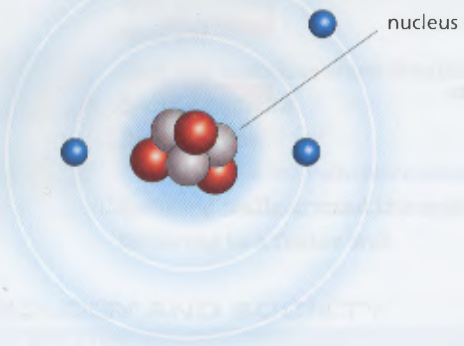
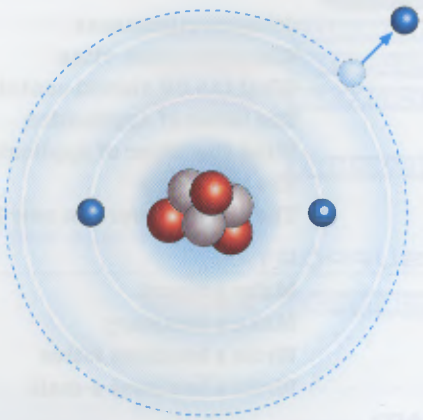
ELECTRIC ENERGY

Atoms and electrons

A



B



To understand what electricity is we have to look at the composition of **matter**.
All matter is composed of microscopic particles called atoms. But each atom is itself made up of even smaller particles. In the centre of each atom there is a nucleus made up of protons and neutrons. Other particles, called electrons, **spin** around the nucleus.
Electrons carry a negative electric **charge**, protons carry a positive electric charge and neutrons are electrically neutral. Normally the number of electrons is equal to the number of protons. The positive electric charge of the protons is **balanced** by the negative electric charge of the electrons and the atom is electrically neutral.
However, atoms can lose electrons. An electron, which orbits far away from the nucleus, can sometimes become **detached** from the atom and change into a 'free electron'. If an atom loses an electron it then has more protons than electrons and its positive charge becomes greater than its negative charge. An atom in this state is called a 'positive ion'.
Atoms can also **gain** extra electrons. If a free electron meets a neutral atom, it may go into the outer orbit around the nucleus. The atom now has more electrons than protons and so it has an overall negative charge. An atom in this state is called a 'negative ion'.
A current of electric energy is the result of the movement through material of free electrons passing from atom to atom.

GLOSSARY

matter: materia
spin: girare
charge: carica
balanced: equilibrato
detached: staccato
gain: guadagnare

1 **Look at the diagrams and answer the questions.**

1 What does the first diagram show?
2 Can you name the different particles?
3 In diagram B, what is happening to one of these particles?

2 1•2 **Read the passage and listen. Are the following sentences true (T) or false (F)?**

		T	F
1	The nucleus is composed of protons, neutrons and electrons.	☐	☐
2	Normally there are as many electrons as protons in an atom.	☐	☐
3	A positive ion is an atom with more electrons than protons.	☐	☐
4	A free electron is one which has become detached from an atom.	☐	☐
5	An electric current is created by the movement of negative ions.	☐	☐

3 **Summarise the key ideas. Answer the questions using your own words.**

1 What does an atom consist of?
2 What kind of electric charge do the different particles have?
3 What sometimes happens to an electron?
4 What is the result of the movement of free electrons?

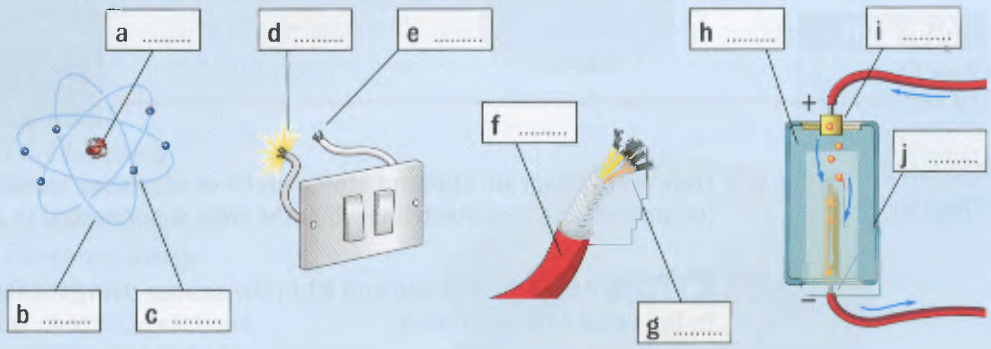
KEY WORDS

4 **Match each word (1-15) with the correct definition (a-o). Write the Italian translation of the words.**

1	☐	anode	.....	**a** A container consisting of one or more cells, in which chemical energy is converted into electricity.
2	☐	attract	.....	**b** A flow of electricity through a wire.
3	☐	battery	.....	**c** A part of an atom that has no electrical charge.
4	☐	cell	.....	**d** A particle that carries positive electricity and, together with a neutron, forms the nucleus of an atom.
5	☐	charge	.....	**e** A piece of equipment for producing electricity from chemicals, heat, or light.
6	☐	current	.....	**f** A very small piece of something.
7	☐	discharge	.....	**g** An atom which has been given a positive or negative force by adding or taking away an electron.
8	☐	electrode	.....	**h** Electricity that is not flowing in a current but collects on the surface of an object.
9	☐	flow	.....	**i** One of the two points at which electricity enters or leaves a battery.
10	☐	ion	.....	**j** The amount of electricity that an electrical device stores or that a substance carries.
11	☐	neutron	.....	**k** The positive electrode of a battery where the electric current enters.
12	☐	particle	.....	**l** To make something move towards another thing through an electrical force.
13	☐	proton	.....	**m** To move in a steady continuous stream.
14	☐	repel	.....	**n** To push something away with an electrical force.
15	☐	static	.....	**o** To send out all the electrical charge stored in a device.

5 **Label the pictures using the following words.**

1 anode
2 atom
3 cathode
4 conductor
5 electrolyte
6 electron
7 insulator
8 nucleus
9 spark
10 wire



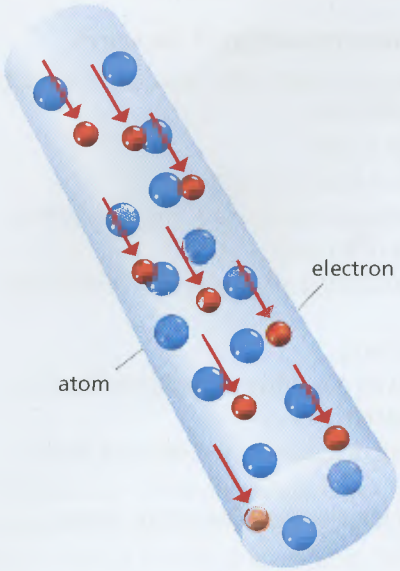
6 **Solve the anagrams (the words underlined) in the following sentences.**

1 If you leave the light on in the car, you'll gridsache the battery.
2 We couldn't hear the radio properly because of all the itcats.
3 The north pole of one magnet will leper the north pole of another.
4 Magnets tactart iron filings.
5 Electricity does not wolf through plastic or rubber.
6 When I touched the fridge door, I felt an electric greach.
7 Atoms consist of protons, nnroutes and electrons.
8 This battery consists of six lelcs.

7 **TRANSLATION** **Translate the following sentences into English.**

1 Gli elettroni portano una carica elettrica negativa.
2 L'energia elettrica è il risultato del movimento degli elettroni liberi.
3 Nel centro di ogni atomo c'è un nucleo composto di protoni e neutroni.
4 Le cariche opposte si attraggono.
5 I metalli sono buoni conduttori perché contengono un gran numero di elettroni liberi.
6 La corrente elettrica scorre attraverso il filo tra i due elettrodi.

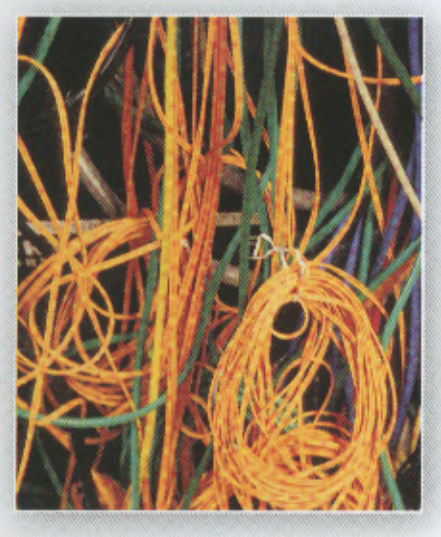
Conductors and insulators



Electric [1] ..... is the flow of electric charge through a material. Electric charge moves through some materials better than others. If electricity moves easily through a substance, the material is called a [2] ..... .

Conductors contain charged particles that are free to move through the material. In most conductors, the free particles are [3] ..... that are not attached to atoms. Metals are good conductors because they contain a large number of these free electrons. Most electric wires are made of [4] ..... , usually copper. Some liquids and gases are also good conductors. Other types of material, known as [5] ..... , resist the movement of electric charge. In insulators, electrons are held more closely to their atoms and are not [6] ..... to move around. If extra electric charge is applied to an insulator, the charge will stay in place and will not move through the material. Glass, rubber, plastic and [7] ..... are good insulators.

Insulators are important for electrical safety. Electrical cables are made from a conducting material covered with an insulating material, such as rubber or plastic. The insulator ensures that the cables are [8] ..... to touch, even when they are connected to an electricity supply. [9] ..... refers to a material's opposition to the passage of electric charges through it. Resistance occurs when electrons moving in the material collide with atoms and give up energy. This energy is converted into [10] ..... . A good conductor has low resistance, whereas insulators have high resistance.



GLOSSARY

flow: flusso
rubber: gomma
cables: cavi
supply: fornitura
collide: entrano in collisione

8 **Look at the diagram showing atoms and free electrons inside a metal wire. What happens to the free electrons when the wire is connected to a battery?**

9 1•3 **Read the passage and fill in the spaces using the following words. Then listen to the recording and check.**

wood • electrons • insulators • resistance • safe • current • conductor • free • heat • metal

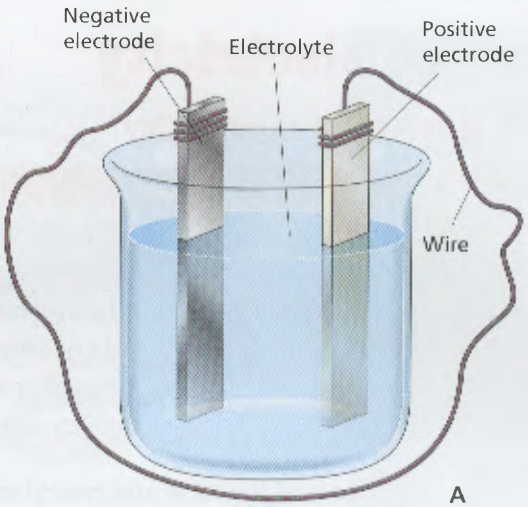
10 EXAM PRACTICE **Summarise the key ideas. Answer the questions using your own words.**

1 What is the difference between conductors and insulators?
2 What materials are good conductors of electricity? Why?
3 What materials are good insulators? Why?
4 Why are insulators important for safety?

The battery

11 **Look at picture A and fill in the missing words.**

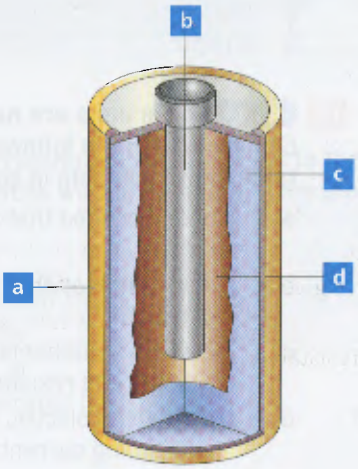
A cell transforms chemical energy into electrical energy. A simple cell consists of three basic parts: a negative[1] ..... , a[2] ..... electrode and a liquid or paste between them called the[3] ..... . The electrodes dissolve in the electrolyte and form charged atoms called ions. This creates an excess charge in the two electrodes. If they are connected by a[4] ..... , an electric current flows between them. A battery consists of two or more cells in combination, although the word is also often used to refer to a single cell.



A

12 **Look at picture B which represents a dry cell battery. Match the correct description (1-4) to each arrow (a-d).**

1 The carbon rod acts as the positive electrode (the anode).
2 The powdered carbon and manganese oxide prevents hydrogen from forming on the carbon rod.
3 The ammonium chloride paste is the electrolyte.
4 The zinc casing acts as the negative electrode (the cathode).

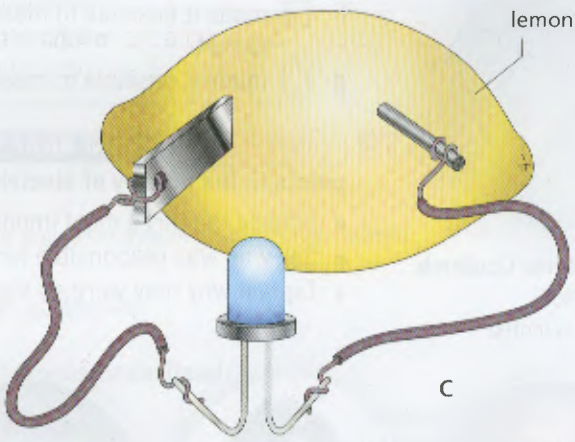


B

GLOSSARY
paste: pasta
rod: barra
casing: rivestimento

13 **Look at picture C. Put the following sentences into the correct order.**

a ☐ A positive charge builds up at one electrode and a negative charge builds up at the other.
b ☐ As a result of the chemical reactions, charged groups of atoms called ions flow through the electrolyte between the two electrodes.
c ☐ Electric current then flows through the wire between the two electrodes.
d ☐ It is possible to make a simple cell by pushing two different types of metal into a piece of fruit and connecting them with a wire.
e ☐ The acid in the fruit helps to cause chemical reactions at each electrode.
f ☐ The electric energy produced powers the small bulb.
g ☐ The metals are the positive and the negative electrodes, and the juice in the fruit, which is a weak acid, functions as the electrolyte.



C

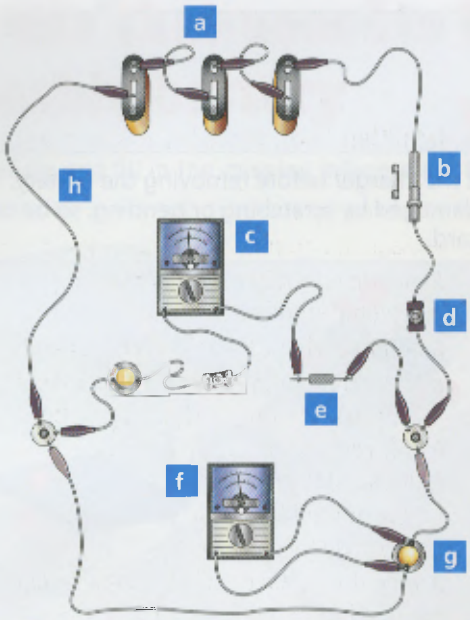
Search the Web
- youtube.com (search 'Create a lemon battery - Science Online')
- explainthatstuff.com (search 'batteries')
- batteryuniversity.com

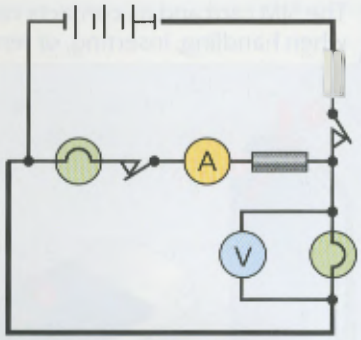
14 COMPETENCES EXAM PRACTICE **Talk to your partner. Explain how the 'lemon battery' works using your own words.**

UNIT 2

ELECTRIC CIRCUITS

A simple circuit





1 Look at the picture of the electric circuit and the corresponding diagram. Match the letters in the picture (a-h) with the correct names (1-8).

1 ☐ ammeter
2 ☐ battery
3 ☐ bulb
4 ☐ fuse
5 ☐ resistor
6 ☐ switch
7 ☐ voltmeter
8 ☐ wire

2 What function does each of these componets in the circuit have?

1 ..... - to allow, or to stop, the flow of electricity at any moment.
2 ..... - to reduce the strength of the current in one part of the circuit.
3 ..... - to provide the source of the electric energy.
4 ..... - to measure the current flowing through part of the circuit.
5 ..... - to measure the electromotive force at one point in the circuit.
6 ..... - to break the circuit if too much current flows through it.
7 ..... - to carry electric energy around the circuit.
8 ..... - to convert electric energy into light.

3 1•7 Read the text and fill in the gaps using the following words. Then listen and check.

• bulb • wire • current (x2) • resistor • fuse • switch • battery

An electric circuit is the path followed by an electric current. It consists of three basic parts: a source of electric energy, such as a [1] ..... or generator; an output device, such as a motor or bulb; and a connection between them such as a [2] ..... or cable. The electric source creates an electromotive force (emf) that causes an electric [3] ..... to flow in the circuit. The output device uses the electric energy from the source to do something useful. For example, a [4] ..... provides light and an electric motor produces mechanical motion.

A circuit may also contain other elements to control the current flowing in it. Most circuits include a [5] ..... to turn a device on and off easily. When it is off, a gap separates the connecting wires so that the current cannot complete its path. A circuit with such a gap is called an open circuit.

Some circuits have a [6] ..... or a circuit breaker. They function as automatic switches that open the circuit if too much [7] ..... flows through it. This prevents the wires from overheating and causing damage.

Sometimes it is necessary to make a current stronger or weaker, rather than simply turn it on or off. One way of doing this is to vary resistance within the circuit using a [8] ..... . The volume control on a radio, for example, operates a variable resistor, which adjusts the flow of current through the radio, making the sound louder or quieter.

GLOSSARY

path: percorso
source: fonte
device: congegno
motion: movimento
gap: spazio
damage: danno
sound: suono

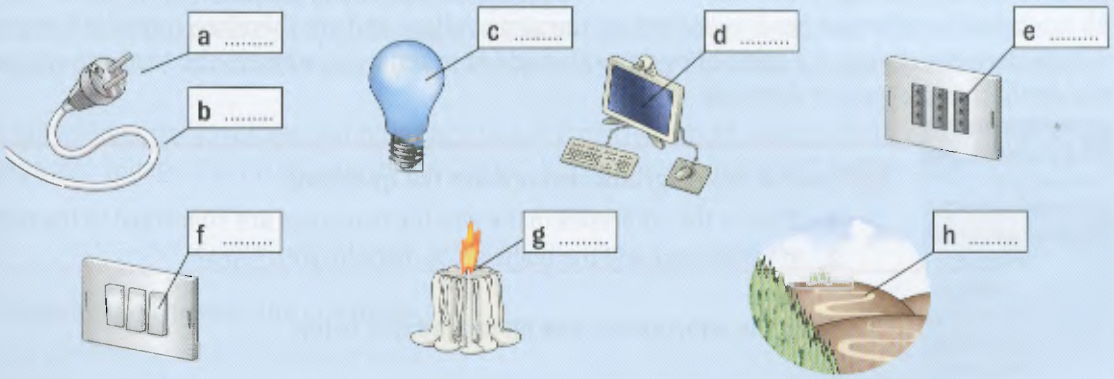
KEY WORDS

4 Match each word (1-15) with the correct definition (a-o). Write the Italian translation of the words.

1	☐	adaptor	a	A device used to oppose, to a fixed degree, the passage of an electric current.
2	☐	cable	b	A piece of equipment designed for a particular purpose.
3	☐	circuit	c	A plastic or rubber tube containing wires that carry electricity or electronic signals.
4	☐	copper	d	A point at which electric current can flow out.
5	☐	device	e	A short thin piece of wire inside electrical equipment that melts and stops the flow of electricity when the current is too strong.
6	☐	earth	f	A soft reddish-brown metal which is a good conductor and is used to make electrical wires.
7	☐	fuse	g	A type of plug that makes it possible to connect more than one appliance to the same.
8	☐	leak	h	A wire that makes a piece of electrical equipment safe by connecting it to the ground.
9	☐	mains	i	An elastic substance which is a good insulator.
10	☐	outlet	j	The amount of electricity produced by a battery or generator.
11	☐	output	k	The complete circle that an electric current travels.
12	☐	overload	l	The place where something originates.
13	☐	resistor	m	The system of wires which carries electricity into a building.
14	☐	rubber	n	To allow liquid or gas to escape through a small opening.
15	☐	source	o	To put too much electricity through an electrical circuit.

5 Label the pictures using the following words.

1 bulb
2 flex
3 melt
4 path
5 plug
6 screen
7 socket
8 switch



6 Solve the anagrams and write the correct name under each symbol.

1 lubb 2 sufe 3 storiesr 4 lelc 5 heart 6 removeltt 7 hitswc

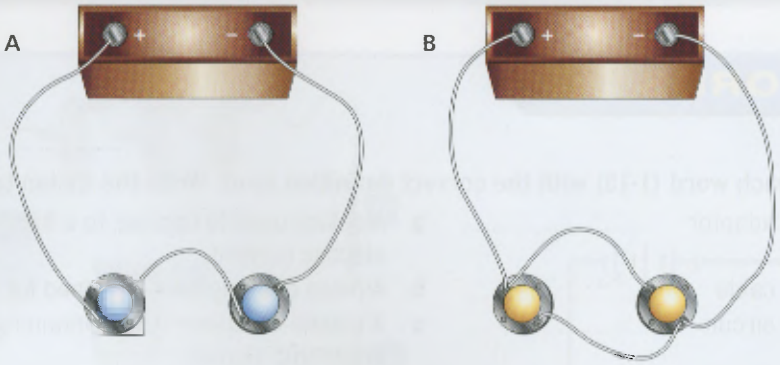
....

7 Insert the names of the electrical units into the correct definitions.

• amp • coulomb • joule • ohm • volt • watt

1 One ..... is a current of 6 million million million electrons per second.
2 One ..... is the electrical force needed to drive 1 amp through a resistance of 1 ohm.
3 One ..... is the resistance of a conductor carrying 1 amp of current when the potential difference across the conductor is 1 volt.
4 One ..... is the electrical charge transmitted by a current of 1 amp in 1 second.
5 One ..... of electrical energy is used every second when a current of 1 amp flows through a resistance of 1 ohm.
6 One ..... is equal to a rate of 1 joule per second.

Types of circuit



Simple electric circuits can be classified into two types: series and parallel. In practice most electrical devices have complex circuits consisting of both series and parallel components.

A **series circuit** uses a single path to connect the electric source to the output device. It is found in very simple equipment such as a torch or Christmas tree lights. These circuits have limited uses because any change in one circuit part affects all the circuit parts. If one light bulb in a series circuit burns out, it opens the circuit and all the other bulbs also go out.

The voltage provided by a group of electric sources connected in series is the sum of their individual voltages. But the same amount of current flows through each source and output device. For example, each battery in a two-battery torch supplies one and a half volts, and the two together supply 3 volts. The same amount of current flows through each battery and the bulb. Electric sources are connected in series to provide more voltage than one source alone can produce.

A **parallel circuit** provides more than one path for current. After current leaves a source, it follows two or more paths before returning to the source. If two identical torch bulbs are connected in parallel, current flows from a battery through each lamp individually and then back to the battery. Either bulb may be removed from the circuit without breaking the circuit for the other bulb.

Parallel circuits provide the same voltage for every source and output device in the circuit. For example, two one-and-a-half-volt torch batteries connected in parallel provide an emf of one-and-a-half volts. Electrical sources are connected in parallel to provide more current than one source can produce.

All household appliances need to operate on the same voltage and are therefore connected in parallel. The voltage does not change if a piece of equipment is added or removed whereas the total current passing through the circuit may increase or decrease.

GLOSSARY

household appliances: elettrodomestici

8 **Look at the diagrams and answer the questions.**

1 What is the difference in the way the two bulbs are connected to the battery?
2 In which case will the bulbs shine more brightly? Why?

9 **Read the information and fill in the table below.**

	Series circuit	Parallel circuit
number of paths		
voltage		
current		

10 **Does each of the following sentences refer to a series circuit (S) or a parallel circuit (P)?**

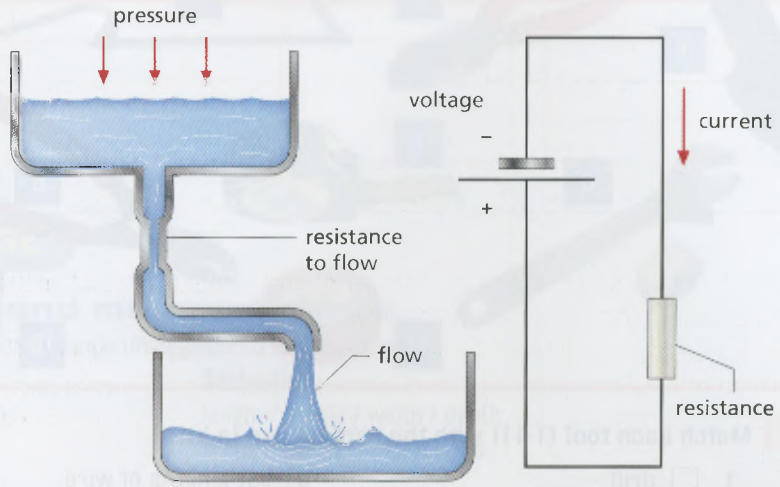
	S	P
1 An additional electric source increases the total voltage.	☐	☐
2 The circuit is not broken if you remove one of the outlet devices.	☐	☐
3 The voltage is divided up between the outlet devices.	☐	☐
4 Each device has the entire voltage running across it.	☐	☐
5 There is only one path for the current to follow.	☐	☐
6 The current can flow along alternative paths.	☐	☐
7 The voltage remains the same but the amount of current may vary.	☐	☐

Search the Web

- youtube.com (search 'Electricity and circuits - Science Online')

11 COMPETENCES EXAM PRACTICE **Talk to your partner. Explain the differences between a series and a parallel circuit.**

Current, voltage and resistance



The flow of electric current through a circuit depends on two factors: the emf and the resistance of the circuit. The electric circuit can be compared to a plumbing system. If the current flow is equivalent to a flow of water through the system, then the emf of the battery (in volts) is equivalent to the water pressure in the top tank (in kilograms per square metre). The flow of current (in amperes) in the circuit is equivalent to the flow of water in the pipe (in litres per minute).

There is a restriction in the pipe that limits the flow. The amount of water that can flow out of the end of the pipe depends on the size of this restriction: if it is very thin, only a little water can flow out. In the electrical system, the equivalent of the restriction is a component called a resistor. The resistor has a greater resistance (measured in units called ohms) to the flow of current than the wires, just as the narrow part of the pipe resists the flow of water more than the rest of the pipe. Without the resistor, a much larger current would flow in the circuit, just as more water would flow out of an unrestricted pipe.

There is a relationship between pressure (emf), flow (current) and the size of the restriction (resistance). For example, if the water pressure were increased, you would expect a greater flow through the same restricted pipe.

The relationship between current, voltage and resistance was first discovered by Georg Ohm in 1827. Ohm's Law (V = IR) states that voltage V (in volts) equals the current I (in amperes) multiplied by the resistance R (in ohms).

GLOSSARY

plumbing system: impianto idraulico
pressure: pressione
tank: serbatoio

12 **Look at the diagram and answer the questions.**

1 What is the electric circuit being compared to?
2 What similarities are there between the two systems?

13 **Read the passage and fill in the table below with the corresponding elements of the electric system.**

Plumbing system	Electric system
water pressure in tank (kg per square metre)	.....
water flow (litres per minute)	.....
restriction in pipe	.....

14 **COMPETENCES** **Work out the answers to the following problems using Ohm's Law.**

1 What is the electric current flowing in a circuit which has a 12 volt battery and a resistor of 100 ohms?
2 What voltage is necessary to send a current of 4 amps through a resistance of 1.5 ohms?
3 What is the resistance in a circuit which has a 3 volt battery and a current of 0.6 amps?

Tools

15 Match each tool (1-11) with the correct use (a-k).

1	☐ drill	a	cut lengths of wire
2	☐ pliers	b	cut pieces of metal
3	☐ hacksaw	c	hold and manipulate wire or small objects
4	☐ screwdriver + screw	d	insert and remove screws
5	☐ soldering iron + solder	e	insulate electric wires
6	☐ spanner + nut	f	make holes
7	☐ tape measure	g	measure the dimensions of an object
8	☐ wire strippers	h	melt solder and join pieces of metal
9	☐ wire cutters	i	protect the eyes
10	☐ safety goggles	j	remove the insulation from a wire
11	☐ insulating tape	k	turn nuts and bolts

GLOSSARY
plug: spina
breadboard: piastra per montaggio di circuiti elettronici
ceiling: soffitto

16 COMPETENCES **What tools would you probably need to do the following jobs? Why?**

1 changing the plug on an electrical appliance
2 building an experimental circuit on a breadboard
3 fitting a fluorescent light onto a ceiling

KEY LANGUAGE

Describing purpose

Le strutture più comuni per descrivere a che cosa serve uno strumento sono *to do* e *for doing*.

➡ *You can use a circuit continuity tester* ***to check*** */* ***for checking*** *the continuity of circuits.*

17 COMPETENCES EXAM PRACTICE **Describe an activity or experiment that you have done using some of the tools mentioned above.**

1 What was the purpose of the activity / experiment?
2 What tools did you use?
3 What did you use each tool for?

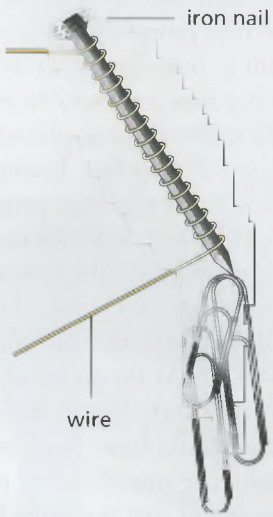
18 1•8 **Listen to the dialogue between a customer and an assistant in a DIY (Do-It-Yourself) store. Tick the photographs showing the things the customer buys.**

UNIT 3

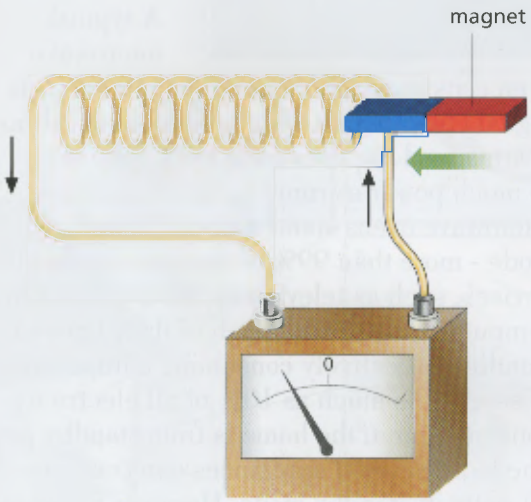
ELECTROMAGNETISM AND MOTORS

Electricity and magnetism

A



B



1 Look at diagrams A and B. What basic principles do they demonstrate?

2 1•12 Read the passage and fill in the gaps using the following words. Then listen to the recording and check.

current • wire • magnetic • generators • repel • poles • electromagnetism • voltage • field • magnets

Electricity and magnetism were originally studied separately. But we now know that they are both manifestations of a single force,[1] ..... , one of the fundamental forces of nature.

Just as an electric field surrounds an electric charge and produces a force that affects other charges, so a[2] ..... field surrounds a magnet and produces forces that act on other[3] ..... . Like an electric charge, a magnet will attract or[4] ..... another magnet.

Electromagnetism is based on the fact that the motion of electric charges can produce magnetic fields, and changing magnetic fields can produce electric currents. For example, passing an electric current through a coil of[5] ..... makes the coil a temporary magnet called 'an electromagnet'. The electric current creates a magnetic[6] ..... around the coiled wire. As long as the current flows, the coil is a magnet. If the direction of the current changes, the north and south[7] ..... of the electromagnet change places.

Magnetism can, in turn, produce an electric[8] ..... by means of electromagnetic induction. A magnet moving through a coil of wire, for example, causes the[9] ..... to vary from point to point along the wire. An electric current flows along the wire as long as the magnetic field passing through the wire is changing.

[10] ..... produce electric current through this process.

3 EXAM PRACTICE Look at the diagrams again and talk to your partner. Answer the questions using your own words.

1 What is the connection between electricity and magnetism?
2 What happens to the iron nail when an electric current passes through the wire?
3 What happens to the coil of wire when a magnet is moved inside it?

Search the Web

youtube.com (search 'Electromagnetism - Science Online')

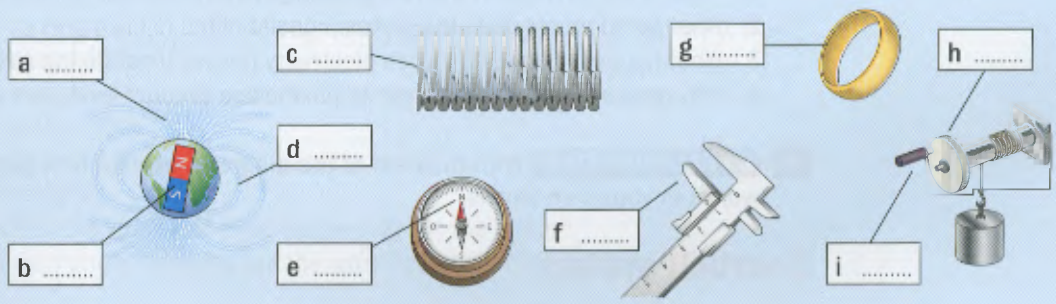
KEY WORDS

4 **Match each word (1-15) with the correct definition (a-o). Write the Italian translation of the words.**

1 ☐ armature	.....	a	A device consisting of a cylindrical coil of wire surrounding a moveable iron core.
2 ☐ brake	.....	b	A piece of equipment that makes a machine or vehicle go more slowly or stop.
3 ☐ button	.....	c	A piece of metal that becomes magnetic when an electric current passes through it.
4 ☐ commutator	.....	d	A small, circular object which you press to operate a device or a machine.
5 ☐ drive shaft	.....	e	An attachment making an electrical connection to the armature of a motor or generator and enabling the current to flow as direct current.
6 ☐ electromagnet	.....	f	An elastic device, usually a metal coil, used to exert constant pressure.
7 ☐ engine	.....	g	An instrument for measuring the size or amount of something.
8 ☐ feed (past fed)	.....	h	The amount of weight to carry or work to do.
9 ☐ gauge	.....	i	The central part of a wheel.
10 ☐ hub	.....	j	The part of a generator or motor that rotates producing either electricity or movement.
11 ☐ load	.....	k	The part of a motor which carries the mechanical energy produced by the motor so that it can be put to use.
12 ☐ rotate	.....	l	The part of a vehicle that produces power to make it move.
13 ☐ solenoid	.....	m	To provide a regular supply of something.
14 ☐ spring	.....	n	To turn something, such as wire, repeatedly around something else.
15 ☐ wind (past wound)	.....	o	To turn with a circular movement around a central point.

5 **Label the pictures using the following words.**

1 coil
2 compass
3 gauge
4 handle
5 magnet
6 magnetic field
7 pole
8 pulley
9 ring



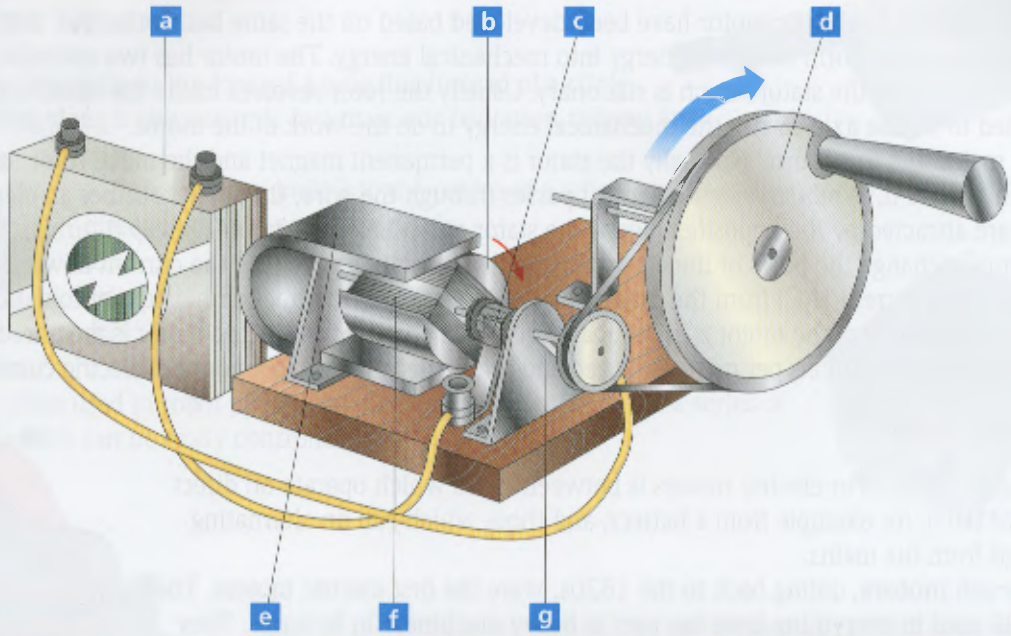
6 **Solve the anagrams (the words underlined) in the following sentences.**

1 The rediv hafts connects the engine to the wheels.
2 The wire is downu into circles to make a coil.
3 This pulley can lift a doal of up to a ton.
4 When the turmarea starts to rotate it produces electricity.
5 A motor working with alternating current does not need a courtatomm.
6 A battery is used to deef electricity into the system.
7 Press on the baker to slow the car down.

7 **TRANSLATION** **Translate the following sentences into English.**

1 Campi magnetici variabili possono produrre correnti elettriche.
2 La corrente continua scorre soltanto in una direzione.
3 Quando la corrente elettrica passa per la bobina, l'indotto si trasforma in elettrocalamita.
4 Come una carica elettrica, una calamita attrae o respinge un'altra calamita.
5 Il movimento di cariche elettriche può produrre campi magnetici.
6 I motori di molti elettrodomestici funzionano con la corrente alternata.

The electric motor



11 **Look at the diagram and answer the questions.**

1 What does the diagram show?
2 What happens when the battery is connected?

12 **Match the letters in the diagram (a-g) with the following descriptions (1-7).**

1 ☐ **armature** - a cylinder with a coil of wire wound around it, which becomes an electromagnet and rotates
2 ☐ **permanent stationary magnet** - establishes a constant magnetic field which causes the armature and its coil of wire to rotate
3 ☐ **commutator** - a ring divided into two segments which changes the direction of the current after each half turn
4 ☐ **drive shaft** - connected to the armature, it carries the mechanical energy produced by the motor to the pulley
5 ☐ **coil of wire** - when electrical current passes through it, it transforms the armature into an electromagnet
6 ☐ **battery** - provides the source of electrical energy for the motor
7 ☐ **pulley** - turns the handle, carrying out the work required from the motor

13 1·13 **Put the following sentences into the correct order to describe how the motor works. Then listen to the audio CD to check.**

a [2] A battery feeds direct current into the coil.
b ☐ The continuous turning motion of the armature drives the motor.
c ☐ The current is reversed every half-turn by an attachment called a commutator.
d ☐ A simple electric motor consists of a cylindrical armature, with a coil wound around it, which is positioned between the north and south poles of a permanent magnet.
e ☐ The permanent magnetic field interacts with the magnetised armature forcing it to rotate, as the north pole of the permanent magnet attracts the south pole of the armature.
f ☐ This has the effect of reversing the north and south poles of the armature thus keeping it in a state of rotation.
g ☐ This produces a magnetic field around the coil transforming the armature into an electromagnet.

14 COMPETENCES EXAM PRACTICE **Talk to your partner. Use the diagram to explain, in your own words, how a simple electric motor works.**

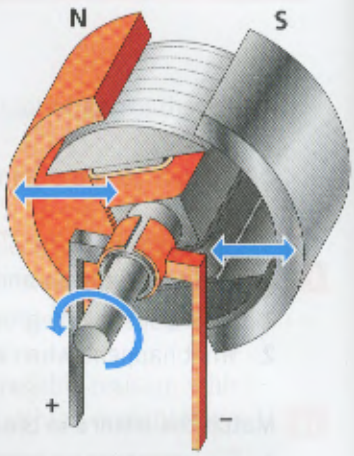
Types of electric motor

Many varieties of electric motor have been developed based on the same basic principle: they use the force of magnetism to transform electrical energy into mechanical energy. The motor has two essential parts: the rotor which moves and the stator which is stationary. Usually the rotor revolves inside the stator and turns an axle attached to it. The axle carries the mechanical energy to do the work of the motor.

What makes the rotor turn? Normally the stator is a permanent magnet and the metal rotor has coils of wire wound around it. When an electric current passes through the wire, the rotor becomes an electromagnet. Its poles are attracted by the opposite poles of the stator and it begins to turn. To keep it turning it is necessary to continually change the poles of the electromagnet by constantly reversing the current flowing through the wire. If alternating current (AC) from the mains is used, this reversal in direction happens automatically.

The turning power of the motor is called the torque. The power of an electric motor is measured in watts and the speed in rpm (revolutions per minute). Speed and torque depend on the amount of electric current and voltage.

DC Motors

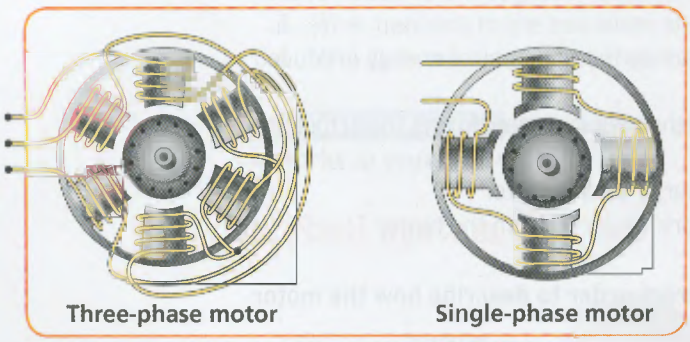


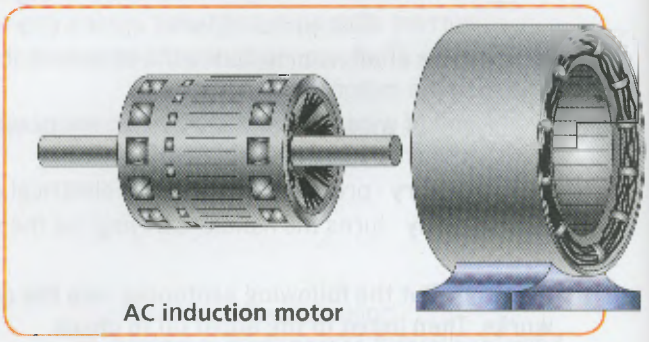
The main division in electric motors is between those which operate on direct current (DC), for example from a battery, and those which run on alternating current from the mains.

DC brush motors, dating back to the 1820s, were the first electric motors. They are still used in everything from toy cars to heavy machinery in factories. They are very adaptable for varying combinations of speed and torque. Their ability to produce high torque at low speed makes them particularly useful for railway locomotives. However, the use of DC means that they have to incorporate a commutator to continually reverse the direction of the current and keep the rotor turning. The commutator uses brushes to make contact with the rotor and these eventually become worn down and have to be replaced. They may also create sparks making the motor dangerous to use in certain environments.

The **brushless DC motor** (**BLDC**) eliminates the need for a commutator and brushes. It uses an electronic switching circuit to continually reverse the direction of the electric current.

AC Motors





AC motors were developed when electricity from the mains, based on alternating current, became available in the early 20th century. The use of AC means that the direction of the flow inside the motor's electromagnet is automatically reversed and so there is no need for a commutator and brushes. This makes the AC motor simpler and more convenient. The speed of the motor depends on the frequency of the AC current.

The **AC induction motor** is commonly used for household appliances like washing machines and fans. It is inexpensive, reliable and requires little maintenance. In this motor the stator, not the rotor, has the electric windings connected to the electricity supply. The stator induces an electric current in the rotor to make it an electromagnet. At the same time it creates a rotating magnetic field which pulls the rotor around.

A **three-phase AC motor** is a more powerful version for use in heavy machinery. It has three different windings, each connected separately to the electricity supply.

A **synchronous AC motor** operates in a similar way to an induction motor but it is more complex and specially designed to maintain a very consistent speed. This makes it suitable for use in devices like clocks, CD players and computer hard drives. It is not suitable for operations requiring high torque.

GLOSSARY

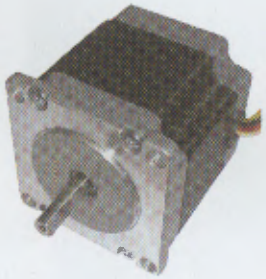
brush: spazzola
worn down: consumati
sparks: scintille
fans: ventilatori

Design variations

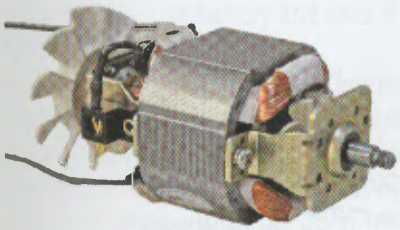
There are many variations in the design of electric motors so that they can be used for particular applications.

A **linear motor** has the stator in the form of a long line instead of a circle with the rotor moving along it (for example in a magnetic levitation railway line).

A **hub motor** is built into the centre of a wheel and uses the rotor to turn the wheel directly without needing an axle.



A **stepper motor**, often used in robot operations, allows movement through a series of precise small steps which can be easily controlled by a computer.



A **universal motor** can work with both AC and DC current.

15 **Read the information and find the names for the following definitions:**

1 The part of an electric motor which turns. .....
2 The part of an electric motor which remains stationary. .....
3 The part of a motor which carries the mechanical energy to do the work. .....
4 The turning power of a motor. .....
5 The unit used to measure the power of a motor. .....
6 The part connecting the commutator to the rotor. .....

16 COMPETENCES **Match the name of each application (1-9) with a suitable motor type (a-i). Give a reason in each case.**

1 ☐ battery-operated machine near flammable material
2 ☐ computer hard drive
3 ☐ electric vehicle with no central axle
4 ☐ heavy machinery running on mains electricity
5 ☐ household washing machine
6 ☐ machine which needs to work from mains or battery
7 ☐ magnetic levitation train line
8 ☐ railway locomotive
9 ☐ robot

a AC induction motor
b brushless DC motor
c DC brush motor
d four hub motors
e linear motor
f stepper motor
g synchronous AC motor
h three-phase AC motor
i universal motor

17 **Explain why...**

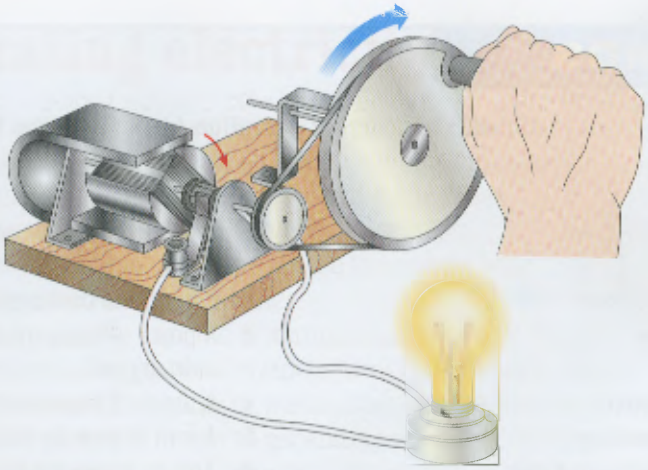
1 the rotor in an electric motor turns.
2 a DC motor needs a brush.
3 an AC motor does not need a brush.
4 a DC brush motor can be dangerous.
5 a brushless DC motor does not need a commutator or brush.
6 AC motors only became common in the early 20th century.
7 a three-phase motor is more powerful.
8 a synchronous AC motor is unsuitable for applications requiring high torque.

18 COMPETENCES EXAM PRACTICE **Give a summary of the main types of electric motor and the differences between them.**

Search the Web

- howstuffworks.com (search 'How electric motors work')
- explainthatstuff.com (search 'Electric motors')
- youtube.com (search 'How electric motors work')

The generator



10 Look at the diagram of a simple generator. Match the beginning of each sentence (1-7) with the correct ending (a-g).

1 ☐ A generator transforms mechanical energy
2 ☐ It is based on the principle of
3 ☐ The generator uses the same basic equipment as
4 ☐ Turning the handle of this simple generator causes
5 ☐ As the coil of wire moves in the magnetic field,
6 ☐ The direction of the current in the wire reverses every half-turn because
7 ☐ However the current that passes through the bulb flows only in one direction because

a a coil rotating in a magnetic field.
b an electric current is induced inside it.
c each side of the coil alternately passes up and down through the magnetic field.
d into electrical energy.
e the armature to rotate between the poles of the permanent magnet.
f the commutator changes the connections every half-turn.
g the electric motor: an armature, a coil, a permanent magnet and a commutator.

11 Compare this diagram of a generator with that of the electric motor (page 35). What similarities and differences are there?

12 COMPETENCES EXAM PRACTICE Talk to your partner. Explain in your own words how a simple generator works.

KEY LANGUAGE

Prepositions

13 Look at the diagram of the generator and choose the correct preposition.

1 A wooden base lies *behind* / *between* / *under* the generator.
2 A lamp is positioned *above* / *next to* / *along* the generator.
3 An electric current runs *along* / *across* / *behind* the wire from the generator to the lamp.
4 The north pole of the magnet is *in front of* / *opposite* / *across* the south pole.
5 A wire is wound *around* / *through* / *under* the cylinder of the armature.
6 The armature rotates *above* / *around* / *between* the two poles of the magnet.
7 The drive shaft passes *through* / *across* / *around* a hole to connect the handle with the generator.
8 A belt runs *in front of* / *around* / *along* the wheel of the handle.
9 The drive shaft transfers energy *opposite* / *around* / *from* the handle to the generator.