●●●○○ Level 3 · Science S3.8

Energy stores and transfers

Energy is stored in food, fuel and moving things, and it moves from one store to another.

Name the places energy is kept, follow it as it moves, see why some always spreads out as waste heat, tell heat from temperature, find how heat travels and how to slow it, read food energy in kilojoules, and sort fuels into renewable and not.

YOU ARE READY FOR THIS BOOK IF

You can name three things at home that get hot when they are used.

One step up	S4.9 Energy, work and power
This book	**S3.8 Energy stores and transfers**
One step down	S2.7 Sound

Contents

S3.8.1 Energy stores

S3.8.2 Energy transfers

S3.8.3 Energy is never used up

S3.8.4 Heat and temperature

S3.8.5 How heat travels

S3.8.6 Keeping warm and cool

S3.8.7 Energy from food

S3.8.8 Fuels and energy resources

Key words, A to Z

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S3.8.1 CHAPTER 1

Energy stores

Is there energy in a banana?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Yes. Energy is kept in the banana, ready for you to use.
- ☐ **B** No. Only moving things have energy.
- ☐ **C** No. Only batteries have energy.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Bones, muscles, teeth and food, S2.3.5. Food gives your body energy.

BY THE END YOU CAN

- Name energy stores, such as chemical, kinetic, elastic and thermal
- Give an example of each store from daily life

Amina eats a banana. A little later she runs to the well and back. She is not tired at all. Where did her running come from?

Energy is what makes things happen. It makes things move, get hot, shine and make a sound. Nothing happens without it.

Energy is kept in places we call **stores**. A store is not a box. It is a way a thing holds energy, ready to use. We measure energy in joules, J. The next chapter uses them.

DRAW IT FIRST

Draw three energy stores

chemical



wax

1 Draw a candle. The wax is a **chemical store**. Energy waits in it until the candle burns.

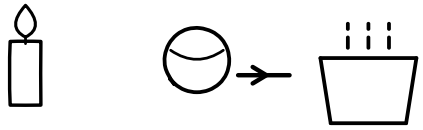
chemical **kinetic**



wax moving ball

2 Draw a ball with an arrow. A moving thing has energy in its **kinetic store**.

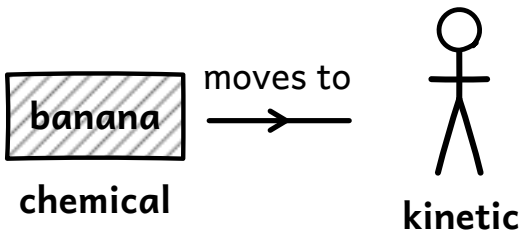
chemical **kinetic** **thermal**



wax moving ball hot tea

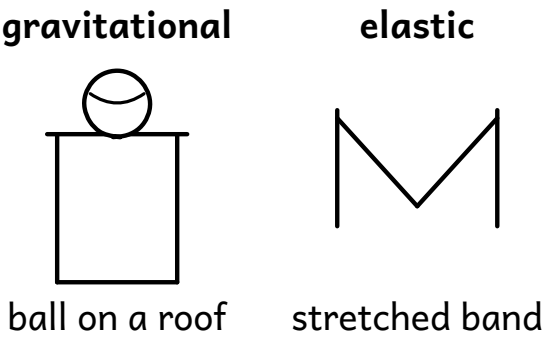
3 Draw a cup with steam. Hot things have energy in their thermal store.

Food and fuel are chemical stores. So are the wax of a candle, a battery and a bag of rice. They hold energy until something changes them.



The energy for Amina's run was in the banana. Her body moved it from a chemical store to a kinetic store.

A ball that is up on a roof has energy too, because it can fall. This is its **gravitational store**. A stretched rubber band has energy because it can spring back. This is its **elastic store**.



Neither thing is moving. Each holds energy, because of where it is or how it is stretched.

One more store is the thermal store. A hot thing holds energy in it. The hotter the thing is, the more it holds.

Light and sound are not stores. They are ways that energy moves from place to place. You will see this in the next chapter.

SEE IT THREE WAYS

As a picture

store	example
chemical	food, fuel
kinetic	rolling ball
gravitational	raised stone
elastic	rubber band
thermal	hot water

In words

Every store has a name from what it is. Food and fuel hold chemical energy. Moving things hold kinetic energy. Raised things hold gravitational energy. Stretched things hold elastic energy. Hot things hold thermal energy.

TRY IT

Hunt for stores at home

You need: paper and a pencil, a walk round your home or yard.

Be safe: Look, do not touch, anything hot. Keep away from fires, stoves and hot pots.

1. Draw a table with two columns: "what I found" and "store".
2. Look for something that holds a chemical store. Write it in the table.
3. Find a moving thing, a raised thing, a stretched thing and a hot thing. Add each one to the table.
4. Write the name of the store next to each thing.

What you will see: Most homes have all five stores. Most of them do not look like they hold energy, because they sit still. Your list will be different from ours.

If you cannot try it, this is what happens.

what I found	store
bag of rice	chemical
cart rolling	kinetic
pot on shelf	gravitational
rubber band	elastic
hot tea	thermal

A WRONG IDEA MANY PEOPLE HAVE

~~A thing that is not moving has no energy.~~

Why it feels right: We see energy when something moves or burns, so a still thing seems to have none.

The test that breaks it: Hold a stone high over soft sand, then let go. It lands with a thud. Before you let go, it held energy in its gravitational store.

What is true: Stored energy cannot be seen. A still thing can hold a lot, such as food, a raised stone or a stretched band.

KEY WORDS

energy
what makes things move, heat up, shine and make sounds.

stores
a way a thing holds energy, ready to use.

chemical store
energy kept in food, fuel and batteries.

kinetic store
energy of a moving thing.

gravitational store
energy of a thing held up high.

elastic store
energy of a stretched or squashed thing.

BACK TO YOUR GUESS

The answer is A: Yes. Energy is kept in the banana, ready for you to use.

Yes. Food keeps energy in it, in a store. Your body takes that energy out when you move, grow and stay warm. Things that are not moving can still hold energy.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Which store holds the energy in a lump of coal that is not burning?

   A Kinetic store

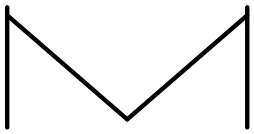
   B Chemical store

   C Thermal store

   D Elastic store

   Answer at the back of the book.

2. Ravi pulls back a rubber band. Which store has the energy?



stretched band

   A Gravitational store

   B Kinetic store

   C Elastic store

   Answer at the back of the book.

3. Which of these hold energy mainly in a chemical store?

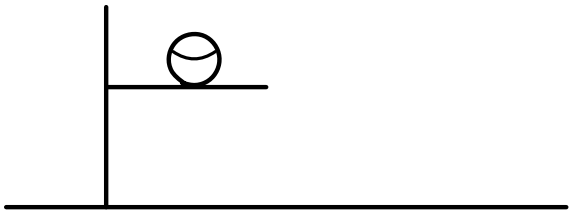
   A A bag of beans

   B A cup of hot tea

   C A ball rolling along the ground

   Answer at the back of the book.

4. A stone sits on a high shelf. Which store has the energy?



stone on a shelf

A Kinetic store

B Gravitational store

C Chemical store

Answer at the back of the book.

5. Tariq eats rice and then runs. In which stores is the energy, first and then later?

A Kinetic store first, then chemical store

B Thermal store first, then elastic store

C Gravitational store first, then thermal store

D Chemical store first, then kinetic store

Answer at the back of the book.

6. Which of these holds energy, even though it is not moving?



hot soup

A Nothing: still things hold no energy

B Only the steam, because it moves

C The hot soup, in its thermal store

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Energy is kept in stores: chemical (food, fuel), kinetic (moving), gravitational (raised), elastic (stretched) and thermal (hot). A still thing can hold energy.

Draw: A banana, an arrow, and a runner. Write chemical under the banana and kinetic under the runner.

S3.8.2 CHAPTER 2

Energy transfers

When a candle burns, where does its energy go?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** It moves out into the air and the room, as warmth and light.
- ☐ **B** It is used up, and then it is gone.
- ☐ **C** It stays inside the candle.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Energy stores and transfers, S3.8.1. You need the names of the stores.
- Level 2, Light and shadows, S2.6.1. A candle gives out light.

BY THE END YOU CAN

- Describe how energy moves when a candle burns or a ball falls
- Draw an energy transfer diagram

Light a candle and watch it. The wax slowly gets shorter. The flame gives light and warmth. The energy that was in the wax has gone somewhere. Where?

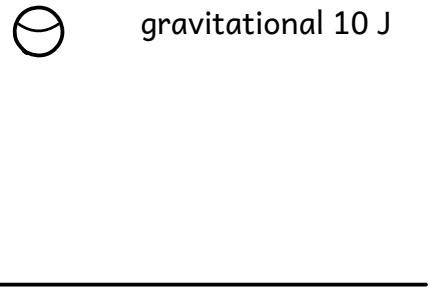
When energy moves from one store to another, we call it an **energy transfer**. Things happen when energy moves. A ball falls. A candle shines.

We count energy in **joules**, J. Lifting a small apple up one metre moves about 1 J into its gravitational store. A candle gives out about 80 J every second.

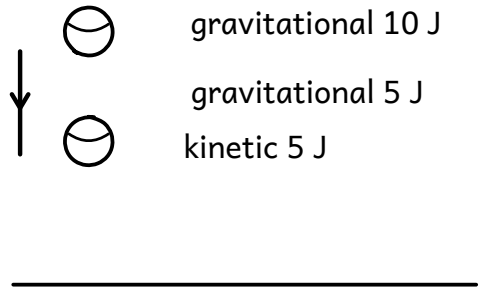
Energy moves in different ways. A force moves it when something pushes, pulls or falls. Heating moves it from hot to cool things. Light, sound and an electric current also move it.

DRAW IT FIRST

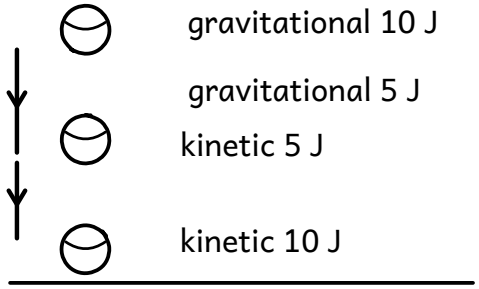
Draw *a* ball falling



1 Draw *a* ball held high. All its energy is in its gravitational store: 10 J.



2 Let it fall. Halfway down, 5 J has moved into its kinetic store. 5 J is still in the gravitational store.

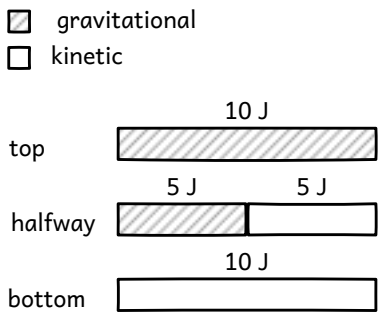


3 Just before it lands, all 10 J is in the kinetic store. The total has stayed at 10 J.

The ball moved its energy **<u>by *a* force</u>**. The pull of gravity is *a* force. It pulled the ball down and moved the energy from one store to the other.

SEE IT THREE WAYS

As a picture



In words

Each bar is the same length. The energy is shared between two stores. As one store gets smaller, the other gets bigger by the same amount.

In symbols

At the top: 10 J + 0 J. Halfway: 5 J + 5 J. At the bottom: 0 J + 10 J. The total is always 10 J.

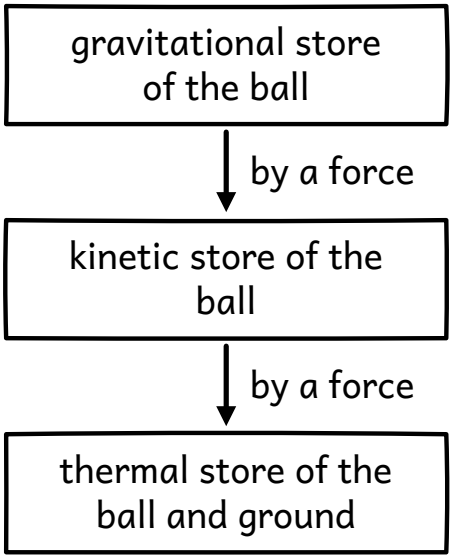
WORKED EXAMPLE

A ball has 10 J in its gravitational store when it is held high. Halfway down, 5 J is still in that store. How much energy is in its kinetic store?

1. The total stays 10 J.
2. The gravitational store holds 5 J.
3. The kinetic store holds the rest: 10 − 5 = 5 J.

Answer: 5 J

Now the ball lands. The ball and the ground squash a little, and they get a tiny bit warmer. So some energy moves to the thermal store of the ball and the ground. A tiny part, far less than 1 J, goes out as sound, which you hear as a thud. A ball that bounces keeps the rest in its kinetic store.



This is a **transfer diagram**: stores in boxes, and the way the energy moves on each arrow.

WORKED EXAMPLE

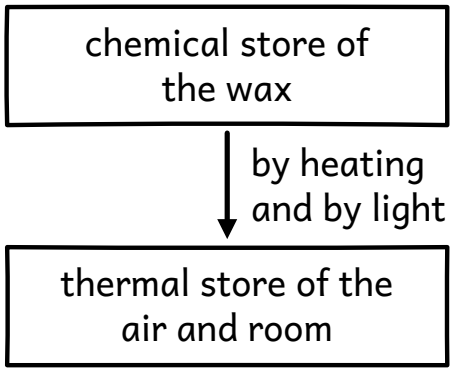
A ball has 20 J in its kinetic store just before it lands. It bounces up with 12 J in its kinetic store. How much went into the thermal store of the ball and ground?

1. The total stays 20 J.
2. 12 J is back in the kinetic store.
3. The thermal store took the rest: 20 - 12 = 8 J.
4. Check: 12 + 8 = 20 J. That is the total again.

Answer: 8 J

where	joules
kinetic, before	20 J
kinetic, bounce	12 J
thermal, after	8 J

The numbers for the second worked example.



A burning candle moves energy out of the wax. The room gets a little warmer.

The words **by heating** mean energy moves from a hotter thing to a cooler one. The flame is hot, so energy moves into the cooler air around it.

TRY IT

Feel a candle's energy leave

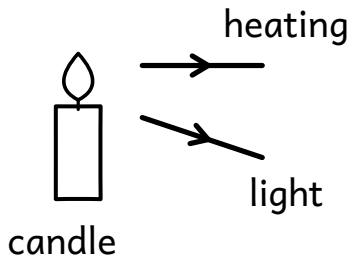
You need: a candle in a dish, matches, used only by an adult, a room with no draught.

Be safe: An adult lights and blows out the candle and stays close. Tie back long hair. Keep cloth and paper away from the flame. Never hold a hand above it.

1. Ask an adult to light the candle on a flat table and to stay with you.
2. Hold your hand beside the flame, about 20 cm away. Keep your palm facing the flame.
3. Notice the warmth on your palm. Move your hand away and notice it fade.
4. Look at the wall or table near the candle. See the light on it.
5. Ask the adult to blow the candle out.

What you will see: You feel warmth and you see light. Both are energy leaving the wax. Hold your hand beside the flame, never above it. Hot air rises there.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~A falling ball makes new energy as it speeds up.~~

Why it feels right: A falling ball goes faster and faster, so it looks as though it is gaining energy.

The test that breaks it: Look at the bars. At the top the ball has 10 J. Halfway it has 5 J + 5 J. At the bottom it has 10 J. The total never grew.

What is true: The ball does not gain energy. Energy moves from the gravitational store into the kinetic store.

KEY WORDS

energy transfer
energy moving from one store to another.

joules
the units we count energy in. We write J.

by a force
a way energy moves, when things push, pull or fall.

by heating
a way energy moves, from a hotter thing to a cooler one.

transfer diagram
boxes for stores, with arrows for the way energy moves.

BACK TO YOUR GUESS

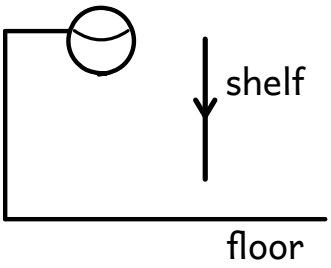
The answer is A: It moves out into the air and the room, as warmth and light.

The energy in the wax moves out of its chemical store. It goes into the air and the room, as warmth and as light. It does not disappear.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. A ball falls from a shelf to the floor. What happens to its stores while it falls?



A Its kinetic store gets smaller and its gravitational store gets bigger.

B Its gravitational store gets smaller and its kinetic store gets bigger.

C Both stores get bigger, because the ball speeds up.

Answer at the back of the book.

2. A candle burns. Where does energy move from, and to?

A From the air and room into the wax.

B Nowhere. The flame makes energy from nothing.

C From the kinetic store of the flame to the wax.

D From the chemical store of the wax to the thermal store of the air and room.

Answer at the back of the book.

3. A ball has 20 J in all. Partway down a fall, 8 J is in its gravitational store. How much is in its kinetic store?

A 28 J

B 8 J

C 12 J

D 20 J

Answer at the back of the book.

4. Mei draws a transfer diagram for a falling ball. It goes from the gravitational store to the kinetic store. What should she write on the arrow?

   A By light

   B By heating

   C By sound

   D By a force

   Answer at the back of the book.

5. Which of these is a way that energy moves, and not a store?

   A Light

   B Chemical

   C Kinetic

   D Elastic

   Answer at the back of the book.

6. **From an earlier chapter**

   Review: which of these holds energy in a chemical store?

   A A cart rolling along

   B A tank of cooking gas

   C A stretched band

   D A cup of hot tea

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Energy moves from one store to another. A falling ball moves energy from the gravitational store to the kinetic store, by a force. The total stays the same.

Draw: Three boxes joined by arrows: gravitational store, kinetic store, thermal store. Write the way on each arrow.

S3.8.3 CHAPTER 3

Energy is never used up

A bicycle rolls to a stop. Where did its energy go?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** It is used up and gone for ever.
- ☐ **B** It goes back into the rider.
- ☐ **C** It spreads out into the ground, the tyres and the air, as a little warmth.

IF THIS FEELS HARD, READ THIS FIRST

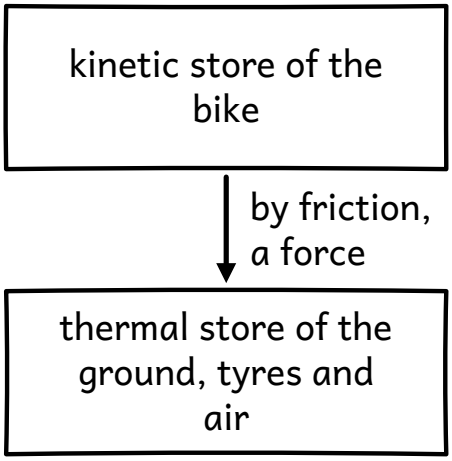
- Level 3, Energy stores and transfers, S3.8.2. You need energy transfers and joules.
- Level 2, Forces: friction, falling and floating, S2.5.3. Friction is what slows the bicycle.

BY THE END YOU CAN

- Explain that energy is not made or destroyed, only moved
- Explain why some energy always ends up as wasted heat

Kofi rides along a flat road and stops pedalling. The bicycle slows down and stops. Its kinetic store is empty. Has the energy gone?

Here is one of the biggest ideas in science. Energy is never made. Energy is never destroyed. It only moves from one store to another.

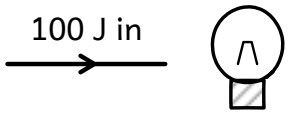


The bicycle stops, but its energy has only moved. The ground, tyres and air are a little warmer.

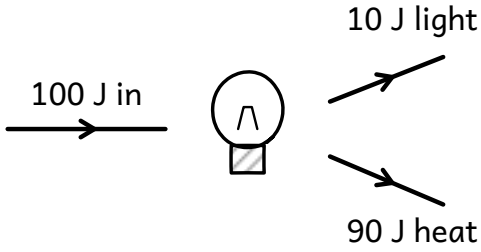
Every time energy moves, some of it spreads out into the **surroundings**. These are the air, the ground and everything else nearby. The surroundings get a little warmer.

DRAW IT FIRST

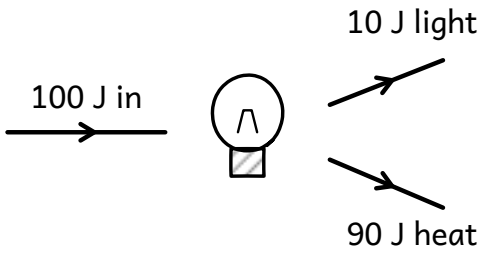
Draw where *a* bulb's energy goes



1 A small torch bulb takes in 100 J from its cell. Draw an arrow going in.



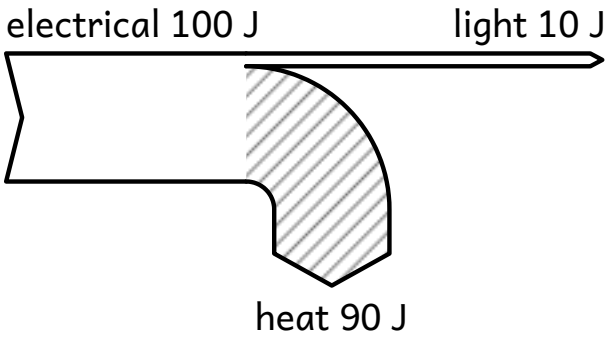
2 Draw two arrows going out. 10 J leaves as light. 90 J leaves as heat.



10 J + 90 J = 100 J

3 Add up the energy coming out: 10 + 90 = 100 J. It is the same as the energy that went in.

We want light from *a* bulb. The light is its **useful energy**. The heat is **wasted energy**. Wasted does not mean destroyed. It means the energy went where we cannot use it.



An **energy flow diagram**. Each arrow is as wide as its joules. The two arrows out are together as wide as the arrow in.

The wasted heat warms the air a tiny bit. It spreads out so thin that we cannot use it again. It is still there. It is wasted, not used up.

SEE IT THREE WAYS

As a picture

item	in	useful	wasted
bulb	100 J	10 J	90 J
toy	50 J	30 J	20 J
body	100 J	25 J	75 J

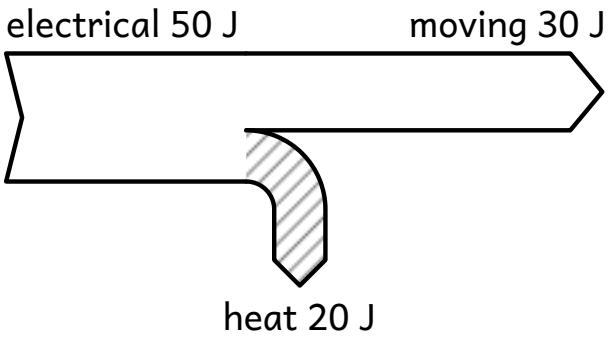
In words

For every thing, the useful energy and the wasted energy add up to the energy that went in. None of it is lost. The body moves less than it takes in, and the rest warms you.

In symbols

energy in = useful out + wasted out. For the bulb: 100 J = 10 J + 90 J.

We can say how good a thing is at its job. This is its **efficiency**. Efficiency = useful energy out ÷ energy in × 100. We write it as a percentage, %.



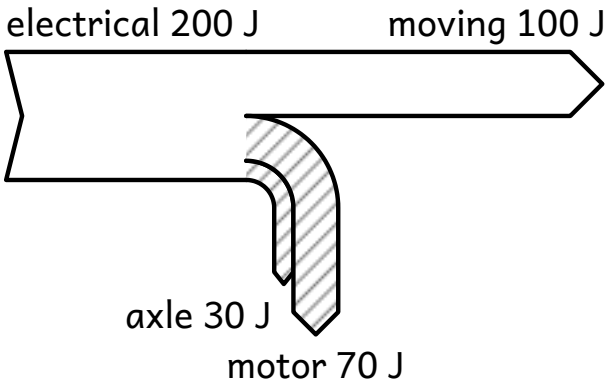
A toy motor with a small cell. The numbers for the first worked example.

WORKED EXAMPLE

A toy motor takes in 50 J. 30 J moves the toy. The rest warms the motor and the air. How much is wasted, and what is the efficiency?

1. Wasted energy = energy in − useful energy.
2. Wasted = 50 − 30 = 20 J.
3. Efficiency = useful ÷ in × 100.
4. Efficiency = 30 ÷ 50 × 100 = 60%.

Answer: 20 J wasted, efficiency 60%



A fan. It wastes energy in two places, in the motor and at the axle. It also hums, but far less than 1 J leaves as sound.

WORKED EXAMPLE

A fan takes in 200 J. 100 J turns the blades. 70 J warms the motor. The rest warms the axle by friction. What is its efficiency?

1. Useful energy out = 100 J.
2. Axle = 200 − 100 − 70 = 30 J.
3. Wasted = 70 + 30 = 100 J.
4. Efficiency = 100 ÷ 200 × 100 = 50%.
5. Check: 100 + 100 = 200 J, the same as the energy in.

Answer: 50%

TRY IT

Rub your hands

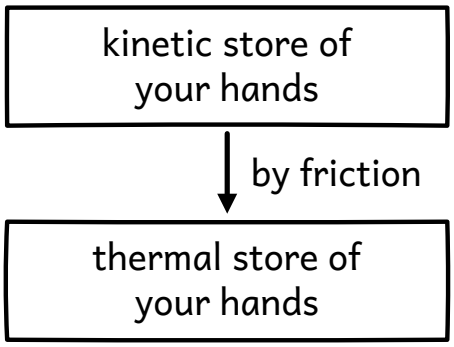
You need: your two hands.

Be safe: Rub gently enough that your skin does not hurt.

1. Hold your palms against your cheeks. Notice how warm they feel.
2. Rub your palms together fast for 15 seconds.
3. Press your palms to your cheeks again. Notice the difference.

What you will see: Your hands are warmer. Your moving hands had energy in a kinetic store. Friction moved it into a thermal store. The energy did not vanish.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~Wasted energy is destroyed.~~

Why it feels right: We cannot use it or find it again, so it seems to have gone.

The test that breaks it: Look at the bulb. 100 J goes in. 10 J is light and 90 J is heat. Add them up and you get 100 J. Nothing is missing.

What is true: Wasted energy is still there. It has spread into the surroundings and warmed them a tiny bit. It is too thin to use.

KEY WORDS

surroundings
the air, the ground and everything else near a thing.

useful energy
the energy that does the job we want.

wasted energy
energy that spreads into the surroundings, mostly as heat.

efficiency
useful energy out ÷ energy in × 100, as a percentage.

energy flow diagram
a picture where each arrow is as wide as its joules.

BACK TO YOUR GUESS

The answer is C: It spreads out into the ground, the tyres and the air, as a little warmth.

The energy did not vanish. Friction moved it into the thermal store of the ground, the tyres and the air. They got a tiny bit warmer, too little to feel.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. A ball rolls along the ground and stops. What has happened to its energy?

    A It has moved to the thermal store of the ball, the ground and the air.

    B It has been used up and destroyed.

    C It has moved to the gravitational store of the ball.

    Answer at the back of the book.

2. A small lamp takes in 60 J. It gives out 6 J as light. How much energy is wasted as heat?

    A 66 J

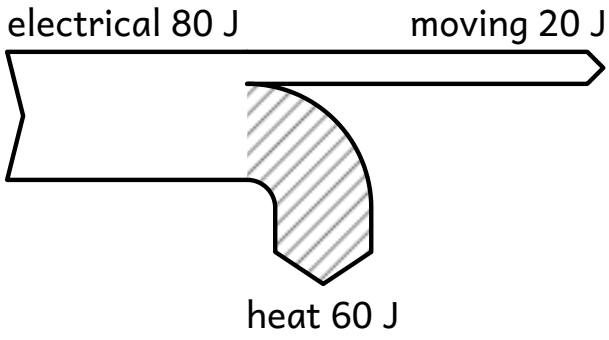
    B 6 J

    C 10 J

    D 54 J

    Answer at the back of the book.

3. A motor takes in 80 J and gives 20 J of useful energy. What is its efficiency?



    A 75%

    B 25%

    C 4%

    D 60%

    Answer at the back of the book.

4. Why can we not use the wasted heat from a bulb to light the bulb again?

   A The wasted energy has been destroyed.

   B It goes back into the cell by itself, so there is no need.

   C It has spread into the surroundings and is too thin to use.

   Answer at the back of the book.

5. A gadget takes in 150 J. Which pair of outputs is possible, if 40 J is useful?

   A 40 J useful and 110 J wasted

   B 40 J useful and 120 J wasted

   C 40 J useful and 80 J wasted

   Answer at the back of the book.

6. **From an earlier chapter**

   Review: a 40 J ball is partway down a fall. 30 J is still in its gravitational store. How much is in its kinetic store?

   A 70 J

   B 10 J

   C 30 J

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Energy is never made or destroyed. In every transfer some spreads into the surroundings as wasted heat. Efficiency = useful out ÷ energy in × 100.

Draw: A bulb with 100 J in, 10 J light and 90 J heat. Write 10 + 90 = 100.

S3.8.4 CHAPTER 4

Heat and temperature

Which holds more energy, a cup of boiling water or a bath of warm water?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** The cup, because boiling water is hotter.
- ☐ **B** They hold the same, because both are hot.
- ☐ **C** The bath, because there is so much more water.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Tables and charts, M2.7.6. You read a graph of temperature against time.
- Level 3, Energy stores and transfers, S3.8.2. Heating is one way energy moves.

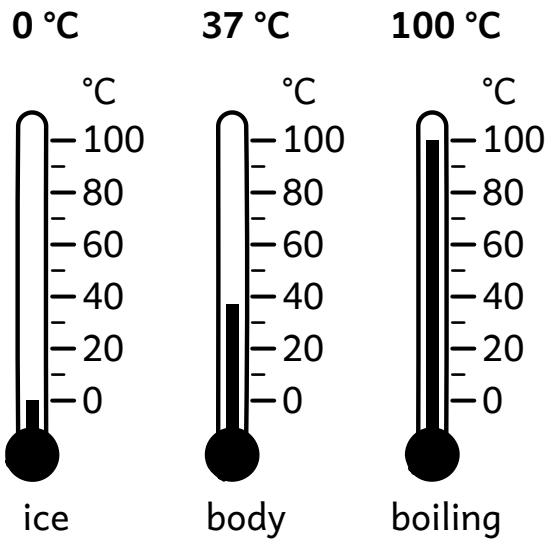
BY THE END YOU CAN

- Explain the difference between heat and temperature
- Read a thermometer and record temperatures in degrees Celsius

Amina touches a cup of hot tea and pulls her hand away. Then she steps into a bath that only feels warm. Which one holds more energy?

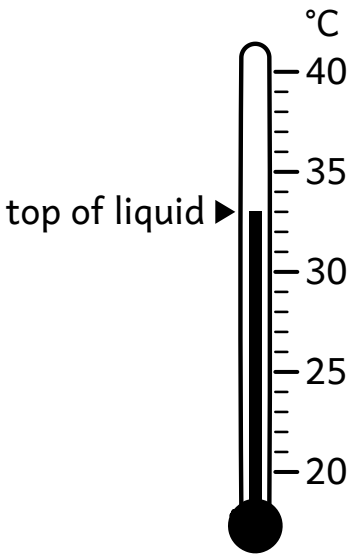
Temperature tells you how hot something is. We measure it in degrees Celsius, written °C. A **thermometer** is the tool that measures it.

Water freezes at 0 °C. Water boils at 100 °C at sea level. High on a mountain it boils at a lower temperature. A healthy body is about 37 °C.



Ice water, a healthy body and boiling water, on a scale from 0 to 100 °C.

To read a thermometer, look at the top of the liquid. Find the nearest number below it. Then count the small marks up from that number.

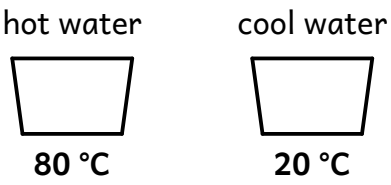


The liquid is 3 marks above 30. Mei's tea is 33 °C. Always write the unit: 33 °C.

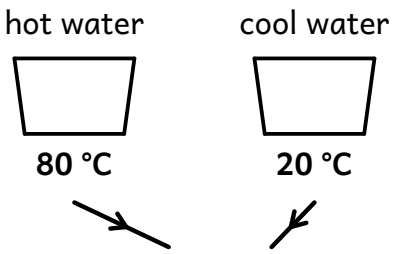
Heat is energy moving from a hotter thing to a cooler thing. It always moves that way. It stops when both are at the same temperature.

DRAW IT FIRST

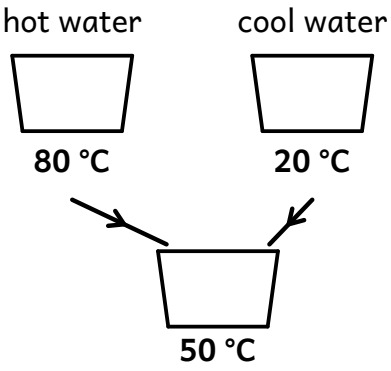
Draw hot and cool water mixing



1 Draw a cup of hot water at 80 °C and a cup of cool water at 20 °C. Use the same amount in each.

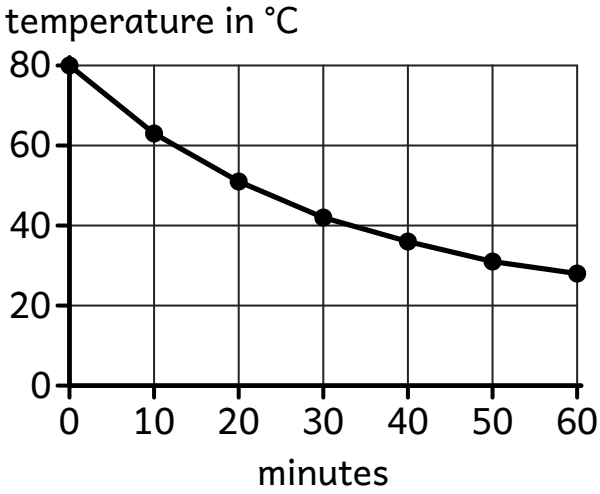


2 Pour them together. Energy moves from the hot water to the cool water.



3 They end at one temperature, about halfway between: about 50 °C. Heat stopped moving.

The energy in a thermal store depends on two things. One is the temperature. The other is how much of the stuff there is. **Thermal energy** is the energy in a thermal store.



Tea cooling in a room at 20 °C. Heat moves out of the tea until it is as cool as the room.

WORKED EXAMPLE

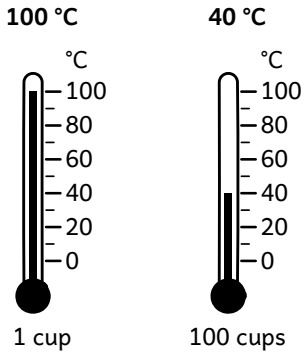
Use the graph. How many degrees did the tea cool in the first 10 minutes? How many in the next 10?

1. At 0 minutes the tea is 80 °C. At 10 minutes it is 63 °C.
2. First 10 minutes: 80 – 63 = 17 °C.
3. At 20 minutes it is 51 °C. Next 10 minutes: 63 – 51 = 12 °C.
4. The tea cools by less each time, because it is closer to the room temperature.

Answer: 17 °C, then 12 °C

SEE IT THREE WAYS

As a picture



In words

The cup is hotter. The bath is cooler, but it holds a hundred times as much water. A bigger amount of warm water can hold more thermal energy than a small amount of hot water.

In symbols

Warming 1 cup of water (about 250 mL) by 1 °C takes about 1 kJ. Above 20 °C: the cup holds 1 × 80 kJ. The bath holds 100 × 20 kJ.

WORKED EXAMPLE

The room is at 20 °C. Which holds more thermal energy: 1 cup of water at 100 °C, or 100 cups at 40 °C? Warming 1 cup of water (about 250 mL) by 1 °C takes about 1 kJ.

1. The cup is 80 °C above the room. The bath is 20 °C above the room.
2. Energy = number of cups × degrees above the room × 1 kJ.
3. Cup: 1 × 80 = 80 kJ.
4. Bath: 100 × 20 = 2000 kJ.
5. The bath holds far more thermal energy, even though it is cooler.

Answer: The bath: 2000 kJ, against 80 kJ for the cup

TRY IT

Fool your hands

You need: three bowls, cool water, warm water: an adult mixes a little hot water from a pot into cool water.

Be safe: An adult makes the warm water and checks that it feels comfortable on their wrist. Never use hot water.

1. Put cool water in the first bowl and warm water in the third bowl. Mix some of each in the middle bowl.
2. Put your left hand in the cool bowl and your right hand in the warm bowl. Wait 30 seconds.
3. Put both hands in the middle bowl. Notice how each hand feels.

What you will see: The middle bowl is at one temperature. Yet it feels warm to the hand that was cool, and cool to the hand that was warm. Your hands feel heat moving, not temperature. A thermometer is fairer.

If you cannot try it, this is what happens.

hand was in	it feels
cool bowl	warm
warm bowl	cool

A WRONG IDEA MANY PEOPLE HAVE

~~Heat and temperature are the same thing.~~

Why it feels right: People say "hot" for both a high temperature and a lot of heat.

The test that breaks it: The cup is at 100 °C and the bath at 40 °C. The cup has the higher temperature. The bath holds 2000 kJ above room temperature, against 80 kJ for the cup.

What is true: Temperature tells how hot a thing is. Heat is energy moving from hot to cool. A thing's thermal energy depends on its temperature and on how much of it there is.

KEY WORDS

temperature
how hot something is, in degrees Celsius.

thermometer
a tool that measures temperature.

heat
energy moving from a hotter thing to a cooler one.

thermal energy
the energy in a thermal store. It depends on temperature and amount.

BACK TO YOUR GUESS

The answer is C: The bath, because there is so much more water.

The bath holds far more thermal energy. Hot is only part of the story. How much water there is matters too.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Room temperature is 20 °C. Which holds more thermal energy? 1 cup of water at 90 °C, or a bucket of 20 cups at 50 °C?

   A The bucket

   B The cup, because it is hotter.

   C They hold the same, because both are hot.

   Answer at the back of the book.

2. A hot spoon is put into a bowl of cool water. Which way does energy move?

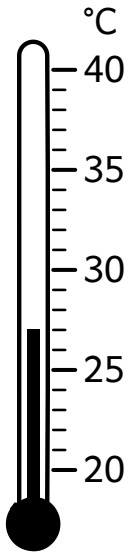
   A From the cool water into the spoon, because cold flows into hot things.

   B From the spoon into the cool water.

   C It does not move. Each keeps its own temperature.

   Answer at the back of the book.

3. What temperature does this thermometer show?



   A 22 °C

   B 23 °C

   C 30 °C

   D 27 °C

   Answer at the back of the book.

4. The air is 24 °C in the morning and 31 °C in the afternoon. How many degrees warmer is it in the afternoon?

   A 55 °C

   B 31 °C

   C 7 °C

   Answer at the back of the book.

5. What does the thermal energy in a pot of water depend on?

   A Its temperature and how much water there is.

   B Only its temperature.

   C Only how much water there is.

   Answer at the back of the book.

6. **From an earlier chapter**

   Review: a gadget takes in 70 J and gives 20 J of useful energy. How much is wasted?

   A 90 J

   B 50 J

   C 20 J

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Temperature tells how hot a thing is, in °C. Heat is energy moving from hot to cool. Thermal energy depends on temperature and on how much there is.

Draw: A thermometer with the liquid at 27 °C. Mark 20, 25 and 30 on it.

S3.8.5 CHAPTER 5

How heat travels

> **Why does the metal spoon in hot tea get hot, while the wooden spoon stays cool?**

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** The metal spoon is heavier.
- ☐ **B** Wood cannot be warmed at all.
- ☐ **C** Heat travels along metal much better than along wood.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Energy stores and transfers, S3.8.4. Heat moves from hotter things to cooler ones.
- Level 2, Solids, liquids, gases and the water cycle, S2.4.1. Solids, liquids and gases hold their particles in different ways.

BY THE END YOU CAN

- Explain conduction, convection and radiation with examples from home
- Compare how fast metal and wooden spoons warm in hot water

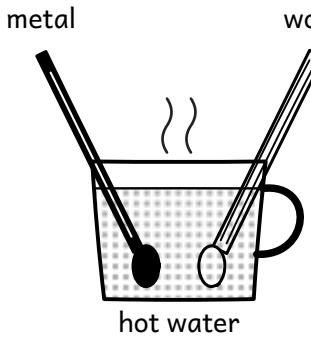
Ravi stirs his tea and leaves a metal spoon in the cup. When he lifts it out, the handle is hot. His wooden spoon stood in the same cup, and its handle is cool.

Heat moves from hot things to cool things in three ways. They are called conduction, convection and radiation. We will take them one at a time.

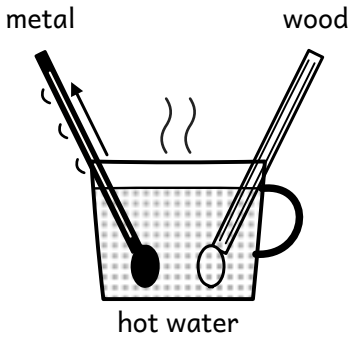
Conduction is heat moving through a solid, from one particle to the next. In the hot end of a spoon the particles shake hard. They bump the next ones and pass the energy along.

DRAW IT FIRST

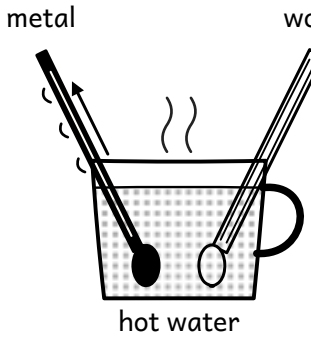
Draw heat moving along a spoon



1 Draw a cup of hot water. Stand a metal spoon and a wooden spoon in it.



2 Draw an arrow up the metal handle. Heat moves along the metal from the water.



heat travels up the metal

3 Write: heat travels up the metal. The wooden handle stays cool.

A **conductor** lets heat pass through it easily. Metals are good conductors. An **insulator** lets heat pass through slowly. Wood, plastic, cloth and air are insulators.

material	through it
metal spoon	fast
wooden spoon	slowly
plastic spoon	slowly
air	very slowly

How fast heat moves through each material.

min	metal °C	wood °C
0	20	20
1	28	20
2	33	21
3	36	21
4	38	21

One set of readings of the top of each handle, taken with a thermometer, once a minute.

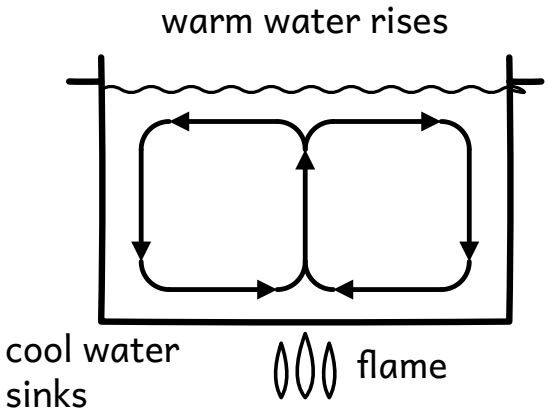
WORKED EXAMPLE

Use the table. By how many degrees did the metal handle warm in 4 minutes? How about the wooden handle?

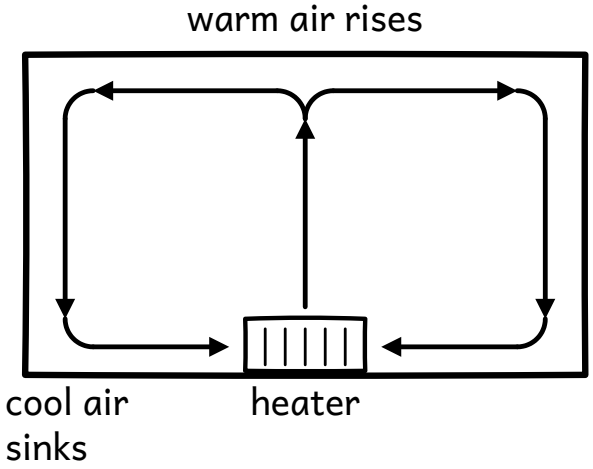
1. After 4 minutes the metal handle is 38 °C. It started at 20 °C.
2. Metal: 38 − 20 = 18 °C.
3. Wood: 21 − 20 = 1 °C.
4. The metal handle warmed 18 times as much.

Answer: metal 18 °C, wood 1 °C

Convection is heat moving in a liquid or a gas. Water at the bottom of a pot is heated. It spreads out a little. A cupful of it then weighs less than a cupful of the cool water above, so it rises.

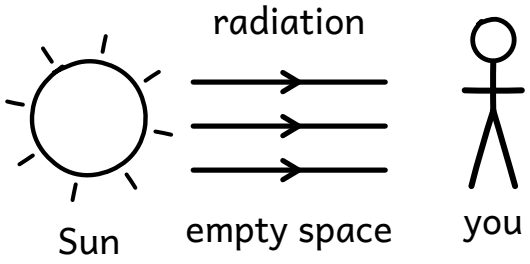


Warm water rises and cool water sinks to take its place. The loop spreads the heat through the pot.



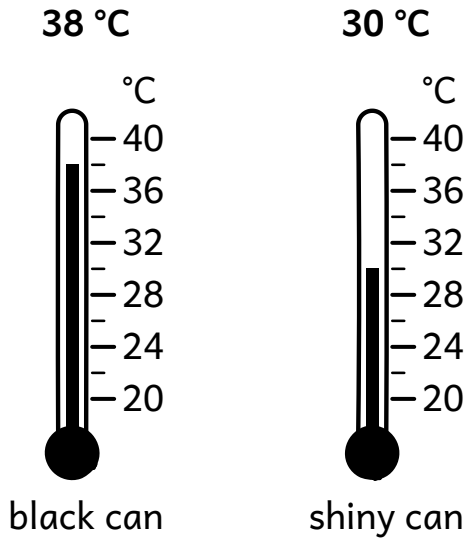
Air does the same. This is why the air near the ceiling is warmer than the air near the floor.

Radiation is heat that travels as invisible waves called **infrared**. It needs no material at all. It crosses empty space. The Sun warms the Earth with light and with infrared.



The space between the Sun and Earth is almost empty. Radiation crosses it, so no conduction or convection is needed.

A dark, dull surface takes in radiation best. It also gives out radiation best. A shiny, light surface sends most of it back. This is why a black can warms faster in the sun than a shiny one.



Example readings. Both cans started at 25 °C. The black can ends hotter.

SEE IT THREE WAYS

As a picture

way	example
conduction	hot spoon
convection	hot air rises
radiation	Sun on skin

In words

Conduction moves heat through solids, such as a hot spoon. Convection moves heat in liquids and gases, such as warm air over a stove. Radiation moves heat as infrared, even through empty space, such as the Sun on your skin.

TRY IT

Race a metal and a wooden spoon

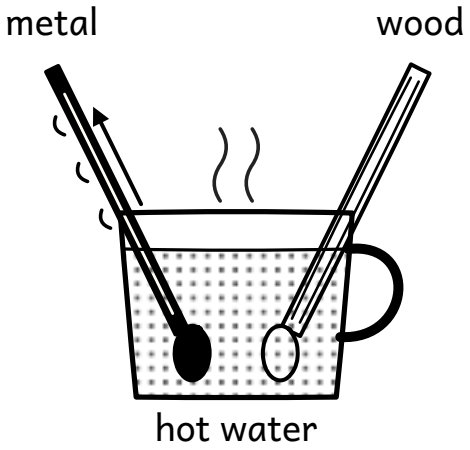
You need: a metal spoon and a wooden spoon of the same length, a cup, hot water, poured by an adult, a clock, or a friend who counts seconds.

Be safe: An adult pours the hot water and stays close. Never grab a spoon that has stood in hot water. Test it gently with one finger first, and take your finger away at once if it feels hot.

1. Ask an adult to pour hot water into the cup. Let it stand for five minutes first if it came from a kettle.
2. Stand both spoons in the cup with their handles leaning on the rim. Start counting.
3. After one minute, touch the top of each handle very briefly with one finger. Do not hold on.
4. Test again after two and three minutes. Write down which handle feels warmer each time.

What you will see: The metal handle warms up within a minute or two. The wooden handle stays cool for much longer. Heat travels fast along the metal and slowly along the wood.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~A metal chair is colder than a wooden chair in the same room.~~

Why it feels right: Metal feels much colder when you touch it, so it seems colder.

The test that breaks it: Both chairs have stood in the room all day. A thermometer reads the same on both. Metal feels colder because it carries heat away from your hand fast.

What is true: Both are at the same temperature. Metal is a good conductor, so it takes heat from your hand quickly. Wood is an insulator and takes it slowly.

KEY WORDS

conduction
heat moving through a solid.

convection
heat moving in a liquid or gas, as warm fluid rises.

radiation
heat moving as infrared, with no material needed.

conductor
a material that lets heat pass through it easily.

insulator
a material that lets heat pass through slowly.

infrared
invisible waves that carry heat.

BACK TO YOUR GUESS

The answer is C: Heat travels along metal much better than along wood.

Heat moves along metal quickly. It moves along wood very slowly. Wood does warm up, but only after a long time.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. The handle of a metal spoon in hot tea gets hot. Which way is the heat travelling?

    A By conduction

    B By convection

    C By radiation

    Answer at the back of the book.

2. The bottom of a pot of water is heated. What does the warm water do?

    A It sinks, because heat is heavy.

    B It rises, and cooler water sinks to take its place.

    C It stays at the bottom, because the flame holds it there.

    Answer at the back of the book.

3. How does the Sun's warmth reach the Earth across empty space?

    A By conduction, along the air.

    B By convection, in rising air.

    C By radiation

    Answer at the back of the book.

4. Which is the best handle for a cooking pot?

    A Wood, because it is an insulator.

    B Metal, because it is strong.

    C It does not matter. They all warm up at the same speed.

    Answer at the back of the book.

5. A learner tests three spoons in hot water. After 2 minutes the handles read as shown. How many degrees warmer is the copper handle than the steel handle?

spoon	after 2 min
copper	41 °C
steel	33 °C
wood	22 °C

A 74 °C

B 19 °C

C 21 °C

D 8 °C

Answer at the back of the book.

6. **From an earlier chapter**

Review: a cup of tea is 88 °C when it is poured. Half an hour later it is 46 °C. How many degrees did it cool?

A 134 °C

B 42 °C

C 46 °C

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Conduction: heat through solids, fast in metals. Convection: warm liquid or gas rises, cool sinks. Radiation: infrared crosses empty space. Insulators slow heat down.

Draw: A metal spoon and a wooden spoon in a cup, with an arrow up the metal one.

S3.8.6 CHAPTER 6

Keeping warm and cool

How can I keep my tea warm for longer?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Put it in a metal tin, because metal holds heat in.
- ☐ **B** Leave the cup open so the heat settles.
- ☐ **C** Wrap it in cloth or wool, which traps still air.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Energy stores and transfers, S3.8.5. Insulators slow down conduction and convection.
- Level 2, Solids, liquids, gases and the water cycle, S2.4.4. A wet clay pot cools by evaporation.

BY THE END YOU CAN

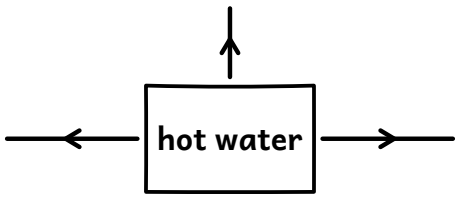
- Test which material keeps hot water warm longest
- Explain how a wet clay pot keeps water cool

Mei pours hot tea for her grandmother. It must still be warm when she wakes up. Mei wraps the cup in a cloth. Does that help?

Wool, cloth, feathers and foam are **insulation**. They hold many tiny pockets of still air. Still air is a poor conductor, and it cannot carry heat by convection. So heat leaves slowly.

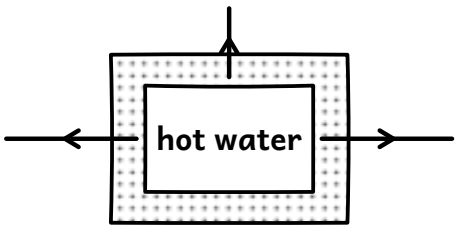
DRAW IT FIRST

Draw *a* cup wrapped in cloth



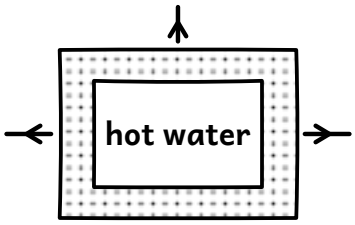
heat escapes fast

1 Draw *a* cup of hot water. Draw long *a*rrows for the heat escaping from it.



cloth: trapped *a*ir

2 Wrap it in *a* cloth. Dots show the tiny pockets of trapped *a*ir.



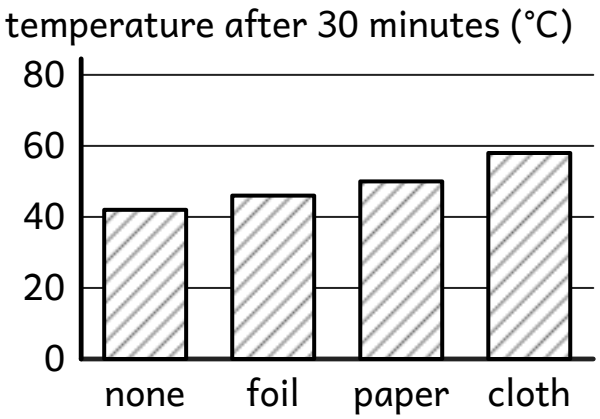
heat escapes slowly

3 Now draw short *a*rrows. The cloth slows the heat down, so the tea stays warm longer.

How can we find the best wrap? We do *a* **fair test**. We change only one thing, which is the wrap. We keep everything else the same.

we	what
change	the wrap
measure	temperature
keep same	cup, water, time

A fair test. Use the same cup, the same amount of water and the same time for every wrap.



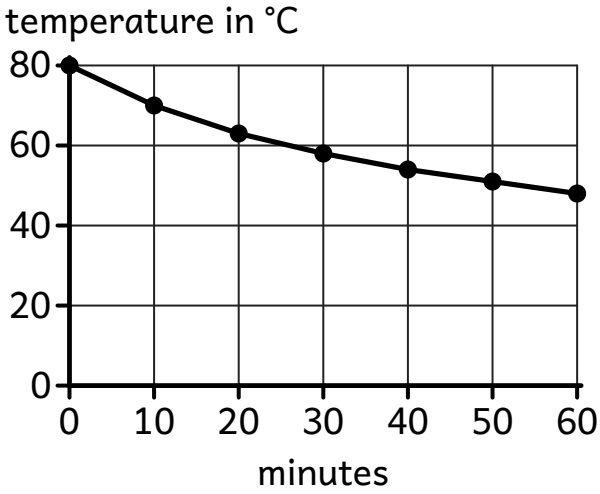
Example results. Every cup started at 80 °C in a room at 20 °C. Cloth keeps the water warmest.

WORKED EXAMPLE

Use the bars. How many degrees did the bare cup lose in 30 minutes? How many did the cloth cup lose? How much warmer is the cloth cup?

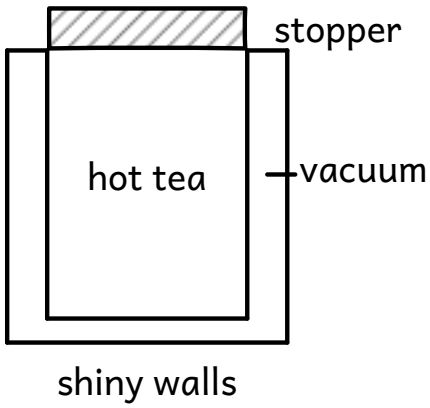
1. Bare cup: 80 − 42 = 38 °C lost.
2. Cloth cup: 80 − 58 = 22 °C lost.
3. The cloth cup lost 38 − 22 = 16 °C less.

Answer: bare 38 °C, cloth 22 °C, 16 °C warmer



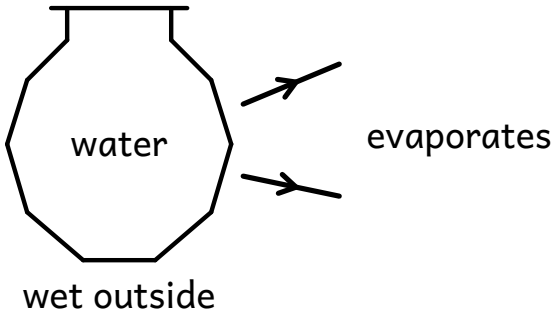
The cloth cup cools slowly. Compare this with the bare cup in chapter 4, which had cooled to 42 °C by 30 minutes.

A **vacuum flask** uses every trick at once. Its double wall has a gap with no air, so heat cannot conduct or convect across it. Shiny walls send radiation back. The stopper stops warm air escaping from the top.



No air in the gap means no conduction or convection. Shiny walls cut radiation.

Now keeping things cool. In many hot places people store drinking water in a clay pot. The clay has tiny holes. A little water seeps through to the outside.

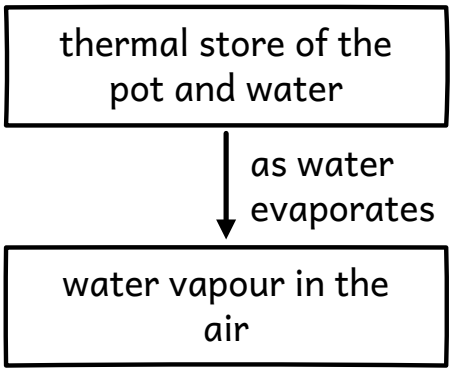


Water seeps through the clay and evaporates from the outside.

To evaporate, water needs energy. It takes that energy from the pot and the water inside. So the water in the pot gets cooler.

SEE IT THREE WAYS

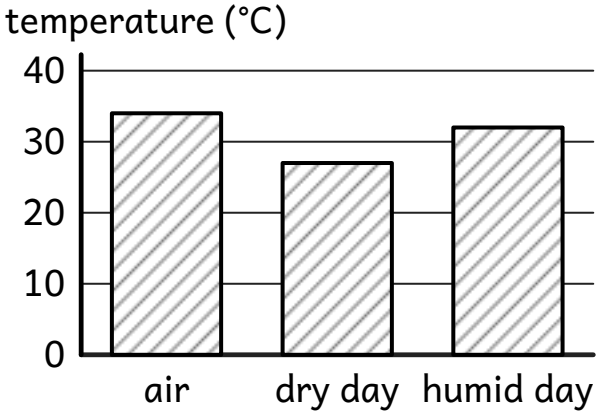
As a picture



In words

Energy leaves the pot with the water that evaporates. The pot loses energy, so it cools. It cools the water inside.

It works best when the air is dry and moving, because water evaporates fast. In humid air the water evaporates slowly, so the pot cools less.



Example readings. The pot water is cooler than the air, and cooler still on a dry day.

WORKED EXAMPLE

The air is 34 °C. How many degrees cooler is the pot water on a dry day? On a humid day?

1. Dry day: 34 – 27 = 7 °C cooler.
2. Humid day: 34 – 32 = 2 °C cooler.
3. The pot does its job better on the dry day, by 5 °C.

Answer: dry day 7 °C, humid day 2 °C

TRY IT

Which wrap keeps water warm longest?

You need: three identical cups, a piece of cloth and a piece of paper, hot water, poured by an adult, a clock, a thermometer, if you have one.

Be safe: An adult pours the hot water and stays close. Never put a finger in the water. Carry nothing hot.

1. Wrap one cup in cloth and one in paper. Leave the third bare.
2. Ask an adult to pour the same amount of hot water into each cup. Mark the level with a pencil first.
3. Leave them for 20 minutes. Do not touch them.
4. Ask the adult to take off the wraps and touch the side of each cup for a moment. Or use a thermometer if you have one. Rank the cups from warmest to coolest.

What you will see: The cloth cup stays warmest and the bare cup is coolest. The paper cup is in between. Your cups may differ a little, but the order should be the same.

If you cannot try it, this is what happens.

cup	after 20 min
cloth	warmest
paper	warm
bare	coolest

A WRONG IDEA MANY PEOPLE HAVE

~~A woollen jumper makes heat.~~

Why it feels right: You feel warm when you put one on, so the jumper seems to give out warmth.

The test that breaks it: Wrap one cup of cold water in a woollen sock and put a bare cup beside it. After an hour the wrapped water is no warmer than the bare one. The wool made no heat.

What is true: Wool is an insulator. It traps the heat your own body gives out, and it slows that heat from escaping.

KEY WORDS

insulation
a material that holds still air and slows heat down.

fair test
a test where only one thing is changed.

vacuum flask
a bottle with a double wall and no air in the gap.

BACK TO YOUR GUESS

The answer is C: Wrap it in cloth or wool, which traps still air.

Wrap it in cloth or wool. These trap still air, and still air passes heat on very slowly. A metal tin would let the heat out fast.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Why does a woollen cloth keep a cup of tea warm?

   A It traps still air, and still air passes heat on very slowly.

   B It makes heat of its own.

   C Wool is a good conductor, so it spreads the heat around the cup.

   Answer at the back of the book.

2. Amina wraps a cloth round one cup, and paper round a bigger cup with more water. She says cloth is best. Why is her test not fair?

   A Cloth is never better than paper.

   B She changed two things: the wrap and the amount of water.

   C Paper cannot be used in a test.

   Answer at the back of the book.

3. Two cups start at 90 °C. After 30 minutes the cloth cup is 62 °C and the foil cup is 53 °C. How many degrees warmer is the cloth cup?

cup	after 30 min
cloth	62 °C
foil	53 °C

   A 115 °C

   B 28 °C

   C 37 °C

   D 9 °C

   Answer at the back of the book.

4. How does a wet clay pot keep its water cool?

   A The clay makes cold and puts it into the water.

   B The clay is an insulator, so no heat can get in.

   C Water seeps out and evaporates, and takes energy from the pot and the water.

   Answer at the back of the book.

5. When does a wet clay pot cool its water best?

   A In dry air that is moving.

   B In humid air that hardly moves.

   C In a closed, damp room.

   Answer at the back of the book.

6. **From an earlier chapter**

   Review: warm air rises above a heater and cool air sinks to take its place. What is this way of moving heat called?

   A Conduction

   B Convection

   C Radiation

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Insulators trap still air and slow heat down. A fair test changes one thing. A wet clay pot cools water as water evaporates and takes energy away, best in dry air.

Draw: A cup in a cloth with short arrows. Next to it a wet pot with arrows going out.

S3.8.7 CHAPTER 7

Energy from food

Why am I so hungry after playing all day?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Hunger has nothing to do with energy.
- ☐ **B** Only people who feel cold need more food.
- ☐ **C** Playing moves energy out of my body, so I need food to put it back.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Bones, muscles, teeth and food, S2.3.5. Starch and fat give energy.
- Level 3, Energy stores and transfers, S3.8.3. Your body is a machine that wastes some energy as heat.

BY THE END YOU CAN

- Compare the energy in foods using a table in kilojoules
- Explain why active people need more food energy

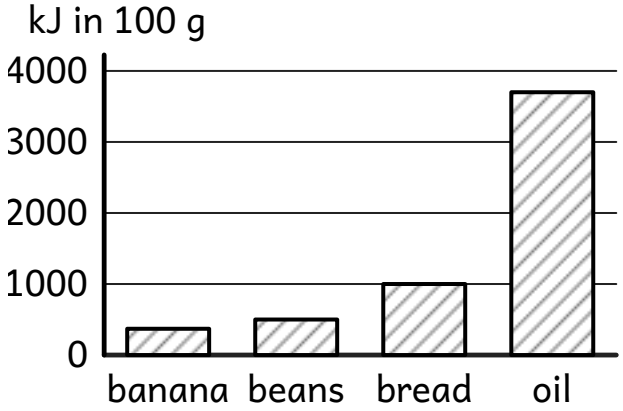
Kofi plays football from morning until the sun is low. By the evening he is very hungry. His little sister sat in the shade all day and is only a little hungry.

Food is a chemical store. The energy in food is counted in **kilojoules**, written kJ. One kilojoule is 1000 joules. Your body takes the energy out of food and uses it.

Foods do not all hold the same amount. We compare them by the **food energy** in the same weight, usually 100 g. The numbers here are about right, not exact.

food	kJ per 100 g
cooked rice	550 kJ
bread	1000 kJ
cooking oil	3700 kJ
banana	370 kJ
cooked beans	500 kJ
boiled egg	600 kJ

About how many kilojoules are in 100 g of each food.

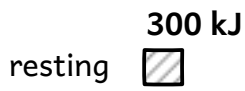


Oil holds the most energy in the same weight. It is a fat. Fruit holds less, even when it tastes sweet.

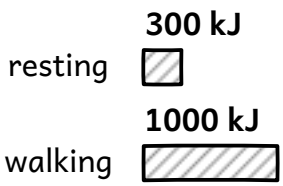
Now the other side. Moving, thinking, growing and keeping warm all take energy out of your body. You are always using some, even when you sleep.

DRAW IT FIRST

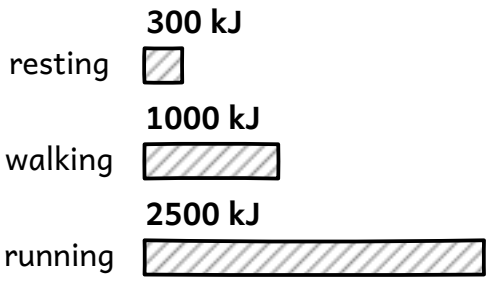
Draw how much energy an hour of each activity uses



1 Draw a short bar for resting. In an hour it moves about 300 kJ out of the body.

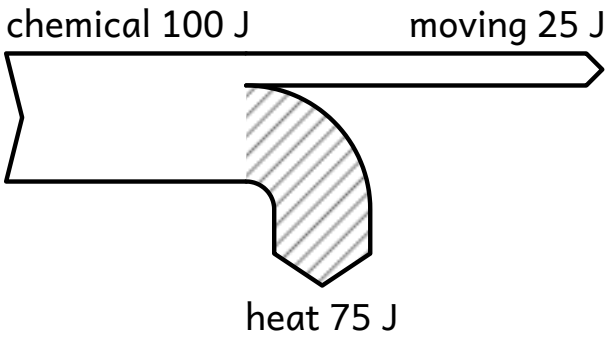


2 Draw a longer bar for walking. It moves about 1000 kJ in an hour.



3 Draw the longest bar for running. It moves about 2500 kJ in an hour. The numbers are rough, for a grown person.

The more you move, the more energy leaves your body each hour. So active people need more food energy to put it back. Growing bodies also need food energy, to build new parts.



Muscles turn only about a quarter of the food energy into movement. The rest is heat, and it keeps you warm.

WORKED EXAMPLE

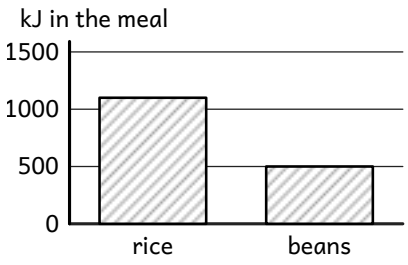
Tariq eats 200 g of cooked rice and 100 g of cooked beans. How much food energy is that?

1. Rice: 200 g is 2 lots of 100 g. Each lot is about 550 kJ.
2. Rice energy = 2 × 550 = 1100 kJ.
3. Beans: 1 × 500 = 500 kJ.
4. Total = 1100 + 500 = 1600 kJ.

Answer: about 1600 kJ

SEE IT THREE WAYS

As a picture



In words

To find the energy in a meal, work out how many lots of 100 g there are. Multiply by the kJ in 100 g. Do this for each food and add up.

In symbols

energy = (grams ÷ 100) × kJ per 100 g. For the rice: 2 × 550 = 1100 kJ.

WORKED EXAMPLE

Joseph walks for 3 hours. Walking moves about 1000 kJ an hour. How much bread, in grams, holds the same energy? Bread has about 1000 kJ in 100 g.

1. Energy moved = 3 × 1000 = 3000 kJ.
2. Lots of 100 g of bread = 3000 ÷ 1000 = 3.
3. Bread = 3 × 100 = 300 g.

Answer: 300 g

TRY IT

Feel your body move energy

You need: a clock or a friend who counts seconds, flat ground.

Be safe: Stop at once if you feel dizzy or any pain. Jog on flat ground with space around you.

1. Sit still for two minutes. Press two fingers on your wrist, below the thumb, until you feel the pulse.
2. Count the beats for 15 seconds. Multiply by 4. Write the number.
3. Jog on the spot for one minute. Then count the pulse for 15 seconds again and multiply by 4.

What you will see: Your heart beats faster after jogging. Your muscles are moving more energy, so they need more oxygen and food energy. Your numbers will differ from ours.

If you cannot try it, this is what happens.

when	per minute
resting	72 beats
after jogging	126 beats

A WRONG IDEA MANY PEOPLE HAVE

~~Only sweet foods have energy.~~

Why it feels right: Sugar gives a quick feeling of energy, so sweet things seem to be the energy foods.

The test that breaks it: Look at the table. Cooking oil is not sweet, yet it has about 3700 kJ in 100 g. Bread and beans are not sweet, and a banana is sweet but has only about 370 kJ.

What is true: Starch, sugar, fat and protein all hold energy. Fat holds the most in the same weight.

KEY WORDS

kilojoules
the units we count food energy in. We write kJ. 1 kJ is 1000 J.

food energy
the energy kept in a food, in its chemical store.

BACK TO YOUR GUESS

The answer is C: Playing moves energy out of my body, so I need food to put it back.

Playing moves energy out of your body, into movement and heat. Food is a chemical store that puts energy back in.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. A table gives the kJ in 100 g of four foods. Which food has the most energy in the same weight?

food	kJ per 100 g
lentils	480 kJ
boiled potato	360 kJ
groundnuts	2400 kJ
milk	270 kJ

   A lentils

   B milk

   C boiled potato

   D groundnuts

   Answer at the back of the book.

2. A boiled egg has about 600 kJ in every 100 g. How much food energy is in 300 g of egg?

   A 1800 kJ

   B 180000 kJ

   C 900 kJ

   D 600 kJ

   Answer at the back of the book.

3. Why do people who run or dig all day need more food energy?

   A Being active makes food weigh more.

   B Their bodies move more energy out, so they need more food to put it back.

   C They do not. Everyone needs exactly the same food energy.

   Answer at the back of the book.

4. Digging moves about 1200 kJ out of the body each hour. How much energy does 4 hours of digging move?

   A 300 kJ

   B 1204 kJ

   C 4800 kJ

   Answer at the back of the book.

5. In what unit is the energy in food counted?

   A Kilograms, kg

   B Degrees Celsius, °C

   C Newtons, N

   D Kilojoules, kJ

   Answer at the back of the book.

6. **From an earlier chapter**

   Review: a body takes in 200 J from food and moves with 40 J. What is the efficiency?

   A 20%

   B 80%

   C 5%

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Food is a chemical store, counted in kilojoules. Foods hold different amounts. Active people move more energy out of their bodies, so they need more food energy.

Draw: Three bars: resting, walking, running. Make each one longer. Write kJ beside each bar.

S3.8.8 CHAPTER 8

Fuels and energy resources

Will we ever run out of fuel?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** No. There is always more under the ground.
- ☐ **B** Sunlight and wind will not run out, but coal, oil and gas will.
- ☐ **C** Yes. Sunlight and wind will run out too.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Energy stores and transfers, S3.8.3. Cooking fires waste some of their energy.
- Level 2, How plants grow. Wood comes from trees that grow back.

BY THE END YOU CAN

- Sort energy resources into renewable and non-renewable
- Explain how burning fuels adds carbon dioxide to the air
- Compare cooking with wood, gas and sunlight

Amina's family cooks on a wood fire. Her cousin cooks on gas. At Ravi's school the cooks use a box that catches the Sun. All of them are using energy to heat food.

A **fuel** is a chemical store that we burn to get heat. Wood, charcoal, coal, oil and gas are fuels. An **energy resource** is anything we get useful energy from. That includes fuels, sunlight, wind and flowing water.

Some resources are **renewable**. They keep coming, or are replaced as fast as we use them. Sunlight, wind and flowing water are renewable.

Others are **non-renewable**. Coal, oil and gas took millions of years to form. Once we burn them, they are gone for any time we can imagine.

DRAW IT FIRST

Draw a sort of energy resources

renewable	non-renewable

1 Draw a line down a page. Write renewable on the left and non-renewable on the right.

renewable	non-renewable
sunlight	
wind	
flowing water	

2 List the resources that keep coming: sunlight, wind and flowing water.

renewable	non-renewable
sunlight	coal
wind	oil
flowing water	gas

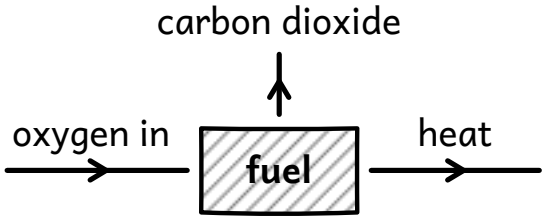
3 List the fuels that took millions of years to form: coal, oil and gas.

Wood sits in the middle. It is renewable only if trees are planted as fast as they are cut down. If not, forests shrink and the wood runs out.

renewable	sunlight, wind
if replanted	wood
non-renewable	coal, oil, gas

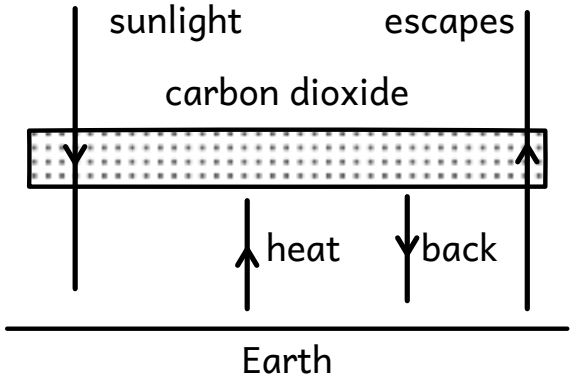
Wood has a row of its own. It is renewable only when trees are replanted as fast as they are cut.

What happens when a fuel burns? Wood, coal, oil and gas all contain carbon. The carbon joins with oxygen from the air. This makes **carbon dioxide**, a gas, which goes into the air.



A burning fuel takes oxygen from the air. It gives out heat and carbon dioxide.

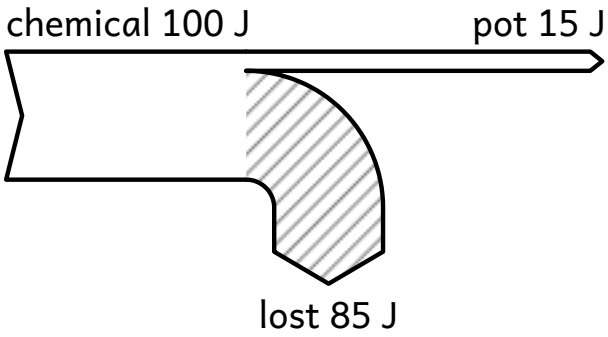
Carbon dioxide in the air traps some of the heat that rises from the ground. More carbon dioxide traps more heat. That warms the whole Earth a little.



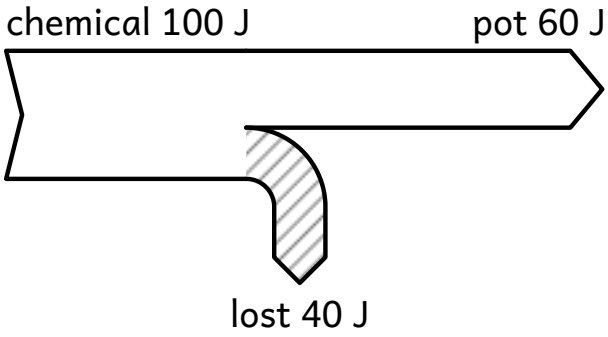
The carbon dioxide works like a blanket. Some heat still escapes, but a thicker blanket sends more back down.

Trees take carbon dioxide from the air as they grow. So wood burned from trees that are replanted can balance out. Wood from forests that are not replanted cannot.

Now cooking. Every fire wastes energy. Only some of the energy in the fuel goes into the pot. An open wood fire puts about 15 J in the pot for every 100 J of wood. A gas stove puts about 60 J.



An open wood fire. Most of the energy warms the air.



A gas stove. A lot more of the energy goes into the pot.

WORKED EXAMPLE

A pot of beans needs 4800 kJ. An open wood fire is about 15% efficient. How many kJ must the wood hold, and how many kg of wood is that? Dry wood holds about 16000 kJ in each kg.

1. Fuel energy = useful ÷ efficiency × 100 = 4800 ÷ 15 × 100.
2. 4800 ÷ 15 = 320.
3. 320 × 100 = 32000 kJ.
4. Wood = 32000 ÷ 16000 = 2 kg.

Answer: 32000 kJ, which is 2 kg of wood

WORKED EXAMPLE

The same pot needs 4800 kJ. A gas stove is about 60% efficient. How many kJ must the gas hold? How many times as much fuel energy did the wood fire need?

1. 4800 ÷ 60 = 80.
2. 80 × 100 = 8000 kJ.
3. The wood fire needed 32000 kJ. 32000 ÷ 8000 = 4 times as much.

Answer: 8000 kJ, and the wood fire needs 4 times as much

A solar cooker uses no fuel at all. A shiny surface sends sunlight onto a dark pot. The dark pot takes in the radiation and heats up. It makes no smoke and no carbon dioxide. But it needs strong sunshine, and it cooks slowly.

Be safe. Smoke from a cooking fire indoors harms the lungs. Cook outdoors, or where the smoke can leave, and keep small children away. Never look at sunlight bouncing off a shiny surface.

SEE IT THREE WAYS

As a picture

cook with	renewable
wood	if replanted
gas	no
sunlight	yes

In words

Wood and gas both make carbon dioxide when they burn. Gas is non-renewable. Wood is renewable only when trees are replanted. Sunlight makes no carbon dioxide while you cook.

TRY IT

Catch the Sun with a dark bottle

You need: two clear plastic bottles of the same size, with caps, water from the same jug, black paper or cloth, and shiny foil or a white cloth, a sunny spot on the ground.

Be safe: Never look at the Sun. If you use foil, never look at sunlight bouncing off it. Keep it turned away from anyone's eyes.

1. Fill both bottles with the same cool water and put on the caps.
2. Wrap one bottle in black paper. Wrap the other in shiny foil, or in a white cloth.
3. Stand them side by side in the sunshine for one hour. Turn the foil away from faces.
4. Unwrap both. Hold the back of your hand against the outside of each bottle. Feel which one is warmer.

What you will see: The black bottle is warmer. Dark surfaces take in more of the Sun's radiation. Shiny foil or white cloth sends most of it away. Your bottles may differ a little.

If you cannot try it, this is what happens.

bottle	after 1 hour
black paper	warm
shiny foil	cool

A WRONG IDEA MANY PEOPLE HAVE

~~Wood is natural, so burning it adds no carbon dioxide.~~

Why it feels right: Trees are alive and part of nature, so their smoke seems harmless.

The test that breaks it: Think of a wood fire. It gives off heat, light and smoke. Wood contains carbon, so burning it makes carbon dioxide, like any other fuel.

What is true: Burning wood adds carbon dioxide to the air. Growing trees take it back in, but only if trees are replanted as fast as they are cut.

KEY WORDS

fuel
a chemical store we burn to get heat.

energy resource
anything we get useful energy from, such as fuels, sunlight and wind.

renewable
an energy resource that keeps coming or is replaced as fast as we use it.

non-renewable
an energy resource that took millions of years to form and will run out.

carbon dioxide
a gas made when fuels with carbon burn. It traps heat in the air.

BACK TO YOUR GUESS

The answer is B: Sunlight and wind will not run out, but coal, oil and gas will.

Coal, oil and gas took millions of years to form. We use them far faster than they form, so they will run out. Sunlight and wind keep coming.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Which of these energy resources is renewable?

   A Coal

   B Gas

   C Oil

   D Sunlight

   Answer at the back of the book.

2. A family burns gas to cook. What gas does burning add to the air, and what does more of it do?

   A Oxygen, which makes the air cleaner.

   B Carbon dioxide, which cools the Earth.

   C Carbon dioxide, which traps more heat and warms the Earth.

   Answer at the back of the book.

3. On a sunny day a family wants to cook with no smoke and no carbon dioxide. Which is best?

   A A solar cooker

   B A wood fire

   C A gas stove

   Answer at the back of the book.

4. A pot needs 1800 kJ. An open fire is about 15% efficient. How many kJ must the fuel hold?

   A 270 kJ

   B 1815 kJ

   C 1800 kJ

   D 12000 kJ

   Answer at the back of the book.

5. Is wood a renewable energy resource?

   A No, because burning it always uses it up for ever.

   B Yes, but only if trees are replanted as fast as they are cut.

   C Yes, always, because it is natural.

   Answer at the back of the book.

6. **From an earlier chapter**

   Review: a food has about 800 kJ in every 100 g. How much food energy is in 300 g of it?

   A 240000 kJ

   B 1100 kJ

   C 2400 kJ

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Renewable: sunlight, wind, water, and wood if replanted. Non-renewable: coal, oil, gas. Burning fuels makes carbon dioxide, which traps heat. A solar cooker burns nothing.

Draw: A page split in two: renewable and non-renewable. List three resources under each.

Key words, A to Z

Every key word in this book, what it means, and the chapter that teaches it.

by a force
a way energy moves, when things push, pull or fall. S3.8.2

by heating
a way energy moves, from a hotter thing to a cooler one. S3.8.2

carbon dioxide
a gas made when fuels with carbon burn. It traps heat in the air. S3.8.8

chemical store
energy kept in food, fuel and batteries. S3.8.1

conduction
heat moving through a solid. S3.8.5

conductor
a material that lets heat pass through it easily. S3.8.5

convection
heat moving in a liquid or gas, as warm fluid rises. S3.8.5

efficiency
useful energy out ÷ energy in × 100, as a percentage. S3.8.3

elastic store
energy of a stretched or squashed thing. S3.8.1

energy
what makes things move, heat up, shine and make sounds. S3.8.1

energy flow diagram
a picture where each arrow is as wide as its joules. S3.8.3

energy resource
anything we get useful energy from, such as fuels, sunlight and wind. S3.8.8

energy transfer
energy moving from one store to another. S3.8.2

fair test
a test where only one thing is changed. S3.8.6

food energy
the energy kept in a food, in its chemical store. S3.8.7

fuel
a chemical store we burn to get heat. S3.8.8

gravitational store
energy of *a* thing held up high. S3.8.1

heat
energy moving from *a* hotter thing to *a* cooler one. S3.8.4

infrared
invisible waves that carry heat. S3.8.5

insulation
a material that holds still air and slows heat down. S3.8.6

insulator
a material that lets heat pass through slowly. S3.8.5

joules
the units we count energy in. We write J. S3.8.2

kilojoules
the units we count food energy in. We write kJ. 1 kJ is 1000 J. S3.8.7

kinetic store
energy of *a* moving thing. S3.8.1

non-renewable
an energy resource that took millions of years to form and will run out. S3.8.8

radiation
heat moving as infrared, with no material needed. S3.8.5

renewable
an energy resource that keeps coming or is replaced as fast as we use it. S3.8.8

stores
a way *a* thing holds energy, ready to use. S3.8.1

surroundings
the air, the ground and everything else near *a* thing. S3.8.3

temperature
how hot something is, in degrees Celsius. S3.8.4

thermal energy
the energy in *a* thermal store. It depends on temperature and amount. S3.8.4

thermometer
a tool that measures temperature. S3.8.4

transfer diagram
boxes for stores, with arrows for the way energy moves. S3.8.2

useful energy
the energy that does the job we want. S3.8.3

vacuum flask
a bottle with a double wall and no air in the gap. S3.8.6

wasted energy
energy that spreads into the surroundings, mostly as heat. S3.8.3

Answers

S3.8.1. Energy stores

1. **Chemical store**

   Fuels such as coal, wood and gas hold chemical energy. It comes out when they burn.

   - **If you chose A:** Kinetic energy is for moving things. Coal sitting still is not moving. Go to S3.8.1.
   - **If you chose C:** Thermal energy is for hot things. Cold coal is not hot until it burns. Go to S3.8.1.
   - **If you chose D:** Elastic energy is for stretched or squashed things. Coal is neither. Go to S3.8.1.

2. **Elastic store**

   A stretched band holds energy in its elastic store. When it springs back, that energy moves.

   - **If you chose A:** Gravitational energy is for things held up high. The band is stretched, not raised. Go to S3.8.1.
   - **If you chose B:** It is not moving yet. The energy waits in the stretch. It becomes kinetic only when you let go. Go to S3.8.1.

3. **A bag of beans**

   Food holds energy in a chemical store. Your body takes it out when it digests the food.

   - **If you chose B:** The tea is hot, so it holds energy in its thermal store. It is not a fuel or a food in this question. Go to S3.8.1.
   - **If you chose C:** A rolling ball holds energy in its kinetic store, because it is moving. Go to S3.8.1.

4. **Gravitational store**

   A thing held up high holds energy in its gravitational store, because it can fall.

   - **If you chose A:** It is not moving. Kinetic energy is for moving things. Go to S3.8.1.
   - **If you chose C:** A stone is not a food or a fuel. Its energy comes from being up high. Go to S3.8.1.

5. **Chemical store first, then kinetic store**

   Food is a chemical store. When the body moves, the energy goes into a kinetic store.

   - **If you chose A:** This is the wrong way round. The rice is a chemical store. Running makes a kinetic store. Go to S3.8.1.
   - **If you chose B:** The rice may be warm. But the energy for running was in the food, as a chemical store. Go to S3.8.1.
   - **If you chose C:** Rice is not held up high. The energy for running was in the rice, as a chemical store. Go to S3.8.1.

6. **The hot soup, in its thermal store**

   Hot things hold energy in a thermal store. The soup does not move, but it is hot.

   - **If you chose A:** Still things can hold a lot of energy. Hot soup, food and raised stones are all still. Go to S3.8.1.
   - **If you chose B:** The steam moves, but the soup itself is hot and holds more. Hot things hold thermal energy even when still. Go to S3.8.1.

S3.8.2. Energy transfers

1. **Its gravitational store gets smaller and its kinetic store gets bigger.**

   Energy moves from the gravitational store to the kinetic store by a force. The total stays the same.

   - **If you chose A:** This is the wrong way round. The ball loses height and gains speed. Go to S3.8.2.
   - **If you chose C:** Energy is not made. As the gravitational store shrinks, the kinetic store grows by the same amount. Go to S3.8.2.

2. **From the chemical store of the wax to the thermal store of the air and room.**

   The wax is a chemical store. When it burns, the energy moves out by heating and by light. It warms the air and the room.

   - **If you chose A:** This is the wrong way round. The wax is the store that gets smaller. Go to S3.8.2.
   - **If you chose B:** Energy is not made from nothing. It moves out of the wax and into the surroundings. Go to S3.8.2.
   - **If you chose C:** A flame is not a store of moving energy. The wax holds the energy, and the flame lets it out. Go to S3.8.2.

3. **12 J**

   The total is 20 J. Kinetic = 20 - 8 = 12 J.

   - **If you chose A:** You added. The two stores share the total, so subtract the gravitational energy from the total. Go to S3.8.2.
   - **If you chose B:** You copied the number from the other store. The two stores are not usually equal. Subtract to find the kinetic store. Go to S3.8.2.
   - **If you chose D:** All of it is in the kinetic store only at the bottom. Here some is still in the gravitational store. Go to S3.8.2.

4. **By a force**

   Gravity pulls the ball down. A pull is a force, so the energy moves by a force.

   - **If you chose A:** The ball is not giving out light. Light moves energy only when something shines. Go to S3.8.2.
   - **If you chose B:** No hot thing is warming a cool thing here. Gravity pulls the ball, and a pull is a force. Go to S3.8.2.
   - **If you chose C:** Sound comes later, when the ball lands. While falling, gravity pulls the ball. Go to S3.8.2.

5. **Light**

   Light, sound, heating and a force are ways energy moves. Chemical, kinetic and elastic are stores.

   - **If you chose B:** Chemical is a store. Food and fuel hold energy in it. Go to S3.8.1.
   - **If you chose C:** Kinetic is a store, for moving things. Light is a way energy travels. Go to S3.8.1.
   - **If you chose D:** Elastic is a store, for stretched or squashed things. Go to S3.8.1.

6. **A tank of cooking gas**

   Fuels such as gas are chemical stores. The energy comes out when they burn.

   - **If you chose A:** The cart is moving, so it holds energy in a kinetic store. Go to S3.8.1.
   - **If you chose C:** A stretched band holds energy in an elastic store. Go to S3.8.1.
   - **If you chose D:** Hot tea holds energy in a thermal store. Go to S3.8.1.

S3.8.3. Energy is never used up

1. **It has moved to the thermal store of the ball, the ground and the air.**

   Friction moves the energy into thermal stores. The energy is still there, spread out as a tiny bit of warmth.

   - **If you chose B:** Energy is never destroyed. It only moves to another store. Go to S3.8.3.
   - **If you chose C:** The ball did not go higher, so its gravitational store did not grow. Friction warmed the ground and the ball. Go to S3.8.3.

2. **54 J**

   Wasted = energy in − useful = 60 − 6 = 54 J.

   - **If you chose A:** You added. Wasted energy is what is left after the light, so subtract. Go to S3.8.3.
   - **If you chose B:** That is the light, which is the useful part. The wasted part is the rest. Go to S3.8.3.
   - **If you chose C:** You divided. To find what is left, subtract the light from the energy in. Go to S3.8.3.

3. **25%**

   Efficiency = useful ÷ in × 100 = 20 ÷ 80 × 100 = 25%.

   - **If you chose A:** That is the wasted share. Efficiency uses the useful energy, divided by the energy in. Go to S3.8.3.
   - **If you chose C:** You divided the energy in by the useful energy, which is upside down. Divide useful by in. Go to S3.8.3.
   - **If you chose D:** You subtracted the two numbers. Efficiency is a division: useful ÷ in × 100. Go to S3.8.3.

4. **It has spread into the surroundings and is too thin to use.**

   Wasted heat warms the air and the walls a tiny bit. It is spread over so much that it cannot do a job.

   - **If you chose A:** Energy is never destroyed. The wasted heat is still there. Go to S3.8.3.
   - **If you chose B:** Energy does not flow back to where it came from. It spreads out into the air and things nearby. Go to S3.8.3.

5. **40 J useful and 110 J wasted**

   The outputs must add up to the energy in. 40 + 110 = 150 J.

   - **If you chose B:** Together these give out more energy than went in. Energy cannot be made from nothing. Go to S3.8.3.
   - **If you chose C:** Together these give out less than went in. Energy is never destroyed, so 30 J would be missing. Go to S3.8.3.

6. **10 J**

   Kinetic = 40 - 30 = 10 J.

   - **If you chose A:** You added. The two stores share the total, so subtract. Go to S3.8.2.
   - **If you chose C:** You copied the gravitational store. The kinetic store is what is left of the total. Go to S3.8.2.

S3.8.4. Heat and temperature

1. **The bucket**

   Cup: 1 × 70 = 70 kJ. Bucket: 20 × 30 = 600 kJ. The bucket holds more.

   - **If you chose B:** Temperature is only half the story. The bucket has twenty times as much water. Go to S3.8.4.
   - **If you chose C:** They do not. Work out cups × degrees above the room for each one. Go to S3.8.4.

2. **From the spoon into the cool water.**

   Heat always moves from the hotter thing to the cooler thing. The spoon cools and the water warms until both are at one temperature.

   - **If you chose A:** There is no flow of cold. Energy only moves from the hotter thing to the cooler thing. Go to S3.8.4.
   - **If you chose C:** Energy does move. It keeps moving until the spoon and the water are at the same temperature. Go to S3.8.4.

3. **27 °C**

   The liquid is 2 marks above 25. Each mark is 1 °C. So the reading is 25 + 2 = 27 °C.

   - **If you chose A:** You counted two marks up from 20. The liquid is higher: count up from 25. Go to S3.8.4.
   - **If you chose B:** You counted down from 25 by two. The liquid is above 25, so count up. Go to S3.8.4.
   - **If you chose C:** You read the number above the liquid. Count the small marks up from 25. Go to S3.8.4.

4. **7 °C**

   Change = 31 − 24 = 7 °C.

   - **If you chose A:** You added the two temperatures. To find how much warmer, subtract. Go to S3.8.4.
   - **If you chose B:** That is the afternoon temperature. The question asks for the change. Go to S3.8.4.

5. **Its temperature and how much water there is.**

   Thermal energy depends on both. A hotter thing holds more, and a bigger amount holds more.

   - **If you chose B:** Temperature matters, but so does the amount. A big pot of warm water holds more than a small cup of hot water. Go to S3.8.4.
   - **If you chose C:** The amount matters, but so does the temperature. The same amount holds more energy when hotter. Go to S3.8.4.

6. **50 J**

   Wasted = 70 − 20 = 50 J.

   - **If you chose A:** You added. Wasted energy is what is left over, so subtract the useful energy. Go to S3.8.3.
   - **If you chose C:** That is the useful energy. The wasted energy is the rest. Go to S3.8.3.

S3.8.5. How heat travels

1. **By conduction**

   Heat moves through a solid by conduction, from particle to particle. Metal conducts heat well.

   - **If you chose B:** Convection happens in liquids and gases that can flow. A spoon is a solid, so its heat conducts through it. Go to S3.8.5.
   - **If you chose C:** Radiation travels as infrared through space. Here the heat passes through the metal itself. Go to S3.8.5.

2. **It rises, and cooler water sinks to take its place.**

   Warm water has spread out, so a cupful of it weighs less, and it rises. Cooler water sinks in to replace it. This loop is convection.

   - **If you chose A:** Warm water has spread out, so a cupful of it weighs less than a cupful of cool water. So it rises. Go to S3.8.5.
   - **If you chose C:** The warm water is free to move. It has spread out, and it rises. Go to S3.8.5.

3. **By radiation**

   Radiation travels as infrared and needs no material. It crosses empty space.

   - **If you chose A:** Conduction needs a material to pass through. Space between the Sun and Earth is almost empty. Go to S3.8.5.
   - **If you chose B:** Convection needs a liquid or gas that can flow. Space has almost none. Go to S3.8.5.

4. **Wood, because it is an insulator.**

   Wood lets heat pass slowly, so the handle stays cool enough to hold.

   - **If you chose B:** Metal is strong, but it conducts heat to your hand fast. It could burn you. Go to S3.8.5.
   - **If you chose C:** They do not. Metal warms much faster than wood, as the spoons showed. Go to S3.8.5.

5. **8 °C**

   Copper 41 °C and steel 33 °C. 41 − 33 = 8 °C.

   - **If you chose A:** You added the two readings. To find how much warmer, subtract. Go to S3.8.5.
   - **If you chose B:** You took the wooden spoon instead of the steel one. Read the steel row. Go to S3.8.5.
   - **If you chose C:** That is how much the copper handle warmed from 20 °C. The question compares it with steel. Go to S3.8.5.

6. **42 °C**

   Cooling = 88 − 46 = 42 °C.

   - **If you chose A:** You added the two temperatures. The cooling is the difference, so subtract. Go to S3.8.4.
   - **If you chose C:** That is the temperature at the end. The question asks how much it fell. Go to S3.8.4.

S3.8.6. Keeping warm and cool

1. **It traps still air, and still air passes heat on very slowly.**

   Wool holds many pockets of still air. Air is a poor conductor and cannot circulate, so heat leaves slowly.

   - **If you chose B:** Wool makes no heat. It only slows down the heat that is already in the tea. Go to S3.8.6.
   - **If you chose C:** A good conductor would carry heat away fast. Wool is an insulator. Go to S3.8.5.

2. **She changed two things: the wrap and the amount of water.**

   A fair test changes only one thing. Here both the wrap and the amount of water changed, so you cannot tell which made the difference.

   - **If you chose A:** That is not the problem. The problem is that she changed more than the wrap. Go to S3.8.6.
   - **If you chose C:** Paper is a fine thing to test. The test just needs the same cup and the same water. Go to S3.8.6.

3. **9 °C**

   62 - 53 = 9 °C.

   - **If you chose A:** You added the two readings. To find how much warmer, subtract. Go to S3.8.6.
   - **If you chose B:** That is how much the cloth cup lost. The question asks how much warmer it is than the foil cup. Go to S3.8.6.
   - **If you chose C:** That is how much the foil cup lost. Compare the two readings instead. Go to S3.8.6.

4. **Water seeps out and evaporates, and takes energy from the pot and the water.**

   Evaporating water needs energy. It takes it from the pot and the water inside, which cool as a result.

   - **If you chose A:** There is no such thing as made cold. Cooling is energy leaving, not cold arriving. Go to S3.8.6.
   - **If you chose B:** An insulator would only slow the warming. It could not make the water cooler than the air. Go to S3.8.6.

5. **In dry air that is moving.**

   Dry, moving air takes the water vapour away. The water evaporates fast, so more energy leaves the pot.

   - **If you chose B:** In humid air the water evaporates slowly. Slow evaporation takes away little energy. Go to S3.8.6.
   - **If you chose C:** A closed, damp room is humid. The water cannot evaporate quickly, so the pot cools little. Go to S3.8.6.

6. **Convection**

   Convection is heat moving in a liquid or a gas as warm fluid rises and cool fluid sinks.

   - **If you chose A:** Conduction is heat moving through a solid. Air can flow, so this is something else. Go to S3.8.5.
   - **If you chose C:** Radiation is infrared that needs no material. Here the moving air carries the heat. Go to S3.8.5.

S3.8.7. Energy from food

1. **groundnuts**

   Groundnuts have about 2400 kJ in 100 g. That is the biggest number in the table.

   - **If you chose A:** You may have picked the first row. Compare every number, not only the top one. Go to S3.8.7.
   - **If you chose B:** Milk is a drink, so it can seem light. But 100 g of milk holds far less than 100 g of groundnuts. Compare the numbers. Go to S3.8.7.
   - **If you chose C:** A potato is bulky, but bulk is not energy. Read the kJ numbers. Go to S3.8.7.

2. **1800 kJ**

   300 g is 3 lots of 100 g. 3 × 600 = 1800 kJ.

   - **If you chose B:** You multiplied the grams by the kJ. First find how many lots of 100 g there are, then multiply. Go to S3.8.7.
   - **If you chose C:** You added. The kJ are for each 100 g, so multiply by the number of lots of 100 g. Go to S3.8.7.
   - **If you chose D:** That is only for the first 100 g. There are more lots of 100 g in this amount. Go to S3.8.7.

3. **Their bodies move more energy out, so they need more food to put it back.**

   Movement moves energy out of the chemical stores in the body. Food puts energy back in.

   - **If you chose A:** Food does not change. The body simply moves more energy out when it is active. Go to S3.8.7.
   - **If you chose C:** People differ. More movement takes more energy out of the body, so active people need more. Go to S3.8.7.

4. **4800 kJ**

   4 hours × 1200 kJ = 4800 kJ.

   - **If you chose A:** You divided. Each hour moves the same amount, so multiply the rate by the hours. Go to S3.8.7.
   - **If you chose B:** You added kJ and hours, which cannot be added. Multiply the kJ in one hour by the number of hours. Go to S3.8.7.

5. **Kilojoules, kJ**

   Food energy is counted in kilojoules. 1 kJ is 1000 J.

   - **If you chose A:** Kilograms measure mass, which is how much stuff there is. Energy is counted in joules or kilojoules. Go to S3.8.7.
   - **If you chose B:** Degrees Celsius measure temperature, not energy. A cold food can hold a lot of energy. Go to S3.8.7.
   - **If you chose C:** Newtons measure a force. Energy is measured in joules. Go to S3.8.7.

6. **20%**

   Efficiency = 40 ÷ 200 × 100 = 20%.

   - **If you chose B:** That is the wasted share. Efficiency uses the useful energy divided by the energy in. Go to S3.8.3.
   - **If you chose C:** You divided the energy in by the useful energy, upside down. Divide useful by in, then multiply by 100. Go to S3.8.3.

S3.8.8. Fuels and energy resources

1. **Sunlight**

   Sunlight keeps coming every day, so it is renewable. Coal, oil and gas are non-renewable.

   - **If you chose A:** Coal took millions of years to form. It cannot be replaced as fast as we burn it. Go to S3.8.8.
   - **If you chose B:** Gas took millions of years to form. Once we burn it, it is gone. Go to S3.8.8.
   - **If you chose C:** Oil took millions of years to form, so it is non-renewable. Go to S3.8.8.

2. **Carbon dioxide, which traps more heat and warms the Earth.**

   Gas contains carbon. It burns to make carbon dioxide. More carbon dioxide traps more heat.

   - **If you chose A:** Burning uses up oxygen from the air. It does not add it. Go to S3.8.8.
   - **If you chose B:** Carbon dioxide traps heat, so it warms the Earth. It does not cool it. Go to S3.8.8.

3. **A solar cooker**

   A solar cooker uses sunlight and burns no fuel. It makes no smoke and no carbon dioxide. It needs strong sun.

   - **If you chose B:** A wood fire makes smoke and carbon dioxide, and it is renewable only if the trees are replanted. Go to S3.8.8.
   - **If you chose C:** A gas stove burns gas, which makes carbon dioxide and is non-renewable. Go to S3.8.8.

4. **12000 kJ**

   Fuel energy = 1800 ÷ 15 × 100 = 12000 kJ.

   - **If you chose A:** You multiplied by the efficiency. A fire wastes energy, so the fuel must hold more than the pot gets. Divide. Go to S3.8.3.
   - **If you chose B:** You added a percentage to kJ, which cannot be added. Divide the useful energy by the efficiency, then multiply by 100. Go to S3.8.3.
   - **If you chose C:** That would be a fire that wastes nothing. This fire wastes most of its energy, so it needs much more. Go to S3.8.3.

5. **Yes, but only if trees are replanted as fast as they are cut.**

   Trees grow back, so wood can be renewable. If we cut more than we replant, it runs out.

   - **If you chose A:** Trees grow back. Wood can be renewable if new trees are planted as fast as old ones are cut. Go to S3.8.8.
   - **If you chose C:** Natural does not mean renewable. If trees are cut faster than they grow, forests shrink and the wood runs out. Go to S3.8.8.

6. **2400 kJ**

   300 g is 3 lots of 100 g. 3 × 800 = 2400 kJ.

   - **If you chose A:** You multiplied the grams by the kJ. First find how many lots of 100 g there are. Go to S3.8.7.
   - **If you chose B:** You added. The kJ are for each 100 g, so multiply by the number of lots of 100 g. Go to S3.8.7.

About this book

For learners who can read a page alone and do sums with the four operations. In many schools this fits children of about 11 to 13, and older learners can use it too. Activities use water, cloth, paper, cups, spoons, plastic bottles, a candle and the Sun. Anything

with hot water or a flame needs an adult to pour the water, light the candle and stay close. A learner can work alone: every exercise has its answer and the reason for it.

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