5.1 Energy around you

Science understanding

Verbal/Linguistic

1 There are many different forms of energy. Using the list below, **classify** which types of energy are present in each of the following situations.

kinetic energy	sound energy	light energy	heat energy
electrical energy	chemical energy	gravitational potential energy	
elastic potential energy	nuclear energy		

Situation		Types of energy present
(a)	A racing car starts a race.	kinetic, heat, sound
(b)	A rubber ball warms up in the sun.	
(c)	A hot air balloon sails above some clouds.	
(d)	The springs on a trampoline are stretched before it bounces upwards.	
(e)	Petrol is put into a car.	
(f)	A desk lamp shines brightly.	
(g)	A candle burns.	
(h)	A ball rolls down a hill.	
(i)	A boy brushes his teeth.	
(j)	A cat climbs up a tree.	

2 Kinetic energy is the energy of a moving object. Potential energy is the energy stored in an object. **Classify** each example below as having either kinetic or potential energy.

(a) A slingshot about to fire ______________________

(b) A ball at the highest point of a bounce ______________________

(c) A swimmer about to dive from a high platform ______________________

(d) A swimmer hitting the water from a dive ______________________

(e) A teenager skating along a footpath ______________________

(f) A hamburger with the lot sitting on a plate ______________________

(g) A stone rolling along a road ______________________

(h) A new packet of AA batteries ______________________

(i) A bowl of cereal with milk ______________________

(j) A leaf on a tree ______________________

5.2 Energy changes

Science understanding

Visual/Spatial **Verbal/Linguistic**

Energy makes things happen. When something happens, energy may be passed, or *transferred*, from one object to another. This happens when you hit a tennis ball. Some of the kinetic energy of the racquet is transferred to the ball. Energy can also be *transformed* into another type of energy. In order to hit the tennis ball, chemical energy from food that you ate was transformed into kinetic energy in your arm.

1 For each example below, the source of the energy is given. **State** the receiver of this energy and **identify** whether energy was transferred or transformed in the process.

Example	Source of energy	Receiver of energy	Is energy transferred or transformed?
(a) Tom runs in a race.	chemical energy (food)		
(b) A shirt hanging on a washing line dries in the sun.	heat energy (the Sun)		
(c) An aeroplane takes off.	chemical energy (fuel)		
(d) A golf club hits a golf ball.	kinetic energy (the club)		
(e) A cat warms up by an open fire.	heat energy (the fire)		
(f) A ceiling fan is switched on.	electrical energy		

2 An energy flow diagram is a way of showing the energy changes that happen. **Construct** an energy flow diagram for the following energy changes.

(a) A petrol lawn mower cuts some grass.

(b) A solar cell is used to operate an outside light.

(c) An electric knife is used to carve a roast.

(d) A wind-up beetle is released and scuttles across the floor.

5.3 Specific heat capacity

Science understanding, Science inquiry

Logical/Mathematical **Verbal/Linguistic**

You may have walked along the beach on a hot day and felt the sand burning your feet, but jumped in the water and cooled down straight away. This happens because it only takes 880 J of energy to raise the temperature of sand by 1°C, but 4200 J to raise the temperature of the same amount of water by 1°C. As a result, sand heats up much faster (and cools down much faster) than water. The amount of energy required to raise the temperature of 1 kilogram of a substance by 1°C is called its specific heat capacity (symbol *c*).

The table below lists the specific heat capacity of a number of common substances.

Substance	Specific heat capacity, *c* (J/kg/K)
Water	4200
Human body	3500
Alcohol	2450
Ice	2100
Steam	2000
Rubber	1700
Air	1000
Aluminium	900
Sand	880
Glass	670
Iron	440
Copper	390
Lead	130

The amount of heat energy needed to change the temperature of a substance by a certain number of degrees can be calculated using the formula:

Amount of heat energy required (J) = $m \times c \times \triangle T$

where m = mass of substance (kg)

c = specific heat capacity (J/kg/K)

$\triangle T$ = temperature change (°C)

Worked example

1 **Calculate** the amount of heat energy required to raise the temperature of:

(a) 2 kg of water by 5°C

(b) 2 kg of copper pipe by 5°C.

2 **Compare** these results.

Solution

1 (a) For water, $m = 2\,\text{kg}$, $c = 4200\,\text{J/kg/K}$ and $\triangle T = 5°\text{C}$.
Using the formula:
Amount of heat energy required (J) = $m \times c \times \triangle T$
$= 2 \times 4200 \times 5$
$= 42\,000\,\text{J}$

(b) For copper $m = 2\,\text{kg}$, $c = 390\,\text{J/kg/K}$, $\triangle T = 5°\text{C}$.
Amount of heat energy required (J) = $m \times c \times \triangle T$
$= 2 \times 390 \times 5$
$= 3900\,\text{J}$

2 This explains why a copper pipe will heat up much faster than the same mass of water when equal amounts of heat energy are absorbed.

1 As humans, we can absorb a lot of heat before our temperature rises. **Explain** why this is beneficial to us.

____

2 Water is used in the radiator of a car to absorb heat from the engine. **Explain** why water is suitable for this task.

____

3 Refer to the formula stated opposite and the specific heat capacities listed in the table to **calculate** the amount of heat needed or released in raising or lowering the temperature of the following materials:

(a) A 1 kg iron bar heats up from 10°C to 30°C lying in the sun.
Amount of heat required = $m \times c \times \triangle T$

____

(b) 1 kg (1 litre) of water at 12°C is boiled in a kettle.
Amount of heat required = $m \times c \times \triangle T$

____

(c) 2 kg of water in a hot water bottle cools from 39°C to 10°C overnight.
Amount of heat released = $m \times c \times \triangle T$

____

(d) A 100 gram (0.1 kg) aluminium spoon heats up from 8°C to 28°C while being used to stir a mug of hot chocolate.
Amount of heat required = $m \times c \times \triangle T$

____

(e) A 500 gram (0.5 kg) glass bottle that was 60°C cools to 20°C.
Amount of heat released = $m \times c \times \triangle T$

____

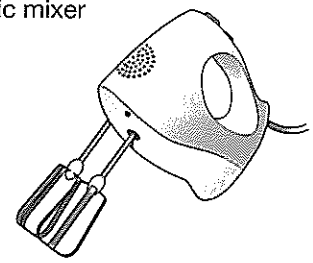
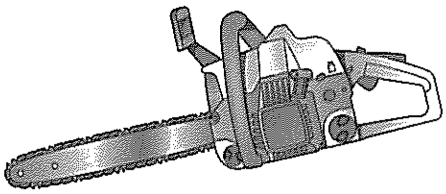
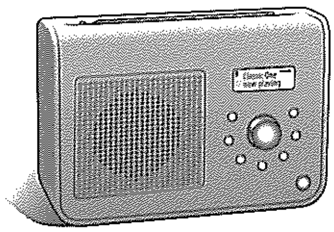
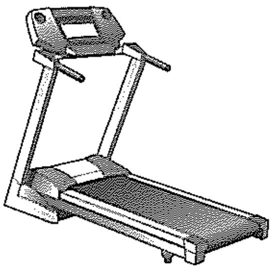
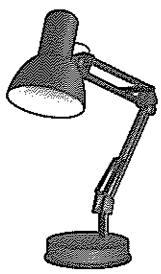
5.4 Energy efficiency

Science understanding

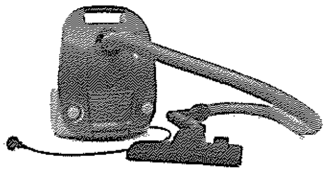
Logical/Mathematical **Visual/Spatial**

Many household devices convert electrical energy into other forms.

1 **Identify** the types of energy, both useful and wasted, that result from transformations by the following devices. The first example has been done for you.

Device	Useful energy produced	Wasted energy produced
(a) Electric mixer 	kinetic	heat, sound
(b) Chain saw 		
(c) Radio 		
(d) Treadmill 		
(e) Desk lamp 		

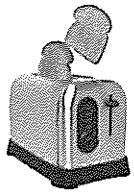
2 The following devices convert the electrical energy supplied into specific amounts of other forms of energy. Recalling that energy is conserved, **calculate** the missing values to complete the following energy conversions:

(a) 500 J ⟶ 

⟶ 150 J heat energy

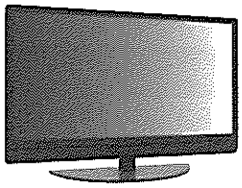
⟶ 50 J sound energy

⟶ __________ J kinetic energy

(b) 500 J ⟶ 

⟶ __________ J heat energy

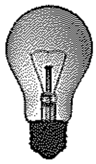
⟶ 50 J light energy

(c) 500 J ⟶ 

⟶ __________ J heat energy

⟶ 100 J light energy

⟶ 50 J sound energy

(d) 100 J ⟶ 

⟶ 70 J heat energy

⟶ __________ J light energy

3 The efficiency of the devices in the previous question can be calculated using the following equation:

$$\frac{\text{useful energy output (J)}}{\text{energy input (J)}} \times 100$$

(a) Use the equation above to **calculate** the efficiency of the toaster.

____

____

(b) Assuming that light and sound are the useful forms of energy from a television, **calculate** the efficiency of the plasma television.

____

____

(c) **State** whether the toaster or the television is more energy efficient.

____

(d) **Justify** your answer above.

____

____

5.5 Space heating energy consumption in Australia

Science understanding, Science inquiry

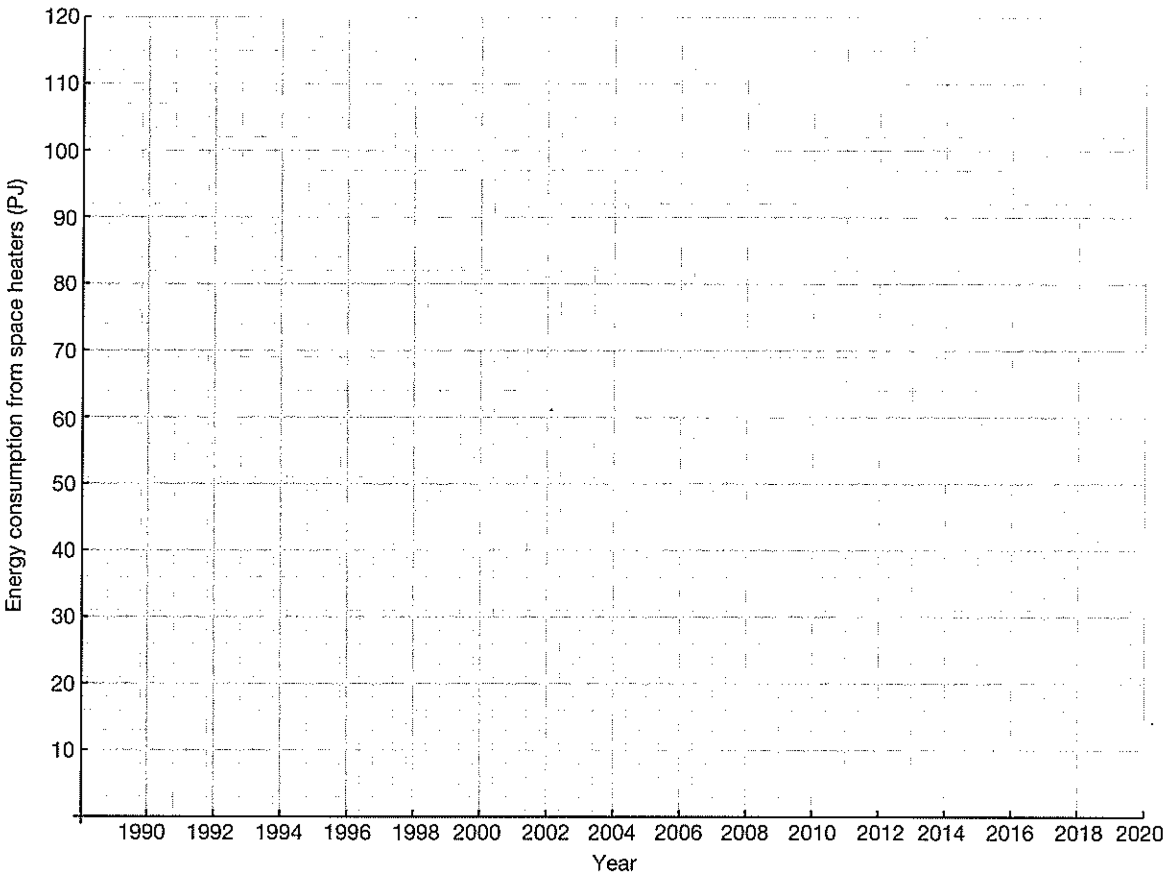
Logical/Mathematical **Visual/Spatial** **Verbal/Linguistic**

An Australian government report titled *Energy Use in the Australian Residential Sector 1986–2020* presents data about how Australian households use energy, and predicts how this will change. Despite the increasing floor area of new homes and the trend for larger televisions and more household appliances, consumption is predicted to drop by 6% by 2020. This decrease is expected as a result of the use of energy-efficiency awareness programs. Table 5.5.1 lists data from each state and territory of Australia. It outlines energy use and projected energy use of space heaters. Space heaters use about 38% of total household energy.

Table 5.5.1 Space heating energy consumption (petajoules) by state 1986–2020
(1 petajoule (PJ) = 1 000 000 000 000 000 J)

Year	NSW	Vic	Qld	SA	WA	Tas	NT	ACT
1990	26.6	62.6	3.4	9.4	7.7	14.0	0.0	2.6
1991	24.0	59.3	2.8	8.2	7.1	13.0	0.0	2.4
1992	26.2	64.8	3.1	8.9	7.4	14.7	0.0	2.9
1993	29.1	63.3	2.9	9.8	8.4	15.7	0.0	3.5
1994	25.9	67.2	2.7	8.5	7.3	14.6	0.0	3.2
1995	30.1	78.5	3.5	9.6	9.1	15.7	0.0	3.5
1996	28.8	80.2	3.1	9.2	8.8	15.5	0.0	3.7
1997	29.3	78.0	3.7	9.6	8.7	15.4	0.0	3.8
1998	28.8	82.8	3.1	9.4	8.8	14.5	0.0	3.8
1999	28.6	80.1	2.6	9.6	8.3	14.8	0.0	4.0
2000	25.5	70.2	3.1	8.4	7.3	13.7	0.0	4.1
2001	23.8	71.4	3.2	8.3	6.7	12.5	0.0	4.1
2002	24.8	76.4	3.1	9.3	7.2	12.0	0.0	4.2
2003	22.3	71.9	3.2	8.3	6.3	10.7	0.0	4.2
2004	24.9	84.6	3.1	9.6	7.0	11.1	0.0	4.7
2005	25.4	85.9	3.3	9.2	7.7	11.0	0.0	5.0
2006	25.3	87.1	3.2	9.1	7.6	10.9	0.0	5.2
2007	25.2	88.4	3.2	9.1	7.5	10.8	0.0	5.4
2008	25.1	89.7	3.2	9.0	7.4	10.6	0.0	5.6
2009	25.0	90.0	3.2	9.0	7.3	10.5	0.0	5.8
2010	24.9	92.3	3.2	9.0	7.3	10.4	0.0	5.9
2011	24.9	93.8	3.2	9.0	7.2	10.2	0.0	6.1
2012	24.9	95.5	3.2	8.9	7.2	10.1	0.0	6.3
2013	24.9	97.3	3.2	8.9	7.1	10.0	0.0	6.5
2014	24.9	99.2	3.2	8.9	7.1	10.0	0.0	6.7
2015	25.0	101.1	3.2	8.9	7.1	9.9	0.0	6.9
2016	25.0	103.1	3.2	8.9	7.1	9.8	0.0	7.1
2017	25.1	105.2	3.2	9.0	7.1	9.7	0.0	7.3
2018	25.1	107.4	3.2	9.0	7.0	9.7	0.0	7.6
2019	25.2	109.5	3.2	9.0	7.0	9.6	0.0	7.8
2020	25.3	111.8	3.2	9.1	7.0	9.5	0.0	8.0

1 Use the data in Table 5.5.1 to **construct** a line graph for each state and territory on the axes below to show its energy consumption for space heating. Show each graph as a different colour or use a key to label them. (Round the decimal points off to the nearest whole number to plot these graphs.)



2 (a) **State** which state or territory uses the most energy for space heating.

(b) **Propose** reasons that could explain this result.

3 Tasmania has the coolest climate in Australia yet does not use the most energy for heating. **Propose** a reason to explain why.

4 **Discuss** how increasing the floor area of new homes and extensions of existing homes affect the cost of heating and cooling.

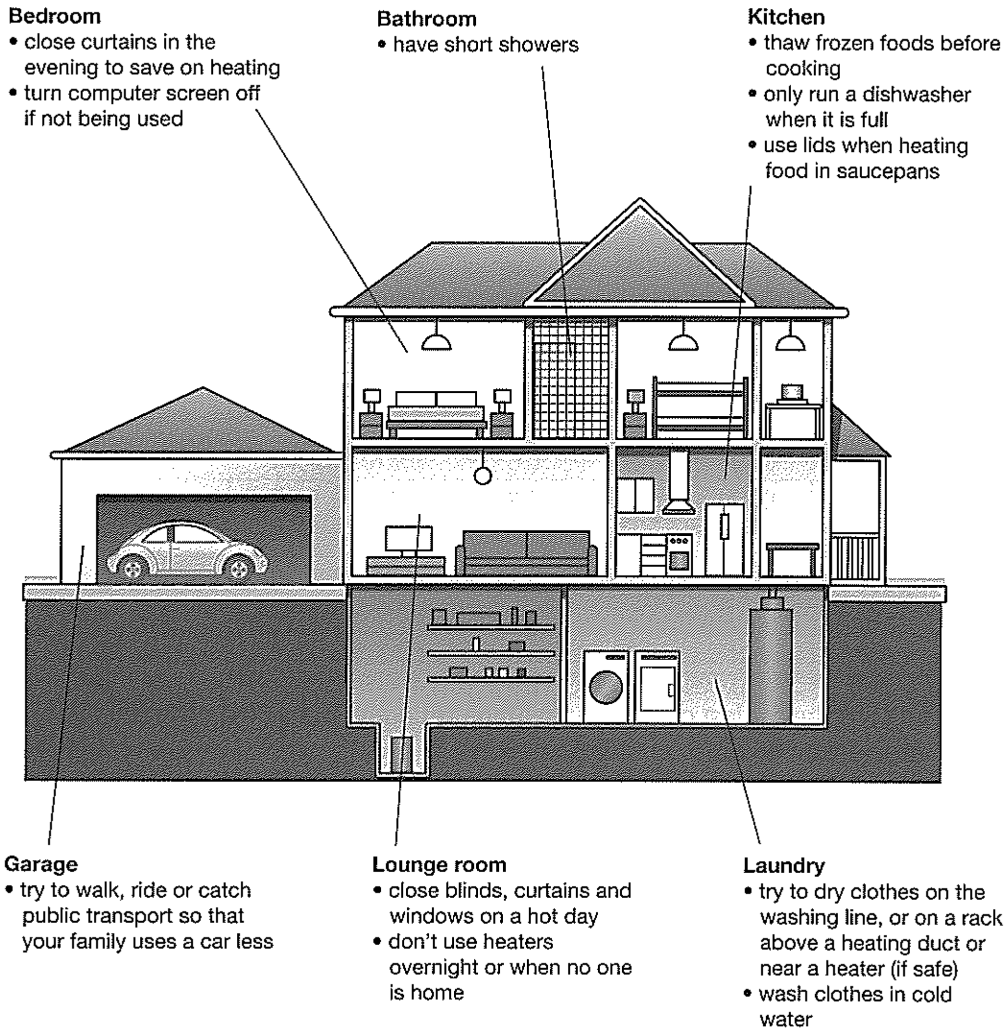
5 New building standards demand that the shell of a home be better insulated. **Explain** how this would affect heating and cooling costs.

Science understanding, Science as a human endeavour

Verbal/Linguistic **Visual/Spatial**

If we can reduce our energy use, then we will reduce greenhouse gas emissions. Some ways of saving energy are very simple, such as turning off an appliance at the power point when it is no longer being used. The diagram below gives some tips on how you can save energy around your home.

Propose as many additional ways to save energy as you can by adding these to the diagram.



Science as a human endeavour

Verbal/Linguistic

Heat naturally flows from regions of higher temperature to regions of lower temperature. As a result, when you use heating to warm up the living areas of your home in winter, this warm air, if it can flow, will flow through cracks or gaps in walls to the cool air outside. Alternatively, heat can flow up into the roof space, or through walls into a garage. This means that to keep a house warm in winter, householders need to use a lot of energy.

Similarly, in summer, the warm air outside will naturally flow into a cool house. Once again, householders need to use a lot of energy to cool their homes.

Insulation is a material that can be added in ceilings and between the walls of a home to reduce heat flow. If heat flow is restricted, the energy costs required to heat and cool a home are reduced. The following fact sheet produced by the Queensland Government explains what types of insulation are available.

EnergyWise Queensland

Insulation – saving energy and money

Energy efficient cooling and heating

Insulation can be the most effective item you can add to your home to improve its energy efficiency.

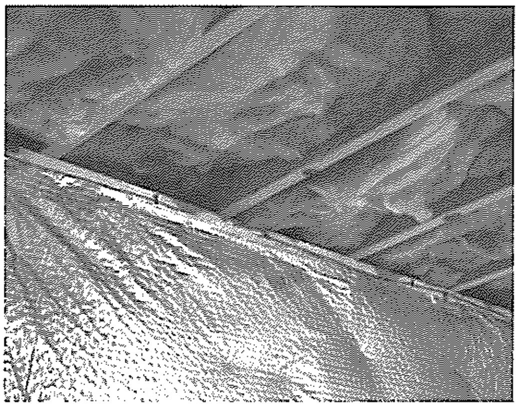
Insulation works by creating a barrier to heat transfer through the ceiling and walls. In summer it helps keep your home cooler by reducing the amount of heat entering your home. In winter it helps keep your home warmer by trapping the warm air inside. For best results, all ceilings, walls and raised walls should be insulated.

Save up to 45 percent on heating and cooling energy with roof and ceiling insulation.

Insulate to help cut air conditioning and heating running costs

Ceiling insulation can make a significant difference to the cost of running your air conditioner.

When your home is insulated, it will be more comfortable regardless of the season, and less reliant on climate-controlled appliances, such as air



conditioners and heaters. As you reduce the amount of energy you use to stay comfortable, you will save money on appliance running costs and reduce the amount of greenhouse gases emitted.

When you do turn on your air conditioner or heater, it will use less energy and cost you less to run. There will also be less wear and tear on your heating and cooling appliances as they don't have to work as hard.

5.7

Types of insulation available

There is a variety of insulation products available and it is important to assess the type of insulation that will best suit your energy needs. There are three main types of ceiling insulation—loose fill, bulk fill (commonly referred to as 'batts') and reflective foil. The right type for your home will depend on the type of ceiling cavity, access available to the ceiling and personal choice.

The most important thing to consider when choosing insulation is the **R value**. An R value is a measure of the insulation's resistance to heat flow and therefore, its performance.

The higher the R value, the greater the resistance to heat transfer. The climate where you live and the design of your home will influence the R value and type of insulation suitable for your home, and potential for energy savings.

Enhancing home insulation

You may already have adequate roof insulation, however, **roof ventilators** are recommended when you install bulk fill insulation. Ventilation removes excess heat in summer preventing overheating and removes moisture in winter. **Eave vents**, usually small rectangular grids located under your eaves, are required when a roof ventilator is installed. The roof ventilator extracts air from the roof and the eave vents replenish the ceiling cavity with fresh air from outside.

West-facing **windows should be shaded or tinted** to maximise the benefit of insulation. This can be achieved with awnings, blinds or specialised products such as solar window tinting.

1 **Explain** why, without insulation, it is hard to keep a home cool in summer and warm in winter.

____

____

2 **List** places that insulation may be used in a home.

____

3 **Explain** how adding insulation to a home will improve its energy efficiency.

____

____

4 **List** the three main types of ceiling insulation that is available.

____

5 (a) **Explain** what is meant by the term 'R value'.

____

(b) **State** whether it is better to use insulation with a low or a high R value.

____

____

5.8 The development of aircraft

Science as a human endeavour

Verbal/Linguistic

Refer to the Science as a Human Endeavour on pages 195 and 196 of your student book to answer the following questions.

1 **Recall** the name of the flying machine that Leonardo da Vinci designed in the 1480s.

2 **Describe** how Sir George Cayley discovered many principles of flight.

3 **Identify** three features of George Cayley's fixed-wing flying machine.

4 **Identify** the two types of gliders built by Otto Lilienthal. **Explain** the basic difference between the two types.

5 **Describe** the major change to aircraft bodies that happened in the early 1900s, which enabled aircraft to fly faster.

6 **Recall** what provided thrust for aircraft built after World War 2.

7 Jet engines were developed in 1937. **Explain** how a jet engine works.

8 **Discuss** the advantage of using composite materials such as carbon fibre reinforced plastic in improving the efficiency of modern passenger jets.

9 **Describe** what powered the flight of the *Solar Impulse* in 2010.

10 **Outline** what you think have been the most important developments in aircraft design since the early 1900s.

11 **Design** what you think aircraft of the future may look like in the space below.

Science understanding

Verbal/Linguistic

1 **Use** the clues to **identify** the missing words.

CLUE	WORD
(a) We measure energy using this unit.	j _ _ _ _
(b) Energy of movement	_ i _ _ _ _ c
(c) Energy that warms you up	_ _ _ t
(d) Energy that enables us to see	l _ _ _ t
(e) This energy is caused by vibrations	_ _ _ nd
(f) Energy that powers a television	e _ _ ct _ _ _ _ _ _
(g) Stored energy	_ ot _ _ _ _ _ _
(h) Stored energy due to height above the ground is called	g _ _ _ it _ _ _ _ _ _ _ potential energy
(i) The stored energy found in food and fuel	_ h _ m _ _ _ _
(j) Energy stored in a stretched rubber band	_ _ _ _ tic
(k) Energy stored inside the particles that make up matter	n _ _ _ _ _ _
(l) A measure of the proportion of useful energy that is produced by a device	_ f _ _ _ _ _ _ _ _
(m) A law that states that energy can never be created or destroyed is called the law of ________ of energy.	_ _ _ s _ _ _ _ _ _ _ _
(n) A label showing a number of stars that is used to compare energy efficiency of appliances is called the energy ________ label.	_ _ t _ _ _