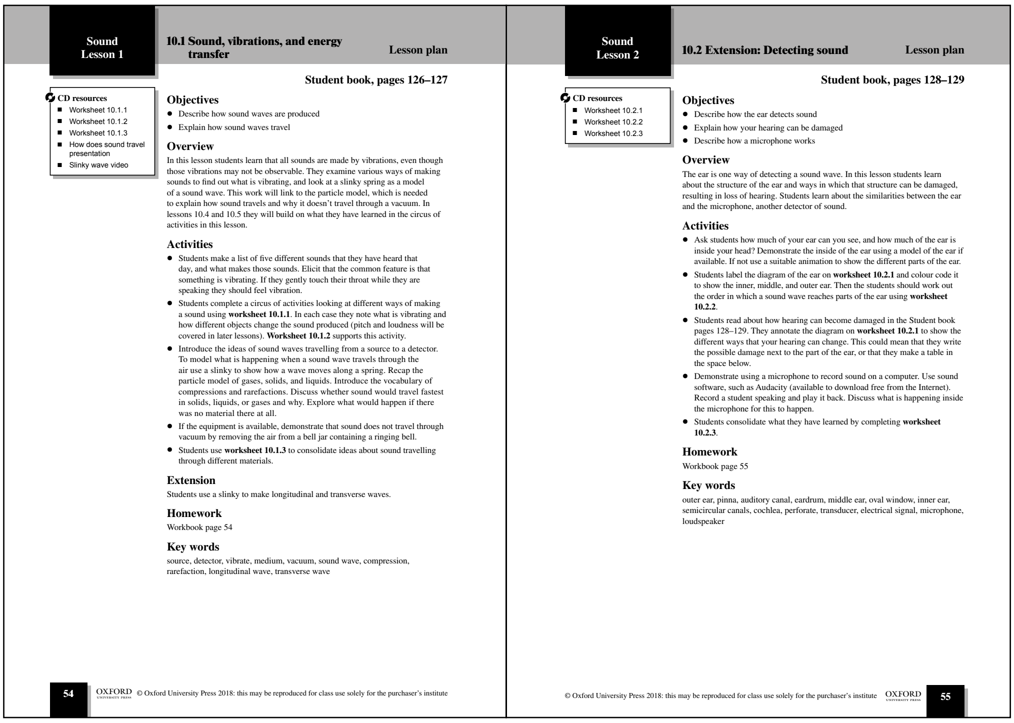
How to use your Teacher Pack

Welcome to your **International Secondary Science 3** Teacher Pack. This Teacher Pack has been written to provide teaching materials and classroom support.

Your Teacher Pack includes a book of lesson plans as well as answers to all of the Student Book and Workbook questions for your reference at any time. The accompanying CD-ROM includes a wide variety of additional resources to support you and your students in the classroom.

Using your book

This book contains suggested lesson plans and answers to all of the questions in the Student Book and Workbook.



Sound
Lesson 1

10.1 Sound, vibrations, and energy transfer — **Lesson plan**

Student book, pages 126–127

CD resources
- Worksheet 10.1.1
- Worksheet 10.1.2
- Worksheet 10.1.3
- How does sound travel presentation
- Slinky wave video

Objectives
- Describe how sound waves are produced
- Explain how sound waves travel

Overview

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 slinky spring as a model of a sound wave. This work will link to the particle model, which is needed to explain how sound travels and why it doesn't travel through a vacuum. In lessons 10.4 and 10.5 they will build on what they have learned in the circus of activities in this lesson.

Activities
- Students make a list of five different sounds that they have heard that day, and what makes those sounds. Elicit that the common feature is that something is vibrating. If they gently touch their throat while they are speaking they should feel vibration.
- Students complete a circus of activities looking at different ways of making a sound using **worksheet 10.1.1**. In each case they note what is vibrating and how different objects change the sound produced (pitch and loudness will be covered in later lessons). **Worksheet 10.1.2** supports this activity.
- Introduce the ideas 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 vacuum by removing the air from a bell jar containing a ringing bell.
- Students use **worksheet 10.1.3** to consolidate ideas about sound travelling through different materials.

Extension

Students use a slinky to make longitudinal and transverse waves.

Homework

Workbook page 54

Key words

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

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Sound
Lesson 2

10.2 Extension: Detecting sound — **Lesson plan**

Student book, pages 128–129

CD resources
- Worksheet 10.2.1
- Worksheet 10.2.2
- Worksheet 10.2.3

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 that structure 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 you see, 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 on **worksheet 10.2.1** and colour code it to show the inner, middle, and outer ear. Then the students should work out the order in which a sound wave reaches parts of the ear using **worksheet 10.2.2**.
- Students read about how hearing can become damaged in the Student book pages 128–129. They annotate the diagram on **worksheet 10.2.1** to show the different ways that your hearing can change. This could mean that they write the possible damage next to the part of the ear, or that they 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 from the Internet). 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 by completing **worksheet 10.2.3**.

Homework

Workbook page 55

Key words

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

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There is one lesson plan for every spread in the Student Book, including enquiry and extension pages. Each lesson plan suggests activities for use in the classroom linked to the topics covered on the Student Book spread.

Each lesson plan begins with a reference to the pages of the Student Book that it covers and a summary of their objectives. Any key words from the Student Book pages are included at the bottom of the page.

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 Cambridge 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, class discussions or Internet research.

Lesson plans that are matched to enquiry spreads 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® and O level. Some of these could be carried out in class, whilst others could be set as homework.

Every spread 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*.

There are lots of extra resources on the CD to accompany every lesson plan. These are listed in the *CD Resources* box at the top of the page, and suggestions on how they can be used are given in the *Activities* section of the lesson plan.

At the back of this book are the answers for all of the questions in both the Student Book and Workbook for quick reference in the classroom. All of these answers have been written by the authors of this book and have not been provided by Cambridge International Examinations.

Using your CD-ROM

The CD-ROM that accompanies this book contains additional resources to support you in the classroom.

Every lesson plan in the book is also found on the CD-ROM as both a PDF, for easy printing, and as a Word document, so that you can tailor the lesson to your classroom and your students' needs.

All of the extra worksheets listed on the lesson plans can be found on the CD-ROM as PDFs and as Word documents, so that they can be added to or changed as required. Most of these worksheets are a single page so that they are easy to print and photocopy.

Extra worksheets for each chapter focus on the scientific vocabulary introduced in that chapter. These will help support lower ability students or students that speak English as an additional language.

There are animations and slideshows that can be used on an interactive whiteboard or screen at the front of the class to encourage interaction and discussion. They cover topics that are difficult to explain using just the words and pictures in the Student Book. The CD also includes a number of interactive spreadsheets, which can be used to record and analyse results during class activities and experiments.

Table of contents

Student book, pages 2–3

CD resources
- PowerPoint 1.1.1
- Worksheet 1.1.2
- Worksheet 1.1.3

Objective

- Describe the importance of plants to life on Earth and collect evidence for photosynthesis

Advanced preparation

- Place pondweed under a funnel and collect the oxygen it produces the day before the lesson.
- Place variegated and green geraniums (or similar plants) in a well-lit position for 2 days before the lesson. A class set of green leaves should be half-covered with black card or foil.

Overview

The lesson introduces the equation for photosynthesis and the structure of leaves. Students test leaves for starch to demonstrate that photosynthesis has taken place.

Health and safety

Students should wear eye protection for the practical activity. All Bunsen flames are must be turned off before the bottle of ethanol is opened. Students should take care with sharp scissors and must not get iodine on their skin as it will stain.

Activities

- Click **PowerPoint 1.1.1** to start the graph plotting. It will plot a straight line for 10 seconds. Use this time to shut all the doors and windows. The graph will show the amount of carbon dioxide in the room rising for 30 seconds with the caption: 'What is happening in here?'. Just before the 30 seconds is up, bring out some large potted plants and say 'that's better' as the graph gets a bit less steep. Challenge students to explain the graph. Students should recognise that their respiration adds carbon dioxide to the air and photosynthesis removes it.
- Students read pages 2–3 of the Student book, to the end of the section on leaves before completing **worksheet 1.1.2.** The expected answers are: 1 – waxy layer; 2 – epidermis; 3 – palisade cells; 4 – mesophyll cells; 5 – epidermis; 6 – stoma; 7 – guard cells; 8 – xylem vessels; 9 – phloem tubes; 10 – veins.
- Students read the rest of page 3 of the Student book.
- Demonstrate the production of oxygen by pondweed and the procedure for testing a leaf for starch.
- Students test a variegated leaf and a leaf with half its surface covered with black card or foil. Both need to have been kept in a sunny position, and the card should have been in place for at least 2 days. **Worksheet 1.1.3** supports this activity. Students should recognise that starch is made only in the green parts of leaves and only when they are exposed to light.

Extension

Students could stain thin slices of potato with iodine solution to view the starch grains in their cells.

Homework

Workbook page 1

Key words

biomass, photosynthesis, palisade, chloroplasts, xylem, stomata, spongy mesophyll

Student book, pages 4–5

CD resources
- Worksheet 1.2.1
- Worksheet 1.2.2

Objectives
- Understand what makes a question scientific
- Be able to develop a scientific question that can be investigated

Overview
Students plan how to compare the effect of light intensity on photosynthesis.

Advanced preparation
Fill six 600 cm^3 beakers with 1% sodium hydrogencarbonate solution. Place three 7 cm lengths of oxygenating pondweed (e.g. *Elodea*) upside down under a funnel in each beaker. The funnel must be short enough to fit below the water level. The pondweed should be trimmed under water make it easier for oxygen to escape from it. A 10 cm^3 measuring cylinder will be needed to collect the oxygen produced in each beaker.

Activities
- Students discuss how they can make plants grow better and what evidence they can collect to support their ideas.
- Students read pages 4–5 of the Student book, to see how different light intensities could be compared. Then they plan how to collect evidence and use their understanding of photosynthesis to predict what results they will get. **Worksheet 1.2.1** could be used to structure this activity.
- Demonstrate how to fill a 10 cm^3 measuring cylinder with water and invert it over the end of a funnel. Groups should set up their apparatus at different distances from a sunny window or powerful lamp.
- If pondweed is not available, students could draw conclusions from the evidence presented on page 5 of the Student book or use the specimen results on **worksheet 1.2.2** to plot a graph.

Extension
Students could revise their plan to investigate the effect of water temperature on the rate of photosynthesis.

Homework
Workbook page 2

Key words
scientific question, rate

Student book, pages 6–7

CD resources
- Worksheet 1.3.1
- Worksheet 1.3.2

Objective

- Describe how water and minerals are absorbed by roots and transported to leaves

Overview

Students observe the organs, tissues, and specialised cells that transport water through plants.

Advanced preparation

Plant cress seeds 10 days before the lesson. Two days before the lesson leave some large, thin leaves to wilt and place some stems in a solution of red or blue food colouring to stain their xylem vessels. Celery is best for this. One day before the lesson, lay a toothpick near the edge of a 1 cm^3 area on the underside of each leaf (but not over a vein), paint a single coat of clear nail varnish over it and leave it to dry overnight. Most small, non-hairy dicot leaves will give results; spider plants (*Chlorophytum comosum*) work well.

Activities

- Show the wilted leaves and ask students why plant leaves don't usually dry out.
- Then introduce **worksheet 1.3.1**. Pairs of students use microscopes to examine and draw the prepared leaf undersides, plant stems, and cress roots. Students who require more support could observe prepared slides and use **worksheet 1.3.2** to record their observations.
- Students read pages 6–7 of the Student book, to consolidate their ideas about the movement of water through root hair cells, xylem vessels, and stomata.

Extension

Students could examine commercial slides of root, stem, and leaf sections as an extension exercise.

Homework

Workbook page 3

Key words

wilts, turgid, flaccid, transpiration, stomata, xylem, stoma, guard cells

Student book, pages 10–11

CD resources
- Worksheet 2.1.1
- Worksheet 2.1.2

Objectives

- List the components of blood
- Describe the function of each component

Overview

Students review and extend their understanding of the content and function of blood.

Activities

- Ask students to describe blood. Check their ideas by showing them the images on page 10 of the Student book or letting them look at prepared human blood film slides under the microscope.
- Students analyse evidence that blood collects oxygen and glucose from the lungs and small intestine, and delivers them both to other organs. **Worksheet 2.1.1** structures this activity.
- Students read page 10 of the Student book and answer the questions on page 11.
- Students complete **worksheet 2.1.2**. They could use the ideas on the card as the basis for a piece of extended writing or simply arrange them into a sensible order, e.g. A, G, C, D, B, E, F, J, H, I.

Extension

- Students read page 11 of the Student book and summarise the similarities and differences between sickle-cell anaemia, malaria, and sleeping sickness, e.g. similarities: they all cause illness, they can all be detected by looking at blood under the microscope; differences: you are born with sickle-cell anaemia but malaria and sleeping sickness are infectious diseases.

Homework

Workbook page 4

Key words

plasma, white blood cell, red blood cell, capillaries, large surface area, platelets, urea, kidneys, urine, diffusion, diffuse

Student book, pages 12–13

CD resources
- Worksheet 2.2.1
- Worksheet 2.2.2

Objectives

- Make simple calculations
- Recognise what we can learn from blood tests

Overview

Students learn how to analyse a blood sample to diagnose some illnesses.

Activities

- Check that students remember the main components of blood. Explain that many illnesses change the amounts of these components.
- Give each group a sample of 'blood'. Four different samples can be prepared as follows:
  A 40 red beads, 1 white bead, 4 blue beads, 55 yellow beads; **B** 25 red beads, 1 white bead, 4 blue beads, 70 yellow beads; **C** 8 red beads, 3 white beads, 4 blue beads, 55 yellow beads; **D** 40 red beads, 1 white bead, 1 blue bead, 58 yellow beads.
- Students display the percentage of each component in their sample using **worksheet 2.2.1**. They then use a blood data card from **worksheet 2.2.2** to decide whether their sample is from a healthy person or from someone with an illness. The expected answers are: A – healthy; B – anaemic; C – has an infectious disease such as flu; D – has haemophilia.
- Students read pages 12–13 of the Student book and work through the questions to analyse the test results presented.

Extension

- Students could copy the diagram of Sara's packed cell volume results from page 13 of the Student book and then display the results for an average woman and an average man in the same way for comparison.

Homework

Workbook page 5

Key word

anaemia

Student book, pages 14–15

CD resources
- Animation 2.3.1
- Worksheet 2.3.2
- Worksheet 2.3.3
- Worksheet 2.3.4
- Worksheet 2.3.5

Objectives

- List the components of the circulatory system
- Describe the function of each component

Preparation

Print out a set of posters from **worksheet 2.3.2** and obtain 50 pieces of red card, 50 pieces of blue card, and 50 pieces of white card**.**

Health and safety

- Any dissected material should be sealed in a large plastic bag for disposal, working surfaces should be wiped with soapy water, and dissecting equipment should be sterilised.

Overview

Students review and extend what they learned about the circulatory system in lesson 2.4 of International Secondary Science 2.

Activities

- Ask students how far they can run and what makes them stop eventually.
- Use page 14 of the Student book to remind students how blood circulates. An animation of both sides of the heart pumping in unison could be used to show that it is a double pump e.g. the *Beating heart with blood flow* animation from the Hybrid Medical Animation website (search the site for 'Beating heart with blood flow'*)*.
- Lay out coloured posters made from **worksheet 2.3.2** to represent the lungs, heart, small intestine, and leg muscles. Two volunteers take red cards to represent oxygen and wait at the lungs. Another four take blue cards to represent carbon dioxide and wait at the muscles and small intestine. Position a box of white cards – to represent glucose molecules – near the small intestine. The rest of the students represent blood. As they walk round the circuit they pick up oxygen from the lungs and exchange it for carbon dioxide in the small intestine and muscles. As they leave the left side of the heart, alternate students collect glucose from the small intestine and deliver any glucose they already have to the muscles. Students label a copy of **worksheet 2.3.3**.
- Use page 15 of the Student book to remind students what is different about arteries, capillaries, and veins. Students could draw labelled diagrams to summarise these differences.

Extension

- Demonstrate the dissection of a heart: allow students to dissect a heart following **worksheet 9.3.4** on YouTube. They could then complete **worksheet 2.3.5** to summarise what they have learned.

Homework

Workbook page 6

Key word

Models

Student book, pages 16–17

CD resources
- Worksheet 2.4.1
- Worksheet 2.4.2

Objectives

- Understand how the circulatory system responds to exercise
- Identify trends and patterns in results

Overview

Students practise analysing graphs in the context of the body's response to exercise.

Activities

- Ask students what happens to their heart rate when they run, and when they stop running. Check that they appreciate that active muscles need more oxygen so they need a greater blood supply.
- Read pages 16–17 of the Student book and practise analysing the graph presented using page 217 of the Student book as a guide.
- **Worksheet 2.4.1** displays further data for students to analyse. They look for three differences between the two sets of heart rate data to summarise the changes that take place as someone becomes more fit. Students should spot that the resting heart rate and peak heart rate both go down and the heart rate returns to normal more quickly after exercise. **Worksheet 2.4.2** provides support for less able students.

Extension

- Ask students to draw a graph that shows one of the patterns illustrated on page 217 of the Student book. Then challenge them to describe each other's graphs without referring to the Student book.

Homework

Workbook page 7

Key words

pulse, curve of best fit, line of best fit, correlation, negative correlation

Student book, pages 18–19

CD resources

- Worksheet 2.5.1
- Worksheet 2.5.2
- Worksheet 2.5.3
- Worksheet 2.5.4

Objective

- Understand the relationship between diet and fitness

Overview

Students learn why blood pressure usually increases with age and about factors that increase our risk of heart disease.

Activities

- Use page 18 of the Student book to explain what blood pressure is and why it tends to rise with age.
- Students use sand as a model for blood and measure the difference in flow rate through tubes of different diameter. **Worksheet 2.5.1** supports this activity. They should be encouraged to plan their own way of comparing the tubes and displaying the data. **Worksheet 2.5.2** provides a more structured approach for students who need more support.
- Discuss the pros and cons of the model, e.g. one good point is that it shows how much harder it is to move fluids through narrow diameters; one bad point is that the sand is falling, not being pumped. Also the red cells in real blood are smaller and more flexible than sand particles, and they are suspended in a liquid.
- Students read page 19 of the Student book to learn about the risk factors involved in heart disease. Students complete **worksheet 2.5.3** to see how body mass affects blood pressure.

Extension

- Students complete **worksheet 2.5.4** to see how smoking affects blood pressure. They should deduce that although smoking increases the risk of having a heart attack, it does not do this by increasing blood pressure. It must damage the heart in a different way.

Homework

Workbook page 8

Key word

plaque

Student book, pages 22–23

CD resources

- Animation 3.1.1
- Worksheet 3.1.2

Objectives

- Recognise the main parts of the respiratory system
- Describe what these organ systems do

Preparation

Arrange to have a sheep's lungs delivered if a dissection is to be carried out.

Health and safety

If the sheep's lungs are not damaged, a bicycle pump can be used to inflate them. This must be done inside a large plastic bag to avoid releasing a fine spray which could contain pathogens. The work surface, dissecting tray, and instruments should be cleaned with hot water and detergent after the lesson.

Overview

Students learn how air is moved in and out of the lungs and where gas exchange takes place.

Activities

- Ask students to take a deep breath. What makes air move in and out of their lungs?
- Use page 22 of the Student book to explain. Then use a bell jar model like the one illustrated on **worksheet 3.1.2** to demonstrate the action of the diaphragm.
- Use a bell jar model to explain what makes air move in and out of the lungs.
- Demonstrate what lung tissues are like by carrying out a lung dissection. Show the reinforced windpipe and display the branching tubes taking air into both lungs. The tissue could be sliced to show some of the smaller airways in cross section and let students feel the soft, elastic quality of the tissue.
- Red centicubes, or 1 cm^3 pieces of Plasticine, could be distributed with the information that a piece of lung tissue this size is divided into more than 150 000 air spaces.
- Read page 23 of the Student book and use **animation 3.1.1** to show how gas exchange takes place in the alveoli.
- Student complete **worksheet 3.1.2** using pages 22–23 of the Student book for reference.

Extension

- Use video on the internet *Gaseous exchange in the lungs* on website and the final section from the Student book page 23 to show the adaptations that allow rapid gas exchange in the alveoli.

Homework

Workbook page 9

Key words

intercostal muscles, diaphragm, trachea, bronchi, bronchus, bronchiole, alveoli, gas exchange

Student book, pages 24–25

CD resources
- Spreadsheet 3.2.1
- Worksheet 3.2.2
- Spreadsheet 3.2.3

Objectives
- Describe aerobic respiration
- Distinguish between respiration and gas exchange

Overview
Students measure the effect of exercise on breathing and distinguish between respiration and gas exchange.

Health and safety
The steps used for the activity must be well constructed and stable and the exercise must be supervised so that it does not become competitive. Any students with asthma could be put in charge of data collection. If stairs are used students must keep one hand on the hand rail.

Activities
- Students measure their breaths per minute sitting down. Stress that breathing in and out counts as 1 breath. Then time how long they can hold their breath for when standing up.
- Take one student's result for breaths/minute and ask for students' higher and lower values to establish the minimum and maximum values for the class. Enter these in **spreadsheet 3.2.1**, and display the range. Page 3 of the spreadsheet shows the world record.
- Students read page 24-25 of the Student book, to see how the world record was achieved by reducing the demand for oxygen for respiration.
- Students measure the effect of exercise on their breathing rates following the procedure outlined on **worksheet 3.2.2**. The simplest way to organise the exercise is for students to do step-ups onto a low step or bench in time to four beats (first leg up, second leg up, first leg down, and second leg down). If a metronome is available, 72 beats per minute is suitable. Students could use **spreadsheet 3.2.3** to plot an instant graph of their results and calculate the percentage increase in their breathing rate.
- Students should notice that their breaths per minute and the depth of their breathing both increase after exercise. Use the graphs on page 25 of the Student book to show just how much their oxygen uptake can increase. If lung volume bags are available, students could measure the maximum volume they can breathe out after taking a deep breath.
- Ask students to spot the mistakes in the following sentences to check they understand the difference between respiration and gas exchange: 'Your lungs are vital because they carry out respiration.' 'Tom Seitas broke the Guinness World Record when he stopped respiring for 22 minutes.'

Extension
- Discussion discuss why it is more difficult to take in oxygen at high altitudes.

Homework
Workbook page 10

Key word
respiration

Student book, pages 26–27

CD resources
- Worksheet 3.3.1
- Spreadsheet 3.3.2
- Worksheet 3.3.3

Objectives
- Understand the process of anaerobic respiration
- Recognise that anaerobic respiration produces lactic acid

Overview
Students learn about anaerobic respiration and demonstrate that it cannot continue for long.

Activities
- Ask students what makes Usain Bolt so good at the 100 m sprint. Then use page 26 of the Student book to explain that he doesn't have time to breathe during his races so he cannot take in extra oxygen for respiration. He relies on anaerobic respiration.
- Students measure how easily finger muscles tire by following the instructions on **worksheet 3.3.1**. They could use **spreadsheet 3.3.2** to plot graphs of their results or compare their results with the rest of the class. Explain that finger muscles rely mainly on anaerobic respiration so they tire easily, even in people who are used to typing all day. Small, precise finger movements only use a few muscles cells at a time. A peg press uses a lot of muscles at once so individual cells have less time to recover.
- Students read page 27 of the Student book to learn more about anaerobic respiration.

Extension
- Students take home **worksheet 3.3.3** which has space to record their peg challenge results every other day for 2 weeks to see the effect of training.

Homework
Workbook page 11

Key words
mitochondria, aerobic respiration, anaerobic respiration

Student book, pages 28–29

CD resources

- Worksheet 3.4.1
- PowerPoint 3.4.2
- Worksheet 3.4.3
- Worksheet 3.4.4
- Worksheet 3.4.5
- Worksheet 3.4.6

Objectives

- Describe the effects of smoking
- Name some harmful substances in cigarette smoke

Preparation

- Assemble the smoking machine illustrated on worksheet 10.4.1 in a fume cupboard and acquire a cigarette.

Overview

Students learn how cigarette smoke damages the body.

Activities

- Ask students why cigarettes are harmful. Then burn a cigarette without a filter in the 'smoking machine' shown on **worksheet 3.4.1**. **PowerPoint 3.4.2** shows the expected results.
- Students read pages 28–29 of the Student book to learn how tar and the other chemicals in smoke damage the body. They complete **worksheet 3.4.1**.
- Video on *Lung cancer: surgical extraction of a tumour* on the YouTube could be used to show cancer of the lungs.
- Explain that smoking eventually breaks down the walls between the alveoli and reduces the surface area available for gas exchange. This sort of lung damage is emphysema. Students complete **worksheet 3.4.3** to describe how it affects gas exchange. **Worksheet 3.4.4** is a more structured version for students who need more support.
- Video clip *The effect of smoking on the lungs* on the internet can be used to summarises the effects of smoking.

Extension

- Students prepare an advert to persuade their peers not to start smoking. **Worksheet 3.4.5** supports this activity and **worksheet 3.4.6** is an evaluation sheet that can be used to provide feedback.

Homework

Workbook page 12

Key words

tar, mucus, ciliated, cilia, carcinogenic, cancer, carbon monoxide, addictive, nicotine

Student book, pages 30–31

CD resource

- Worksheet 3.5.1

Objectives

- Discuss results using scientific knowledge and understanding
- Communicate explanations clearly to others

Overview

Students learn more about asthma and practise writing explanations about lungs.

Preparation

An unopened packet of straws is needed, and peak flow meters with disposable mouthpieces would be useful.

Health and safety

If peak flow meters are used, make sure that each student uses a different mouthpiece. Disposable mouthpieces should be placed in a waste-disposal bag as soon as they have been used. Reusable ones need to be soaked in sterilising solution for 30 minutes and then rinsed before reuse.

Activities

- Student pairs discuss what they know about asthma. What happens during an asthma attack and what causes them?
- Students read page 30 of the Student book to learn how asthma can be diagnosed.
- If peak flow meters are available, students could measure their own PEF values. They should try three times and take the maximum value, as this takes a little practice.
- Use page 31 of the Student book to introduce the idea of using a model to explain asthma. Students could blow out through a straw and then squeeze the straw and see what difference it makes. Relate the effect of squeezing the straw to the images in the Student book.
- Pairs complete the questions on page 30 of the Student book. **Worksheet 3.5.1** is a help sheet for students who need support with these explanations.

Extension

- For questions 4–6 in the Student book, students could role-play explaining their answers to patients in front of the rest of the class.

Homework

Workbook page 13

Key words

asthma, peak expiratory flow (PEF)

Student book, pages 34–35

CD resource
- Worksheet 4.1.1

Objectives

- Describe the causes and consequences of air pollution
- Compare evidence from first-hand experience with secondary sources
- Look critically at sources of secondary data

Preparation

- Collect rainwater and a soil sample so that the class can measure their acidity.

Overview

Students investigate the acidity of rainwater and learn where most of the acid comes from.

Activities

- Ask students to predict the pH of rainwater and give their reasons. Then use an indicator or pH meter to reveal its actual pH. Discuss why this is pH 7 or below, depending on the results.
- Video clip *Acid rain threatens the forests of Karkonosze* on the YouTube explains how forests are being damaged by acid rain in Poland.
- Use page 34 of the Student book to introduce the use of lichens as living indicators.
- Students could survey trees or walls around the school to determine which lichens are most common and whether this agrees with the amount of air pollution indicated by the pH of the rain.
- If the rainwater was acidic, shake some local soil with distilled water, allow the soil particles to settle, and then measure the pH of the solution to check its acidity. Some soils are affected more by acid rain than others.
- Students read the section on acidic gases from pages 34–35 of the Student book to learn the source of acid rain and the damage it does to plants, water life, and buildings.
- Review the class results and stress that this is classified as primary data because they collected it themselves. To study global trends in acid rain production we need to rely on secondary data that has been collected by many different people over many years.
- Students read the section on reducing pollution from page 35 of the student book.
- Students complete **worksheet 4.1.1** to examine secondary evidence about the way sulfur dioxide emissions are changing.

Extension

- Scientists from Johnson Matthey explain the importance of catalysts in reducing pollution and improving the quality of the air we breathe http://www.rsc.org/learn-chemistry/resource/res00000378/faces-of-chemistry-catalysts.

Homework

Workbook page 14

Key words

lichens, living indicators, sulfur dioxide, oxides of nitrogen, acid rain, flue gas desulfurisation

Student book, pages 36–37

CD resources
- Worksheet 4.2.1
- Worksheet 4.2.2

Objective

- Understand the relationship between carbon dioxide production and global warming
- Recognise how scientists work today and how they worked in the past

Overview

Students learn how scientists all over the world collaborated to establish a correlation between rising temperatures and an increase in the amount of carbon dioxide in the atmosphere.

Activities

- Use page 36 of the Student book to introduce students to the creative thinking and analysis that led scientists to suggest a link between the amount of carbon dioxide in the atmosphere and Earth's average temperature.
- Ask students to imagine setting up an observatory to measure atmospheric carbon dioxide concentrations – where would they put it? Point out that the observatory in Hawaii is a long way from any cities or power stations and is shielded from dust and wind by a mountain. Scientists trust the measurements the observatory collects.
- Students read page 37 of the Student book to examine the correlation between rising temperatures and the amount of carbon dioxide in the atmosphere. Stress that this does not prove that carbon dioxide causes climate change, but evidence from scientists all over the world suggests that Earth is getting warmer.
- Video on *Evidence of climate change* on the internet shows how tree rings and ice cores provide evidence of climate change.
- Ask students what could be making the amount of carbon dioxide in the atmosphere increase faster now than it ever has before. They should recognise that deforestation and burning fossil fuels both increase the amount of carbon dioxide in the atmosphere.
- Students complete **worksheet 4.2.1** to identify the sources of greenhouse gases, and **worksheet 4.2.2** to identify the main carbon dioxide producers and current trends.

Extension

- Students could debate whether countries that produce least carbon dioxide at the moment should be allowed to increase the amount they produce now that we know that we have more evidence that it causes climate change.

Homework

Workbook page 15

Key words

greenhouse effect, global warming, tree rings, ice cores, climate change

Student book, pages 38–39

CD resources
- Worksheet 4.3.1
- Worksheet 4.3.2
- PowerPoint 4.3.3

Objective

- Describe the causes and consequences of water pollution

Overview

Students explore the consequences of adding minerals to lakes and rivers.

Activities

- Tell students that dead fish have been found floating in a lake. They must use the clues on cards cut from **worksheet 4.3.1** to find out how they died.
- Use page 38 of the Student book to review the sequence of events that can take place when excess minerals are washed into water from either fertilisers or sewerage.
- If an oxygen sensor is available its use could be demonstrated.
- To mimic the effects of adding fertiliser to a lake, students could fill two clear plastic tanks with pond water (about 1 dm^3), keep one tank as a control and add liquid fertiliser to the other. Both tanks should be placed in strong sunlight and checked the following week.
- Use page 38 of the Student book to show how invertebrates can be used as living indicators of water pollution. If possible, students should examine the invertebrates present in a local stream.

Extension

- Students read about bioaccumulation on page 38 of the Student book. To model bioaccumulation: scatter 25 pieces of coloured paper and 100 white pieces. Choose one student to be a polar bear and five to be seals. The rest collect the paper – they are the fish. Explain that the coloured paper represents a persistent pollutant. The fish each pass their 'pollutant' to one of the seals. Then the seals pass them all to the polar bear.
- Discuss the maximum quantity of 'pollutant' each member of the food chain had. Students could shade a copy of **worksheet 4.3.2** to show how its concentration increased as it moved along the food chain. **PowerPoint 4.3.3** reviews the activity.

Homework

Workbook page 16

Key words

eutrophication, living indicators, persistent organic pollutants, bioaccumulation,

Student book, pages 40–41

CD resources
- Worksheet 4.4.1
- Worksheet 4.4.2

Objectives

- Understand why deforestation is happening
- Discuss ways of limiting deforestation

Overview

Students explore the reasons for deforestation and ways of reducing it.

Activities

- Show images of rainforests, or video *The global importance of rainforest photosynthesis* and explain how important rainforests are. They contain half the animal species found on Earth and produce the biomass and oxygen that sustains them. So why would anyone want to destroy the forests?
- Give each group of students a role. They can be:
  1 young farmers who need to grow enough to support their families
  2 companies who need to make a profit
  3 governments who need to earn enough to pay for healthcare and education and make sure that people can travel from one end of the country to the other quickly
  4 environmentalists who want to preserve the forest for future generations.
- Groups 1 to 3 should prepare a 1-minute presentation on why they need to chop down trees and how they will minimise the harm they do to the forest. Group 4 should prepare a 1-minute presentation on why the forests should be preserved. **Worksheet 4.4.1** supports this activity.
- Students read pages 40–41 of the Student book and summarise the main issues by completing the questions.
- Video *Rainforest destruction – Kalimantan, Indonesia and Costa Rica* contrasts the way rainforests have been destroyed in Borneo and conserved in Costa Rica, and *Rainforest sustainability – Costa Rica* gives an example of sustainable farming in Costa Rica.

Extension

- Students could use the internet to produce a report on how the people of Borneo could earn a living from the forest without making orang-utan extinct in the wild. **Worksheet 4.4.2** structures the activity.

Homework

Workbook page 17

Key words

deforestation, recycle

Student book, pages 44–45

CD resources

- Worksheet 5.1.1
- Worksheet 5.1.2
- Worksheet 5.1.3

Objective

- Use and construct keys

Overview

Students practise using keys and make their own.

Activities

- Use page 44 of the Student book to introduce numbered keys and branched keys and explain why they are useful.
- Students use **worksheet 5.1.1** to practise using a key.
- Use page 45 of the Student book to take students through the process of constructing a key to distinguish between species of wild cats. Stress that they need to keep asking questions that divide groups into small sub-groups until each animal has its own group.
- Students use the information on **worksheet 5.1.2** to construct a key to identify a species of butterfly. **Worksheet 5.1.3** can be used to simplify the task.

Extension

- Students could convert the branched key they constructed into part of a numbered key.

Homework

Workbook page 18

Key word

key

Student book, pages 46–47

CD resources

- PowerPoint 5.2.1
- Worksheet 5.2.2
- PowerPoint 5.2.3
- Worksheet 5.2.4
- Worksheet 5.2.5
- PowerPoint 5.2.6

Objectives

- Recognise that genes are parts of chromosomes
- Understand that we inherit two copies of each chromosome, one from each parent

Overview

Students learn that genes are parts of chromosomes and that we inherit two copies of every chromosome, one from each parent. One of these pairs determines our sex. Students can also be given the opportunity to extract genetic material from a plant.

Activities

- Use **PowerPoint 5.2.1** to remind students that we inherit a random selection of genes from each of our parents. Introduce the idea that each parent has two sets of genes and each set is split into 23 groups of genes. Students should complete **worksheet 5.2.2** by throwing a dice to determine which groups of genes their offspring will inherit.
- Students read page 46 of the Student book to learn that each group of genes is part of a chromosome and that one pair of chromosomes determines whether you are a girl or a boy.
- Use **PowerPoint 5.2.3** to show how DNA can be extracted from plant material. The detergent dissolves the cell membranes and the salt makes the DNA clump together. The genetic material doesn't dissolve in alcohol so it precipitates out as white, jelly-like strands. Full instructions for the practical are given on **worksheet 5.2.4**. The salty detergent solution is made up by mixing 900 cm^3 of water with 30 g salt and 100 cm^3 of washing up liquid. The salt needs to be dissolved first. The washing-up liquid needs to be stirred in gently to avoid forming froth.
- Video clip *Sex chromosomes* revisits genes and chromosomes and explains how X and Y chromosomes determine a person's sex.

Extension

- Student complete **worksheet 5.2.5** to test their understanding. **PowerPoint 5.2.6** displays the incorrect sentences.

Homework

Workbook page 19

Key words

chromosomes, DNA, genes

Student book, pages 48–49

CD resources

- Worksheet 5.3.1
- PowerPoint 5.3.2
- Worksheet 5.3.3
- Worksheet 5.3.4
- PowerPoint 5.3.5
- Worksheet 5.3.6
- PowerPoint 5.3.7
- Worksheet 5.3.8

Objectives

- Recognise that genes are parts of chromosomes
- Understand that we inherit two copies of each chromosome, one from each parent

Preparation

- Copy the chromosome cards on **worksheet 5.3.1** once onto blue card and once onto pink card for each student group, and cut them up to produce 28 chromosome cards per group, 14 of each colour.
- Copy the gene cards on **worksheet 5.3.3** onto a different coloured card and cut out one set for each group of students.

Overview

Students use Punnett diagrams to explain how features controlled by single genes are inherited, and what determines whether the dominant or recessive feature appears in the offspring.

Activities

- Give each student one card from **worksheet 5.3.1** and ask them to pair up with someone with the same letter (capital or small) but on the opposite card colour. Then use **PowerPoint 5.3.2** to explain what the cards represent.
- Students read page 48 of the Student book to learn about Mendel's work.
- Students use cards from **worksheet 5.3.3** to match the features of parent pea plants to the next generation, and look for patterns. **Worksheet 5.3.4** gives instructions and **PowerPoint 5.3.5** explains the results. Students should spot that the next generation is short if both parents are short, and tall if either one or both parents are tall (type 1). When the parents are tall (type 2), one-quarter of the offspring are short.
- Video clip *Smoke rings* on the internet summarises Mendel's work.
- **Worksheet 5.3.6** prompts students to predict the outcome of two other crosses.
- Video clip *Inheritance of eye colour* applies the idea of dominant and recessive genes to eye colour.
- **PowerPoint 5.3.7** shows six other pea features that are inherited in the same way as tallness. Students use sets of blue and pink cards from **worksheet 5.3.1** to model the inheritance of different combinations of features from parents that have two different genes for each feature. **Worksheet 5.3.8** structures this activity.

Extension

- Video clip *A history of sex, genes and DNA* summarises the development of scientific ideas about inheritance.

Homework

Workbook page 20

Key words

dominant, recessive

Student book, pages 50–51

CD resources
- Worksheet 5.4.1
- Worksheet 5.4.2
- Worksheet 5.4.3
- PowerPoint 5.4.4

Objective

- Describe how selective breeding can produce new varieties

Overview

Students model selective breeding and how it has been used to improve crops and farm animals.

Activities

- Use page 50 of the Student book to show students how different pet cats can be, despite belonging to the same species. Explain that the pet cats we have now were produced by selective breeding.
- Students use dice, and the cards from **worksheet 5.4.1**, to model selective breeding. Students record their results on **worksheet 5.4.2**, and **worksheet 5.4.3** provides detailed instructions. The first two slides of **PowerPoint 5.4.4** introduce the task, and slide 3 has the data students need to see if their kitten has inherited a health problem. It is important to note that this is a simulation. In real life, inbreeding increases the risk of animals inheriting faulty genes but the genes are rarely linked directly to physical features.
- Use pages 50–51 of the Student book to show how plants and animals on farms have been improved by selective breeding.
- Video clip *Norman Borlaug and selective breeding of wheat* on the internet could be used to show selective breeding was used to produce the high-yielding dwarf wheat that is now grown all over the world.

Extension

- Students could debate the ethics of breeding closely related animals, given that it increases their risk of inheriting health problems.

Homework

Workbook page 21

Key words

selective breeding, mutations

Student book, pages 52–53

CD resource
- Worksheet 5.5.1

Objective

- Describe how new theories are developed

Overview

Students learn how Darwin developed his theory of evolution by natural selection.

Activities

- Use page 52 of the Student book to introduce the term 'theory' to describe an idea supported by evidence that explains a lot of observations and answers a lot of questions.
- The summary at http://www.cnrs.fr/cw/dossiers/dosdarwinE/darwin.html could be used to introduce the voyage around the world that allowed Darwin to collect evidence for his theory of evolution.
- Students read pages 52–53 of the Student book, and complete the questions, to see some of the evidence that supports Darwin's theory.
- Clip *Darwin's finches* on the internet shows how the finches that colonised the islands have since evolved by natural selection to become different species on different islands. Clip *Darwin's pigeons* describes the pigeons Darwin used to investigate selective breeding.
- Students complete **worksheet 5.5.1** to look in more detail at the way the environment selects which finches survive, reproduce, and pass on their genes.

Extension

- Clip *Evolution of complex life* on the YouTube describes more fossil evidence for evolution.

Homework

Workbook page 22

Key word

natural selection

Student book, pages 54–55

CD resource
- Worksheet 5.6.1

Objective
- Describe Darwin's theory of evolution by natural selection

Overview
Students consider the processes involved in evolution by natural selection.

Activities
- Use pages 54–55 of the Student book to explain the four main ideas that make up Darwin's theory of evolution by natural selection: living things produce many offspring, but most don't survive; every individual is different and some are more likely to survive; successful individuals pass their characteristics to their offspring; over time, these characteristics become more common and the population evolves.
- Video clip *Variation and inheritance* on the internet explains Darwin's idea that variation leads to natural selection as individuals struggle to survive. Clip *Natural selection and survival of the fittest* shows how animals with a slight advantage have a better chance of survival and clip *Sexual selection* shows how sexual selection led to the evolution of the peacock's tail.
- Students use **worksheet 5.6.1** to summarise the theory of evolution by natural selection.

Extension
- Clip *The tree of life* on the YouTube explains how all life is descended from a single common ancestor.

Homework
Workbook page 23

Student book, pages 56–57

CD resources
- Worksheet 5.7.1
- PowerPoint 5.7.2
- Worksheet 5.7.3
- Worksheet 5.7.4
- Worksheet 5.7.5

Objective
- Describe how living things can be genetically engineered to make new products

Overview
Students learn how an organism's features can be changed by adding new genes to their cells.

Activities
- Use page 56 of the Student book to introduce the idea that genes can be moved from one organism to another.
- Students check their understanding of the role of genes by completing the matching pairs activity on **worksheet 5.7.1**. The pairs are: 1F, 2H, 3G, 4B, 5E, 6C, 7D, and 8A and a sensible order to put them in is 1F, 4B, 8A, 7D, 3G, 5E, 2H, and 6C. Students should recognise that genes influence many of our features by controlling what our cells make. But cells can make different things if we give them new genes. If we want to add genes to a whole animal, we need to put them in a fertilised egg cell so they will be copied to every cell as the animal grows.
- Pairs use Plasticine to model the transfer of glow genes to bacteria. **PowerPoint 5.7.2** guides the activity and the **worksheet 5.7.3** has outlines of a bacterial cell and a jellyfish for them to put their Plasticine strands of genes in.
- Video clip *Genetically modified crops* shows the steps involved in genetically modifying organisms.
- Use page 57 of the Student book to introduce the use of genetically modified organisms to produce medicines. Explain that many people object to this. Students take turns to read arguments from **worksheet 5.7.4** and sort them into 'benefit' and 'risk' piles. Then they arrange each pile in order of importance and decide as a group whether they are for or against growing plants that make medicines. Benefits are highlighted on cards 4, 6, 7, 8, 9, and 11 and risks on the rest.
- Video clip *Creating a GM plant* shows a genetically modified plant being made.

Extension
- Students complete **worksheet 5.7.5** to consider how medicine-making crops could be grown safely in the open.

Homework
Workbook page 24

Key words
genetic engineering, plasmids, pharming

Student book, pages 58–59

CD resources
- Worksheet 5.8.1
- Worksheet 5.8.2
- Worksheet 5.8.3
- PowerPoint 5.8.4

Objective

- Understand that selective breeding and genetic engineering can be used to produce medicines

Overview

Students explain how organisms can be made more useful by selective breeding and genetic engineering. They research the processes and costs involved in each and present a case for investing money in one or the other, taking into account social and economic implications.

Activities

- Use page 58 of the Student book to introduce malaria and ask students what could be done to help children like Abha and why it isn't happening already. Good suggestions are: destroy the mosquitoes; cover the water where they breed; use bed nets; vaccinate people against malaria; and find more effective or cheaper medicines.
- Explain why effective malaria drugs are not available to everyone and that selective breeding or genetic engineering could make them more affordable.
- Students complete **worksheet 5.8.1** to check they understand what these techniques involve.
- Explain that scientists who think their work could solve a problem have to bid for money to pay their wages and buy their equipment. To be selected they need to convince the funding body that they know what they are doing and their method will definitely make artemisinin cheaper.
- Allocate genetic engineering or selective breeding to each student group. They should read their section in the Student book and follow the advice on their section of **worksheet 5.8.2**. They will need time to prepare their posters or presentations. It will be helpful if they have access to the internet. Otherwise, the research could be set as homework.
- Encourage students to make constructive comments on each other's presentations using **worksheet 5.8.3** and then give them a chance to circulate and read each other's at the end of the activity.

Extension

- **PowerPoint 5.8.4** is a quiz to consolidate learning from the lesson.

Homework

Workbook page 25

Key words

resistant, genetic engineering

Student book, pages 62–63

CD resources

- Worksheet 6.1.1
- Worksheet 6.1.2
- Worksheet 6.1.3
- 6.1.4 The atom illustration

Objectives

- Name the three sub-atomic particles, and describe their properties
- Describe the structure of an atom

Overview

This lesson introduces students to sub-atomic particles and atomic structure. Students learn the mass and charge of each sub-atomic particle, and that the nucleus is made up of protons and neutrons. In a neutral atom, the numbers of protons and electrons are equal.

The illustration from page 62 of the Student book is included on the CD-ROM with and without labels. This could be used as plenary activity to find out what students already know about atoms.

The arrangement of electrons in shells around the nucleus is covered in lesson 6.4.

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 and diffusion. Tell students that the solid atom model cannot explain everything in chemistry, for example reactions. A new model is needed.
- Describe an atom as consisting 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. **Worksheet 6.1.1** supports this activity.
- **Practical activity:** Explain that every atom of a certain element has the same number of protons. Student pairs use beans to model atomic structures of given atoms. At this stage they do not arrange electrons in shells, but simply spread them out around the outside of the nucleus. Students draw their models. **Worksheet 6.1.2** supports this activity.

Extension

Students tackle the questions on the sizes and masses of atoms, nuclei, and sub-atomic particles on **worksheet 6.1.3**.

Homework

Workbook page 26

Key words

sub-atomic particles, protons, neutrons, electrons, nucleus

Student book, pages 64–65

CD resources
- Worksheet 6.2.1
- Worksheet 6.2.2

Objective
- Describe how scientists work using historical examples

Overview
This lesson describes the contributions of two scientists to the development of models of atomic structure. Students first explore how J. J. Thomson used experimentation, evidence, and creative thought to discover electrons. They then make physical models to represent the models of atomic structure developed by Thomson and Nagaoka. Finally, students script a conversation in which Thomson and Nagaoka discuss and compare their models.

Activities
- Describe to students how Thomson explored cathode rays. Use the diagram to explain how he used experimentation, evidence, and creative thought to discover that cathode rays are negatively charged. Read from page 148 of the Student book.
- Students complete the diagram on **worksheet 6.2.1** to show how Thomson discovered that electrons are particles that are part of atoms. Higher attaining students can complete the diagram in their own words; students can also write phrases from the bottom of the sheet in the correct boxes on the diagram.
- **Practical activity:** Students make physical models to represent Thomson's plum pudding model and Nagaoka's Saturn model. Use beans or stones to represent electrons, and clay or dough to represent the positive parts of the atoms. Read from page 65 of the Student book.
- Student pairs script – and then perform – imaginary conversations in which Thomson and Nagaoka compare their models. The writing frame on **worksheet 6.2.2** supports this activity.

Extension
Explore the history of the discovery of the electron in more detail. This website is a useful starting point: *www.aip.org/history/electron/jjhome.htm*

Homework
Workbook page 27

Key words
nucleus, electrons, model

Student book, pages 66–67

CD resources

- Worksheet 6.3.1
- Worksheet 6.3.2
- Worksheet 6.3.3

Objective

- Describe the method and discoveries of Rutherford

Overview

This lesson describes how Rutherford and his colleagues, Geiger and Marsden, discovered the nucleus. The lesson begins with a description of the scientists' experiment, in which the scientists fired positively-charged particles at gold foil. Students then model one aspect of the experiment themselves. They next complete a comic strip, imagining conversations between the scientists as they do the experiment and later explain it. Finally, students are introduced to the neutron.

Activities

- Tell students that Rutherford wanted to test Thomson's plum pudding model. He worked with colleagues to do an experiment to gather evidence. Use the Student book to describe the experiment, or show an animation. **Worksheet 6.3.1** supports this activity.
- **Practical activity:** As a class, model the experiment as follows. Tie a piece of string to a large ball. Suspend it from the ceiling, or a tree. This represents a nucleus. Students throw small balls (or screwed-up pieces of paper) at the big ball. These represent positively-charged particles. Most small balls do not change direction. A few hit the nucleus and change direction. **Worksheet 6.3.2** supports this activity.
- Students add text to speech bubbles on the comic strip on **worksheet 6.3.3** to describe and explain the results of the Geiger-Marsden experiment.
- Students read the section *Inside the nucleus* from page 67 of the Student book. This introduces protons and neutrons.

Extension

Use the Internet to find out more about the discovery of the neutron. Go to *cambridgephysics.org* and click on the browse icon.

Homework

Workbook page 28

Key words

nucleus, electrons, model

6.4 Protons, electrons, and the periodic table

Student book, pages 68–69

CD resources
- Worksheet 6.4.1
- Worksheet 6.4.2
- Worksheet 6.4.3

Objectives
- Draw the structures of atoms of the first twenty elements
- Describe patterns in the structures of these atoms

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.

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. In a neutral atom, the number of protons is equal to the number of electrons.
- **Practical activity:** Tell students that electrons occupy shells in atoms. Students use beans to model the electronic structures of atoms. They draw the arrangements, and then write the electronic structures in the form 2,8,1 and so on. **Worksheet 6.4.1** supports this activity.
- **Worksheet 6.4.2:** Students draw the electronic structures of atoms of the first three elements of Group 1 of the periodic table. They repeat for Groups 2 and 0, and look for patterns.
- **Worksheet 6.4.3:** Teacher reads out statements about electronic structure. Students show thumbs up for true statements, thumbs down for false statements, and thumbs horizontal if they are not sure.

Extension
Use the Internet to find out about the similarities in properties of the Group 1 elements, in preparation for lesson 6.6.

Homework
Workbook page 29

Key words
shells, energy levels, orbits, electronic structure, protons, electrons

Student book, pages 70–71

CD resources

- Worksheet 6.5.1
- Worksheet 6.5.2
- Worksheet 6.5.3

Objectives

- Work out the proton number and nucleon number of an atom
- Explain what isotopes are

Overview

This lesson introduces proton number and nucleon number, and links the concept of proton number to the periodic table. Students model atoms with different proton and nucleon numbers, and use a periodic table to identify them. They then do calculations linking proton number, nucleon number, and number of neutrons. Finally, students are introduced to the idea of isotopes. They make human models of isotopes before calculating the numbers of neutrons in different isotopes of an element.

Activities

- Explain that proton number is the number of protons in an atom of an element. Then explain that protons and neutrons are both nucleons, and that the number of nucleons in the nucleus of an atom is its nucleon number.
- **Practical activity:** Students use beans or bottle tops to model atoms given their proton and nucleon numbers. They then use the periodic table to identify the elements the atoms are from. **Worksheet 6.5.1** supports this activity.
- Students do the calculations linking proton number, nucleon number, and number of neutrons on **worksheet 6.5.2**.
- Explain that isotopes are atoms of the same element with different numbers of neutrons. Students take the role of protons and neutrons, to model three hydrogen isotopes. They then calculate the numbers of neutrons in different isotopes of an element. **Worksheet 6.5.3** supports this activity.

Homework

Workbook page 30

Key words

proton number, nucleon, nucleon number, mass number

Student book, pages 72–73

CD resources
- Worksheet 6.6.1
- Worksheet 6.6.2
- Worksheet 6.6.3

Objective

- Describe trends in properties of the Group 1 elements

Overview

In this lesson, students observe the reactions of the Group 1 elements with water, either as a teacher demonstration or on video clips. They use ideas about electronic structure to explain why the reactions are similar. Students then work in groups to find out about trends in the physical properties of the elements.

Activities

- **Practical activity:** Locate Group 1 in the periodic table. Then demonstrate the reactions of lithium, sodium, and potassium with water, or show video clips of the reactions. Students complete **worksheet 6.6.1**. For demonstration instructions go to *www.nuffieldfoundation.org/practical-chemistry* and search for *Group 1*. For video clips, search YouTube for *sodium and water*.
- Divide students into groups of 4. These are *home groups*. Within the home groups, each student is allocated one question from **worksheet 6.6.2**.

  Students doing the same question then get together in new groups of 4. These are *expert groups*. Each expert group tackles its question using the data on **worksheet 6.6.3**, and plans how to teach home groups what they have learnt.

  Students return to their home groups, and teach each other what they have learnt.
- Students remain in home groups. Teacher asks a few questions about trends in the physical properties of the Group 1 elements, to check learning from the previous activity.

Extension

Use the Internet to research the uses of Group 1 elements and their compounds. These websites are good places to begin: *rsc.org/periodic-table* and *webelements.com*

Homework

Workbook page 31

Key words

group, patterns, properties, trend, metal

Student book, pages 74–75

CD resource
- Worksheet 6.7.1

Objective

- Describe trends in the properties of the Group 2 elements

Overview

In this lesson, students use electronic structures to explain why the properties of the Group 2 elements are similar. They then use their knowledge of the trends of the reactions of the Group 1 elements with water to predict a trend for Group 2. Next, students react calcium and magnesium with cold water, to test their prediction. They also learn how to test for hydrogen gas.

Activities

- Locate Group 2 in the periodic table. Students write the electronic structures of the elements in the form 2,8,2. Guide them to explain that all Group 2 elements have two electrons in their outermost shell. This is why their reactions are similar.
- **Practical activity:** Students use their knowledge of Group 1 reactions to predict the trend in the reactions of Group 2 elements with water. They test their prediction by reacting magnesium and calcium with cold water. **Worksheet 6.7.1** supports this activity.
- **Practical activity:** Students react calcium with cold water again, and test the gas given off to show that it is hydrogen (a lighted splint held in the gas will go out with a squeaky pop). Use the guidelines on page 218 of the Student book.
- Students consider the reactions of the Group 2 elements with acids, and answer question 3 on page 75 of the Student book to suggest how to compare the vigour of the reactions of beryllium and magnesium with hydrochloric acid.

Extension

Use the Internet to research the uses of Group 2 elements and their compounds. These websites are good places to begin: *rsc.org/periodic-table* and *webelements.com*

Homework

Workbook page 32

Key words

group, properties, pattern, trend, reaction

Student book, pages 76–77

CD resources
- Worksheet 6.8.1
- Worksheet 6.8.2

Objective

- Describe trends in the properties of Group 7 elements

Overview

In this lesson, students examine the physical properties of the halogens, and model their molecular structure. They then watch videos showing the reactions of the halogens with iron wool, and consider their hazards. They also write equations for the reactions.

Activities

- Locate Group 7 in the periodic table. Student pairs discuss what they know about the elements in this group, and then read the section *Deadly elements* on page 76 of the Student book.
- Students plot the melting points and boiling points of the halogens on a number line, and use this to answer questions about their states at different temperatures. Questions 1 and 2 on **worksheet 6.8.1** support this activity.
- **Practical activity:** Make models of halogen molecules, using matchsticks and plasticine, or students holding hands in pairs. Explain that elements that exist as molecules, like the halogens, are often gases; unlike most metals, which do not exist as molcules.
- Students read the section *Reactions of the Group 7 elements* in the Student book. Show videos of the reactions of the halogens with iron – search YouTube for *halogens iron wool*. **Worksheet 6.8.2** supports this activity.

Extension

Use the Internet to research the uses of Group 7 elements and their compounds. These websites are good places to begin: *rsc.org/periodic-table* and *webelements.com*

Homework

Workbook page 33

Key words

halogen, trend, properties, pattern, non-metal

Student book, pages 78–79

CD resource
- Worksheet 6.9.1

Objective

- Look critically at sources of secondary data

Overview

Students begin by finding out about the history of adding chlorine and its compounds to drinking water. They make a small poster to summarise what they learn. Students then read about a scientific study on the effects of chlorinating water. In groups they create, perform, and evaluate a radio programme to tell listeners about the study and its findings.

Activities

- Students read about the history of adding chlorine and its compounds to drinking water. They make small illustrated posters to summarise their findings. Read from pages 78–79 of the Student book.
- Students read about a scientific study on the effects of chlorinating water. In groups of three, they use **worksheet 6.9.1** to help them create a radio programme to tell listeners about the study and its findings.
- Student groups perform their radio programmes to at least one other group. The listening groups evaluate the programmes according to the criteria at the bottom of **worksheet 6.9.1**.

Extension

Use the Internet to research the chlorination of drinking water in more detail. Start by looking at *worldchlorine.org* and navigating to publications.

Homework

Workbook page 34

Key words

chlorine, secondary data, evidence

Student book, pages 80–81

CD resources
- Worksheet 6.10.1
- Worksheet 6.10.2

Objectives
- Describe trends in periods of the periodic table
- Describe patterns in data

Overview
Students begin by colouring in different groups and periods of the periodic table, for easy identification. They then plot bar charts of the melting points of the elements of periods 4 and 5 from secondary data, and identify any trends. They then compare these trends to those of periods 2 and 3 that are described in the Student book.

Activities
- Students colour in different groups and periods on the periodic table on **worksheet 6.10.1**.
- Students use data given on **worksheet 6.10.2** to plot bar charts of the melting points of the elements of periods 4 and 5. They identify the trends seen. There are no simple patterns, but students should describe any general trends.
- Students compare the trends in melting points for periods 4 and 5 given on **worksheet 6.10.2** to those of periods 2 and 3, given on page 81 of the Student book. Again, there are no easy answers – students should describe overall trends, similarities, and differences.

Extension
Use the Internet to find pictures of the elements of periods 2 and 3, and to find out about the uses of the elements of one of these periods. These websites are good places to begin: *rsc.org/periodic-table* and *webelements.com*

Homework
Workbook page 35

Key words
period, trend

6.11 Enquiry: how scientists work: inside sub-atomic particles

Student book, pages 82–83

CD resources
- Worksheet 6.11.1
- Worksheet 6.11.2

Objective
- Describe how scientists work today

Overview
This enquiry lesson explores the work of scientists looking for the particles that make up protons and electrons, so addressing one of the *Ideas and evidence* statements in the specification. The lesson begins with a brief look at the work of Bose and Einstein in predicting a new state of matter, and the 1964 predictions of Higgs. Students then create a poster about the work of scientists developing and using the Large Hadron Collider to search for the Higgs boson. They gather information for this task either from the Student book, or from the Internet.

Activities
- Students use the Student book to help them complete the flow chart on **worksheet 6.11.1** summarising some of the early work leading to the prediction of the existence of the Higgs boson. They should focus on the processes involved in suggesting explanations, and on how scientists build on each other's ideas.
- Students use information from the Student book, and – optionally – the Internet to create a poster about the Large Hadron Collider. This may include information about its design and the 2012 detection of a new boson. It should emphasise how scientists from many countries are working together on the project, and how electronic communication has made such collaboration possible. **Worksheet 6.11.2** supports this activity.
  Useful websites include:
  - *http://public.web.cern.ch/public/en/lhc-en.html*
  - *www.newscientist.com/topic/larg-hadron-collider*
  - *www.lhc.ac.uk/*
- You can also search for *Large Hadron Collider [country name]* to find out about the contributions of scientists from your country.

Homework
Workbook page 36

Key words
particle, sub-atomic, evidence, explanation, proton

Student book, pages 86–87

CD resource
- Worksheet 7.1.1

Objective

- Investigate the burning reactions of metals

Overview

This lesson involves a series of practical activities, in which students try burning metals in air and list the metals in order of the vigour of their reactions.

Students begin by sprinkling iron filings in a Bunsen burner flame. They then burn a piece of magnesium ribbon. They think about their investigation so far – which metal is more reactive? Is the investigation fair? Students then try burning pieces of iron and copper of similar size to the magnesium ribbon to more fairly compare the vigour of their reactions.

Finally, students compare the reaction of aluminium and oxygen with that of iron and oxygen.

Activities

- **Practical activity:** Students sprinkle a spatula measure of iron filings into a hot Bunsen flame, and record their observations. **Worksheet 7.1.1** supports this activity.
- **Practical activity (continued):** Students burn magnesium ribbon in a Bunsen flame, and record their observations. Students should not look directly at the magnesium as it burns, since the bright white flame can cause eye damage. **Worksheet 7.1.1** supports this activity.
- **Practical activity (continued):** Ask students to compare the vigour of reaction of iron and magnesium with oxygen from the air. Guide students to the conclusion that it is not fair to compare the two burning reactions, since the metal pieces are of different sizes. Give students pieces of iron and copper of similar size to the magnesium ribbon. Ask them to compare the vigour of the reactions of the three metals when heated in air. **Worksheet 7.1.1** supports this activity.
- Students write equations for the reactions they have observed. Questions 2 and 3 on **worksheet 7.1.1** sheet support this activity.

Extension

Demonstrate the burning reaction of aluminium powder by sprinkling it into a Bunsen flame. Compare the vigour of the reaction with that of iron.

Homework

Workbook page 37

Key words

preliminary work, burning, metals, oxygen, oxide

Student book, pages 88–89

CD resources
- Worksheet 7.2.1
- Worksheet 7.2.2

Objective
- Describe how metals react with water

Overview
This lesson starts with a look at metals that do not react with water, and why they are useful. Students then try reacting five metals with water. They note the vigour of the reactions and test the gaseous product formed. Students then observe as the teacher demonstrates the reaction of lithium with water. The lesson concludes with a comparison of the reactions of metals with oxygen (see lesson 7.1) and with water. Do metals that react vigorously with oxygen also react vigorously with water?

Activities
- Students look at the cartoon at the top of page 88 of the Student book. They discuss these questions: Why is it useful that some metals do not react with water? Which metals do not react with water?
- **Practical activity:** Students add five metals to water – copper, magnesium, calcium, lead, and iron. They observe and compare the vigour of their reactions with water. **Worksheet 7.2.1** supports this activity.
- **Practical activity (continued):** Students repeat the test with calcium, this time testing the gas produced to find out if it is hydrogen or oxygen. The gas is hydrogen. There is a pattern in the reactions – all metals that react with water produce hydrogen gas. Students write equations for the reactions they have observed. **Worksheet 7.2.1** supports this activity.
- Demonstrate the reaction of lithium with water. Test to show that the gas produced is hydrogen. Part 1 of **worksheet 7.2.2** supports this activity.
- Students list the metals tested in order of reactivity. In pairs, they discuss whether metals that react vigorously with oxygen also react vigorously with water. Part 2 of **worksheet 7.2.2** supports this activity.

Homework
Workbook page 38

Key words
reaction, metal, water, hydroxide

Student book, pages 90–91

CD resources
- Worksheet 7.3.1
- Worksheet 7.3.2

Objective

- Describe how metals react with acids

Overview

Students begin by predicting whether copper or magnesium will react more vigorously with acid. They then plan an investigation to compare the vigour of the reactions of five metals with hydrochloric acid. Students then carry out their investigation, and compare the pattern observed to those of the metals with oxygen and water. As an extension task, students write word equations for the reactions observed, and predict the products of the reactions of metals with other acids.

Activities

- Students discuss which is likely to react with hydrochloric acid more vigorously – copper or magnesium, and justify their choice.
- Students plan an investigation to compare the vigour of the reactions of magnesium, lead, iron, zinc, and copper with hydrochloric acid. **Worksheet 7.3.1** guides them to consider how to make the test fair, how to manage risk, and how to test the gaseous product.
- Students carry out their investigation, and list the metals used in order of the vigour of their reactions with hydrochloric acid. They compare this pattern with those of the metals with oxygen and water. Part 1 and questions 1 and 2 on **worksheet 7.3.2** support this activity.

Extension

Students write word equations for the reactions observed, and for the reactions of metals with sulfuric acid. Questions 3 and 4 on **worksheet 7.3.2** support this activity.

Homework

Workbook page 39

Key words

acids, metal, hazard, risk, hydrogen

Student book, pages 92–93

CD resources
- Worksheet 7.4.1
- Worksheet 7.4.2

Objective

- Understand the reactivity series

Overview

Students begin by considering their findings from lessons 7.1, 7.2, and 7.3, and organise metal information cards in order of reactivity. They then write down the reactivity series, and make some notes about it.

Students then look at links between the reactivity series and corrosion. They predict which metals will corrode most and least easily, and then make a poster describing and explaining different techniques of preventing corrosion.

Activities

- Student groups study the metal reaction data on the cards on **worksheet 7.4.1**, and place the cards in order of metal reactivity.
- Students list metals in order of reactivity, and read pages 92–93 of the Student book to note key points about the reactivity series.
- Students use the reactivity series to predict which metal will corrode most easily. Question 1 of **worksheet 7.4.2** supports this activity.
- Students make a poster describing and explaining different techniques of preventing corrosion. Question 2 of **worksheet 7.4.2** supports this activity.

Extension

Students use the Internet to do further research about preventing corrosion of metal objects at sea, for example offshore wind farms, oil rigs, and ships. Start by searching for *corrosion prevention oil rig*.

Homework

Workbook page 40

Key words

corrosion, reactivity series

7.5 Enquiry: metals in the reactivity series

Student book, pages 94–95

CD resource

- Worksheet 7.5.1

Objective

- Plan an enquiry and interpret evidence to work out the position of an unknown metal in the reactivity series

Overview

This lesson is about the position of metals in the reactivity series. The lesson starts with a quick introduction to nickel. Students then interpret secondary evidence, and plan how they would collect and interpret primary evidence. The secondary data given on the worksheet is for nickel; but nickel and its salts are toxic only allow students to plan their investigations. Do not carry them out in the classroom.

Activities

- Introduce the lesson with a review of the reactivity series. Students should recall what they have learnt in lesson 7.4.
- Tell students they will plan an investigation to find the position of a metal in the reactivity series. Ask pairs to discuss how to approach this task.
- Students examine secondary data about the burning reactions of metal powders. They use secondary data to compare the reactions of an unknown metal and other metals with dilute hydrochloric acid, and interpret the data collected. **Worksheet 7.5.1** supports this activity.

Extension

Tell the students that the unknown metal is nickel. Students then use the Internet to find out more about nickel. How are its properties linked to its uses? Start by looking at these websites: *rsc.org/periodic-table* and *webelements.com*

Homework

Workbook page 41

Key words

reactivity series, nickel, corrosion, evidence

Student book, pages 96–97

CD resources
- Worksheet 7.6.1
- Worksheet 7.6.2

Objective

- Explain what displacement reactions are, and how they are useful

Overview

This lesson begins by looking at copper – why is it useful? How is it extracted from copper ore waste? Students carry out reactions in which more reactive metals displace less reactive metals from their compounds. The lesson concludes with a demonstration of the dramatic thermite reaction, in which aluminium displaces iron from one of its oxides.

Activities

- Introduce copper as a vital metal, useful for electric cables and water pipes. Copper ore supplies are running out, so companies extract copper from copper ore waste. Students read about how this is done on page 96 of the Student book. Set up a demonstration by immersing an iron nail in copper sulfate solution. Return to this towards the end of the lesson to observe the copper formed.
- **Practical activity:** Tell students the reaction of iron with copper sulfate solution is a displacement reaction. In these reactions, a more reactive metal displaces a less reactive metal from its compounds. Students predict which metal – salt solution pairs react, and carry out a practical to test their predications. **Worksheet 7.6.1** supports this activity.
- Demonstrate the thermite reaction. This is described in detail at *www.nuffieldfoundation.org/practical-chemistry/thermite-reaction*. It is vital to follow the safety guidance. Students then tackle questions about this reaction on **worksheet 7.6.2**.
- Watch a video clip in which the thermite reaction is used to weld railway rails together. Search online for *thermite welding railway* to find a video clip.

Extension

Demonstrate the burning reaction of aluminium powder by sprinkling it into a Bunsen flame. Compare the vigour of the reaction with that of iron.

Homework

Workbook page 42

Key words

displaced, displacement reaction, thermite reaction

7.7 Extension: using the reactivity series: extracting metals from their ores

Student book, pages 98–99

CD resources
- Worksheet 7.7.1
- Worksheet 7.7.2

Objective

- Explain the link between the position of a metal in the reactivity series, and how the metal is extracted from its ore.

Overview

This lesson links the reactivity series with metal extraction techniques. First, students consider gold. They use panning to separate the metal (or something that looks like it!) from a mixture of sand and water. Students then use carbon to extract copper and iron from their oxides. Finally, they learn that electrolysis is used to extract metals that are high in the reactivity series.

Activities

- **Practical activity:** Introduce gold as an unreactive metal at the bottom of the reactivity series. Since it is unreactive, it is found as an element in the Earth's crust. In some areas, gold is found in stream beds, mixed with sand and gravel. Students use panning to separate iron pyrites – or another substance that looks like gold, and has a high density – from a mixture of sand and water. **Worksheet 7.7.1** supports this activity.
- **Practical activity:** Iron and copper are towards the middle of the reactivity series. They are extracted from their naturally-occurring compounds by heating with carbon. Students heat the two metal oxides with carbon powder to illustrate this process. **Worksheet 7.7.2** supports this activity.
- Tell students that aluminium and metals above it in the reactivity series are strongly joined to other elements in compounds. These metals cannot be extracted from their compounds by heating with carbon. Instead, they are extracted by electrolysis. Students find out more about this process by reading page 195 of the Student book and by watching a video clip. Search online for *aluminium extraction – Royal Society of Chemistry* for a video clip.

Homework

Workbook page 43

Key words

ore, metal, extracting metals, reactivity

Student book, pages 100–101

CD resources

- Worksheet 7.8.1
- Worksheet 7.8.2
- Worksheet 7.8.3

Objective

- Write balanced symbol equations for simple reactions.

Overview

This lesson begins with a quick look at word equations, and why they are useful. Students are then guided through the process of interpreting symbol equations. Next, students use displayed formula cards to help them balance symbol equations for burning and displacement reactions. The lesson concludes with a chance to balance unbalanced symbol equations and write balanced symbol equations given word equations and formulae.

Activities

- Through discussion, elicit that word equations are useful because they show the reactants and products in a reaction. Students practise writing word equations on Part 1 of **worksheet 7.8.1**.
- Explain that symbol equations give more information about a reaction. They give formulae, relative amounts, and show how atoms are rearranged. Students learn how to interpret symbol equations using Part 2 of **worksheet 7.8.1**.
- Students use displayed formula as a first stage in helping them to balance equations. **Worksheet 7.8.2** supports this activity.
- Go through the stages given on pages 100–101 of the Student book to show students how to balance equations for burning magnesium and burning lithium. Students then balance unbalanced symbol equations and write balanced symbol equations given word equations and formulae on **worksheet 7.8.3**.

Homework

Workbook page 44

Key words

chemical symbol, burning, state symbols, equations

8.1 Making salts – acids and metals

Student book, pages 104–105

CD resources
- Worksheet 8.1.1
- Worksheet 8.1.2

Objective

- Describe how to make salts by reacting acids with metals

Overview

The lesson starts with a look at salts – can students remember what they are? They then make their own salt – magnesium chloride – by reacting magnesium with dilute hydrochloric acid. Before the practical, students make choices about the best equipment to use. The lesson ends with questions about the different stages of the practical, focusing on the purpose of each stage.

Activities

- Display crystals of different salts. Include coloured salts, for example copper sulfate and salts of iron. Remind students that a salt is a compound made when a metal replaces hydrogen in an acid.
- Tell students they will make their own salt. Display apparatus pairs, as below, and ask students to choose the more suitable piece of apparatus from each pair.
  - Measuring cylinder or beaker to measure acid volume.
  - Filter paper and funnel or sieve to separate solid magnesium from magnesium chloride solution.
- **Practical activity:** Students follow the instructions to make magnesium chloride crystals from magnesium and dilute hydrochloric acid. **Worksheet 8.1.1** supports this activity.
- Students answer the questions on **worksheet 8.1.2** about the purpose of each stage of the practical, and about making other salts.

Homework

Workbook page 45

Key words

salt, compound, acid, metal

Student book, pages 106–107

CD resources
- Worksheet 8.2.1
- Worksheet 8.2.2

Objective

- Describe how to make salts by reacting acids with carbonates

Overview

The lesson starts with a look at copper sulfate. How is it useful? Having assessed hazards, students make copper sulfate from copper carbonate and sulfuric acid. They consider how to maximise the yield of the product, and write word equations to summarise the reactions of other carbonates with acids.

Activities

- Display crystals of copper sulfate. Ask how the salt is useful. One use is as a fungicide – farmers use it to control fungi on grape plants.
- Tell students they will make their own copper sulfate crystals. Ask students to identify hazards, and suggest how to minimise risk from these hazards. Use **worksheet 8.2.1** as teacher support only at this stage.
- **Practical activity:** Students follow instructions to make copper sulfate crystals from copper carbonate and dilute sulfuric acid. **Worksheet 8.2.1** supports this activity.
- Students answer questions about the procedure they have followed, particularly about maximising the yield of the product, and write word equations for other carbonate – acid reactions. **Worksheet 8.2.2** supports this activity.

Homework

Workbook page 46

Key words

equation, salt, compound, acid, carbonate

8.3 Extension: making salts – acids and alkalis

Student book, pages 108–109

CD resources
- Worksheet 8.3.1
- Worksheet 8.3.2

Objective

- Describe how to make salts by reacting acids with alkalis

Overview

The lesson starts with a look at sodium chloride. What is it used for? Why is it extracted from the sea, or mined from rock, rather than made in the laboratory? Students then prepare samples of sodium chloride by reacting hydrochloric acid with sodium carbonate. Two methods are given, so that half the class can follow each method. Having prepared their salt, students compare the two methods. Which gives a greater amount of product from given amounts of starting materials? Why?

Activities

- Display sodium chloride. Elicit that it is used to flavour and preserve food, and to make other chemicals such as chlorine and sodium hydroxide. Explain that sodium chloride is extracted from sea or mined from rock. It is not made in the laboratory since the process would be very expensive and is unnecessary since large amounts of the substance exist naturally.
- Tell students they will make their own sodium chloride by neutralising dilute hydrochloric acid with sodium carbonate solution. They cannot use the same method as in lessons 8.1 or 8.2 since both reactants are soluble. Students will follow one of two methods as shown on **worksheets 8.3.1** and **8.3.2**. Students may need guidance using the pipette and burette in method 2.
- Students compare the two methods. Which gives a greater amount of product from given amounts of starting materials? Why? The answer is that the titration method produces less product since this method involves discarding the first sample of sodium chloride solution that is made. Student book page 109 can be used to guide the discussion.

Homework

Workbook page 47

Key words

salt, acid, alkali, neutralise

Student book, pages 110–111

CD resource
- Worksheet 8.4.1

Objective

- Identify salts used as fertilisers

Overview

The lesson begins with a discussion about fertilisers. Why do farmers add them to crops? Which salts do plants require? Students then make a soluble salt – ammonium sulfate – that is used as a fertiliser. If time allows, they use information from the Student book and/or the Internet to create a poster to show why plants need nitrogen, phosphorus, and potassium minerals.

Activities

- Ask students why farmers add fertilisers to crops. Elicit that they may use natural fertilisers, such as manure and compost, and synthetic fertilisers, such as ammonium compounds.
- **Practical activity:** Students follow the instructions on **worksheet 8.4.1** to make a fertiliser salt, ammonium sulfate. The salt is soluble in water, and so are the compounds it is made from. This means that it is not possible to filter off an excess of one reactant. Instead, students will detect the end of the reaction by smelling when ammonia is present in excess, and by then removing a small sample and checking it is alkaline.
- Students use information from pages 110–111 of the Student book, or the Internet, to create a poster to show why plants need nitrogen, phosphorus, and potassium minerals.

Homework

Workbook page 48

Key words

salt, fertiliser, plants, ammonia, nitrogen, phosphorous, potassium

Student book, pages 114–115

CD resources
- Worksheet 9.1.1
- Worksheet 9.1.2

Objective

- Understand how to follow the rate of reaction that produces a gas

Overview

This lesson introduces rates of reaction. The first activity asks students to consider why reaction rate is important, and to give examples of slow and fast reactions. The main activity of the lesson is a practical, in which students follow the reaction of dilute hydrochloric acid with magnesium. Students then plot graphs to show the progress of the reaction, and finish by interpreting these.

Activities

- Student pairs give examples of fast and slow reactions, and consider why chemists might want to change the rate of a reaction. Read page 114-115 of the Student book.
- **Practical activity:** Students follow the reaction of dilute hydrochloric acid with magnesium by measuring the volume of hydrogen gas made every 10 seconds. They record their results in a table. **Worksheet 9.1.1** supports this activity.
- Students use the guidance on **worksheet 9.1.2** to plot a line graph of gas volume against time. They then answer questions to help them interpret the graph – they are likely to need help with this task. The graph shows that the reaction is fastest at the beginning. The rate gradually falls as the magnesium is used up. The reaction finishes when all the magnesium is used up. This is shown by the horizontal section of the graph.

Homework

Workbook page 49

Key words

reaction rate, patterns, collisions

Student book, pages 116–117

CD resources
- Worksheet 9.2.1
- Worksheet 9.2.2
- Worksheet 9.2.3

Objective
- Describe and explain how concentration affects reaction rate

Overview
In this lesson students consider factors that affect reaction rates. They then investigate one of these factors, the concentration of solution. The reaction chosen is the same as that in lesson 9.1, so as to make it possible for students to devise their own investigation. Having planned and carried out their investigation, students draw a graph and write a conclusion. They then consider the approach and note down suggestions for reducing error and obtaining more reliable results. Finally, student use a model to explain why increasing concentration increases rate.

Activities
- Lead a discussion to elicit factors that may have changed the rate of the reaction studied in lesson 9.1. Students might suggest acid concentration, temperature, or size of magnesium pieces. Adding a catalyst might also change its rate, although students are unlikely to suggest this.
- Students follow the guidance on **worksheet 9.2.1** to design an investigation to study the effect of concentration on reaction rate. They then carry out their investigations.
- Students use their data to plot a line graph and write a conclusion for their investigation. The higher the acid concentration, the faster the reaction. Students consider how to reduce error and obtain more reliable results. They could do this by repeating the investigation three times at each concentration, and calculating the mean. **Worksheet 9.2.2** supports this activity.
- **Practical activity:** Pairs use uncooked rice and beans, and pieces of cardboard, to model the reaction and to help them explain why increasing concentration increases rate. **Worksheet 9.2.3** supports this activity.

Homework
Workbook page 50

Key words
reaction rate, concentration, correlation, evidence

Student book, pages 118–119

CD resources

- Worksheet 9.3.1
- Worksheet 9.3.2

Objective

- Describe and explain how temperature affects reaction rate

Overview

In this lesson students investigate the effect of temperature on the rate of the reaction of sodium thiosulfate with hydrochloric acid. Having obtained, presented and considered their evidence, extension students suggest how they could investigate the effect of temperature on the rate of another reaction. The lesson finishes with modelling an explanation for the findings of the lesson – at higher temperatures, particles move faster. This makes them collide more frequently, and increases the number of successful collisions in a given time.

Activities

- Ask students whether potatoes/cassava cook faster in boiling oil or in boiling water. Elicit that the reason for quicker cooking in boiling oil is that its temperature is higher.
- **Practical activity:** Students carry out an investigation to study the effect of temperature on reaction rate. Students must work in a well-ventilated room, and wear eye protection. **Worksheet 9.3.1** supports this activity.
- Students use their data to plot a line graph to display their results. Part 1 of **worksheet 9.3.2** supports this activity.
- Students make a human model to explain the findings of the lesson. Half the students take roles of particles from sodium thiosulfate solution, the other students are particles from hydrochloric acid. Students move around. At ‘low temperatures’ they move slowly. Their collisions are infrequent. At ‘higher temperatures’ they move faster. Their collisions are more frequent. The reaction is faster. Read page 119 of the Student book.
- Students complete Part 2 of **worksheet 9.3.2**.

Extension

Students plan how to investigate the effect of temperature on the reaction rate of hydrochloric acid and magnesium. They do not carry out this practical.

Homework

Workbook page 51

Key words

reaction rate, temperature

Student book, pages 120–121

CD resource

- Worksheet 9.4.1

Objective

- Describe and explain how surface area affects reaction rate

Overview

This lesson shows how surface area affects reaction rate. It starts with a dramatic demonstration, either in the lab or as a video clip. Students then watch a demonstration of the effect of increasing surface area on the rate of reaction of calcium carbonate with dilute hydrochloric acid. They record the results and draw a bar chart. Finally, students draw diagrams to explain the results using ideas about colliding particles.

Activities

- Use a Bunsen burner to try to set fire to a small pile of cornflour (very fine maize flour). Then show the impact of increasing surface area – either as a video clip (search YouTube for *flour explosion the Barton special)* or by performing the demonstration shown on the video clip yourself.
- Demonstrate the effect of increasing surface area on the rate of the reaction of calcium carbonate with dilute hydrochloric acid, following the procedure on **worksheet 9.4.1**. This can be tackled as a class practical if you have enough balances.
- Students follow the guidance on **worksheet 9.4.1**, and use information from pages 120–121 of the Student book, to write a conclusion for the investigation. This should include diagrams to explain the results using ideas about colliding particles.

Extension

Students devise an investigation to find out about the effect of increasing surface area on the reaction of hydrochloric acid with magnesium.

Homework

Workbook page 52

Key words

reaction rate, surface area, predictions, evidence

Student book, pages 122–123

CD resources
- Worksheet 9.5.1
- Worksheet 9.5.2

Objective

- Describe and explain how catalysts affects reaction rate

Overview

The lesson begins with a review of learning so far – what factors affect reaction rate? There is then a short demonstration to show students the effect of adding liver to hydrogen peroxide. Students then investigate the effectiveness of other catalysts in speeding up the decomposition of hydrogen peroxide solution, and draw a bar chart to display their results. The lesson ends with a research task on catalysts, and the creation of posters to display findings.

Activities

- Briefly review learning on reaction rates by asking students what factors affect reaction rate. Tell students that they will now investigate one final factor – catalysts. Demonstrate adding a small piece of sheep or chicken liver to 2.5 vol hydrogen peroxide solution. Bubbles of oxygen gas, which relight a glowing splint, are produced. By the end of the lesson students should be able to explain their observations.
- **Practical activity:** Students investigate the effectiveness of different catalysts in speeding up the decomposition of hydrogen peroxide solution. **Worksheet 9.5.1** supports this activity. They present their results on bar charts. Parts 1 and 2 of **worksheet 9.5.2** support this activity.
- Go back to the liver demonstration. Elicit an explanation for the observations – a substance in liver (catalase) has speeded up the decomposition reaction of hydrogen peroxide. Explain that catalase is an enzyme. Enzymes are a type of natural catalyst found in most cells.
- Students research uses for catalysts, and make posters to display their findings. Part 3 of **worksheet 9.5.2** supports this activity.

Homework

Workbook page 53

Key words

catalyst, enzyme, reaction rate

Student book, pages 126–127

CD resources

- Worksheet 10.1.1
- Worksheet 10.1.2
- Worksheet 10.1.3
- How does sound travel presentation

Objectives

- Describe how sound waves are produced
- Explain how sound waves travel

Overview

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 slinky spring as a model of a sound wave. This work will link to the particle model, which is needed to explain how sound travels and why it doesn't travel through a vacuum. In lessons 10.4 and 10.5 they will build on what they have learned in the circus of activities in this lesson.

Activities

- Students make a list of five different sounds that they have heard that day, and what makes those sounds. Elicit that the common feature is that something is vibrating. If they gently touch their throat while they are speaking they should feel vibration.
- Students complete a circus of activities looking at different ways of making a sound using **worksheet 10.1.1**. In each case they note what is vibrating and how different objects change the sound produced (pitch and loudness will be covered in later lessons). **Worksheet 10.1.2** supports this activity.
- Introduce the ideas 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 vacuum by removing the air from a bell jar containing a ringing bell.
- Students use **worksheet 10.1.3** to consolidate ideas about sound travelling through different materials.

Extension

Students use a slinky to make longitudinal and transverse waves.

Homework

Workbook page 54

Key words

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

Student book, pages 128–129

CD resources
- Worksheet 10.2.1
- Worksheet 10.2.2
- Worksheet 10.2.3

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 that structure 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 you see, 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 on **worksheet 10.2.1** and colour code it to show the inner, middle, and outer ear. Then the students should work out the order in which a sound wave reaches parts of the ear using **worksheet 10.2.2**.
- Students read about how hearing can become damaged in the Student book pages 128–129. They annotate the diagram on **worksheet 10.2.1** to show the different ways that your hearing can change. This could mean that they write the possible damage next to the part of the ear, or that they 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 from the Internet). 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 by completing **worksheet 10.2.3**.

Homework
Workbook page 55

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

Student book, pages 130–131

CD resources
- Worksheet 10.3.1
- Worksheet 10.3.2
- Worksheet 10.3.3
- Worksheet 10.3.4
- Worksheet 10.3.5

Objectives
- Know how we measure sound intensity or loudness
- Describe some of the risks of loud sounds and how to reduce the risks

Overview
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 meter. They learn about how loud sounds can damage hearing and how to reduce the risk of that damage. This lesson links what they have learned about the ear to what they will learn next lesson about amplitude and how sound is displayed on an oscilloscope.

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 use page 130 of the Student book and **worksheet 10.3.1** to make a decibel scale.
- Students investigate the sound level in and around the classroom or other parts of the school using **worksheet 10.3.2**. They display the results and interpret them using the decibel scale that they made on **worksheet 10.3.1** and **worksheet 10.3.3**.
- Students may be surprised to know that listening to music on earphones can be damaging to their hearing. Studies have shown that there is a big increase in risk of hearing loss by so doing. Use this example to introduce the idea of the 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. **Worksheet 10.3.4** supports this activity.
- Students analyse the results of their experiment using **worksheet 10.3.5**. Ask groups to come up with two ways that they could improve the test, and feedback those ideas to the class.

Homework
Workbook page 56

Key words
noise, intensity, sound meter, decibel, risk, probability, consequence, shield, ear defenders

Student book, pages 132–133

CD resources
- Worksheet 10.4.1
- Worksheet 10.4.2
- Worksheet 10.4.3
- Amplitude presentation

Objectives
- Know the properties of waves
- Understand what affects the loudness of a sound
- Interpret waveforms shown on an oscilloscope

Overview
Students learn about the properties of waves and how they can be shown on an oscilloscope. They build on what they learned in lesson 10.1 about how you can change sounds, and link the change in amplitude to a change in loudness. They investigate the impact of putting a box under an elastic band, and whether that increases the loudness of the sound. 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 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 the base of it 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 on **worksheet 10.4.1** 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. **Worksheet 10.4.2** supports this activity. Discuss the results. The box will amplify the sound, just like an amplifier that is used at a music concert.
- Students make a simple game to demonstrate their understanding of the waveforms on an oscilloscope using **worksheet 10.4.3**. 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.

Homework
Workbook page 57

Key words
properties, wavelength, amplitude, frequency, oscilloscope, amplifier

Student book, pages 134–135

CD resources
- Worksheet 10.5.1
- Worksheet 10.5.2
- Pitch and frequency presentation
- Harmonics presentation

Objectives

- Describe the link between pitch and frequency
- Know the range of hearing in humans
- Describe differences between the range of hearing in humans and in animals
- Know why musical instruments are distinct

Overview

Students will know that some sounds are high and some are low and this lesson establishes the link between pitch and frequency. Students learn that changing the frequency is distinct from changing the amplitude of a sound. Students 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 and are called ultrasound. This links to what they will learn in lesson 10.7 on echoes and their uses.

Activities

- Discuss the results of the experiments in lesson 10.1. Elicit what is meant by 'high' and 'low' notes, and how this 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 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. **Worksheet 10.5.1** supports this activity. 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 look at the range of hearing in other animals on page 135 of the Student book and compare the hearing ranges. 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 from lesson 10.1.
- Record the same note on several instruments and play them to the class. Ask them to identify the instruments. Use Audacity (free software available to download) to show the timbre of different musical instruments. Play the same note on lots of different 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. Discuss why different instruments sound so distinct.
- Students consolidate what they have learned about frequency, pitch, and how waves are represented on a screen using **worksheet 10.5.2**.

Homework

Workbook page 58

Key words

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

Student book, pages 136–137

CD resources
- Worksheet 10.6.1
- Worksheet 10.6.2
- Worksheet 10.6.3

Objective

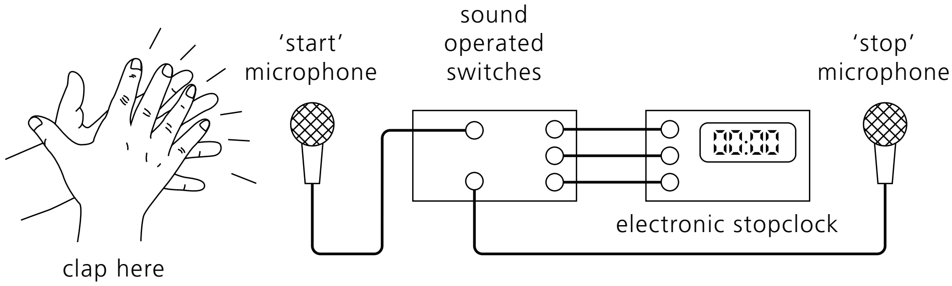
- Make calculations involving the speed of sound

Overview

In this lesson students explore the reflection of echoes to measure the speed of sound. This links to what they have learned about the speed of light and the reflection of light in International secondary science 1. They consider how to make accurate measurements by timing lots of echoes and dividing by the number, rather than timing one echo.

Activities

- Introduce the idea of the reflection of sound by discussing where you might hear echoes, and where you might hear particularly clear echoes.
- Students investigate the reflection of sound from a hard surface using the instructions on **worksheet 10.6.1**.
- Discuss what the fact that we hear echoes tells us about the speed of sound. Students carry out an experiment to measure the speed of sound using the instructions on **worksheet 10.6.2**. Students analyse their results to find the speed of sound.
- Alternatively demonstrate the measurement of the speed of sound using two microphones and a timer.



- Show pictures of thunder and lightning. Elicit that the speed of sound is much less than the speed of light, so we can use this distance to work out how far away things are. This was one of the original methods for measuring the speed of sound. Students explore this idea and practice calculations by completing **worksheet 10.6.3**. They compare methods of measuring the speed of sound for accuracy.

Extension

Students research the history of supersonic travel and produce a poster.

Homework

Workbook page 59

Key words

echo, accurate, supersonic, Mach

Student book, pages 138–139

CD resources

- Worksheet 10.7.1
- Worksheet 10.7.2
- Worksheet 10.7.3
- Sonar presentation
- Ultrasound presentation

Objectives

- Describe how echoes are formed
- Explain how echoes can be used

Overview

In this lesson students learn about the uses of echoes, and some of the problems that occur because of them. They investigate how sound can be absorbed to reduce reverberation. They find out how people and animals use sound to locate things like food. They look at information from research into ultrasound and produce a leaflet explaining what an ultrasound scan is.

Activities

- Recap that echoes are reflections of sound. Discuss places where you would not want to have echoes/reverberation. Show pictures of the insides of cinemas and theatres. Students work out the best material for absorbing sounds using **worksheet 10.7.1**. Make a table of results for the class. Discuss why the best material absorbs most sound.
- Students consider how animals and humans use sound. They should read p138–139 of the Student book to find out more about sonar and echolocation and make a poster that compares bats catching their food with humans using sonar. They should think about the impact of the speed of sound in different media and the types of transmitter and receiver that are used when comparing them.
- There are lots of uses of ultrasound in hospitals. Students consider information about the repeated use of ultrasound scans and write a leaflet. **Worksheet 10.7.2** supports this activity. **Worksheet 10.7.3** contains further information about research into the effect of ultrasound on children's development.

Homework

Workbook page 60

Key words

reverberation, sonar, transmitter, receiver, echolocation

Student book, pages 142–143

CD resources
- Worksheet 11.1.1
- Worksheet 11.1.2
- Worksheet 11.1.3

Objectives
- Describe the properties of magnets
- Know what magnetic materials are

Overview
Students will be familiar with magnets. This lesson recaps what they know about repulsion and attraction, and magnetic materials. Students investigate magnetic materials and magnetise a needle, and make a compass. This will be developed in the next lesson when students learn about the Earth's magnetic field. As an extension introduce students to the domain theory as a model to explaining how and why magnetic materials can be magnetised.

Activities
- Revise what was learned at earlier with a quiz. Students each write three questions with answers from what they remember about magnets. Use their questions to make a quiz for the whole class. Show the students lodestone, if available, and talk about the origins of the discovery of magnetism.
- Students explore magnets and magnetic materials using **worksheet 11.1.1**. Discuss what they found out. Elicit that magnetism is a non-contact force, that magnets repel and attract, and you can only tell if something is a magnet if it repels another magnet. Add cobalt and nickel to their list of magnetic materials if these were not available. Introduce the idea of soft and hard magnetic materials, which will be needed for lesson 11.3 on electromagnets.
- Students make a compass by stroking a steel needle with a magnet using **worksheet 11.1.2**. Students will need to know which direction is north. Discuss, or demonstrate, methods of demagnetising materials.
- Students consolidate what they have learned in the lesson by writing a 'Did you know?' factsheet about magnets and magnetic materials and completing **worksheet 11.1.3**.

Extension
Ask why some materials are magnetic but others are not. Introduce the idea of domains using diagrams, and ask students to explain what they think will happen if you stroke a piece of un-magnetised magnetic material with a magnet.

Students investigate domain theory and use it to explain what would happen if you broke a magnet in two.

Homework
Workbook page 61

Key words
lodestone, non-contact, north pole, south pole, nickel, cobalt, elements, oxides, magnetised, demagnetised, domains

Student book, pages 144–145

CD resources

- Worksheet 11.2.1
- Worksheet 11.2.2
- Worksheet 11.2.3

Objectives

- Know what a magnetic field is
- Explain why compasses point north
- Describe how you can find the shape of a magnetic field around a bar magnet

Overview

In this lesson students learn about the magnetic field around a bar magnet, and the concept of a field as regions in space where something experiences a force. This can be linked to what they learned about gravitational fields in lesson 1.4 Gravity. They find out about the shape of the field using iron filings and plotting compasses and learn about the neutral point. They learn that we use magnetic field lines to represent magnetic fields, and what they represent. Finally they learn about the Earth's magnetic field and link it to the compass that they made last lesson.

Activities

- Students recap what they learned last lesson about the attraction and repulsion of magnetic materials. Introduce the idea of a magnetic field, and link it to gravity.
- Students investigate the field around a bar magnet, two magnets that are attracting and two magnets that are repelling. They should be able to indicate the neutral point. Discuss their drawings and how we represent a field. Introduce magnetic field lines as a model for representing magnetic fields. Discuss the conventions (arrows, the direction, the density indicating strength). Students draw the magnetic fields from their experiment using magnetic field lines. **Worksheet 11.2.1** supports this activity.
- Students investigate which materials block the magnetic field of a magnet using **worksheet 11.2.2**. They learn that magnetic materials block the magnetic field of a magnet, and that this is another method of working out which materials are magnetic.
- Recap the experiment to make a compass from last lesson. Elicit that the compass needle must be made of a magnet or magnetic material. Students make a model of the Earth's magnetic field using **worksheet 11.2.3**. Discuss the way that they made it, particularly that the south pole has to be at the north. Discuss the difference between magnetic north and geographic north.

Extension

Students answer the extension question on **worksheet 11.2.2**. Students find out how scientists think the magnetic field of the Earth is formed.

Homework

Workbook page 62

Key words

magnetic field, neutral point, magnetic field lines

Student book, pages 146–147

CD resources
- Worksheet 11.3.1
- Worksheet 11.3.2

Objectives
- Describe how to make an electromagnet
- Describe how to change the strength of an electromagnet

Overview
In this lesson students learn how to make an electromagnet. They start by investigating the magnetic field around a single wire, and then build an electromagnet. This lesson links to the previous lesson as students use what they learnt about investigating magnetic fields by investigating the magnetic field around an electromagnet. In the next lesson students will investigate the factors affecting the strength of an electromagnet in more detail.

Activities
- Students discuss the places where it might be helpful if you could turn a magnet on and off.
- Students investigate the magnetic field around a single wire using a plotting compass and iron filings. They find out what happens when the direction of the current is reversed and what happens when you use several loops of wire. **Worksheet 11.3.1** supports this activity. Discuss how you can make an electromagnet that would act like a bar magnet.
- Students make a simple electromagnet by wrapping a piece of insulated wire around a nail using **worksheet 11.3.2** as a guide. They investigate the magnetic field around the electromagnet using a plotting compass and iron filings and compare the strength of the electromagnet with the strength of the bar magnet.
- Students brainstorm ideas for testing the strength of the electromagnet in preparation for next lesson.

Extension
Students investigate how commercial electromagnets are constructed.

Homework
Workbook page 63

Key words
electromagnet, core

Student book, pages 148–149

CD resources
- Worksheet 11.4.1
- Worksheet 11.4.2

Objectives

- Describe the difference between dependent and independent variables
- Show that you have controlled variables in an investigation

Overview

This lesson is about variables. Students use the context of an electromagnet to learn about dependent and independent variables. They decide which variables to investigate and how to control the other variables.

Activities

- Students complete a card sort to remind them how to plan an investigation in pairs. They compare their order with other groups. Discuss whether there is a 'definitive' order. **Worksheet 11.4.1** supports this activity.
- Set them the task of completing an investigation into the strength of electromagnets. The key idea is to present their results in a way that shows very clearly:
  - which is the independent variable
  - which is the dependent variable
  - how the other variables were controlled.
- Students complete their investigations and prepare a presentation for the rest of the class. **Worksheet 11.4.2** supports this activity.
- Students evaluate each other's methods and presentations and produce a checklist to help them when they do an investigation in the future.

Homework

Workbook page 64

Key words

dependent variable, independent variable

Student book, pages 150–151

CD resources

- Worksheet 11.5.1
- Worksheet 11.5.2
- Worksheet 11.5.3

Objectives

- Describe some uses of electromagnets
- Explain why electromagnets are used instead of permanent magnets

Overview

This lesson introduces students to some of the wide range of uses of electromagnets. The first activity asks them to design and make a very simple device: a relay. This is an opportunity to consolidate their knowledge about electromagnets and magnetic materials by asking them to explain how it works. They use what they know about electromagnets to explain how an electric bell works. They summarise what they have learnt by making a table of all the different uses of electromagnets.

Activities

- Students make a simple relay using a coil of wire using **worksheet 11.5.1** as a guide. Set students the challenge to turn on one circuit using a magnet, then to use an electromagnet to make a switch close. Discuss the possible uses of this kind of circuit and how it is more useful to use an electromagnet to switch on circuits remotely than using a permanent magnet.
- Students use what they know about electromagnetism to design a mechanism that keeps fire doors open. **Worksheet 11.5.2** supports this activity.
- Give students a picture of an electric bell. Students use the diagram and what they know about electromagnets to explain how the bell works using **worksheet 11.5.3**.
- Show pictures of MRI scans and briefly discuss how they are made. Discuss the pros of cons of MRI scans and X-rays.
- Students make a table of the uses of electromagnets that they have seen in the lesson. In each case they explain why electromagnets are used rather than permanent magnets.

Homework

Workbook page 65

Key words

relay, reed switch, armature, magnetic resonance imaging (MRI) scanner

Student book, pages 154–155

CD resources
- Worksheet 12.1.1
- Worksheet 12.1.2
- Worksheet 12.1.3
- Measuring pressure presentation

Objectives

- Explain the difference between weight and pressure
- Be able to calculate pressure

Overview

In this lesson students learn about the idea of pressure, and how to calculate it. They look at situations where it is advantageous to spread a force out over a large area. This links to the next lesson where they will look in more detail at the situations where you need the pressure to be small *and* large. In the first two experiments they calculate the pressure that they exert, and that a block of wood exerts. Finally they complete another experiment making indentations in soft materials to work out forces and areas using the pressure equation. Students may need support with conversions between units of mass and working out weight.

Students could also be asked to prepare material about how scientists work ready for lesson 12.10 – see lesson plan for that lesson.

Activities

- Show pictures of birds feet, camels feet, and an earth mover and ask students for the connection between them. Elicit that the area in contact with the ground is large so that they do not sink.
- Introduce the concept of a force being spread out over a particular area and that we call that pressure. Discuss what you might measure pressure in, and show students how to calculate it using the pressure equation. Discuss the fact that the units of pressure will depend on the units of area. Students practise using the equation using **worksheet 12.1.1**.
- Students explore the idea of pressure in two experiments using **worksheet 12.1.2**. In the first experiment they calculate the pressure that they exert on the ground when they are standing on one foot and then two. In the second experiment they calculate the pressure when a brick is placed on a desk on sides of different area. Discuss the results, and their suggestions for demonstrating the difference in pressure. Elicit/suggest putting the brick on a surface that is easily deformed, like mud.
- Students complete a further experiment into pressure using plasticine or a similar material. They estimate the pressure needed to make an indentation in the plasticine and use that number to estimate the weight or area of other object that would be needed to produce a similar indentation. **Worksheet 12.1.3** supports this activity.

Homework

Workbook page 66

Key words

pressure, force, area, newtons per metre squared, newtons per centimetre squared

Student book, pages 156–157

CD resources
- Worksheet 12.2.1
- Worksheet 12.2.2

Objectives

- Apply ideas of pressure to a range of situations
- Be able to calculate pressure

Overview

In this lesson students apply what they have learned about pressure in the previous lesson in a variety of situations. They complete an investigation based on a bed of nails to show how a bed of nails spreads the force over a large area. They use what they have learned to think about the design of footwear for soft surfaces that use studs, spreading force over a big area in terms of animals' feet and quicksand.

Activities

- Show pictures of people lying or sitting on a bed of nails. Tell students that it doesn't hurt and ask why. Elicit that the force (weight) is being spread out over a large area.
- Students design an experiment to find the effect of using lots of nails using **worksheet 12.2.1** and present their results in a graph. They use their results to predict the effect of having very large numbers of nails, such as in a bed of nails. You may need to steer students to producing a cylinder about the same size as an inflated balloon. They put the boards with nails pointing up at the bottom, then the balloon, then the piece of card/thin wood with the masses on top. Alternatively students could design an experiment to show the link between force, area, and pressure. This could involve measuring the depth that blocks of different area and weight make in a soft material, like dough.
- There are situations where we want a large pressure, and places where we want the pressure to be small. Students think of a variety of examples and give reasons for their answers.
- They investigate the design of boots with studs and animal feet size and walking on quicksand using **worksheet 12.2.2**.

Extension

Students work out the pressure required to burst the balloon in each of their experiments and comment on their answer in the extension questions on **worksheet 12.2.1**.

Homework

Workbook page 67

Key words

pressure, force, area

Student book, pages 158–159

CD resources
- Worksheet 12.3.1
- Worksheet 12.3.2
- Pressure in liquids presentation

Objectives
- Explain what is meant by liquid pressure
- Describe what determines the pressure in a liquid

Overview
In this lesson students investigate the pressure in liquids and how it varies with depth. They learn about the force of a liquid acting in all directions and link the pressure in liquids to the incompressibility of liquids. How liquid pressure relates to these things will be explored further in the next lesson on using hydraulic machines. Students learn about the effect of liquid pressure on divers and how divers deal with liquid pressure effectively. They learn how to measure pressure with a pressure gauge.

Activities
- Hold a plastic bag full of water over a big bowl. Ask students to draw what they think will happen if you make a hole in the bag. Demonstrate that the water leaves the bag in a direction that is at right angles to the side of the bag. Make holes all over the bag to show that this is always the case. Make sure that you have a big enough bowl or tray to catch the water.
- Discuss how pressure might vary with depth. Ask students what impact that might have on the design of a dam, or for submarines and other vessels that go deep in the ocean. Show pictures of a cross section of a dam, and a submarine or similar vessel.
- Students investigate how pressure varies with depth using a large plastic bottle with a hole at the bottom. They learn about how it is important to repeat experiments where it is difficult to take reliable readings, as in this case. **Worksheet 12.3.1** supports this activity. Students could be asked to present their finding to the class, and explain the measures they took to get accurate results, and their choice of graph. Elicit the link between liquid pressure produced by the weight of water above the hole, and depth as demonstrated in the experiment.
- Students read the section on page 159 of the Student book about the bends. Demonstrate the Cartesian diver (available online *http://www.exploratorium.edu/snacks/condiment_diver/* or *http://www.physics.org/tricks/cartesian-diver/*). Show how an increase in pressure in the liquid compresses the gas inside the diver so that he sinks (this will be explored more next lesson). Take a large transparent bottle of carbonated water or soda. Shake the bottle and show that there are no bubbles. Release the lid partially and then screw it back on. Lots of bubbles will form. Take another bottle and repeat but this time release the pressure very slowly so that bubbles are not produced. Ask students to use those demonstrations to explain the bends using **worksheet 12.3.2**.

Extension
- Students could work out how the demonstrations link to diving before reading the section in the book.
- Find out how a decompression chamber works, and how divers can use it to avoid getting ‘the bends’.

Homework
Workbook page 68

Key words
compressed, incompressible, upthrust, liquid pressure, the bends, pressure gauge

Student book, pages 160–161

CD resources
- Worksheet 12.4.1
- Worksheet 12.4.2

Objectives

- Explain how hydraulic machines work
- Describe some uses of hydraulic machines

Overview

Students learned about the incompressibility of liquids last lesson. In this lesson they will use what they have learned last lesson and in lesson 12.1 to work out how hydraulic machines work. Students may think that you get something for nothing with a hydraulic machine. Emphasise that although the force is bigger the distance through which the force moves is less (by the same proportion). This is the first time that students will have considered simple machines. They will meet the lever in lesson 12.11.

Activities

- Give students sealed syringes of water (melt the end of a plastic syringe to seal it) and ask them to try to compress the water.
- Use the incompressibility of water to introduce the idea of a hydraulic machine. Demonstrate the syringes the students will use in the practical. Students investigate a simple hydraulic machine using **worksheet 12.4.1**. This will require careful explanation before the students start. The idea is that the students should get a feel for the fact that you need to apply a small force to a syringe with a small area to balance a big force acting on a big area.
- Discuss what students have found out in the practical and introduce the idea of the hydraulic machine as a force multiplier. Students can use their equipment to compare the distance moved by each syringe to see that it does not move so far.
- Show an appropriate animation to show how a hydraulic lift works, for example: *http://www.hyjacks.net/animation.htm*
- Students research one use of hydraulics and present it to the rest of the class. Examples include the hydraulic press and hydraulic brakes, but could be extended to include cranes and lifts. **Worksheet 12.4.2** supports this activity. Sheets from the various websites could be provided if no Internet access is available.

Extension

Students use the masses and areas to calculate the weight and pressure on each syringe to show that it is equal in question 4 on **worksheet 12.4.1**.

Homework

Workbook page 69

Key words

hydraulic machine, incompressible, force multiplier, hydraulic brakes

Student book, pages 162–163

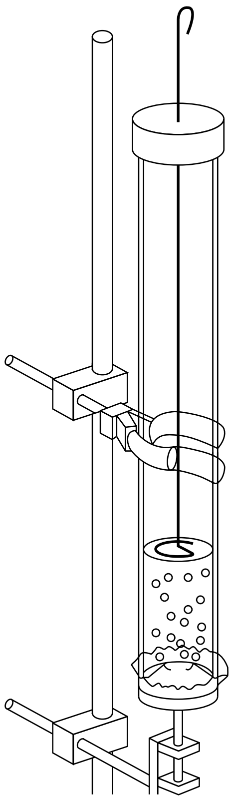
CD resources
- Worksheet 12.5.1
- Worksheet 12.5.2

Objectives
- Explain what is meant by gas pressure
- Explain the link between pressure and volume

Overview
In this lesson students learn about the way that a gas exerts a pressure on the walls of a container because the gas molecules collide with them. They learn about how the pressure changes with volume and link that with the behaviour of gas molecules. They learn about atmospheric pressure and explain some effects of atmospheric pressure. In the extension lesson that follows they will consider the macroscopic properties of pressure, volume, and temperature and how that links to the microscopic behaviour of gas molecules.

Activities
- Heat approximately 2 cm of water in a conical flask until it boils. Turn off the Bunsen burner and then place a hard-boiled egg (shell removed) into the neck of the flask.
  As the water vapour cools back to liquid the air pressure on the egg from outside will be greater than from inside and the egg will appear to be sucked in whole. Use this to stimulate discussions of pressure. Explain what is happening in terms of particles using a suitable animation. Discuss how gases produce pressure because of collisions with the container.
- Students complete an experiment to collapse a can using air pressure with **worksheet 12.5.1**.
- Students explain what happened in the collapsing can experiment by drawing a storyboard of each stage of the experiment. Alternatively they explain what is happening using **worksheet 12.5.2**.
- Use a demonstration with ball bearings in a clear plastic tube with a plastic piston to show the change in the number of collisions.

  Make the diaphragm at the bottom vibrate the tube with the piston at a certain height. Move the piston down and make the diaphragm at the bottom vibrate it again.
- Ask students to describe what happens to the collisions between the molecules and the walls of the container as the volume is decreased. They use words such as more/less/bigger/smaller.
- Demonstrate how you can use a pressure gauge to measure the pressure of a gas. They will be using such a gauge next lesson. Challenge groups to work out what is inside it.



Extension
In the final activity get students to think about the quantitative effect of halving the volume.

Homework
Workbook page 70

Key words
gas pressure, compressed, directly proportional, inversely proportional, atmospheric pressure

Student book, pages 164–165

CD resources
- Worksheet 12.6.1
- Worksheet 12.6.2

Objectives

- Explain the links between pressure, volume, and temperature
- Apply ideas about pressure, volume, and temperature to everyday situations

Overview

In this lesson students take some measurements of the pressure of a gas as the temperature or the volume is changed. They use what they learned about gas pressure in the previous lesson to explain the changes to the pressure in terms of gas molecules. They learn about inverse proportionality.

Activities

- If a refrigerator is available blow up a balloon, seal it, and put it in the refrigerator for the rest of the lesson. Students will look at the balloon at the end of the lesson and explain what they see. Ask them to predict what will happen.
- Demonstrate that the pressure in a gas increases as the volume decreases using the appropriate equipment (Boyle's Law). Students write down pairs of readings and use the data to plot a graph of pressure against volume. They look at the definitions of directly and inversely proportional and decide how to apply the terms to pressure and volumes. Alternatively students use sample data on **worksheet 12.6.1**. This activity could be extended to plotting pressure against 1/volume to get a straight line.
- Students conduct an experiment to measure the change in pressure when the temperature changes. They heat a fixed volume of gas in a flask in a water bath and measure the pressure with a pressure gauge using **worksheet 12.6.2**. They plot graphs and analyse the data in a similar way to the pressure and volume experiment.
- Take the balloon out of the refrigerator and ask students to explain what has happened and to suggest the link between volume and temperature.
- Show a suitable animation that links the microscopic model of a gas with the macroscopic quantities of pressure, volume and temperature. A suitable animation can be found here: *http://phet.colorado.edu/* by searching for 'gas properties'.
- Students could (carefully!) model the changes in pressure/volume by 'being' gas molecules in a people animation of what is happening in the balloon/Boyle's law/flask experiment. Alternatively challenge groups to come up with instructions for another class to make such an animation.

Homework

Workbook page 71

Key words

pressure, volume, temperature

Student book, pages 166–167

CD resource

- Worksheet 12.7.1

Objectives

- Know what is meant by preliminary work
- Understand how preliminary work can be used to plan an investigation

Overview

In this lesson students learn the importance of doing preliminary work. It is a common misconception that preliminary work is doing the entire experiment first, so the purpose of preliminary work needs to be carefully explained.

Activities

- Students read through the Student book pages 166–167 to find out about the different reasons for doing preliminary work.
- They make a list of all the different reasons to do preliminary work.
- Students complete a range of different experiments to work out how to do an experiment into the effect of temperature on the volume of a liquid. They will need to think about how to use the equipment to produce reliable data over a reasonable range. They use **worksheet 12.7.1**.
- You may wish to remind students of work that they have done in chemistry about the expansion of liquids when they are heated, or discuss how thermometers work.
- Students prepare a presentation for the rest the class that shows what preliminary work they did and what they learned from it. They present their ideas to the class.
- Students complete the plan of their investigation, and if time allows, carry out the investigation.

Homework

Workbook page 72

Key word

preliminary work

Student book, pages 168–169

CD resource
- Worksheet 12.8.1

Objectives

- Explain what is meant by density
- Describe how to measure the density of solids, liquids, and gases

Overview

This is first of three lessons on density. In this lesson students focus on the range of methods that can be used to make measurements of mass and volume in order to be able to calculate density. They find the density of a range of solids (fruit and vegetables) and liquids and consider how it might be possible to measure the density of a gas.

Activities

- Introduce the idea of density by showing blocks that are the same size (volume) but have different masses (e.g. metal, wood, glass).
- Recap the units of mass and volume. Introduce density as the ratio of the mass to the volume. Do a simple calculation for one of the blocks. Demonstrate how to measure the volume of the block and use a balance to measure the mass. Discuss all the possible units for density given the possible units for mass and volume.
- Give students measuring cylinders with coloured liquid and ask them to measure the volume by looking upwards at the scale, downwards at the scale and straight at it. Discuss the effect of the meniscus, and how you should measure volume. This can be extended to making accurate measurements with a ruler.
- Give students a fruit or a vegetable and ask them to suggest how they would measure its volume. Elicit that you can measure the volume of an irregular solid using a measuring cylinder or beaker of water.
- Students find the densities of a range of objects using **worksheet 12.8.1**. Students put the fruit and vegetables in order of most dense to least dense before they start, and do the same with the liquids. Make sure that the liquids are presented in containers of different volumes.
- Ask students to think about how you would measure the density of a gas. Students could make an estimate of the mass of air in the room given the density of air.

Homework

Workbook page 73

Key words

density, mass, volume, meniscus

Student book, pages 170–171

CD resources
- Worksheet 12.9.1
- Worksheet 12.9.2

Objectives

- Explain why solids are denser than liquids or gases
- Explain why objects float or sink

Overview

Students build on what they learned about density last lesson by thinking about the reasons why solids have different densities to liquids, and why different solids have different densities. This will build on what they have learned about the arrangements of particles in solids, liquids, and gases in International secondary science 1. They learn about how density is related to floating and sinking, and consolidate what they have learned by making calculations of density to predict whether objects will float or sink.

Activities

- Show students two blocks of metal that are the same size. Recap that if they have different masses then the densities will be different. Students could hold the blocks to work this out. Discuss the reasons why they might have different densities.
- Students model the reasons for different densities with **worksheet 12.9.1**. They learn about the impact of the arrangement of particles and the different masses of particles. Bring out the main reasons for differences in density during a discussion of their results.
- Discuss why things float or sink. Take a fruit with a skin that is not very dense (mandarin oranges work well). Show that it floats in water. Peel it and show that is sinks in water. The peel should float. Ask the students to explain this. Recap upthrust and weight. They should now link weight and mass to density.
- Students complete **worksheet 12.9.2** to investigate floating and sinking and look for a pattern in their results. Discuss the results, and what they think would happen if you put two liquids of different densities in the same beaker.
- Demonstrate that things 'float' at the boundary where they are more dense than the top layer by putting liquids of different densities in a large measuring cylinder and adding different fruit/vegetable/other objects. The experiment can be found here: *http://www.stevespanglerscience.com/experiment/seven-layer-density-column*
- If available demonstrate that lead and other metals will float in mercury. Consult hazard information for the safe use of an open source of mercury.
- As a final challenge ask students to explain the Cartesian diver that you showed them in lesson 12.3 in terms of density.

Extension

Students complete the extension activity on **worksheet 8.9.2**.

Homework

Workbook page 74

Key words

density, float, sink

12.10 Enquiry: questions, evidence, and explanations

Student book, pages 172–173

CD resources
- Worksheet 12.10.1
- Worksheet 12.10.2

Objective

- Understand how scientists worked in the past and how they work now

Overview

In this lesson students learn about Al-Biruni and how he worked as a scientist hundreds of years ago. They examine his method for working out the density of a solid and compare its precision with methods used today. They consider the range of activities in which scientists engage now and how that differs from how they worked in the past. Finally they consider the role of technology in making precise and accurate measurements.

Activities

- Students start by reading about Al-Biruni and the experiments that he did with gemstones on pages 172–173 of the Student book. Discuss the issues with making very precise measurements of density.
- If available show some minerals, and pictures of jewellery with various gemstones in them.
- Students complete an activity to compare the methods of measuring the density of a regularly shaped piece of glass and an irregularly shaped crystal using **worksheet 12.10.1**. In this activity they make a model of Al-Biruni's apparatus for measuring volume and compare it to using other methods.
- Discuss the results that they have obtained, particularly in terms of precision. Groups could present their results and the results collated to show the variation that that there is between the results. Discuss how scientists obtain very precise values of things like density. If available show a range of different balances that measure mass to different degrees of precision. Find the mass of some objects on each balance and discuss the differences.
- Students consolidate their knowledge by looking at the data of various gemstones on **worksheet 12.10.2**.
- Students research how scientists work today, and how that compares to Al-Biruni using sites such as *http://weirdsciencekids.com/WhatDoScientistsDo.html*. They make a poster that describes the similarities and differences between them and how they work today. Alternatively students could be asked to research a scientist from the past and a scientist who works today and prepare a poster that contrasts how they work. Students could do this in preparation for this lesson and present their findings at the end.

Homework

Workbook page 75

Key word

minerals

Student book, pages 174–175

CD resources
- Worksheet 12.11.1
- Worksheet 12.11.2

Objectives

- Describe what a lever is
- Describe how we use levers

Overview

In this lesson students learn about levers and how they can be used to lift loads. They learn about turning forces, effort, load, and pivots, and use levers in a range of situations. They learn about levers as force multipliers and this will be developed when they learn about the law of moments in the next lesson.

Activities

- Ask students how they could lift a heavy stone or make it easier to lift a stone. Alternatively get a student to lift you with a simple seesaw with the pivot near one end. Elicit that there are simple machines that you can use, like levers. Introduce the terminology: load, effort, pivot or fulcrum.
- Students investigate a range of levers in **worksheet 12.11.1**. In each case they describe how the lever is being used and sketch a diagram and label the pivot, load, and effort.
- Students consolidate what they have learned with **worksheet 12.11.2**.
- They can produce a poster showing a range of ways that levers are used in everyday life. Elicit that lots of simple tools are used as levers. Students organise the levers on their poster to reflect whether they are force or distance multipliers. A tray of simple machines could be passed around to provide ideas for their poster.

Homework

Workbook page 76

Key words

pivot, effort, load, lever, turning force, force multiplier, distance multiplier

Student book, pages 176–177

CD resources

- Worksheet 12.12.1
- Worksheet 12.12.2
- Calculating moments presentation

Objectives

- Define the moment of a force
- Use the principle of moments

Overview

Students build on the previous lesson by learning about the moment of a force and the principle of moments. They do an experiment involving balancing a see-saw and deduce the principle of moments.

Activities

- Recap what was learned last lesson in terms of a lever as a force multiplier. Introduce the idea of the moment of a force and its unit. Students measure the force needed to pull open a door with a forcemeter. They measure the distance from the handle to the pivot and calculate the moment of the force.
- Students carry out a practical activity to investigate balancing seesaws. **Worksheet 12.12.1** supports this activity.
- Students balance a metre rule with masses placed on either side of the pivot. The 1 N mass on the left-hand side is moved to balance the rule gradually increasing the mass on the right-hand side which is kept 0.1 m from the pivot. Students record the distance of the 1 N mass on the left-hand side from the pivot when the rule is balanced for each new mass on the ride-hand side. They should notice that the 1 N mass has to be moved further away from the pivot as each mass is added to the right-hand side. As an extension they experiment with different masses at different distances.
- Elicit that the moments must balance and introduce the law of moments including clockwise and anticlockwise moments. Explain that the law enables us to predict whether a see-saw will balance.
- Students consolidate what they know with **worksheet 12.12.2**.

Extension

Complete questions 3 and 4 on **worksheet 12.12.2**.

Homework

Workbook page 77

Key words

moment, equilibrium, principle of moments, clockwise, anticlockwise

12.13 Enquiry: planning

Student book, pages 178–179

CD resources
- Worksheet 12.13.1
- Worksheet 12.13.2

Objectives
- How to plan an investigation
- How to reduce error and collect reliable data

Overview
In this lesson students learn the importance of repeat readings in experiments that involve measuring time. They also learn that in order to plan effectively you need to do preliminary work to find out the appropriate range and number of readings to take. They start by evaluating the plans in the Student book and by carrying out the investigations as suggested. Then they plan their own investigation into the period of a mass on a spring.

Activities
- Students revise what they know about planning investigations by drawing a flow chart of the stages or using the card sort from **worksheet 12.4.1**.
- Give out stop-clocks and get students to see how fast they can turn a stop-clock on and off. Remind them about reaction time and discuss why it is an issue in measuring time intervals.
- Students read the plans of the two students on pages 178–179 of the Student book. Discuss which might be the best method for measuring the period, or if they are the same.
- Students carry out the investigations as described in the book using **worksheet 12.13.1**.
- Discuss any differences that the students found in the methods for measuring time.
- Students then plan and carry out an investigation into the time period of a mass on a spring. Set up a mass on a spring and show how the mass oscillates if it is pulled down. Ask the students to define the period. They plan and carry out the investigation using **worksheet 12.13.2**.
- Ask students to summarise what they have found out about the importance of doing preliminary work. Groups look at the summaries. As a group/class decide on how do preliminary work well (trying a very wide range to work out the best range, working out how many readings you need to be able to plot a good graph).

Homework
Workbook page 78

Key words
period, reaction time, preliminary work

12.14 Extension: centre of mass and stability

Student book, pages 180–181

CD resources
- Worksheet 12.14.1
- Worksheet 12.14.2

Objectives
- State what is meant by the centre of mass (or centre of gravity)
- Explain why some objects topple over easily and others do not

Overview
In this lesson students learn about the concept of centre of mass (or gravity) and how it links to why objects topple. First they learn how to find the centre of mass of an object using a plumb line. They use what they learn about centre of mass and what they learnt about moments in lesson 12.11 and 12.12 to explain why things topple. They link the position of the centre of mass of an object to its tendency to topple if pushed, or to be difficult to topple.

Activities
- Ask students to try to balance a pencil vertically on its end. Establish that is difficult. Elicit that some objects are more stable than other. Take a Bunsen burner and demonstrate how its stability changes when you try to balance it on its base or on the funnel.
- Introduce the idea of the centre of mass (gravity) of an object, and that knowing about the centre of mass can help us to explain why some objects are stable.
- Students find the centre of mass of an irregularly shaped piece of card using a plumb line with **worksheet 12.14.1**. They repeat with a regular piece of card and learn that the centre of mass of regularly shaped objects is in the centre.
- Elicit from discussion that if the card was moved so that the centre of mass was no longer above or below the pivot then there was a turning force that moved the card. Show this with a simple diagram.
- Students investigate the stability of boxes and link stability to the position of the centre of mass using **worksheet 12.14.2**.
- Show a variety of pictures of acrobats making different shapes and ask students which is the most stable.
- Demonstrate that you cannot pick a chair up while you are standing against the wall as shown on page 181 of the Student book and link the difficulty to your centre of gravity.

Homework
Workbook page 79

Key words
centre of mass, centre of gravity, stable

Student book, pages 184–185

CD resources

- Worksheet 13.1.1
- Worksheet 13.1.2
- Worksheet 13.1.3

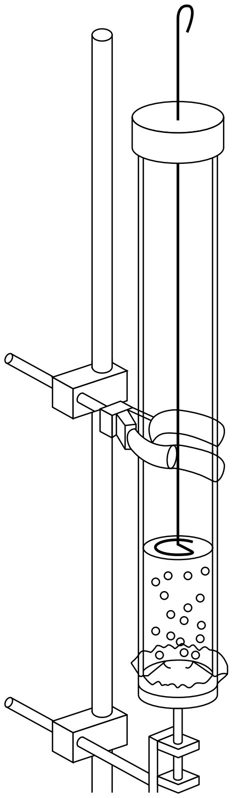
Objectives

- Explain the difference between temperature and thermal energy
- Describe what happens to particles in solids, liquids, and gases when you heat them

Overview

In this lesson students learn the difference between thermal energy and temperature. 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 using **worksheet 13.1.1**. 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 model the particles in a solid, liquid, and gas using **worksheet 13.1.2**.
- Demonstrate the marbles in the tube demonstration. See the diagram to the left.
- Ask students to compare and contrast the models using **worksheet 13.1.3**.

Extension

Students heat a different liquid using the experiment on **worksheet 13.1.1** as a guide.

Homework

Workbook page 80

Key words

thermal image, temperature, thermometer, degrees Celsius (°C), thermal energy

Student book, pages 186–187

CD resource
- Worksheet 13.2.1
- Worksheet 13.2.2
- Conduction animation

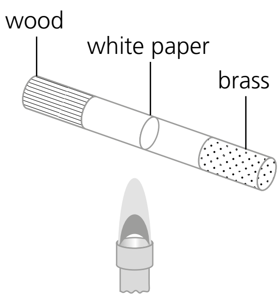
Objectives

- Know the names of some conductors and insulators
- Explain why some materials feel warmer than others

Overview

The lesson introduces students to thermal energy transfer by conduction. They discover that all good conductors are solid and that the best conductors are metals. The mechanism of conduction is linked to particle motion, building on lesson 13.1. 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. (Take care not to set the paper 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 places where it is important to have good conductors. Elicit that good conductors are usually metal.
- Students compare two methods for working out which is the best conductor of thermal energy in **Worksheet 13.2.1**. After the practical bring the class together to collate results. Do the students agree on the order of best to worst conductor? Discuss the reliability of each experiment, and ways that it could be made more reliable.
- Discuss in terms of particles how thermal 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 is transferred along the rod. Ask them how they could demonstrate this in the way that they move.
- Pass around materials that are used to insulate (to keep hot things hot or cold things cold). Elicit that they have pockets that trap air, and 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.

Homework

Workbook page 81

Key word

conduction

Student book, pages 188–189

CD resources

- Worksheet 13.3.1
- Worksheet 13.3.2
- Convection presentation

Objectives

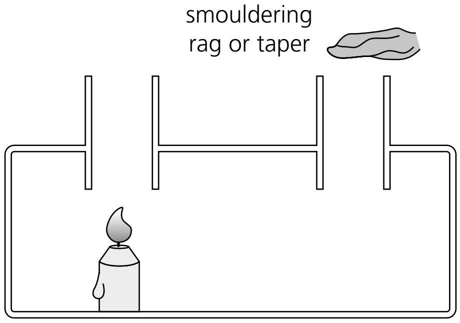
- Describe what happens in convection
- Explain how convection currents are formed

Overview

The lesson introduces students to thermal energy transfer by convection. They observe convection currents in liquids and gases and discover that though liquids and gases do not conduct thermal energy 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 thermal energy transferred by conduction in solids last lesson, but that they learned that liquids and gases are not good conductors. They do an experiment to find out what happens when they heat a liquid using **worksheet 13.3.1**.
- Demonstrate the same effect in air using a box containing a candle and some smoldering paper.



  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 bowl of water: *http://www.thenakedscientists.com/HTML/content/kitchenscience/*. Search for 'wind in a bowl'.
- Students work through **worksheet 13.3.2** to use the idea of density to explain convection.
- Students design a poster that explains how convection keeps a refrigerator cold.
- Return to the video of the birds and gliders and ask students to explain how they work.

Homework

Workbook page 82

Key words

convection, convection current, thermal

Student book, pages 190–191

CD resource

- Worksheet 13.4.1

Objectives

- Know some sources of infrared radiation and the similarities between light and infrared
- Describe how infrared is transmitted, absorbed, and reflected
- Explain what is meant by the greenhouse effect

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 to conduction and convection, and complete an investigation into which material absorbs infrared radiation fastest.

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.
- Students complete an investigation into how different materials absorb infrared using **worksheet 13.4.1**. 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 used by making 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 page 191 of the Student book about the greenhouse effect. They research the greenhouse effect, climate change and global warming using: *www.nasa.gov, http://www.esa.int/esaKIDSen/Earth.html* and produce a leaflet for other students that explains what climate change is, and the link to greenhouse gases and infrared radiation.

Extension

Students complete the Extension activity on **worksheet 13.4.1**, plot graphs, and consider the rate of temperature increase for each material.

Homework

Workbook page 83

Key words

infrared radiation, vacuum, greenhouse gases, greenhouse effect

Student book, pages 192–193

CD resource
- Worksheet 13.5.1

Objectives

- Understand why liquids evaporate
- Describe some uses of cooling by evaporation

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 the average speed. Work through the example on pages 192–193 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, 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 use **worksheet 13.5.1** to 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 192–193 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 84

Key words

evaporation, evaporate, average speed, evaporative coolers, refrigerator, refrigerant

Student book, pages 194–195

CD resource
- Worksheet 13.6.1

Objectives

- Explain the difference between primary and secondary energy sources
- Describe how the world's energy needs have changed and are likely to change in the future
- Explain how to use data critically

Overview

This lesson sets the scene for what students will learn in the next few lessons. It introduces the idea of renewable and non-renewable resources, and that renewable energy does not mean that you can use it again. They learn that power station generators convert primary sources into electricity, a secondary source, and that hydrogen gas is also a secondary source. In lesson 13.11 students will consider how we will meet our energy needs in the future, so in this lesson they learn how global energy demand has changed, and how it varies from country to country. There are a lot of new words to learn in this lesson, but they will meet them again in the following lessons.

Activities

- Students read page 194 of the Student book and make a table of renewable and non-renewable resources. In pairs they make memory cards with the name of each resource on each card, and the same number of cards with renewable/non-renewable written on them. Then shuffle the cards and place them face down. Students take turns to pick two cards. If they match a resource with the correct renewable/non-renewable card they keep them. The winner is the student with the most pairs.
- Discuss the idea of primary and secondary sources and the converters shown in the table. They will look at these sources and converters in more detail in the following lessons.
- Students look at the graph of global energy demand and individually write down three things that they notice from the graph. Then they share their ideas with their partner, and then with others in their group. Each group reports back on the three most striking things about the graph.
- Students analyse data about energy consumption and production, and the use of oil and renewables. Give students the data on **worksheet 13.6.1**. Ask them to present the data in a suitable way and to describe what the data shows. Students could look for other sources of data to check the data that they have been given. Emphasise that all secondary data should be checked.
- Students present their findings to the rest of the class. Each group thinks of a question that they would like to answer while they look at energy resources and generating electricity for the future and make a display of questions that can be revisited in lesson 13.11.

Homework

Workbook page 85

Key words

primary source, secondary source, coal, oil, natural gas, wind, water, biofuels, biomass, geothermal, energy converters, power stations, refineries, hydrogen gas, renewable, non-renewable, exojoule, secondary data, primary data

Student book, pages 196–197

CD resources

- Worksheet 13.7.1
- Worksheet 13.7.2
- Worksheet 13.7.3

Objectives

- Describe how fossil fuels were formed
- Explain how a fossil fuel fired power station works

Overview

In the first half of this lesson students learn how fossil fuels were formed. They produce a piece of work based on their formation and learn why they are called fossil fuels. Students learn how primary sources like fossil fuels are used to produce electricity, a secondary source, in a power station. Finally students look at where the fossil fuel reserves are in their country and consider how much of the electricity that is needed should be generated with fossil fuels. There is a link with Chapter 9 of International Secondary Science 1 when students consider how the landscape must have changed over millions of years.

Activities

- If available show students a lump of coal and a sealed container of crude oil (or 'fake' crude oil). Show them charcoal or charred wood and establish that the coal is effectively carbon, and that crude oil also contains carbon. Ask why they are called 'fossil' fuels. Elicit that they must be millions of years old and that living trees and animals contain carbon.
- Students read about the formation of fossil fuels on page 196–197 of the Student book. They complete an activity to produce a cartoon, poster or poem about the formation of coal, oil, gas or all three using **worksheet 13.7.1**. Alternatively, divide the class into groups and each one produces a short section of a television programme on the formation of each of the fossil fuels.
- Consolidate what they know using **worksheet 13.7.2**.
- Show a suitable animation about how a power station works.
- Students read the Student book and label a diagram of a power station using **worksheet 13.7.3**.
- Provide students with a map showing where fossil fuel reserves are located in the local/national area. Consider how they got there with reference to the rock cycle in Chemistry lesson 9.6 of International Secondary Science 1. Students debate how much of the electricity generation in their country should rely on fossil fuels (link to lesson 13.6)

Homework

Workbook page 86

Key word

coal-fired power station

Student book, pages 198–199

CD resources

- Worksheet 13.8.1
- Worksheet 13.8.2
- Worksheet 13.8.3
- Making electricity presentation

Objectives

- Describe how generators work
- Explain the difference between a simple generator and a power station generator

Overview

The lesson focuses on how electricity is generated in dynamos and generators. It starts by looking at a bicycle dynamo. Students then revise magnetism and electromagnetism before investigating electromagnetic induction. They link what they have learned to large scale power generation, for example in a fossil fuel power station that they learned about last lesson.

Activities

- Start by demonstrating a generator like a dynamo, either on a bicycle and/or a hand-turned model, to light a lamp. Show the effect of pedalling, or turning the handle, faster. Explain that the dynamo generates electricity.
- Elicit from the students that the source of the energy is the chemical energy of the cyclist which provides the input energy (kinetic) for the bicycle dynamo.
- Students revise what they learned about magnets using **worksheet 13.8.1**.
- Students carry out an investigation to produce an electric current using a moving magnet and coil of wire.
- Students use **worksheet 13.8.2** to learn about how to induce a voltage in a coil.
- Discuss the results with the class. It may be useful to have a demonstration set available to reinforce results as you go over it. In particular, demonstrate how to change the size and direction of the induced voltage. They may not have changed the strength of the magnets. Emphasise that something must be **changing** to induce a voltage. This can be achieved by moving the bar magnet, the coil*, or both.*
- Show pictures of the inside of a power station, and emphasize the size and the use of electromagnets. Students consolidate what they have learned using **worksheet 13.8.3**.

Homework

Workbook page 87

Key words

induced, dynamo

13.9 Renewable energy – solar and geothermal

Student book, pages 200–201

CD resources

- Worksheet 13.9.1
- Worksheet 13.9.2
- Solar energy presentation

Objectives

- Describe how the energy from the Sun can be used
- Explain how energy from the Earth can be used to generate electricity

Overview

This is the first of two lessons on renewable energy sources. In this lesson students learn how energy from the Sun can be harnessed to generate electricity or heat water. They learn that although some methods of generating electricity do not produce greenhouse gases while they are operating but greenhouse gases will be generated when they are produced. They investigate solar cells by changing the distance from the lamp to the solar cell and the power of the lamp.

Activities

- Ask students to recall the difference between renewable and non-renewable energy sources in lesson 13.6. Then ask them to name as many renewable energy sources as they can.
- Show pictures of solar cells on roofs. Demonstrate connecting a solar cell to a voltmeter and hold it near a window or source of light. Students investigate solar cells using **worksheet 13.9.1**.
- Discuss findings of the investigations, and how they got reliable results, and made it a fair test. Remind students about efficiency and discuss the efficiency of solar cells and how it has improved.
- Ask students to think about other ways that people could use the energy from the Sun. Show pictures of solar water heating, or demonstrate a solar oven if available. Students consider the practicality of using a solar roadway made of solar cells using **worksheet 13.9.2**
- Ask students to think of observations that you could make that could be explained by the fact that the Earth is very hot in the centre (volcanoes, geysers). Ask how this energy could be harnessed to heat homes or generate electricity using ideas from previous lessons. This can be linked to the lesson about the structure of the Earth in Chapter 9 of International Secondary Science 1.
- Students investigate the energy transfer from 'hot rocks' in **worksheet 13.9.3**. In discussions bring out that the rocks need to be at a much higher temperature to heat water to boiling point.
- Display a map of geothermal power stations such as http://www.stelr.org.au/geothermal-energy/. Emphasise that they do not need to be near plate boundaries to produce significant effects.

Extension

Students work out the relationship between the distance and the output of the solar cell, and the power of the lamp and the output of the solar cell using the Extension section of **worksheet 13.9.1**.

Homework

Workbook page 88

Key words

solar cell, heat pump

13.10 Renewable energy – wind, wave, tidal, hydroelectric

Student book, pages 202–203

CD resources
- Worksheet 13.10.1
- Worksheet 13.10.2
- Worksheet 13.10.3
- Worksheet 13.10.4
- Worksheet 13.10.5
- Worksheet 13.10.6
- Wind energy presentation

Objective

- Describe how wind, waves, tides, and water behind dams can be used to generate electricity

Overview

This is the second lesson on renewable energy sources. Students learn about the various methods that can be used to generate electricity using wind and water. They start by using a simple motor (as a generator) to make a model of a wind turbine. Groups then research each of the following methods of generating electricity: off-shore wind farms, tidal energy, wave energy, hydroelectric energy.

Activities

- Recap how a simple dynamo works from lesson 10.8. Demonstrate how a simple motor can be connected to a voltmeter to produce a voltage when you spin it. (Do not discuss the workings of a motor at this stage).
- Students use the motor and voltmeter to model a simple wind turbine using **worksheet 13.10.1**. They investigate how the number of blades or angle of the blades affects the voltage produced.
- Discuss the findings of the groups. Show pictures of wind turbines and ask whether the results that they obtained agree with the designs of real turbines. Ask them to suggest what the reasons might be for the differences.
- Discuss the ways that the same principle that they have used to generate electricity from the motion of the air might be used to generate electricity from the motion of water (tides, waves) and introduce the idea of hydroelectricity. Divide the class into groups and assign a different to each group. Each group uses one of **worksheet 13.10.2–5**, the book (and websites if available) to research the way that electricity is generated and the advantages and disadvantages of the method. They produce a leaflet and prepare a short presentation.
- Students use the material from last lesson to complete the table for solar energy and geothermal energy using **worksheet 13.10.6**.

Homework

Workbook page 89

Key words

reservoir, wind power, wave power, tidal power

Student book, pages 204–205

CD resources
- Worksheet 13.11.1
- Worksheet 13.11.2
- Worksheet 13.11.3
- Worksheet 13.11.4
- Worksheet 13.11.5

Objective

- Describe the some of the issues in providing energy for the future

Overview

In this lesson students think about the issues of generating electricity and transportation in the future given that fossil fuels are running out. They learn about payback time and economic as well as environmental considerations. They consider the use of renewables, including biofuels and hydrogen, as possible solutions to the problems that we will face in the future. In this lesson they should draw on ideas from the preceding lessons to inform their choices.

Activities

- Students play a card game to elicit some of the advantages and disadvantages of ways of generating electricity that they have learned about in previous lessons using **worksheet 13.11.1**.
- Discuss the economic factors involved in electricity generation and transportation – cost to manufacture, install and run, and all the pollution/ greenhouse gases produced in those processes. Explain the idea of payback time. Students complete **worksheet 13.11.2** to practise what they have learnt.
- Discuss the use of biofuels and hydrogen as possible fuels for the future. Explain what a hybrid car is. Students read the information on **worksheet 13.11.3** and use it to complete the table on **worksheet 13.11.4**.
- To finish the entire section on energy resources by asking students to decide the energy resources for an island that is completely ‘fossil free’. Give each group a map of the island on **worksheet 13.11.5**. They work out how the people who live on the island can generate their electricity without using any fossil fuels. They can make a model of the island, or make a poster with the island at the centre, and add diagrams or labels to it showing how they will make use of the available resources to generate electricity and provide for transportation on the island. They need to make sure that there is the minimum of pollution or greenhouse gas production. Each group can present their solution to the class and the class can debate the different choices that have been made.
- Students can revisit the questions that they wrote at the start of this chapter to see if they have been answered.

Homework

Workbook page 90

Key words

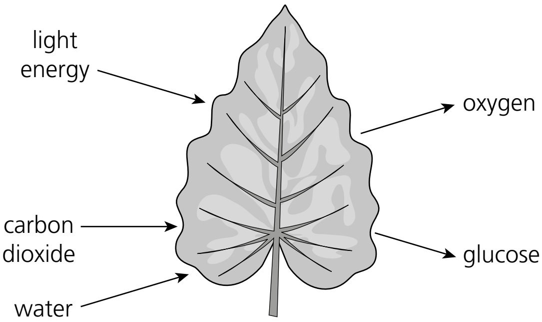
electric cars, hybrid cars, payback time, biodiesel, bioethanol, biomass, biogas, hydrogen, hydrogen cars, fuel cells

1 Plants

1.1 Why we need plants

1 Plants use photosynthesis to produce glucose which they use to build biomass; this feeds animals so it provides all the food that we eat. Photosynthesis is also our only source of oxygen for respiration.

2 Students should draw a simple outline of a leaf with arrows entering it labelled light energy, carbon dioxide, and water, and arrows leaving it labelled glucose and oxygen, e.g.

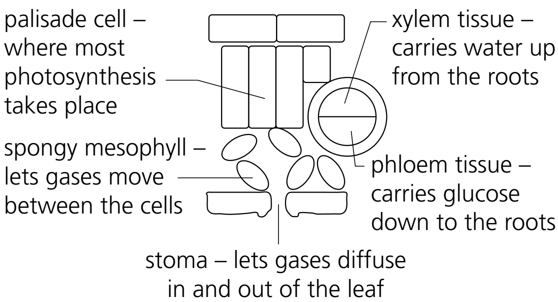


3 Plants use some of the glucose they make in respiration to release energy. The rest is used for the growth and repair which increases the plant's biomass.

4 Small molecules of glucose are joined to form giant starch molecules which can be stored in the leaves and broken down when the glucose is needed.

5 The Sun.

6



1.2 Asking scientific questions

1 The question involves something you can change (the temperature of the water) and something you can measure (the time it takes pondweed to release 1 cm^3 of oxygen).

2 Oxygen is produced during photosynthesis and it can be can be collected/measured quickly and easily using a measuring cylinder.

3 Photosynthesis produces glucose. This is used to create new biomass for growth. The faster photosynthesis occurs, the more glucose is made and the more new biomass the plant produces.

4 Any two from: the temperature; carbon dioxide concentration; mineral supply.

5 Graphs make it easier to see trends or patterns in the results.

1.3 Water and minerals

1 A: xylem vessel cell – these cells are hollow to allow water to travel up from the roots to the leaves.
B: guard cell – these cells have specialised cell walls. They push each other apart when turgid to open up the stoma between them and allow carbon dioxide to pass into the leaf. When the cells lose water and become flaccid, the stoma between them closes and prevents water loss from the leaf.
C: root hair cell – these cells give roots a large surface area to take in water and minerals from the soil.

2 More water leaves the bottom of the leaf because this is where the stomata are.

3 The water molecule is taken up by root hair cells, enters xylem vessels, and travels up the stem into a leaf. It evaporates and diffuses through air spaces in the leaf. If the guard cells are turgid, the stoma between them will be open. The water will escape through a stoma on the bottom of the leaf.

4 Students should draw a flaccid plant cell like the one shown on page 88 of the Student book. Cells like this do not provide support so the leaves and stem droop downwards and the plant wilts.

5 Plant cells use minerals to build new cell components. The minerals are taken in by root hair cells and travel through the plant in xylem vessels.

1.4 Review

1a Climbing allows *Convolvulus* to collect more light for photosynthesis.

b Cutting the stem prevents xylem vessels bringing water for support and to use in photosynthesis.

2a The pondweed uses carbon dioxide for photosynthesis. Removing carbon dioxide from the solution turns the indicator purple.

b In the dark, respiration adds carbon dioxide to the water.

3a As the light intensity increased, the amount of dissolved oxygen increased.

b As the light intensity increased, the amount of dissolved carbon dioxide would decrease because more would be used for photosynthesis.

4a Oxygen.

b Apparatus B.

c Any one from:increase the carbon dioxide concentration further; increase the light intensity; increase the temperature of the water.

5a Plant a will lose more water because water is lost through stomata on the underside of the leaf. Covering the top surface with oil will not reduce water loss.

b The pots are covered to prevent water evaporating from the soil so that water loss from the leaves can be compared fairly.

6a Stomata.

b Any one from: to allow the plant to take in carbon dioxide for photosynthesis; to control water loss from the plant.

c In wetter climates plants can use more stomata to take in more carbon dioxide for photosynthesis because they can replace all the water they lose through the open stomata.

7a Palisade (leaf) cell.

b They can absorb more light for photosynthesis at the top of the leaf.

c Plants use starch grains to store glucose to use for respiration when they cannot photosynthesise.

d The number would decrease. The plant would use up the glucose stored in the starch grains because it cannot photosynthesise in the dark but still requires energy.

8 Plant B has access to minerals from the soil. These minerals are required for growth, building cell components, and the formation of flowers.

9a Xylem vessels (cells)

b It carries water and soluble minerals from the roots up to the leaves.

10a How does the amount of carbon dioxide available affect the amount of starch a leaf stores (how does it affect the rate of photosynthesis in a leaf)?

b Leaf B (the leaf that received extra carbon dioxide).

11a Water is leaving the underside of the leaf through the stomata.

b Transpiration.

12a The question includes a variable you can change by selecting places with different annual rainfalls to collect plants from. It also includes a variable you can measure by counting the number of stomata these plants have.

b Plants would have fewer stomata in places with a lower average rainfall. Water is lost through stomata and if less water is available to the plant, it would be likely to minimise its water loss by having fewer stomata.

2 Circulation

2.1 Blood

1

Blood component	Main function
red blood cell	Picks up oxygen in the lungs and transports it to every other part of the body.
white blood cell	Helps to destroy micro-organisms.
platelet	Congregates around damaged blood vessels and helps to seal cuts.
plasma	Carries nutrients, carbon dioxide, and waste products in your blood.

2 Students should draw a side view of a red blood cell like the one on page 112 of the Student book.

3 Their biconcave shape makes them flexible and lets them squeeze through tiny capillaries. Their shape also gives them a large surface area so they can pick up oxygen quickly. They are full of haemoglobin which binds oxygen in the lungs and releases it in other tissues.

4

Substance	From	To
oxygen	lungs	every cell
carbon dioxide	every cell	lungs
digested food	small intestine	every cell
urea	liver	kidneys

5 Micro-organisms grow and divide quickly in blood because it is warm and contains lots of nutrients, including glucose, which they can use for respiration.

2.2 Anaemia

1 Healthy people have a range of red cell counts but most lie within a certain range.

2 No – her red cell count is 3 billion cells per dm^3, which is below the normal range (3.8–5.0 billion cells per dm^3).

3 No – her haemoglobin level is 93 g per dm^3, which is below the normal range (110–150 g per dm^3).

4 They are paler than normal red cells.

5a Students should have five values between 5.5 and 7.5 mm.

b Their average values should be between 6 and 7 mm.

c Students should have five values between 6.5 and 8.5 mm and an average value between 7 and 8 mm.

6 Sara's red cells are smaller and paler than normal cells.

7a 15 mm

b 50 mm

c Packed cell volume = $\frac{15 \times 100\%}{50} = 30\%$

8 Yes – Sara's packed cell volume is lower than normal (36–46%) which agrees with the results from her other tests.

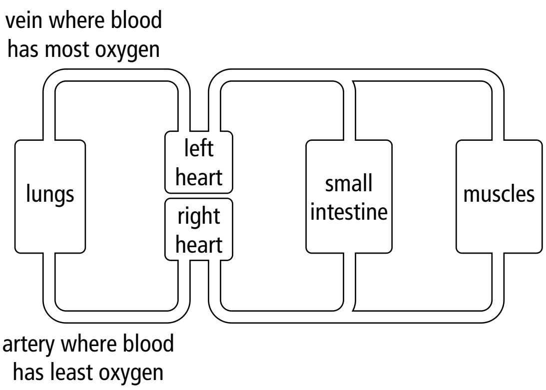
2.3 The circulatory system

1 The heart pumps blood to the lungs to collect oxygen. This blood returns to the heart to be pumped to every other part of the body.

2 The right side.

3 Blood (low in oxygen) leaves capillaries in the muscles. The capillaries join to form veins. Veins join and carry blood to the right side of your heart. The heart pumps this blood (low in oxygen) through arteries to capillaries in the lungs. Red blood cells pick up oxygen there. The blood (now rich in oxygen) travels through veins back to the heart. Then the heart pumps this oxygen-rich blood through arteries to return it to capillaries in the muscles.

4



3.4 Identifying trends

1 Students should make a copy of the graph on page 16 of the Student book and describe the graph, e.g. his maximum heart rate after exercise was 170 beats per minute. His heart rate dropped quickly in the first 4 minutes after exercise (to 95 bpm) and then more slowly until it reached his resting heart rate (between 70 and 75 bpm) after 9 minutes.

2

	Before training	**After training**
resting heart rate (beats/minute)	70–75	60–65
maximum heart rate (beats/minute)	170	135
recovery time (minutes)	9	4

3 The heart rate drops as the volume of oxygen blood can carry increases. This means that there is a negative correlation between the heart rate during exercise and the oxygen content of the blood.

2.5 Diet and fitness

1 Students should draw simple cross-sections of two blood vessels. The one labelled 'normal' should be clear in the centre. The other should be almost blocked by plaque.

2 Plaque is made of fat, cholesterol, and blood cells.

3 Plaque narrows arteries and raises blood pressure. It can reduce blood flow to the body's tissues and organs. This can cut their supplies of glucose and oxygen and can cause them to stop working properly. This is particularly dangerous in arteries supplying the heart, as it could cause a heart attack.

4 Consistently high blood pressure readings suggest that the arteries have become narrower. The heart has to pump much harder to get blood through a narrower tube.

5 Heart attacks and strokes can both be caused by a blockage in an artery. If an artery supplying your heart muscle is blocked by plaque, blood flow to the heart is reduced. This can cause part of the heart muscle to die. If an artery that supplies your brain is blocked it can cause part of your brain to die.

6 By changing their diet, people can avoid being overweight, eating unhealthy food, and having a high salt intake.

2.6 Review

1a C

b A

c B

2a C

b A

3 A – oxygen; B – glucose.

4a Plasma.

b Any two from: carbon dioxide; nutrients (glucose); urea (waste products).

5a Lungs

b C, D

6a After 5 minutes.

b When she exercises, her muscles need more glucose and oxygen so they can release more energy using respiration. Her heart has to pump/beat more times per minute to get blood to her muscles fast enough.

c At 26 minutes.

7a An artery.

b B

c C (a capillary) because small molecules such as glucose and oxygen need to diffuse through their walls very rapidly.
8a Their heart rates rose to increase the blood flow to their muscles.
b Student B because their resting heart rate is lower and it does not increase so much during exercise.
c Take more frequent exercise that raises their heart rate such as running or swimming.
9a A, the right-hand side (shown on the left in the image).
b D, E
10a B
b A
11a It has just come from the lungs, where it picked up oxygen.
b B
c C
12a Valve.
b It ensures that blood only flows in one direction.

3 Respiration and gas exchange

3.1 Lungs

1 Your intercostal muscles and diaphragm make you breathe.
2 They work together to increase the volume of your chest. The intercostal muscles contract to bring your ribs up and out. Your diaphragm contracts and flattens. The increased volume makes air rush into your lungs.
3 Lungs contain air so they are less dense than water.
4 Students should describe the route an oxygen molecule takes to get into the blood, e.g. I enter the body through the nose/mouth. I pass down the trachea. I choose between two paths to lungs, one through each bronchus. The bronchus keeps branching into many smaller tubes, the bronchioles. These tubes get narrower until I reach a tiny air sac – an alveolus. I dissolve in its moist lining and diffuse through its thin walls into the bloodstream.
5 The arteries that carry blood into the lungs should be coloured blue. Normally arteries carry blood that is full of oxygen, but the arteries to your lungs are carrying blood that has returned from the rest of your body. It picks up oxygen in the lungs, and then veins return to the heart which pumps blood full of oxygen through all your other arteries.

3.2 Respiration and gas exchange

1 Respiration;
glucose + oxygen → carbon dioxide + water
2 Gases are exchanged in the lungs so the percentage of carbon dioxide increases and the percentage that is oxygen decreases.
3 Your body needs more energy when it is exercising, so its muscles can contract more strongly/quickly. Muscle cells release this energy by respiring more quickly so more oxygen is required.
4a 0.3 dm^3/min
b 2.6 – 0.3 = 2.5 dm^3/min
c 3 breaths
d 12 breaths per minute
e 0.5 dm^3
f His breathing rate increased (to 16 breaths per minute) and the volume of each breath increased (to 3.0–3.2 dm^3).

3.3 Anaerobic respiration

1 Most respiration takes place in mitochondria. The heart needs a lot of energy to pump blood around the body, so needs to have lots of mitochondria.
2

Aerobic respiration	Anaerobic respiration
releases all the energy stored in glucose	releases 5% of the energy from glucose
needs oxygen to release energy from glucose	doesn't need oxygen to release energy from glucose
used in long-distance running	used in sprints
can be used continuously	can only be used for a short time
produces carbon dioxide	produces lactic acid

3 Anaerobic respiration allows you to release energy from glucose much faster than is possible with aerobic respiration. This is useful when energy is needed very quickly, e.g. when sprinting.
4a Fast twitch.
b Slow twitch.
c Slow-twitch fibres have many capillaries so oxygen can diffuse into the muscle cells/fibres much more rapidly.
d A sprinter has a greater proportion of fast-twitch fibres, which can produce stronger contractions, allowing them to run faster.
5 A cheetah would have mainly fast-twitch fibres.

3.4 Smoking and lung damage

1

Chemical	Damage caused
tar	Paralyses cilia, leading to a build-up of mucus, causing coughing and increasing the chance of infection. Increases the risk of developing lung cancer.
carbon monoxide	Binds to red blood cells, reducing the amount of oxygen they can carry.
nicotine	Acts on brain cells and makes people addicted to cigarettes. Narrows blood vessels, and increases your risk of having a heart attack or stroke.

2 The baby is more likely to be smaller than average.
3 Smoking is most damaging during the final months of pregnancy.
4a The smoker's alveolar walls have broken down. The individual alveoli have combined to form larger clumps. This has reduced the surface area available for gas exchange.
b Their oxygen uptake will be reduced because gas exchange will be slower.
5 Nicotine is addictive, so their cells rely on nicotine to function normally.

3.5 Communicating findings

1 Lower – the average value for her height is 425 dm^3; her PEF is only 320 dm^3.
2 Kemi's bronchioles are easily irritated by substances in the air. They produce more mucus which clogs up the bronchioles and makes them narrower. This makes it harder for air to get into and out of the lungs.
3 Students should draw simplified versions of the normal and constricted bronchioles shown on page 133 of the Student book.
4 Students should write what they would explain to Kemi, e.g. your peak expiratory flow (PEF) is lower than the average value for someone of your height. Your PEF value is below the blue line, which means that it is also lower than 95% of people who are the same height as you. This means that you aren't able to blow air out of your lungs as quickly as they can. The tubes that take air into your lungs are narrower than normal – like straws that have been squeezed shut. Your tubes are easily irritated by things in the air. They produce more mucus and become narrower.
5 Students should write what they would explain to the patient, e.g. we have looked at the results of your scan and we have found a blood clot. It is blocking the blood flow to one of your lungs. That means your blood can't get enough oxygen. That's why you are finding it hard to breathe. If it gets any worse your body will not get enough oxygen to survive. This is a very dangerous situation so we want to start treatment immediately to remove the blockage.
6 Students should write what they would explain to the patient, e.g. there is a build-up of sticky mucus in the tubes that carry air into your lungs. Some of the cells inside your lungs act like little brushes and sweep this mucus out. Unfortunately your mucus is thicker and more sticky then normal – a bit like honey. It is blocking the tubes and making it hard for you to take enough oxygen in. This is why you are finding it hard to breathe. We have some medication that will make your mucus thinner. Then your lungs will keep themselves clean and you will breathe more easily.

3.6 Review

1a E
b D
c A
d B
e C
2a Alveoli.
b Bronchus.
c Bronchioles.
3a Trachea and bronchi.
b The diaphragm.
c Air rushes in and the lungs inflate.
d Any one from: the bronchioles; the intercostal muscles; the alveoli.
4 E, C, B, D, A
5a X alveolus; Y capillary.
b A oxygen; B carbon dioxide.
c This allows the air in the alveolus and the blood to get very close together, which speeds up diffusion/gas exchange.
6a Her heart and lungs worked harder. Her heart beat more quickly and she took more breaths per minute
b The heart needs to pump faster to ensure that enough oxygen is delivered to the muscle cells for respiration. The breaths per minute need to increase to allow oxygen to diffuse into the blood rapidly.
7a B
b A
c C
8a Tar.
b Any one from: can cause lung cancer; can cause bronchitis; can cause emphysema; can reduce gas exchange.
c It is acidic.
d It is addictive.

9a They waft it up the tubes in your lungs towards your throat, to be swallowed.
b Mucus traps microbes. If the cilia are paralysed, they are unable to move the microbes out of your lungs, so the microbes multiply there and cause an infection.
10a Glucose + oxygen → carbon dioxide + water
b Respiration releases energy, which cells need to stay alive.
11a Mass of air.
b Any one from: number of breaths taken; age of participants; size/type of balloon.
c Yes – on average, the 10 smokers blew out a lower mass of air than the non-smokers.
12a 3 dm^3
b 5 dm^3
c 12 breaths per minute
d 18 breaths per minute
e His breathing is faster and deeper during exercise.

4 Human influences

4.1 Air pollution
1 Acid rain is caused by sulfur dioxide and oxides of nitrogen. Sulfur dioxide is released when fuels burn and when metals are extracted. Cars release oxides of nitrogen.
2 Many lichens cannot survive in polluted air so the varieties of lichen species present shows how clean the air is.
3 Acid rain damages plants in three ways: it makes soil more acidic which can stop plants getting essential mineral elements; it dissolves aluminium from rocks, which can poison plants; it damages leaves and seeds, so pathogens can infect plants more easily.
4 Air pollution has increased in the past 100 years because the human population is larger, we have more cars, and we burn more fuels.

4.2 How scientists work
1 Carbon dioxide could make Earth warmer by preventing heat from leaving the atmosphere.
2 Arrhenius predicted that doubling the amount of carbon dioxide in the atmosphere would make it 5 °C warmer.
3 One piece of evidence that supports this prediction is that the amount of carbon dioxide in the atmosphere, and its temperature, are both increasing.
4 Some scientists don't agree that humans cause global warming. They argue that natural events have a bigger effect on our atmosphere.
5 As the Earth warms there could be more storms, droughts, and heatwaves.
6 The IPCC studies evidence from thousands of scientists all over the world and publishes conclusions.

4.3 Water pollution
1 Fertilisers make plants and algae grow faster by providing extra minerals.
2 Eutrophication happens when fertiliser enters water, algae multiply rapidly and block off the light, plants below the surface die, micro-organisms use up oxygen as they decompose dead plants, and finally fish die from a lack of oxygen.
3 We can stop sewage polluting rivers by storing it in huge tanks while micro-organisms break its contents down.
4 Invertebrates can be used to monitor water pollution because they act as living indicators. Many species cannot survive in polluted water, so the species present show how polluted the water is.

4.4 Saving rainforests
1 A growing population removes trees for many reasons: to grow food; to keep farm animals; to remove metal ores, oil, or coal from the ground; to use the wood as a fuel or building material; to grow food crops to sell to other countries; to grow biofuels to sell to other countries; to build new roads and houses.
2 Other countries encourage tropical countries to remove forests by buying crops grown in deforested areas.
3 Deforestation damages the local environment by: destroying habitats; removing people's access to the food and fuel the forest provided; making the local climate warmer, windier, and drier; making soil erosion more common; making rivers flood more easily.
4 Deforestation affects the world's climate by adding carbon dioxide to the atmosphere and increasing global warming.
5 Countries can earn money from sustainable forests by encouraging tourists to visit them and selling rainforest products such as fruits and nuts.
6 Wealthy countries can help to save forests by using fewer resources. To do this they need to limit population growth, reuse products and recycle materials, use energy more efficiently so less fuel is needed, and make farms more efficient so less land is needed for crops.

4.5 Review
1a B, C
b A, D
c Sulfur dioxide; oxides of nitrogen
d Sewage; fertiliser
e B, C
f Acid rain could be killing the trees.
2a Humans add sulfur dioxide to the air by burning fossil fuels, especially coal.
b When the amount of sulfur dioxide in the air rises, the number of deaths rises.

c Sulfur dioxide damages the lungs.
d Reducing acid rain an international problem because winds carry acidic gases from one country to another.
3a Walls have more lichen species growing on them.
b The greater the distance from the city centre, the more different lichen species are found.
c The main source of air pollution in cities is traffic.
d Tall, bushy lichens most likely to be found in the country (in unpolluted areas).
4 From least to most polluted the samples are: B, A, C.
5a B
b The oxygen concentration is lower at site B because there are more decomposers using the oxygen for respiration.
6a The mass of bacteria could increase 2 km from the town centre because there is sewage or rotting plant material in the water (causing eutrophication).
b The extra bacteria could reduce the number of fish in the river by lowering the water's oxygen concentration as they respire.
7 Tench would survive best in water polluted with sewage because they require least oxygen.
8a The animals would lose their habitat.
b Heavy rains could wash soil away from the hillside (cause erosion).
9a 15%
b Any two from the following:
Deforestation reduces photosynthesis.
The roots and branches left behind add carbon dioxide to the atmosphere as they decompose.
The machinery used for deforestation burns fossil fuels.
The fires used to remove the trees add carbon dioxide to the atmosphere.
10a Any two from the following:
It reduces biodiversity.
It reduces photosynthesis.
It increases global warming.
b Any two ways of limiting the need to remove trees to grow crops such as the following:
Limit population growth.
Make farms more efficient so less land is needed for crops.
Encourage tourists to visit the forest, to provide local employment.
Harvest rainforest products such as fruits and nuts for export.
Encourage wealthy people to buy trees in the forest and protect them.

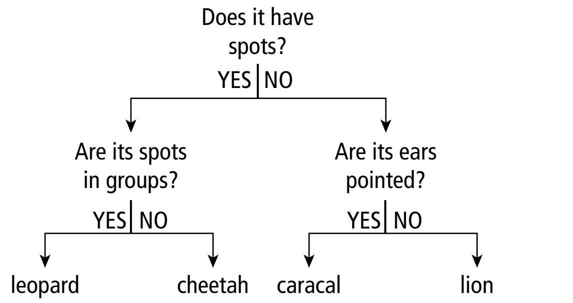
5 Variation and classification

5.1 Using keys

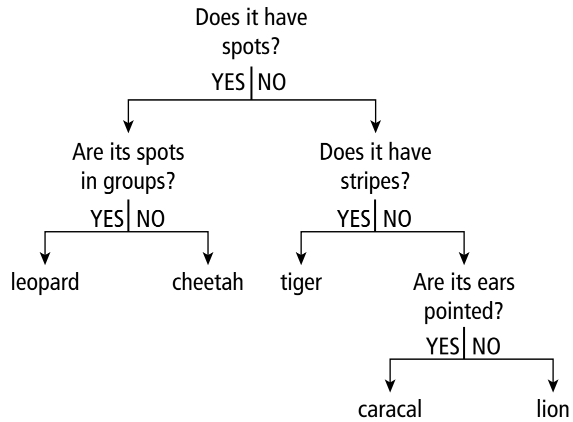
1

1. Does it have spots?	yes	see 2
	no	see 3
2. Are its spots in groups?	yes	leopard
	no	cheetah
3. Are its ears pointed?	yes	caracal
	no	lion

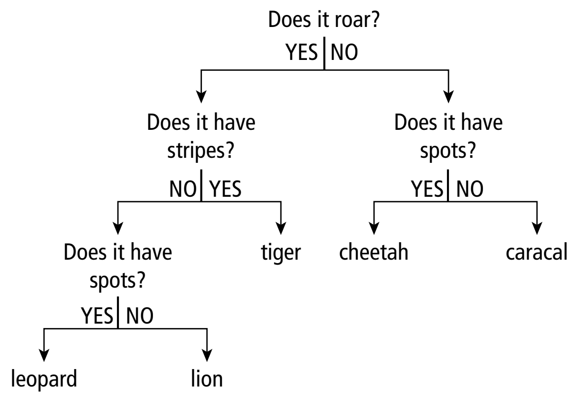
2



3 Students should modify the branching key produced for question 2 to include a tiger, e.g.



4 Students should modify the branching key produced for question 3 to start with the question: does it roar?



5.2 Chromosomes

1 Students should produce a labelled diagram like the one at the 47 of the Student book showing genes on chromosomes in the nucleus of a cell.

2 The nucleus of a human cell contains 23 pairs of chromosomes or 46 individual chromosomes.

3 You have two copies of every gene because the chromosomes in each pair carry the same genes. We inherit one set from each parent.

5.3 Investigating inheritance

1 Mendel's second-generation pea plants only inherited their height from one of their parents. They were all tall. None were short.

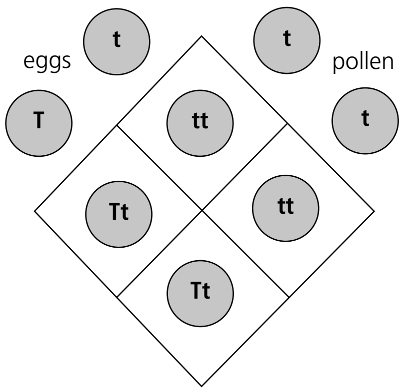
2 Mendel made his tall and short plants fertilise each other by preventing self-pollination and using a brush to transfer the chosen pollen to their flowers.

3 The gene that makes peas tall must be a dominant gene because plants are tall even when they only have one copy of the gene.

4 The second-generation plants inherit a gene from each parent so they have both sorts: **T** and **t**. The **T** version is dominant so the pea plants are all tall.

5 Each of the second generation plants makes two sorts of sex cell. On average, half carry **T** and half carry **t** genes. Male sex cells carrying **t** genes could fertilise female sex cells with the same gene. The offspring would have **tt** genes so they would be short.

6



1 in 2 or 50%
of the offspring will be tall.

5.4 Selective breeding

1 Members of a species show a lot of variation because they inherit unique combinations of genes from their parents.

2 Selective breeding involves three steps: decide what characteristics you want the next generation to have; choose parents that have some of these features and breed them together; select the offspring with the characteristics you prefer and breed these together. The process needs to be repeated over many generations.

3 Selective breeding is useful to farmers because it has produced better farm animals and crops.

4 Selective breeding has produced cows that give more milk, resist disease, or are stronger.

5 Selective breeding can produce cereal crops such as maize with bigger seeds (so more food is grown on the same amount of land).

5.5 Developing a theory

1 Students should describe an observation that suggests species change over time, e.g. many fossils are similar to modern animals, but not identical.

2 In the Galapagos Islands, there are different mockingbirds and finches on different islands.

3 Students should sketch two beaks. One should be long and pointed and labelled 'suitable for collecting insects'. The other should be short and wide and labelled 'suitable for crunching seeeds and nuts'.

4 The finches with the beaks that suit the food available will collect more food, so they are more likely to survive.

5 Selective breeding occurs when humans choose which members of a species breed and produce offspring. Natural selection occurs when environmental factors, such as the availability of food, select which individuals survive and reproduce.

5.6 Darwin's theory of evolution

1 Plants and animals keep producing offspring, but their total numbers usually stay the same because most of their offspring don't survive.

2 Plants compete for patches of soil, water, and sunlight, and animals compete for food and places to live.

3 Some animals are more likely to survive than others because they are better adapted to their environment.

4 Students should name a characteristic that could improve an animal's chance of surviving for long enough to reproduce, e.g. the ability to run fast to catch prey or escape from predators.

5 Evolution by natural selection could have made modern cheetahs run faster than their ancestors over many generations, e.g. the speeds of cheetahs vary. A fast cheetah catches more prey. This allows them to feed more offspring. So their speed passes to the next generation. Over time this characteristic becomes more common.

5.7 Moving genes

1 Genetic engineering adds genes to cells.

2 Genetic engineering is easier in bacteria because their cells are simpler, their genes are loose in the cytoplasm, and they reproduce very rapidly.

3 Students should produce a series of labelled diagrams, like those at the top of page 57 of the Student book, to explain how new genes are transferred to bacteria.

4 Genetic engineering can make micro-organisms more useful by giving them genes that make them produce products we need.

5 Some people worry about genetically engineered plants because their pollen or seeds could contaminate food crops or cause other problems we can't predict. Genetically engineered bacteria grow indoors in large tanks and few people worry about them escaping.

5.8 Using genes

1 Most of the medicines used to treat malaria no longer work because the protozoa that cause malaria have developed resistance to them.

2 Artemisinin comes from a Chinese plant. It is expensive because it is difficult to extract from the plant.

3 Selective breeding could be used to make artemisinin cheaper by producing new varieties of the plant that contain more artemisinin.

4 The genes that plants use to make artimisinin can be put into yeast cells. Then the yeast cells can be grown in tanks all over the world to produce artemisinin quickly.

5 Governments and charities need to raise money to tackle malaria because it costs billions to find new medicines and most malaria victims are too poor to pay for them.

5.9 Review

1 A – dragonfly larva.
B – stonefly larva.
C – damselfly larva.

2a A – water mite.
C – water boatman.
E – midge larva.

b Students should produce a question that will distinguish between invertebrates B and D, e.g. how many tail filaments does it have?

3a Any one from: dark hair; eyebrow shape; ear shape; nose shape; large eyes.

b Any one from: mouth shape; straight hair.

c Karis looks a bit like each parent because she inherited genes from each of them, and genes control characteristics.

4a Nucleus.

b The genes are copied so that each cell gets a full set.

c Each egg or sperm cell contains half the normal number of genes.

d The genes in the parents' egg and sperm cells combine during fertilisation to give each embryo a full set of genes.

5 Different breeds of dog are produced by selective breeding.

6 Breed varieties A and C together; select the offspring with the shortest stems and highest mass of grain, and breed these together; repeat the process over many generations.

7a The population changed from 1% black to 90% black.

b Light moths.

c Light moths could be seen more easily on the darker tree trunks so birds caught more of them. The dark moths were more likely to survive and produce offspring.

8 a and c are true.

9a A

b C

c Genes.

d Different foods were available on each island. The birds with the best adapted beaks survived and passed the genes that controlled their beak shape to their offspring.

e The finches evolved from the same group of finches.

10 Any two from the following:
Armadillos showed variation.
Those with the biggest claws dug more insects out of the soil.
They survived and passed their genes to their offspring.
Over time, bigger claws became more common.

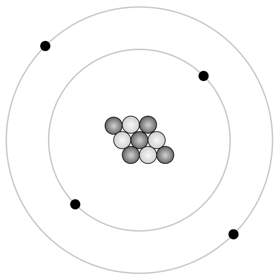
6 Material properties

6.1 Atomic structure

1 Proton: charge +1, mass 1
Neutron: charge 0, mass 1
Electron: charge −1, mass 1/1840

2 Proton and neutron

3



4 Beryllium has four protons with a total charge of +4 and four electrons with a total charge of −4. The net charge of the beryllium is 0 making it electrically neutral.

6.2 Finding electrons

1 When Thomson passed cathode rays between electrically charged pieces of metal, the rays bent towards the positively charged metal, suggesting that they are negatively charged.

2 Thomson's plum pudding model suggests that electrons are placed within a positively charged sphere (like plums dotted throughout a plum pudding). Nagaoka's Saturn model suggests that the atom has a large positive mass at the centre with negative charges surrounding the positive mass in rings.

3 Nagaoka said that it is not possible for negative charges to be spread through a positively charged sphere.

6.3 Discovering the nucleus

1 Rutherford's model of the atom suggests that most of the mass of an atom is in a nucleus in the centre of the atom. The nucleus is positively charged. Surrounding the nucleus is a big, empty space in which electrons move.

2 Rutherford, Geiger, and Marsden fired positive alpha particles at a thin piece of gold foil. A fluorescent screen surrounded the foil to record where the alpha particles collided with the screen, allowing Rutherford to determine whether or not the particles had changed direction.

3 By firing positive particles into the air, Rutherford found that tiny positive particles were formed from the nuclei of nitrogen atoms. These tiny positive particles were protons.

6.4 Protons, electrons, and the periodic table

1 Students should copy the lithium, sodium, and potassium diagrams on page 153. All three atoms have 2 electrons in the first shell and 1 electron in the outer shell.

2 Helium: 2, neon: 2,8, argon: 2,8,8. Helium, neon, and argon have 2 electrons in the inner shells. Both neon and argon have 8 electrons in the outer shells.

3 Lithium: 2,1, beryllium: 2,2, boron: 2,3, carbon: 2,4, nitrogen: 2,5, oxygen: 2,6, fluorine: 2,7, neon: 2,8. The number of electrons in the outer shell of the elements increase (by one) as you move across the periodic table.

6.5 Proton number, nucleon number, and isotopes

1 Isotopes are atoms of the same element with different number of neutrons.

2 proton number: 15, nucleon number: 31

3 19 protons, 20 neutrons

6.6 The Group 1 elements

1 As you move down Group 1, the melting point of the metals decreases.

2 Generally, as you move down Group 1, the density of the metals increases. Potassium does not fit the pattern.

3 Group 1 element + water → Group 1 hydroxide + hydrogen. e.g sodium + water → sodium hydroxide + hydrogen. As you move down the group, the reactions become more vigorous.

6.7 The Group 2 elements

1 calcium + water → calcium hydroxide + hydrogen
strontium + water → strontium hydroxide + hydrogen
barium + water → barium hydroxide + hydrogen

2 Beryllium is at the top of group 2. The reactions get more vigorous as you move down the group. As beryllium is at the top of the group, it would be the least reactive (far less reactive than calcium).

3 Set up the apparatus as shown on page 159. Place a piece of magnesium in the bottom of a test tube. Repeat with a piece of beryllium of the same size. Put some dilute hydrochloric acid into the test tube and observe the reaction. Whichever metal produces more hydrogen bubbles is more vigorous.

6.8 The Group 7 elements

1 Group 7 elements have low melting and boiling points compared to most metals. As you move down the group, the melting and boiling points increase. This is because the atoms (and molecules) of the elements get bigger as you move down the group.

2 iron + chlorine → iron chloride
iron + bromine → iron bromide
iron + iodine → iron iodide
Moving down the group the reactions get less vigorous.

6.9 Looking at secondary data – chlorinating water

1 By asking many people, the data is more reliable and other scientists would be more likely to trust the scientist's results.

2 The scientists may not have been able to find any more people.
It would have been more expensive to question more people.
There may have been time limits on the study.
Any reasonable answer is acceptable.

3 The benefits of adding chlorine (reducing deaths from waterborne diseases) outweigh the possible risk of cancers.

6.10 Periodic trends

1 lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, neon

2 Vipasa does not have the equipment or the metals available.

3 Generally, as you move across period 3 (left to right), the melting points increase, peaking at silicon and then decreases very quickly.

6.11 How scientists work: inside sub-atomic particles

1 Scientists can divide up the tasks and work separately to solve problems faster.
The best scientists available from each country can work together.

2 Time differences, language barriers.
3 Modern technology such as telephones, Internet, and readily available international transport.

6.12 Review

1 Clockwise from top: electron, neutron, nucleus.

2

Sub-atomic particle	Charge	Relative mass
proton	+1	**1**
neutron	**0**	**1**
electron	**–1**	1/1840

3 There are the same number of protons (15) and electrons (15). The positive charge of the protons (+15) neutralises the negative charge of the electrons (–15).

4a Most of an atom is empty space (between the electrons and the nucleus), so the positive alpha particles travelled straight through.

b Some of the positive alpha particles hit the positive nucleus and bounced (were repelled) backwards.

5a See diagram on page 69.

b See diagram on page 69.

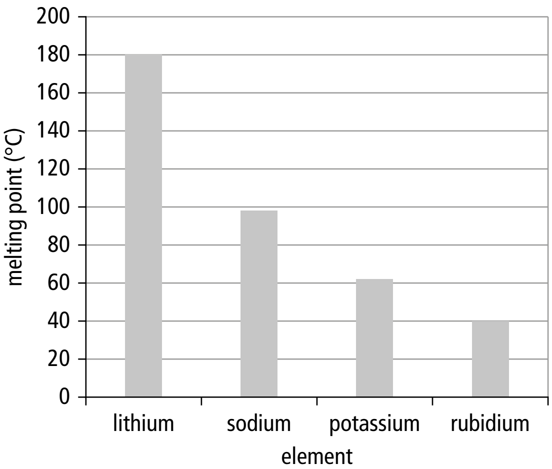
c See diagram on page 69.

6a sodium: 2,8,1
potassium: 2,8,8,1

b Both sodium and potassium have 2 electrons in the inner shell and 8 electrons in the middle shells.

c Sodium and potassium are in Group 1 and both have 1 electron in the outer shell.

7a



b As you move down the group, the melting point decreases.

8a The bubbles show that hydrogen is being produced.

b The sodium hydroxide that is formed is alkaline.

c sodium + water → sodium hydroxide + hydrogen

d i Hydrogen is produced. An alkaline solution is produced.

ii The reaction of potassium is more vigorous.

e As you move down Group 1, the reactions become more vigorous.

9a The relative size of the atom increases down the group.

b The number of electron shells increases (as you move down the group), increasing the relative size of the atom.

10a As you move down Group 2 (beryllium to strontium), the boiling point decreases.

b Barium would have a lower boiling point.

c Prediction: the melting point would decrease as you move down the group. Reason: the boiling point decreases, suggesting that the melting point would too.

11a variable to change: element
variable to observe: how vigorous the reaction is

b the amount of element used, the temperature of the water

c Collect data about the reactions and the amount of chemicals to use. Carry out a risk assessment.

d The reaction of strontium with water is very vigorous and can be dangerous.

12a Two of: fluorine, chlorine, bromine, iodine, astatine.

b do not conduct electricity, poor conductors of heat

c i bromine

ii As you move down the group the boiling point increases.

iii Approximately –101 °C

d See images on page 161.

13a magnesium: 2,8,2
aluminium: 2,8,3
silicon: 2,8,4
phosphorus: 2,8,5
sulfur: 2,8,6
chlorine: 2,8,7
argon: 2,8,8

b sodium, magnesium, aluminium

c phosphorus, sulfur, chlorine, argon, (silicon is a semiconductor)

d As you move across the period (left to right) the relative size of the atoms decreases.

7 The reactivity series

7.1 The reactions of metals with oxygen

1 Bright white flame and crackling sounds.
2 iron oxide
3 zinc + oxygen → zinc oxide
4 magnesium, iron, copper

7.2 The reactions of metals with water

1 potassium, sodium, lithium, calcium
2 Products: potassium hydroxide and hydrogen
Potassium + water → potassium hydroxide + hydrogen
3 Gold does not react with cold water.

7.3 The reactions of metals with acids

1 potassium, sodium, lithium, calcium.

2 Products: magnesium chloride and water
magnesium + hydrochloric acid →
magnesium chloride + water

3 Collect the hydrogen in a test tube. Put a lit splint into the test tube. The splint makes a squeaky pop and goes out.

4 To ensure that there is the same amount of metal free to react, allowing him to compare the results.

7.4 The reactivity series

1 More reactive: potassium, sodium, lithium, calcium.
Less reactive: aluminium, zinc, iron, lead, copper, silver, gold.

2 The potassium would react violently with dilute acid.

3 Magnesium, like zinc, is more reactive than steel. The magnesium reacts with the water instead of the iron in the steel, thus protecting the boat's steel hull.

7.5 Nickel in the reactivity series

1 Rosa used secondary sources because the tests were too hazardous for her to carry out herself.

2 When reacting with oxygen, all of the metals formed oxides quickly. There was no clear difference in the speeds of the reactions.

3 Rosa has one piece of evidence to suggest that nickel is higher in the reactivity series than lead. To be confident, Rosa needs to collect more evidence supporting this conclusion.

7.6 Metal displacement reactions

1 A displacement reaction is a reaction in which one element displaces (pushes out) another element from its compound.

2 magnesium + copper oxide → magnesium oxide + copper
zinc + magnesium oxide → No reaction
zinc + copper sulfate solution → zinc sulfate + copper

3 aluminium + iron oxide → aluminium oxide + iron.
This reaction is known as the thermite reaction. The thermite reaction is used to produce liquid iron to join railway tracks together.

7.7 Using the reactivity series: extracting metals from their ores

1 potassium, sodium, calcium, magnesium, aluminium

2 Most iron exists in the Earth's crust as iron oxide. Carbon is more reactive than iron, so can displace the iron from the iron oxide to produce iron.

3 Metals near the top of the reactivity series are extracted using electrolysis, whilst metals below aluminium are extracted from their oxides by heating with carbon.

7.8 Writing symbol equations

1 $4Na + O_2 \rightarrow 2Na_2O$

2 $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

3 $K(s) + H_2O(l) \rightarrow KOH(aq) + H_2(g)$

7.9 Review

1a magnesium + oxygen → magnesium oxide
b zinc + oxygen → zinc oxide
c potassium + oxygen → potassium oxide

2a sodium
b iron, zinc, magnesium, sodium
c no reaction
d No reaction, platinum is unreactive in water, dilute acids, or oxygen.
e magnesium, zinc (sodium is incorrect as it reacts vigorously with water)

3a hydrogen
b Add Universal Indicator, the solution would turn blue/purple.
c lithium hydroxide
d potassium + water → potassium hydroxide
e potassium, lithium, magnesium
f sodium
g Potassium and lithium react violently with dilute acids.

4a **i** the metal
ii Amount of dilute hydrochloric acid and the amount of metal added.
iii To ensure that they are the only variables influencing the results (to make it a fair test).
b Half fill the test tubes with dilute hydrochloric acid. To each test tube, add either a spatula of iron, zinc, or 1 cm of magnesium ribbon. Observe the reactions.
c

Metal	Reaction
iron	
zinc	
magnesium	

d To determine whether the type of acid affects the reaction.
e Collect the gas produced in a test tube. Place a lit splint inside. If the splint makes a squeaky pop and goes out, there is hydrogen present.

5a ii and iii will react
b lead + copper oxide → lead oxide + copper
zinc + lead oxide → zinc oxide + lead

6a copper, zinc sulfate
b The zinc has displaced the copper.
c **i** Zinc is more reactive as it displaces the nickel.
ii zinc + nickel nitrate → zinc nitrate + nickel
iii There would be no reaction as nickel is less reactive than zinc.

7a **i** Zinc is more reactive than iron, lead, and tin.
ii A metal cannot displace itself, so it would be a waste of resources.

b Tin is less reactive than iron and zinc, but more reactive than lead.

c Mary could add lead to tin chloride to see if there is a reaction.

8 Making salts

8.1 Making salts – acids and metals

1 Filtration removes the metal from the solution.

2 zinc + hydrochloric acid → zinc chloride + hydrogen

3 magnesium metal + nitric acid

7.2 Making salts – acids and carbonates

1 evaporation

2 zinc carbonate + hydrochloric acid → zinc chloride + carbon dioxide + water

3 zinc carbonate + nitric acid

7.3 Making salts – acids and alkalis

1 Add charcoal to the solution, then filter the solution.

2 potassium hydroxide + nitric acid → potassium nitrate + water
The salt made is potassium nitrate.

3 potassium hydroxide + hydrochloric acid

7.4 Making salts – fertilisers

1 ammonium nitrate

2 evaporation

7.5 Review

1 A compound made when a metal replaces the hydrogen in an acid.

2a magnesium sulfate
b zinc chloride
c magnesium nitrate
d copper chloride
e zinc sulfate
f copper nitrate

3a Collect the hydrogen gas, place a lit splint inside. If the splint makes a squeaky 'pop' and goes out, the gas is hydrogen.
b bubbles forming

4a magnesium nitrate + hydrogen
b zinc sulfate + hydrogen
c magnesium chloride + hydrogen
d copper chloride + carbon dioxide + water
e zinc nitrate + water

5a sulfuric acid
b **i** copper sulfate + carbon dioxide + water
ii copper carbonate + sulfuric acid → copper sulfate + carbon dioxide + water
iii copper sulfate + water
iv copper oxide + sulfuric acid → copper sulfate + water
c **i** copper sulfate, water, copper oxide
ii filtration
d Transfer the solution into the evaporating dish. Using the beaker set up a water bath with the evaporating dish on top. Gently heat the beaker, evaporating the water in the evaporating dish, leaving copper sulfate crystals behind.

6a **i** carbon dioxide
ii copper carbonate + hydrochloric acid → copper chloride + carbon dioxide + water
b A, D, F, B, E, C, G, H

7a zinc + hydrochloric acid → zinc chloride + hydrogen
b **i** Dilute hydrochloric acid can cause harm in cuts.
ii The reaction releases hydrogen which is extremely flammable.
iii Dilute hydrochloric acid and zinc chloride crystals/concentrated solution can damage the eye.
iv Zinc chloride crystals and concentrated solutions of zinc chloride are corrosive and will burn the skin.
c Heating the evaporating dish over a water bath heats the zinc chloride more evenly and gently, reducing spitting and reducing the loss of zinc chloride.

9 Rates of reaction

9.1 Rates of reaction

1 Very fast reaction: the chemical reaction in fireworks. Very slow reaction: rust forming on a car.

2 55 cm^3

3 The graph evens out and continues horizontally.

9.2 Concentration and reaction rates

1 It is easier to compare or see a trend or pattern in continuous data by using a line graph.

2 As the concentration of the acid increases, the reaction rate increased.

3 In a more concentrated solution, there is a greater number of acid particles that can react with the magnesium particles, increasing the rate of the reaction.

4 The student could use the same method to test equivalent concentrations of different acids.

9.3 Temperature and reaction rates

1 The higher the temperature, the faster the rate of reaction.

2 At higher temperatures, particles have more energy so move around faster. This increase in movement leads to an increase in collisions between reacting particles, leading to an increase in rate of reaction.

3 Farai could time how long it takes for a 5 cm piece of magnesium to stop reacting in hydrochloric acid at different temperatures.

9.4 Surface area and reaction rates

1 Temperature, amount of dilute hydrochloric acid, total amount of calcium carbonate used.

2 The greater the surface area, the faster the rate of reaction.

3 One gram of solid has a much smaller surface area than one gram of powdered solid. During a reaction, the reactants can only act with the surface of the solid. As the powder has a greater surface area, more reactions are able to take place, speeding up the rate of reaction.

9.5 Catalysts and reaction rates

1 Catalysts speed up reactions without being used up in the reaction.

2 Salivary amylase, catalase (from liver), manganese(IV) oxide, lead(IV) oxide, iron, catalytic converters (platinum, rhodium, palladium).

3 Catalysts make it easier for the reaction to start.

9.6 Review

1a zinc + hydrochloric acid → zinc chloride + hydrogen

b **i** Between 0 and 1 minute.

ii 3 minutes

iii 80 cm^3

c **i** amount of zinc used, temperature, amount of acid used

ii To ensure that any results are caused by the change of concentration of acid (make it a fair test).

iii

Concentration of acid	**Amount of gas produced (cm^3)**

2a **i** temperature

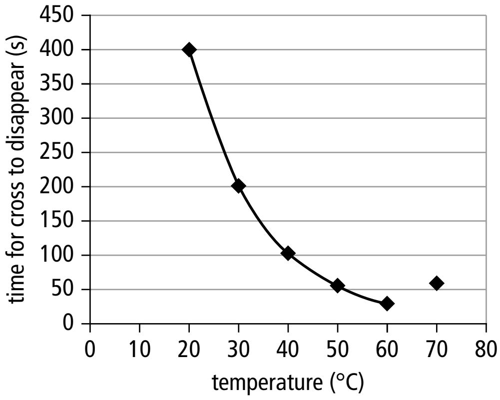
ii time taken for the cross to disappear

iii amount of sodium thiosulfate, amount of hydrochloric acid, concentration of sodium thiosulfate, concentration of hydrochloric acid, temperature

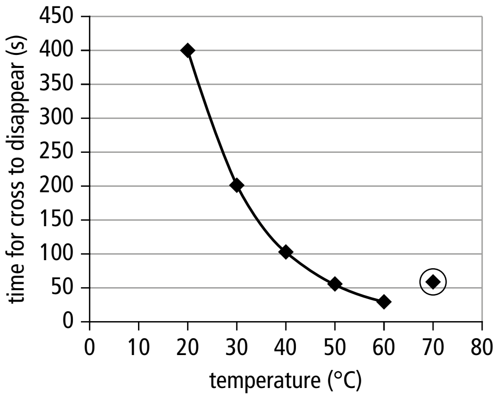
b **i** To reduce error and increase the reliability of his results.

ii 200

iii



iv



v As temperature increases, the time taken for the cross to disappear decreases.

c At higher temperatures, particles have more energy so move around faster. This increase in movement leads to an increase in collisions between reacting particles, leading to and increase in rate of reaction.

3a carbon dioxide

b **i** The product that is formed as gas escapes into the air.

ii B

c **i** size of calcium carbonate – surface area

ii time taken for 1.0 g of gas to be made

iii the amount of calcium carbonate, temperature, amount of hydrochloric acid

iv

Size of calcium carbonate	**Time taken for 1.0 g of gas to be produced**
big lumps	
small lumps	
powder	

v For a certain mass of calcium carbonate, the powder has the biggest surface area.

4a A catalyst is a chemical that helps to speed up a reaction without being used up.

b

Catalyst	Volume of gas produced (cm^3)

10 Sound

10.1 Sound, vibrations and energy transfer

1 Any suitable answer.
2 Sound cannot travel through a vacuum as it is the movement of air particles. There are no air particles in a vacuum.
3 Sound travels slower in air than water because the air particles are more spread out than those in water.
4 Sound is produced in a guitar when the string is plucked. The string then vibrates creating sound waves in the air around it.

10.2 Detecting sounds

1 Your ear is like a microphone because it converts the energy of a sound wave into an electrical signal in your auditory nerve.
2 The diaphragm.
3

Part of the ear	What it does
pinna	**gathers the sound waves and directs it to the eardrum**
eardrum	**sound waves make this vibrate and starts the ossicles vibrating**
ossicles	passes the vibration from the eardrum to the cochlea
cochlea	**contains fluid that vibrates and passes the signal to hairs inside it**

4 It would be dangerous to put a sharp object in your ear as you could pierce your eardrum and it would no longer detect sound waves.
5 Yes, a microphone detects sound waves and converts them into an electrical signal using a diaphragm connected to a coil and magnet. A speaker converts an electrical signal into a sound wave by using a cone, like the diaphragm, using a magnet.

10.3 Loudness and the decibel scale

1 Noise is sound that we do not want to hear.
2 40 dB is ten times louder than 30 dB.
3 He could limit the amount of time he listens to music with earphones and reduce the volume of the music he is listening to.
4 Any suitable answers: for example, road worker, builder, aeroplane engineer.
5 Trucks have very noisy engines, they can damage hearing after 8 hours a day, so truck drivers should not drive for long periods to avoid damaging their hearing.

10.4 Loudness, amplitude and oscilloscopes

1 Missing words in order: loud, quiet
2 How loud a sound is.
3 An amplifier increases the amplitude of a sound wave – it will make a sound louder.
4 b and c
5 It is a transverse wave because the rope moves up and down as the wave travels. If it was a longitudinal wave, the rope would move backwards and forwards.
6 The screen of an oscilloscope displays how the pressure on the microphone diaphragm is changing with time. The peaks of the wave are where the pressure is high, a compression, and the troughs are where it is low, a rarefaction.

10.5 Pitch and frequency

1 The string is vibrating 512 times a second.
2 Missing words in order: frequency, shorter.
3 Sound: 30 Hz, 1500 Hz, 4500 Hz.
Ultrasound: 30 000 Hz, 100 000 Hz.
4 whale
5 harmonics

10.6 Making simple calculations

1 The speed of light is approximately 1 million times faster than the speed of sound.
2 Distance = speed × time = 330 m/s × 1.5 s = 495 m. Distance to the wall is 247.5 m.
3 When the storm is directly overhead, Maria will hear the thunder and see the lightning at the same time.
4 There are speakers behind the starting blocks to ensure that all of the athletes hear the start gun at the same time.
5 400 m/s, 1500 km/h

10.7 Echoes

1 A fisherman can use sonar to find fish by using the transmitter and receiver to find out where there are large shoals of fish.
2 Time to the seabed = 4/2 = 2 s. Distance = 1500 m/s × 2 = 3000 m/s
3 Time = distance / speed = 500 m / 1500 m/s = 0.33 s
4 Dolphins can find food at greater distances than bats because sound travels much faster in water than in the air.
5 Time = 0.075 m / 1500 m/s = 0.00005 s

10.8 Review

1 1 – C, 2 – D, 3 – B, 4 – A
2a False
b True
c False
3a closer together
b closer together
c less
4a B and C
b D and F
c A and E
d E
e D
5

Arrow	Wavelength?	Amplitude?	Neither?
A		✔	
B			✔
C		✔	
D	✔		
E			✔
F	✔		

6a A frequency of 1500 Hz means that 1500 vibrations are occurring each second.
b If the frequency increase to 2000 Hz, the pitch would get higher.
7a dB is a decibel – it is a unit of sound intensity.
b Traffic on the way home would sound the loudest.
c To reduce the risk of damaging his hearing he could reduce the volume of the music he is listening to and reduce the amount of time he listens to loud music each day.
8 1 – D, 2 – C, 3 – A, 4 – B.
9a True
b False
c True
d True
10a 0.2 seconds
b Distance = 1500 m/s × 0.2 s = 300 m
c This is the signal from the seabed. The seabed is further from the boat than the fish and any ultrasound that passes through gaps in the shoal will detect the seabed, but it will take longer to return to the receiver than the waves reflected off the shoal.
11a 330 m/s × 4 s = 1320 m
b Adami has assumed that the speed of sound she is hearing thunder from the flash of lightning that she is seeing.
12a The two waves have the same main, fundamental, frequencies.
b The waves have different harmonic frequencies, so they must be different instruments.

11 Magnetism

11.1 The properties of magnets

1 Magnetic: steel, iron, nickel.
Non-magnetic: brass, copper, wool, wood, cotton.
2 Steel – steel can be magnetised.
3a B – north pole, C – south pole, D – north pole.
b Experiment 1 – the magnets will repel each other.
Experiment 2 – the magnets will repel each other.
4a In a magnet there are lots of small regions call domains, each one behaves like a small magnet so when a magnet is broken both parts still have a north and south pole.
b Heating a magnet disrupts the domains and they no longer line up.
c Iron does not stay magnetised because the domains are easy to line up, this means they are also easy to disrupt again and they will not stay lined up.

11.2 Magnetic fields

1 A magnetic field is the region around a magnet where magnetic materials will experience a force.
2 The magnetic field of a bar magnet is strongest at the two poles, because if you plot field lines around a magnet to show the field they are closest together at the poles, indicating the field is strongest here.
3a Diagram showing two north poles with field lines repelling, and north and south pole with field lines from north to south.
b If you place a steel ball at the neutral point nothing would happen.
c Nothing would happen because the two magnetic fields have cancelled each other out.
4 He has not made a magnetic field with the iron filings, he has used the iron filings to show to location of the magnetic field of a magnet.

11.3 Electromagnets

1 An electromagnet could be used to sort a mixture of iron and copper pieces by first switching it on to attract all of the iron to the magnet. The magnet can then be moved and switched off. The iron would fall off in this new location to leave two separate piles of metal.
2 It will reverse.
3a Iron can be easily magnetised to make a strong electromagnet, but it will not stay magnetised when the current is switched off.
b Steel will stay magnetised when the current is switched off.
4 The wire wrapped around the core of an electromagnet is insulated, so it will not flow

through the core. An electromagnet with an iron core is strong because iron is easily magnetised.

11.4 Identifying and controlling variables

1 An independent variable is the one that will be changed during the experiment. A dependent variable is the variable that will change when the independent variable changes.

2a Independent variable – force applied

b Dependent variable – extension

3a surface

b height of the bounce

c They could repeat each measurement to get more accurate results.

d

Surface	Height of bounce (cm)
Surface 1	
Surface 2 …	

11.5 Using electromagnets

1 You would use a relay when you want to control a high voltage or high current circuit that it might be dangerous to control directly.

2a A doorbell circuit is called a 'make-and-break' circuit because when the switch is pressed the current magnetises and electromagnet, which then attracts a metal strip to break the circuit. The circuit continues to be made and broken by the electromagnet being switched on and off for as long as the switch is held down.

b In a relay circuit the armature is either on or off in order to control a different circuit, in a doorbell circuit the armature moves backwards and forwards while the switch is pressed.

c Both types of circuit use electromagnets and armatures to make or break a circuit.

3 You could use an electromagnet to make a burglar alarm. The electromagnet could control the switch of another circuit, the alarm circuit. Whilst the electromagnet is on the armature of the switch is attracted to it and does not complete the alarm circuit. If the circuit was built onto a door or window frame so that the current flowed when they are shut, when the door or window is opened unexpectedly by a burglar the circuit would break, the electromagnet would switch off and the alarm circuit would be completed sounding an alarm.

4 Any suitable answers including: pros – safe, painless, produce more detailed images than X-rays; cons – expensive, the patient must lie still in a small space.

11.6 Review

1a False

b True

c False

d False

2 A, B, C, F

3a A – right, B – down, C – down, D – left.

b Up. Blue magnet horizontal with the north pole on the right, bring the north pole of the green magnet towards the north pole of the blue magnet from below.

4a magnetic field, magnetic field

b field strength, high, poles

c pole

5a Use iron filings to show the field shape, or use plotting compasses to draw field lines.

b The neutral point is where the magnetic field of the two magnets cancel each other out.

c Magnet 1, the neutral point if further from this magnet meaning that the field is as strong as the other magnets field at this point. Because it is further from the magnet it means the field must be stronger.

d Any suitable answer: e.g. Place a steel bead in different places around the magnets until it is not attracted or repelled by either of them.

6 In the first picture the compass needle is aligned with the Earth's magnetic field. In the second picture it has aligned to the bar magnets magnetic field because it is stronger.

7a A magnet that remains magnetised all of the time.

b A material that will be attracted to a magnet.

c The area around a magnet where magnetic metals will experience a force.

d Line that can be drawn to represent the field of a magnet.

e A metal core made of a magnetic material with a coil wrapped around it that only becomes magnetic when a current runs through the wire.

8a North pole at the bottom and south pole at the top.

b Compass needles point north when they align with the Earth's magnetic field. This means that the south pole of the magnetic field is in the northern hemisphere.

c Arrows should point from the north magnetic pole to the south magnetic pole.

d Lodestone is naturally magnetic – if it is placed near a compass the needle will align to its magnetic field.

9a Abasi should wrap the piece of wire around the nail and use the ends to make a circuit with the battery and switch.

b To increase the strength he could wind more coils around the nail, or change the nail to a different material, use a higher voltage battery or use a different kind of wire.

c A, C, D, B

10 a, d

11a iron

b Copper is not a magnetic material, so it would not be magnetised when current flows through the wire. Steel would remain magnetised when the current is switched off.

12a type of core

b strength of the electromagnet

c The number of coils, the current of the circuit, the object the magnet will be picking up, the type of wire.

d Small paper clip – these are most suitable as they are easy to count, but also easy to pick up if the electromagnet is weak.

e

Core metal	Number of paper clips

12 Forces

12.1 Pressure

1

Force	Area	Pressure
150 N	25 cm^2	6 N/cm^2
60 N	15 m^2	4 N/m^2
5 N	0.1 cm^2	50 N/cm^2

2 3 N

3 30 cm^2

4 Each foot is 0.04 m^2

12.2 The effects of pressure

1 The feet of camels and wading birds are wide and flat to reduce the amount of pressure they put on the ground. This means they can walk over sand and wade in mud without sinking.

2 The bird with the larger feet would produce less pressure on the ground.

3 A road bike has a very thin tyre and would produce more pressure than a mountain bike with a wide tyre. It would sink into the soft surface.

4 Horse A would produce a greater mass on the ground because it has a larger mass spread over the same area.

12.3 Pressure in liquids

1 Liquid pressure is due to the force between the particles of the liquid and the surfaces of a container.

2 Pressure is higher at the bottom of the Pacific Ocean than near the surface due to the weight of the water above pushing down on the water at the bottom of the ocean.

3a Hole at the bottom – it is under greater pressure due to the pressure of the weight of water above.

b The pressure is acting at right angles to the surface of the bottle, so the water will move in this direction.

c It slows down because there is less force acting on the water because there is less water.

12.4 Using pressure in liquids

1 A hydraulic jack can be used to lift a car because the pressure applied down over the small area of one piston will be transferred by the liquid to the larger piston, which will then act in an upwards lifting the car.

2 Hydraulic brakes are less effective if there is air in the liquid, because the air can be compressed and so the force is not transferred as effectively.

3

Area of piston A	Force applied to piston A	Pressure in the liquid	Area of piston B	Force produced by piston B
2 cm^2	8 N	**4 N/cm^2**	25 cm^2	**100 N**
5 cm^2	20 N	**4 N/cm^2**	20 cm^2	**80 N**
0.01 m^2 = 100 cm^2	6 N	**0.06 N/cm^2**	0.1 cm^2	**0.006 N**

4 Area is 3 times bigger, so force is 3 times bigger. Force B = 3 × 2 N = 6 N

12.5 Pressure in gases

1 Gas pressure is caused by particles in the gas colliding with the walls of a container.

2 It is possible to compress a gas because the particles are far apart. The particles in a liquid are too close together to be compressed.

3 When you pump up a tyre you are increasing the number of gas particles inside the tyre. These collide with the walls of the tyre more often and the pressure increases.

4 Aircraft cabins have to be pressurised to allow the passengers to breathe. At high altitudes the atmospheric pressure decreases because there are fewer particles in the air, humans are used to the air pressure on the Earth's surface, so we would not survive if the aircraft cabin was not pressurised.

5 The pressure and volume of a gas are inversely proportional, so if the volume was decreased to one-third the size of the original volume, then the pressure would triple.

12.6 Pressure, volume, and temperature in gases

1 Missing words in order: increase, faster, more

2 The circumference of the balloon increased at a higher temperature because the particles began to move faster and spread apart. As the temperature decreased the particles moved slower and were less spread out, so the circumference of the balloon decreased.

3a He could measure the temperature using the thermometer and measure the circumference of the balloon at different temperatures.

b His graph would show that as temperature increases, the circumference of the balloon also increases. The line of best fit would be positive.

4 This is more likely to happen on a hot day as the pressure in the tyre increase with temperature.

12.7 Preliminary work

1 Size of the block of ice, how to apply the force, changed the string for wire, changed the size of the wire.

2 Jabari wore safety goggles to stop anything, like the ice or wire if it breaks, getting into his eyes.

3 It will be difficult to get precise results because his experiment takes a long time.

4 There are advantages to both approaches, but preliminary work avoids wasting time on an experiment that does not work. If Jabari had not done preliminary work he would have wasted a lot time trying to do an experiment that did not work.

12.8 Density

1 Water curves upwards at the edges, you can only see the meniscus if you look straight at the scale.

2a air, petrol, ice, water, flour, silver, lead, gold

b Ice – most solids are more dense than the same material in a liquid or gas state.

3a Material A = 30 g / 2 cm^3 = 15 g/cm^3

b Material B = 8 g / 10 cm^3 = 0.8 g/cm^3

c Material B because liquids are usually is less dense.

4 Bigger.

12.9 Explaining density

1 Iron is a solid but oxygen is a gas at room temperature, so there are more particles of iron in the same volume than of iron making it more dense. Also the individual particles of iron have more mass than those of oxygen.

2 Pumice is less dense than water, but ironwood is more dense than water. Pumice is less dense because it is a volcanic rock with lots of air pockets inside.

3 The particle arrangements in both metals will be similar, so the density is more likely to be a result of different particle masses.

4a Sink in mercury and water.

b Float in mercury, sink in water.

c Float in mercury and water.

12.10 Questions, evidence, and explanations

1 pearl

2 quartz

3 It is very impressive because it took over 700 years for scientist to be able to make as precise measurements of density.

4a Any suitable answers: e.g. Al-Biruni asked a questions, developed an explanation and then collected evidence to see if his explanation was true. Like scientist today he built on the ideas of other scientists. He shared his ideas by writing about them.

b Any suitable answers: e.g. Al-Biruni did not specialise in one area of science like modern scientists. He did not work with a team of other scientists.

12.11 Levers

1 Correct words in order: bigger, smaller

2a C

b A

c B

3 We use tongs in a chemistry lab so that we do not get burned holding test tubes or beakers over Bunsen burners.

12.12 Calculating moments

1 Missing words in order: big, small, equilibrium, moments

2 When a gymnast puts her arms out they cancel out the turning force and help her balance.

3 Clockwise – the right side will move down.

4 450 N × 1.2 m = 600 N × ?, ? = 0.9 m

12.13 Planning

1 Sara repeated her experiment three times for each length to find the average time.

2 Jane timed sets of ten swings and divided by ten to find an average time for one swing.

3 Jane's experiment is better than Diya's minimises the effect of reaction time by timing ten swings and then dividing by ten to find the average time for one wing.

4 Sara's experiment is better than Jane's because she repeats each measurement three times. This will make any anomalous results more obvious.

5 It is easier to time when the mass is at the top of the swing than at the bottom, because it is stationary briefly. At the bottom of the swing the pendulum is moving at its fastest and it is difficult to tell when it passes the same point.

12.14 Centre of mass and stability

1 When you swing backwards in a chair a turning force is being applied around the pivot, which is the back two legs. Normally the centre of mass of a chair is between the front and back legs, but when you are swinging on it this moves towards the back legs. Up to a point the turning force is acting to bring the chair back onto all four legs. But if you swing too far the centre of mass moves to the other side of the pivot and the turning force causes the chair to fall over.

2 As more acrobats are added to the top the centre of mass moves higher. If the centre of mass is high the pile is less stable and it takes less force for it to topple.

3 The centre of mass should be on the handle close to the head of the brush, because most of the mass of the brush is in the head.

4 It is difficult to balance a pencil on its point because the centre of mass is very high and it does not take much movement for it to topple over.

12.15 Review

1

Quantity	Unit name	Unit letter
time	second minute hour	s m h
force	**newtons**	**N**
area	**cm^2 m^2**	**centimetres squared, metres squared**
pressure	**Pascals N/m^2 N/cm^2**	**Pascals, newtons per metre squared, newtons per centimetre squared**
density	**g/cm^3 kg/m^3**	**Grams per centimetre cubed, kilograms per metre cubed**
volume	**cm^3 m^3**	**centimetres cubed metres cubed**
mass	**g kg**	**grams kilograms**
moment	**Ncm Nm**	**newton centimetres newton metres**

2

Force (N)	Area (m^2)	Pressure (N/m^2)
100	2	**50**
250	**50**	5
1200	6	200
5	0.1	**50**
0.01	0.25	0.04

3a The pressure will be higher in the glass of fruit juice because there is a greater mass of liquid.

b C, B, A

4a Pressure = 5000 N / 0.25 m^2 = 20 000N/m^2

b Force = 20 000 N/m^2 × 0.01 = 200 N

c Liquids are used because they cannot be compressed and so they transfer the force from one piston to another. Gases would be compressed and not transfer the force.

5a The volume of the balloon will increase.

b When the gas particles warm up they have more thermal energy and move faster and further apart increasing the air pressure in the balloon. The balloon can stretch so the volume increases.

6a 10 cm × 20 cm × 6 cm = 100 cm^3

b Density = 240 g / 100 cm^3 = 2.4 g/cm^3

7a False

b True

c True

d True

8 If the fish fills its swim bladder with air it is decreasing the density of its body. The density of air is so low that the fish is now less dense than the water around it and it rises.

9 c

10a 6 s / 10 = 0.6 seconds

b One swing is so short that your reaction time would have a big impact on the accuracy of the measurement.

c Mass has no effect on the period of the swing.

11 b

12a Moment = 10 N × 2 m = 10 Nm

b Moment = 2 N × 0.4 m = 0.8 Nm

c Moment = 0.1 N × 0.2 m = 0.02 Nm

13a It will go down at the end where Maria is sitting.

b He should sit halfway between the pivot and the end of the see-saw.

c No, Jamal weighs less than Ryan so he would need to be sitting further away from the pivot to balance the see-saw. This is not possible if Ryan sits at the end of the see-saw.

13 Energy

13.1 Hot and cold

1 Temperature is a measure of how hot or cold something is. Thermal energy is heat.

2 Missing words in order: faster, gas, solid.

3 It takes more energy to heat up 1 kg of water because it has a greater mass. There are more particles in a greater mass, so more energy must be transferred to get them all moving faster.

4 It takes longer to boil a kettle of water, than to heat the same kettle water to a lower temperature because you need to transfer more energy to get the particles moving even faster to reach the higher temperature.

13.2 Energy transfer: conduction

1 A conductor transfers thermal energy very quickly. An insulator transfers thermal energy slowly.

2 It would take a very long time to heat water in a saucepan that is made of a material that is not a good conductor. To heat water enough thermal energy must be transferred to make all the particles move faster, if this is transferred at a slow rate it will take a long time to reach this point.

3a A drysuit keeps a diver warm because it traps a layer of air between the suit and the skin. Air is a poor conductor so thermal energy is not conducted away from the body and the diver stays warm b A drysuit keeps a diver warmer than a wetsuit.

c When a diver wears a wetsuit there is no layer of air between the suit and the skin, water is also an insulator but not as good as air, so thermal energy is conducted away from the body much quicker than if there were a layer of air, cooling the diver down.

4 A blanket is normally made of material that is a poor conductor of thermal energy. It will keep you warm because thermal energy is not being conducted away from the body as quickly as it would be without the blanket.

13.3 Energy transfer: convection

1 Conduction is the transfer of thermal energy through a substance by increasing the energy of particles. Convection is the transfer of thermal energy by the movement of the substance.

2 When particles in a gas are heated they gain more energy. These particles move further apart because they have more energy and the warm gas becomes less dense. A less dense, warmer, gas will rise above a more dense, or cooler, gas.

3a anticlockwise

b As the air warms it will become less dense and rise, but then as it moves away from the Earth's surface it will cool and its density will decrease causing it to sink. Therefore the red part of the circle must be gas moving away from the Earth's surface, and the blue gas must be moving towards the Earth's surface.

4 There are no convection currents in solids because the particles cannot move in a solid, they only vibrate on the spot, when they are heated they just vibrate faster.

13.4 Energy transfer: radiation

1a The image is created using measurements of infrared radiation. We cannot see infrared because the wavelength is longer than the visible range.

b The person does not emit light because they are not producing enough thermal energy. On object will producing visible light if it is emitting enough thermal energy as radiation.

2 The fire is producing energy that is being transferred as thermal radiation.

3 The atmosphere does not trap heat, it absorbs and re-emits thermal radiation that was emitted by the Earth's surface, but this has come from the Sun originally.

4 Icecaps melting, changes in weather patterns.

13.5 Cooling by evaporation

1 Liquid does not evaporate because it boils away. A liquid only boils when the average temperature of a liquid reaches its boiling point, but it can evaporate at much lower temperatures. This is because some molecules in a liquid have more energy than others, some of these molecules have enough energy to leave the surface of the water and become a gas molecule – they evaporate.

2 Water will evaporate faster if the air around it is warmer because energy from molecules in the air will transfer to water molecules when they collide. This increases the number of molecules in the water with enough energy to evaporate into the air.

3 Your hands feel cool if they get wet because thermal energy from your skin will transfer to the molecules of water. Some molecules will have enough energy to evaporate and when they do the average temperature of the liquid will decrease and the liquid will get cooler.

4 Evaporative coolers need a supply of electrical energy to power the fan.

13.6 The world's energy needs

1a A primary energy source are sources of energy that can be used directly, some of these sources of energy are used to create secondary energy sources.

b Petrol is a secondary energy source because it is produced from oil, a primary energy source.

c Oil is primary energy source because it can be used to produce energy directly.

2a coal

b oil

c ten-times bigger

3 A renewable source of energy will not run out, like wind power or solar power. A non-renewable source of energy will run out, like oil or gas, because there is only a limited amount available.

4 China, India, and Indonesia

13.7 Fossil fuels

1 Missing words in order: water, steam, turbine.

2 You need to build a fossil-fuel power station near a river or the sea so that it has a constant and large supply of water.

3 Coal and oil are both formed by thermal energy and pressure transforming the remains of living things into a useful fuel. Coal is created from the remains of plants and oil is created from the remains of dead sea creatures.

4 Coal, oil, and gas are called fossil fuels because they are created from the remains of plants and animals that lived millions of years ago.

13.8 generating electricity

1 Induced voltage is voltage generated when a magnet is moved near a coil of wire, or a coil of wire is moved near a magnet.

2 A bicycle dynamo is much smaller than a power station generator. It also uses a permanent magnet rather than an electromagnet like the power station generator.

3 The voltage will be negative because the field direction has been reversed.

4a A bicycle dynamo is more environmentally friendly than using batteries, and it will never run out.

b The voltage of the light will depend on how fast you are cycling, and if you stop, for example at a traffic light, then your light will turn off, which is very dangerous.

13.9 Renewable energy: solar and geothermal

1 You need to connect lots of solar cells together because each one does not produce much voltage on their own.

2 70% of energy is wasted in a modern solar cell.

3 A modern solar cell is six times more efficient than an older one.

4 The source of geothermal energy is the thermal energy of the Earth's core and magma beneath the crust. Some of this is stored energy and some is generated by nuclear reactions.

5a Both power stations use thermal energy, from beneath the Earth or from burning coal, to heat water to produce steam that then turns a turbine and generator to produce electricity.

b The coal power station burns coal to produce the thermal energy to boil the water to make steam. But the geothermal power station heats the water by pumping it down below the surface of the Earth.

6 You would need four solar power stations to produce the same power as the Olkaria II geothermal power station.

13.10 Renewable energy: using water and wind

1 Tidal power and hydroelectric power both generate electricity from water trapped behind a dam or barrage flowing through turbines and turning a generator.

2 Wind power and wave power are not free – there is a cost to building a wind farm or a wave power station.

3a Any suitable answers: The main advantages of wind power are that it does not produce greenhouse gases. The main disadvantages of wind power are that it is an unreliable source of power, and the turbines contribute to noise and visual pollution.

b Any suitable answers: The main advantages of hydroelectricity are that it can be produced on demand when it is needed, and it does not produce greenhouse gases. The main disadvantages are that it is expensive to build a hydroelectric power station, it cause flooding and environmental damage behind the dam.

4 All methods produce greenhouse gases whilst they are being constructed both to make the materials they are built from and to provide the power for building. Once they have been built they do not produce greenhouse gases.

13.11 Energy for the future

1 Yes, biomass is a renewable fuel because the plants can be regrown.

2 You do not see many cars powered by hydrogen because

3a Payback time is how long it takes to save the cost of installing something.

b Payback time = 24 000 / 3000 = 8 years

4 It is difficult to decide which is the best source of energy to use because all of them have their advantages and disadvantages. Deciding which one is best is a matter of opinion and different people will have different opinions

13.12 Review

1a temperature

b energy

c more

2a The substance you are heating, and the mass you are heating.

b C, A, B

3a Saucepans are made of metal because it is a good conductor of thermal energy and will heat the contents of the saucepan quickly.

b Black clothes dry quicker in the Sun that white clothes because they absorb more infrared radiation.

c A breeze comes onto the land during the day because the land warms up when the Sun hits it. This then warms the air above the land, which becomes less dense and rises drawing air in off the sea to take its place.

d A bird plumps up its feathers when it is cold because this increases the amount of pockets of air between the feathers. Air is a good insulator and stops the bird losing so much thermal energy.

4a The thermometer with the bulb covered in black paper.

b The black paper absorbs the energy from the bulb and warms up. The foil reflects more of the heat and does not warm up as much.

5a Some of the thermal energy of the tea is conducted through the cup to the table and into the environment. This cools the tea.

b Convection

c Radiation

d Putting a lid on the top of the cup of tea will reduce the amount of thermal energy lost to the surroundings keeping the tea warmer for longer.

6a The greenhouse effect warms the Earth's surface as heat from the surface after it has been warmed by the Sun is emitted. This heat is absorbed by greenhouses gases and some is emitted back towards the surface keeping the atmosphere warm.

b The greenhouse effect is a good thing as it means the Earth is warm enough to support life.

c The greenhouse effect is a problem because it is contributing to climate change.

7a Infrared radiation from the Sun is absorbed by the drink warming it up. Inside the house the drink would not be exposed to the infrared radiation from the Sun.

b The can is cooler because water evaporates from the pot lowering the average temperature of the rest of the water. This cools the pot because the water has sunk into it and its contents.

c He has to keep pouring water over it so that water can keep evaporating, as once it has all evaporated the pot will warm up again.

8a B, D, F, H, I, J, L

b A, C, E, G

c A, C, G, I

d A, C, G, L

e D, H, J

f Electricity is a secondary energy source, all of the rest are primary sources.

9a False

b False

c True

d True

e False

10a E

b B

c A

d D

e C

f Turbine, generator, water, steam.

g Turbine and generator.

11a Hydroelectricity

b Coal, oil, gas and biomass.

c Hydroelectricity, tidal

d Sunlight, wind, and waves.

e Coal, oil, hydroelectricity, uranium, gas, biomass.

12a 40 m^2

b 300 kg

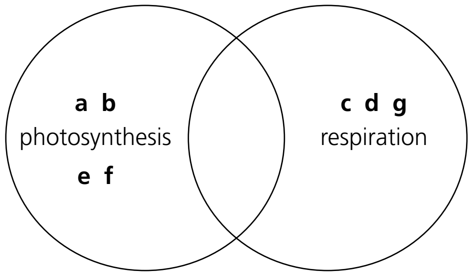
c Maximum – the amount of energy that solar panels produces depends on the weather. This information has been provided by the company that sells them, so it is likely they will use the best figures possible.

1 Plants

1.1 Why we need plants

1 The missing words are: biomass, photosynthesis, energy, carbon dioxide, water, oxygen, respiration.

2



3 Palisade cells – contain most chloroplasts to absorb light.
Stomata – tiny pores which let gases in and out of leaves.
Xylem vessels – hollow tubes that carry water up from the roots.
Mesophyll cells – form a spongy layer which gases can diffuse through.

E In summer there is more light so more photosynthesis takes place and the glucose that isn't needed is stored as starch. In winter there is less light, less photosynthesis takes place, and the plant's glucose stores are depleted.

1.2 Asking scientific questions

1 The missing words are: variables, changed, measured, more, repeat, reliable.

2 **a** S **b** NS **c** NS **d** S **e** S

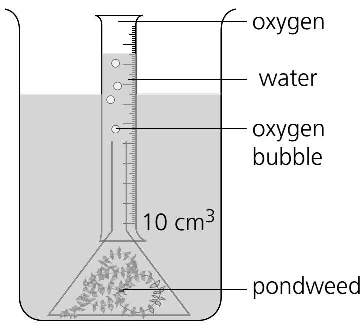
3a The volume of water the plant receives.

b The increase in height or mass.

c Any two from: the age, height, mass, number of leaves and type of plant; the amounts of light, minerals, carbon dioxide and space they are given.

4 **a** B **b** B **c** L **d** L **e** B

Ea Set up the apparatus shown below in each beaker. Make sure the pondweed in each beaker is identical, has the same temperature, and receives the same amount of light.



Time how long it takes to produce a specific volume of oxygen, or measure the volume of oxygen produced in a certain time.

b Up to a certain point, the plants will carry out photosynthesis faster when they have more carbon dioxide, because carbon dioxide is needed for photosynthesis – so the measuring cylinders will fill faster. After a certain point, adding more carbon dioxide will make no difference because the plants cannot make food any faster without extra light, minerals, or a higher temperature.

1.3 Water and minerals

1 The missing words are: water, photosynthesis, absorb, vacuoles, cell, support, wilt.

2 **A** Water evaporates through stomata.
B Moves up through xylem vessels.
C Taken in through root hair cells.

3 Plants continually lose water because it evaporates from their leaves.
There are pores on the undersides of leaves to allow carbon dioxide to enter them.
Root hairs give plants a large surface area to help them absorb more water.
Water flows from the roots to leaves because it is pulled up xylem tubes to replace the water that evaporates.
Plants lose less water at night because their stomata close.

Ea Root cells need oxygen for respiration.

b A shortage of oxygen reduces the rate of respiration so less energy is available and fewer minerals can be taken in.

2 Circulation

2.1 Blood

1a Clockwise from the top right the labels are: platelet, red blood cell, plasma, white blood cell.

b Most cells look paler in the centre because red blood cells are biconcave – thinner in the middle.

2a Red blood cells.

b White blood cells.

c Red blood cells.

d White blood cells.

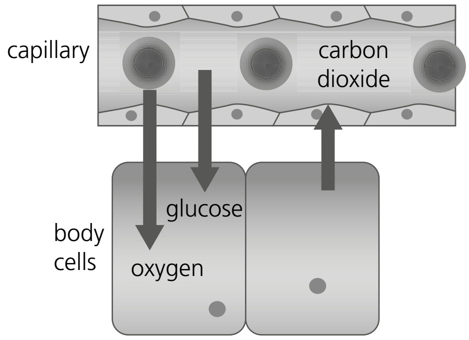
e Plasma.

f Plasma.

g Platelet.

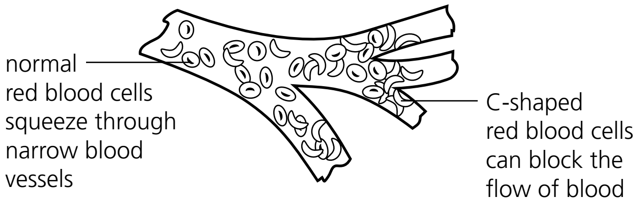
h Red blood cell.

3a Labels should be added to the diagram as shown below.



b Molecules move in and out of the blood by diffusion. They move from where they are concentrated to where their molecules are more spread out.

E The symptoms of sickle-cell anaemia include severe pain in tissues all over the body. People born with sickle-cell anaemia have faulty haemoglobin. It makes red blood cells curve into long thin C shapes which can block narrow blood vessels and leave tissues short of oxygen.



2.2 Anaemia

1 **a** T **b** F **c** F **d** T
e F **f** T **g** F

b Anaemia prevents blood from carrying enough **oxygen**.

c Anaemic blood contains fewer **red** blood cells than normal.

e **Low** packed cell volume shows that a patient has anaemia.

g You can reduce the symptoms of anaemia by eating **more** red meat.

2a 14.5 g per 100 cm^3 = 145 g/dm^3

b Patient C has anaemia – they have a low red blood cell count, a low haemoglobin level, and a low packed cell volume.

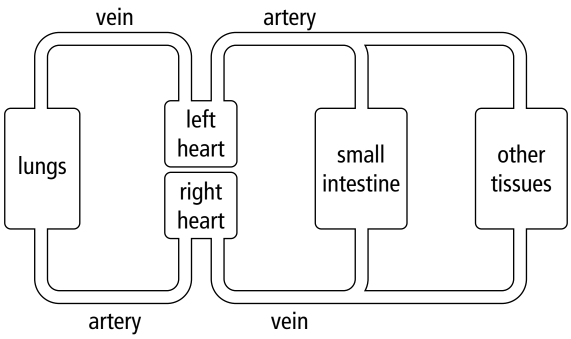
c Patient A is male – they have the highest red blood cell count, haemoglobin level, and packed cell volume.

3 A patient with anaemia has fewer red blood cells in the same volume and the cells are smaller and paler (because they contain less haemoglobin).

2.3 The circulatory system

1 The missing words are: arteries, veins, lungs, oxygen, body, and cells.

2 **a, c** The diagram should be labelled as shown below.



b The top half of the diagram should be coloured red and the bottom half should be coloured blue.

3a As blood passes through capillaries in your lungs it gains oxygen and loses carbon dioxide.

b As blood passes through capillaries in your small intestine it gains glucose and carbon dioxide and loses oxygen.

E Valves are found in veins (or in the heart). They are needed to prevent blood from flowing in the wrong direction.

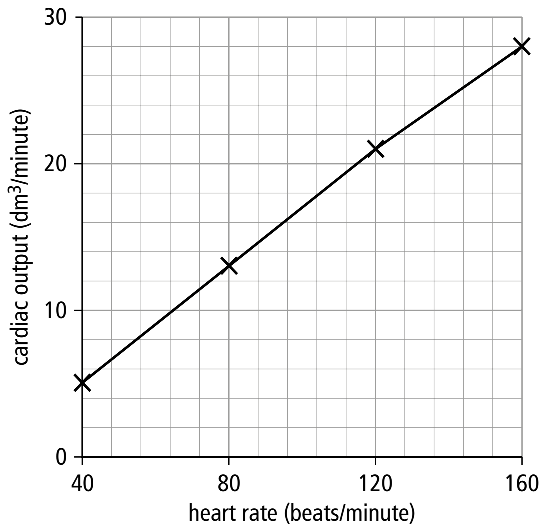
2.4 Identifying trends

1 The missing words are: faster, efficient, decreases, heart, shortens, time.

2a A is fittest.

b A has the lowest resting heart rate and the shortest recovery time.

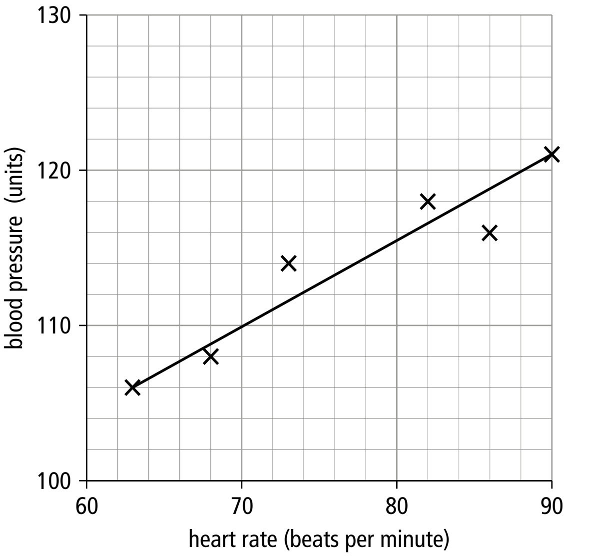
3a Graph as shown below.



b There is a positive correlation between the athlete's cardiac output and their heart rate. Their cardiac output changes by the same amount for each increase in their heart rate. Credit any attempt to describe the pattern quantitatively, e.g. when the heart rate is 40 beats per minute, the cardiac output is 5 dm^3/minute. The cardiac output rises to 28 dm^3/minute when the cardiac output is 160 beats per minute. The cardiac output increases by about 0.2 dm^3/minute for every extra beat per minute.

c An athlete's heart rate needs to increase when they run faster to supply extra oxygen (and glucose) to their muscles so they respire and release energy faster.

E Graph as shown below.

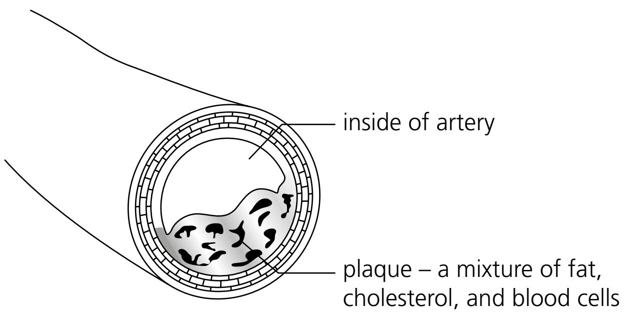


a There is a positive correlation between her heart rate and her blood pressure. Credit any attempt to describe the pattern shown by the line of best fit quantitatively, e.g. her blood pressure increases by about 0.5 units for every extra beat per minute.

b Her blood pressure would be between 114 and 116 units if her heart rate was 80 beats per minute.

2.5 Diet and fitness

1a The diagram should be labelled as shown below.



b blockages like this raise blood pressure.

2 The correct order is: C, E, B, G, D, F, A, H.

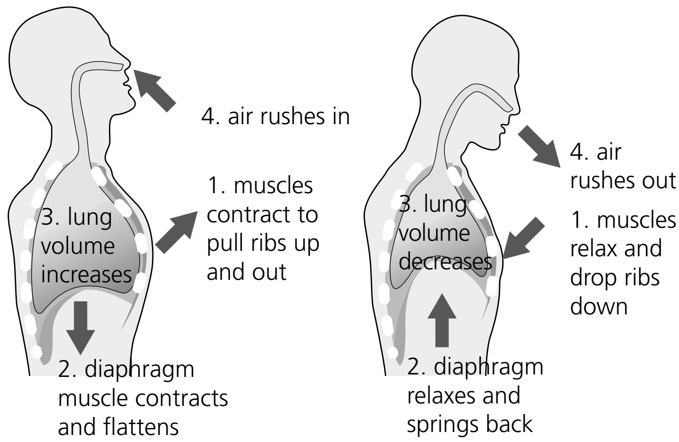
3 Patient B's diet increases their risk of having a stroke because it contains processed food, which could be high in saturated fats and salt, and a sugary snack and drink. A diet containing large amounts of sugar and fat will increase the patient's risk of becoming overweight and developing a high blood pressure, which could cause a stroke.

E The office worker should: stop smoking, ensure they take regular exercise, try to reduce their blood pressure.

3 Respiration and brathing

3.1 Lungs

1 Labels should be added to the diagram as shown below.



2 Clockwise from the top right the labels are: trachea, bronchus, bronchiole, alveoli, diaphragm, lung, rib.
Arrows should be added to show air travelling through the trachea, one of the bronchi, and a bronchiole, to reach a bunch of alveoli.

3 The missing words are: muscles, ribs, lungs, bronchioles, alveoli, diffuses, leaves, exchange.

E Alveoli allow rapid diffusion between blood and air because they have a good blood supply and thin walls and they provide a large surface area. (Also, the inner surface of each alveolus is covered with a thin layer of moisture in which gases dissolve.)

3.2 Respiration and gas exchange

1 The missing words are: blood, alveoli, energy, glucose, cells, exercise, exchange, oxygen.

2

Gas	Breathed in air (%)	Breathed out air (%)
oxygen	21	**18%**
carbon dioxide	0.03	**3%**
nitrogen and other gases	79	79

Credit any values that produce a total of 100% and show that there is still some oxygen in the breathed out air.

3a Breaths in 10 seconds = 3
Breaths in 60 seconds = 18

b She takes in 0.5 dm^3 of air with each breath.

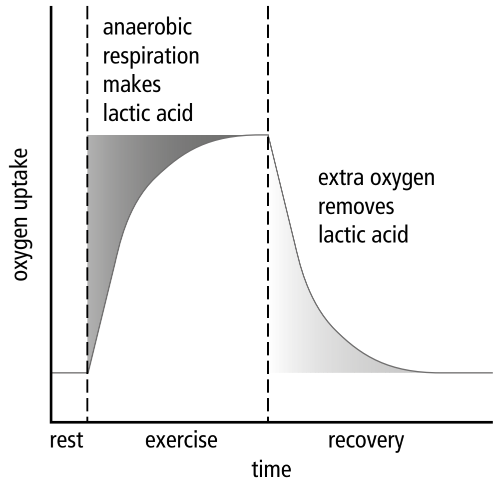
c The graph should show the peaks getting taller and closer together as she breathes faster and deeper.

E After training at high altitudes athletes' bodies make more red blood cells and grow extra capillaries in their muscles. This allows them to take more oxygen out of the air so their ventilation rate drops.

3.3 Anaerobic respiration

1 Glucose + oxygen → carbon dioxide + water
Glucose → lactic acid

2a Labels should be added to the diagram as shown below.



b Anaerobic respiration can't be used all 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.

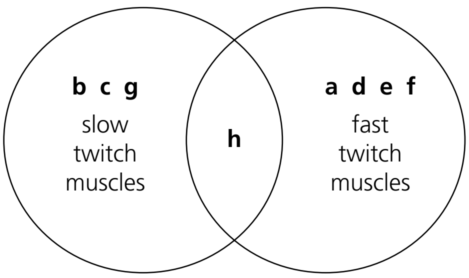
3 **a** T **b** F **c** T **d** F **e** F

b **Anaerobic** respiration provides only short bursts of energy or aerobic respiration **provides a continuous supply of energy**.

d Anaerobic respiration releases **a smaller** percentage of the total energy in glucose **than** aerobic respiration.

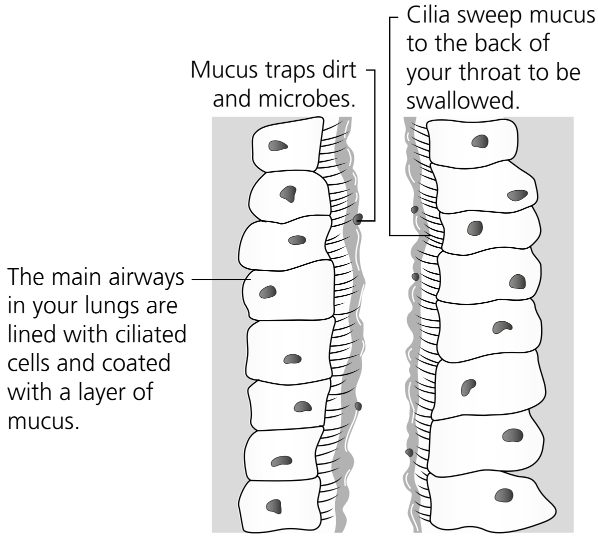
e **Aerobic** respiration is the main type used in marathons *or* anaerobic respiration is the main type used in **sprints**.

4 Letters should be added to the diagram as shown below.



3.4 Smoking and lung damage

1a Labels should be added to the diagram as shown below.



b Any six from the following.
Cilia are paralysed (stop moving).
Dirt, microbes, and chemicals from cigarette smoke build up in the mucus;
Oxygen uptake slows.
Lung infections increase.
Mucus is coughed up.
The airways become narrower.
Breathing becomes difficult.
The alveoli walls break down.
The surface area available for gas exchange is reduced.

c Smokers are more likely to suffer from lung cancer and heart disease.

2 The missing words are: harmful, cilia, cancer, reduces, raises, narrower, heart, addictive.

E Mohamed is the smoker. His race time is slower because his lungs are damaged. They take up oxygen more slowly so his muscles respire more slowly and release energy more slowly.

3.5 Communicating findings

1 The missing words are: clearly, pictures, explanations, details, relevant.

2a Your Peak Expiratory Flow (PEF) shows how fast you can blow air out of your lungs.

b Asthma makes it harder to breathe. When someone has asthma, the tubes that should let air into their lungs become too narrow.

3a 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.

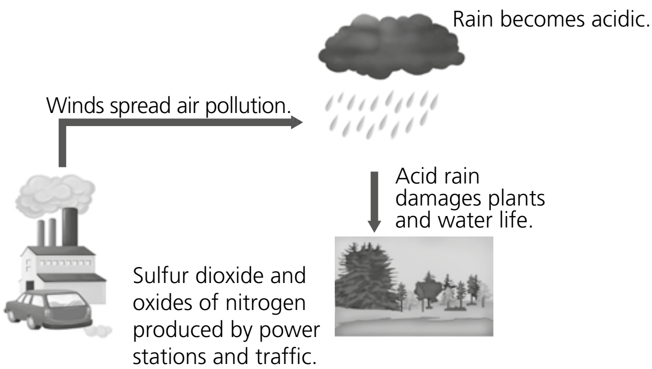
Ea The explanation uses a lot of scientific words which patients with no scientific knowledge may not recognise or understand.

b Students should rewrite the explanation in the Student book without using scientific terms, e.g. healthy lungs keep themselves clean but the chemicals in cigarette smoke shut down the cleaning process. Then dirt and micro-organisms get trapped in your lungs and cause infections.

4 Human influences

4.1 Air pollution

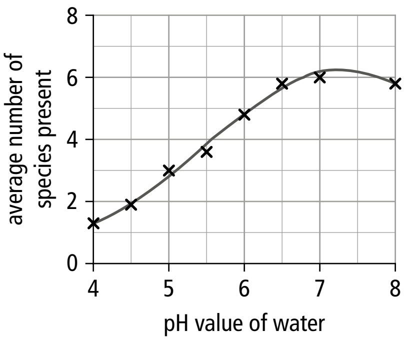
1 Diagram as shown below.



2 **A** Heavily polluted air.
B Clean air.
C Slightly polluted air.

3 **a** Decreased. **b** Decreased.
c Increased **d** Increased

Ea Graph as shown below.



b Between pH values of 4 and 6.5, the average number of species present increases as the pH value increases – by about 2 species per pH unit; between pH values of 6.5 and 8, the average number of species present shows no significant change.

c It was important to have a lot of lakes in each group to give a reliable result.

d Flue gas desulfurisation captures sulfur dioxide, the gas that causes acid rain, before it escapes from power stations. Catalytic converters remove oxides of nitrogen from petrol engine exhausts.

4.2 How scientists work

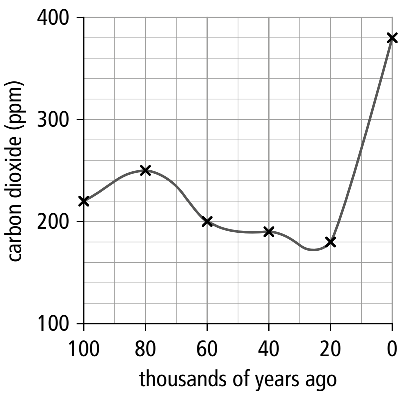
1 Joseph Fourier wonders why Earth is warm – ask a question.
Joseph Fourier writes: the atmosphere must trap the Sun's heat – suggest an explanation.
John Tyndall measures how much heat gases absorb – test the explanation.
John Tyndall finds that a small amount of carbon dioxide traps a lot of heat –check the evidence.

2 Svante Arrhenius predicted: Doubling the amount of carbon dioxide in the atmosphere would make it 5 °C warmer and we could easily double the amount of carbon dioxide by burning fossil fuels.

3

Measurements taken	What the evidence shows
past temperature readings from weather stations all over the world	Earth's average temperature is rising
the thickness of tree rings, which show how fast trees grew each summer	Earth's temperature has risen and fallen in the past
the amount of carbon dioxide trapped in layers of ice which shows how much was in the atmosphere	the amount of carbon dioxide in the atmosphere has risen and fallen in the past

Ea Graph as shown below.

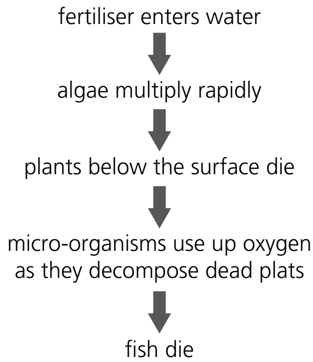


b Carbon dioxide levels are 200 ppm higher than they were 20 000 years ago.

c Many scientists worry that carbon dioxide levels are rising faster than they ever have in the past 100 000 years.

4.3 Water pollution

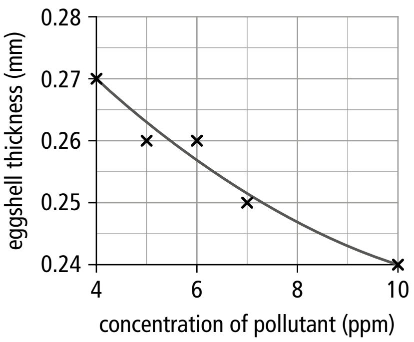
1 The labels shown below should be added to the diagram.



2 **a** Rise **b** Rise **c** Fall **d** Fall.
e Rise **f** Rise **g** Rise
h Fall **i** Fall **j** Fall

Ea Invertebrates absorb the pollutant from sea water and store it in their fat. When fish eat the invertebrates the pollutant goes into their bodies. Moving along the food chain the concentration of pollutant gradually builds up because each predator eats a lot of prey. This is bioaccumulation.

b Graph as shown below.



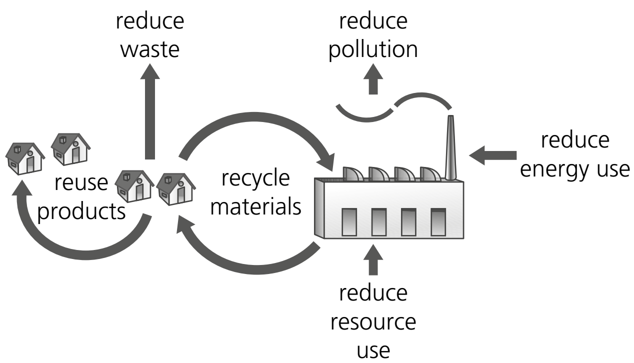
The graph shows that eggshell thickness decreases as the concentration of the pollutant increases.

c Fewer birds may be raising offspring successfully because their egg shells are too thin and this makes them crack easily.

4.4 Saving rainforests

1 **a** Positive **b** Negative **c** Positive **d** Negative
e Negative **f** Positive **g** Negative **h** Positive
i Negative **j** Negative **k** Negative

2 The labels shown below should be added to the diagram.



3a Aluminium
b Paper
Ea South America has the largest area of forest.
b Africa and South America have lost most forest in recent years.

5 Variation and classification

5.1 Using keys

1a B
b It has hollow fangs, a heart-shaped head and 18–22 V-shaped stripes.
c A is another Bitis species because has hollow fangs and a heart-shaped head but a different pattern; C is another venomous viper because it has hollow fangs but its head is not heart shaped.

2 The words shown below should be added to the table.

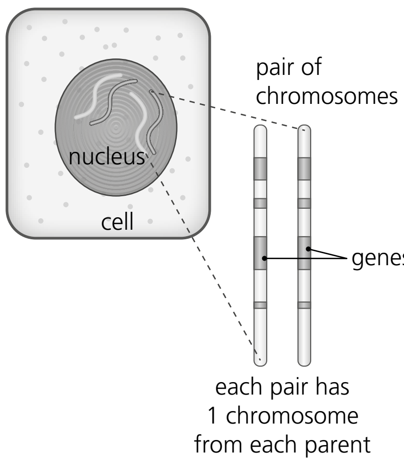
cats with spots **cheetah and leopard**		cats with no spots **lion and caracal**	
cats with spots in groups **leopard**	cats with separate spots **cheetah**	cats with rounded ears **lion**	cats with pointed ears **caracal**

E Credit any unambiguous numbered key, e.g.

1	Has long legs	see 2
	Does not have long legs	see 3
2	Has a long thin neck	ostrich
	Has a short neck	stilt bird
3	Has a thin long thin beak	see 4
	Has a short beak	see 5
4	Flies	humming bird
	Does not fly	kiwi
5	Has webbed feet	puffin
	Has feet with claws	parrot

5.2 Chromosomes

1a The labels shown below should be added to the diagram.



b The nucleus in the diagram has two pairs of chromosomes, but real human cells have 23 pairs. The chromosomes in the diagram each contain four different genes, but real human chromosomes contain up to 1000 genes.

c Females have two X chromosomes but males have an X chromosome and a Y chromosome.

2 **a** Both. **b** Both. **c** Chromosomes. **d** Chromosomes. **e** Genes. **f** Genes. **g** Chromosomes.

Ea Children who suffered severe maltreatment had a higher index of antisocial behaviour than those who did not, whether they had low or high enzyme activity. When children with low enzyme activity suffered severe maltreatment, their index of antisocial behaviour was much higher than for children with high enzyme activity.

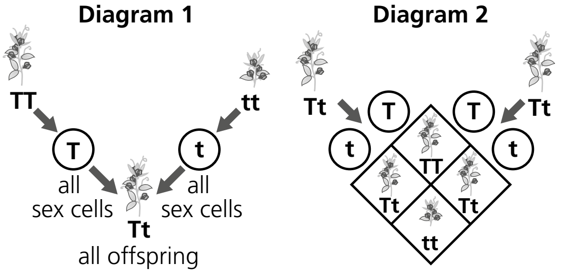
b Genes don't always decide your exact characteristics. Genes and environmental factors work together to produce most of your characteristics.

5.3 Investigating inheritance

1 To learn about inheritance, Mendel looked at the features pea plants passed to their offspring.
He worked with pea plants because it was easy to control which male pollen fertilised each female ovule.
When pollen from tall plants fertilised short pea plants all the offspring in the second generation were tall.
When tall plants from the second generation fertilised each other some of their offspring (the third generation) were short.
Mendel realised that two 'factors' control each inherited feature – one from each parent.
When peas inherit two different 'factors' the dominant 'factor' stops the other one having an effect.

2 **a** Tall. **b** Short. **c** Tall.

3 The labels shown below should be added to the diagram.



4 **a** Recessive. **b** Dominant. **c** Recessive.

5.4 Selective breeding

1 Wild cats show a lot of variation because each cat inherits a unique combination of genes.
Pet cats were produced by selecting which cats were allowed to breed together.
Each parent cat had some desirable features so their offspring could inherit them from both parents.
The best offspring were used to produce the next generation so eventually all the offspring had the desirable features.
Over many generations different breeders produced cat breeds with very different characteristics.

2a Cows A and E.

b Cows B and D.

E Parent plants that produced long bananas or bananas with fewer or smaller seeds were selected and bred together.
The offspring that produced bananas with the desired characteristics were used to produce the next generation.
Over many generations plants were produced that made long bananas with no seeds.

5.5 Developing a theory

1 The missing words are: explain, questions, explanations, evidence, scientific, observations.

2 Rocks change gradually over many years – the Earth is very old.
Fossilised mammals have skeletons similar to modern animals but not identical – mammals have changed over time.
Different birds are found on different Galapagos Islands – over many generations, each population changed in different ways.
The birds on each island have beak shapes that suit the food they eat – birds with well adapted beaks survive and pass their genes to the next generation.

Ea Mammal skeletons provide strong evidence that they share the same ancestor because they have a similar number of bones arranged in the same order but their sizes and shapes are different in each species.

b The bats' finger bones are extended so they hold out its wings to give a large surface area to help it fly. All the bones are very thin to reduce their mass, which also makes flight easier.

c The arm bones are very short and wide for strength and the central finger bones are extended to give the fin a streamlined shape.

5.6 Darwin's theory of evolution

1 The missing words are: characteristics, offspring, generation, common, evolution.

2 Evolution – the way natural selection can turn populations that become separated into different species.
Variation – the differences between individuals that make some more likely to survive and reproduce.
Overproduction – the huge number of offspring that most living things produce.
Survival of the fittest – the survival of individuals best adapted to their environments.

Natural selection – the way environmental factors such as predators and the food supply influence survival.
Species formation – the way plants and animals change over many generations.

3a White fur provides better camouflage in the Arctic which makes it easier for bears to catch their prey.

b Bears with white fur are more successful hunters so they are more likely to survive and reproduce. The genes that made them successful are passed to the next generation. Over many generations these genes become more common and the whole population may eventually have white hair.

Ea Antibiotics are medicines used cure infections by destroying bacteria.

b When antibiotics are used they destroy the bacteria with least resistance first. Any resistant bacteria left will reproduce and pass the genes that made them resistant to future generations. Over many generations the whole population could become resistant.

5.7 Moving genes

1 The missing words are: engineered, products, insulin, diabeties, milk, separated, diabetics.

2a Genetic engineering.

b Plasmids.

c Pharming.

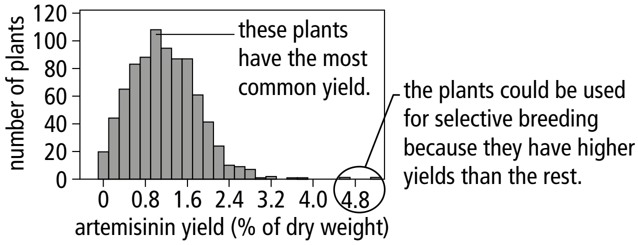
3 Scientists can move genes from one species to another because the genes in all living things are made from the same chemicals.
Any gene put into a fertilised egg is copied every time it divides so every cell in the plant or animal produced has a copy of the gene.
It is easier to transfer genes to bacteria than to plant or animal cells because bacteria have no nucleus. Their genes are loose in the cytoplasm.
New genes are often added to plasmids because these can be moved in and out of bacterial cells.
Bacteria with added genes can make large amounts of useful proteins because bacteria can grow and reproduce rapidly in large tanks.

4 Students should list two medical products made by genetically engineered bacteria and say what they are used for, e.g. clotting factors to treat people with haemophilia, whose blood does not clot when their blood vessels are damaged; human growth hormone to help short children grow taller.

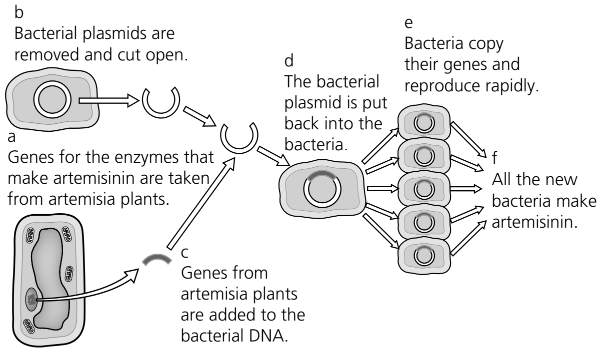
5.8 Using genes

1 The missing words are: malaria, complicated, breeding, genetic, yeast, reproduce, medicine.

2 The labels shown below should be added to the diagram.



3 The labels shown below should be added to the diagram.



4 Students should produce a definition of synthetic biology and two things it might be used for in the future, e.g. synthetic biology is the design and construction of useful biological systems. In the future synthetic biology could be used to build new strands of DNA which could be placed into living cells to make them do things that living cells have never done before such as make fuels or plastics, or destroy pollutants.

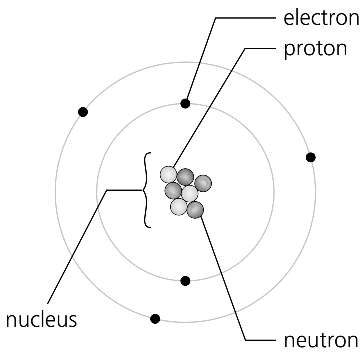
6 Material properties

6.1 Atomic structure

1

Phenomenon	The solid sphere model of atoms *can* explain this.	The solid sphere model of atoms *cannot* explain this.
Diffusion	✔	
Chemical reactions		✔
Changes of state	✔	
Atoms joining together		✔

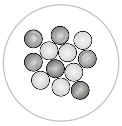
2



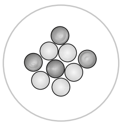
3

Sub-atomic particle	Relative charge	Relative mass
Proton	+1	**1**
Neutron	**0**	**1**
Electron	**–1**	$\frac{1}{1840}$

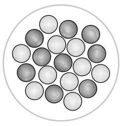
4a 5
b 19
c 28
d 33
5a



b



c



E In an atom of beryllium, there are 4 protons, 4 electrons and 5 neutrons with a total relative mass of 9 and 5/1840. The majority of the mass (99.97% of the atom's mass) is in the centre of the atom whilst the remaining is found in the outside of the atom.

6.2 Finding electrons

1a From top to bottom: i, iii, ii, iv
b The cathode ray bent towards the positively-charged metal suggesting that the cathode ray is negatively-charged (because it is made up of electrons).
c think creatively
E A paragraph comparing the findings from the table.

6.3 Discovering the nucleus

1a A or B or C or F
b D or E
c G
2 nucleus, mass, positive, electrons, orbitals
3

Observation	Explanation
Most particles travel straight through the foil.	These particles travelled very close to a positively-charged nucleus.
A very few particles bounce backwards off the foil.	These particles hit a positively-charged nucleus.
Some particles change direction slightly when they travel through the foil.	These particles travelled through the empty space between nuclei.

E a explanation
b evidence
c prediction

6.4 Protons, electrons, and the periodic table

1a F – The nucleus is made of protons and neutrons.
b T
c F – The first electron shell can hold two electrons.
d F – The number of protons is equal to the number of electrons.

2

Element	Number of electrons in an atom of the element	Electronic structure
helium	2	**2**
lithium	**3**	2, 1
boron	5	**2, 3**
nitrogen	7	**2, 5**
fluorine	9	**2, 8, 1**
magnesium	**10**	2, 8, 2
silicon	14	**2, 8, 4**
sulfur	16	**2.8.6**

3 See diagrams on page 153 of the Student book.
E

Electronic structures of group 1 elements	Electronic structures of group 2 elements
Lithium: 2,1 Sodium: 2,8,1 Potassium: 2,8,8,1	Beryllium: 2,2 Magnesium: 2,8,2 Calcium: 2,8,8,2

As you move down the group, the number of shells increases, but the number of electrons in the outer shell remains the same/is the same as the group number.

6.5 Proton number, nucleon number, and isotopes

1

Proton number is	the total number of protons and neutrons in the nucleus of an atom.
Mass number is	the number of protons in the nucleus of an atom.
Nucleon number is	

2

75	23	53	14	8	7	53	16	9	92	7
Re	V	I	Si	O	N	I	S	F	U	N

Revision is fun.

3

Atom of the element…	**Proton number**	**Nucleon number**	**Number of neutrons**
Hydrogen	1	1	**0**
Helium	2	**4**	2
Beryllium	4	9	**5**
Nitrogen	7	**14**	7
Sodium	11	23	**12**
Sulfur	16	**32**	16
Titanium	22	**48**	26

4a 3

b 4

c silicon

d gallium

e half

f neon

6.6 The Group 1 elements

1a A, O

b A, O

c O

d O

e O

f O

2a **i** lithium + water → lithium **hydroxide** + hydrogen

ii sodium + **water** → **sodium hydroxide** + hydrogen

iii potassium + **water** → **potassium hydroxide** + **hydrogen**

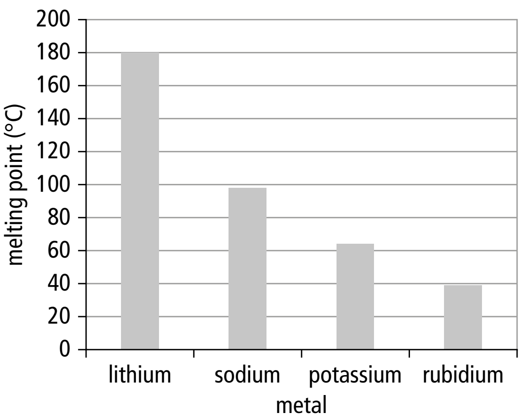
b As you move down the group, the reactions of Group 1 metals with water becom more vigorous.

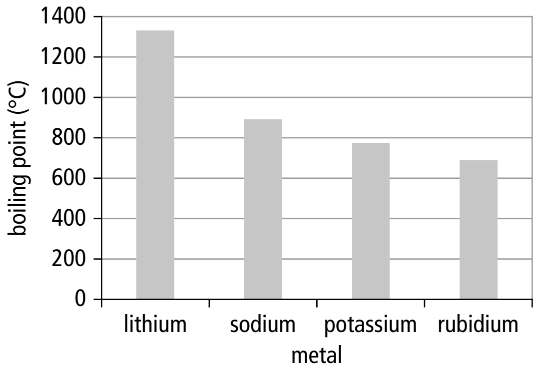
3a Top to bottom: 0.53 g/cm^3, 21.43 g/cm^3, 0.86 g/cm^3, 20 g/cm^3.

b A, C, both of these metals have low densities.

E

a





b The melting and boiling points decrease as you move down the group.

6.7 The Group 2 elements

1 Second group (column) on the periodic table shaded in.

2a Bubbles more vigorously (more than calcium but less than barium). Colourless solution formed.

b calcium + water → calcium hydroxide + hydrogen

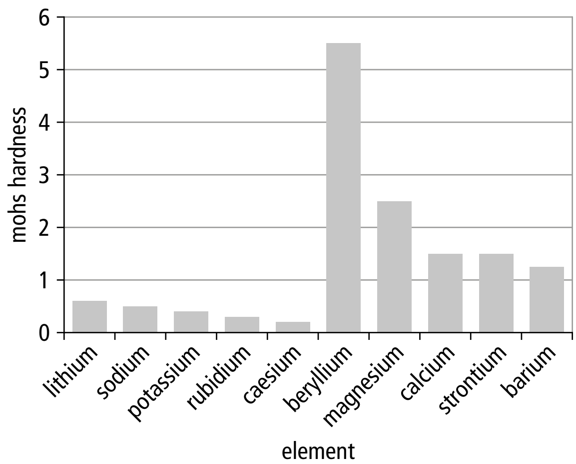
c barium + water → barium hydroxide + hydrogen

3a calcium chloride + water + hydrogen

b calcium + hydrochloric acid → calcium chloride + water + hydrogen

E

a



b The hardness values for Group 2 decrease as you move down the group.

c Both Group 1 and Group 2 elements decrease in hardness as you move down the group. The group 2 elements are almost 10 times harder than group 1. In both groups, the reactions with water become more vigorous as you move down the group.

6.8 The group 7 elements

1a chlorine

b iron bromide

c iodine

d potassium bromide

e chlorine

f sodium chloride

2 There are strong forces between the two atoms of a chlorine molecule.

There are weak forces between a chlorine molecule and its neighbours.
There are strong forces between the two atoms of a iodine molecule.
There are weak forces between a iodine molecule and its neighbours.

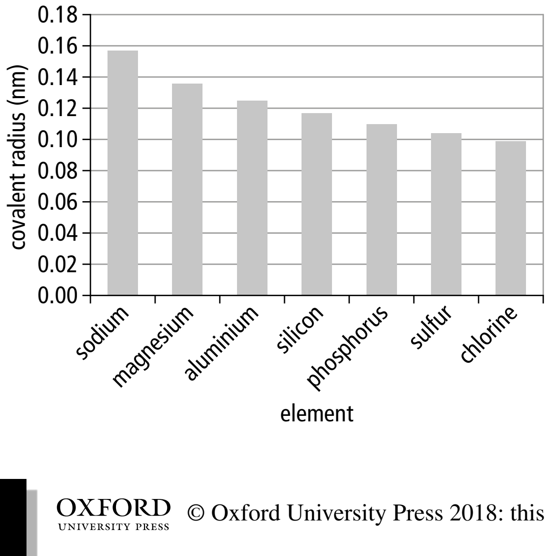
3a 7
b 7
c B
d 7
e B
f 7
g 1
h B
E Most: potassium and fluorine,
Least: lithium and iodine

6.9 Looking at secondary data

1 Larger sample numbers makes the results more reliable and reduces errors.
2 To compare the affect of fluoridation with no fluoridation.
3 2007–2012 is a larger time frame so she would be able to determine the affects 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 tooth disease) and the number of 12–13 year olds with surface decay decreased however the same affect was seen in town D which did not have access to chlorinated water.
5 If the water did not contain adequate levels of fluorine, it is possible that the affects of the fluorine may have not been as significant as if the correct levels of fluorine were used.

6.10 Periodic trends

1a 7th group (penultimate column)
b 2nd row (Li, Be, B, C, N, O, F, Ne)
c 4th row (K, Ca, Sc, Ti, V,Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr)
2a It is not possible to measure the covalent radius of an atom in a school laboratory (no suitable equipment).
b **i** A bar chart. The data is discrete.
ii



c As you move across the period, the covalent radius decreases.
E The radius of atoms decreases as you move across (left to right) period 3 of the periodic table. The rate at which the elements decrease in size decreases as you move across the period. Chitra needed to specify which group and/or use some form of data.

6.11 How scientists work: inside sub-atomic particles

1a

Statement describing what scientists did	Stage of developing a scientific explanation
Scientists suggested that there is a particle called the Higgs boson that gives protons and neutrons their mass. They described the properties of this particle.	**A** Use creative thought to suggest an explanation.
Scientists built the Large Hadron Collider. They made protons collide in it. They examined the products of the collisions.	**B** Check the evidence to see if it supports the suggested explanation.
Scientists wondered what gives protons and neutrons their mass.	**C** Ask a question.
Scientists compared the products of the collisions with the predicted properties of the Higgs boson.	**D** Collect evidence to test the suggested explanation.

b C, A, D, B
c There would be a larger number of people who would look at it. The best physicists in lots of different countries could work with the data.
d To be certain that they have and to continue any other research.
2a International communications Modern technology makes it possible for people to communicate quickly over long distances.
b Top to bottom: B, A, A, D.

7 The reactivity series

7.1 The reactions of metals with oxygen

1 oxygen, oxides, iron oxide, element, compound

2a lithium, potassium, sodium

b gold, platinum

c potassium, sodium, lithium, platinum/gold

3a oxygen

b iron oxide

c potassium

d lead oxide

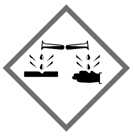
e oxygen

f zinc

E order of reactivity (most to least reactive): magnesium, zinc, copper, iron.

7.2 The reactions of metals with water

1a

Hazard symbol	Meaning of hazard symbol
	corrosive
	highly flammable

Action to reduce risk from hazard
Wear eye protection.
Use a tiny piece of potassium.
Place a screen between the glass trough and the students.
Do not touch the metal – handle with forceps.
Replace the lid on the potassium container as soon as possible.
Wear gloves.

b **i** It was easy for Mr Fissoo to cut the potassium.

ii The potassium floated.

iii The potassium moved around quickly.

iv There was a red flame.

v The Universal Indicator solution changed colour from green to blue.

2a T

b F – Calcium reacts with water to make calcium hydroxide and hydrogen gas.

c T

d F – sodium + water → sodium hydroxide + hydrogen

7.3 The reactions of metals with acids

1a copper and gold

b magnesium

c magnesium, zinc, iron, copper/gold

2a Place a lit splint into the gas. If the splint goes out and makes a squeaky pop, the gas is hydrogen.

b **i** hydrogen

ii zinc sulfide

iii hydrochloric acid, hydrogen

iv zinc, hydrogen

E a magnesium, water, magnesium chloride

b Filter out the magnesium, evaporate the water off to leave magnesium chloride.

7.4 The reactivity series

1a potassium

b gold

c magnesium, calcium, lithium, sodium, potassium

d lead, copper, silver, gold

2a Use the same amounts of metal, use the same amount of hydrochloric acid.

b zinc

3a copper

b zinc + oxygen → zinc oxide

4

Metal
magnesium
calcium
copper

Observation
no reaction
bubbles vigorously
small bubbles on surface of metal

E Zinc and magnesium are more reactive than the iron so the zinc/magnesium corrode instead of the iron.

7.5 Tin in the reactivity series

1a **i** Tin is more reactive as it reacts with hydrochloric acid whilst copper does not.

ii To collect some preliminary data and to make sure the investigation would work.

b **i** zinc

ii tin

iii Tin is below zinc and above lead in the reactivity series.

c **i** Iron is between lead and zinc in the reactivity series. Senni can use this information to determine the location of tin in relation to iron.

ii Resources/ reliability of data.

iii Based on the data from **b** and **iii**, tin is less reactive than iron, making the reactivity series as follows: zinc, iron, tin, lead.

7.6 Metal displacement reactions

1 copper, iron sulfate, displacement, more, copper, displaces, more, less

2 See the table at the bottom of the page.

3a iron + copper sulfate solution → iron sulfate + copper

b magnesium + lead nitrate solution → magnesium nitrate + lead

c iron + copper oxide → iron oxide + copper

d zinc + iron nitrate solution → zinc nitrate + iron

e zinc + lead oxide → zinc oxide + lead

f magnesium + copper chloride solution → magnesium chloride + copper

E a aluminium and iron oxide

b Lots of sparks and molten iron.

c aluminium + iron oxide → aluminium oxide + iron

7.7 Extracting metals from their ores

1 more, more, more, more

2a aluminium, magnesium, calcium, lithium, sodium, and potassium are removed using electrolysis

b zinc, iron, lead, copper

c silver, gold

3 Carbon is more reactive than some metals so it can be used to displace the metals from their oxides. Some metals are more reactive than carbon so must be extracted using electrolysis.

4a tin + carbon dioxide

b lead + carbon dioxide

5 iron sulfate + copper

E a sodium and magnesium

b sodium + titanium chloride → titanium + sodium chloride

magnesium + titanium chloride → titanium + magnesium chloride

7.8 Writing symbol equations

1a O_2

b N_2O_2

c 2

d 8

e 2

2a $S + O_2 \rightarrow SO_2$

b $\mathbf{2}Zn + O_2 \rightarrow \mathbf{2}ZnO$

c $Mg + \mathbf{2}HCl \rightarrow MgCl_2 + H_2$

d $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

e $\mathbf{2}Na + \mathbf{2}H_2O \rightarrow \mathbf{2}NaOH + H_2$

f $\mathbf{2}K + \mathbf{2}H_2O \rightarrow \mathbf{2}KOH + H_2$

g $Mg + CuO \rightarrow MgO + Cu$

h $CuSO_4 + Fe \rightarrow Cu + FeSO_4$

3a $C + O_2 \rightarrow CO_2$

b $\mathbf{2}Mg + O_2 \rightarrow \mathbf{2}MgO$

c $Zn + \mathbf{2}HCl \rightarrow ZnCl_2 + H_2$

d $\mathbf{2}Li + \mathbf{2}H_2O \rightarrow \mathbf{2}LiOH + H_2$

e $TiCl_4 + \mathbf{2}Mg \rightarrow \mathbf{2}MgCl_2 + Ti$

8 Making salts

8.1 Making salts – acids and metals

1 Dasbala

2a chloride

b nitric

c sulfate

3 A, D, F, B, E, C

4a zinc chloride

b magnesium sulfate

c magnesium chloride

d iron sulfate

5 Place a lit splint inside a container with the gas. If the splint goes out and a squeaky pop sound is made, the gas was hydrogen.

compound / **metal**	magnesium chloride solution	iron chloride solution	lead nitrate solution	copper oxide
magnesium		✔	✔	✔
zinc		✔	✔	✔
iron			✔	✔
lead				✔
copper				

8.2 Making salts – acids and carbonates

1 See the table at the bottom of the page.

2a copper chloride

b carbon dioxide

3a copper carbonate + hydrochloric acid → **copper chloride** + **carbon dioxide** + water

b zinc carbonate + sulfuric acid → **zinc sulfate** + carbon dioxide + **water**

c magnesium carbonate + **nitric acid** → magnesium nitrate + **carbon dioxide** + **water**

d **copper carbonate** + sulfuric acid → copper sulfate + carbon dioxide + **water**

4a The carbonate will stop bubbling.

b B, E, F

c E, F

E The direct heating causes the copper sulfate to spit, losing some of the product as well as being a danger. Heating indirectly over a water bath ensures even evaporation and reduces the amount of product lost.

8.3 Making salts – acids and alkalis

1a Sodium chloride

b Sodium nitrate

c Potassium sulfate

d Potassium chloride

2a hydrochloric acid + sodium hydroxide → **sodium chloride** + water

b **nitric acid**+ sodium hydroxide → sodium nitrate + **water**

c nitric acid + potassium hydroxide → **potassium nitrate** + **water**

d hydrochloric acid + **potassium chloride** → potassium chloride + **water**

3a **i** Use a **measuring cylinder** to accurately measure 25.00 cm^3 of sodium carbonate solution.

ii Place this solution in a **conical flask**. Add a few drops of Universal indicator solution.

iii Add hydrochloric acid to the sodium carbonate solution and indicator. Stop adding when the mixture is **green**.

iv Add charcoal powder to the mixture. Filter the mixture. Keep the **colourless** solution.

v Pour the solution into an **evaporating basin**.

vi Heat the solution until **half the solution has evaporated. Place the evaporating basin in a warm place for several days for the remaining water to evaporate.**

b So he can determine when the sodium carbonate has been neutralized.

c To remove the charcoal powder (which has removed the colour).

8.4 Making salts – fertilisers

1a To increase the nutrient content in the soil and increase crop yields.

b manure and compost

c nitrogen, phosphorus, potassium

d nitrogen, hydrogen

2a T

b F – The reaction also produces water.

c T

d T

e F – The volume of acid required is also dependent on the concentration of the ammonium nitrate.

f F – To make ammonium sulfate, you need to react ammonium hydroxide with sulfuric acid.

3 From left to right: ammonia solution, burette, conical flask, litmus paper, glass rod, evaporating dish, pipette, nitric acid

9 Rates of reaction

9.1 Rates of reaction

1a Rusting

b Reactions that make useful chemicals e.g. soap, fertilisers, medicines.

2a calcium carbonate + **hydrochloric acid** → **calcium chloride** + carbon dioxide + water

b The gas made in the reaction is soluble in water.

c **i** In this section the volume of gas is increasing quickly. **D**

v The reaction is happening quickly. **E**

Box 2

ii The reaction is slowing down. **E**

iv In this section the volume of gas is increasing slowly. **D**

Box 3

iii In this section the volume of gas is not changing. **D**

vi The reaction has finished. **E**

9.2 Concentration and reaction rate

1a **i** Flavia

ii Harry

iii Rebecca

	copper carbonate	**magnesium carbonate**	**zinc carbonate**
hydrochloric acid	***copper chloride***	***magnesium chloride***	***zinc chloride***
nitric acid	***copper nitrate***	magnesium nitrate	***zinc nitrate***
sulfuric acid	***copper sulfate***	***magnesium sulfate***	***zinc sulfate***

b Top to bottom: change, control, control, measure, control, control

2 The diagram on the right, since there are more acid particles in the same volume of solution.

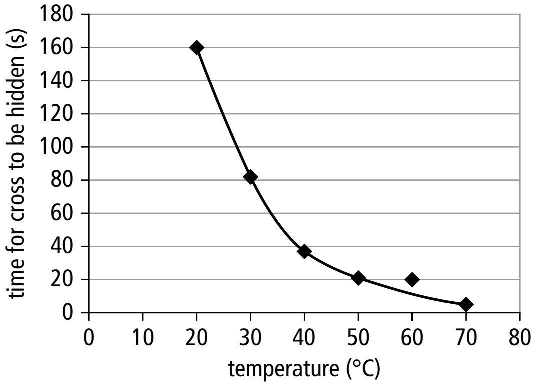
3 collide, more, collide, faster

E Diagrams similar to those in 9.2 (page 116) of Student book.
Labelled beaker and acid particles.

9.3 Temperature and reaction rate

1a **i** Ebba
ii Wanda

b **i**



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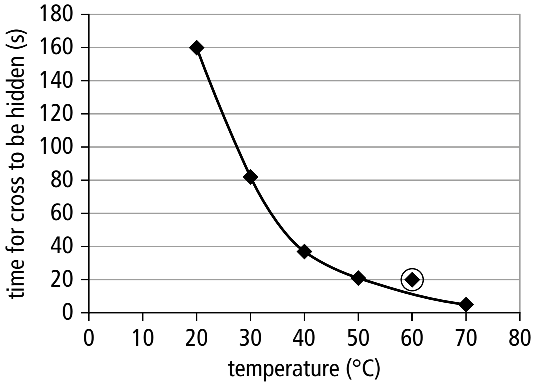


iii By repeating the investigation, the student can reduce error and make the investigation more reliable.

iv The variables are both continuous.

c At higher temperatures, the particles have more energy and collide more frequently. Therefore, the rate of reaction is faster.

9.4 Surface area and reaction rate

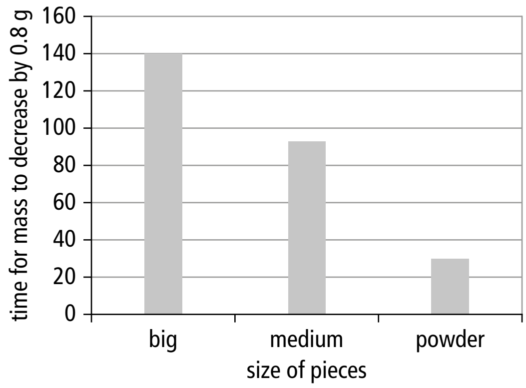
1 A

2a Carbon dioxide is a gas and escapes into the air.

b **i**

Size of pieces	**Time for mass to decrease by 0.8 g**
Big	140
Medium	93
Powder	30

ii



iii Increasing the surface area of the calcium carbonate increases the number of particles that can react with the hydrochloric acid, increasing the rate of reaction.

9.5 Catalysts and reaction rate

1 temperature, concentration, surface area, catalyst, is not, amylase, glucose.

2a hydrogen peroxide → water + oxygen

b Place a glowing splint into the gas. If the splint relights, the gas is oxygen.
i Manganese(IV) oxide
ii Iron oxide and zinc oxide

E a Catalysts speed up reactions without themselves being used up in the reaction.

b Platinum, rhodium, and palladium are used in catalytic converters to remove carbon monoxide from car fumes. Iron catalyses the production of ammonia from hydrogen and nitrogen when producing fertilisers.

10 Sound

10.1 Sound vibrations and energy transfer

1a Missing words in order: vibrating, vacuum.

b Missing words in order: waves, compressions, rarefactions.

2a B

b gas

c ten times faster

E P- waves are longitudinal waves because the movement of the particles is in the direction of the motion of the wave creating compressions and rarefactions. S-waves are longitudinal waves because the motion of the particles is up and down.

10.2 Detecting sounds

1a 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.

2a B

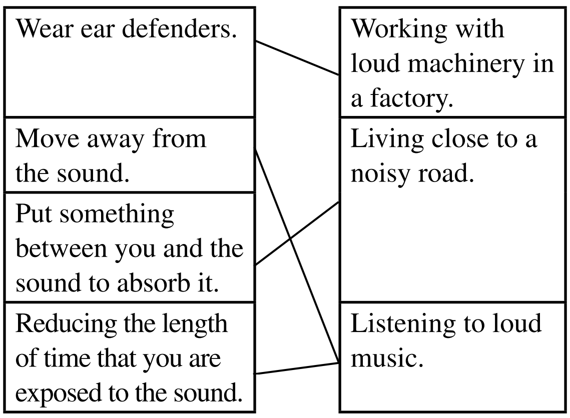
b F
c C
d E, D, and C
e C

3a 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 noises are picked up.

10.3 Loudness and the decibel scale

1a 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



E a As the sound level increase 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.

10.4 Loudness, amplitude, and oscilloscopes

1a The wavelength of the sound is the distance from the 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 An amplifier increases the amplitude of a wave.
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.

2a Sound is produced by the vibrations of the ruler causing compressions in the air.
b The student can make the sound louder by increasing the size of the vibrations by pushing the ruler down further.
c Any wave with a greater amplitude, the wavelength would be longer as the vibrations would be further apart by the increased distance the ruler must travel.

3a The wave that you hear with the box has a greater amplitude.
b amplify
c An oscilloscope displays how pressure changes with time as the compressions and rarefactions of the sound wave reach the microphone.
d The sound is louder with a box, so the amplitude will be greater.

10.5 Pitch and frequency

1 Correct words in order: frequency, higher, thousand, second.

2a 82 Hz is the frequency of the wave – there are 82 waves per second.
b The 6^{th} string will produce the highest note.
c The 1^{st} string will produce the lowest note.
d The piano and guitar would have different timbres.

3a D
b B
c E

E a Students should plot the data as a line graph.
b As the pipe length increase the frequency decreases.
c Yes, the frequency and wavelength are linked. A high frequency sound has a short wavelength and a low frequency has a longer wavelength. Therefore as the frequency of the noise is decreasing, the wavelength is getting longer.

10.6 Making simple calculations

1a A The time 6 seconds is for the student to clap ten times, not once.
B The distance is incorrect – it should be 200 m as the sound travels to and back from the wall.
C The calculation is not correct – 200/6 is 333.33 m/s to 2 decimal places.
b Speed = 200 m/0.6 s = 333.33 m/s
c The measurement is not completely accurate as their measurments would include their reaction times.

2a The sound signal reaches all of the speakers and therefore the athletes at the same time, but the sound from the gun would reach the athletes at different times as it takes time for the sound to travel.
b They are more important in staggered races where

the athletes could be several metres from the gun and so hear the sound a few seconds later, which can have a big effect on the outcomes of short races.

E a 3 times the speed of sound.

b 1.5 Mach

c The object is moving slower than the speed of sound if it has a Mach number of less than 1.

10.7 Echoes

1a Sonar works by emitting a pulse of ultrasound. The waves travel until the reach a surface and then they are reflected back to the source of the sound and are detected. The distance can be calculated by the time this takes.

b 3750 m –distance travelled in 2.5 s. Otherwise you could not tell which pulse reflection has been detected.

c Ultrasound is used rather than sound so that there isn't interference from other sources of sound.

2 0.00003 s

3a 330 m

b 495 m

c 4 s

d 825 m

4a 5.1 s

b It would take 0.033 seconds for the pulse to reach the Bukoba and for the echo to return to the ship. So the pulses need to be at least this length of time apart.

11 Magnetism

11.1 The properties of magnets

1 Missing words in order: iron, attracted, repelled by, Iron, repelled by, south.

2a The fish cannot be made from wood if the games is based on magnetism as wood is not a magnetic material.

b The following two statements are correct: The ball at the end of the rod is a magnet and the fish are made of a magnetic material. The ball at the end of the rod is a magnet and the fish are magnets.

c The game would not work if both the rod and fish were made of magnetic materials, at least one must be a magnet.

E a Students should draw aligned domains pointing north to south in the magnet and unaligned in the rod.

b A is the north pole.

11.2 Magnetic fields

1 Diagram 1: north on the left, south on the right. Diagram 2: draw field lines from north to south.

2 Diagram 1: two repelling north poles. Diagram 2: north on the left, south on the right. Diagram 3: two repelling south poles.

3a in front of you

b to your right

c behind you

E a magnetic material

b top

c The top is the region that contains the magnet, these field are weak and need to be close to the surface to hold the magnet on.

11.3 Electromagnets

1a F

b F

c T

d T

e F

f F

2a Students should draw arrows pointing clockwise around the wire.

b They would face the opposite direction.

3a She should wrap the copper wire around an iron nail and connect it to a battery.

b Both types of nail can be magnetised in this way, but the steel nail will remain magnetised when the current is switched off. It is more useful to use iron, which will not remain magnetised.

E a A straight line should be drawn close to all of the points.

b The line of best fit should be higher – double each point.

c This will be above line A because the iron makes the electromagnet stronger.

11.4 Identifying and controlling variables

1a Correct answers in order: 6, 8, 12, 18, 23, 26, 32.

b Variables to control: type of wire and core, type and size of paper clips, current and voltage of the circuit.

2a A, F, E

b B, F

c A, D

d C, E

3a The strength of the electromagnet will not be affected by the size of the paper clip, but it may be able to pick up fewer because they are heavier.

b Any suitable answer: for example, an electromagnet can pick up more small paper clips, so it will be easier to observe any smaller differences in strength.

c Any suitable answer: for example, Sinta will need fewer paper clips and they will not take up so much space on the electromagnet, whilst small ones might give an inaccurate result as they may fill the surface area of the magnet.

11.5 Using electromagnets

1 When the window is closed the contacts in circuit 1 are touching and the circuit is complete. This means the electromagnet attracts and opens the switch for circuit 2 and the bell does not ring. If the window is opened, circuit 1 is broken and the electromagnet is switched off. This closes the switch in circuit 2 and the bell begins to ring.

2a When the current is too big the electromagnet increases in strength and attracts the soft iron armature. This then stops holding the contacts together and they are pulled apart by the spring breaking the circuit.

b The circuit is reset by pressing the button. The electromagnet is no longer attracting the iron arm, so the reset button pushes the contacts back together and the springs pulls the armature back into place to hold them together.

3 Any suitable answers: for example electromagnets are used to control X-ray machines from a distance, or in MRI machines.

12 Forces

12.1 Pressure

1 Missing words in order: force, area, bigger, smaller, force divided by area, pascals.

2a 50 N/5 m^2 = 10 N/m^2

b 100 N/5 m^2 = 20 N/m^2

c 300 N/0.5 m^2 = 600 N/m^2

3a 10 N/cm^2 – when it is stood on the end with the smallest area 5 cm × 2 cm.

b 0.4 N/cm^2 – when it is stood on the end with the largest area 10 cm × 5cm.

E

Force (N)	**Area**	**Pressure**
20	4 cm^2	**5 N/cm^2**
60	**40 m^2**	1.5 N/m^2
0.6	12 m^2	0.05 N/m^2
75	5 m^2	15 N/m^2

12.2 The effects of pressure

A large force can be easily applied to the flat head of a pin, this applies a large pressure at the point so that it is easy to push the pin in.	Round stones have a larger surface area in contact with your foot than sharp stones, so the pressure is less and it is less painful to walk on them.	Mud is softer than dry ground and it can hold less pressure before you begin to sink into it.
The sharp point of the pole means that the force applied by the hammer creates a larger pressure on the ground.	A plank of wood spreads the force over a greater surface area, lessening the pressure on the quicksand so you won't fall in.	A narrow handle spreads the weight of the bag over a very small area exerting a greater pressure, which can be painful.
Swampy ground is soft and can support less pressure. The force (house weight) needs to be spread over a greater area to avoid sinking.	Studs have a smaller area than the surface of the boot, this means they exert greater pressure and will sink into the ground.	Animals that live in a muddy area have big feet to spread their weight over a greater area and therefore exert less pressure on the mud to avoid sinking.

E a 15 cm × 0.05 cm = 0.75 cm^2

b Pressure = 15 N/0.75 cm^2 = 20 N/cm^2

c 15 cm × 0.15 cm = 2.25 cm^2

d Pressure = 15 N/2.25 cm^2 = 6.667 N/cm^2

e The cook must use more force to cut with the blunt knife now.

12.3 Pressure in liquids

1a T

b F – The upthrust is the same.

c F – the bottom of a dam is wider than the top of a dam.

d T

2a Water cannot be compressed, so under pressure it is forced out of the holes.

b She will not be able to push down because water cannot be compressed and there are no holes for it to escape from.

3a Missing words in order: decrease, nitrogen

b Missing words in order: decompresses, nitrogen, carbon dioxide

c Missing words in order: bends, high, low

E a 12 000 N/m^2

b There is a curled up tube in a pressure gauge that straightens out as pressure increase moving the needle.

c B = 18 kPa
C = 24 kPa

12.4 Using pressure in liquids

1a Hydraulic means using liquids to produce large forces.

b Missing words in order: input, pressure, incompressible, output, air, bigger

c 150 N/cm^2

d A braking system is a force multiplier as the different areas of the input and output cylinders mean that it is possible to produce a greater force at the output cylinder than was applied at the input cylinder.

e Missing words in order: large, small

E A mechanic has to pump the handle several times as a small force has to move through a large distance at the input cylinder to produce a large force that only moves a small distance at the output cylinder. To raise the car a small amount a mechanic must move the input cylinder a lot.

12.5 Pressure in gases

1

The particles in a gas are …	… spread out.
If you compress a gas …	… the particles are closer together.
Gas pressure is produced …	… when molecules collide with a container's walls.
The particles in a liquid are	… close together.
If you try to compress a liquid …	… you cannot compress it.

2 B – atmospheric pressure is greatest at B because it is the lowest point and there is more gas exerting pressure above it than any other point.

3 a decreases

b There are fewer particles in the can because they escaped as steam when the water boiled, so when the gas cools there are fewer collisions with the walls of the can and the can collapses inwards.

c The can collapses because there are fewer collisions between the gas inside the can and the walls of the can. The walls collapse because the pressure outside the can has not changed and is now greater than inside.

E a When you suck the straw you reduce the number of air particles, and so the air pressure in the straw, the liquid moves into the area of lower pressure and moves up the straw.

b You cannot change the air pressure enough in a long straw by sucking to move the liquid up the whole length of the straw.

12.6 Pressure, volume and temperature in gases

1 Missing words in order: different, collide with, volume, more, increases.

2

	Increases, decreases, or stays the same
Speed of gas particles	increases
Pressure in the flask	increases
Mass of particles	stays the same
Volume of gas	stays the same

3a As temperature increases the particles have more energy and move faster, oxygen gas expands and takes up more volume.

b The pressure would increase because the student is decreasing the volume.

12.7 Preliminary work

1

Preliminary work	**What the preliminary work was for**
She tried lots of different sized diameters.	To find out which diameters of tubes liquid rises in and how far and quickly it does.
She tried very hot and very cold water.	To check that temperature does affect the amount a liquid rises.
She tried lots of different ways of measuring how far the liquid went up the tube.	To find the most accurate and precise method.
She looked up the hazards of using different kinds of liquids.	To carry out a safe experiment and reduce risk.
She tried different liquids.	To find the best one to use.
She worked out how man time she would need to repeat her experiment.	For accurate results and to reduce the chance of an error affecting her results.

E Students' own answers.

12.8 Density

1a

balance	mass
measuring cylinder	liquid volume
ruler	volume of a regular solid

b It is important to be at the same level as the meniscus when measuring a liquid.

2 Correct answers in order: 0.17 kg/m^3, 2.20 g/cm^3, 2.65 g/cm^3, 1.40 kg/m^3.

3a B, A, E, F, C, D

b You could measure the mass of the object before or after measuring the volume.

c A, E, F, C, B, D

E a (70 kg × 7 billion)/1 cm^3 = 490 billion kg/cm^3

b 140 000 000 elephants

c Density of air = 90 kg/75 m^3 = 1.2 kg/m^3. Aerogel is less dense than air.

12.9 Explaining density

1 Missing words in order: bigger, are not, smaller, are.

2a When a submarine's tank are filled with water they increase the mass of the submarine and therefore it's density. If the density is greater than that of water it will submerge.

b Air is pumped into the tanks and water out to surface. Air is less dense than water and so the submarine's mass and density decreases until it is less than that of the water.

3a F

b F

c F

d T

e F

E The density of the submarine when its tanks are filled with air is 8 000 000 kg/10 000 m^3 = 800 kg/m^3. This is less than the density of water, so it will float. However when the outer tanks are full the density of the submarine changes to (8 000 000 + 6 500 000)/
10 000 m^3 = 1450 kg/m^3. This is greater than the density of water, so it will sink.

12.10 Questions, evidence, and explanations

1a Any suitable answer, for example: Henry Cavendish is like Al-Biruni because he spent a lot of time doing experiments and was interested in calculating density.

b Any suitable answer: Al-Biruni was able to do experiments on the density of gemstone to test his predictions, Cavendish used data to make predictions about the density of the Earth that he was unable to test.

c Scientists today have more observations and better technology and can make more accurate measurments.

d more precise

e more accurate – scientist have more information available to make a more accurate calculation than Cavendish.

f Any suitable answer: Scientists used telescope to make observations about the Sun to work out its density. Lots of scientist worked together to do this. Cavendish worked alone.

E a three times

b Any suitable answer: the instruments we have today compared to Al-Biruni and Cavendish enable scientists to make more accurate and more precise measurements. We also know more about the Earth and the Sun and density than they did.

12.11 Turning forces

1 Missing words in order: machine, multiplier, pivot, effort, load, pivot, effort, pivot, load

2a A turning force is the movement of the force applied to the lever.

b Centre of the nut.

c A

d C

e You would need to apply more force to turn the handle.

3a Point where the screwdriver rests on the outer edge of the tin.

b Pivot to the point the screwdriver contacts the lid.

c Pivot to the hand.

d The distance from the effort to the pivot is much greater than from the pivot to the load, so you only need to apply a small effort for a big output force.

12.12 Calculating moments

1a T

b F

c T

d T

2a 0.1 N × 4 cm + 0.1 N × 12 cm = 1.6 Ncm

b 0.2 N × 8 cm = 1.6 Ncm

c Yes, the clockwise and anticlockwise moments are equal so the game is balanced.

d Yes, she can add a monkey to the second hole on the right to make the moments equal – 2.4 Ncm.

3a Anticlockwise moment = 400 N × 2 m = 800 Nm. Distance Tom sits from the centre = 800 Nm/500 N = 1.6 m

b Students should draw a seesaw correctly labelled with the weights and distances.

E clockwise moment = anticlockwise moment
X N × 25 cm = (1 N × 10 cm) + (2 N × 45 cm)
X = 100 Ncm/25 cm = 4 N

12.13 Planning

1a He has not included units.

b Any suitable answer: e.g. repeating measurments, ensuring other variables are controlled.

c Any suitable answer at the teacher's discretion. Students should clearly state the dependent and independent variables, controlled variables and what they are testing.

E a You can do preliminary work.

b Any suitable answer: Preliminary work ensures you are testing the right range of variables and that you experiment will work.

13 Energy

13.1 Hot and cold

1 Missing words in order: mass, temperature, longer, mass, energy, energy, mass, temperature.

2a It takes longer to heat a cinema as more energy is needed to heat the greater mass of air needs to be heated 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 °C.

3

	Thermal energy	Temperature
Measured in joules.	✔	
Measured with a thermometer		✔
Does not depend on how much material there is.	✔	
Measure in degrees Celsius		✔
Increases if you heat something for longer.		✔

4a 8400 J
b 12 600 J
E Statement c is true.

13.2 Energy transfer: conduction

1a T
b F – Things that feel warm do not conduct thermal energy away from our habds.
c T
d F – The particles in a metal that is hot are vibrating more than the particles in a metal that is cold.
2a foam
b paper
c Air is a poor conductor of thermal energy, so a material that contains pockets of air will be a good insulator.
3a T
b T
c Order of best to worst conductor: copper, aluminium, iron

13.3 Energy transfer: convection

1 Missing words in order: expands, decrease, upwards, colder, denser, convection current.
2a 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, beginning to move up again as it warms.
3a 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.

E a The lid stops heat energy being transferred into the environment and away from the beaker.
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 thermal energy away from the bottle.
c Warm air rises, so the hottest part of the oven is at the top. The thermal energy will be transferred to the food.

13.4 Energy transfer: radiation

1a 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.
2a 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.

E
a

radio	microwave	infrared	visible	UV	X-rays	gamma

b They have a higher frequency and shorter wavelength, this means they are more damaging to the body.

13.5 Cooling by evaporation

1a 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.
2a The ethanol evaporates
b Ethanol has a lower boiling temperature than water so it's molecules can evaporate more quickly transferring thermal energy away from your body more quickly.
3a The ether evaporates transferring thermal energy away from the water until it cools enough to freeze.
b In a refrigerator, coolant circulates transferring thermal energy away from the air in the fridge cooling it and the contents.
E 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.

13.6 The world's energy needs

1a hydroelectric

b coal, oil, gas, nuclear

c

Fuel	Percentage use in 1971	Percentage use in 2007	Percentage change in use
coal	40.0	41.5	+1.5
oil	20.9	5.6	–15.3
gas	13.3	20.9	+7.6
nuclear	2.1	13.8	+11.7
hydroelectric	23.0	15.6	–7.4

d In order: oil, hydroelectric, coal, gas, nuclear

e He isn't correct, the only renewable source of energy shown on the pie chart is hydroelectric power and use of this has decreased by 7.4%.

f oil

g One of the following: solar power, biomass, wind power, tidal power, wave power, geothermal power.

E a 36 years

b

Percentage change per year
+0.04
–0.43
+0.21
+0.33
–0.21

13.7 Fossil fuels

1 Missing words in order: trees, millions, mud, rock, compressed, millions, mud, trees.

2 A

	True for coal	True for oil	True for both
Took a very long time to form.			✔
Made from trees.	✔		
Made from sea creatures.		✔	
Can be found underground.			✔
Formed as a result of heat and pressure			✔

3a C, B, D, A, E

b 70 J thermal energy

c 30 %

E a Students' own answers.

b It is not possible to predict when fossil fuels will run out because our use of them is always changing, and we do not know if we will find more deposits.

c Fossil fuels takes millions of years to form under high temperatures and pressures so it is not possible to make more of them.

13.8 Generating electricity

1a Missing words in order: coil, magnetic, speed, strength

b Missing words in order: coil, poles, coil, more, coil, more

2a The voltage would be lower.

b The voltage would stay the same.

c The voltage would stay the same.

3a Labels the block as magnet, and coils are around the magnet.

b Voltmeter should be connected in parallel around the motor.

c **i** T

ii T

iii F

E a left

b The magnetic field of the Earth is very weak.

c Use a longer piece of wire, use a large coil of wire so there are more turns, or ask the students to move their arms more quickly.

13.9 Renewable energy: solar and geothermal

1a Missing words in order: Sun, light, light, electrical, closer, brighter.

b Missing words in order: light, water, renewable.

c Missing words in order: greenhouse.

d Missing words in order: dark.

2a Clockwise from the top: generator, hot water, cold water.

b Geothermal power stations do not produce carbon dioxide when they are running, but lots is produced whilst they are being built, so they do contribute to climate change.

c The best place to put a geothermal power stations is one where the Earth's crust is thinner, so the warm magma is closer to the surface.

3

Advantage or disadvantage	Solar	Geothermal	Both
It is unreliable.	✔		
It doesn't produce much carbon dioxide when running.			✔
It is expensive to produce/build.			✔
It won't run out.			✔

13.10 Renewable energy: using water and wind

1

Hydroelectricity …	… when they are being manufactured.
When water falls through turbines in a dam …	… can destroy habitats when valleys are flooded.
A tidal barrage contains turbines and generators …	… electricity is generated by wave power.
Wind turbines produce carbon dioxide …	… electricity (called hydroelectricity) is generated.
When water moves into a chamber on a shoreline …	… to generate electricity when the tide goes out.

2a Graph
b best fit
c 5 km/h
d 1170 watts
e Approximately 400 watts
f Wind power does not generate any greenhouse gases.

E a Waves are very unreliable and vary a lot.
b wind
c Any suitable answer: Wind power is unreliable, there can be days when there is no wind at all.
d Any suitable answer: The power output of the largest power station is quite low, and there are few suitable places to build tidal power stations.

13.11 Energy for the future

1 From top to bottom: 6 years, 14 years, 10 years.
2 Students' own answers.

E a Carbon dioxide is a greenhouse gas and contributes to climate change.
b Students' own answers – they should compare the data and decide which values are most important to them.

Notes