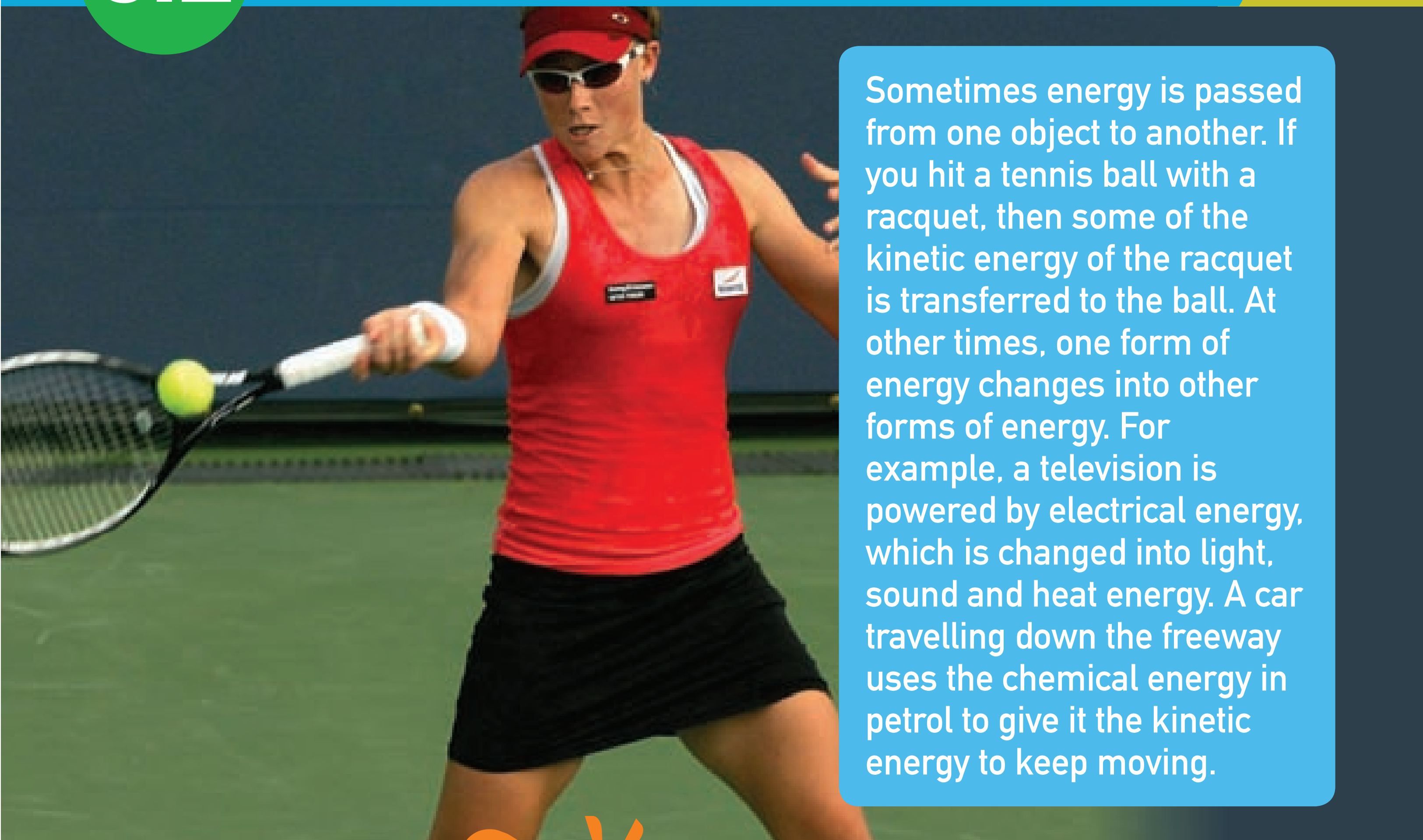
5.2 Energy changes



Sometimes energy is passed from one object to another. If you hit a tennis ball with a racquet, then some of the kinetic energy of the racquet is transferred to the ball. At other times, one form of energy changes into other forms of energy. For example, a television is powered by electrical energy, which is changed into light, sound and heat energy. A car travelling down the freeway uses the chemical energy in petrol to give it the kinetic energy to keep moving.

INQUIRY science 4 fun

Energy transfer

How is energy passed on from one object to another?

Yes

Collect this ...

- dominoes

Do this ...

1. Carefully stand each domino vertically with only a centimetre or so between each one.
2. Give the first domino a gentle push.

Record this ...

Describe what happened to the other dominoes.

Explain why you think this happened.

Energy transfer

Energy can be passed from one object to another. This is known as **energy transfer**. If you stand in front of a heater, then heat energy is transferred from the heater to you, warming you up. As Figure 5.2.1 shows, when you kick a ball, kinetic energy from your foot is transferred to the ball, causing the ball to move.

Figure 5.2.1 When a ball is kicked, kinetic energy is transferred from the person's foot to the ball.

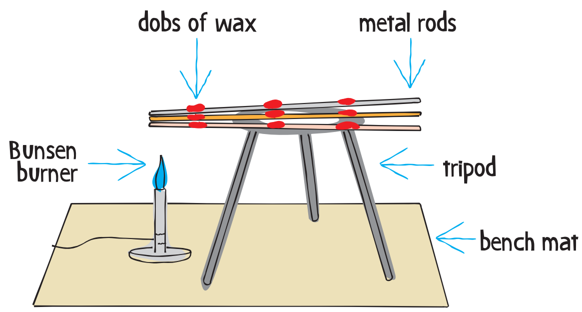
INQUIRY

science 4 fun

Heat transfer

How is heat energy transferred?

No



Collect this …

- three rods of different metals (e.g. iron, copper and steel)
- Bunsen burner, tripod and bench mat
- candle
- timer
- matches

Do this …

1 Place a tripod on a bench mat.

2 Lie the three metal rods on top of the tripod as shown.

2 Place the Bunsen burner just below the ends of the rods.

3 Light the candle and drip dobs of wax onto each rod as shown.

4 Heat the ends of the rods using the blue flame of the Bunsen burner. Time how long each dob of wax takes to melt.
Note: Do not touch the metal rods until they have cooled down.
If a dob of wax has not melted after 10 minutes, turn off the Bunsen burner.

5 From your observations, identify the rod that was best at transferring heat.

Record this …

Describe what happened.

Explain why you think this happened.

1 p187

Energy transformation

Energy can be transferred from one object to another. Energy can also be changed, or transformed, from one type of energy into another type of energy. Whenever you watch TV, listen to music or play on a games console, you are relying on **energy transformation**. Computers, TVs and MP3 players convert electrical energy into sound, light and heat energy. Figure 5.2.2 shows some energy transformations using an **energy flow diagram**.

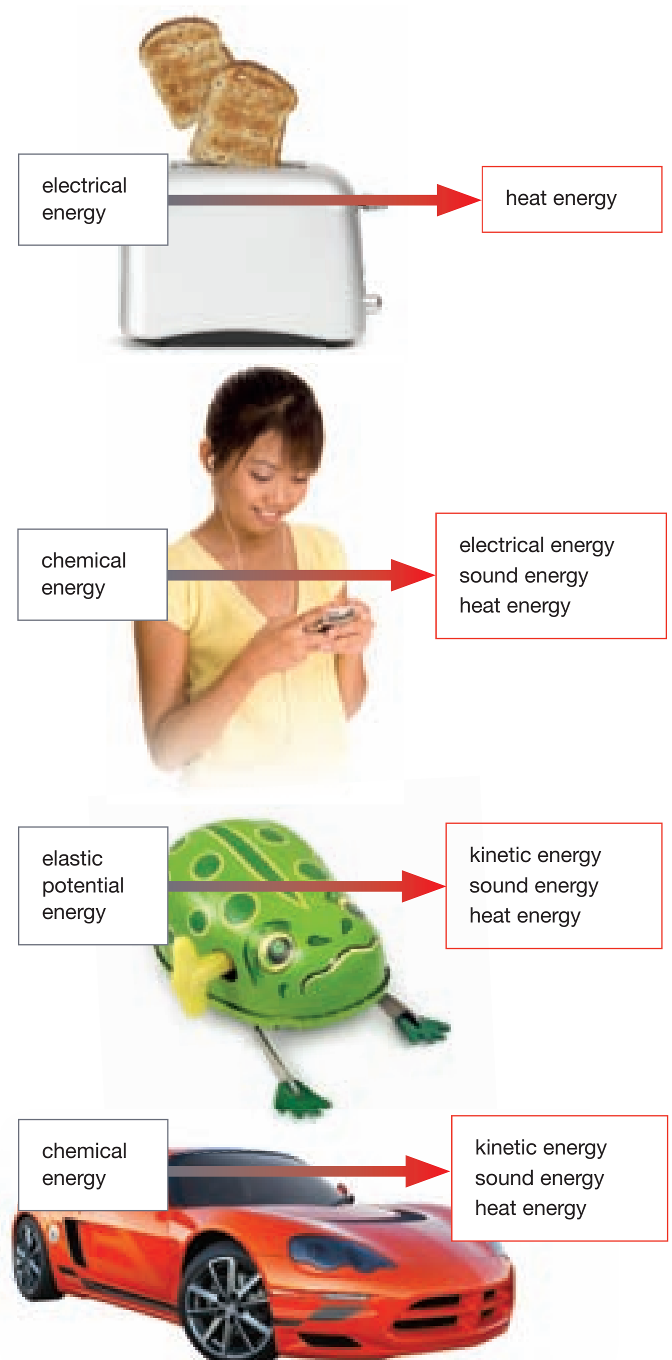
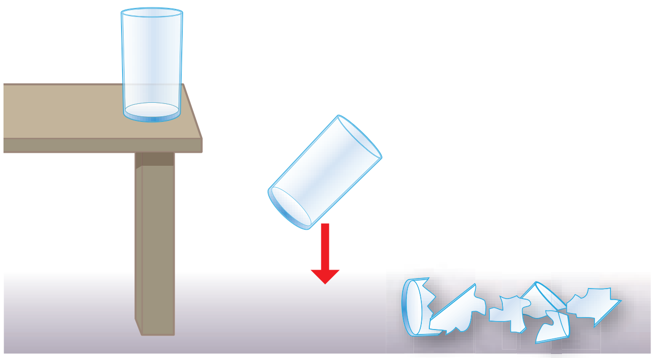


Figure 5.2.2 Energy transformations are shown using an arrow. Here are some energy transformations that occur when using a toaster, an MP3 player, a wind-up toy and a car.

Sometimes a number of different energy changes happen all at once. Imagine that you accidentally knock a glass off a table. The glass falls and smashes on the floor below. The glass initially has gravitational potential energy. When it is falling, this energy is changed into kinetic energy and some heat energy. When it hits the floor, some of the kinetic energy is transferred to the pieces of glass that break and fly off in all directions. Some kinetic energy is converted into sound and heat energy. Figure 5.2.3 describes these changes in a flow diagram.



Glass resting on table has → Glass falls → Glass breaks

gravitational potential energy → kinetic energy + heat → kinetic energy + heat + sound

Figure 5.2.3 There are many energy changes happening when a glass falls off the table.

A solar cell converts light energy into electrical energy. This energy can then be converted into many different types of energy. Figure 5.2.4 shows an energy flow diagram for the energy changes involved in using a solar fan.

The law of conservation of energy

Sometimes it looks as though energy disappears. For example, when you kick a ball, the kinetic energy you give the ball seems to be lost when the ball stops moving. Actually, this kinetic energy has been converted into other forms of energy, such as heat and sound energy.

The **law of conservation of energy** states that energy can never be created or destroyed. It can only be converted from one form to another.

This means that:

- energy might be passed on or wasted, but it is never lost
- if one object wastes energy, then it is always gained by another object, usually as heat.

2 p188

5.2

5.3

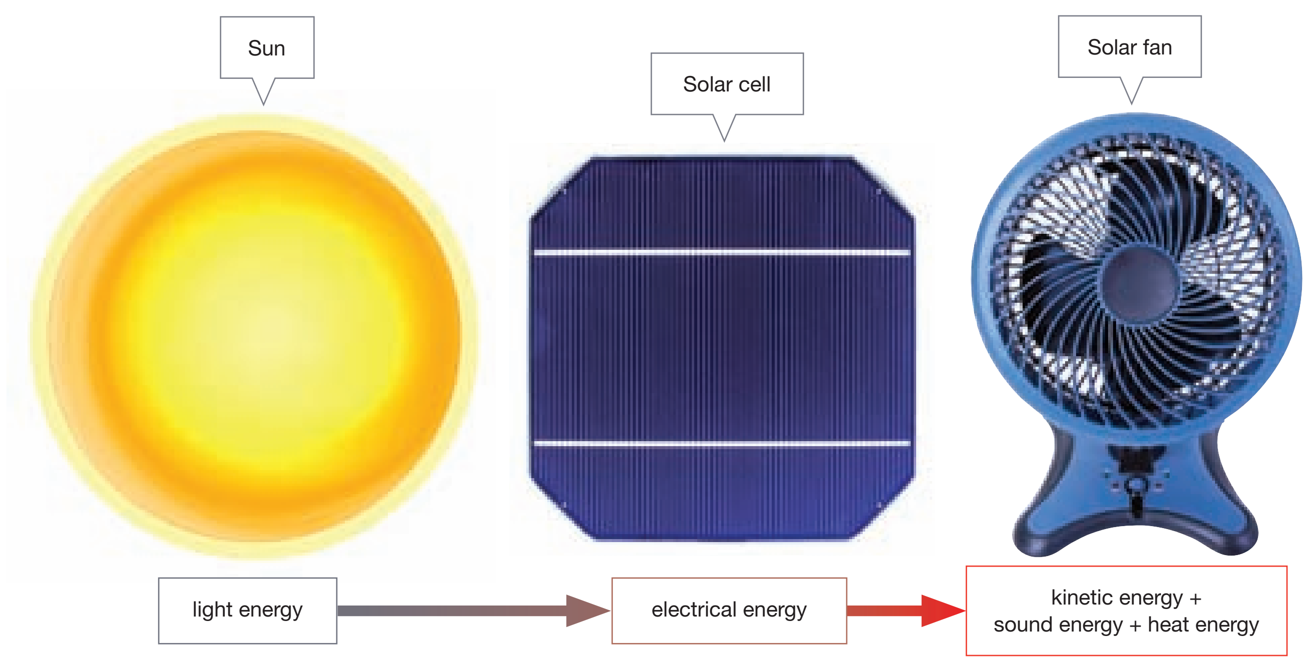


Figure 5.2.4 A solar cell converts light energy from the Sun directly into electrical energy. This electrical energy is converted into the kinetic energy of the blades, as well as sound and heat energy produced by the solar fan.

Useful and wasted energy

Any object that moves, or has moving parts, has kinetic energy. A child pushing a toy car gives the car kinetic energy. When the child stops pushing, the car keeps moving along the ground. However, friction between its wheels and the ground produces heat energy. Eventually, the car will stop moving because all of its kinetic energy has been converted into heat energy. This heat energy is wasted energy. The energy has been transformed into a form that is not useful.

INQUIRY science 4 fun

Hot stuff!

Does friction produce heat?

Yes

Collect this ...

- hose or needle attachment that fits the bike tyre or ball
- bike tyre or inflatable ball
- pump

Do this ...

1 Fit the hose to the bike tyre or the needle into the ball.
2 Pump up the tyre or ball. *Note:* Do not over-inflate balls or tyres or they could explode.
3 Undo the hose or needle attachment.
4 Feel the end of the hose or needle.

Record this ...

Describe what happened.

Explain why you think this happened.

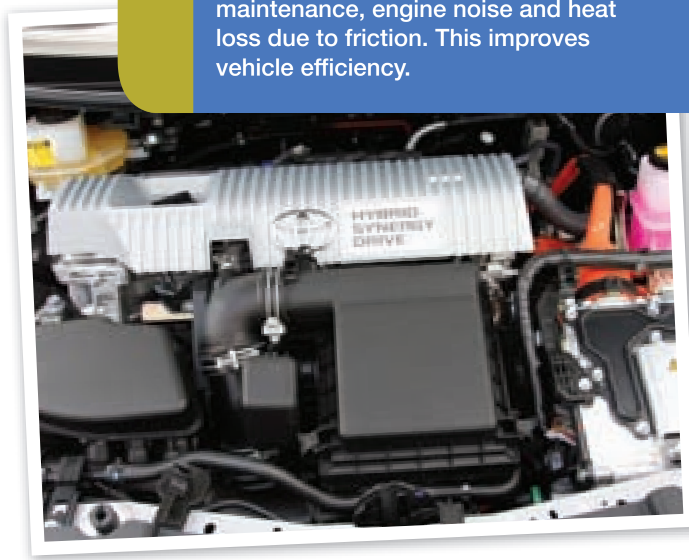
Figure 5.2.5

The useful energy you want from a torch is light energy. The heat released is wasted energy.

SciFile

Beltless

If you have ever looked at a car engine while it is running, you have probably noticed belts used to transfer energy.
For example, a fan belt is used to turn a fan that cools the engine.
Some new cars now rely on electrical systems to replace the use of belts.
A beltless engine reduces car maintenance, engine noise and heat loss due to friction. This improves vehicle efficiency.



Most energy conversions waste some energy, usually releasing it as heat and perhaps some sound. For example, you can feel unwanted heat coming from computers, TVs and light globes. This heat wastes some of the electrical energy used to operate the appliance, making it more expensive to run. Some examples of energy conversion and wasted energy are shown in Table 5.2.1.

Table 5.2.1 Examples of energy conversions

Example	Initial energy	Useful energy produced	Wasted energy
Using an electric toothbrush	Electrical energy	Kinetic energy	Heat and sound energy
Playing cricket	Chemical energy from food digested	Kinetic energy of moving cricket bat and ball	Heat and sound energy
Using an MP3 player	Chemical energy from batteries	Sound and light energy	Heat energy
Using a torch (Figure 5.2.5)	Chemical energy from batteries	Kinetic energy	Heat energy

Energy efficiency

Any device that converts energy, such as a car or a computer, requires some form of energy to make it run. This is its input. Useful energy is its output. As we have seen, unwanted forms of energy are released too, usually as heat. **Energy efficiency** is a measure of how much input energy is converted into useful output energy. The greater proportion of useful output energy, the greater the energy efficiency of the device. If most of the input energy is converted into useful output, then the device is energy efficient. If a lot of the input energy is wasted, then the device is inefficient.

In an electric fan, electrical energy is converted into the kinetic energy of the fan blades, which produces a breeze. If all of the electrical energy was converted into kinetic energy, then the fan would be extremely energy efficient. In reality, an electric fan wastes some of its electrical energy by converting it into sound and heat. This makes it inefficient. Figure 5.2.6 shows one inefficient and one efficient energy conversion.

SciFile

Idle energy

Long-distance truck drivers often keep their truck's engine running during their rest breaks. This keeps the truck's heating, cooling and other features working, but wastes billions of litres of fuel worldwide each year. Auxiliary power units (APUs) reduce these energy losses. These portable, truck-mounted units provide power and climate control without the need to keep the engine running.

Renewable energy

Some energy sources are renewable. This means that they are unlimited in supply and can be used over and over again. Examples are solar energy, wind energy and hydroelectric energy. Most of the electrical energy that supplies Australian households comes from burning fossil fuels, such as coal, oil or natural gas. These fossil fuels were formed over millions of years and are known as non-renewable energy sources. Fossil fuels contain chemical potential energy, which is released when the fuel is burnt. Figure 5.2.7 on page 184 shows that only a small fraction of the original chemical potential energy of a fossil fuel is converted into the useful energy needed to operate devices in our homes. This happens because heat energy is lost at each step of generating and delivering the electricity.

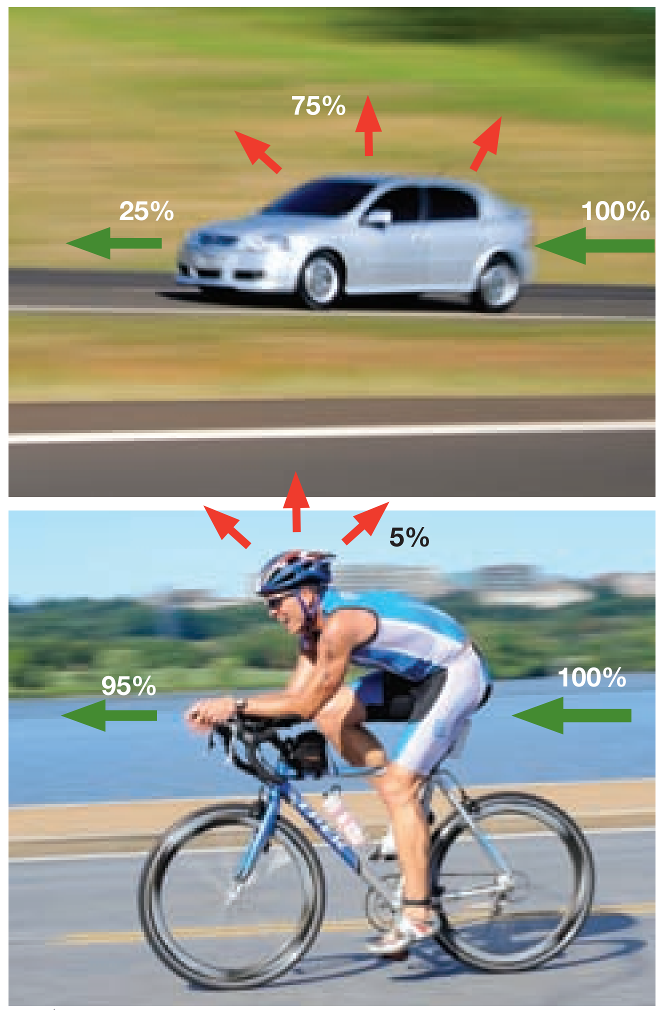


Figure 5.2.6 Only about one-quarter of the chemical energy supplied to a car goes into making it move. In other words, for every 100 J of chemical energy supplied, only 25 J of kinetic energy is produced. In contrast, when riding a bike, up to 95kJ out of every 100kJ of energy that your muscles supply is converted into the kinetic energy of the bike.

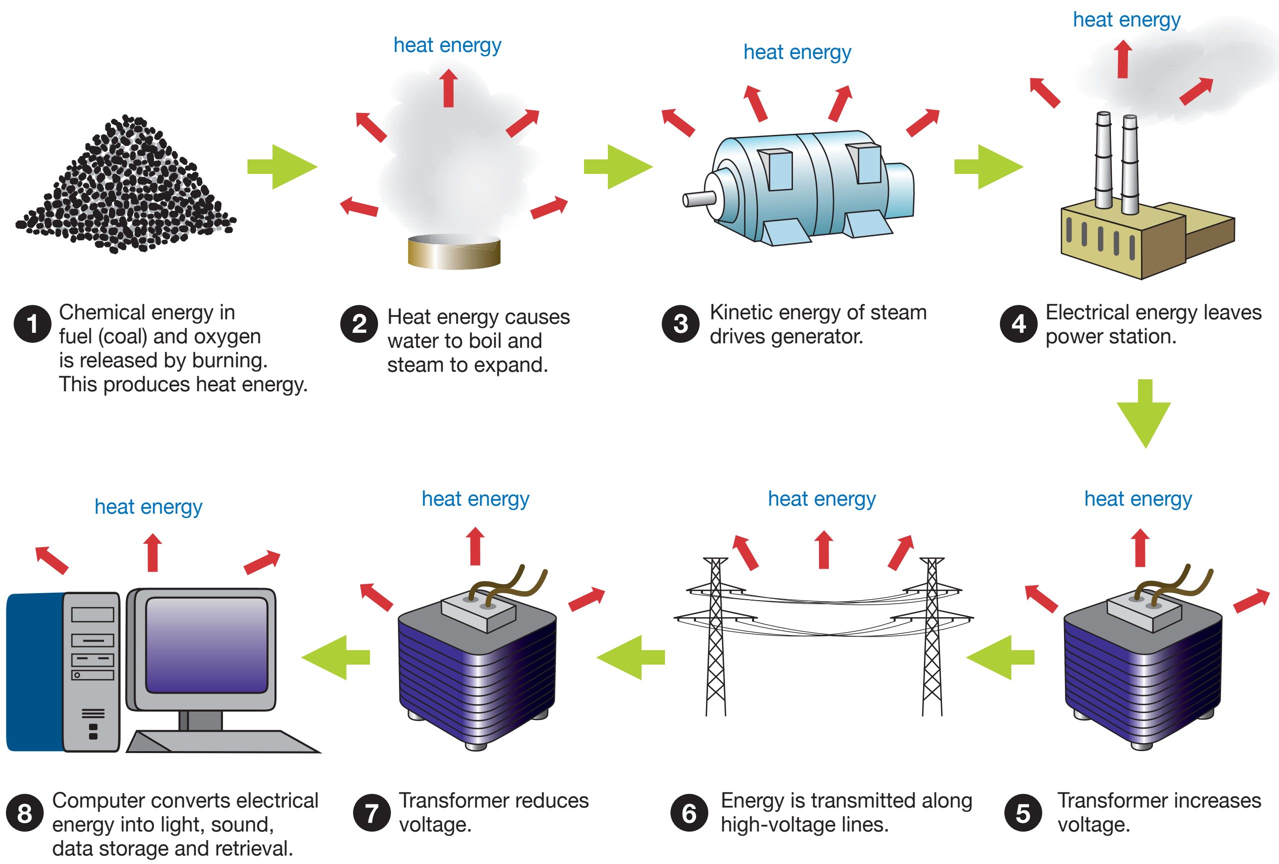


Figure 5.2.7 There are many steps needed to convert the chemical energy of coal into electrical energy for households. Heat energy is produced at each stage of this process. These losses of heat energy reduce the efficiency of the process.

Table 5.2.2 compares the typical percentage energy efficiencies of some energy converters.

Table 5.2.2 Energy efficiencies of some energy converters

Energy converter	Efficiency (%)
Incandescent light globe	5
Electric motor	80
Steam engine	40
Power station	30
Human	25

5.4
3 p189

WORKED EXAMPLE
Energy efficiency

Problem

In 5 minutes, a particular battery-operated remote-controlled car used 1800 J of chemical energy. Of this chemical energy, it converted:

- 450 J into kinetic energy
- 300 J into sound energy
- 1050 J into heat energy.

Given that the useful energy output of this device is kinetic energy, calculate the percentage energy efficiency of the car.

Solution

The useful energy output is the 450 J of kinetic energy and the total energy input is the 1800 J of chemical energy supplied by the battery.

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

$$= \frac{450}{1800} \times 100$$

$$= 25\%$$

This means that 25% of the energy input is converted into a useful form of energy output, so the car is 25% efficient.

5.2 Unit review

Remembering

1 **Recall** two examples of energy transfer.

2 **Name** the type of energy that is produced by a solar cell.

3 Refer to Table 5.2.1 on page 182 and **list** the wasted forms of energy that occur when you:
  a listen to an MP3 player
  b play cricket.

4 Refer to the law of conservation of energy and **state** whether the following statements are true or false.
  a If energy is wasted, then it is lost altogether.
  b If energy is lost from one object, then it will be gained by another.
  c The total amount of energy in the universe is always changing.

5 **Name** the type of energy possessed by fossil fuels.

Understanding

6 a Use an example to **explain** what is meant by the term *energy transformation*.
  b **Describe** the energy transformation(s) that take place when you cook rice in a microwave oven.

7 a **State** the law of conservation of energy.
  b **Explain** what this law means, using an example.

8 **Explain** why any object on Earth that moves will get warmer than if it was not moving.

9 **Define** the term *energy efficiency*.

10 **Describe** how heat losses reduce the efficiency of a device.

11 **Outline** why the process of converting the chemical energy of coal into electrical energy is very inefficient.

Applying

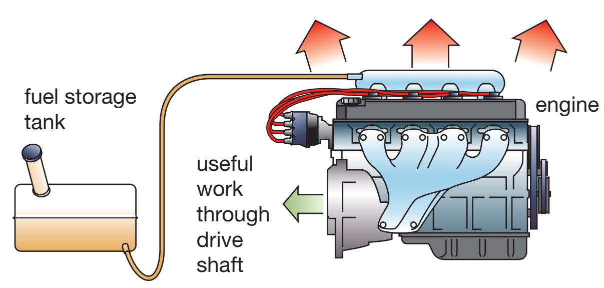


Figure 5.2.8

12 a **Use** the information in Figure 5.2.8 to **rank** the different engines from most to least efficient.
  b If 100 MJ of energy is supplied to a jet turbine, **calculate** the amount of energy that is converted into useful energy required to fly the jet.
  c **Calculate** the percentage of energy that is wasted in a typical petrol engine.

13 You ride a skateboard down the street.
  a **Identify** the source of energy input for this activity.
  b **Identify** the types of energy that are produced.

14 **Use** your knowledge of energy transformations to match the situations a–e below with the appropriate energy transformations i–v.
  a A girl toboggans down a slope.
  b You ride a bike.
  c A wind-up toy car travels across the floor.
  d A boy swims in a pool.
  e Wood burns in a fire.
  i chemical energy → kinetic energy + sound energy + heat energy
  ii gravitational potential energy → kinetic energy + sound energy + heat energy
  iii chemical energy → heat energy + light energy + sound energy
  iv elastic potential energy → kinetic energy + sound energy
  v chemical energy → kinetic energy + sound energy + heat energy

5.2 Unit review

Analysing

15 In 10 minutes, a power saw used 6050 J of electrical energy. It converted:
- 1210 J into kinetic energy
- 1520 J into sound energy
- 3320 J into heat energy.

  a **Identify** useful output energy from the saw.
  b **Calculate** percentage energy efficiency of the saw.

16 An iPod dock is supplied with 2000 J of electrical energy. Of this, 900 J is converted into heat energy, 300 J is converted into kinetic energy of the sound system and the remaining energy is converted into sound. **Calculate** the:
  a number of joules of sound energy produced
  b percentage efficiency of the device for converting electrical energy into sound energy.

17 A car is a very inefficient machine.
  a **List** which forms of wasted energy are produced.
  b Cars would soon overheat if they didn't have a radiator. **Analyse** what the purpose of a radiator is.

18 An apple that falls from the top of an apple tree hits the ground at a greater speed than an apple that falls from near the base of the tree. **Analyse** why this happens.

Creating

19 **Construct** a flow diagram to show the energy changes that happen when you:
  a ring a doorbell
  b light a match
  c fall over.

20 **Use** Figure 5.2.9 to **construct** a flow diagram to show the energy changes that occur when you vacuum the floor using electricity from a wind generator.

Inquiring

1 Materials differ in how well they transfer heat. If heat travels easily through a material it is called a good conductor of heat. If heat is not easily conducted through a material, it is called an insulator. Research which materials are good conductors of heat and which materials are insulators.
  a List three conductors and three insulators.
  b Discuss ways that materials can be used based on how well they transfer heat.

2 A scramjet is a new type of jet engine that is designed to operate at very high speeds. It has no moving parts, which is necessary to avoid losing energy due to friction at high speeds. Research the scramjet and outline four facts about it.

3 **a** Using materials such as rubber bands or hat elastic, craft sticks or pieces of dowel, construct a model bungee. Securely fix a weighted bungee-jumper to your bungee and examine changes in speed and motion as the bungee operates.
  b Construct a flow diagram to describe the energy transformations that occur during a bungee jump.
  c Propose reason why the bungee will eventually come to a stop.

4 Does a ball bounce higher if it is warmer? Investigate, using a ball and a hair dryer.

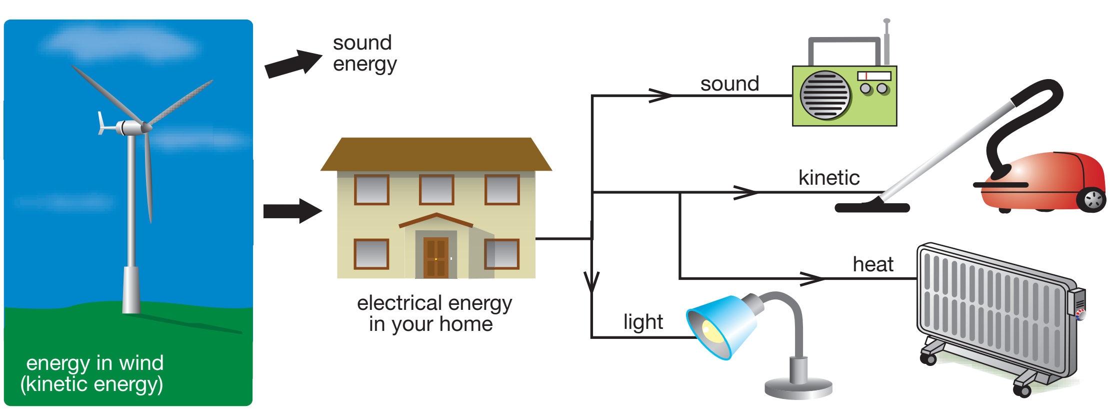


Figure 5.2.9

5.2 Practical activities

1 Investigating heat

Heat can be transferred in a number of different ways. If two substances are in contact, then the heat of one substance can be transferred to the second substance through a process called conduction. Some materials are better conductors than others.

Purpose

To compare how effectively different substances conduct heat.

Materials

- supply of hot water
- polystyrene cup
- metallic mug
- ceramic coffee mug
- thermometer or temperature probe and data logger

SAFETY
Handle hot liquids with care.

Procedure

1 Copy the results table below into your workbook.

2 Carefully pour 100 mL of hot water into each cup or mug. Make sure that the water poured into each is at the same temperature.

3 Place a temperature probe or thermometer into each cup or mug.

4 Record the starting temperature using the data logger or thermometer and take measurements for 10 minutes.

Results

Construct a line graph showing the temperature of the water in the cup and mugs over the 10 minutes.

Discussion

1 To be a fair scientific test, the three containers used in this experiment should be the same thickness and have the same diameter opening at the top. **Explain** why these factors are important.

2 Based on your results, **identify** the material that was the:
   a best conductor of heat
   b worst conductor of heat.

3 A pool blanket is used to trap heat within a swimming pool. **Propose** whether the blanket should be made from material that is a good or a poor conductor of heat.

Time (minutes)	Temperature of water in		
	Polystyrene cup (°C)	Metallic mug (°C)	Ceramic coffee mug (°C)
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

2 Energy changes

Purpose

To observe and identify different energy changes.

Materials

Part A

- alligator clips
- light globe
- 6 V battery

Part B

- steel wool
- bench mat
- alligator clips
- 6 V battery and switch

Part C

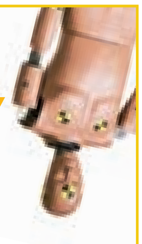
- tuning fork
- rubber stopper
- beaker of water

Part D

- 200 g mass
- modelling clay

Part E

- rubber band
- polystyrene ball



SAFETY

Wear safety glasses for these tasks.

In part B, do not leave the switch closed as the steel wool could catch fire.

In part E, do not flick polystyrene balls near people.

Procedure

Copy the results table into your workbook. As you complete each task, fill in your observations in this table.

Part A

1. Use two alligator clips to connect a light globe to a battery or power pack as shown in Figure 5.2.10.

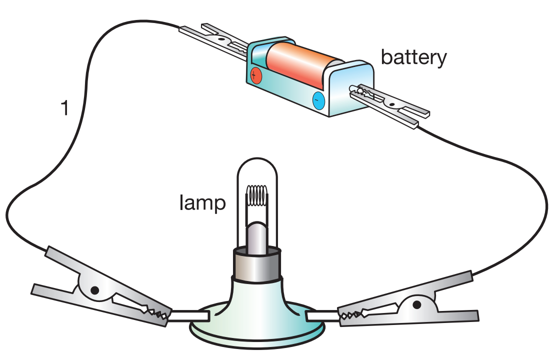


Figure 5.2.10

Part B

2. Place the strands of steel wool on a bench mat. Use alligator clips to connect these to a battery and a switch as shown in Figure 5.2.11. Close the switch for a few seconds and watch the steel wool.

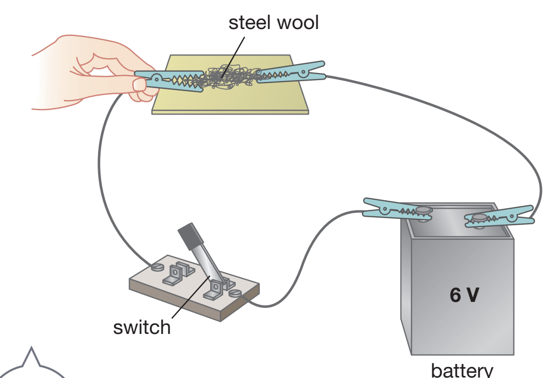


Figure 5.2.11

Part C

3. Strike a tuning fork on a rubber stopper. Put the ends of the tuning fork into a beaker of water.

Part D

4. Drop the 200 g mass onto a lump of modelling clay from a height of about 30 cm.

Part E

5. Place the polystyrene ball on the bench. See if you can make the ball roll along the bench using a stretched rubber band. Figure 5.2.12 shows the method.

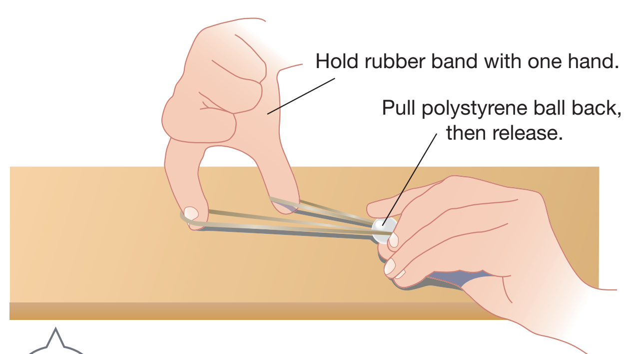


Figure 5.2.12

Results

1. Copy the table below into your workbook. Use it to record your observations.
2. Next to the observations recorded in your results, list the source of energy in each case, and any forms of energy produced.

Discussion

1. **Discuss** whether there were any situations in which energy was transferred but not transformed into a different form.
2. **Name** two devices that you have used today. **State** the energy changes that occurred in these devices.

Prac	Situation	Observations	Energy supplied	Energy produced
Part A	Connecting a light globe to a battery			
Part B	Connecting steel wool to a battery			
Part C	Striking a tuning fork and dipping its ends into water			
Part D	Dropping a 200 g mass onto a lump of modelling clay			
Part E	Propelling a polystyrene ball using a rubber band			

3 Investigating the efficiency of bouncing balls

Purpose

To calculate and compare the efficiency of bouncing balls.

Materials

- different types of balls
- equipment to measure the height of a bounce (such as a video camera or metre ruler)

Procedure

When a ball is dropped from a height, its gravitational potential energy is converted to kinetic energy and heat. As the ball rebounds from the floor, some of its kinetic energy is converted back into gravitational potential energy. This process continues until all of the initial gravitational potential energy has been converted into other forms of energy. The efficiency of the first bounce of the ball can be calculated as:

$$\text{Efficiency} = \frac{\text{rebound height of first bounce}}{\text{initial height above ground}} \times 100\%$$

Design an experiment to calculate the percentage efficiency of the first bounce of a range of different types of balls. Use apparatus such as a video camera and metre ruler to assist you in measuring the rebound height.

Results

1. Compare the efficiency of the different balls in your sample.
2. Summarise your aim, materials, procedure, results and discussion in a report.

Discussion

1. **Propose** ways to improve your experiment design.
2. **Propose** reasons why the balls varied in efficiency.