Energy test

Assessment description

Under supervised conditions students identify and investigate changes within systems caused by energy, and discuss efficiency and the use of technology in finding solutions to contemporary problems.

Category

Written

Technique

Supervised assessment

Context for assessment

Energy appears in a number of different forms and is needed to cause change in systems. The sourcing of energy is a contemporary issue in which technology is integral to finding solutions. Students will:

- identify types of energy and describe transformations
- solve problems by calculating gravitational potential energy and kinetic energy and efficiency
- analyse data to draw conclusions
- evaluate claims.

Alignment

Australian Curriculum v7.0, Year 8 Science Australian Curriculum content and achievement standard ACARA — Australian Curriculum, Assessment and Reporting Authority www.australiancurriculum.edu.au

Year 8 Science standard elaborations www.qcaa.qld.edu.au/yr8-science-resources.html

Connections

This assessment can be used with the QCAA Australian Curriculum resource titled *Year 8 Year plan* available at: www.qcaa.qld.edu.au/yr8-science-resources.html

Definitions

- **Kinetic energy** = $1/2\ mv^2$
- **Gravitational potential energy** = mgh
- **Percentage efficiency** = (output/input) * 100

In this assessment

Teacher guidelines

Task-specific standards — continua

Task-specific standards — matrix

Assessment resource: Sample response

Assessment resource: Current scientific conceptions and students' prior understandings

Assessment resource: Energy test stimulus

Student booklet

Assessment materials

Calculator

Stimulus (for Part B)

Teacher guidelines

Identify curriculum

Content descriptions to be taught

Science Understanding	Science as a Human Endeavour	Science inquiry skills
Physical sciences • Energy appears in different forms including movement (kinetic energy), heat and potential energy, and causes change within systems ACSSU155	**Nature and development of science** • Science knowledge can develop through collaboration and connecting ideas across the disciplines of science ACSHE226 **Use and influence of science** • Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations ACSHE135	**Processing and analysing data and information** • Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate ACSIS144 • Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions ACSIS145

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 8 Science Australian Curriculum and resources page www.qcaa.qld.edu.au/yr8-science-resources.html

- Literacy
- Numeracy
- Critical and creative thinking

Achievement standard

This assessment provides opportunities for students to demonstrate the following highlighted aspects.

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and predict the properties and behaviours of substances. They identify different forms of energy and describe how energy transfers and transformations cause change in simple systems. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborated to generate solutions to contemporary problems.

Students identify and construct questions and problems that they can investigate scientifically. They consider safety and ethics when planning investigations, including designing field or experimental methods. They identify variables to be changed, measured and controlled. Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others. They use appropriate language and representations to communicate science ideas, methods and findings in a range of text types.

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 8 Science unit overview. The knowledge, understanding and skills developed in the exemplar unit will prepare students to engage in this assessment:

- See Year 8 plan — Australian Curriculum: Science exemplar

www.qcaa.qld.edu.au/downloads/p_10/ac_science_yr8_plan.docx

Adjustments for needs of learners

To make adjustments, teachers refer to learning area content aligned to the student's chronological age, personalise learning by emphasising alternate levels of content, general capabilities or cross-curriculum priorities related 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 students with diverse learning needs www.qcaa.qld.edu.au/10188.html
- Australian Curriculum Student Diversity www.australiancurriculum.edu.au/StudentDiversity/Overview
- 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

Online

- The Learning Federation, *Learning objects in the Energy chains series (Years 4–8) Primary*, www.ndlrn.edu.au/using_digital_resources/australian_curriculum_resources/science.html
- BBC, *Energy transfer and storage*, www.bbc.co.uk/schools/ks3bitesize/science/energy_electric'ity_forces/energy_transfer_storage/activity.shtml
- Alternative Fuel Vehicles, *Transportation Energy: A student's guide to alternative fuel vehicles*, www.energyquest.ca.gov/transportation/electric.html
- Discovery Education, *Energy and Cars: What does the future hold?* www.discoveryeducation.com/teachers/free-lesson-plans/energy-and-cars-what-does-the-future-hold.cfm Bureau of Meteorology, *Indigenous weather knowledge* www.bom.gov.au/iwk
- Oresome resources: Minerals and Energy Education, *Coal-fired energy plant interactive*, www.oresomeresources.com/interactives_view/resource/interactive_coal_fired_energy_plant/section//parent//category/
- Khan Academy — Physics https://www.khanacademy.org/science/physics

Objects

- Calculator

Develop assessment

Preparing for the assessment

Learning experiences in preparation for the assessment could include:

Revising key concepts

- Revise from Year 6 that:
  - electrical circuits provide a means of transferring and transforming electricity
  - energy from a variety of sources can be used to generate electricity
  - change in state is caused by heating or cooling.

Exploring energy

- Use the units of energy (joules and kilojoules) to describe the amount of energy in a range of everyday situations.
- Identify and describe the common forms of energy in everyday situations, e.g. kinetic, gravitational potential, elastic potential, chemical, nuclear, sound, heat, light and electrical.
- Investigate and draw conclusions about energy transfers and transformations in experiments.
- Identify energy transfers and transformations in household appliances and draw energy chains to show energy conversions.
- Solve word problems to calculate kinetic energy and gravitational potential energy.
- Calculate the percentage efficiency of an energy transformation.
- Link heat loss to change of state.
- Recognise and discuss that heat energy is often produced as a by-product of energy transfers and transformations, such as brakes on a car and light globes.
- Draw line graphs to represent two sets of experimental data.
- Interpret data in tables and represented in graphs and use to justify conclusions.
- Discuss issues associated with the use of petroleum fuels in cars.
- Research alternative sources of energy to power future cars, including hybrid vehicles. Discuss the advantages and disadvantages of each alternative.
- Recognise the different greenhouse gases and their sources.

Implementing

Teacher role

When implementing the assessment, consider:

- whether the test will be implemented in one session, or over multiple sessions using the separate sections of the Student booklet:
  - Part A: Short-response questions
  - Part B: Stimulus-response questions
- the time required for students to complete each section of the assessment (Part A approximately 60 minutes, Part B approximately 30 minutes)
- the distribution of stimulus multiple days before the assessment and clarifying the instructions with students
- allowing calculators to be used in the assessment
- clarifying what is required in the *Student booklet* and the *Task-specific standards* as needed
- instructing students to work individually throughout the assessment
- reading questions aloud to the class, if required, to ensure literacy demands do not prevent students from providing evidence of their understanding and skills in science
- encourage students to highlight key words to assist with the deconstruction of the questions.

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 8 standard elaborations. See www.qcaa.qld.edu.au/yr8-science-resources.html

The Queensland standard elaborations for Science

The Queensland Year 8 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. Understanding and Skills in Science are organised as Understanding dimension and Skills dimension.

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	Analysis of data and information to identify types of energy, describe energy transfers, transformations, efficiency and develop explanations **Section A: Questions 1, 2, 5, 6, 7**
		Application of science knowledge to generate solutions about: • kinetic energy • gravitational potential • energy • percentage efficiency **Section A: Questions 3, 4, 9, 10**
	Science as a Human Endeavour	Explanation of how evidence has improved understanding of science ideas and informed the collaboration of scientists to generate solutions to contemporary problems **Section B: Questions 11, 13**
Skills dimension	Processing and analysing data and information	• Use of patterns and trends in graphs to explain relationships and justify conclusions • Construction of graphs to reveal patterns and trends about greenhouse gas emissions in cars vs. trains **Sections A and B: Questions 8, 12**

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

- matrix
- 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 students' 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 students' 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. Offer feedback that: • maximises students' opportunities to succeed in the assessment by providing feedback on: – constructing data representations – developing justified explanations (rather than descriptions) – identifying patterns and relationships in data – interpreting data, information and diagrams to solve problems • involves students in the process by providing opportunities to ask follow-up questions • focuses on each student's personal progress relative to previous achievements • identifies the characteristics of a high-quality response that aligns with the descriptors in the task-specific standards. The task-specific standards for this assessment can be used as a basis for providing feedback to students.
Resources	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

Energy test

Name ....

Purpose of assessment: To demonstrate understanding of different forms of energy and the changes they cause within systems.

Understanding dimension			Skills dimension	
Science Understanding		**Science as a Human Endeavour**	**Science Inquiry Skills**	
Section A: Questions 1, 2, 5, 6, 7 Analysis of data and information to identify types of energy, describe energy transfers, transformations, efficiency and develop explanations	**Section A: Questions 3, 4, 9, 10** Application of science knowledge to generate solutions about: • kinetic energy • gravitational potential energy • percentage efficiency	**Section B: Questions 11, 13** Explanation of how evidence has improved understanding of science ideas and informed the collaboration of scientists to generate solutions to contemporary problems	**Sections A and B: Questions 8, 12** • Use of patterns and trends in graphs to explain relationships and justify conclusions • Construction of graphs to reveal patterns and trends about greenhouse gas emissions in cars vs. trains	
◀ Integration of analysis of diagrammatic or graphical data with science knowledge to develop justified explanations about: • the quantitative comparison of energy efficiency of light bulbs and describe the safety advantages (Q6) • how the relationship between KE and GPE represents the position of a skateboard rider (Q7)	◀ Accurate interpretation of text/diagrams to: • compare KE and GPE (Q9) • convert units and substitute values into the appropriate equation to solve energy efficiency multistep, sequential problems (Q10)	◀ Links to the background information and use of the data about total greenhouse gas emissions from 1990–2020 to explain why the initial development of the UltraBattery™ targeted cars rather than trains (Q13)	◀ Use of data from the graph to compare the cooling rates of the different methods when drawing a justified decision about the accuracy of the claim (Q8) Following of conventions to systematically construct accurate graphs to reveal patterns and trends about greenhouse gas emissions (Q12)	**A**
				B
◀ Identification of different types of energy and description of energy transfers and transformations (Q1,2) Identification of the: • point where GPE is greatest (Q5) • energy transformation in light bulbs (Q6) • graph that represents the PE and GPE of a skateboard rider at particular positions (Q7)	◀ Substitution of values into the appropriate equation to solve simple word problems (Q3, 4)	◀ Explanation about total greenhouse gas emissions from 1990–2020 (Q11) Description of why the UltraBattery™ was developed (Q13)	◀ Use of data from the graph to draw justified decisions about gaining a food safety certificate (Q8) Construction of graphs to reveal and analyse patterns and trends about greenhouse gas emissions (Q12)	**C**
				D
◀ Recall of science facts about energy	◀ Recall of energy equations	◀ Statements about greenhouse gas emissions and the UltraBattery™	◀ Restatement of data (Q8) Partial construction of graphs (Q12)	**E**

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Energy test

Name ....

Purpose of assessment: To demonstrate understanding of different forms of energy and the changes they cause within systems.

			A	B	C	D	E
Understanding dimension	Science Understanding	**Section A** **Questions 1, 2, 5, 6, 7** Analysis of data and information to identify types of energy, describe energy transfers, transformations, efficiency and develop explanations	Integration of analysis of diagrammatic or graphical data with science knowledge to develop justified explanations about: • the quantitative comparison of energy efficiency of light bulbs and describe the safety advantages (Q6) • how the relationship between KE and GPE represents the position of a skateboard rider (Q7)	Linking analysis of diagrams or graphs with science knowledge to: • explain why the identified point has the greatest GPE (Q5) • qualitatively compare energy efficiency of light bulbs and describe the safety advantages (Q6) • explain which KE and GPE graph represents the position of a skateboard rider (Q7)	Identification of different types of energy and description of energy transfers and transformations (Q1,2) Identification of the: • point where GPE is greatest (Q5) • energy transformation in light bulbs (Q6) • graph that represents the PE and GPE of a skateboard rider at particular positions (Q7)	Definition of different types of energy and recall of energy science knowledge	Recall of science facts about energy
		Section A **Questions 3, 4, 9, 10** Application of science knowledge to generate solutions about: • kinetic energy • gravitational potential energy • percentage efficiency	Accurate interpretation of text/diagrams to: • compare KE and GPE (Q9) • convert units and substitute values into the appropriate equation to solve energy efficiency multistep, sequential problems (Q10)	Interpretation of text/diagrams to substitute values into the appropriate equation to: • calculate KE and GPE (Q9) • solve multistep and sequential problems (Q10)	Substitution of values into the appropriate equation to solve simple word problems (Q3, 4)	Substitution of values into equations to partially solve word problems	Recall of energy equations
	Science as a Human Endeavour	**Section B** **Questions 11, 13** Explanation of how evidence has improved understanding of science ideas and informed the collaboration of scientists to generate solutions to contemporary problems	Links to the background information and use of the data about total greenhouse gas emissions from 1990–2020 to explain why the initial development of the UltraBattery™ targeted cars rather than trains (Q13)	Use of the data about total greenhouse gas emissions from 1990–2020 to explain why the initial development of the UltraBattery™ targeted cars rather than trains (Q13)	• Explanation about total greenhouse gas emissions from 1990–2020 (Q11) • Description of why the UltraBattery™ was developed (Q13)	Statements about greenhouse gas emissions and the development of the UltraBattery™ to solve a problem	Statements about greenhouse gas emissions and the UltraBattery™

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			A	B	C	D	E
Skills dimension	Processing and analysing data and information	**Sections A and B Questions 8, 12** • Use of patterns and trends in graphs to explain relationships and justify conclusions • Construction of graphs to reveal patterns and trends about greenhouse gas emissions in cars vs. trains	• Use of data from the graph to compare the cooling rates of the different methods when drawing a justified decision about the accuracy of the claim (Q8) • Following of conventions to systematically construct accurate graphs to reveal patterns and trends about greenhouse gas emissions (Q12)	• Use of data from the graph to describe the cooling rates of the different methods and draw a justified decision about the accuracy of the claim (Q8) • Following of conventions to systematically construct graphs to reveal patterns and trends about greenhouse gas emissions (Q12)	• Use of data from the graph to draw justified decisions about gaining a food safety certificate (Q8) • Construction of graphs to reveal and analyse patterns and trends about greenhouse gas emissions (Q12)	• Partial development of conclusions about food safety and cooling methods (Q8) • Partial construction of graphs to reveal and analyse patterns and trends about greenhouse gas emissions (Q12)	• Restatement of data (Q8) • Partial construction of graphs (Q12)

Energy test

Current scientific conceptions and students' prior understandings

Current scientific conceptions

Energy

Energy is the ability to do work. It can be classified as either kinetic or potential energy. Kinetic energy is the energy an object possesses when it is moving. It is often called movement energy. Potential energy is energy that is stored. It can be stored in a variety of forms. For example, the energy stored in food is chemical potential energy.

Energy comes in many forms — for example, heat, light, sound, solar and electrical energy. These forms of energy may come from a variety of sources. It is important to recognise the difference between an energy source and an energy form — that is, the energy source produces the particular form(s) of energy. For example, food is a source of chemical potential energy.

Heat energy

Heat is a form of energy that comes from many sources. The sun, friction, some chemical reactions (including burning) and reactions occurring in the Earth's core all provide heat energy.

Light energy

Some wavelengths of radiant energy from the sun can be detected by our eyes. These wavelengths are called light energy.

Sound energy

Sound is a form of energy that travels as vibrations through solids, liquids and gases. The sounds we hear are caused when a moving object makes the air vibrate. These vibrations, travelling through the air, are picked up by our ears and translated by our brains into sounds.

Solar energy

The sun produces radiant energy over a range of wavelengths. Some wavelengths are detected by our eyes and are called light energy. When wavelengths in the infra-red range come into contact with matter, they are changed to heat energy.

Electrical energy

An electric current consists of a flow of tiny particles called electrons.

Batteries are a useful way of storing energy. They change chemical potential energy into electricity. Each cell of a battery contains two electrodes. A chemical reaction occurring at one electrode makes that electrode positively charged. A different chemical reaction at the other electrode makes that electrode negatively charged. When the electrodes are connected via an external circuit, electrons from the negative electrode flow through the circuit to the positive electrode. This is the electric current.

Transfer and transformation of energy

Energy can be converted from one form to another, but it cannot be created or destroyed. This can also be stated as energy input is equal to energy output. This is a difficult idea for students who may hold a belief that energy is ‘used up’ during interactions — for example, the energy in fuel and batteries.

Objects with kinetic energy can give other objects a push or pull. This is called energy transfer.

Some types of energy can be changed to another form of energy. This changing from one type of energy to another is called energy transformation.

Students need to consider the range of energy conversions and the idea that, in all energy transformations, some energy is converted to heat. In many situations, the heat energy produced is not useful.

The efficiency of energy converters is determined by comparing the energy output (in a useful form) to the energy input and expressing this as a percentage:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

The efficiency of an energy converter is less than 100 per cent since some energy is always converted to heat in a form that is not useful.

Students’ prior understandings

Forms of energy that should be familiar to students should include heat, light, sound and electrical energy. However, students’ prior understandings may differ from current scientific conceptions in a range of ways.

Some students may:

- not distinguish between forms and sources of energy
- use the terms ‘energy source’ and ‘energy form’ interchangeably
- have heard about energy only in relation to foods such as bread, breakfast cereals and sports drinks
- believe that energy is associated only with living things or moving things
- believe that energy is used up.

Some students may think that energy is a ‘concrete’ substance that can be used up, which differs from the scientific idea that energy is conserved.

Resources

Sourcebook modules provide teachers with a range of learning and teaching ideas. Teachers are encouraged to modify modules to meet the specific needs and interests of particular groups of students and individual students, their own needs and the learning environment.

- QSA, Science (1999) sourcebook module > Energy and change > Forms and sources of energy www.qcaa.qld.edu.au/992.html.
- QSA, Science (1999) sourcebook module > Energy and change > Alternatives in energy www.qcaa.qld.edu.au/992.html.
- QSA, Science (1999) sourcebook module > Energy and change > Obtaining and using energy efficiently www.qcaa.qld.edu.au/992.html.

Energy test: stimulus

Energy for transport

You:

- will bring this stimulus sheet into the test with you
- will use the research below as the source of information when responding to questions in the test
- should ask questions of your teacher if you do not understand the content below. It is important that you understand what you are reading before the test
- can make extra notes in the margins or on the blank page at the end of the stimulus sheet if you have done further research to assist you to understand the information — the sources of the information below can be found in the references list.

Greenhouse gases background information

Greenhouse gases include carbon dioxide, methane, fluorocarbons and nitrous oxide. These gases act as a shield to trap heat in the earth's atmosphere. This trapped heat contributes to the greenhouse effect.

Human activities are increasing greenhouse gas levels in the Earth's atmosphere. These activities include the burning of fossil fuels (coal, oil and natural gas) for electricity production and transportation, agriculture and industrial processes.

In December 2007, Australia ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change, agreeing to limit greenhouse gas emissions pollution. The Australian Government has also committed to a long-term target to cut pollution.

Emission predictions

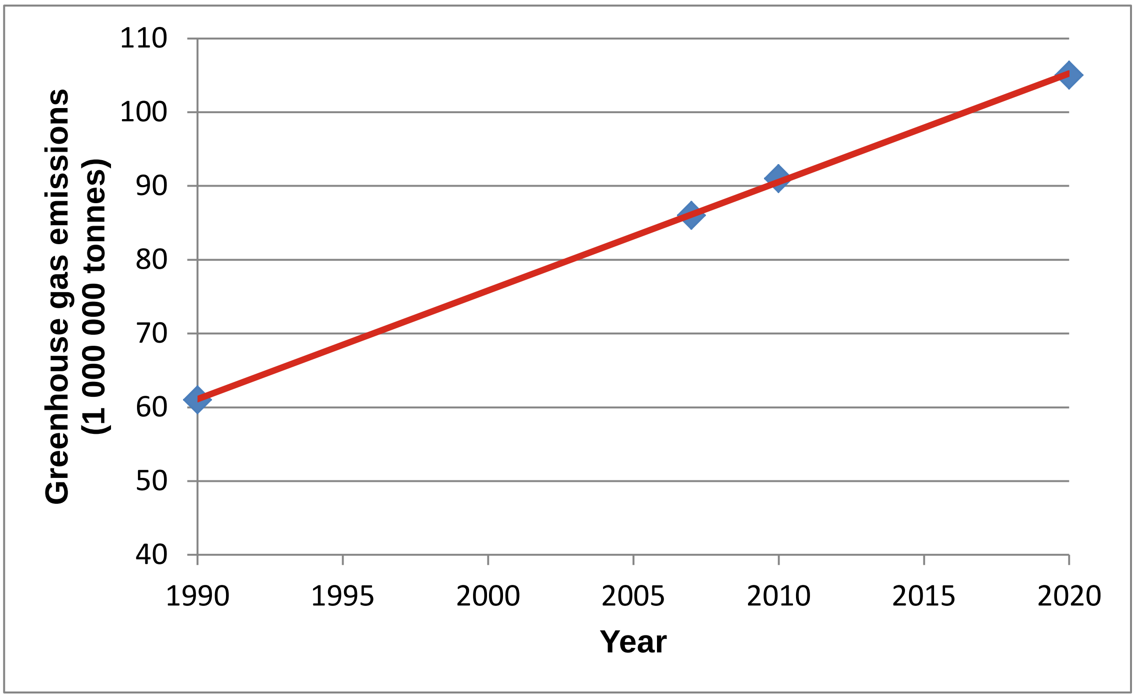
The Bureau of Infrastructure, Transport and Regional Economics (BITRE) conducted a study during 2007 to predict greenhouse gas emissions from the different forms of transport in Australia. Transport is the third largest emitter of greenhouse gases in Australia behind energy generation and agriculture.

It was predicted that emissions from the transport in 2010, would be around 48% above the level for 1990 and by 2020 emissions would be around 70% above 1990 levels. Passenger cars would contribute the most to these emissions.

Figure 1: Predicted greenhouse gas emissions from transport in Australia

Year	Cars	Other road users	Air	Rail	Marine	Other	Total	Per cent change from 1990
	(1 000 000 tonnes)							
1990	34	19	2	2	2	0.060	59	
2007	44	29	6	3	2	0.094	84	42
2010	46	32	7	3	2	0.097	90	53
2020	49	41	8	4	2	0.107	104	76

Figure 2: Total predicted greenhouse gas emissions predictions from transport in Australia



Technologies in development

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is conducting research that focuses on developing clean, affordable energy and transport technologies. The initial goal of this research was to develop an efficient, low emission power source for hybrid electric vehicles (HEVs).

A hybrid vehicle is a vehicle that uses two or more distinct power sources to move the vehicle. The most common type of hybrid vehicle contains parts of both petrol and electric vehicles i.e. HEVs.

UltraBattery™

The UltraBattery™ is a hybrid energy storage device developed by the CSIRO. This technology has two major applications:

- energy source for low emission transport e.g. hybrid electric vehicles (HEVs)
- storage of renewable energy from wind and solar sources.

The UltraBattery™ has advantages over the batteries currently used in HEVs. It is approximately 70% less expensive, has lower maintenance needs and charges faster — all with comparable performance. It is expected that the recycling rates of the UltraBattery™ will be 100%.

The testing of the UltraBattery™ was a collaborative process involving government and commercial laboratories in the USA, Japan and Australia.

Future applications of UltraBattery™ technology

Railway power source

Battery energy storage could be used to provide hybrid power in trains. The change to hybrid power should be made easier as many trains already have both diesel and electric motors. The advantages to this application of the UltraBattery™ include:

- hybrid power allows emissions-free train movements in populated areas
- railway carriages are built to last a long time, so it can make economic sense to retrofit a hybrid power system to existing cars rather than waiting to order replacements.

Wind energy storage

The UltraBattery™ might provide an effective means for the storage of wind energy. The battery cell would allow storage of a large amount of energy. Converting wind energy to electricity is approximately 8–10 times cheaper than converting solar energy to electricity.

References

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- UltraBattery™ FAQs
  www.csiro.au/en/Outcomes/Energy/Storing-renewable-energy/Ultra-Battery/FAQs.aspx
- UltraBattery™ White Paper
  www.industrie.com/it/mediatheque/2/1/6/000011612.pdf

Energy test

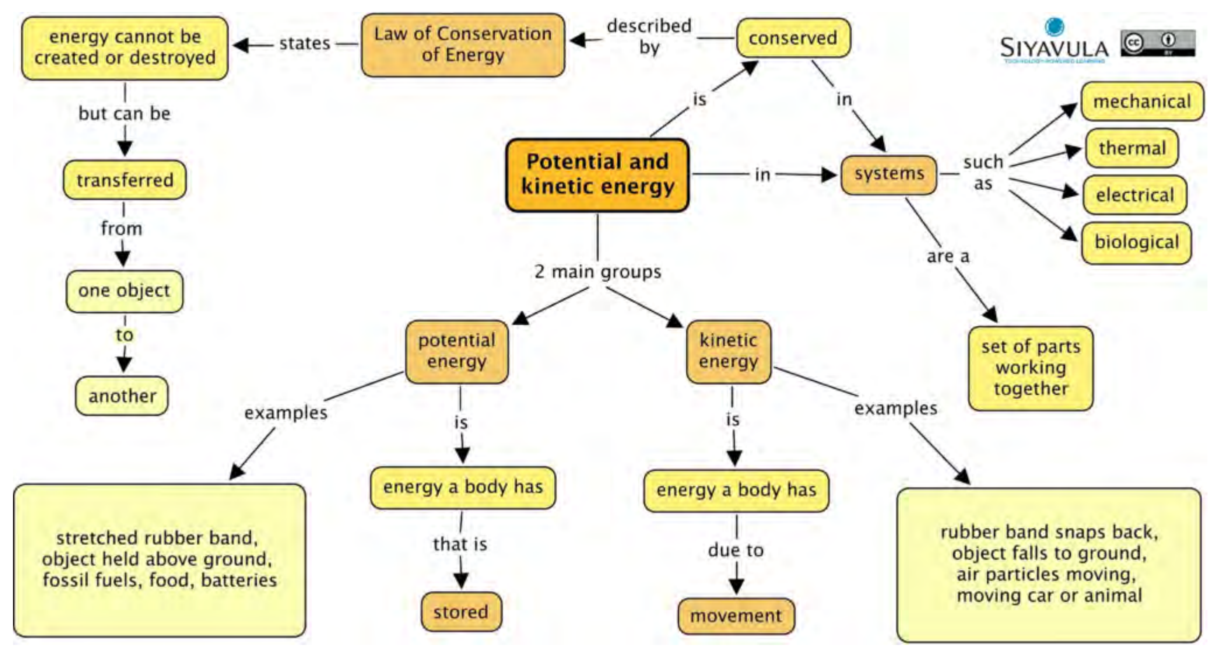


Image: *Potential and Kinetic energy*, Slyavula Education, Creative Commons Attribution 2.0, https://flic.kr/p/mEmSYE

Solve problems about changes within systems caused by energy transfers and transformations.

You will:
- identify types of energy and describe transformations
- analyse and calculate the efficiency of energy-transformation devices
- solve problems by calculating gravitational potential energy and kinetic energy
- link knowledge of thermal energy to change of state
- analyse data to draw conclusions and evaluate claims.

List of equations

The following equations are required to solve some of the questions in this test

$GPE = m \times g \times h$

$KE = {}^{1}/_{2}\, mv^2$

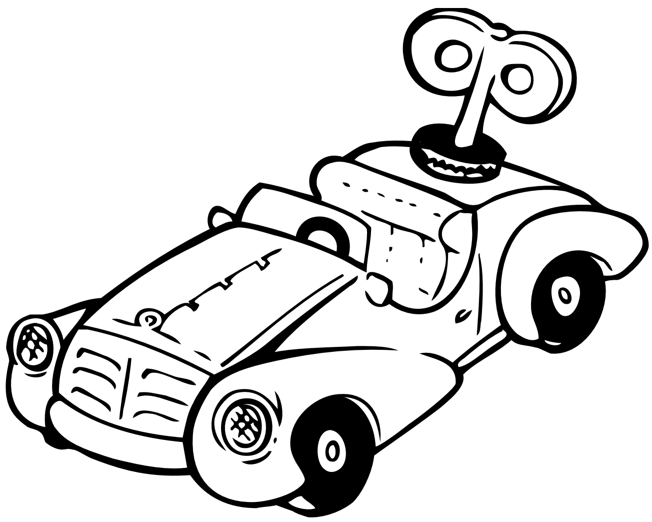
Part A: Short-response questions

1. Complete the table below to identify the energy transformation caused by each energy converter.

Main energy form used	Energy converter	Main energy form produced
	toaster	heat
chemical potential	torch	
	car	
	iPod	

2. This toy car moves when you wind it up and let it go.

Diagram 1: Wind-up toy car



Complete the energy chain below to identify three energy transformations starting with a person, winding the toy, to the toy moving.

	⇨		⇨		⇨	

Shade the bubble of your chosen response for Questions 3 to 5.

In the space provided under each question show all working or provide full explanations to justify your choice of answer.

3. What is the kinetic energy of a 0.158 kg cricket ball travelling at 28 m/s?

- ◯ 61 936 J
- ◯ 4.42 J
- ◯ 247.74 J
- ◯ 61.94 J

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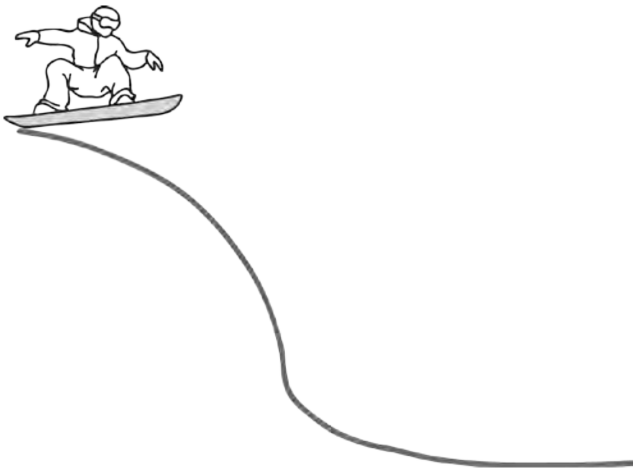
4. Janie is at the top of a ski run which is elevated 40 vertical metres above the ground. Her mass (including her equipment) is 60 kg. Calculate her gravitational potential energy at the top of the slope.

Diagram 2: Ski run



- ◯ 23 520 J
- ◯ 109.8 J
- ◯ 940 800 J
- ◯ 8 160 J

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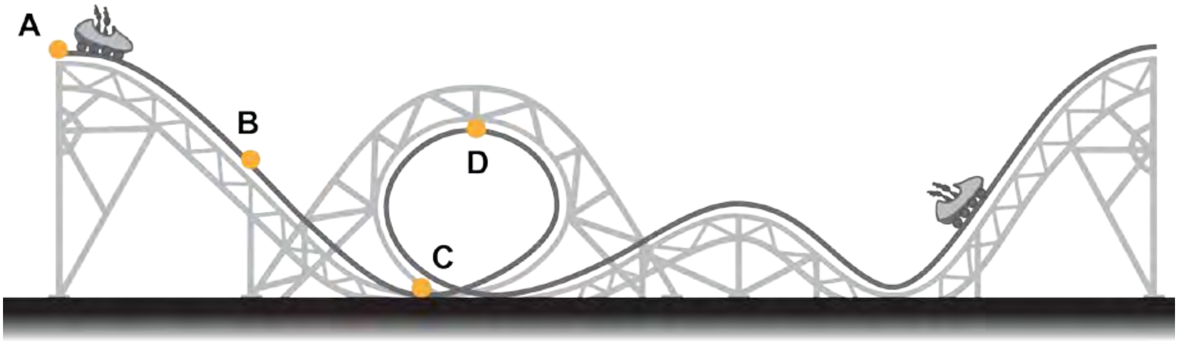
5. Consider points A, B, C and D on the roller coaster in the diagram below.

Diagram 3: Roller coaster



At which point does the roller coaster have the greatest gravitational potential energy?

- ❍ A
- ❍ B
- ❍ C
- ❍ D

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6. Quantitatively analyse the information in the diagrams below and:

   a. compare the efficiency of the energy transformation in a filament electric light bulb with that of an energy efficient electric light bulb

   b. describe the safety advantages of using energy efficient electric light bulbs in preference to filament light bulbs.

Diagram 4: Energy transformations of a filament electric light bulb

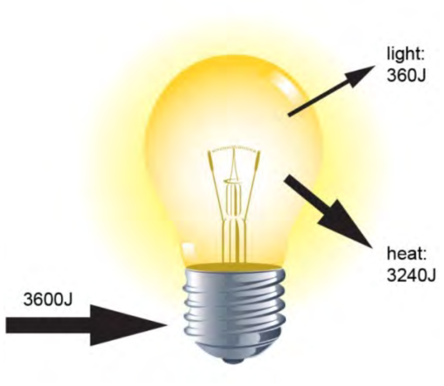
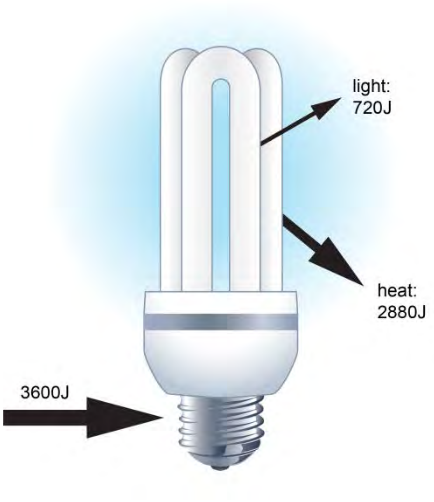


Diagram 5: Energy transformations of an energy efficient electric light bulb



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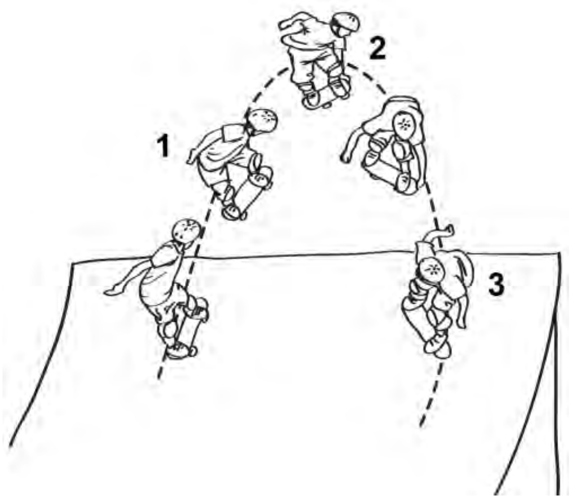
7. Diagram 6 shows a skateboard rider performing a trick on a ramp.

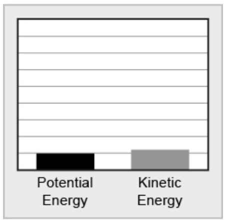
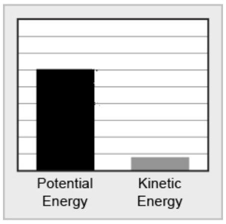
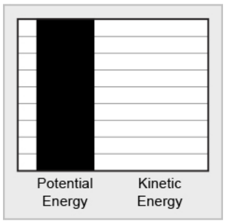
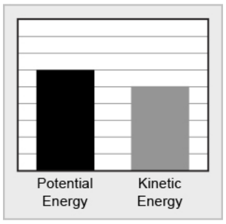
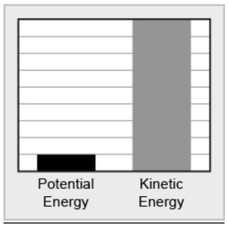
Diagram 6: Path of skateboard rider



---------- Path of the rider

a. Choose the graph in the table below that best represents the potential and kinetic energy of the rider at each of the positions 1, 2 and 3. NOTE: There are two graphs that will not be used when answering this question.

b. Justify your choices.

Graph 1	Graph 2	Graph 3	Graph 4	Graph 5
				

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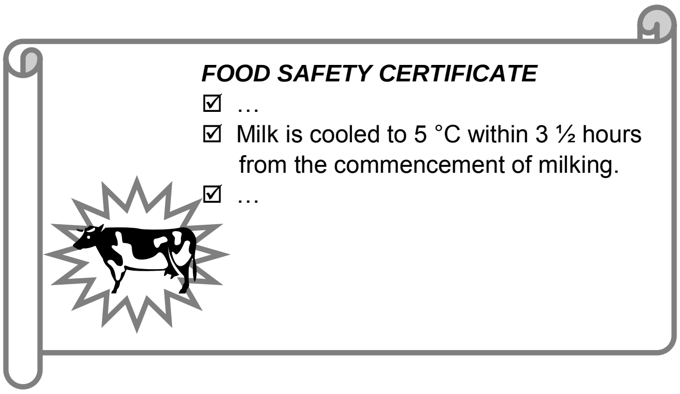
8. Cooling milk quickly for storage is an important part of the food safety plan of every dairy farm. Farmers in Australia must cool their milk to 5 °C within 3½ hours from the commencement of milking.

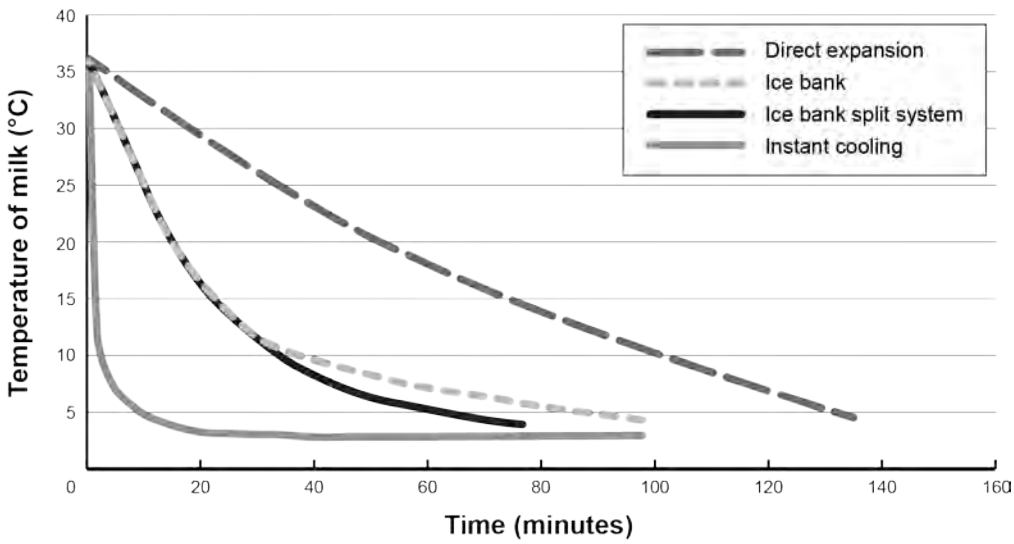


A farm is investigating different methods of cooling its milk.

The temperature of the milk is measured regularly after milking a herd of cows.

The graph below shows the drop in temperature of the milk over time using different methods of cooling.

Diagram 7: The cooling rates of milk using different methods.



Source: http://www.dairytechrefrig.com.au/pre-chilling

a. Would each of these methods allow the farmer to gain a Food Safety Certificate? Justify your answer.

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b. Evaluate the accuracy of the claim, 'The Ice bank cools milk to 10 °C, 50% faster than other methods'.

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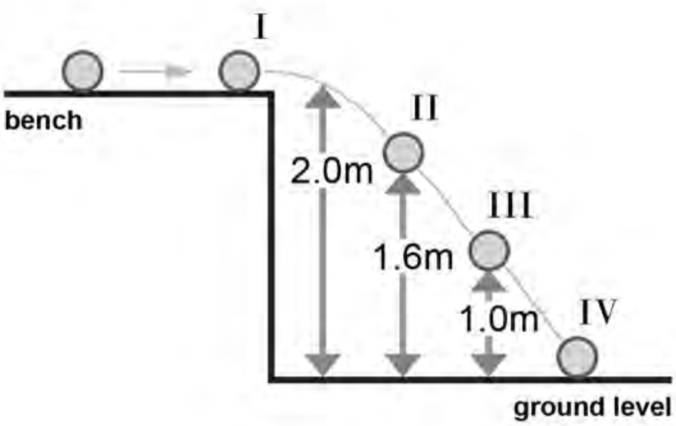
9. A steel ball-bearing of mass 0.2 kg is rolled across a frictionless bench top at 2.0 m/s. It rolls off the edge and falls 2.0 m to the ground as shown in Diagram 8.

Diagram 8: A falling ball-bearing.



Compare the kinetic energy and the gravitational potential energy of the ball-bearing at position I.

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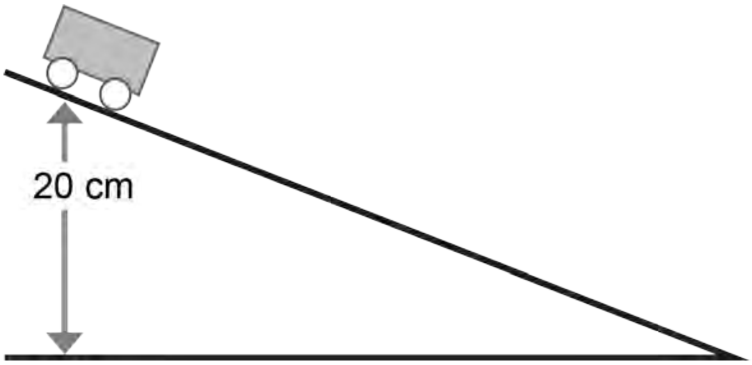
10. During an experiment, a Year 8 student releases a 500 g cart from rest and accelerates down an inclined plane 1.2 m in length, as shown in Diagram 9.

Diagram 9: A cart rolling down a ramp



a. Given the initial height of the trolley on the inclined plane, calculate the initial gravitational potential energy of the trolley.

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b. Calculate the kinetic energy of the trolley at the base of the incline if the velocity at the base is 1.7m/s.

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c. Calculate the percentage efficiency of the energy transformation.

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Part B: Stimulus-response questions

Use the information and data in the stimulus to answer the questions below.

11. Explain what the data indicates about Australia's total predicted greenhouse gas emissions from transport between 1990–2020.

12. On the axes below, sketch graphs that compare the greenhouse gas emissions of cars with trains (rail) from 1990–2020.

13. Suggest why the UltraBattery^{TM} was initially targeted at cars rather than trains.

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