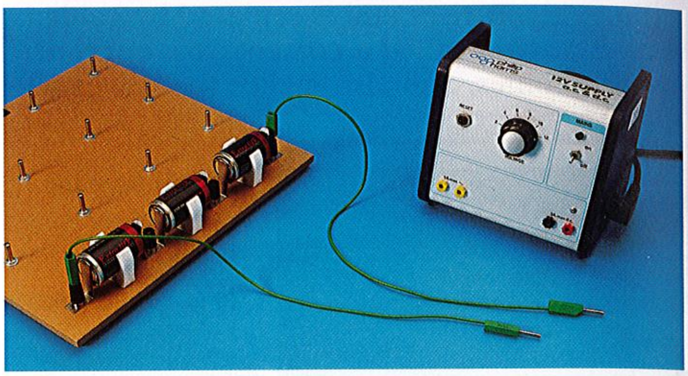
7Ja Live and dangerous!

How can we use electricity safely?

Electricity is very useful, but it can also be very dangerous if it is not used properly.

Electricity experiments at school are safe because we use **cells** or **power packs** that provide a **low voltage**.

These appliances all use mains electricity.



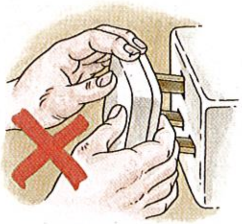
Several cells used together are called a battery.

Lights use **mains** electricity, and so do things like cookers and televisions. Mains electricity has a higher voltage than cells, and can be dangerous.

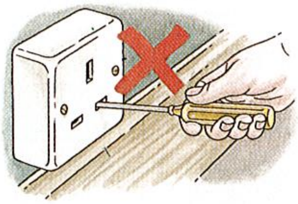
1 Write down five things at home that use cells.

2 Write down five things at home that use mains electricity.

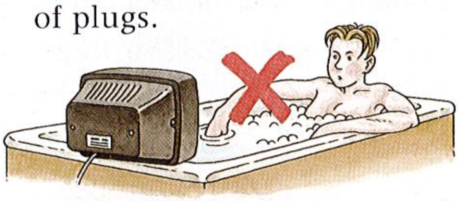
General safety rules



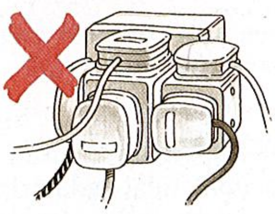
- Never touch the bare metal parts of plugs.



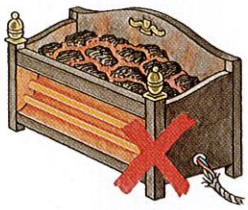
- Never poke things into sockets.



- Keep electricity away from water.



- Do not plug too many things into one socket.



- Never use something that has a damaged wire.

Safety rules in science lessons

- Show your circuits to your teacher before switching them on.
- Never try to invent your own circuit.
- If you change your circuit, always switch the electricity off first.

3 Write down five things you should remember to stay safe when using electricity at home.

4 Design a poster to remind people how to use electricity safely at school.

You should know...

- **The rules for using electricity safely at home and at school.**

7Ja Switched on

What is an electric circuit?

Anything that uses electricity has to have:
- something to make the electricity flow (e.g. a cell)
- a complete **circuit** for the electricity to flow around.

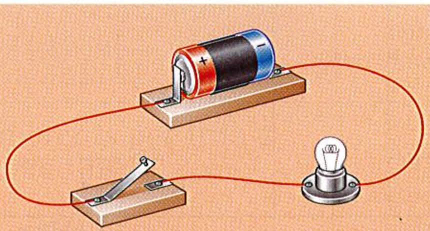
The moving electricity is called an **electric current**.

Small things like personal stereos or torches do not need much energy, and cells can be used to make the electricity flow. Larger appliances, like kettles, need to be plugged into the mains supply (where a far off power station has generated the electricity).

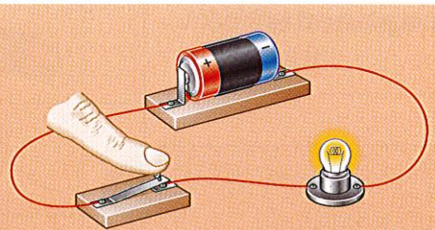
A circuit is a complete loop that an electric current can flow around. If there is a gap in the circuit the current cannot flow.

1 Write down two things that you need to make something work using electricity.

Stephen Gray (1666–1736), a British chemist, was the first person to discover that electricity can flow through wires. He carried out his experiment in 1729.



We can control electricity using a **switch**. This switch is open so there is a gap in the circuit and the current cannot flow.



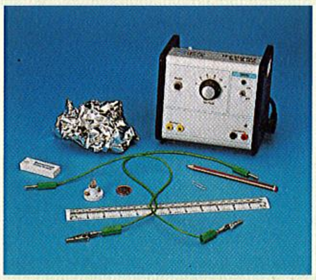
When we close the switch there is a complete circuit for the current to flow around and the bulb lights up.

Not all materials can be used to build a circuit. An electric current can only flow through some materials, called **electrical conductors**. **Metals** are good electrical conductors. Materials which do not conduct electricity are called **electrical insulators**. Plastic, wood and air are all good insulators. A good insulator is a poor conductor.

2 Why are electrical wires made of metal?

3 Why are electrical wires usually covered in plastic?

How could you show that some materials conduct electricity and some do not?
- What apparatus and materials would you need?



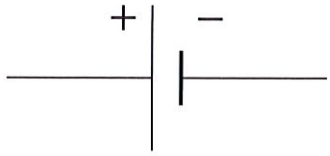
You should know...
- What an electric circuit is.
- Circuits can be controlled using switches.
- Metals conduct electricity.
- Plastic, wood and air are all insulators.

7Ja Circuit diagrams

How do we draw electric circuits?

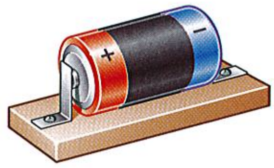
We use special symbols to draw electrical circuits because it is easier for people to understand the circuit. It is also easier to draw circuits with symbols.

It is much easier to draw this:



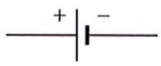
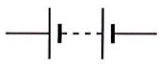
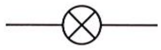
the symbol for a cell

than this:



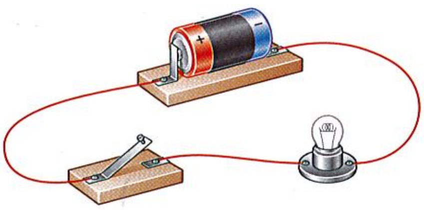
a cell

These are some of the symbols we use when we draw electrical circuits. Things in circuits, like switches and bulbs, are called **components**.

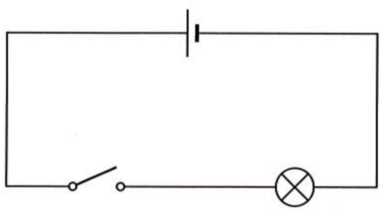
Component		Symbol
	cell	 *
	battery (two or more cells)	
	wire	
	bulb	
	switch	

* We do not always put the + and – signs on, but the long part of the symbol always represents the + end of the cell.

This circuit:



would be drawn like this:



1 Why do we use circuit symbols?

2 Draw neat copies of the symbols for a bulb, a cell, a wire, and a switch.

You should know...

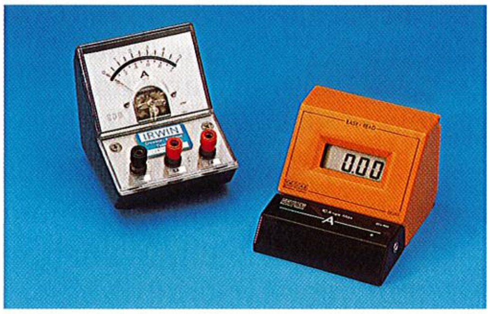
- **The symbols for bulbs, cells and switches.**

7Ja Current affairs

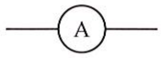
How do we measure electricity?

The **current** is the amount of electricity that is flowing around a circuit. A large current in a circuit makes bulbs bright. A small current gives dim bulbs.

We measure the current using an **ammeter**. The units for current are **amps** (**A**).



Different kinds of ammeter.



This is the symbol for an ammeter.

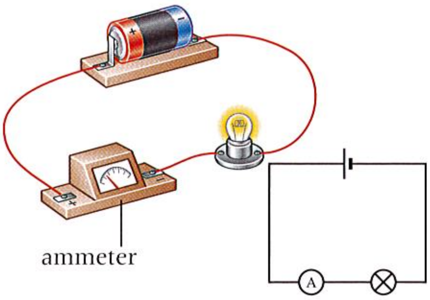
The unit for current is named after André-Marie Ampère (1775–1836) who was the first scientist to build a machine to measure the flow of electricity.

1 What does an ammeter measure?

2 Draw the symbol for an ammeter.

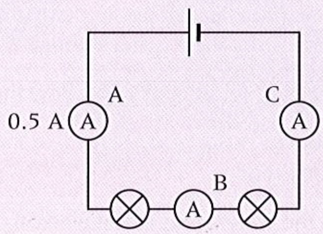
How would you find out whether it matters where you put the ammeter in a circuit?

An ammeter is put into a circuit like this:



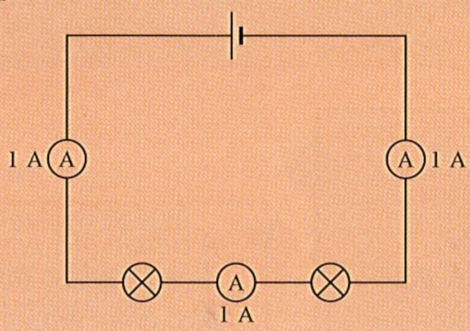
3 a) What current would ammeter B show?

b) What current would ammeter C show?



It does not matter where the ammeter goes in the circuit. The current is the same everywhere.

Current is not used up as it goes around the circuit. The bulbs light up because the current carries energy to the bulbs. The energy that the current carries is used up, not the current itself.



You should know...

- **The size of the current is measured using an ammeter.**
- **Current is not used up as it flows around a circuit.**

7Jb Go with the flow

How much current will flow around a circuit?

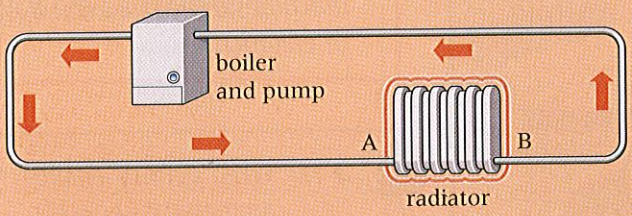
All materials are made of tiny particles called **atoms**, and all atoms have even smaller particles called **electrons** inside them. In some materials the electrons can move around easily. An **electric current** is a flow of electrons, and carries **electrical energy**.

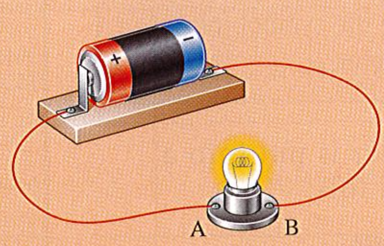
Metals are conductors because the electrons can move around easily inside them. Electrons cannot move around inside insulating materials.

It is difficult to think about electrons, because they are too small to see, even with a very powerful microscope. We can use a **model** to help us to think about electricity.

> **1** What is an electric current?

> **2** Why are metals conductors?

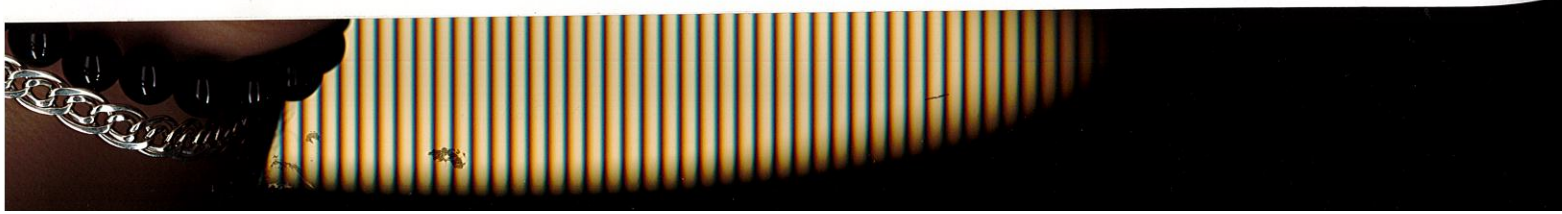




Central heating model	Electricity in a circuit
A central heating system can keep your house warm.	This circuit can provide light energy.
The boiler transfers heat energy to the water, and a pump pushes the water through the pipes.	The cell transfers energy to the electrons and pushes them through the wires.
The pipes let the hot water flow through them.	The wires are good conductors and let electrons flow through them.
In the radiator, heat energy is transferred from the hot water to the room.	In the bulb, electrical energy is transferred to the room as light and heat energy.
All the water stays in the pipes. If you measured the amount of water *flowing*, you would get the same reading at A and B. But the water at B would have less heat energy than the water at A.	All the electrons stay in the wires. If you measure the current (the amount of electricity *flowing*) you get the same reading at A and B. The current at B has less energy.

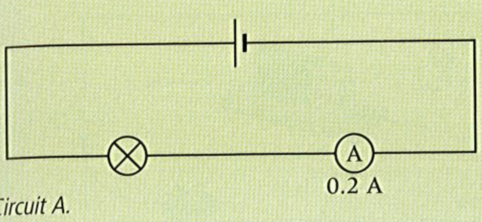
> **3** Why do we need to use a model to help us to think about electricity?
>
> **4** Using the model to help you, explain:
> a) why a central heating boiler is like a cell
> b) why a radiator is like a light bulb.

> *A current of 1 amp means there are 6 250 000 000 000 000 000 electrons going past every second.*



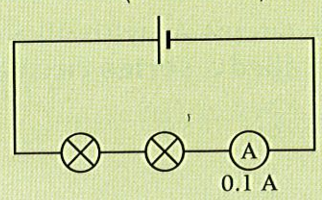
ou can change the current in a circuit by
hanging the components in the circuit.

Circuit A has one bulb, and the current is 0.2 A.



Circuit A.

If you add another bulb, the current drops to 0.1 A (circuit B).



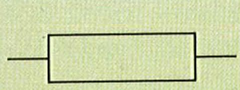
Circuit B.

t is quite difficult for the current to flow through a circuit vith a bulb in it. The current has to flow through a very thin iece of wire called the **filament**. If there are two bulbs in he circuit, it is even more difficult for the current to get round the circuit, so the current is smaller.

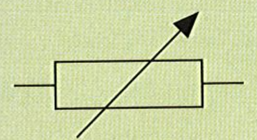
omponents (including bulbs) which make it more difficult or a current to flow around a circuit have a high **resistance**. omponents which do not make it difficult for the current to low have a low resistance.

> **P** How could you find out whether a long wire or a short wire has the highest resistance?
> - What equipment would you need?

ometimes we only need a very small current n a circuit. We can make the current smaller y using a **resistor** in the circuit. A resistor as a high resistance, and makes it harder for lectricity to flow. **Variable resistors** can be djusted to change their resistance.

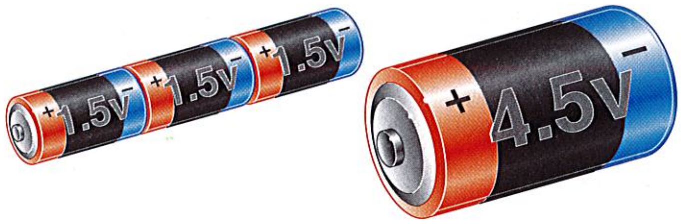


This is the symbol for a resistor.



This is the symbol for a variable resistor.

The current in a circuit can also be changed by changing the **voltage**. A cell has a voltage marked on it. Cells with high voltages will produce bigger currents. You can put cells together in a circuit to get a bigger voltage.



These cells give the same voltage… Notice how cells are connected + to –. *… as this cell.*

The chemicals inside the cell provide the voltage.

You should know…

- Current is a flow of electrons.
- Current transfers energy provided by cells.
- Resistance is a way of saying how easy it is for current to flow through something.

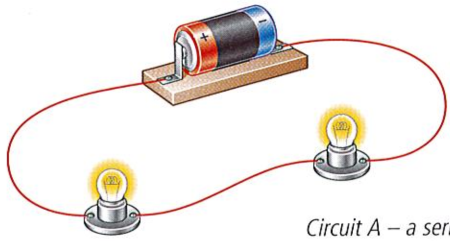
?

5 Look at the circuits at the top of the page.
  a) What would happen to the current if you put another bulb into circuit B?
  b) Which has the highest resistance, circuit A or circuit B? Explain your answer.

7Jc Series and parallel

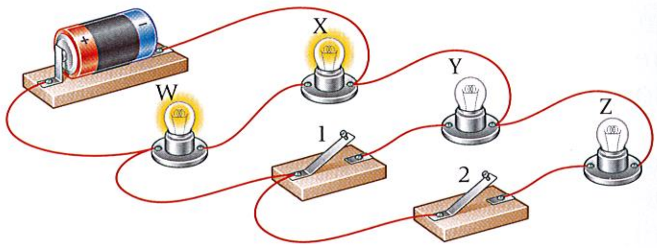
What are the differences between series and parallel circuits?

A circuit like circuit A, with all the bulbs in one loop, is called a **series** circuit.



Circuit A – a series circuit.

If the bulbs are on separate branches of a circuit, it is a **parallel** circuit. A parallel circuit can have lots of branches. Each branch can have more than one **component** in it.

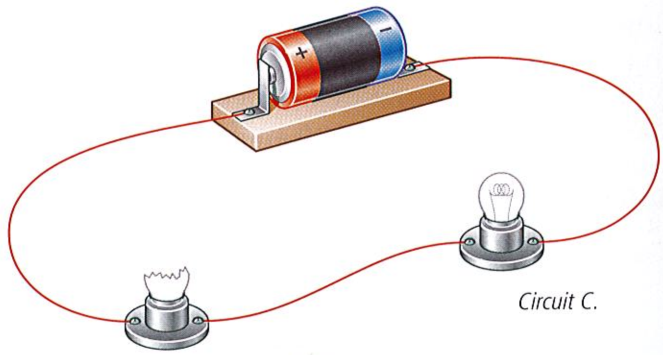


Circuit B – a parallel circuit.

> **?** **1** What is the difference between a series and a parallel circuit?

In a series circuit, all the bulbs light together. If one bulb breaks there is a gap in the circuit, so no current can flow. The other bulbs will not work (circuit C).

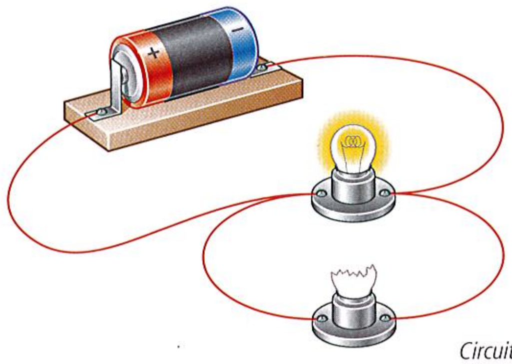
In a parallel circuit, the current can flow along each branch. Even if one bulb is broken, the others still work (circuit D).



Circuit C.

Parallel circuits are useful because each light can be switched on and off separately from the others.

In circuit A, both bulbs are on all the time. In circuit B, bulbs W and X are on all the time. Bulb Y only comes on if you press switch 1. If you want all the bulbs to come on you have to press both switches.

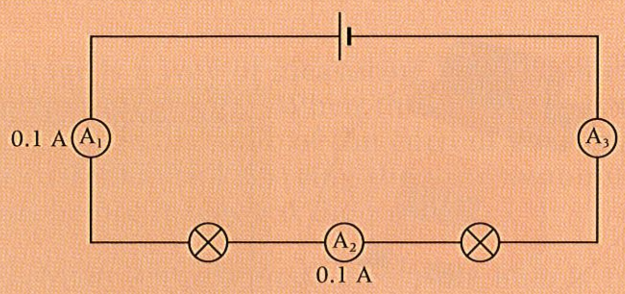
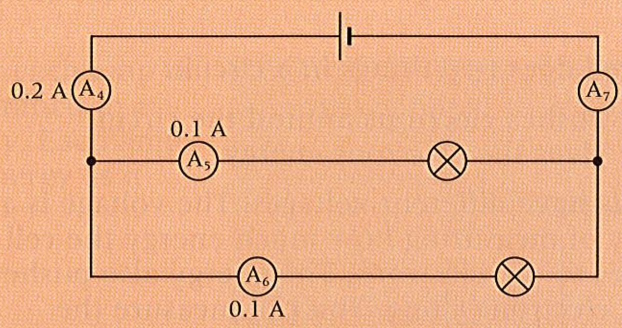


Circuit D.

> **P** How would you investigate what happens to the brightness of bulbs if you put more of them into a series circuit?
> - What happens when you add bulbs to a parallel circuit?

> **?** **2** Do you think the lights in your house are on a series or a parallel circuit? Explain your answer.

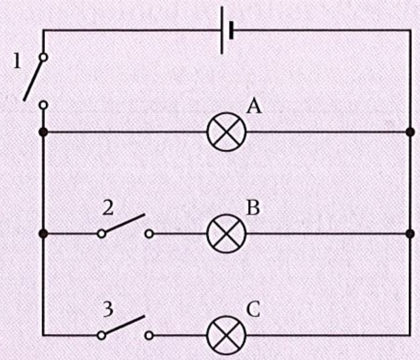
These diagrams show two different circuits with ammeters and bulbs.

Series circuit	Parallel circuit
	
Series circuit	**Parallel circuit**
The current is the same everywhere.	The current splits up when it comes to a branch. The current in all the branches adds up to the current in the main part of a circuit.
If you put more bulbs in they will be dimmer, because it is harder for the current to get through. The resistance of the circuit is higher.	If you add more branches with bulbs in, all the other bulbs stay bright. It is easier for the current to flow with more branches, because there are more ways for the electrons to go.
If one bulb breaks, all the others go off.	If one bulb breaks, the bulbs in the other branches stay on.
3 What will the reading be on ammeter 3?	**4** What will the reading be on ammeter 7?

5 Look carefully at this circuit:

a) Which switches have to be closed for bulb A to come on?

b) Which bulbs will come on if you press switches 1 and 3?



6 Mrs Jones has some Christmas tree lights, and one bulb is broken. They will not come on until she has replaced the bulb.

a) Are the lights connected in series or parallel?

b) Explain your answer.

7 Only one of Mr Patel's headlights is working on his car. Are the lights in series or parallel? Explain your answer.

8 A cell connected to two bulbs in a series circuit will last longer than if it is connected to the same two bulbs in a parallel circuit. Explain why this happens.

You should know...

- What series and parallel circuits are.
- What happens to the current in a parallel circuit.
- How to use switches to control parts of a parallel circuit.

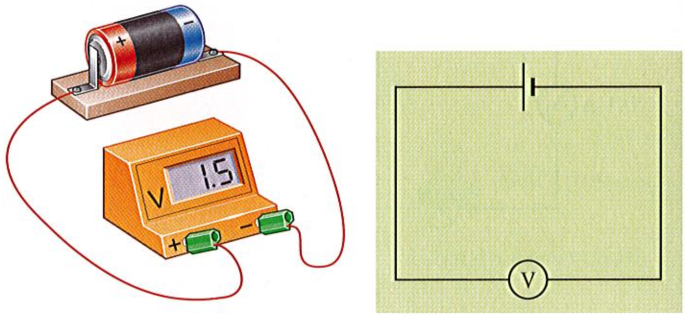
Voltage in series

What is voltage and how is it measured?

A cell does two things in a circuit:

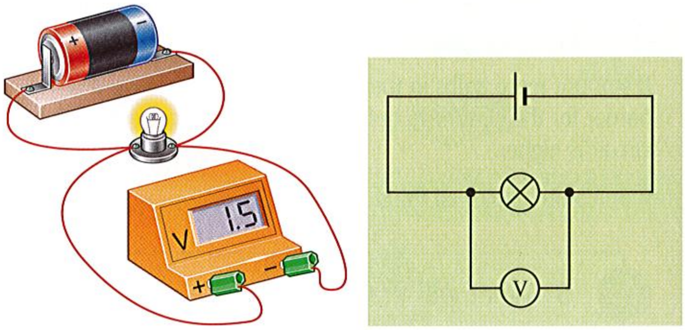
- it pushes electrons around the circuit
- it gives the electrons energy.

Cells have different voltages. The voltage is a way of measuring how much energy the cell gives to the electrons. The energy also pushes the electrons along. You can measure the voltage of a cell using a **voltmeter**, like this:



This voltmeter is measuring the voltage across the cell. The voltmeter has a very high resistance so no current flows in this circuit.

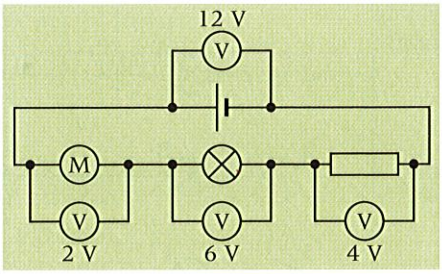
The energy carried by the current gets used up as the current flows around a circuit. The voltmeter measures the difference in energy between two parts of a circuit. It is always connected **in parallel** to part of the circuit. The units for voltage are **volts (V)**.



This voltmeter is measuring the voltage across the bulb. Current is only flowing through the bulb, not the voltmeter.

If the cell or power supply has a higher voltage, more current flows around the circuit. As the current flows around the circuit, some of the energy it is carrying is **transferred** to the components in the circuit. You can compare the amount of energy used by different components by measuring the voltage across each one.

The bulb is using the most energy in this circuit. The motor is using the smallest amount of energy. If you add up the voltages across the components, the answer will be the same as the voltage across the cell.

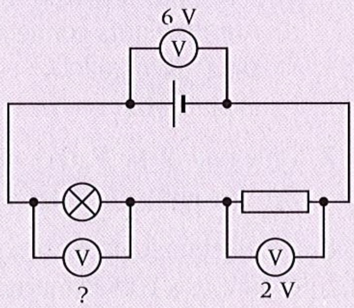


–(M)– *is the symbol for a motor.*

P How would you investigate the connection between the voltage of a cell or power supply and the amount of current in the circuit?

?

1. Why do you need a cell in a circuit?
2. How is a voltmeter connected in a circuit?
3. What are the units for voltage?
4. What is the voltage across the bulb in this circuit?

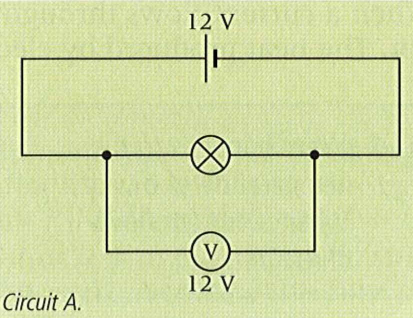


Voltage in parallel

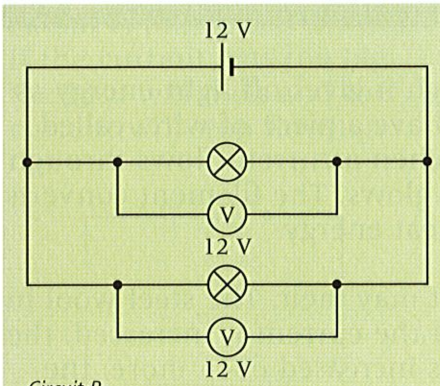
What happens to the voltage in a parallel circuit?

Voltage is a way of measuring how much energy each amp of current is carrying. When the current gets to a branch in a parallel circuit some of the current goes each way. Each amp of current is still carrying the same amount of energy as it was before it reached the join.

In circuit A the voltage across the bulb is 12 V.



Circuit A.

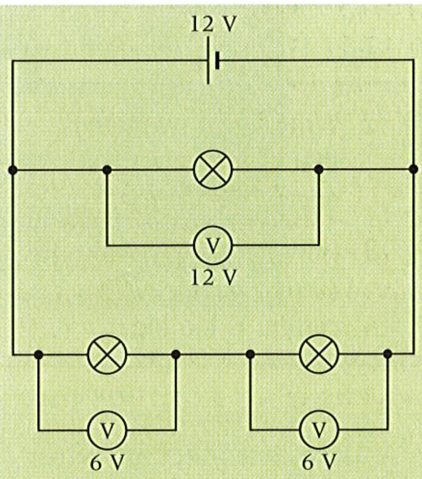


Circuit B.

In circuit B the current splits up and some goes through each branch. Since each amp of current is still carrying the same amount of energy, the voltage across each bulb is still 12 V.

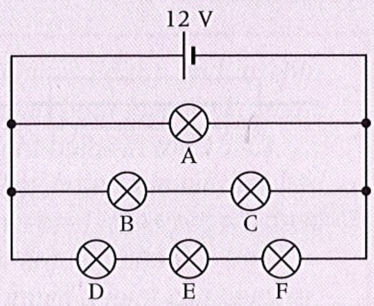
Even if there is more than one component in each branch, the voltage across the *whole branch* will always be the same as the voltage of the power pack or cell.

In circuit C, there are two bulbs in the second branch, so the voltage is divided between them just as it would be for two bulbs in a series circuit. You can think of a complicated parallel circuit as lots of 'mini-circuits' joined together – each branch is a mini series circuit.



Circuit C.

1 a) How much voltage does each branch of a parallel circuit get?
b) Why does this happen?



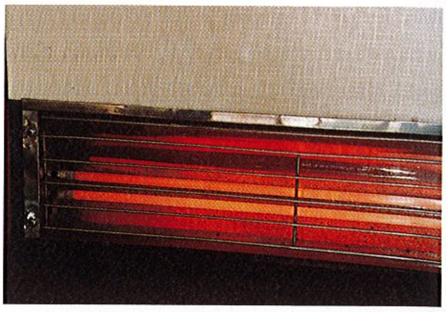
Circuit D.

2 a) What will the voltage be across each of the bulbs in circuit D? (All the bulbs have the same resistance.)
b) Which bulb or bulbs will be the brightest? Explain your answer.
c) If you put an ammeter in each branch of the circuit, which one would give the lowest reading? Explain your answer.

7Jd Using electricity

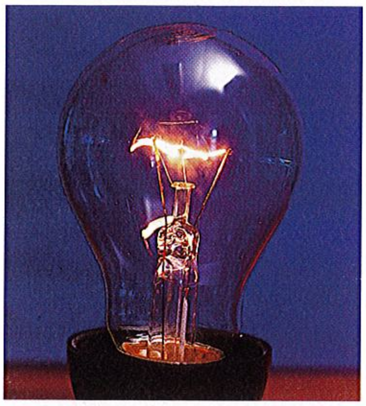
How do we use electricity?

When a current flows through a wire, the wire sometimes gets hot. The heat produced by electricity can be useful.



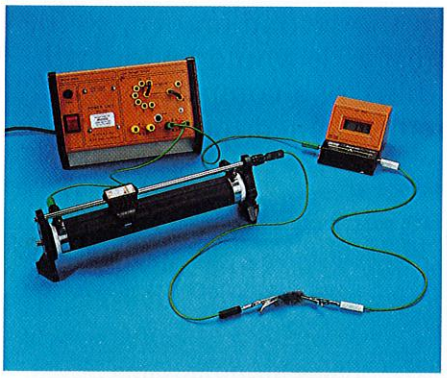
> **1** What happens to the temperature of a wire when a current flows through it?

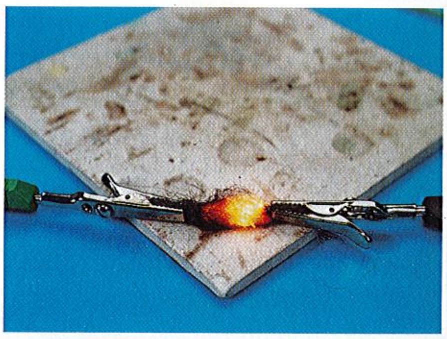
This electric fire has a coil of wire. When an electric current flows through the coil it gets hot, and changes electrical energy to heat energy.



If a piece of metal gets hot enough it gives off light energy as well as heat energy. Light bulbs have a piece of wire, called the **filament**, inside the glass. When a current flows through the filament it gets so hot that it glows. The filament converts electrical energy into light and heat energy.

If a piece of metal gets too hot, it may melt. The steel wool in this circuit conducts electricity. If the current is increased, the steel wool glows. If the current is increased even more, the steel wool will melt.

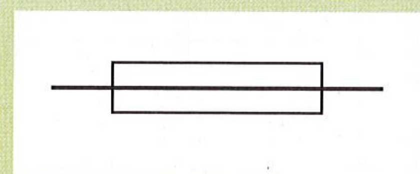




> **2** Write down two things that change electrical energy into heat energy.
>
> **3** How does a fuse stop the current flowing if the current is too big?

A **fuse** is a piece of wire that is designed to melt if the current gets too big. Fuses are used to make sure that people do not get electric shocks.

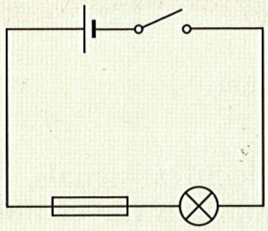
A fuse.



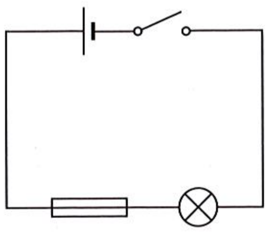
This is the symbol for a fuse.

How would you find out how much current can flow through a piece of fuse wire before it melts?

- What apparatus would you need?
- What circuit would you use?



Some expensive electrical equipment can be damaged if the current flowing through it is too big. The fuse in this circuit is protecting the bulb. If the current gets too big, the fuse will melt and the current will stop flowing.

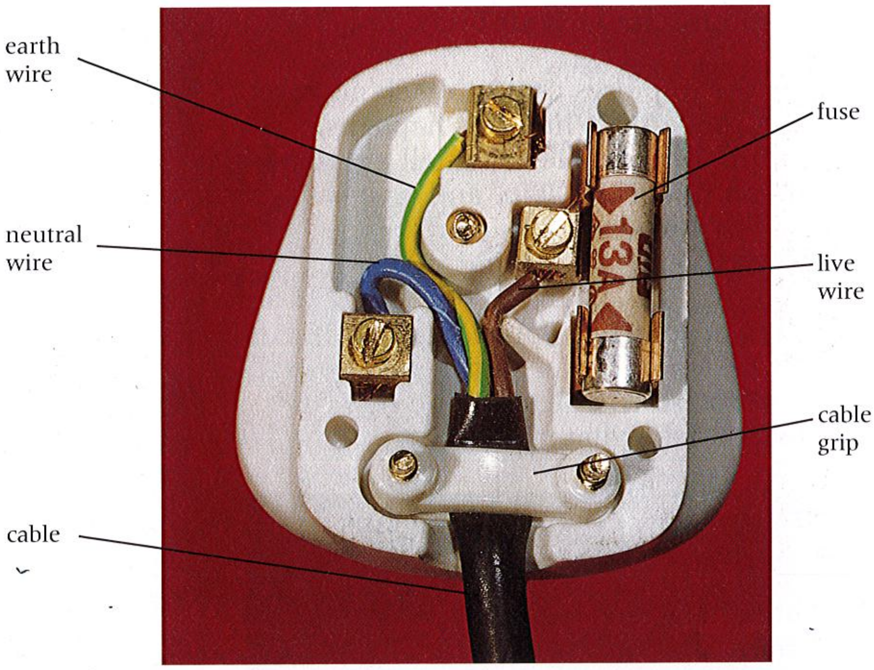


It is important to have the correct fuse fitted in a plug.

Equipment	Fuse
Kettle	13 A
Iron	13 A
TV	5 A
Music centre	5 A
Video	3 A
Central heating pump	3 A

Thomas Edison and Joseph Swan both invented electric light bulbs in the 1870s. They both claimed they had invented it first, but instead of arguing about it they formed a joint company to make light bulbs in 1883.

For most pieces of electrical equipment, the fuse is fitted in the plug. For instance, if something like an iron goes wrong a lot of electricity may flow through the wires. Anyone touching it could get an electric shock. The plug has a fuse in it to stop this happening. The high current makes the fuse melt, and so no more current can flow.



4 How can a fuse protect electrical equipment?

5 Which pieces of equipment in the table use the most current? Explain how you worked out your answer.

You should know...

- **Some wires get hot when a current flows through them.**
- **A fuse melts if too much electricity flows through it.**

7Je Electricity and you

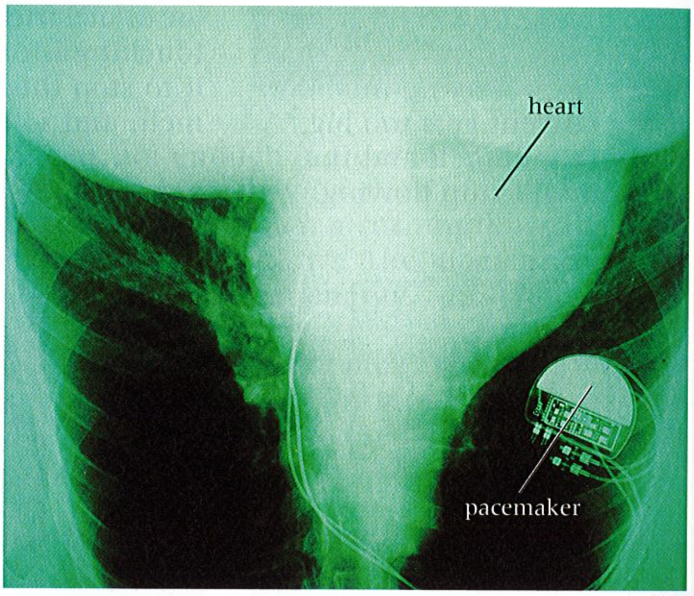
How do our bodies use electricity?

When you move, your brain sends electrical signals, called **impulses**, to your muscles. These impulses travel along your **nerves**. Your nerves are not made out of metal, and electricity does not travel through them in the same way as it does through a wire.

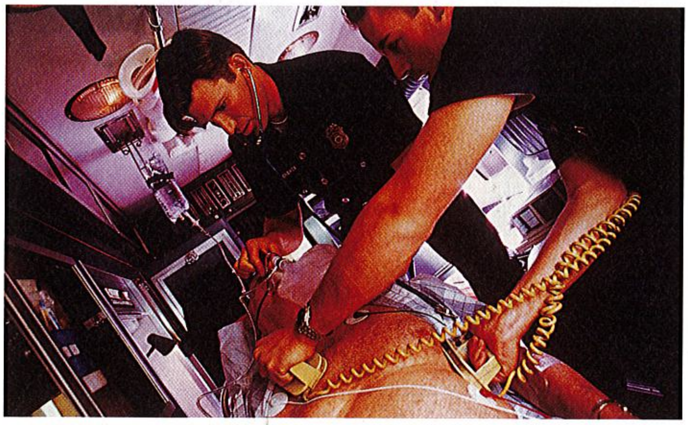
One of the most important muscles in your body is your heart. Your heart can only pump blood properly if the different parts of it move at the right times. The heart muscle is controlled by electrical impulses, just like all the other muscles in your body.

Sometimes the impulses cannot reach all parts of the heart properly. When this happens, doctors can fit a pacemaker. A small electrical cell is put just under the skin, and a very thin wire goes into the heart. This carries impulses to the muscles at the right times.

If a patient's heart has stopped beating, it can sometimes be made to start again by passing electricity through it. The machine that does this is called a defibrillator.



An X-ray of a person's chest. A pacemaker has been fitted.



A defibrillator being used.

Some animals can make electricity in their bodies. An electric eel can give a shock of 1000 volts.

1 a) Which cells carry electricity around your body?
b) How do these cells help the body?

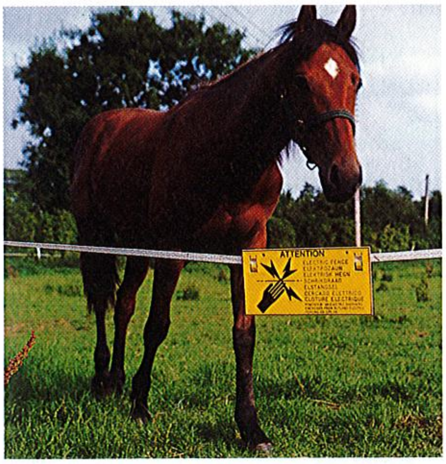
Our bodies use electricity, but electricity can also harm us. An **electric shock** can burn the skin, or it can stop our nerves working properly. Electric shocks can kill people by upsetting the nerves that control their hearts, or the nerves that control their breathing.

2 You might have a current of 0.2 A flowing in a circuit you use at school, but if you accidentally touch the bare wires you do not usually feel a shock. Why not? (*Hint:* think about the resistance of a bulb compared to the resistance of your body.)

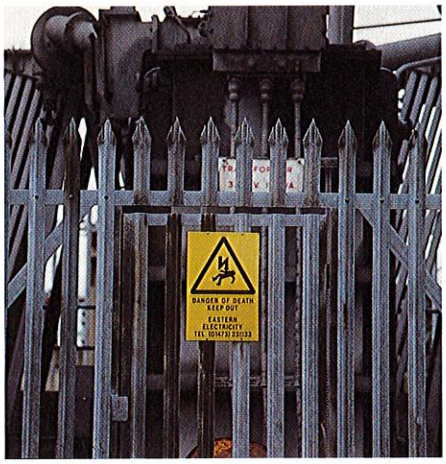
This table shows the effects of different currents on a human body.

Current	Effect
0.001 A	this current can be felt
0.005 A	this amount of current is painful
0.010 A	this current can make muscles contract
0.015 A	you cannot control your muscles if there is this current flowing through your body
0.070 A	this current can kill you

People sweat very slightly when they are telling lies. This makes their skin wetter and changes its resistance. Lie detectors measure the resistance of the skin, and show when someone is lying. Unfortunately these detectors are not very reliable!



This electric fence is used to stop horses getting into the wrong field. The horses get a small electric shock if they touch it, so they do not try to push it over.



This electrical equipment is at a very high voltage. You could be killed if you touch it.

3 Describe two ways in which an electric shock could kill you.

4 How can electric shocks be useful?

5 Why is it dangerous to use electrical equipment with wet hands? Explain in as much detail as you can.

Your body has a much higher resistance than a component like a light bulb. That is why you do not usually feel anything if you accidently touch a 12 V circuit in a school experiment. However, mains electricity at 230 V will give you a nasty shock.

The resistance of your skin is much lower when it is wet, so a much higher current would flow through you. This is why it is so dangerous to use switches or other electrical equipment with wet hands. Light switches in bathrooms are fitted in the ceiling so that you cannot touch them with wet hands. You have to pull a long cord to turn the switch on or off.

You should know...

- **Nerves carry electrical impulses around the body.**
- **Electricity can harm the body.**