Electric kettles

Assessment description	Category
Students use the particle model and the relationships between energy, power, voltage, current and resistance to demonstrate their understanding of energy transfer in electric circuits. They investigate factors that affect the transfer of energy.	Written
	Technique
	Supervised assessment Experimental investigation
Context for assessment	**Alignment**
Electric appliances containing heating elements are common in students' daily lives. Heating elements change electrical energy into heat energy and an understanding of electrical energy, power and Ohm's law can be used to explain how heating elements work. Heating elements are made of metals with high resistance, such as nichrome wire, and the size of the wire affects the amount of electrical energy flowing in the wire and therefore the heat energy produced. The practical investigation of this topic and communication of findings provide opportunities for students to develop skills used by the scientific community.	*Australian Curriculum v7.0,* Year 9 Science Australian Curriculum content and achievement standard ACARA — Australian Curriculum, Assessment and Reporting Authority www.australiancurriculum.edu.au Year 9 Science standard elaborations available at: www.qcaa.qld.edu.au/downloads/p_10/ac_sci_yr9_se.docx
	Connections
	This assessment can be used with the QCAA Australian Curriculum resource titled *Year 9 plan — Australian Curriculum: Science* exemplar available at: www.qcaa.qld.edu.au/downloads/p_10/ac_science_yr9_plan.doc
	Definitions
	See the Australian Curriculum glossary for technical terms used in this assessment www.qsa.qld.edu.au/yr9-science-resources.html
In this assessment	**Assessment materials**
Teacher guidelines Student booklet Task-specific standards — continua Task-specific standards — matrix Sample response Assessment resource — Explaining resistance in terms of the particle model Assessment resource — Scientific inquiry process	**Section 2:** • variable power supply (power pack) • ammeter and voltmeter or 2 multimeters • switch • 6 connecting wires, with alligator clips • heatproof mat • 50 cm and 100 cm lengths of 20 swg (0.91 mm diameter) and 26 swg (0.46 mm diameter) nichrome wire

Teacher guidelines

Identify curriculum

Content descriptions to be taught		
Science Understanding	**Science as a Human Endeavour**	**Science Inquiry Skills**
Physical sciences • Energy transfer through different mediums can be explained using wave and particle models ACSSU182	**Use and influence of science** • People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions ACSHE160	**Planning and conducting** • Plan, select and use appropriate investigation methods, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods ACSIS165 • Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data ACSIS166 **Processing and analysing data and information** • Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies ACSIS169 • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence ACSIS170 **Evaluating** • Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data ACSIS171 **Communicating** • Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations ACSIS174

General capabilities (GCs) and cross-curriculum priorities (CCPs) This assessment may provide opportunities to engage with the following GCs and CCPs. Refer also to the Resources tab on the Year 7 Science curriculum and assessment page: www.qcaa.qld.edu.au/yr9-science-resources.html	
Literacy Numeracy	ICT capability Critical and creative thinking
Achievement standard This assessment provides opportunities for students to demonstrate the following highlighted aspects.	
By the end of Year 9, students explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They analyse how biological systems function and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives. Students design questions that can be investigated using a range of inquiry skills. They design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trends in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence. They evaluate others' methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.	
Source: ACARA, The Australian Curriculum v7.0, www.australiancurriculum.edu.au	

Sequence learning

Suggested learning experiences
This assessment leads on from the learning experiences outlined in the QCAA's Year 9 Science Year level plan. The knowledge, understanding and skills in the Year level plan will prepare students to engage in this assessment: • See Year 9 plan — Science exemplar www.qcaa.qld.edu.au/downloads/p_10/ac_science_yr9_plan.doc
Adjustments for needs of learners
To make adjustments, teachers refer to learning area content aligned to the child's chronological age, personalise learning by emphasising alternate levels of content, general capabilities or cross-curriculum priorities in relation to the chronological age learning area content. The emphasis placed on each area is informed by the student's current level of learning and their strengths, goals and interests. Advice on the process of curriculum adjustment for all students and in particular for those with disability, gifted and talented or for whom English is an additional language or dialect are addressed in *Australian Curriculum — Student Diversity* materials. For information to support students with diverse learning needs, see: • Queensland Curriculum and Assessment Authority materials for supporting children with diverse learning needs www.qcaa.qld.edu.au/10188.html • Australian Curriculum Student Diversity www.australiancurriculum.edu.au/StudentDiversity/Student-diversity-advice • The *Melbourne Declaration on Educational Goals for Young Australians* www.curriculum.edu.au/verve/_resources/national_declaration_on_the_educational_goals_for_young_australians.pdf

- The *Disability Standards for Education* www.ag.gov.au

Resources

- Education Queensland Classroom activity risk management guidelines http://education.qld.gov.au/curriculum/carmg/index.html

Develop assessment

Preparing for the assessment

Learning experiences in preparation for the assessment could include:

Exploring energy, energy changes and electricity

- Identify forms of energy and energy changes in electric appliances (e.g. kettles, toasters, washing machines and stereos) in energy chains.
- Discuss the concept of electricity, including current, voltage and resistance, in terms of the flow of electric charges carried by electrons between atoms in the wires of an electric circuit. This can be explained by comparing it to the flow of water in a water circuit for a swimming pool.
- Identify the relationships between electric current, voltage, energy and power.
- Make a glossary of key scientific language, including energy, joules, electrical energy, voltage, current, resistance, voltmeter, ammeter, series and parallel circuits, volts, amps, ohms, Ohm's law, power, watts.
- Discuss the use of different amounts of electrical energy by different appliances and practise calculations using the formula $E = Pt$.
- Research the use of resistors as heating elements in electric appliances and write a paragraph to summarise the findings.
- Discuss the unit of measurement for nichrome wire. Standard wire gauge (swg) is a measurement of the diameter of wire.

Conducting investigations to explore energy, energy changes and electricity

- Identify risks and management strategies when conducting experiments with electric circuits.
- Construct electric circuits using bulbs and switches in series and parallel and using measuring devices for voltage and current (voltmeters and ammeters or multimeters).
- Investigate Ohm's law experimentally to find out how voltage, current and resistance in an electric circuit are related.
- Record data in tables using Microsoft Excel.
- Analyse and interpret the results mathematically using the formula and create a graph of data collected in the investigation using Microsoft Excel.
- Draw conclusions about the relationships between the variables in Ohm's law.
- Practise mathematical calculations using Ohm's law ($V = IR$) and $P = VI$ to solve problems with unknown variables.
- Work in a group to plan and conduct an investigation associated with electric circuits (e.g. How well do different types of pencil lead of the same length and diameter conduct electricity?).
- Identify variables for investigation.
- Formulate a question and hypothesis.
- Design a method to test the hypothesis and control variables.
- Design a data table to record results.
- Analyse and interpret the results to draw conclusions.
- Evaluate the conclusions based on the reliability and validity of the data.
- Explain specific actions to improve the quality of collected evidence.
- Write a scientific report on the investigation.

Implementing

Section 1. Explaining how heating elements in electric kettles work

- Supervise students in answering Questions 1–7.
- Where necessary, explain the requirements of questions so that literacy demands do not prevent students from providing evidence of their science understanding.

Section 2. Identifying factors which effect energy transfer in electric circuits

Hints for ensuring safe collection of valid data:

- It is important that currents through nichrome wire should be kept as low as possible, to minimise heating and to avoid exceeding the current rating of the power supply (usually 10 A but some power supplies are rated at 3 A).
- Remind students to read meters quickly and then switch off to avoid overheating of wire.
- Suggestions for minimising current:
  - use 50 cm as a minimum length of nichrome wire (dependent on swg of wire), longer samples will reduce currents. Wire can be rolled into a coil to save space
  - three different voltages are required, though actual values are not crucial. Do not exceed 6 volts.
- It is important that teachers test circuits beforehand to ensure currents are not exceeded over the range of chosen voltages and that the meters chosen are of an appropriate range
- Discuss safety expectations for the investigation. See Education Queensland *Classroom activity risk management guidelines* http://education.qld.gov.au/curriculum/carmg/index.html
- Ensure all students understand how the materials and equipment are to be assembled.
- Check circuits before students begin measurements.

Hints for purchasing materials

- Nichrome wire is an inexpensive product that can be purchased by the roll. At the time of developing this assessment cost was $22 per roll.
- Each roll of 20 swg nichrome wire contains 8.5 metres and it is anticipated that 2 rolls would be needed for a class set (assuming 3 students per group in a class of 30 students).
- Each roll of 26 swg contains 34 metres and it is anticipated that 1 roll would be needed for a class set (assuming 3 students per group in a class of 30 students).
- The nichrome wire coils are not classified as a consumable resource and can be reused for multiple classes.

Section 3. Planning an investigation: Checking the power rating of a kettle

- Provide an electric kettle to assist students with their planning of the investigation.
- Ensure students understand the question they are investigating.
- Emphasise the danger of 240 volts and remind students that they must plan to use a low voltage source for their investigation, this could include a discussion about why safety switches are installed in houses.
- Discuss the hint (at the beginning of Section 3) with students and remind them to refer to Sections 1 and 2 when planning the investigation.
- Discuss safety expectations for the investigation.
- Check methods and circuits before students begin measurements.

Make judgments

When making judgments about the evidence in student responses to this assessment, teachers are advised to use the task-specific standards provided. The development of these task-specific standards has been informed by the Queensland Year 9 standard elaborations.
See www.qcaa.qld.edu.au/downloads/p_10/ac_sci_yr9_se.docx

The Queensland standard elaborations for Science

The Queensland Year 9 standard elaborations for Science are a resource to assist teachers to make consistent and comparable evidence-based A to E (or the Early Years equivalent) judgments. They should be used in conjunction with the Australian Curriculum achievement standard and content descriptions for the relevant year level.

The Queensland Science standard elaborations provide a basis for judging *how well* students have demonstrated what they know, understand and can do using the Australian Curriculum achievement standard.

The Australian Curriculum achievement standards dimensions of Understanding and Skills are used to organise the Queensland Science standard elaborations.

The valued features of Science drawn from the achievement standard and the content descriptions for Understanding dimension and Skills dimension are organised as:

- Science understanding
- Science as a human endeavour
- Questioning and predicting
- Planning and conducting
- Processing and analysing data and information
- Evaluating
- Communicating.

Task-specific standards

Task-specific standards give teachers:

- a tool for directly matching the evidence of learning in the response to the standards
- a focal point for discussing students' responses
- a tool to help provide feedback to students.

Task-specific standards are not a checklist; rather they are a guide that:

- highlights the valued features that are being targeted in the assessment and the qualities that will inform the overall judgment
- specifies particular *targeted aspects* of the curriculum content and achievement standard
- aligns the valued feature, task-specific descriptor and assessment
- allows teachers to make consistent and comparable on-balance judgments about student work by matching the qualities of student responses with the descriptors
- clarifies the curriculum expectations for learning at each of the five grades (A–E or the Early Years equivalent)
- shows the connections between what students are expected to know and do, and how their responses will be judged and the qualities that will inform the overall judgment
- supports evidence-based discussions to help students gain a better understanding of how they can critique their own responses and achievements, and identify the qualities needed to improve

- encourages and provides the basis for conversations among teachers, students and parents/carers about the quality of student work and curriculum expectations and related standards.

Task-specific valued features

Task-specific valued features are the discrete aspects of the valued features of Science targeted in a particular assessment and incorporated into the task-specific standards for that assessment. They are selected from the Queensland Science standard elaborations valued features drawn from the Australian Curriculum achievement standard and content descriptions.

Task-specific valued features for this assessment

The following table identifies the valued features for this assessment and makes explicit the understandings and skills that students will have the opportunity to demonstrate. This ensures that the alignment between what is taught, what is assessed and what is reported is clear.

Australian Curriculum achievement standard dimensions	Queensland standard elaborations valued features	Task-specific valued features
Understanding dimension	Science understanding	**Section 1: Questions 1–7** Description of energy transfer in electric circuits and heating appliances and explanation of the factors that affect energy transfer using the particle model **Section 3: Introduction** Background information about factors affecting energy transfer
Skills dimension	Planning and conducting	**Section 2: Questions 8 and 9a** • Measurement of voltage and current for various lengths and thickness of wire • Identification and description of safety considerations **Section 3: Materials and Method** Design of an appropriate investigation to determine the resistance of the heating element of a kettle
	Processing and analysing data and information	**Section 2: Questions 9b, 10 and 11** Analysis of trends in data to draw conclusions consistent with evidence about how current, resistance and voltage relate to the wire's dimensions **Section 3: Results, Analysis of results, Discussion, Conclusion** Analysis of trends in data to draw conclusions consistent with evidence about the power of a kettle element
	Evaluating	**Section 3: Discussion** Analysis of the method to propose effective modifications
	Communicating	**Sections 1 and 2** Communication of findings and ideas about factors that affect energy transfer in electric circuits **Section 3** Communication of findings and ideas using appropriate language, symbols, units and conventions

The task-specific standards for this assessment are provided in two models using the same task-specific valued features:

- a matrix
- a continua.

Matrix and continua

Task-specific standards can be prepared as a matrix or continua. Both the continua and the matrix:

- use the Queensland standard elaborations to develop task-specific descriptors to convey expected qualities in student work — A to E (or the Early Years equivalent)
- highlight the same valued features from the Queensland standard elaborations that are being targeted in the assessment and the qualities that will inform the overall judgment
- incorporate the same task-specific valued features, i.e. make explicit the particular understanding/skills that students have the opportunity to demonstrate for each selected valued feature
- provide a tool for directly matching the evidence of learning in the student response to the standards to make an on-balance judgment about achievement
- assist teachers to make consistent and comparable evidence-based A to E (or the Early Years equivalent) judgments.

Matrix

The matrix model of task-specific standards uses the structure of the Queensland standard elaborations to organise the task-specific valued features and standards A to E (or the Early Years equivalent). The task-specific descriptors of the standard described in the matrix model use the same degrees of quality described in the Queensland standard elaborations.

Teachers make a judgment about the task-specific descriptor in the A to E (or the Early Years equivalent) cell of the matrix that best matches the evidence in the student responses in order to make an on-balance judgment about how well the pattern of evidence meets the standard.

The matrix is a tool for making both overall on-balance judgments and analytic judgments about the assessment. Achievement in each valued feature of the Queensland standard elaboration targeted in the assessment can be recorded and feedback can be provided on the task-specific valued features.

Continua

The continua model of task-specific standards uses the dimensions of the Australian Curriculum achievement standard to organise task-specific valued features and standards as a number of reference points represented progressively along an A to E (or Early Years equivalent) continuum. The task-specific valued features at each point are described holistically. The task-specific descriptors of the standard use the relevant degrees of quality described in the Queensland standard elaborations.

Teachers determine a position along each continuum that best matches the evidence in the student responses to make an on-balance judgment about achievement on the task.

The continua model is a tool for making an overall on-balance judgment about the assessment and for providing feedback on task-specific valued features.

Use feedback

Feedback to students	Evaluate the information gathered from the assessment to inform teaching and learning strategies. Focus feedback on the student's personal progress and the next steps in the learning journey. The task-specific standards for this assessment can be used as a basis for providing feedback to students. This assessment provides opportunities to give feedback to students on how well they: • understand the concepts of energy, power, voltage, current and resistance (Many students carry misconceptions about electricity, particularly in relation to voltage and power) • set up electric circuits and understand why voltmeters are connected in parallel with a component and ammeters in series • follow instructions to accurately collect and record data • analyse and interpret data and draw conclusions consistent with evidence • use scientific understandings as a basis for planning investigations • methodically write a scientific report, making fluent use of scientific terms and conventions.
Resources	Hattie, J and Timperley, H 2007 'The Power of Feedback', *Review of Educational Research*, Vol. 77, No.1, pp. 81–112. For guidance on providing feedback, see the professional development packages titled: • *About feedback* www.qcaa.qld.edu.au/downloads/p_10/as_feedback_about.docx • *Seeking and providing feedback* www.qcaa.qld.edu.au/downloads/p_10/as_feedback_provide.docx

Electric kettles

Image: QCAA

To demonstrate understanding of energy transfer in electric circuits and to investigate factors that affect the transfer of energy.

You will:

- Use the particle model and the relationships between energy, power, voltage, current and resistance to demonstrate your understanding of energy transfer in electric circuits.
- Investigate some of the factors that affect energy transfer in electric circuits.
- Plan an investigation to check the power rating of an electric kettle.

Section 1. Explaining how heating elements in electric kettles work

1. Electric appliances transform energy from one form to another. Describe the principal energy transformation occurring in an electric kettle.

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2. Electric kettles have a power rating measured in watts. Describe the relationship between power and energy.

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3. Write the formula that shows how power, energy and time relate to each other (include units).

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4. Write the formula for calculating the electrical power from the voltage applied to a heating element and the current flowing through it (include units).

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5. Heating elements are made from metals that are electrical resistors. Ohm's law shows how the current changes when the voltage across a resistor is changed.

   a. Write the formula for Ohm's law (include units)

   b. Describe the relationship between current and voltage.

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6. Use the formulas in questions 4 and 5 to give the formula for calculating power from resistance and voltage (include units and show all working).

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7. With reference to the particles that make up a resistor, draw a labelled diagram to support an explanation of how electrical energy is transformed into heat when the resistor is connected in an electric circuit.

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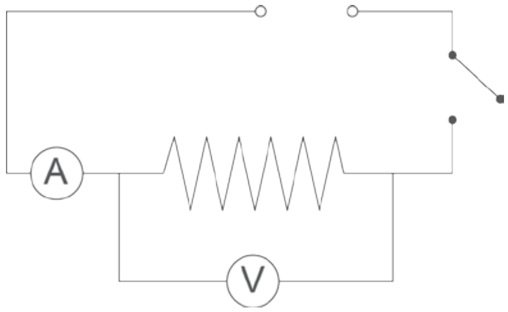
Section 2. Identifying factors that affect energy transfer in electric circuits

Nichrome wire is commonly used to make heating elements because it is a good electrical resistor. The size of the nichrome wire affects the properties of the electric circuit.

Question to be investigated

What effect does changing the thickness and length of a piece of nichrome wire have on the circuit measurements of voltage, current and resistance?



Materials

- variable power supply (power pack)
- ammeter and voltmeter or 2 multimeters
- switch
- 6 connecting wires, with alligator clips
- heatproof mat
- 50 cm and 100 cm lengths of 20 swg (0.91 mm diameter) nichrome wire
- 50 cm and 100 cm lengths of 26 swg (0.46 mm diameter) nichrome wire

Risk assessment

8. a. Identify potential safety risks for this investigation.

   b. Describe how to manage these safety risks.

Risk	Management strategies

Method

I. Using the 50 cm coil of 20 swg nichrome wire as a resistor, set up the electric circuit shown in the diagram above. Make sure the ammeter is connected in series with the resistor, and the voltmeter is parallel across it.

II. Place the circuit on the heatproof mat.

III. Set the power pack to 2 volt DC.

IV. Close the switch, read the voltmeter and ammeter as quickly as possible, then open the switch.

V. Record the voltage (V) and the current (I) in the results table below.

VI. Repeat steps 3–5 for 4 volts DC and 6 volts DC.

VII. Repeat the investigation using the 100 cm length of 20 swg nichrome wire as a resistor.

VIII. Repeat the investigation using the 50 cm length of 26 swg nichrome wire as a resistor.

IX. Repeat the investigation using the 100 cm length of 26 swg nichrome wire as a resistor.

Results

9. Once you have recorded the values for voltage (V) and current (I) collected during the investigation, complete the results table by:

   a. using Ohm's law to calculate the resistance (R) for each trial

   b. calculating the average resistance for each circuit.

Length of wire (cm)	Thickness of wire (swg)	Voltage (volts)	Current (amps)	Resistance (ohms)	Average resistance (ohms)
50	20 (0.91 mm)				
50	26 (0.46 mm)				
100	20 (0.91 mm)				
100	26 (0.46 mm)				

Data analysis

10. Use the data in the results table to identify the relationships in the table below.

Circuit measurement	Relationship to wire thickness	Relationship to wire length
Resistance		
Current		
Voltage		

Discussion

11. Use the particle model to explain the relationships you identified in the data analysis table above.

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Section 3. Planning an investigation: Checking the power rating of a kettle

In Australia, most electrical appliances operate at 240 V and have a power rating stamped on them.

Question to be investigated

Is the stated power rating of my kettle accurate?

Important note: 240 volts is a dangerously high voltage and must not be used in the planning and conducting of your investigation. The DC voltage range from a laboratory power supply should be sufficient.

Hint: You will need to determine the resistance of the kettle element. Refer to Sections 1 and 2 to decide what to measure to find the resistance and calculate the power of the kettle element.

Science report

Develop a plan for your investigation. Use the following checklist as a guide.

Introduction

- ☐ The aim of the investigation.
- ☐ Background information based on your ideas and findings in Section 1 and Section 2.
- ☐ Description and justification of variables to be controlled and measured.

Materials

- ☐ A list of everything you used in the investigation.

Method

- ☐ A risk assessment.
- ☐ Numbered steps detailing how you would carry out the investigation.
- ☐ A circuit diagram.

Results

- ☐ A data table with suitable headings and units of measurement.

Analysis of results

- ☐ Include any formulas used for calculations.

Discussion

- ☐ A description of the results and a discussion of the relationships and trends shown by the data.
- ☐ An explanation of identified relationships and trends, using scientific ideas from Section 1 and 2 and additional research, to justify conclusions.
- ☐ An evaluation of conclusions based on the reliability and validity of the method.
- ☐ A discussion of specific ways to improve the method so the quality of the data collected is improved.

Conclusion

- ☐ A summary of results relating to the investigation question.
- ☐ Suggestions of further investigations based on the findings.

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Sections 1 and 2 purpose of assessment: To demonstrate understanding of energy transfer in electric circuits and to investigate factors that affect the transfer of energy in an electric kettle.

Understanding dimension	Skills dimension			
Science Understanding	**Planning and conducting**	**Processing and analysing data and information**	**Communicating**	
Section 1: Questions 1–7 Description of energy transfer in electric circuits and heating appliances and explanation of the factors that affect energy transfer using the particle model	**Section 2: Questions 8 and 9a** • Measurement of voltage and current for various lengths and thickness of wire • Identification and description of safety considerations	**Section 2: Questions 9b, 10 and 11** Analysis of trends in data to draw conclusions consistent with evidence about how current, resistance and voltage relate to the wire's dimensions	**Sections 1 and 2** Communication of findings and ideas about factors that affect energy transfer in electric circuits	
Manipulation of formulas to derive the formula, with units, for calculating power from resistance and voltage (Q6). Thorough explanation of how electrical energy is transformed into heat integrated with an appropriate labelled diagram (Q7)	Accurate and precise measurement of reliable voltage and current data for various lengths and thickness of wire (Q9a) Description of how to manage identified safety risks (Q8)	Accurate calculation of resistance (Q9b) and analysis of trends in data to identify relationships (Q10) to inform the thorough explanation of how current, resistance and voltage relate to the wire's dimensions, using the particle model (Q11)	Concise and coherent use of appropriate language and representations when communicating findings and ideas	**A**
				B
Description of energy transformations (Q1), definitions (Q2), relationships using formula (Q3, 4, 5a), units for resistance and voltage (Q6), how electrons move through a resistor (Q7)	Accurate measurement of voltage and current for various lengths and thickness of wire (Q9a) Description of identified safety risks (Q8)	Calculation of resistance (Q9b) and analysis of trends in data to identify how current, resistance and voltage relate to the wire's dimensions (Q10)	Use of appropriate language and representations when communicating findings and ideas	**C**
				D
Restatement of science facts	Collection of voltage and current data (Q9a)	Restatement of given information and data about current, resistance and voltage	Fragmented use of language and representations	**E**

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Section 3 purpose of assessment: To plan an investigation to investigate the question: *Is the stated power rating of my kettle accurate*?

Understanding dimension		Skills dimension		
Science Understanding	**Planning and conducting**	**Processing & analysing data & information Evaluating**	**Communicating**	
Section 3: Introduction Background information about factors affecting energy transfer	**Section 3: Materials and Method** Design of an appropriate investigation to determine the resistance of the heating element of a kettle	**Section 3: Results, Analysis of results, Discussion, Conclusion** Analysis of trends in data to draw conclusions consistent with evidence about the power of a kettle element Analysis of the method to propose effective modifications	**Section 3** Communication of findings and ideas using appropriate language, symbols, units and conventions	
Explanation of the factors affecting energy transfer integrated with the findings in Section 2 and the particle model	Design and refinement of a method that controls, and accurately measures variables to ensure the systematic collection of reliable data Description of how to manage safety considerations	Calculation of resistance and analysis of trends in data to identify and explain relationships between variables to: • draw a justified conclusion about the power rating of the kettle • identify inconsistencies in results Analysis of the method and the quality of data collected to explain how effective actions will improve the quality of evidence	Concise and coherent use of appropriate language and representations when communicating findings and ideas Accurate use of appropriate symbols and conventions and units in formulas and data tables	**A**
				B
Explanation of the factors affecting energy transfer with reference to the particle model	Design of a method that includes the: • control and accurate measurement of variables • systematic collection of data • description of safety considerations	Calculation of resistance and analysis of trends in data to identify relationships between variables and identify inconsistencies in results Analysis of the method and the quality of the data collected Explanation of specific actions to improve the quality of evidence	Use of appropriate language and representations when communicating findings and ideas Use of symbols in circuit diagrams and conventions and units in formulas and data tables	**C**
				D
Restatement of science facts	Use of a given method	Restatement of data Statements about methods, data and explanations	Fragmented use of language and representations	**E**

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Sections 1 and 2 purpose of assessment: To demonstrate understanding of energy transfer in electric circuits and to investigate factors that affect the transfer of energy in an electric kettle.

			A	B	C	D	E
Understanding dimension	Science Understanding	**Section 1** **Questions 1–7** Description of energy transfer in electric circuits and heating appliances and explanation of the factors that affect energy transfer using the particle model	• Manipulation of formulas to derive the formula, with units, for calculating power from resistance and voltage (Q6) • Thorough explanation of how electrical energy is transformed into heat integrated with an appropriate labelled diagram (Q7)	• Description of the relationship between current and voltage using Ohm's law (Q5b) • Partial manipulation of formulas with progress towards deriving the formula for calculating power from resistance and voltage (Q6) • Informed explanation of how electrical energy is transformed into heat integrated with a labelled diagram (Q7)	Description of: • energy transformations (Q1) • definitions (Q2) • relationships using formula (Q3, 4, 5a) • units for resistance and voltage (Q6) • how electrons move through a resistor (Q7)	Identification of: • types of energy (Q1) • units (Q3, 4, 5a, 6) • the particle in a resistor in a diagram (Q7)	Restatement of science facts
Skills dimension	Planning and conducting	**Section 2** **Questions 8 and 9a** • Measurement of voltage and current for various lengths and thickness of wire • Identification and description of safety considerations	• Accurate and precise measurement of reliable voltage and current data for various lengths and thickness of wire (Q9a) • Description of how to manage identified safety risks (Q8)	• Accurate measurement of reliable voltage and current data for various lengths and thickness of wire (Q9a) • Description of implications of identified safety risks (Q8)	• Accurate measurement of voltage and current for various lengths and thickness of wire (Q9a) • Description of identified safety risks (Q8)	• Collection of voltage and current data for various lengths and thickness of wire (Q9a) • Identification of safety risks (Q8)	• Collection of voltage and current data (Q9a)

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			A	B	C	D	E
Skills dimension cont.	Processing and analysing data and information	**Section 2** **Questions 9b, 10 and 11** Analysis of trends in data to draw conclusions consistent with evidence about how current, resistance and voltage relate to the wire's dimensions	Accurate calculation of resistance (Q9b) and analysis of trends in data to identify relationships (Q10) to inform the thorough explanation of how current, resistance and voltage relate to the wire's dimensions, using the particle model (Q11)	Accurate calculation of resistance (Q9b) and analysis of trends in data to identify relationships (Q10) to inform the explanation of how current, resistance and voltage relate to the wire's dimensions, using the particle model (Q11)	Calculation of resistance (Q9b) and analysis of trends in data to identify how current, resistance and voltage relate to the wire's dimensions (Q10)	Partial calculation of resistance (Q9b) and statements about trends in data about current, resistance and voltage (Q10)	Restatement of given information and data about current, resistance and voltage
	Communicating	**Sections 1 and 2** Communication of findings and ideas about factors that affect energy transfer in electric circuits	Concise and coherent use of appropriate language and representations when communicating findings and ideas	Coherent use of appropriate language and representations when communicating findings and ideas	Use of appropriate language and representations when communicating findings and ideas	Use of everyday language and representations when communicating findings and ideas	Fragmented use of language and representations

Electric kettles

Name ....

Section 3 purpose of assessment: To plan an investigation to investigate the question: *Is the stated power rating of my kettle accurate*?

Dimension			A	B	C	D	E
Understanding dimension	Science Understanding	**Section 3: Introduction** Background information about factors affecting energy transfer	Explanation of the factors affecting energy transfer integrated with the findings in Section 2 and the particle model	Explanation of the factors affecting energy transfer linked with the findings in Section 2 and the particle model	Explanation of the factors affecting energy transfer with reference to the particle model	Identification of the factors affecting energy transfer	Restatement of science facts
Skills dimension	Planning and conducting	**Section 3: Materials and Method** Design of an appropriate investigation to determine the resistance of the heating element of a kettle	• Design and refinement of a method that controls, and accurately measures variables to ensure the systematic collection of reliable data • Description of how to manage safety considerations	• Design of a method that controls, and accurately measures variables to ensure the systematic collection of reliable data • Description of implications of safety considerations	Design of a method that includes the: • control and accurate measurement of variables • systematic collection of data • description of safety considerations	Partial design of a method that: • control variables • collect data • identify safety considerations	Use of a given method
Skills dimension	Processing and analysing data and information	**Section 3: Results, Analysis of results, Discussion, Conclusion** Analysis of trends in data to draw conclusions consistent with evidence about the power of a kettle element	Calculation of resistance and analysis of trends in data to identify and explain relationships between variables to: • draw a justified conclusion about the power rating of the kettle • identify inconsistencies in results	Calculation of resistance and analysis of trends in data to identify and describe relationships between variables to: • draw a conclusion about the power rating of the kettle that is consistent with evidence • identify inconsistencies in results	Calculation of resistance and analysis of trends in data to identify relationships between variables and identify inconsistencies in results	Partial calculation of resistance statements about trends and inconsistencies in data	Restatement of data

			A	B	C	D	E
Skills dimensions cont.	Evaluating	**Section 3: Discussion** Analysis of the method to propose effective modifications	Analysis of the method and the quality of data collected to explain how effective actions will improve the quality of evidence	Analysis of the method and the quality of the data collected to explain effective actions to improve the quality of evidence	• Analysis of the method and the quality of the data collected • Explanation of specific actions to improve the quality of evidence	Statements about the method and data	Statements about methods, data and explanations
	Communicating	**Section 3** Communication of findings and ideas using appropriate language, symbols, units and conventions	• Concise and coherent use of appropriate language and representations when communicating findings and ideas • Accurate use of appropriate symbols and conventions and units in formulas and data tables	• Coherent use of appropriate language and representations when communicating findings and ideas • Use of appropriate symbols in circuit diagrams and conventions and units in formulas and data tables	• Use of appropriate language and representations when communicating findings and ideas • Use of symbols in circuit diagrams and conventions and units in formulas and data tables	• Use of everyday language and representations when communicating findings and ideas • Sporadic use of symbols in circuit diagrams and conventions and units in formulas and data tables	• Fragmented use of language and representations

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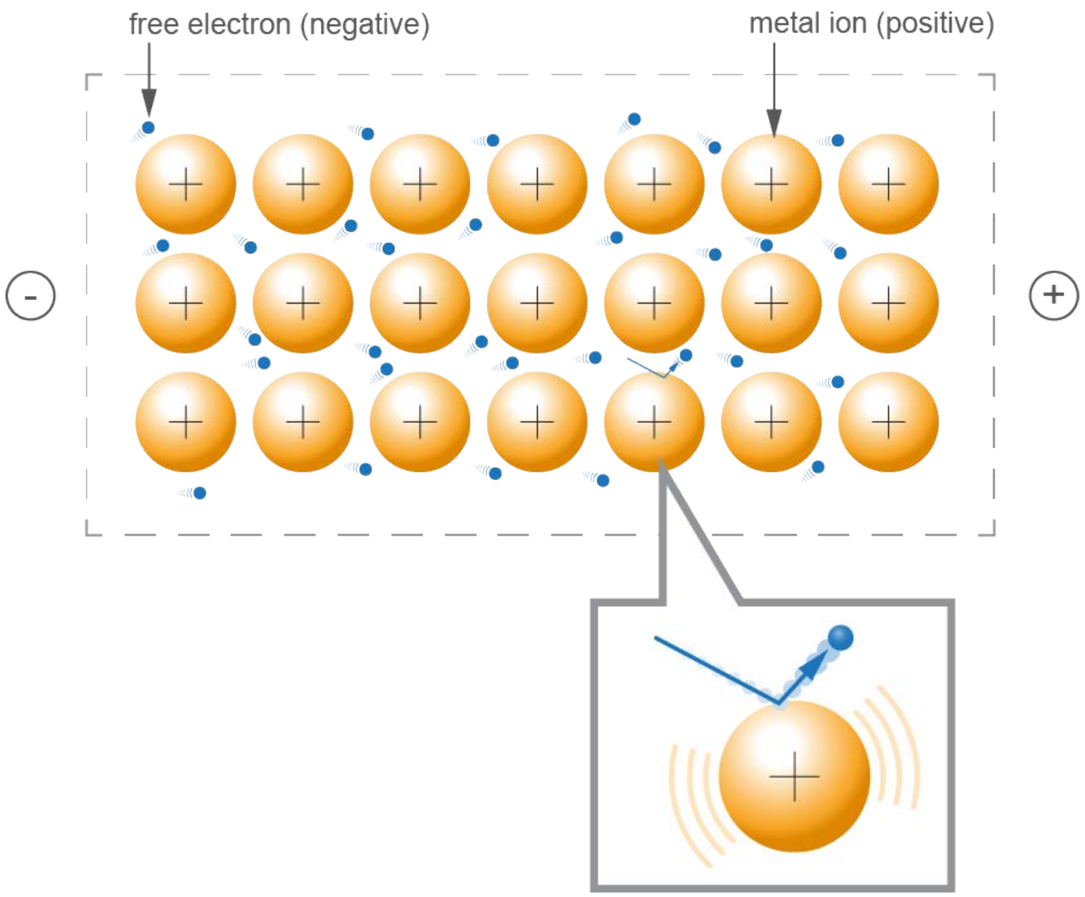
Explaining resistance in terms of the particle model

- A metallic structure consists of metal ions (metal atoms with an electric charge) and a sea of free moving electrons. Normally the motion of these electrons is random due to their thermal energy. However, if a voltage is put across a section of a conductor, the negatively charged electrons are attracted to the positive (+) battery terminal and there is a net drift of the electrons in this direction. As the electrons move, collisions between the electrons and the metal ions occur. This is the cause of resistance.



- Resistance is defined as the opposition to the flow of charge; the opposition comes as a result of these electron–metal ion collisions. Energy transfer takes place during these collisions. The electrical energy of the electrons is transferred to the metal ions as vibrational kinetic energy. This is the reason that current can have a heating effect (remember that a higher average kinetic energy of the particles is recorded as a higher temperature).
- Most materials (excluding superconductors) have some electrical resistance and so some of the electrical energy of the electrons will be converted into heat energy as a current passes through it. If the current is kept low then the heat energy produced by the flow of current can dissipate into the surrounding environment and the substance can remain at room temperature. If the energy transferred from the current does result in a temperature rise then, for metals, the resistance increases. More vibration of the metal ions means that collisions between metal ions and electrons are more likely and the resistance to current flow increases. For example, when electric current passes through the filament of a light bulb, the filament heats up and causes the resistance to increase.
- The reason a voltage needs to be maintained across a component to keep current flowing is because of resistance and the fact that electrical energy is being continually converted into vibrational kinetic energy which manifests itself as heat. A battery or other electrical power source supplies the necessary voltage. If a substance had zero resistance (e.g. a superconductor) then once a current was set up there would not need to be a voltage across it to maintain the current, because electrical energy would not be continually transferred into heat in the substance.

Based on:

- BBC, *GCSE Bitesize,* Accessed 20 August 2013, www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/electricity/resistancerev1.shtml.
- Eastewell, P 1996, *Physics Spectrum*, McGraw-Hill Book Company, Sydney.
- *Hyperphysics*. Accessed 20 August 2013 hyperphysics.phy-astr.gsu.edu/hbase/hframe.html.
- Nelkonn, M & Parker P 1987, *Advanced Level Physics (Sixth Edition)*, Heinemann Educational, London.
- *The Physics Classroom*, www.physicsclassroom.com/class/circuits/u9l3b.cfm.
- Walding, R, Rapkins, G, & Rossiter, G 2004, *New Century Senior Physics*, Oxford University Press, Melbourne.

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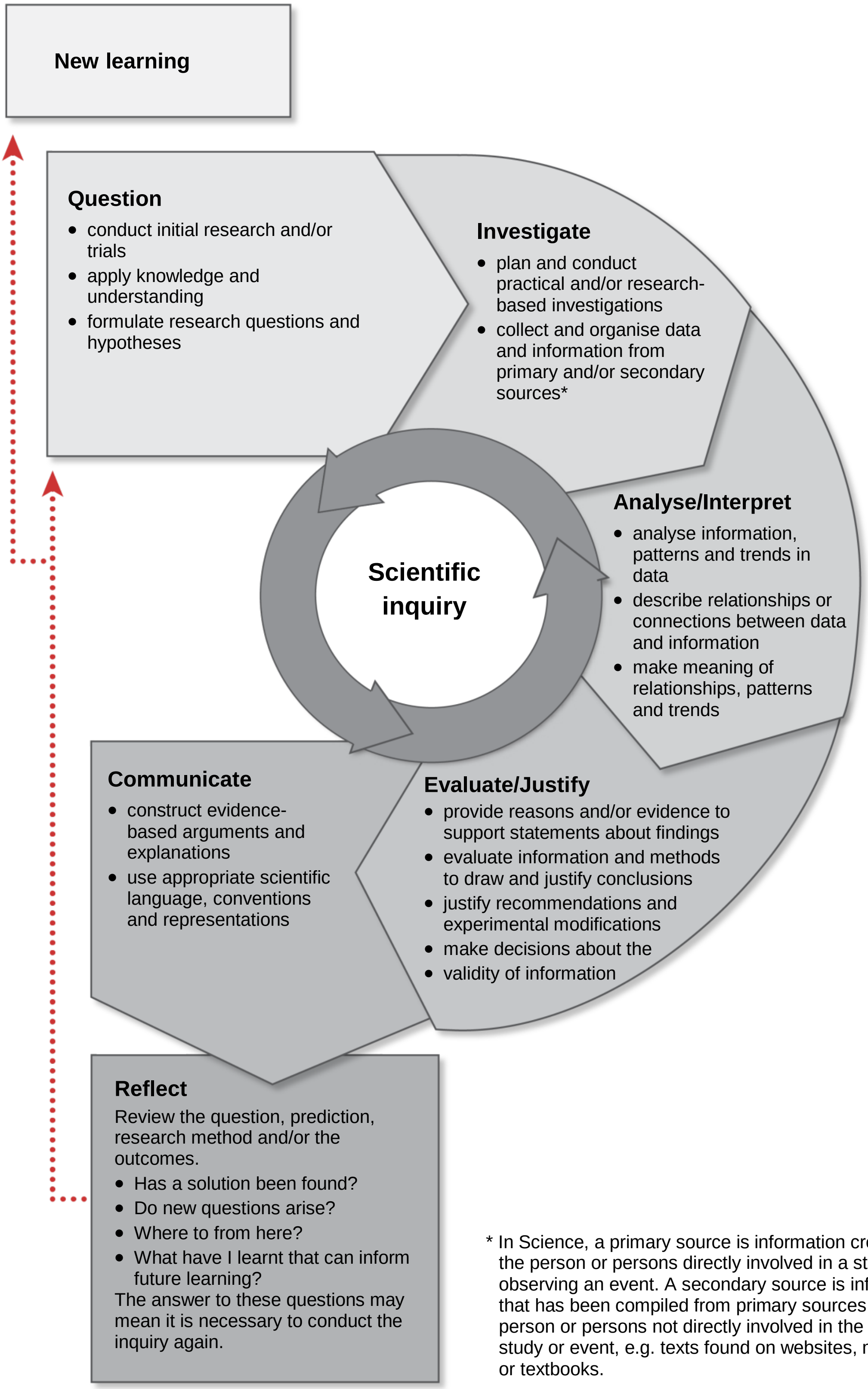
Scientific inquiry process in Years 9–10



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