8K
Energy transfers

This unit looks at energy transfers by heating in the context of homes.

Recommended teaching time for unit: 7.5–10 hours

There is an opportunity for focused development of Working Scientifically skills in Topic 8Kc and of Literacy & Communication skills in Topic 8Ka. You may wish to spend additional time on these topics should you feel that your students would benefit from these skills-development opportunities.

From previous work, most students will be able to:

- use the particle model of matter to explain the properties of solids, liquids and gases (7G)
- recall some ways in which energy is transferred and stored (7I)
- recall the law of conservation of energy, and that the efficiency of a machine tells us how much energy is transferred as wasted energy (7I).

Topic 8Ka considers the difference between internal (thermal) energy and temperature, and looks at the factors that affect the amount of energy stored in a heated substance. It also looks at why evaporation has a cooling effect on the remaining liquid. The Literacy & Communication spread looks at using appropriate language for the audience.

Topic 8Kb describes energy transfer by radiation, and explains conduction and convection in terms of the particle model of matter.

Topic 8Kc looks at ways of controlling energy transfers, including the best colours for emitting and absorbing infrared radiation. The Working Scientifically pages look at accuracy and precision.

Topic 8Kd introduces the idea of power. The equation for calculating efficiency is introduced.

Topic 8Ke describes how energy is paid for and introduces the kilowatt-hour as a unit of energy. The idea of payback time is explained. The final page looks at how our energy use can affect the climate.

National Curriculum coverage

This unit covers the following statements from the UK National Curriculum for Science (2013):

- comparing power ratings of appliances in watts (W, kW)
- comparing amounts of energy transferred (J, kJ, kWh)
- domestic fuel bills, fuel use and costs
- heating and thermal equilibrium: temperature difference between two objects leading to energy transfer from the hotter to the cooler one, through contact (conduction) or radiation; such transfers tending to reduce the temperature difference: use of insulators
- energy as a quantity that can be quantified and calculated; the total energy has the same value before and after a change
- comparing the starting with the final conditions of a system and describing increases and decreases in the amounts of energy associated with movements, temperatures, changes in positions in a field, in elastic distortions and in chemical compositions
- using physical processes and mechanisms, rather than energy, to explain the intermediate steps that bring about such changes.

N.B. Statements in grey are covered in another unit.

In addition to covering a variety of Working Scientifically statements, this unit has a focus on:

- pay attention to objectivity and concern for accuracy, precision, repeatability and reproducibility.

Literacy & Communication skills
- using language appropriate to the audience.

Maths skills
- substituting values in simple formulae and solving resulting equations
- understanding percentages
- drawing and interpreting scale drawings
- choosing and using a suitable level of accuracy for measurements.

Cross-disciplinary opportunities

8Ka – Chemistry 8Ea – energy transfers in combustion

8Ke – Chemistry 8Ea – carbon capture.

Cross-curricular opportunities

8Kc, 8Ke – Design and technology – how the design of buildings and appliances can impact individuals and the environment.

8Kc – Geography – how humans cope with living in different environments

© Pearson

8K Background information

8Ka Temperature changes

The Background information for Unit 7I looked at the current recommendations for how energy is taught. The latest guidance is to avoid talking about 'forms' of energy, but instead to refer to 'energy transferred by heating' or energy stored in moving objects. However, sticking rigidly to this can make the language clumsy and difficult to read. To avoid this we have sometimes referred to energy as is recommended and sometimes referred to, for example, 'thermal energy'.

Thermal energy is measured in joules (J) or kilojoules (kJ). The National Curriculum refers to 'internal energy' – in this unit, this term is used interchangeably with 'thermal energy'. Note, however, that in some circumstances elsewhere, the phrase 'internal energy' can be taken to also include energy stored in chemical bonds.

When discussing the particle model, the general term 'particle' is used, to avoid having to use 'atoms' (if talking about metals) or 'molecules' (if talking about molecular substances). The particles that form all substances are constantly in motion; nothing is ever stationary. In solids, the particles are vibrating; in liquids and gases, they can move past each other. The hotter the object the more energy the particles are storing via their movement (kinetic energy). A hot object placed next to a cold object causes the transfer of thermal energy to the cold object. This transfer of energy only ceases when both objects are at the same temperature.

Temperature is a way of measuring the mean kinetic energy of the particles in a material. This should not be confused with the amount of thermal energy in the material. If two objects of different mass are at the same temperature then their particles are storing the same average kinetic energy, but the more massive object has more heat energy than the less massive one.

The hotter an object, the more kinetic energy its particles have. The reverse is also true. However, it is not possible for the particles to stop moving altogether, and William Thomson (Lord Kelvin) calculated, by extrapolation, that the lowest possible temperature would be –273.15 °C (in practice, this is unobtainable, although cryogenics laboratories have come very close). Kelvin thought it was inconvenient to have negative scales, so he called this point absolute zero and based his scale on this as a starting point. This new scale was called the Kelvin scale in honour of Lord Kelvin, and has the unit kelvin (K).

For simplicity, it is more usual to convert from degrees Celsius to kelvin using the formula: kelvin = degrees Celsius + 273. This scale is very convenient for recording very low temperatures, particularly of elements such as liquid nitrogen and liquid helium. On this scale, nitrogen condenses to a liquid at 78 K or –195 °C, and helium at 4 K or –269 °C.

Relative humidity

Relative humidity is explained on Worksheet 8Ka-6 in the Activity Pack. This is often explained as the amount of water vapour in the air compared with the maximum amount the air can hold at a particular temperature. However, the amount of water vapour does not depend on any property of the air, but only on properties of water. At any temperature, water from liquids (such as puddles or lakes) will be evaporating and water vapour in the air will be condensing. The equilibrium state is when the rate of evaporation equals the rate of condensation. If more water evaporates, then the condensation rate will also increase until the equilibrium is restored. At higher temperatures, evaporation will be favoured over condensation, so there will be a greater amount of water vapour in the air at equilibrium. The amount of water vapour actually in the air compared with this equilibrium value is the relative humidity, which is usually quoted as a percentage.

8Kb Transferring energy

Thermal radiation travels by electromagnetic waves. Electromagnetic waves come from many sources and differ in their wavelengths. However, they do have some properties in common. For instance, all electromagnetic waves travel through a vacuum in straight lines at a speed of 300 000 000 m/s and they do not need a medium in which to travel. The whole range of electromagnetic waves is often referred to as the electromagnetic spectrum.

Infrared (or thermal) radiation should not be confused with radiation of alpha or beta particles. The longest wavelengths in the electromagnetic spectrum are the radio waves. Infrared (heat) and visible light are around the centre of the spectrum and gamma rays have the shortest wavelengths. Generally, the shorter the wavelength the more energy the radiation carries, and the more penetrating and dangerous it is.

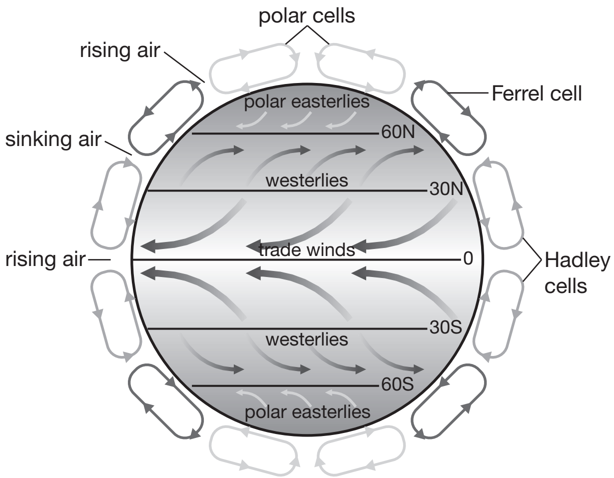
All warm and hot objects give out, or emit, infrared radiation. Some surfaces are better absorbers or emitters of radiation than others. Shiny surfaces reflect radiation best, but are poor absorbers, whilst dull black surfaces are good absorbers and emitters, but bad reflectors. One use of this idea is the shiny reflector behind the bars of an electric fire, which reflects the radiation into the room. Car radiators are often painted black because they need to lose heat quickly and black is a good emitter.

Metals are good conductors of thermal energy because their molecules are arranged in a matrix, or lattice, which allows vibrations to pass through the material more quickly. The dominant method of both heat and electrical conduction through a metal is actually due to the movement of free electrons through the material; however this mechanism is not mentioned in the student materials.

Land and sea breezes are often given as examples of how convection currents cause winds. Water has a large specific heat capacity (the amount of energy needed to heat 1 kg of the substance by 1 °C) compared with most other substances. This, and the large volume of the sea, means that the temperature of the sea remains relatively constant compared with that of the land. During the day, the land heats up and is warmer than the sea, causing a convection current that moves air from the sea towards the land (a 'sea breeze'). The land cools to below the temperature of the sea at night, causing the opposite effect.

© Pearson

Convection currents (together with the rotation of the Earth) are also responsible for large-scale wind systems. The tropics are more strongly heated than parts of the Earth further from the Equator. This sets up convection cells called Hadley cells, named after George Hadley (1685–1768), who used the Earth's rotation, as well as ideas about convection, to explain the direction of the trade winds. The simple north/south directions of the convection cells are converted to easterly or westerly patterns of wind because of the rotation of the Earth.



8Kc Controlling transfers

Poor thermal conductors or thermal insulators are materials in which the molecules or atoms are arranged more randomly and are further apart. Liquids are not good conductors and a practical suggestion to demonstrate this is given in the topic notes. Gas molecules are much further apart than liquid molecules so gases are very poor conductors. Air has about 20 times less conductivity than water and many apparently solid insulators contain tiny pockets of air, which is what gives them their insulating properties. Note that air has to be trapped if it is to contribute to insulating properties, otherwise heat can be transferred by convection.

8Kd Power and efficiency

Whilst energy cannot be made or destroyed, much of what is transferred is wasted energy. This means that the efficiency of any machine is reduced and the more it wastes the less efficient it is.

You can work out efficiency using the formula:

efficiency = useful energy (output)/total energy (input)

This is usually shown as a percentage, so the answer is multiplied by 100.

It is impossible to build a machine that is 100% efficient. Sometimes it is not easy to see where the wasted energy has gone – in almost all cases energy is wasted by heating the surroundings. In most cases, thermal energy produced as a waste energy is too spread out to be of any further use. For instance, if a book falls off a table onto the floor, it is easy to see that gravitational potential energy has converted to kinetic energy, which in turn is converted to sound energy when the book hits the floor. What is not obvious is that the book, in falling through the air, will have heated the air slightly. The impact with the floor will also have caused some heating of the book, the floor and the surrounding air. Thermal energy is the most common form of wasted energy and almost every energy change involves some energy transfer by heating. Sometimes this is the form of energy we want, but more often it is wasted energy.

A Sankey diagram can represent this diagrammatically, with the width of the arrow towards the outcome showing the approximate percentage of each energy form. Drawing Sankey diagrams therefore involves scale drawing.

8Ke Paying for energy

Electricity bills quote the number of units of electricity used, where one unit is a kilowatt-hour (the amount of energy transferred by a 1 kW appliance in 1 hour). In spite of the similarity of the units, it is important to remember that a kilowatt-hour is a unit of energy, not of power.

© Pearson

8Ka
Temperature changes

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	**Understanding (b)**	**Applying (c)**	**Analysing (d)**	**Evaluating (e)**	**Synthesising & creating (f)**
The average kinetic energy of the particles in a gas depends on the temperature.	Describe the movement of particles at absolute zero. Recall the temperature of absolute zero in degrees Celsius.	Convert between the Kelvin and Celsius scales.	Describe how the average kinetic energy of the particles in a gas relates to its Kelvin temperature.			
The amount of [internal, thermal] energy something contains depends on various factors.	Describe the factors that determine the temperature of an object in terms of energy, material and mass. Recall that the speed of movement of particles in a substance depends on the temperature.	Describe the effect of a substance's specific heat capacity on its ability to store heat energy.	Use the formula $E = m \times c \times \theta$	Explain what happens when a system maintains a constant temperature.	Evaluate the effects of thermal mass in controlling the temperature inside buildings.	
[Internal, thermal] energy can be transferred by evaporation from a surface.	State the meaning of: evaporation. Recall the effect of evaporation on the temperature of the remaining liquid. Recall ways of reducing energy transfer by evaporation.	Explain what happens to particles when a liquid evaporates.	Use the particle model of matter to explain energy transfer by evaporation from a surface.		Evaluate qualitative and quantitative ways of [decreasing, increasing] energy transfer by evaporation, including lids, pressure effects, and motion of air.	
The direction in which energy is transferred by heating depends on the relative temperatures of different objects or materials.	Recall that [thermal, internal] energy and temperature are not the same. Recall some common temperatures on the Celsius scale. Recall that energy will be transferred by heating when two [materials, objects] are at different temperatures.	Identify the direction in which energy will be transferred in given circumstances, i.e. from hotter to colder.		Explain the direction in which energy is transferred by heating in a given situation (including the idea of temperature equilibriating).		

© Pearson

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
	Recall some units for measuring temperature and energy.					

Objectives
Developing:

1. Recall some units for measuring temperature.
2. Recall that energy will be transferred by heating between materials at different temperatures.
3. Explain how internal energy and temperature are different.
4. Identify the direction in which energy will be transferred in given circumstances.
5. Recall the effect of evaporation on the temperature of the remaining liquid and recall ways of reducing energy transfers by evaporation.
6. Describe the factors that determine the temperature of an object.

Securing:

7. Describe the factors that affect the rate of transfer of energy by heating.
8. Use the particle model of matter to explain energy transfer by evaporation from a surface.

Exceeding:

9. Convert between the Kelvin and Celsius scales.
10. Describe how the average kinetic energy of the particles in a gas relates to its Kelvin temperature.

Focused Literacy & Communication Objectives
This topic provides an opportunity to focus on key Literacy & Communication skills.

1. Produce authoritative texts by using appropriate vocabulary for a stated audience.

Student materials

STARTERS

1: Quick Quiz
Developing/Securing/Exceeding
BA
Use the 8K Quick Quiz for baseline assessment. Students can use the 8K Quick Quiz Answer Sheet to record their answers. You could use the Quick Quiz to review the relevant prior learning for the whole unit and then use this information to plan relevant actions, depending on students' confidence. Returning to the Quick Quiz at the end of the unit could monitor development of understanding. Alternatively, just use the first four questions, which relate to this topic, to provide information on students' prior learning for your planning. These questions could be revisited formatively in a plenary for this topic. See the ASP for more information about Quick Quizzes. Advice on dealing with any misconceptions highlighted by this activity can be found in the Background information.

Course resources
ASP: 8K Quick Quiz; 8K Quick Quiz Answer Sheet.

2: Concept maps
Developing/Securing/Exceeding
FA
Assessment: Ask students to draw a concept map to help them to recall earlier work that forms the basis for further learning in this unit. This includes ways of transferring and storing energy (Unit 7I), the particle model of matter (Unit 7G), and changes of state. If students have covered Unit 8I at this point, it also includes the expansion on heating and the effect of density on floating. They can work on their concept maps alone, in pairs or in small groups.

Feedback: Build up the key ideas that should be included in the concept maps on the board, eliciting ideas for words and links from the class. Discuss differences in suggested links between ideas. Students should then be asked to make a list of the points they are not sure of. When they have done this, ask for an indication of class confidence in each area of the concept map you have drawn on the board (by asking for a thumbs-up or thumbs-down for each area).

Action: Students can share each other's concept maps to fill in any gaps in their own. The specific

© Pearson

action to be taken depends on the areas of difficulty and on which other activities are already planned for the lesson.

Starter 3 can be used to revise the particle model and changes of state.

3: Revising particles and heating
Securing
Ask students, in pairs, to list the key ideas from Unit 8I – under 'expansion', 'contraction' and 'change of state'. Then use the AT interactives *Changing states 1* and *Changing states 2*. These provide drag and drop activities aimed at helping students to recall work from Unit 8I on particle movement and changes of state. Ask students to review their lists and to add any missing ideas that they were reminded of in the activity.

> **Course resources**
> **AT:** Interactives *Changing states 1*; *Changing states 2*.

4: Living in extremes
Developing/Securing
Ask students to brainstorm the ways in which humans adapt to extreme climates around the world by adapting their housing. Make a list on the board, along with six questions agreed by the class about housing in extremes. The AT video *Living in extremes* provides an overview of some of the ways in which traditional housing styles around the world are adapted to the local conditions.

After watching the video, agree with the class which questions have been addressed – and discuss any gaps in their knowledge.

> **Course resources**
> **AT:** Video *Living in extremes*.

5: Ideas about energy transfers
Securing
BA
The AT interactive *Concept cartoon: Ideas about energy transfers 1* provides three statements connected with energy and insulating materials. Students can discuss the statements in pairs and decide whether or not each one is correct. They can jot down their responses. You can also ask for a show of hands to gauge the level of knowledge, but discussion of the answers is best left to the end of Topic 8Kb (Plenary 5).

> **Course resources**
> AT: Interactive *Concept cartoon: Ideas about energy transfers 1*.

EXPLORING TASKS

1: Comparing energy and temperature
Developing/Securing
Prac WS
Students heat two different volumes of water and time how long it takes to raise the temperature to 60 °C. Start by asking students to predict which will heat up the fastest. With some groups you may wish to elicit the suggestion that if the volume of water is doubled, it will take twice as long to reach the required temperature. Also, help them to relate the energy transferred to the water to the time for which it is heated.

An alternative approach is to split the class into five or six groups. Each group is then given a different volume of water to heat up, thus obtaining a greater range of results in a relatively short time. Results from the different groups can be combined and a class graph produced on the board, or via a spreadsheet program linked to a computer projector. A graph produced is unlikely to be a good straight line – ask students to evaluate the method, in particular what is happening to the energy already transferred to the water while it is still being heated. (The longer the water takes to reach the required temperature, the more time there is for energy to be transferred from the water back to the surroundings.)

Note that the gauze on which the beaker stands should be heated before the first volume of water is heated – if this is not done, the first test will take 15–20 seconds longer to reach the required temperature.

> ⚠ Eye protection should be worn.

> **Equipment**
> 250 cm^3 beaker, thermometer, tripod, gauze, Bunsen burner, heat-resistant mat, measuring cylinder, stop clock, eye protection.
> Optional: 500 cm^3 beaker.

2: Heating different materials
Developing/Securing
Prac WS
Students heat up water and blocks of different metals, all of the same mass, using an immersion heater, and record the temperature change over a fixed time. This will demonstrate the dependence of temperature on material. This is an opportunity to introduce students to the use of dataloggers and temperature sensors. They will use these to record the temperature changes over time as the different materials are heated. You may also wish to discuss

© Pearson

the accuracy of the results – a material that has reached a higher temperature in the fixed time will also have lost more heat to the surroundings.

Securing: Ask students to consider the advantages and disadvantages of pooling the class results. They should think about what data they would need and how the results would need to be manipulated. If you have a range of results, it may be possible to put them into a spreadsheet and discuss with students the effect of taking out some of the results – in some cases, a change in the selection of secondary data can lead to a different conclusion.

Exceeding: Ask students to explain whether their evidence is sufficient for the conclusions they have drawn and to explain any manipulation of their results, such as the omission of outliers when calculating means.

⚠ Check the temperature rise with the blocks and immersion heaters you have available to ensure that the final temperature does not exceed around 50 °C to avoid burns. Take care with electrical wires near water. Mop up any spills straightaway.

Equipment
1 kg metal block calorimeters of different metals, immersion heater, power supply, beaker or tank to contain 1 litre of water, stop clock, thermometer, datalogger, temperature sensor.

3: Sweat and cooling

Developing/Securing

Prac

Show students a plastic drinks bottle filled with warm water and wrapped in a damp paper towel or kitchen roll. Ask them to explain how this models a sweaty human body. Then ask how they can use this model to demonstrate that the evaporation of sweat helps to cool the body. Elicit the idea that a control will also be needed.

Students could carry out preliminary work to determine a suitable starting temperature, suitable time intervals between temperature measurements, etc. If datalogging equipment is available, it could be used to measure the temperatures.

Developing: Instructions are provided on Worksheet 8Ka-2.

Securing: Students plan their own investigation with the aid of Worksheet 8Ka-3. In addition to the prompt questions on the sheet, students should be encouraged to think about the advantages and possible disadvantages of collating class results. They should suggest what results would be collected and how they could be manipulated.

Exceeding: Students could extend the work by:

- carrying out further practical work to find out what effect air blowing over the model has on the cooling rate
- considering the validity of their model, perhaps by researching relevant information about the human body and comparing it with similar information about their model. Factors to be considered include body size and mass, body temperature and normal temperature of the surroundings, etc.

⚠ Mop up any spills straightaway.

Course resources
AP: Worksheets 8Ka-2; 8Ka-3.

Equipment
Two plastic drinks bottles, paper towels or kitchen roll, elastic bands, access to hot water tap, thermometers, stop clock.

Optional: temperature probes, datalogging equipment.

4: Relative humidity

Securing/Exceeding

Worksheet 8Ka-6 introduces the idea of relative humidity. Part of the sheet is an introduction to the idea of an equilibrium – maximum humidity is reached when the rate of condensation of water vapour in the air is the same as the rate of evaporation from liquids. The idea of maximum humidity is often presented as the point when the 'air is holding as much water as it can', but this is a misleading simplification.

Securing: Start by discussing hot weather and the kinds of conditions when the heat is easy to cope with (dry days) or when the air seems 'close'. Link the latter to the idea of humidity and water vapour in the air. Then ask students to read through the sheet and attempt the questions before discussing the answers with them.

Exceeding: Students can work through the sheet alone or in pairs. They can compare answers with one another before submitting the work for marking.

Course resources
AP: Worksheet 8Ka-6.

5: Outdoor survival

Developing/Securing/Exceeding

Lit

Worksheet 8Ka-4 provides some notes for a leaflet

© Pearson

on outdoor survival in cold weather. Students are asked to underline words they do not understand and look them up using dictionaries or the Internet. Then, they are to rewrite part of the material for a general audience. They can be encouraged to use subheadings, bullet points, or other ways of organising the text.

Alternatively, some students could produce a computer presentation summarising the advice using simpler language.

The **AT** presentation *Outdoor survival* provides the same text, with the difficult words highlighted and explanations given, then builds up a simpler paragraph of text.

Developing: Use the presentation to treat this task as a class activity.

Securing: Students work in pairs or small groups to agree on the meanings of the difficult words. Hold a short class discussion when they have completed this part of the activity to share meanings and discuss simpler ways of phrasing parts of the notes. You may wish some groups to look only at the 'Avoidance' section.

Exceeding: Students work alone to rewrite the leaflet before pairing up to compare ideas.

This is also an opportunity to revisit other literacy work (if covered), such as sentences (Unit 7C) and paragraphs (Unit 7D), persuasive writing (Unit 8A), planning an article (Unit 8C) and giving a presentation (Unit 8J).

Course resources
AP: Worksheet 8Ka-4.
AT: Presentation *Outdoor survival*.

Equipment
Internet/library access.

6: Temperatures and scales

Developing/Securing/Exceeding

Students can research a number of topics connected with energy and temperature, some of which are suggested below. Students could choose their own topic or groups could be allocated a topic to report back on. This is an opportunity to practise their skills in tailoring their language for an appropriate audience (Exploring 5 and Explaining 2) or preparing a presentation (8Jd Preparing a presentation). Or, their findings can be presented as posters. Skills Sheets RC 1–RC 5 from the Year 7 Activity Pack may be useful.

Temperature line: Students find out about a range of temperatures, such as the melting and boiling points of various common substances, or the hottest and coldest temperatures in various countries. They could also find out about a much larger range of temperatures, such as the temperature in an oven, the temperature of the surface of the Sun, the temperatures on the surfaces of different planets, etc.

Fahrenheit and Celsius: Students find out about the men who devised these two temperature scales, including the fixed points chosen by Fahrenheit, and who reversed Celsius's original scale that had the freezing point of water at 100 degrees and the boiling point at zero.

Kelvin and absolute zero: Students find the meaning of absolute zero in terms of particle movement and describe the Kelvin scale.

Different types of thermometer: Students find out about different types of thermometer, such as different types of liquid in glass thermometers, bimetallic thermometers, etc. and list some advantages and disadvantages of each.

Course resources
AP: Skills Sheets RC 1 (Year 7); RC 2 (Year 7); RC 3 (Year 7); RC 4 (Year 7); RC 5 (Year 7).

Equipment
Internet/library access.

7: Using evaporation

Developing/Securing

Students find out about topics connected with evaporation and cooling, some of which are suggested below. Students could choose their own topic or groups could be allocated a topic to report back on. This is an opportunity to practise their skills in tailoring their language for an appropriate audience (Exploring 5 and Explaining 3) or preparing a presentation (8Jd Preparing a presentation). Or, their findings can be presented as posters. Skills Sheets RC 1–RC 5 from the Year 7 Activity Pack may be useful.

Zeer: A zeer is a porous pot used to keep food cool in hot climates. Students should explain how it works in terms of evaporation and cooling, and also explain why it is useful in the places where it is used (cooling is possible without the use of electricity).

Windcatchers: These are structures on the roofs of buildings in hot countries that act to draw air through the building. If the air is forced to flow over water, the cooling effect of the draught is increased.

Course resources
AP: Skills Sheets RC 1 (Year 7); RC 2 (Year 7); RC 3 (Year 7); RC 4 (Year 7); RC 5 (Year 7).

Equipment
Internet/library access.

© Pearson

EXPLAINING TASKS

1: 8Ka Living in extremes (Student Book)
Developing/Securing/Exceeding
BA
This page introduces the theme for the unit by looking briefly at how humans manage to live in extreme environments. Questions on the page revise work on the particle model of matter from Unit 7G and on changes of state from Unit 8I, and can be used for baseline assessment.

The **AT** video *Living in extremes* provides an overview of some of the ways in which traditional housing styles around the world are adapted to the local conditions. See Starter 4.

The **AT** interactives *Changing states 1* and *Changing states 2* provide drag and drop activities aimed at helping students to recall work from Unit 8I on particle movement and changes of state. See Starter 3.

Course resources
AT: Interactives *Changing states 1*; *Changing states 2*. Video *Living in extremes*.

2: 8Ka Temperature changes (Student Book)
Developing/Securing/Exceeding
FA
These pages describe the difference between internal energy and temperature, and look at cooling by evaporation. Questions 4 and 6 can be used as formative assessment. Worksheet 8Ka-1 is the Access Sheet.

Course resources
AP: Worksheet 8Ka-1.

3: 8Ka Choosing language (Student Book)
Developing/Securing/Exceeding
Lit
These pages discuss the choice of vocabulary when writing for different audiences. Exploring 5 can be used as a follow up.

4: The cooling effect of evaporation
Securing/Exceeding
The **AT** animation *The cooling effect of evaporation* explains the link between the average speed of particles and temperature, and explains why evaporation produces a cooling effect.

Course resources
AT: Animation *The cooling effect of evaporation*.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
Developing/Securing/Exceeding
FA
Assessment: The 8Ka Quick Check sheet provides a set of answers. Students work alone or in pairs to write questions that will produce these answers. Encourage them to write more than one question if they can.

Feedback: Ask students to volunteer questions to fit the answers. Ask the class to comment on the questions suggested – if answered correctly, would they give the right answers?

Action: Ask students to make a summary of their strengths and weaknesses when answering this type of question. Identify any misconceptions or areas of weakness and recap these now or at the beginning of the next lesson.

Course resources
ASP: 8Ka Quick Check.

2: Quick Check Literacy
Developing/Securing/Exceeding
FA **Lit**
Assessment: The 8Ka Quick Check Literacy sheet provides three passages of text with instructions on using thermometers. Students are asked to describe the differences between them and then link each passage with the given uses. Students should work on this in pairs or small groups.

Feedback: After a few minutes, ask for volunteers to suggest differences between the passages. Elicit ideas about vocabulary, sentence construction and level of detail. Ask students to explain how they decided which text was for which purpose.

Action: Exploring 5 provides further practice on working with texts, if this has not already been used.

Course resources
ASP: 8Ka Quick Check Literacy.

3: Thinking about temperature
Securing
FA
Assessment:
Consider All Possibilities: One block of material is storing more thermal energy than another. (Possible answers: one has more mass than the other; one

© Pearson

is at a higher temperature than the other; one is made of a material that stores more energy for each degree of temperature rise.)

Consider All Possibilities: One liquid evaporates faster than another. (Possible answers: one is hotter than the other; one has a lower boiling point than the other – and so evaporates more easily at a given temperature – one has a larger surface area exposed to the air; one has a breeze blowing over it.)

Plus, Minus, Interesting: Evaporation should not happen below the boiling point of a liquid. (Possible answers: **Plus –** Lakes in hot countries would not dry up; **Minus –** Sweating would not cool us down; puddles would not dry up; paint would not dry; **Interesting –** Would we have to heat painted objects to get the paint to dry? We would never get any more rain, because clouds form by evaporation at temperatures below the boiling point of water.)

Feedback: Ask for volunteers to give some of their answers, then ask if anyone has any comments or corrections on the responses given.

Action: Ask students to write down the best answers (choosing from their own and any they have heard read out) and consider why they think these are the best. Carry out the same process for their weakest answers, with students writing down how they need to improve. List the most common areas needing improvement for the class and make these a focus in future activity. If understanding is poor then revise the concepts as a class activity or plan to address these areas in later lessons.

The **AT** presentation *8Ka Thinking skills* can be used for this activity.

Course resources
AT: Presentation *8Ka Thinking skills*.

4: Cooling by evaporation
Securing
FA **Prac**

Assessment: Put one drop of surgical spirit on to the back of students' hands, and one drop of water. Ensure the surgical spirit and water are at room temperature to start with.

Ask students to work in pairs to explain why the surgical spirit feels colder than the water, even though both are at room temperature.

Feedback: Ask for volunteers to give an explanation. Ask other groups to comment on the feedback.

Action: Build up a paragraph of text on the board that provides an agreed class explanation for the phenomenon. Ask for a thumbs-up/thumbs-down show of hands to indicate individual confidence in the final paragraph. Explaining 4 can be shown if it has not already been used. There will be further opportunities to discuss cooling by evaporation later in the unit.

⚠ Students should wash their hands after this demonstration. Surgical spirit is highly flammable: ensure there are no ignition sources and do not use more than one drop. Do not inhale the vapour.

Equipment
Surgical spirit in dropper bottle, water in dropper bottle.

HOMEWORK TASKS

1: Energy and temperature
Developing/Securing

Worksheet 8Ka-5 provides straightforward questions on the content of this topic.

Course resources
AP: Worksheet 8Ka-5.

2: Breathable waterproofs
Securing/Exceeding

Worksheet 8Ka-7 provides questions on evaporation and cooling in the context of breathable fabrics.

Course resources
AP: Worksheet 8Ka-7.

3: Absolute zero
Securing/Exceeding

Worksheet 8Ka-8 develops the idea of temperature depending on the kinetic energy of particles to look at the idea of absolute zero and the Kelvin temperature scale.

Course resources
AP: Worksheet 8Ka-8.

ActiveLearn
Five ActiveLearn exercises are available for this topic: Temperature changes 1; Temperature changes 2; Temperature changes 3; Choosing language 1; Choosing language 2.

© Pearson

8Kb
Transferring energy

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
[Internal, thermal] energy is transferred by different processes in different circumstances.	Recall that [thermal] energy can be transferred by [evaporation, radiation, convection, conduction].	Identify the [thermal] energy transfer process(es) in a given situation [conduction, convection, radiation].	Explain which [thermal] energy transfer process(es) are happening in a given situation.	Compare [radiation, convection, conduction, evaporation] as methods of [thermal] energy transfer. Identify the energy transfer processes affected by different methods of controlling energy transfers.	Evaluate different ways of keeping something [warm, cool].	Plan ways in which to [increase, decrease] thermal energy transfers.
[Internal, thermal] energy can be transferred by radiation.	State the meaning of: radiation. Recall ways of reducing energy transfer by radiation.	Describe how energy is transferred in radiation.	Apply the idea of different colours being good or poor [emitters, absorbers].		Evaluate qualitative and quantitative ways of [decreasing, increasing] radiation.	Design a house for low-cost heating bills.
[Internal, thermal] energy can be transferred by convection.	State the meaning of: convection. Recall ways of reducing [thermal] energy transfer by convection.	Describe how energy is transferred in convection.	Use the particle model of matter to explain energy transfer by convection.	Compare convection in [liquids, gases], explaining any [similarities, differences]. Use labelled diagrams to show convection currents resulting from parts of a fluid being [heated, cooled]. Explain how thermals form.	Evaluate qualitative and quantitative ways of [decreasing, increasing] convection.	
[Internal, thermal] energy can be transferred by conduction.	Recall examples of common thermal [insulators, conductors]. State the meaning of: conduction.	Describe how energy is transferred in conduction.	Use the particle model of matter to explain energy transfer by conduction. Explain why particular materials are used for given purposes.	Compare conduction in [metals, thermal conductors, thermal insulators], explaining [similarities, differences].	Evaluate qualitative and quantitative energy-saving methods that cut down energy transfer by conduction.	Design a way of quoting the insulating properties of materials.

© Pearson

Objectives
Developing:

1. Recall that energy can be transferred by heating in conduction, radiation and convection.
2. Recall examples of common thermal conductors and insulators.
3. Identify the process(es) in which energy is transferred by heating in a given situation.
4. Describe how energy is transferred in conduction, convection and radiation.
5. Explain why particular materials are used for given purposes.
6. Use the particle model of matter to explain energy transfers by conduction and convection.

Securing:

7. Compare conduction in thermal conductors and thermal insulators.
8. Explain the process(es) in which energy is transferred by heating in a given situation.
9. Compare conduction, convection, radiation and evaporation as methods of heat energy transfer.

Exceeding:

10. Explain the causes and effects of wind chill.

Student materials

Topic notes

- To avoid potential misconceptions, try to avoid the common shorthand of 'heat rises' when discussing convection. Instead, say that 'part of a fluid that is warmer than the surrounding fluid will rise'.

Be prepared
Book the hall for Exploring 3.
Plenary 3 should be practised before the lesson.

STARTERS

1: Touching materials
Securing
Prac

Provide students with a range of different materials, including metal objects and insulating materials, such as polystyrene foam. Ask them to touch each material and decide whether it feels warm or cold to the touch. Ask them to suggest why the materials feel different to the touch and elicit the idea that the ones that feel cold are transferring energy away faster than the ones that feel warm. Get students, in pairs, to sketch an object showing energy transfer between the object and a hand. Ask for volunteers to show their diagrams and get feedback on them.

⚠ Warn against touching materials of unknown temperature (either hot or cold).

Equipment
Range of different materials to include metal objects and some made from insulating materials.

2: Galileo thermometer
Securing
BA **Prac**

Students need to recall work on the effects of heating on particles, expansion/contraction, and floating, sinking and density (covered in Unit 8I) to help them to understand convection.

Show students a Galileo thermometer and explain that the temperature is shown by the lowest number attached to the bulbs that are floating at the top of the tube. Tell students that the bulbs are all the same size but have different masses. Ask students to come up with a theory of how the thermometer works, in small groups or pairs. After 5 minutes of group discussion, ask for volunteers to sit in the 'hot seat' at the centre of the class and to present their explanation. Other groups will ask the hot seat student questions to test whether or not their theory works. Swap the student in the hot seat if there are any alternative theories. Ask questions, if necessary, to help them to explain that the bulbs will therefore have different densities and to explain how the thermometer works.

Equipment
Galileo thermometer (images of a thermometer at different temperatures could be used if necessary – these are available on the Internet).

3: Light and infrared radiation
Securing
Prac

Show students that light from a heat lamp does not make paper get hot at a distance. Then show them how the light can be focused, leaving the lens in place until the paper at the same distance starts to scorch. Ask them to suggest how the heat is getting from the lamp to the paper and how the lens causes additional heating. Get students to sketch the demonstration and to annotate it with an explanation.

⚠ Students should be warned not to use this on skin or to use the Sun. They must NOT look at a heat or light source through the lens.

Equipment
Convex lens, heat lamp, paper.
Optional: lens holder, clamp and stand.

EXPLORING TASKS

1: Good conductors?

Developing/Securing

Prac WS

Investigate which metals are the best conductors by fastening rods of different metals to a tripod and using a Bunsen burner to heat one end. Use a temperature probe at the other end of the rod to determine how long it takes for the temperature to rise by 5 °C.

Developing: Worksheet 8Kb-2 provides instructions for this method.

Securing: Worksheet 8Kb-3 provides more open-ended directions to help students to plan their own method.

If datalogging equipment is not available, the practical can be done by sticking drawing pins to the ends of the rods using petroleum jelly. When the heat from the Bunsen burner has been conducted along the rod it will melt the petroleum jelly and the pins will fall. The first pin to fall should be the one stuck to the best conductor. Some groups could be asked to use this method anyway and the results obtained using the two methods compared. Discuss the benefits and drawbacks of the two methods (with the drawing pins method, it is easier to heat all the rods simultaneously).

⚠ Warn students against touching hot metal.

Course resources
AP: Worksheets 8Kb-2; 8Kb-3.

Equipment
Copper rod, iron rod, rods of other materials (if available), tripod, heat-resistant mat, Bunsen burner, wrap-around or self-adhesive temperature sensors, datalogging equipment, stop clock.
Optional: wax or petroleum jelly, drawing pins.

2: How fast does metal conduct heat?

Developing/Securing

Prac WS

Students clamp a metal rod horizontally and place temperature sensors at equal intervals along it. Heat the end of the rod furthest from the clamp and note the temperature rises at different places. If datalogging equipment is not available, this can be done by using petroleum jelly to stick drawing pins at equal intervals along the rod and timing how long it takes for each pin to fall off. Students could be asked to predict how fast the heat will travel along the bar. If using the drawing pins method, discuss the potential inaccuracies (e.g. different amounts of petroleum jelly).

⚠ Eye protection should be worn.

Equipment
Clamp and stand, metal rod (the vertical rod from a clamp stand is suitable, unscrewed from its base), Bunsen burner, eye protection, heat-resistant mats, temperature sensors, datalogging equipment.
Optional: petroleum jelly, drawing pins, stop clock.

3: Student simulations

Securing/Exceeding

Prac WS

Students can be used to model conduction and convection. You need a clear space to do this.

Conduction: Students link arms firmly in a line so that each student represents a particle in a solid. One student gets ‘heated’ and gently pushes backwards and forwards so that the movements are conducted along the line. This can be repeated for a liquid but this time holding hands loosely. It will be seen to be less effective. For a gas, the students stand separately and hardly any ‘energy’ is passed along.

Convection: Students again represent particles and counters represent energy being transferred. Spread students out in a large room and give those near one end a number of counters. This is the ‘hot’ end of the room. Tell them that the students with the most counters move fastest, towards the back of the room and that they should pass on one counter every time they meet someone with fewer counters. As the ‘hot’ students move away from the ‘hot end’, others move in to take their place and pick up ‘energy’. This should continue until the ‘energy’ is fairly evenly distributed amongst all students. Help students to relate their simulation to what happens in a real convection current.

⚠ Take care that students do not take the colliding too seriously!

© Pearson

Equipment
Access to hall or playing field; approximately 100 counters or small pieces of coloured paper.

4: Explaining conduction and convection
Securing/Exceeding
Worksheet 8Kb-4 provides an image and a set of statements for students to cut out and sort into those explaining conduction and those explaining convection.

Developing: Students follow the instructions on the worksheet.

Securing: Students use the diagrams, but write their own explanations or labels.

Exceeding: Ask students to produce a set of cards to describe what happens in conduction and convection that could be used to help a different class learn about these processes. Alternatively, they could be asked to provide explanations for what happens if part of a fluid is cooled more than its surroundings, or if one end of a solid is cooled. In the latter case, ensure students do not write about 'cold' being transferred.

The **AT** interactive *Explaining conduction and convection* allows students to find out how energy is transferred by conduction and convection when a saucepan of water is heated.

Course resources
AP: Worksheet 8Kb-4.
AT: Interactive *Explaining conduction and convection*.

5: Candles
Securing/Exceeding
Prac
Worksheet 8Kb-6 discusses the supply of oxygen to a candle flame via convection and how this differs in the 'weightless' conditions in orbit. Photos are available on the Internet (search: candle in space).

Securing: Start by showing students a Bunsen burner flame with the air hole open and then closed. Revise learning from earlier topics about the reasons for the difference in the flames. Ask students to use ideas about particles to explain why the hot gas forms a tall 'tear drop' shape (convection). You can also show a lit candle and ask them to compare its flame with the safety flame of the Bunsen burner. Students can then work through the questions on the sheet in pairs.

Exceeding: Students work through the sheet alone or in pairs.

Course resources
AP: Worksheet 8Kb-6.

Equipment
Internet access.
Optional: Bunsen burner, candle, heat-resistant mat.

EXPLAINING TASKS

1: 8Kb Transferring energy (Student Book)
Developing/Securing/Exceeding
FA
These pages describe how energy is transferred by radiation, conduction and convection. Good and poor thermal conductors are discussed, but other aspects of insulation will be covered in 8Kc. Question 8 can be used as formative assessment.

Worksheet 8Kb-1 is the Access Sheet.

The **AT** link *Convection* allows you to turn the labels on and off on photo D. The **AT** video *Natural insulators* shows some natural and traditional building materials which make good insulators.

Course resources
AP: Worksheet 8Kb-1.
AT: Labels on/off *Convection*. Video *Natural insulators*.

2: Convection in water
Securing
Prac
Demonstrate a convection current in water by dropping a potassium manganate(VII) crystal down a tube into the bottom of a beaker of water. Heat the beaker over a Bunsen flame, positioning the flame beneath the crystal. Ask students to explain why some of the water turns purple and then why the purple water moves in the way it does.

The **AT** animation *Convection* explains this process.

⚠ Potassium manganate(VII) is an oxidising agent and is harmful. Wear eye protection. Do not directly handle the crystal. Wash hands after use. Mop up any spills straightaway.

Course resources
AT: Animation *Convection*.

Equipment
Beaker, water, small tube, forceps, potassium manganate(VII), Bunsen burner, tripod, gauze, heat-resistant mat.

© Pearson

3: Convection currents and winds

Securing

The **AT** presentation *Convection currents and winds* explains the origins of land and sea breezes, and the convection cells that are responsible for global winds.

Securing: Show students the screens that explain sea breezes during the day. Tell them that at night the land cools down faster than the sea and ask them to draw a labelled diagram to explain how breezes at night are caused.

Exceeding: Show students only the first two screens for coastal breezes, which explain why air above the land is hotter than air above the sea. Then ask students to draw a diagram to explain how this causes winds. Show the next screen to allow them to check their diagrams and make any corrections necessary, before asking them to repeat the exercise for breezes at night.

Course resources
AT: Presentation *Convection currents and winds*.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check

Developing/Securing/Exceeding

FA

Assessment: The 8Kb Quick Check sheet provides a set of images depicting energy transfers. Students can be asked to identify the energy transfer processes taking place in each image, giving their reasons. They should work in pairs for this, jotting down their answers on scrap paper.

Feedback: Ask pairs to report back on one of the pictures. Other groups should be asked to make constructive comments to help improve the answers. Students should make a note of areas of difficulty they have. If necessary, elicit further details using questions such as, A – will your hand feel warmth if you hold it beside the pan rather than above it? B – will the blacksmith feel hot? C – will their legs feel hot? D – (if Explaining 3 has been used) how will convection currents form? E – will there be convection currents in the sea?

Action: Groups then think up a situation of their own where energy is transferred, and describe the situation and the ways in which energy is being transferred. Students should highlight where they have applied an area of science that they previously found difficult and where they now feel more confident.

Course resources
ASP: 8Kb Quick Check.

2: Thinking about energy transfers

Securing

FA

Assessment:
Plus, Minus, Interesting: Conduction should happen through liquids and gases as well as solids. (Possible answers: **Plus** – Energy would be transmitted more easily; **Minus** – We might get burnt while cooking as energy would travel through the air as easily as through a pan; **Interesting** – Moving liquids and gases do carry energy with them so is this a sort of conduction? Copper conducts energy nearly 700 times better than water and over 16 000 times better than air. Are there liquids that conduct better than solids?)

Odd One Out: conduction, convection, radiation, evaporation. (Possible answers: radiation does not need particles whereas the others do; radiation is the only one that transfers energy from the Sun to the Earth; radiation is the only one that can transfer energy through (some) solids, (some) liquids and gases; evaporation only transfers energy from liquids.)

Odd One Out: glass, air, metal. (Possible answers: radiation will not go through metal; metal is the only good conductor; air is the only one that will allow convection.)

Feedback: Give students a few minutes to think of their responses, then ask for volunteers to provide answers. Ask the class to choose the best answers to each question and suggest why they are the best.

Action: Get students to categorise the areas they need to improve in, e.g. they do not understand the science ideas, poor recall, not reading the task properly, etc. Group together students with similar issues and get them to revise together one area identified for improvement for their group.

The **AT** presentation *8Kb Thinking skills* can be used for this activity.

Course resources
AT: Presentation *8Kb Thinking skills*.

3: Energy transfer demonstrations

Securing/Exceeding

FA **Prac**

Show students two demonstrations and ask them to explain what is happening in each case, using words such as conductor, insulator, density, convection, etc., as appropriate. Students can be asked to sketch each set of apparatus and to annotate their sketches to explain.

© Pearson

Wood and metal: Use a wood and metal cylinder (one end is wood, the other is metal; available from equipment suppliers) and wrap the centre of the bar with a piece of paper. Holding the wooden end of the bar, place a Bunsen burner flame gently over the paper where the two materials join. You should find that the paper becomes scorched where it lies over wood, but not where it lies over the metal.

Smoke box: A smoke box is a glass-fronted box with two glass chimneys (available from equipment suppliers). Set up the box with a candle or tea light beneath one chimney. A smouldering straw or paper towel can be used to provide the smoke. Ask students to suggest what will happen if you hold the straw over first one chimney, then the other, and challenge them to explain what is happening.

⚠ Practise the demonstration before the lesson. Have heat-resistant mats and tongs to hand for hot objects. Smoke can spread so be aware of any asthmatics in the class.

Equipment
Metal/wood cylinder, Bunsen burner, heat-resistant mat, smoke box, tea light or small candle, paper towel or drinking straw.

4: Extending sentences

Securing

FA

The **AT** presentation *Extending sentences* provides a set of simple sentences describing energy transfer processes (including evaporation, covered in Topic 8Ka). Show the first screen to students and ask them to work in groups to extend the sentences by adding details. The remaining screens show an example of an extended version of each sentence. These can be shown when students have completed their own sentences. Students can check they have included all the points given for each one, or can suggest further improvements to each sentence. Ask students to volunteer which sentences they found most difficult to extend – and why.

Course resources
AT: Presentation *Extending sentences*.

5: Ideas about energy transfers

Securing

BA **FA**

The **AT** interactive *Concept cartoon: Ideas about energy transfers 1* provides three statements connected with energy and insulating materials. Students can discuss the statements in pairs and decide whether or not each one is correct, or they can consult the notes they made if this was used in Topic 8Ka Starter 5 and note down any changes in their responses. Ask for volunteers to explain their thoughts about each statement, then ask others in the class if they can improve on the explanations.

Course resources
AT: Interactive *Concept cartoon: Ideas about energy transfers 1*.

6: Energy transfer concept map

Developing/Securing/Exceeding

FA **Prac**

Ask students to draw a concept map to summarise the four ways in which energy can be transferred by heating (evaporation, conduction, convection, radiation). Students may wish to build on concept maps they drew if they did Topic 8Ka Starter 2, or could start fresh maps focused only on energy transfers by heating. Give students 5 minutes to work on their maps, then take ideas from the class to build up a concept map on the board. Students' own maps will not necessarily resemble this, but discussing the main points should allow students to add information to their own maps or correct any misconceptions. If you also ask for a show of confidence (thumbs-up or thumbs-down for each idea), you can note any ideas that will need further reinforcement in the next lesson.

HOMEWORK TASKS

1: Kitchen questions 1

Developing/Securing

Worksheet 8Kb-5 provides questions on the content of this topic.

Course resources
AP: Worksheet 8Kb-5.

2: Kitchen questions 2

Securing

Worksheet 8Kb-7 provides more demanding questions on the content of this topic.

Course resources
AP: Worksheet 8Kb-7.

3: Wind chill

Securing/Exceeding

Worksheet 8Kb-8 describes wind chill and provides a set of questions that help students to explain why

© Pearson

it occurs. It may be helpful to remind students that the rate of energy transfer increases with increasing temperature difference (covered in Topic 8Ka). Students will find question 3 easier if they have used Worksheet 8Ka-6 on relative humidity (Topic 8Ka Exploring 4).

Course resources
AP: Worksheet 8Kb-8.

ActiveLearn
Three ActiveLearn exercises are available for this topic: Transferring energy 1; Transferring energy 2; Transferring energy 3.

© Pearson

8Kc
Controlling transfers

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	**Understanding (b)**	**Applying (c)**	**Analysing (d)**	**Evaluating (e)**	**Synthesising & creating (f)**
The amount of [internal, thermal] energy something contains depends on various factors.	Describe the factors that determine the temperature of an object in terms of energy, material and mass. Recall that the speed of movement of particles in a substance depends on the temperature.	Describe the effect of a substance's specific heat capacity on its ability to store heat energy.	Use the formula $E = m \times c \times \theta$	Explain what happens when a system maintains a constant temperature.	Evaluate the effects of thermal mass in controlling the temperature inside buildings.	
[Internal, thermal] energy can be transferred by evaporation from a surface.	State the meaning of: evaporation. Recall the effect of evaporation on the temperature of the remaining liquid. Recall ways of reducing energy transfer by evaporation.	Explain what happens to particles when a liquid evaporates.	Use the particle model of matter to explain energy transfer by evaporation from a surface.		Evaluate qualitative and quantitative ways of [decreasing, increasing] energy transfer by evaporation, including lids, pressure effects, and motion of air.	
[Internal, thermal] energy can be transferred by radiation.	State the meaning of: radiation. Recall ways of reducing energy transfer by radiation.	Describe how energy is transferred in radiation.	Apply the idea of different colours being good or poor [emitters, absorbers].		Evaluate qualitative and quantitative ways of [decreasing, increasing] radiation.	Design a house for low-cost heating bills.
[Internal, thermal] energy can be transferred by convection.	State the meaning of: convection. Recall ways of reducing [thermal] energy transfer by convection.	Describe how energy is transferred in convection.	Use the particle model of matter to explain energy transfer by convection.	Compare convection in [liquids, gases], explaining any [similarities, differences]. Use labelled diagrams to show convection currents resulting from parts of a fluid being [heated, cooled]. Explain how thermals form.	Evaluate qualitative and quantitative ways of [decreasing, increasing] convection.	

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
[Internal, thermal] energy can be transferred by conduction.	Recall examples of common thermal [insulators, conductors]. State the meaning of: conduction.	Describe how energy is transferred in conduction.	Use the particle model of matter to explain energy transfer by conduction. Explain why particular materials are used for given purposes.	Compare conduction in [metals, thermal conductors, thermal insulators], explaining [similarities, differences].	Evaluate qualitative and quantitative energy-saving methods that cut down energy transfer by conduction.	Design a way of quoting the insulating properties of materials.

Objectives

Developing:

1. Recall ways of reducing energy transfer by conduction, convection and evaporation.
2. Apply the idea of different colours being good or poor emitters or absorbers.
3. Explain why particular materials are used for given purposes.

Securing:

4. Evaluate ways of increasing or decreasing energy transfer by conduction, convection, radiation and evaporation.
5. Compare the effects of different rates of conduction in different materials.

Exceeding:

6. Apply the idea of thermal mass to homes.

Focused Working Scientifically Objectives

This topic provides an opportunity to focus on key Working Scientifically skills.

1. State the meaning of: accuracy.
2. State the meaning of: precision.
3. Use information about resolution to choose measuring instruments.
4. Explain how to avoid systematic and random errors.

Student materials

STARTERS

1: Brainstorm conductors and insulators

Developing

Introduce this topic by brainstorming students' ideas about materials that transfer energy easily and materials that do not. They should list examples of conductors and insulators in a two-column table – or use a framework of their choice. Then they can list the common characteristics of each group of materials. Ask them to suggest what the insulating materials have in common and to keep their notes to revisit later in the lesson.

2: Water as an insulator

Securing

Prac **WS**

Tell students you are going to heat a borosilicate glass boiling tube of water with an ice cube held at its base with a piece of gauze. Ask them what they think will happen. The tube must be held at an angle so that the Bunsen flame can be applied near the top of the tube. The surface water will boil and the ice will not melt straight away. Ask students what they have observed and ask them to explain why the ice does not melt. If necessary, reverse the process so that the ice is floating at the top of the test tube and the bottom of the tube is heated – the ice cube should melt much more quickly in this case. Discuss how what actually happened is different from what students predicted.

If datalogging equipment is available, temperature sensors could be used to monitor the temperature at different places in the boiling tube.

⚠ Water can spit from the end of the tube. Eye protection should be worn. Mop up any spills straightaway.

Equipment

Boiling tube, water, ice cubes, gauze, clamp and stand, Bunsen burner, eye protection.

3: Word challenge

Developing/Securing

Assessment: The **AT** presentation *Energy transfer words* provides a grid with the initial letters of the keywords from Topics 8Ka and 8Kb. Give students a few minutes to work in pairs to put words with as many of the letters as possible.

Feedback: Take each letter in turn and ask for volunteers to say what the word could be and to say what it means. Ask others in the class to say whether the definition is correct or to suggest improvements to it. Students should note any terms that they are unsure of for later revision.

© Pearson

Action: Students could be given copies of the 8K Word Sheets to help reinforce the words with their correct meanings.

Course resources
ASP: 8K Word Sheets.
AT: Presentation *Energy transfer words*.

EXPLORING TASKS

1: Radiation and colours

Developing/Securing

Prac WS

Students investigate if the colour of a material affects how well it absorbs infrared radiation. A ray box is an adequate source of heat and, at its simplest, students can just clamp two thermometers with bulbs painted in different colours in front of the ray box. Then, record the temperature every minute. Instructions are given on Worksheet 8Kc-2. If students have done Explaining 2 you could discuss the degree of accuracy possible/appropriate for this investigation (reading thermometers to the nearest degree is usually sufficient).

Developing: Students follow the instructions on the worksheet. Students may need help drawing the axes for their line graphs.

Securing: Discuss with students how the investigation could be improved or adapted to look at different colours (e.g. by sticking pieces of different coloured paper in front of the thermometer bulbs using modelling clay).

Exceeding: Ask students to plan an investigation to find out if the colour of an object affects how well it emits radiation. In practice, this can be done as part of the same investigation, by continuing to record the temperatures on the two thermometers for 10 minutes after the ray box has been switched off.

The AT spreadsheet *Radiation and colours* provides experimental results and questions, and could be used in place of the practical work.

⚠ Do not allow students to touch the heat source. Take care when clamping glass thermometers.

Course resources
AP: Worksheet 8Kc-2.
AT: Spreadsheet *Radiation and colours*.

Equipment
Two thermometers, with painted ends (one silver, one matt black), ray box and power supply, stop clock.

2: Investigating insulation

Developing/Securing/Exceeding

Prac WS

Students plan and carry out an investigation of the factors that affect insulation. If students have done Explaining 2, you could discuss the degree of accuracy possible/appropriate for this investigation (reading thermometers to the nearest degree is usually sufficient).

Developing: Worksheet 8Kc-3 provides instructions to help students investigate the effect of increasing the number of layers of insulation around a beaker containing hot water. Using this sheet will restrict the marks that students can obtain in the planning strand, if this investigation is used for a Working Scientifically investigation.

Securing: Worksheet 8Kc-4 provides suggestions and questions to help students to plan their own investigation. Students capable of working at higher levels should be encouraged to choose a continuous or discrete variable to investigate rather than a categoric variable.

Exceeding: Students frame their own question and design an investigation, possibly using question 2 on Student Book spread 8Kc Controlling transfers as an initial prompt.

This practical can be used to carry out a Working Scientifically investigation. A set of assessment descriptions is provided in the ASP. Skills Sheets PI 7, PI 8 and PI 9 could be useful.

Course resources
AP: Skills Sheets PI 7; PI 8; PI 9. Worksheets 8Kc-3; 8Kc-4.
ASP: 8K WS Investigations.

Equipment
Beakers, thermometers (two or three per group if possible), stop clock, fleece material, elastic bands or sticky tape, selection of insulating materials.

3: Accuracy and precision

Securing/Exceeding

WS

Worksheet 8Kc-7 shows some different measuring instruments and asks questions. It will be helpful to discuss how a laser measurer works with students to help them with question 3.

If you have an analytical balance available, show it to students and explain some of the differences between it and the balances that students use in investigations (e.g. why there is a screen around the pan).

© Pearson

Course resources
AP: Worksheet 8Kc-7.

Equipment
Optional: balance, analytical balance, laser distance estimator.

4: Traditional homes
Securing/Exceeding
Lit
Worksheet 8Kc-5 describes four different traditional homes designed to help keep the occupants warm or cool (some of which are shown in a video – see Exploring 5). Students are asked to identify features of the houses and explain how they work. Further topics for research are also suggested. Students could build on their literacy work from Topic 8Ka by writing about some of the features in two different styles (e.g. with and without using words such as conduction, convection, etc.). If they have studied Unit 8J, they could also build on literacy work from that unit by preparing presentations on the findings from one or more of the research topics. If Topic 8Ka Exploring 7 has been used, students may have already found out about windcatchers.

Course resources
AP: Worksheet 8Kc-5.

5: Living in extremes revisited
Developing/Securing
Lit
The AT video *Living in extremes* provides an overview of some of the ways in which traditional housing styles around the world are adapted to the local conditions. Students may have already viewed this as part of Topic 8Ka Starter 4. The voiceover to the video describes the climate for which each dwelling was built and some of the features, but does not describe the heat transfer processes involved. Ask students to write a new voiceover to explain the science behind the various features.

You could also extend the literacy work from Topic 8Ka by asking some of the class to write a voiceover suitable for other Year 8 classes. Others in the class could write it in terms more suitable for a Year 6 class who have not studied energy transfer processes.

Course resources
AT: Video *Living in extremes*.

6: Insulation ratings
Securing
Ask students to find out about the different ways in which the insulating properties of materials can be quoted.

Developing: Ask students to find out what a ‘tog’ rating is used for, and whether higher or lower tog numbers represent better insulators.

Securing: Ask students to find out how the insulating properties of duvets and sleeping bags are quoted (tog rating and season rating, respectively), and also how building materials are rated (U values), and to compare these different methods.

Exceeding: As ‘*Securing*’, but ask students also to explain what the scientific units for tog ratings or U values are, or how the values are measured.

Equipment
Internet/library access.

EXPLAINING TASKS

1: 8Kc Controlling transfers (Student Book)
Developing/Securing/Exceeding
FA
These pages describe ways in which energy transfers can be reduced. Question 7 can be used as formative assessment. The houses in photo E on this spread show some features that help to keep them cool.

The AT link *A vacuum flask* allows you to turn the labels on and off on figure F. The AT video *Infrared images* shows how cameras that detect infrared radiation can be used to inspect buildings to see how well they are insulated.

Worksheet 8Kc-1 is the Access Sheet.

Course resources
AP: Worksheet 8Kc-1.
AT: Labels on/off *A vacuum flask*. Video *Infrared images*.

2: 8Kc Accuracy and precision (Student Book)
Developing/Securing/Exceeding
FA WS
These pages look at accuracy and precision, and how these are affected by systematic and random errors. Question 6 can be used for formative assessment.

3: Air as an insulator
Securing
Prac
Demonstrate that most effective insulators consist mainly of air. This can be done by asking students to examine a piece of foam rubber or expanded polystyrene using a hand lens. You could also use a vacuum pump to evacuate the air from a piece of duvet filling or other insulating material. The sample will have to be firmly sealed in a plastic bag. You will need to have a tube connected to the pump with a

© Pearson

filter over the tube to protect the pump. Alternatively, put pieces of expanded polystyrene chips or foam rubber in a bell jar and evacuate the air.

⚠ Ensure the bell jar is not cracked or otherwise damaged, to reduce the risk of implosion.

Equipment
Pieces of expanded polystyrene and foam rubber, hand lens, duvet filling, other insulating materials, vacuum pump, strong clear plastic bag or bell jar.

4: Leslie's cube
Securing
Prac
A Leslie's cube is a hollow metal cube with a different surface finish on its four vertical sides. Fill the cube with hot water, which can be kept near boiling point using a low Bunsen flame. Use an infrared sensor to detect the intensity of infrared radiation given off by each side of the cube, and help students to work out the relationship between colour and emission, and also between shiny or rough surfaces and the amount of radiation emitted.

Equipment
Leslie's cube, Bunsen burner, tripod, gauze, heat-resistant mat, infrared temperature sensor, datalogger.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
Developing/Securing/Exceeding
FA
Assessment: The 8Kc Quick Check sheet provides diagrams of a hay box, a solar cooker and a water purifier. Students are asked to list the features of each design and explain how they are designed to increase or reduce energy transfers. Students can work on all three, or each group could be given just one to consider.

Feedback: Ask for a spokesperson from each group to contribute to making a list of design features of each device on the board and to explain the purpose of each feature. If each group has only looked at one design, encourage other groups to ask questions to clarify points, etc. At the end, ask for a show of confidence (via thumbs-up/thumbs-down) in identifying features involving conduction, convection, radiation and evaporation.

Action: Students should add any additional notes needed following the class discussion. Make a note of any areas of difficulty that can be addressed in later topics or during revision at the end of the unit.

Course resources
ASP: 8Kc Quick Check.

2: Quick Check WS
Developing/Securing/Exceeding
FA **WS**
Assessment: The 8Kc Quick Check WS sheet provides two situations where students have to classify sets of results as high or low accuracy and high or low precision, and to explain their reasoning. Students work in pairs to discuss the answers. Alternatively, you could introduce the sheet by drawing the first target on the board and getting students to explain why this represents low accuracy and high precision, then ask them to draw their own targets for the other three situations before using the worksheet.

Feedback: Ask for a volunteer to classify each situation. Ask the rest of the class to decide whether or not they are correct. Allow students to reach conclusions about the correct answer for themselves, by asking them to provide reasoned arguments, as far as possible.

Action: If students are having difficulty go through the target model in question 1 with them, explaining what each represents and modelling good 'reasoning skills', then ask them to look again at question 2.

Course resources
ASP: 8Kc Quick Check WS.

3: Thinking about controlling energy transfer
Securing
FA
Assessment:
Plus, Minus, Interesting: All materials should be insulators. (Possible answers: **Plus** – We would be less likely to burn ourselves on things; **Minus** – We might not be able to cook food if saucepans did not let any energy through; central heating systems would not work because energy could not go from the hot water through the radiators; **Interesting** – Could energy travel without going through a material? Snow can be a better insulator than wood.)

Odd One Out: glass, feathers, bubble wrap. (Possible answers: glass does not contain pockets of air; feathers come from living things.)

© Pearson

Plus, Minus, Interesting: All materials should reflect infrared radiation. (Possible answers: **Plus** – We would stay cooler on sunny days; **Minus** – We would never feel the warmth of the Sun if our skin reflected all the radiation; **Interesting** – If the Earth reflected all the radiation from the Sun, would everything freeze? **Interesting** – Snowy landscapes reflect a lot more infrared radiation from the Sun than forests or fields.)

Feedback: Students answer the thinking skills questions individually and then discuss their answers in groups, thereby feeding back their thoughts to one another. Ask students to write down their best answers and consider why they think they are the best. Ask them to do the same for their weakest answers, trying to identify what they find difficult about these.

Action: Ask a spokesperson from a number of groups to read out their best answers. Compile a class list of 'features of good answers' and a second list of areas of this topic that need to be reinforced. Identify any ideas that are missing and share them with the class. If understanding is poor, then revise the material at the start of the next lesson.

The **AT** presentation *8Kc Thinking skills* could be used for this activity.

Course resources
AT: Presentation *8Kc Thinking skills*.

4: Spoof adverts
Developing/Securing
FA

Ask students to compose spoof radio adverts or jingles for various items where the 'new, improved version' transmits energy when it should not, or vice versa. For instance: 'Our new, improved central heating radiators are insulated to keep the water inside hot' or 'Our new thin duvet has no trapped air'. It might be best first to ask students to say what each item is supposed to do, and then to work out what would happen if it did the opposite. Alternatively, they could make A4 posters for their spoof adverts. Suitable subjects for adverts include saucepans, oven gloves, table mats, baking tins, central heating radiators, carpets, duvets, jumpers, etc.

Ask students to rate each other's spoof ideas out of 10 for 'original thinking'.

HOMEWORK TASKS

1: Keeping warm
Developing/Securing

Worksheet 8Kc-6 provides questions on insulation and radiation.

Course resources
AP: Worksheet 8Kc-6.

2: Wetsuits
Securing

Worksheet 8Kc-8 applies ideas about energy transfers to wetsuits and drysuits.

Course resources
AP: Worksheet 8Kc-8.

3: Thermal mass
Developing/Securing/Exceeding

Worksheet 8Kc-9 provides more challenging work on the idea of thermal mass.

Course resources
AP: Worksheet 8Kc-9.

ActiveLearn
Four ActiveLearn exercises are available for this topic: Controlling transfers 1; Controlling transfers 2; Controlling transfers 3; Accuracy and precision.

© Pearson

8Kd
Power and efficiency

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
Power is the rate at which work is done.	Describe the relationship between watts and joules/second.	Describe what power means.	Use the formula relating power, energy and time.			
Energy transfers can be shown using Sankey diagrams.	Recall that the width of a Sankey diagram gives an indication of the energy involved.	Match Sankey diagrams to [familiar, simple] situations.	Use Sankey diagrams to compare [processes, inputs].	Draw Sankey diagrams to show energy transfers in [unfamiliar, complex] situations.	Use Sankey diagrams to present arguments about decisions on [energy sources, processes, objects].	
Energy cannot be created or destroyed but in most energy transfers some energy is lost in a form that is not useful.	State the meaning of: efficiency. Recall the law of conservation of energy. Recall some advantages of low-energy appliances.	Identify useful and wasted energies. Describe whether a machine is more efficient than another.	Calculate energy efficiencies. Use data to consider cost efficiency by calculating payback times.	Explain why the efficiency can never be greater than 1 or greater than 100%.	Use data to evaluate [processes, objects, energy-saving devices].	

Objectives
Developing:

1. Match Sankey diagrams to simple situations.
2. State the meaning of efficiency and recall some advantages of efficient appliances.
3. Identify useful and wasted energies.
4. Describe whether one machine is more efficient than another.
5. Describe what power means, and the relationship between watts and joules/second.

Securing:

6. Use Sankey diagrams to compare appliances or processes.
7. Calculate energy efficiencies.
8. Explain why the efficiency can never be greater than 100%.

Exceeding:

9. Use the formula relating power, energy and time (in W, J and s).
10. Evaluate energy-saving appliances or modifications.

Student materials

STARTERS

1: Appliances brainstorm
Developing/Securing
Ask students to work in groups to list all the devices they can that use electricity (either from cells or from the mains). Ask them to agree categories for the main way in which each device transfers energy, then to divide their lists into these categories (so they should end up with a four-way table categorising power supply and energy transfer). See if students can suggest any pattern in their lists. They should notice that devices that produce temperature changes (either heating or cooling) are always powered using mains electricity, never by cells. Ask them to suggest why this is – and then to annotate their lists with an explanation.

2: Truth and lies

Developing/Securing

Reinforce learning from previous topics by asking students to work in groups to write down three statements about what they have learnt in the previous topics. Two of these statements should be correct and one should include a deliberate error. Groups then read out their three statements. Other groups can win a point by being able to say which statement is incorrect, as long as they can give a corrected version. Collect any evidence of misconceptions from students' statements and discussions to address later in the lesson.

3: Power and energy

Securing

The **AT** presentation *Energy and power* provides images showing situations in which the total energy transferred is the same, but the energy is transferred in different times. After the first animation of the moving masses, ask students to compare the energy transferred first. Elicit the idea that the energy transferred is the same, then ask the students to say how else the situations are different. Ask them to discuss what terms they would use to describe this difference in time of energy transfer between situations. Then, continue with the presentation that introduces the idea of power. Check understanding by stopping the presentation again after the kettle animation and asking students to comment on the difference in the way the energy is transferred in the two kettles.

Course resources
AT: Presentation *Energy and power*.

EXPLORING TASKS

1: Power ratings

Securing

Prac

Students examine various items of domestic electrical equipment to find their power ratings. Ask students to find a connection between the type of energy transfer that the device carries out and its power rating. They should find that heating appliances generally have higher power ratings. If possible, also provide some information about non-portable appliances, such as ovens or washing machines.

If a joule meter is available, it can be used to demonstrate the amount of energy used in a fixed time by different pieces of equipment. The results should be linked to the power ratings of the equipment.

⚠ The laboratory mains electricity should be switched off unless students using the equipment are closely supervised.

Equipment
Various items of electrical equipment (e.g. iron, hairdryer, radio, personal stereo, TV, computer, toaster, kettle, light bulbs, hair straighteners). Optional: joule meter.

2: Power of appliances

Securing

The **AT** spreadsheet *Power of appliances* provides power ratings for various items of domestic equipment. This task can be used as a follow-up to Exploring 1 (in which students examined various appliances to find out their power ratings), or in place of that task. The instructions with the spreadsheet ask students to identify the main form of energy transfer each appliance is intended to produce and to plot bar charts of sorted and unsorted data. They are encouraged to conclude that heating appliances generally have higher power ratings.

Course resources
AT: Spreadsheet *Power of appliances*.

3: Sankey diagrams and efficiency 2

Developing/Securing

Worksheet 8Kd-3 provides questions to give students practice in identifying the ways in which energy is transferred usefully and ways in which it is wasted, and in drawing Sankey diagrams. It will be helpful if Explaining 2 has been done first.

Securing: Go through the worksheet first, discussing scales to be used for the Sankey diagrams. Students can work in pairs on the questions.

Exceeding: Students work through the questions alone or in pairs.

Course resources
AP: Worksheet 8Kd-3.

4: Power, energy and time

Securing/Exceeding

Worksheet 8Kd-5 introduces the formula relating power, energy and time, and provides questions to give students practice in its use.

Course resources
AP: Worksheet 8Kd-5.

© Pearson

EXPLAINING TASKS

1: 8Kd Power and efficiency (Student Book)

Developing/Securing/Exceeding

FA

These pages introduce power as the rate of energy transfer and describe how to calculate the efficiency of an appliance. Efficiency was discussed qualitatively in Unit 7I. Questions 3 and 5 can be used as formative assessment.

Worksheet 8Kd-1 is the Access Sheet.

The **AT** video *Designing for efficiency* looks at the launch of Volkswagen's XL1 car, explaining how it has been designed for maximum fuel efficiency.

> **Course resources**
> **AP**: Worksheet 8Kd-1.
> **AT:** Video *Designing for efficiency*.

2: Drawing Sankey diagrams

Securing

The **AT** presentation *Drawing Sankey diagrams* leads students through the process of converting data about energy transfers into a Sankey diagram.

> **Course resources**
> **AT:** Presentation *Drawing Sankey diagrams*.

3: Keeping warm

Securing

The **AT** interactive *Keeping warm* provides a series of questions aimed at getting students to choose the best materials to design a well-insulated house.

> **Course resources**
> **AT:** Interactive *Keeping warm.*

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check

Developing/Securing/Exceeding

FA

Assessment: The 8Kd Quick Check sheet provides a set of statements for students to continue using the conjunctions provided. Students work alone or in pairs to complete the sentences. They should be encouraged to write more than one ending for each, if they can.

Feedback: Ask for volunteers to read out their completed sentences and ask others to comment on whether or not it is correct. Make a note of any incorrect responses.

Action: If there are areas of common difficulty, briefly revisit these, or use Topic 8Ke Starter 3 in the next lesson to revise Sankey diagrams and efficiency.

> **Course resources**
> **ASP:** 8Kd Quick Check.

2: Thinking about power and efficiency

Developing/Securing

FA

Assessment:
Odd One Out: electricity, heating, chemical. (Possible answers: chemical is the only one that is used as a name for an energy store; heating is the only one that is both a useful and a wasteful way of transferring energy.)

Plus, Minus, Interesting: Energy should not be transferred by heating. (Possible answers: **Plus** – Machines could not waste energy by heating; **Minus** – We would all freeze to death as the Earth would not be warmed by the Sun – the top of the Earth's atmosphere receives 174 PW of radiation from the Sun [1 petawatt is 1 000 000 000 000 000 watts]; **Interesting** – Would machines waste more energy in other ways if energy could not be transferred by heating?)

What Was The Question: heating. (Possible questions: In what way is most wasted energy transferred?; In what way does a kettle transfer both useful and wasted energies?; In what way is wasted energy transferred by a light bulb?)

Feedback: Use the 'pose–pause–pounce–bounce' method to obtain feedback for each of the questions above. Give students a few minutes to think of their answers, then pounce randomly on a student for an answer, before bouncing that answer to another student, asking 'What did you think of the answer?'

Action: Identify any misconceptions or areas for which students have poor recall and list these on the board. Get students to make a note of areas they need to review in particular. Depending on the areas of difficulty, the other plenary activities may help to consolidate knowledge from this lesson. Re-check the list after these activities.

The **AT** presentation *8Kd Thinking skills* can be used for this activity.

> **Course resources**
> **AT:** Presentation *8Kd Thinking skills*.

3: Alphabet words
Developing/Securing
FA
Assessment: Ask students to write out the alphabet vertically on a sheet of scrap paper and then to work in small groups to write one or more words connected with the work in this unit for each letter.

Feedback: Give them a few minutes for this task and then ask for suggestions. Ask for someone to explain the meaning of each word suggested. If you wish to introduce a competition, a group gets a point for a word only if no other groups have suggested that word.

Action: Make a note of any words that students have difficulty defining and ask them to write out the word and its definition so they can learn it. Get students to add any keywords and definitions that were not suggested.

HOMEWORK TASKS

1: Energy survey
Developing/Securing
Exploring 1 in Topic 8Ke asks students to carry out a survey of appliances used at home and to find out how long they are used for each day. This task could be set as homework here.

Course resources
AP: Worksheet 8Ke-2.

2: Sankey diagrams and efficiency 1
Securing
Worksheet 8Kd-2 provides questions on the content of this topic.

Course resources
AP: Worksheet 8Kd-2.

3: Kettles and bulbs
Securing/Exceeding
Worksheet 8Kd-4 provides questions to test students on their understanding of the content of this topic.

Course resources
AP: Worksheet 8Kd-4.

4: Efficient heating
Securing/Exceeding
Worksheet 8Kd-6 provides questions to challenge students' understanding of the idea of efficiency.

Course resources
AP: Worksheet 8Kd-6.

ActiveLearn
Three ActiveLearn exercises are available for this topic: Power and efficiency 1; Power and efficiency 2; Power and efficiency 3.

© Pearson

8Ke
Paying for energy

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
Energy used has to be paid for.	Electricity and mains gas are charged for on the basis of the energy transferred.	Explain why power companies use the kWh as a measure of energy.	Use the formula relating power, energy and time (in kW, kWh and hours).			
Energy cannot be created or destroyed but in most energy transfers some energy is lost in a form that is not useful.	State the meaning of: efficiency. Recall the law of conservation of energy. Recall some advantages of low-energy appliances.	Identify useful and wasted energies. Describe whether a machine is more efficient than another.	Calculate energy efficiencies. Use data to consider cost efficiency by calculating payback times.	Explain why the efficiency can never be greater than 1 or greater than 100%.	Use data to evaluate [processes, objects, energy-saving devices].	
[Internal, thermal] energy is transferred by different processes in different circumstances.	Recall that [thermal] energy can be transferred by [evaporation, radiation, convection, conduction].	Identify the [thermal] energy transfer process(es) in a given situation [conduction, convection, radiation].	Explain which [thermal] energy transfer process(es) are happening in a given situation.	Compare [radiation, convection, conduction, evaporation] as methods of [thermal] energy transfer. Identify the energy transfer processes affected by different methods of controlling energy transfers.	Evaluate different ways of keeping something [warm, cool].	Plan ways in which to [increase, decrease] thermal energy transfers.

Objectives

Developing:

1. Recall that electricity and mains gas are charged for on the basis of the energy transferred.
2. Explain why power companies use the kWh as a measure of energy.
3. Recall some advantages of low-energy appliances.

Securing:

4. Use data to consider cost efficiency by calculating payback times.
5. Evaluate different ways of keeping something warm.

Exceeding:

6. Use data to evaluate methods of reducing carbon emissions.

Student materials

STARTERS

1: How do we buy energy?
Securing

Students work in pairs or small groups to list as many ways as they can of buying energy. These include domestic gas and electricity, food, petrol, batteries, camping stove fuel. Collect ideas to make a list on the board, then ask the groups to say how each is paid for. For example, domestic gas and

© Pearson

electricity is metered, petrol is bought by the litre. This leads in to work in this topic on the kilowatt-hour and how electricity is paid for.

2: Domestic fuel bills
Securing
Ask students to work in pairs to come up with as many different explanations for this statement as they can: 'One household spends twice as much as another on gas and electricity each year'. Give the pairs a few minutes to think up some reasons (which could be linked to appliances used, and their power and efficiency, how well their home is insulated, or to the price of the fuel they use). Collect ideas from all groups to make a class list on the board. This could be revisited at the end of the lesson to discuss ways in which fuel bills could be reduced. Students could then summarise 'Reasons for using more energy' and 'Ways to reduce energy use' in a two-column table.

3: Sankey diagrams and efficiency
Securing
Revise the idea of efficiency and the use of Sankey diagrams by drawing an unlabelled Sankey diagram on the board, with one output arrow much wider than the other. Tell students that this represents a machine. Ask them to suggest a machine, and state the energy transfers represented by the input and the output parts of the diagram. Give them a few minutes to work on this in groups and then ask for suggestions. Answers could include light bulbs (electricity → energy transferred by light and heating), kettles (electricity → thermal energy stored in water and thermal energy stored in surroundings), etc.

Ask them to say which output energy is useful and which is wasted, and to say which goes with each output arrow. At this point students are not expected to know the relative amounts of energy transferred as useful or wasted energy. Having allocated their labels, however, they should then be able to say if their machine is more or less efficient than 50%. (This depends on whether they have allocated the useful output energy to the larger or smaller of the two output arrows.) Students should choose one example from another group to make a note of in addition to the diagram they produced.

Exceeding: Ask students to draw a Sankey diagram to scale for a machine that is 75% efficient.

The **AT** presentation *Sankey diagrams and efficiency* provides three unlabelled Sankey diagrams and asks students to suggest what machines they could represent and to identify the types of energy transfer. Some possible answers are included.

> **Course resources**
> **AT:** Presentation *Sankey diagrams and efficiency*.

EXPLORING TASKS

1: Energy survey
Developing/Securing/Exceeding
Ask students to carry out an energy survey, using Worksheet 8Ke-2 for data gathering. This sheet could be given out for homework (see 8Kd Homework 1) and the results analysed in a following lesson. Alternatively, a class discussion could be held to estimate the length of time for which each appliance is used per day. Students should attempt to find out the power ratings of the appliances whose use is recorded in their survey, but warn them that appliances must be switched off before they are examined and that they should ask an adult for help.

The **AT** spreadsheet *Power of appliances* can be used to obtain nominal power ratings for any appliances that students could not get information for.

Developing: The **AT** spreadsheet *Energy use 1* lets students enter their own results and amend any power ratings for which they have information. The spreadsheet is set up to automatically calculate the total energy use for the household.

Securing: The **AT** spreadsheet *Energy use 2* lets students enter their own results and amend any power ratings for which they have information. Instructions with the worksheet guide students to enter formulae into the sheet to calculate the overall energy usage. Follow this up by asking students to estimate energy usage at other times of the year and to plot charts showing the different estimates. If students have done Explaining 3, they could add financial costs to their spreadsheets.

Exceeding: As for Securing, but students could be challenged to set up their own spreadsheet, using only the *Power of appliances* spreadsheet to obtain any necessary power ratings.

Follow up the energy survey by asking students to produce a leaflet explaining the best ways to save energy at home in terms of which items of electrical equipment use the most energy; and so should be switched off whenever they are not in use.

> **Course resources**
> **AP:** Worksheet 8Ke-2.
> **AT:** Spreadsheets *Energy use 1*; *Energy use 2*; *Power of appliances.*

2: Warmer homes
Developing/Securing
Worksheet 8Ke-3 gives some rough estimates of the energy savings possible through various home insulation measures and asks questions based

© Pearson

on this. Students are also asked to find out what each measure involves and to design leaflets for homeowners.

Course resources
AP: Worksheet 8Ke-3.

Equipment
Internet access.

3: Debate
Developing/Securing
Lit
There is an opportunity for a debate using the Have Your Say box on Student Book spread 8Ke Keeping warm. Refer to Skills Sheet RC 5 from the Year 7 Activity Pack for ideas on how to run a debate.

Get students to categorise scientific ideas that support 'for' and 'against' arguments from the debate.

Course resources
AP: Skills Sheet RC 5 (Year 7).

EXPLAINING TASKS

1: 8Ke Paying for energy (Student Book)
Developing/Securing/Exceeding
FA
These pages describe the way in which energy is paid for and introduce the idea of payback time when evaluating energy-saving measures. Question 6 can be used as formative assessment. Worksheet 8Ke-1 is the Access Sheet.

The **AT** link *Ways of reducing energy bills* allows you to turn the labels on and off on diagram D.

Course resources
AP: Worksheet 8Ke-1.
AT: Labels on/off *Ways of reducing energy bills.*

2: 8Ke Keeping warm (Student Book)
Developing/Securing/Exceeding
FA
This page describes some of the consequences of climate change and why we should try to reduce our use of fossil fuels. Questions are provided that will help students to revise some of the content of this unit.

The Have Your Say box suggests that students debate whether the government should be using taxpayers' money to subsidise home insulation (Exploring 3).

3: How much does it cost?
Securing
The **AT** interactive *How much does it cost?* shows a picture of a house with various items you can roll over to see how much power is used and how much this would cost per hour.

Developing: Reinforce ideas about the types of appliances that transfer the most energy by comparing the power used by cooking appliances with that transferred by TVs, etc.

Securing: Ask students to consider the limitations of the interactive as a model for helping people to control their energy use. Weaknesses include the fact that most appliances (other than fridges) are not used continuously.

Exceeding: The cost information is provided per hour of use. Ask students to estimate the cost of using each appliance for a year and state any assumptions that they have made in working out their estimates.

Course resources
AT: Interactive *How much does it cost?*

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
Developing/Securing
FA
Assessment: The 8Ke Quick Check sheet provides a set of revision notes for the whole unit, but there are some deliberate errors. Students note the errors on the sheet and explain what is wrong or write out a corrected version.

Feedback: Go through the notes sentence by sentence, asking for a show of hands to identify any errors. Ask for volunteers to explain the errors spotted and point out any that the class miss. Students can also be asked for a show of confidence in their answers, using thumbs-up/thumbs-down.

Action: Make a note of any areas of difficulty, including any missed errors and revise them with the class.

Course resources
ASP: 8Ke Quick Check.

© Pearson

2: Thinking about temperature

Developing/Securing

FA

Assessment:

Odd One Out: kilowatt, joule, kilowatt-hour. (Possible answers: kilowatt is the only measure for power; kilowatt-hours must be worked out using power and time; kilowatt-hours are the only ones used on electricity bills.)

Plus, Minus, Interesting: Electricity should be free. (Possible answers: **Plus –** People would have more money to spend on other things; **Minus –** People would not be worried about wasting energy, so we would also end up burning more fossil fuels to generate electricity; **Interesting –** Who would pay for the electricity – would taxes go up? Electricity prices in the UK more than doubled between 2005 and 2010. At the time of writing, 11% of an electricity bill goes to government schemes aimed at reducing emissions.)

Consider All Possibilities: A household's energy bills go down. (Possible answers: the cost of electricity or gas has gone down; they are not using as many appliances; they have bought some more efficient appliances; they have insulated their home.)

Feedback: Ask students to volunteer their answers for each of the questions. Use a smiley face on the board to indicate good answers (that show correct understanding of the science) or a sadface to show answers that indicate misconceptions.

Action: Identify any misconceptions or areas for which students have poor recall. Briefly recap those parts of the lesson.

The **AT** presentation *8Ke Thinking skills* can be used for this activity.

Course resources
AT: Presentation *8Ke Thinking skills*.

3: Energy report: Open-ended Assessment Task

Developing/Securing/Exceeding

FA **SA**

Ask students to write a set of notes or a presentation to train energy advisers who will be helping members of the public to reduce their energy bills. It is important that the advisers understand the science behind their advice, so the presentations should include details of the energy transfer mechanisms covered in this unit.

If you wish to extend the literacy work of the unit, students could also be asked to prepare a leaflet for homeowners – students should consider the appropriate use of language in these leaflets.

This activity can be done as an assessed task for summative assessment. You can assess this activity by using the Open-ended Assessment Task sheet or students can assess their own performance by using the Assess Yourself! sheet (see the ASP). If the task is to be used for this purpose, you may wish students to work alone or in pairs of similar ability.

Students could be asked to modify their work to raise its level according to at least two of the assessment descriptors. Re-check their amendments or get other students to do this.

Course resources
AP: 8K Assess Yourself!; 8K Open-ended Assessment Task.

4: Ideas about energy transfers 2

Securing

FA

The **AT** interactive *Concept cartoon: Ideas about energy transfers 2* provides statements about the contents of this unit, some of which are incorrect. Ask students to discuss in pairs whether or not the statements are correct. Then ask for comments on each statement and justifications of any views.

Course resources
AT: Interactive *Concept cartoon: Ideas about energy transfers 2*.

5: Quick Quiz revisited

Developing/Securing/Exceeding

FA **SA**

Revisit the 8K Quick Quiz to test students' knowledge of the content of this unit. Students could fill in their answers on the 8K Quick Quiz Answer Sheet. Encourage students to identify areas for themselves that are still weak and plan, with a partner, how they are going to remedy this.

Course resources
ASP: 8K Quick Quiz; 8K Quick Quiz Answer Sheet.

6: End of Unit Test

Developing/Securing/Exceeding

SA

Use either or both of the End of Unit Tests. A Mark Scheme is given in the ASP. Encourage students to identify areas that are still weak and to formulate plans to strengthen those areas. Summary Sheets are provided to help students with revision.

Course resources
ASP: 8K End of Unit Test Standard (S); 8K End of Unit Test Higher (H); 8K Mark Scheme; 8K Summary Sheets.

© Pearson

7: Progression Check
Developing/Securing/Exceeding
SA
Students should circle the stars next to each statement on the Progression Check to record what they feel they know and how certain they are of it. Encourage students to plan how to do further work on the things about which they remain unsure.

Discuss good ideas for revision and further work with the class. Encourage students to plan how to do further work on the areas they remain unsure about, or areas where they would like to improve their level of understanding.

Course resources
ASP: 8K Progression Check.

HOMEWORK TASKS

1: Energy true or false
Developing/Securing
Worksheet 8Ke-4 provides a set of statements about the content of the unit for students to classify as true or false. They are asked to write corrected versions of the false statements.

Course resources
AP: Worksheet 8Ke-4.

2: Saving in the kitchen
Securing
Worksheet 8Ke-5 compares the use of conventional and microwave ovens in terms of energy used for cooking.

Course resources
AP: Worksheet 8Ke-5.

3: Carbon capture and storage
Securing/Exceeding
Worksheet 8Ke-6 looks at the use of carbon capture and storage as a way of reducing the carbon dioxide emitted by power stations. It would be helpful if students have already used Worksheet 8Kd-6 (see Topic 8Kd Homework 4).

Course resources
AP: Worksheet 8Ke-6.

ActiveLearn
Three ActiveLearn exercises are available for this topic: Paying for energy 1; Paying for energy 2; Paying for energy 3.

© Pearson