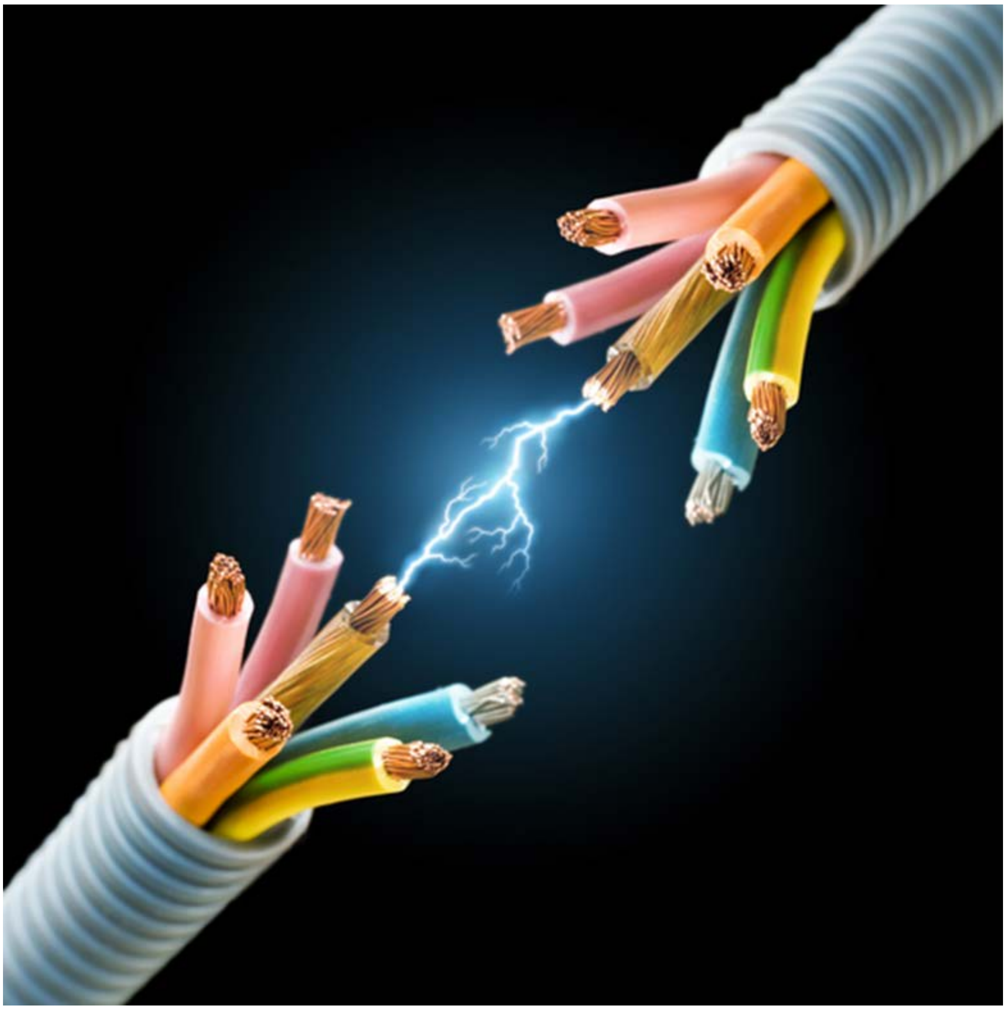
Science

Stage 5

Technology and electricity

Part 1



Distance Education Science Network

NSW Government Education & Communities

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Contents

Outcomes

By completing this unit, you are working towards achieving the following outcomes:

- develop questions or hypotheses to be investigated scientifically
- produce a plan to investigate identified questions, hypotheses or problems, individually and collaboratively
- undertake first-hand investigations to collect valid and reliable data and information, individually and collaboratively
- process, analyse and evaluate data from first hand investigations and secondary sources to develop evidence based arguments and conclusions
- apply scientific understanding and critical thinking to suggest possible solutions to an identified problem
- apply scientific understanding and critical thinking skills to suggest possible solutions to identified problems
- present science ideas and evidence for a particular purpose and to a specific audience, using appropriate scientific language, conventions and representations
- apply models, theories and laws to explain situations involving energy, force and motion
- explain how scientific understanding about energy conservation, transfers and transformations is applied in systems

(Outcomes taken from the Board of Studies NSW Syllabus for the Australian Curriculum SCIENCE Years 7 - 10, 2013)

Content Statements:

1VA, 2VA, 3VA, WS4b, WS5.1a, WS5.1d, WS5.2a, WS5.2c, WS5.2d, WS5.2e, WS5.3a, WS6a, WS6b, WS6c, WS6d, WS6e, WS7.1b, WS7.1d, WS8b, WS8d, WS8e, WS8f, WS9c, PW1e, PW3c

Resources

You will be sent a mini kit to use with this topic. You will also need to collect these items from home:

Part 1:

- a saucer or plate
- two AA batteries

Part 3:

Lesson 1

- piece of A4 paper
- scissors
- needle and thread or tape
- lamp
- saucepan
- teaspoon butter or margarine
- plastic spoon
- stove
- metal spoon
- wooden spoon

Lesson 3

- 2 identical glasses
- double-sided reflecting foil insulation
- two identical chocolates or two cubes of cheese

Please note that the mini-kit we have sent you contains the following items:

1.5V battery holder
two 2.5V flashlight bulbs and holders
4 plastic coated wires with alligator clip ends
Steel wool
Steel pin
Insulating foil
Thermometer

Icons

Here is an explanation of the icons used in Parts 1, 2 and 3

Write a response.

Compare your response with the one in the suggested answers section. Give yourself a tick if you were correct. Make any corrections.

Complete the Send-in exercises corresponding to the lesson.

Perform a practical task or investigation.

Glossary

The following words, listed here with their meanings, are found in the learning material in this part.

allotropes	different forms of an element; atoms arranged differently
alternating current (AC)	current moving backwards and forwards many times per second
appliance	device to carry out a task
carbon footprint	carbon dioxide released due to activities
circuit breaker	stops the current in a circuit when the current is too large
components	parts
conductor of electricity	substance that allows electrons to flow through it
constant	kept the same
control in an experiment	set up to use as a comparison
current	a flow of electrons
diode	made of two electrodes
direct current (DC)	current flows in one direction
ductile	Capable of being drawn out into a wire
efficient	a lot of output for a small input
electric circuit	pathway for electrons to flow
electricity	flow of electrons
electricity grid	electricity delivered from power stations by a network of wires
electrodes	a conductor delivering an electric current to a vacuum tube or a solution
fluorescent	emitting light
greenhouse gases	gases that trap heat in the atmosphere eg carbon dioxide
halogen light	A globe which has a halogen gas such as bromine or iodine
incandescent light	globes that work by electricity heating up a wire filament to white-hot
independent variable	the thing that is changed when setting up a test in a controlled experiment
insulator	substance that does not allow electrons to flow though it
ionic	containing ions (positive or negative particles)
joule (J)	unit of energy or work
kilowatt (kW)	1000 watts
kilowatt-hour (kWh)	1000 watts used for one hour

LED	light emitting diode
mains supply	electricity from power companies
malleable	able to be hammered out into thin sheets
ohm (Ω)	unit of resistance
peak	highest
phosphors	chemicals that change ultraviolet light into visible light
power	the rate at which energy is used; the unit of power is the watt (W)
resistance	reduction to the flow of electrons
resistor	hinders the flow of electrons causing electrical energy to be transformed into heat energy
semi-conductor	allows electrons to flow through it but not as well as conductors
superconductors	substances that allow electrons to flow very easily with hardly any resistance
tonne (t)	unit of mass; 1000 kg
transformed	changed
ultraviolet (UV) light	invisible energy that radiates from the Sun and some electric lights.
variables	things or factors
voltage	the measure of the push forcing electrons to flow
Volt (V)	the unit for measuring voltage
Watt (W)	one joule of energy used per second

Lesson 1: Household use and billing

In this topic you will be looking at the use of electricity in our modern society.

How much do you think you rely on electricity for your modern way of living? Think about what you have done so far today since you woke up until sitting down to start your science lessons for the day. Do you have any idea how much electricity you used? The electric meter box outside your home records how much electricity you use. It may look similar to Figure 1 or Figure 2 below. Figure 1 shows a traditional meter. The dial on the left shows how many lots of 10000 kWh have been used, and in this meter

2 x 10000 kWh have been. The other dials, going from left to right, show the following electricity use: (2 x 1000)(8 x 100) (5 x 10) and 5.5 × 1. Adding all the dial readings together gives a total use of 22855.5 kWh.

Figure 2 shows a digital meter with a reading of 605 kWh.

Figure 1: Traditional meter

Figure 2: Digital Meter

Activity 1: Electrical count

1. Make a list of the things you have used to today that use electricity either connected to a power point (mains supply) or operating from a battery.

   ____

   ____

2. To see how much mains supply electricity you used, I would like you to go outside to the electrical meter box for your home.

   a) Look at the reading on your meter and record the kilowatt-hour (kWh) reading.

      Reading 1: ________________ kWh

   b) Go to the meter at the same time tomorrow and record the kWh reading.

      Reading 2: ________________ kWh

   c) Calculate how much electricity your home used from mains supply for the day (24 hours).

      Reading 2 – Reading 1 = ________________ kWh

   d) Take readings for three more days at the same time, and record these observations in the table in the Send-in exercises for Lesson 1.

EXERCISE

Complete the Send-in exercises for Lesson 1 , <u>Question 1 Only</u>

Paying for electricity

When you pay for electricity you are charged for the amount of electrical energy you have used in different appliances. You receive a bill every three months and are charged for the number of kilowatt-hours you use. Different electrical appliances use different amounts of energy.

The rate at which the energy is used is called power and this is measured as joules of energy per second (watts, W).

One kilowatt is 1000 watts so a kilowatt-hour is 1000 watts used for 1 hour.

The higher the wattage of an appliance, the more energy it uses and the more it costs you to run. A 1000 watt heater uses electricity twice as fast as a 500 watt heater so is more expensive to run for an hour.

When a 1000 watt heater is on for an hour, 1 kilowatt-hour (kWh) will be added to your electricity bill.

Use this information to decide if the heater in Figure 3 or the heater in Figure 4 will cost you more to use for an hour.

Figure 3

Figure 4

The heater in Figure 3 uses 1000 watts (W) when it is on and the heater in Figure 4 will use a maximum of 800 watts (W) so Figure 3 heater is the most expensive to use.

The table below shows how much power is used by some common household appliances.

Table 1: Power rating in watts of appliances

Appliance in home	**Power rating (watts)**
light bulb	60
TV	200
laptop computer	20-50
refrigerator	400-500
electric kettle	2000
toaster	1000
small heater	1000
hair dryer	1500
stove hotplate	2000
dishwasher	2500
hot water system	3000
iron	1000

Activity 2: Analysing power ratings

1. Which household appliance uses the most watts? _______________

2. Which household appliance is the most expensive to use? __________

3. If the dishwasher was working for an hour how many kilowatt-hours would you be charged? ____________________________________

Check your responses by going to the suggested answers section

The price charged for electricity from the electricity grid (mains supply) depends on how much you use and when you use it. Electricity used late at night is the cheapest because there is less demand at this time. This electricity is called **Off Peak**. The peak electricity use time is during the hours when people are going to work and working. Figure 5 shows part of a home electricity bill.

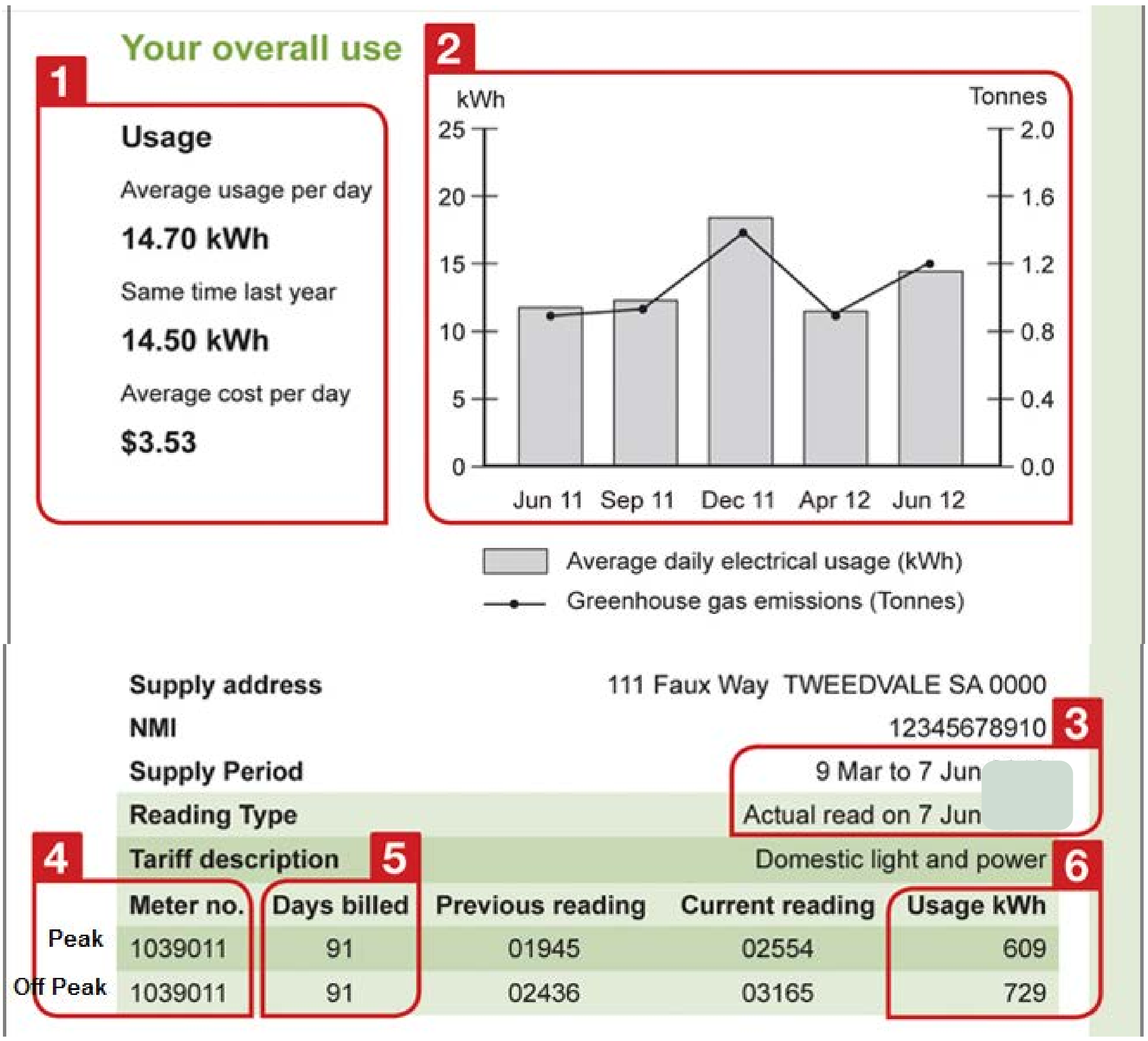


Figure 5: Peak price is 25c per kWh and the Off Peak price is

Activity 3: Analysing electricity bill extract

1. Look at Section 4 of the bill. Explain what is meant by Peak and Off Peak.

   Peak: ____

   Off Peak: ____

2. Look at Section 1 of the bill. What was the average electricity use per day for this home during the three month billing period.

   ____

3. Look at Section 2 of the bill. Why do you think more kWh were used in December compared to April.

   ____

Check your response by going to the suggested answers section

Have a look at Section 2 of the bill again. Notice that on the left hand side of the graph the vertical axis shows the kWh of electricity used. On the right hand side of the graph the vertical axis is labelled Tonnes. This scale shows the amount of greenhouse gases (such as carbon dioxide) emitted into the atmosphere when producing the electricity used by this home.

At present over 80% of electricity in Australia is produced by coal and gas burning power stations that emit a lot of greenhouse gases such as carbon dioxide. Section 2 of the power bill tries to make people aware of their carbon footprint (carbon dioxide released due to their activities).

Figure 6: Coal burning power station

International agreements require countries of the United Nations to reduce their greenhouse gas emissions. One way Australia can reduce its greenhouse gas emissions is to reduce the electricity used that is produced by coal and gas burning.

Think about ways that you could reduce your use of electricity from the electricity grid each day. Reducing your use of this electricity will reduce greenhouse gas emissions.

To finish this lesson, reflect on the main points and read the summary below.

Summary of Lesson 1

- The rate of use of electricity is called power and is measured in watts (W).
- 1 watt (W) = 1 joule of electrical energy used in 1 second
- 1 kilowatt (kW) = 1000 watts
- 1 kilowatt-hour (kWh) = 1000 watts used in 1 hour
- Home use of electricity is measured in kilowatt-hours (kWh) by electricity meters. Electricity companies use the meter readings to charge homes for the kWh of electricity used every three months.
- Different home appliances use different amounts of electricity so have different power ratings (watts).
- Off Peak electricity is electricity supplied when demand is small.
- Greenhouse gases are emitted by the production of most of Australia's electricity.

EXERCISE

Complete the remaining Send-in exercises for Lesson 1

Lesson 2: Electric circuits

In this lesson you will learn how electricity is distributed safely around your home by electric circuits. You will learn about the components that make it safe to use electricity in your home.

A simple circuit

Remember from your previous studies of electrical energy:

- an electric circuit is a pathway for electrons
- electrons have a negative charge
- a flow of electrons produces electricity

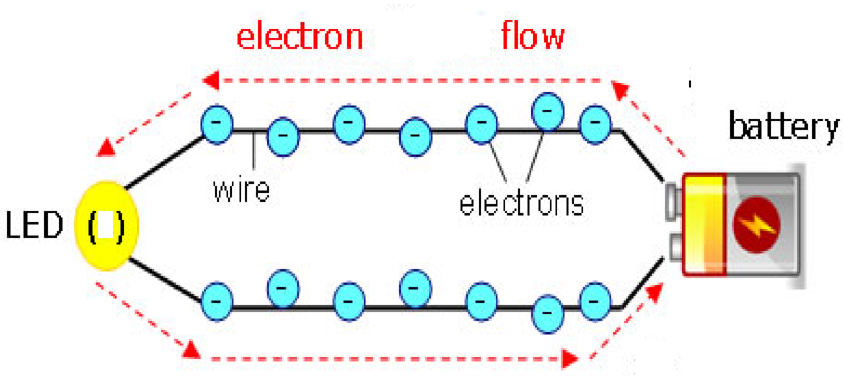


Figure 7

An electrical energy source, such as a power point (switched on) or a battery, acts as a pump pushing electrons around the closed wire loop of a circuit causing an electron flow as shown in Figures 7 and 8. The strength of the push of the pump is called voltage and is measured in volts (V).

Use the above information to help you interpret Figure 8 - an electric kettle circuit. Some circuit symbols have been labelled in the diagram.

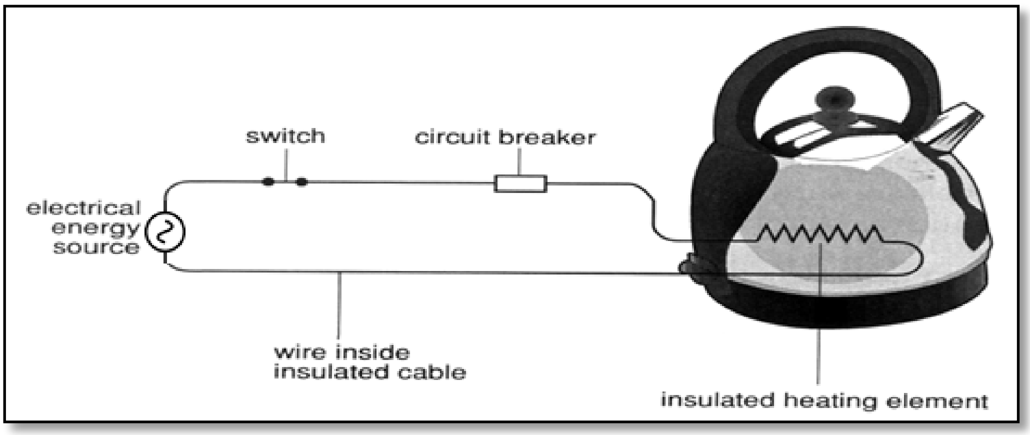


Figure 8: Operation of a 2000W electric kettle

Scientists, electricians and electronics technicians use symbols to draw simple diagrams called circuit diagrams to show the parts of circuits.

The circuit of the operating kettle can be represented by the circuit diagram shown in Figure 9. Wires are drawn as straight lines. The “push” or voltage on the electricity from the power point is 240V (240 volts).

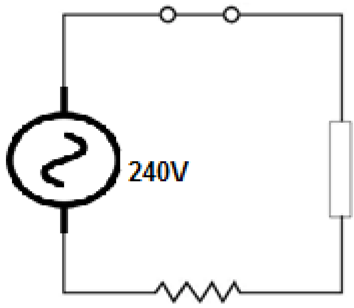
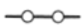
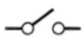


Figure 9

Activity 4: Interpreting circuit diagrams

Look at the symbols in the diagrams in Figures 8 and 9.

1. What does this symbol  represent? ______________________

2. Here are two symbols used for a switch.
   closed switch    open switch 
   Is the switch in the jug circuit open or closed? __________________

3. Do you think that the water in the jug is being heated? ___________
   Explain ____

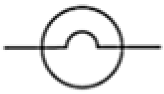
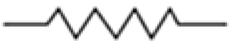
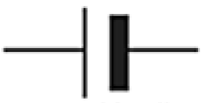
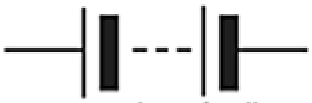
4. What is the voltage push of the power source? _________________

5. How many kWh would the kettle use if it was heating water for a total of an hour in a day? __________________________________

Check your responses by going to the suggested answers section

Table 2 below shows you some of the symbols used in circuit diagrams. Symbols make it easier to draw clear circuits for electricians and scientists to follow.

Table 2: Symbols used in circuit diagrams

Name	Symbol
wire	
closed switch	
open switch	
globe or light	
resistor, fuse or circuit breaker	 or 
power source battery cell	 1.5 V cell  a number of cells
power source power point	

Electric current (I)

A flow of electrons is called an electric current or electricity. The symbol for electric current is **I**.

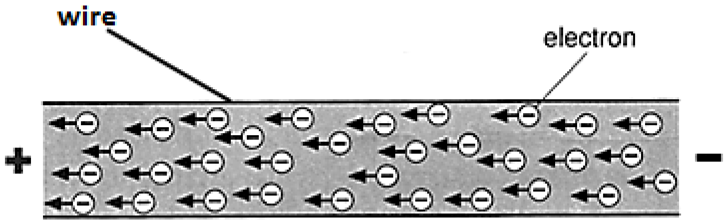


Figure 10: A conductor allowing free electron flow

A substance that allows a current to flow through it is called a conductor as shown in Figure 10.

The size of an electric current is measured in **amperes, amps (A)**.

If the current goes in one direction all the time, it is called **DC, or direct current**. Batteries produce direct current electricity.

If the current goes backward and forward it is called an **alternating current (AC)**.

The current supplied to your home from the main electricity grid is an alternating current.

The voltage push of the electric current delivered to your home is 240 V.

Resistance (R)

Some substances resist the flow of an electric current. This is called the resistance of the substance and the symbol for it is **R**. These substances are called resistors. The amount of resistance of a substance is measured in **ohms (Ω).**

When the movement of electrons is resisted some of the electrical energy is transformed into heat energy. The wire shown in Figure 11 is a resistor.

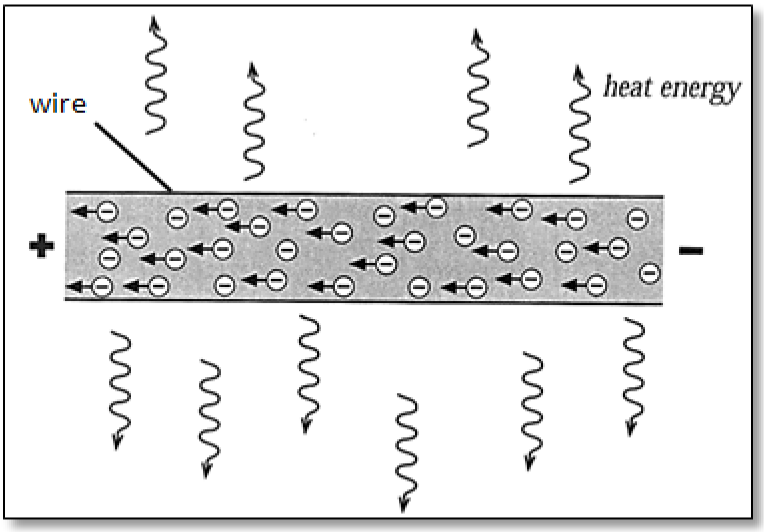


Figure 11

Look back at the electric kettle circuit in Figure 8. The water is heated because the kettle element is resisting the electron flow a lot and giving out a lot of heat energy. In other words, it has high resistance.

Activity 5: Analysing the kettle resistors

1. Draw the circuit symbol for a wire in this box:

2. Two common symbols used for resistors are: 

   Name the two resistors in the kettle circuit in Figure 8.

   ____

3. Which resistor in the kettle circuit opposes the current more, the circuit breaker or the heating element? Give reasons for your answer.

   ____

4. Is the current in the kettle circuit AC or DC? ____________________

   Explain ____

   ____

Check your responses by going to the suggested answers section

Resistors, fuses and circuit breakers

A fuse is a safety device containing a thin piece of wire that melts if too great a current passes through it. Fuse wire is a resistor. It resists the movement of a large current and transforms enough electrical energy into heat energy that the wire melts. This breaks the circuit and the current stops flowing.

Different sizes of fuse wire will melt when different size currents pass through them. The fuse wire is usually inside a plastic or glass cartridge. Figure 12 shows three fuses. The 3A fuse will allow a current up to 3 amps (A) to pass. A current larger than 3A will cause it to get too hot, melt and break.

Figure 12

Modern homes use circuit breakers as the safety device instead of fuses. They are used to break circuits and turn off electricity automatically. When a lot of appliances are on at once, too large a current can pass through circuit wires. This can produce a dangerous amount of heat in the wires. A circuit breaker will switch off the electricity before the wires can overheat and cause a fire.

Figure 13

When a circuit breaker turns your electricity off you would need to turn off all appliances in the circuit. You would then go to your meter box and turn on the circuit breaker. After this, you would turn the appliances back on one at a time. Stop using the extra appliance that triggers the circuit breaker to switch off.

Conductors and insulators

Conductors are substances that allow electrons to flow through them. Good electrical conductors are substances with a low amount of resistance. They let electric current pass through without much energy being lost as heat. Different substances conduct electricity with different ease. A very efficient conductor will deliver more electrical energy to be used without a lot of heat production.

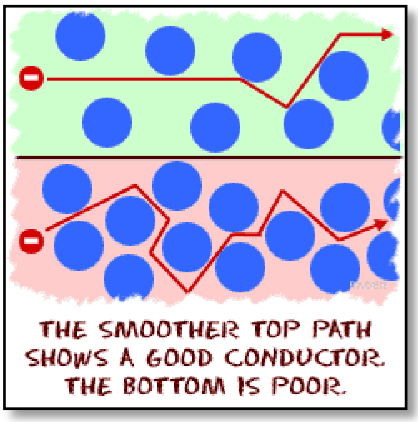


Figure 14

The thickness of a wire, its length and temperature affect its resistance. A thin conducting wire creates a high resistance. A long wire creates a high resistance. A hot wire creates a high resistance.

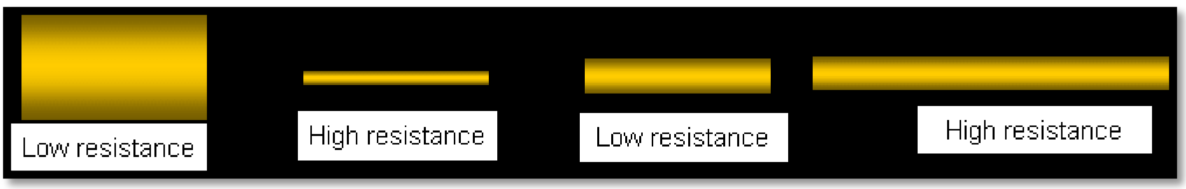


Figure 15

At extremely low temperatures, some substances have no measurable resistance. The substances are known as superconductors.

Some substances have a very high resistance and do not allow electrons to flow through them. These substances are called electrical insulators. Insulators can be used to create a protective barrier and prevent electric currents flowing to unwanted areas.

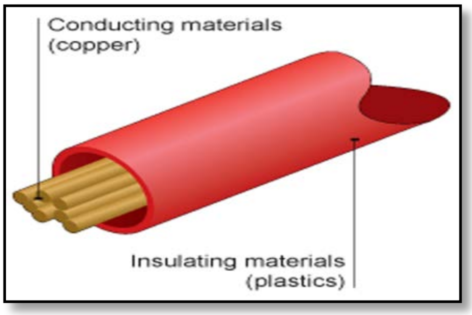


Figure 16

Types of conductors

- Metals are very good conductors. Some of the best metallic conductors are copper (Cu), silver (Ag), and gold (Au). Metals are malleable (can be hammered into shape) and ductile (can be made into wires) to conduct electricity over distances.
- Semi-conductors are substances that are good conductors but not as good as metals. Silicon (Si) is a semi-conductor.
- Carbon is a non-metal. Some carbon allotropes (forms) can conduct electricity. Graphite ('lead' in pencils) conducts but is brittle and can't be made into wires. Graphene and graphyne are very strong and flexible. They conduct electricity much more quickly than any other substance. Little electrical energy is transformed into heat when they conduct.
- Ionic conductors are solutions or molten materials that conduct. For example, saltwater is a conductor.

Figure 17

Activity 6: Analysing conductors and insulators

1. Imagine that it is your job to design a very efficient electric circuit (losing as little energy as heat as possible):-

   a) Which metal would you choose for your wires? ________________

   b) Would you choose a thick or thin wire? ______________________

   c) What substance would you choose to make your circuit safe and insulate the wires? _______________________________________

   Explain your choice: _______________________________________

2. If you were designing a new computer what substance would be preferred as the chip material? _________________________________

   Explain your choice: ____

3. Why should you stop swimming in the ocean when a thunderstorm starts? ____

Check your responses by going to the suggested answers section

Think back over the main points of the lesson then read the following summary.

Summary of lesson 2

- An electric circuit is a pathway for a flow of electrons (current) produced by a power source that pushes electrons through conductors.
- Current (I) is measured in ampere or amps (A)
  The "push" or voltage is measured in volts (V)
  The resistance (R) to the flow of electrons is measured in ohms (Ω).
- When the flow of electrons faces resistance electrical energy is transformed into heat energy.
- A good conductor has a low resistance to the flow of electrons.
- Heating elements, fuses and circuit breakers, work by using the heat produced by resistance.
- The voltage of mains supply electricity to Australian homes is 240V. Alternating current (AC) is used where electrons move back and forth to produce the electric current.

EXERCISE

Complete the Send-in exercises for Lesson 2

Lesson 3: Experiment testing resistance of conductors

In this lesson you will follow instructions to set up an experiment that is a fair test. You will then design an experiment following a similar scientific method.

Activity 7: Experiment – Testing resistance

Aim: To compare the resistance of 25mm lengths of two conductors:

a) a steel pin 1mm in width

b) a single strand of steel wool 0.1mm in width

Materials:

- Two AAA batteries (each produce 1.5 volts)
- One 1.5 V battery holder
- One 2.5 V flashlight bulb and holder (each uses 0.3A of current)
- Three plastic coated (insulated) wires with alligator clip ends
- steel wool and a steel pin
- saucer or plate

Method:

Step 1: Connect a small 2.5-volt flashlight bulb to two 1.5V AAA batteries as shown in the diagram below.

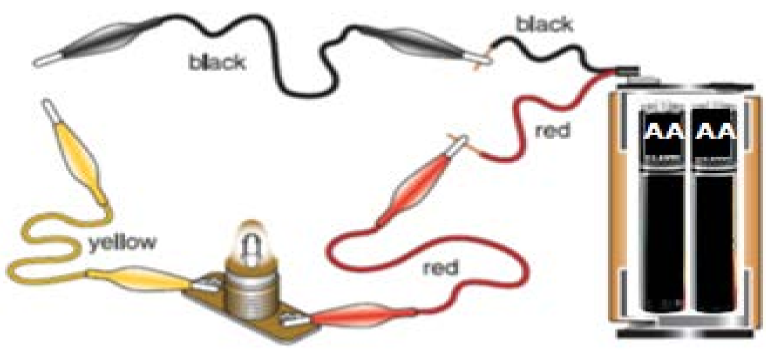
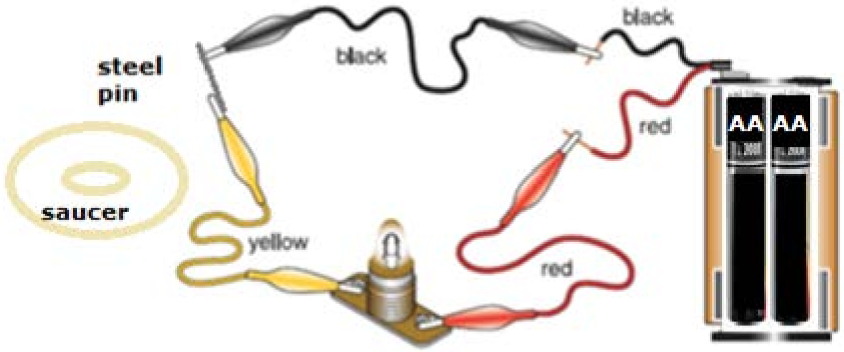


Figure 18

The two batteries are connected in a series connection one after the other in the battery holder. This gives a total of a 3V voltage push for the circuit.

Step 2: Touch the two alligator clip ends of the yellow and black insulated wires together for 10 seconds. Record your observation in the results table on the next page. Repeat three times.

Step 3: Attach one end of the steel pin to the black lead using the alligator clip. Hold above a saucer or plate. Then attach the other end of the steel pin to the



yellow lead using the alligator clip for 10 seconds. Repeat three times. Record your observations in the table on the next page.

Step 4: Take one strand of steel wool and cut it to a length of 25mm.

Step 5: On a saucer or plate, attach one end of the strand of steel wool to the black lead clip and then attach the other end to the yellow lead clip for 10 seconds. Repeat three times with other 25mm steel strands. Record your observations.

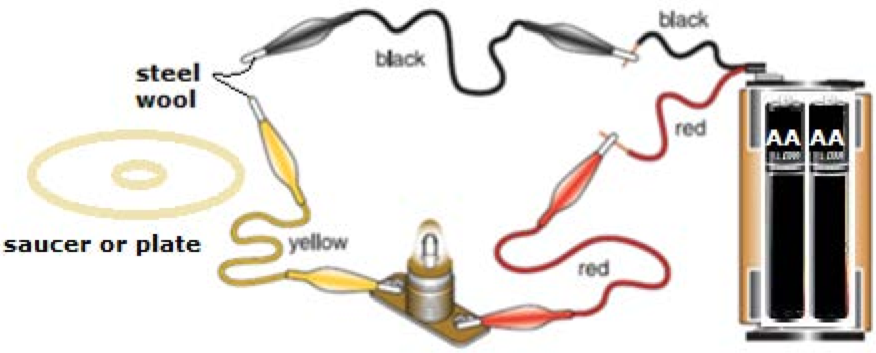


Figure 20

Results:

Conductors	Observations when circuit closed (globe brightness, conductor heat)
alligator clips touching	
steel pin (25mm × 1mm) between alligator clips	
steel strand (25mm × 0.1mm) between alligator clips	

Compare your observations with probable observations in the suggested answers section

Conclusion:

____

____

Compare your conclusion with the one in the suggested answers section

Discussion:

The steel pin conductor was thicker and had a very low resistance. It allowed the current to flow freely to power the light globe.

The thin steel wool strand conductor had a high resistance and stopped a lot of current flowing to the globe reducing the light production.

A lot of electrical energy was converted to heat energy in the steel wool strand. Sometimes this can cause it to burn, melt and break.

Activity 8: Analysis of experiment

1. You set up a controlled experiment to test the resistance of the two conductors.

    a) What things (variables) did you keep the same in each test?

    ____

    ____

    b) Justify (give reasons) why these variables needed to be kept the same (constant).

    ____

    ____

    c) What thing (variable) did you change? Remember in an experiment that is a fair test only one variable should be changed. The thing you change is called the independent variable.

    ____

    d) All experiments must have a **control**. A control is an experimental setup which is used as a comparison. It is the same experiment without the variable or factor you are investigating.
    In which step of the method did you set up a control for comparison?

    ____

    e) What did the control show you?

    ____

    f) What did you observe or measure? This is called the dependent variable.

    ____

g) Why were the test conductors held over a saucer or plate?

____

h) Why were you asked to repeat steps?

____

2. What is the voltage of the current produced by the two AAA batteries?

____

3. What current and voltage was the globe designed to use? (these figures are embossed on the metal base)

____

4. Predict what might happen if a 9V battery is used in Steps 1 and 2 (Remember voltage is the push sending the current around a circuit, the greater the push the larger the current that can flow.)

____

Check your responses by going to the suggested answers section

Summary of Lesson 3

- A thin wire of the same metal will have more resistance than a thicker wire and will transform more electrical energy into heat energy.
- In a fair controlled experiment only one variable is changed. This is called the independent variable.
- A 2.5V, 0.3A light globe is designed to take a maximum current of size 0.3 amperes pushed by a voltage of 2.5 volts.

EXERCISE

Complete the Send-in exercises for Lesson 3

Lesson 4: Resistance, current and voltage

In this lesson you will learn about the very important relationship between the voltage pushing electrons in a circuit, the resistance to the movement, and the electric current that flows.

What is the relationship between current and resistance?

Below are two circuits made with different conductors. Each circuit receives electrical energy with the same voltage (push).

Circuit A

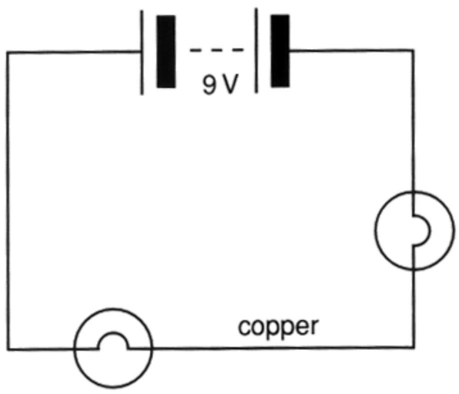


Figure 21

Circuit B

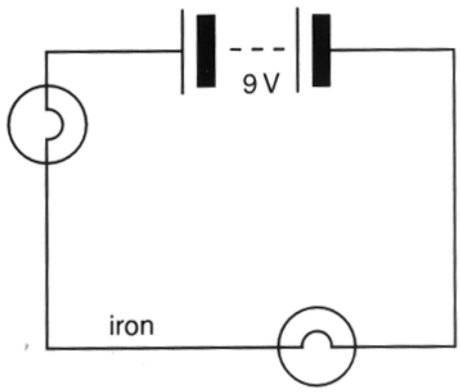


Figure 22

(Did you recognise the symbol  as a light globe?)

Look back at the scale of resistance diagram in Figure 17 (page 23) and then decide which circuit above has more resistance, Circuit A with the copper conducting wire or Circuit B with the iron conducting wire? ______

If you said Circuit B would have more resistance, you are correct.

Figure 17 shows that iron is not as good a conductor as copper.

Iron resists the electron flow more. It transforms a lot of electrical energy into heat energy so less electrical energy goes to the globes to produce light energy.

Which circuit (A or B) do you think has more current flowing through it?

____

If you said Circuit A you are correct. The copper wire does not resist the electron movement much and allows more electron flow and so more electric current.

You have now followed the relationship between resistance and current when the amount of electrical energy pushed into the circuit stays the same (constant). In Circuit A and B the voltage push was 9V.

If the resistance decreases, the current will increase when the voltage is constant.

What is the relationship between voltage and current?

Remember voltage is the ability to cause a current, the ability to push electrons to move.

In Circuit A of Figure 21, electrical energy is supplied by a battery with a voltage of 9 volts (9V). Predict what would happen to the current around Circuit A if a 12V battery were used instead. ________________________

If you said increase you are correct. If a battery that can produce more energy push (12V) is used, a larger current can be produced.

The greater the voltage the larger the possible current produced.

The relationship between voltage, current and resistance

In 1826 the German scientist Georg Ohm investigated how voltage, current and resistance in an electric circuit are related. From his experiments he discovered:

Voltage = Current × Resistance

$(V = I \times R)$

This is known as Ohm's Law.

Activity 9: Making predictions about voltage, current and resistance

Use the relationships between voltage, current and resistance to complete the following table. The first one has been completed for you.

Table 3: V = I × R

Voltage	**Current**	**Resistance**
constant	increased	decreased
decreased		constant
increased		constant

Compare your answers with the ones in the suggested answers section

Calculating resistance

Different appliances in your home require different sized currents and will have different resistances. Look at the current readings in Table 4.

Table 4: Currents used by appliances

Appliance	**Current (symbol, I)** is measured in amps (A)
light globe in a room	0.4 A
Electric jug	12 A

Remember in Australian homes the power point Voltage (V) = 240 V

To work out the resistance (R) in the wire of the electric jug you can use the formula, V = I × R.

If V = I x R, then $R = \frac{V}{I}$

$$= \frac{240\ \text{V}}{12\ \text{A}}$$

$$= 20\ \Omega$$

The resistance in the wire = 20 ohms

Using resistance

Figure 23: Traditional incandescent globe

The nichrome wire used in heating elements and the thin tungsten wire used in incandescent light bulb filaments have a much higher resistance than the copper wire used in electrical wiring. They transform a lot of electrical energy into heat energy. This is very useful for heating elements such as in kettles but very wasteful for lights. In lights you want as much electrical energy to be transformed into light energy as possible.

Figure 24: Halogen incandescent globe

An incandescent light (traditional globe and halogen globes) creates light by running electricity through the filament, which heats up and then literally glows white-hot. It is a very inefficient way of creating light as 90% of the electricity used is turned into heat with only 10% being turned into light.

Other ways of producing lights

Do you have any traditional incandescent light bulbs in your home? Fortunately scientific research in the last 20 years has led to the development of much more efficient light bulbs that transform most of the electrical energy into light energy with little energy wasted as heat.

Figure 25 and the summary below it explains how the energy saving compact fluorescent light (CFL) bulb works. It uses as little as one fifth of the energy of traditional incandescent light bulbs and will last ten times longer.

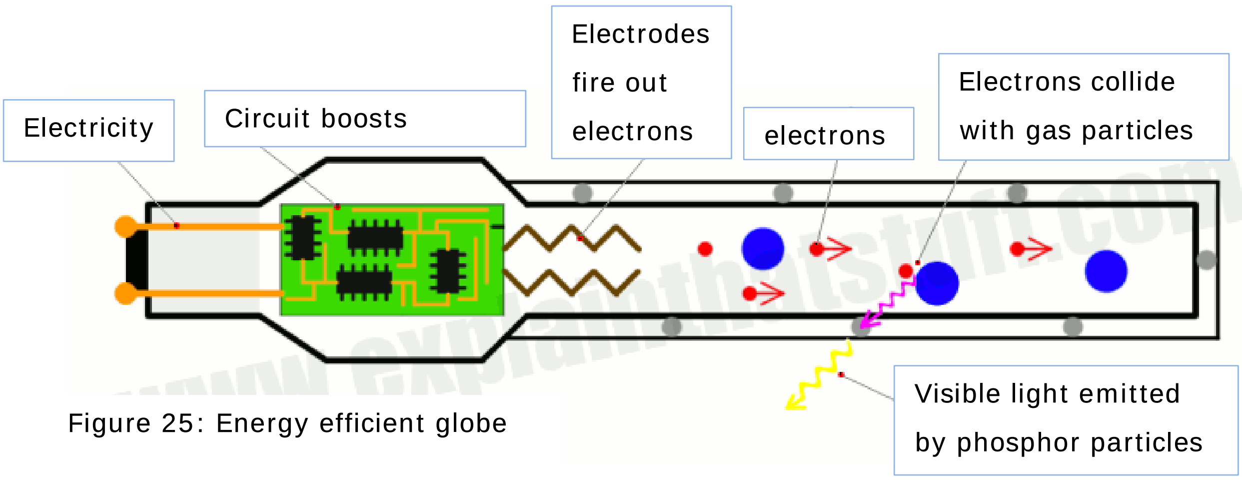


Figure 25: Energy efficient globe

Summary of how a CFL bulb works:

- Electrodes (conductors) deliver electrical energy from the power supply into the glass tube. This produces fast moving electrons.
- The moving electrons collide with poisonous mercury gas particles in glass tubes and ultraviolet light is emitted.
- White chemicals called phosphors, are coated on the inside of the glass tube and they convert the ultraviolet light energy into visible light energy (that we can see).

Activity 10: Light globe analysis

1. Why do traditional globes waste a lot of energy?

   ____

2. Why are CFL called energy efficient lights?

   ____

3. What do you think may have motivated scientific research into discovering ways of producing more efficient electric lighting?

   ____

4. Many businesses in NSW have volunteered as drop off points for used CFLs to allow them to be recycled instead of going to landfill. Do you think this is a good idea? ____________

Explain why you think so: ___________________________________

____

5. Explain why you would save money using CFLs.

____

Check your responses by going to the suggested answers section

Scientists are continuing to research efficient lighting methods. Unfortunately mercury has proved to be the most efficient element for the fluorescent tube gas. Research has led to the amount of mercury used in CFL bulbs being reduced over time. However, a small amount of mercury is still required for CFLs to function properly.

LED bulbs

Scientific research teams have developed a light bulb that is even more efficient than CFLs. The LED, or light-emitting diode, produces light when electrons inside a diode (semiconductor material) are excited by the flow of an electric current.

Figure 26: An assortment of LED bulbs for screw-in bulbs

In LEDs:

- more electrical energy is transformed into light energy than in CFLs and only a small amount of energy is wasted as heat.
- there is no filament to burn out so they last a very long time
- there is no toxic substance like mercury used

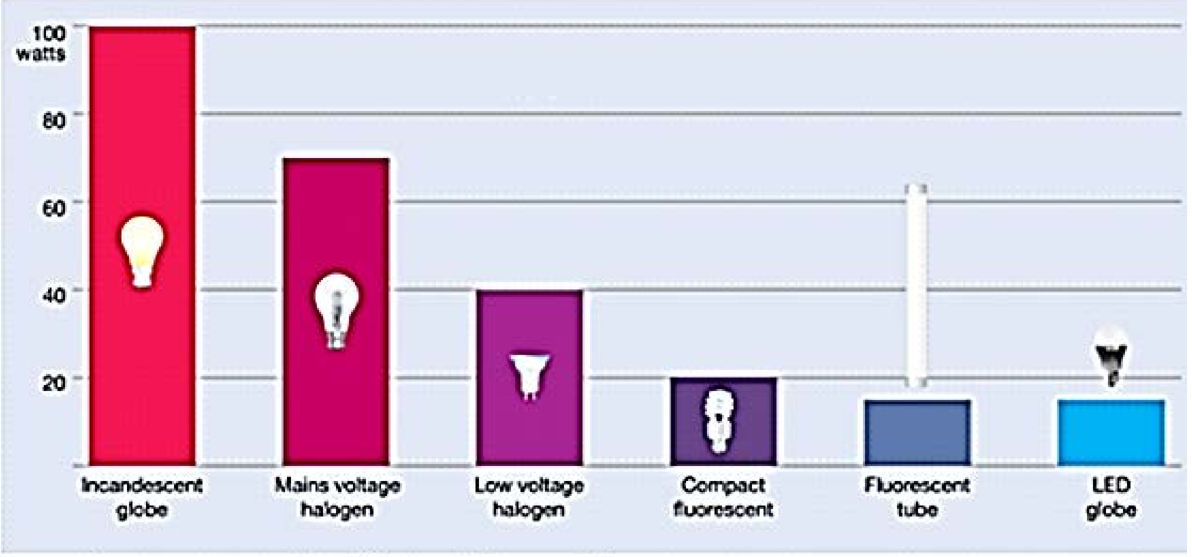
LEDs are expensive but as more people use them and scientific teams improve on the design, production costs should come down.

Development of LEDs

In 1927 a Russian scientist Oleg Losev created the first LED. His research was published in scientific journals but it was not until the 1950s and 60s that teams of scientists in various American laboratories produced coloured LEDs. Then in the 1990s a Japanese scientist Shuji Nakamura, working for a Japanese lighting company, developed the first white LED. He is now Professor of Materials at the University of California, teaching and leading a team of researchers.

Comparing efficiency

The graph below compares the amount of electrical energy in watts used by different light globes to produce the same amount of light energy.



Approximate watts used by different globes to deliver the same light output

Figure 27

Activity 11: Efficient Lights

1. Which light globe in the graph of Figure 27 uses 20 watts to produce the same light energy as an incandescent globe using 100 watts (100 W).

   ____

2. Which globe in the graph is the most energy efficient?

   ____

   ____

3. Explain why using LEDs would be good for the environment.

   ____

   ____

4. Why is it important for scientists to work in teams and publish their findings?

   ____

   ____

Check your responses by going to the suggested answers section

Energy Efficiency Rating

The Australian government requires electrical appliances to display an energy efficiency sticker. The sticker shows the amount of electrical energy the appliance will use in a year measured in kilowatt hours (kWh). If a lot of stars are highlighted this indicates the appliance is very efficient.

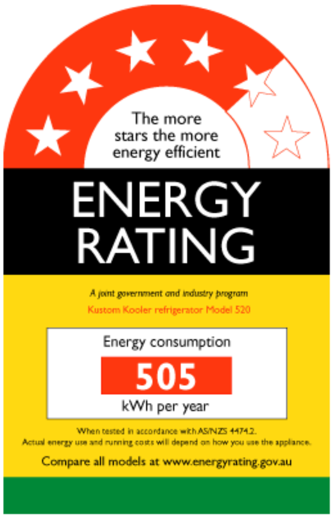


Figure 28

The sticker allows you to choose appliances that will use less electricity and save you money.

Now think back over the main points of the lesson and read the following summary.

Summary of Lesson 4

- Ohm's Law states:

  Voltage = Current × Resistance

  $V = I \times R$

- Incandescent light bulbs (traditional and halogen) use a thin wire filament with a high resistance that gets very hot. The heat energy is transformed into light energy.

- Scientific teams have carried out research leading to more efficient light bulbs – CFLs (compact fluorescent lights) and LEDs (light emitting diodes)

- Lights and appliances that produce more useful energy from electrical energy are said to be more efficient. They waste less energy.

EXERCISE

Complete the Send-in exercises for Lesson 4

Send-in exercises - Technology and electricity Part 1

Lesson 1: Household use and billing

1. (a) Complete the table

Day	Meter reading (kWh)	Use in 24 hours (kWh)
1		no previous reading for calculation
2		Day 2 – Day 1 ________________
3		Day 3 – Day 2 ________________
4		Day 4 – Day 3 ________________

(b) Did your family use the same number of kWh each day? ______

Explain what may have caused any differences.

____

____

2. Look at Table 1 in Lesson 1 (page 12).

Would it be more expensive to leave a stove hotplate or a hot water system on for an hour? _________________________________

Explain why ____

____

3. Discuss the advantage of having your electric hot water system heat your hot water late at night.

____

____

4. Explain how using a doona instead of an electric blanket could reduce greenhouse gas emissions and your personal carbon footprint (how much carbon dioxide is emitted into the atmosphere by your activities).

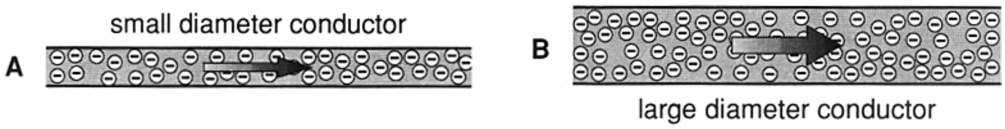
____

____

____

Lesson 2: Electric circuits

1. The diagram below shows two pieces of wire, A and B. The difference between A and B is that B is a much thicker wire than A.



a) Which wire (A or B) can electrons move through more easily? _____

b) Which wire (A or B) carries more electric current? ______________

c) Which wire (A or B) has more resistance? ____________________

d) Look at Figure 17 (page 23) and explain why rubber would be chosen instead of copper as an electrical insulator.

____

____

2. In the space below draw a circuit diagram containing:

- a power source
- a light globe
- a closed switch
- a circuit breaker resistor

Draw all diagrams in pencil. Use a ruler to draw straight lines.

3. a) Explain how a fuse prevents an electric circuit becoming too hot and causing a fire risk.

____

____

____

b) Explain why a circuit breaker could turn itself off to stop an electric current flowing in a circuit in your home.

____

____

____

____

c) Light circuits usually have an 8 amp circuit breaker or fuse. Explain why it would be dangerous to put a 15 amp circuit breaker or fuse in a light circuit.

____

____

____

Lesson 3: Experiment testing resistance of conductors

1. You will not actually do the experiment, but only plan it following the scientific method framework on page 47.

Plan a controlled experiment to test if a 0.3A fuse wire can act as an effective safety devise in a light globe circuit, in which a 9V battery is inserted by mistake.

- Choose the equipment you would need from the following items and circle them.
- Complete the framework for your plan for a controlled experiment.

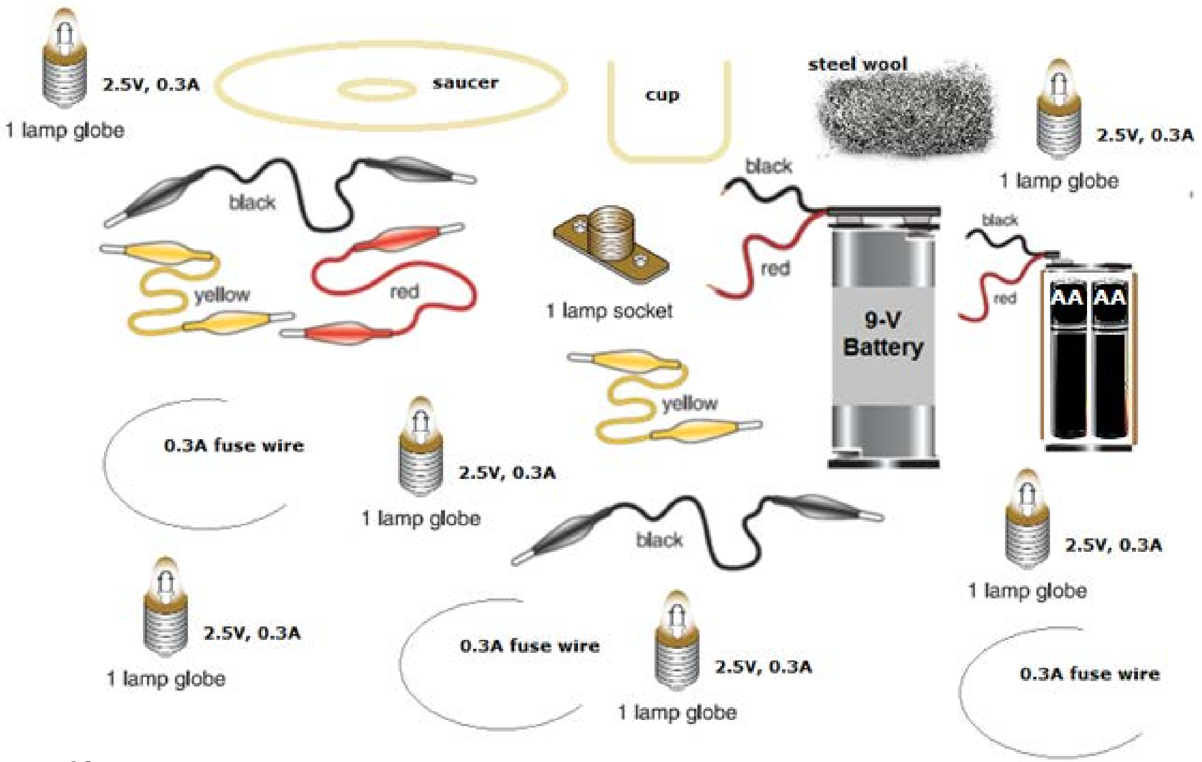


Figure 10

Aim: ____

Materials: ____

____

Method: (in steps and diagram/s, include any safety precautions required)

Steps ____

____

____

____

____

____

____

____

____

____

____

____

____

Diagram

Make some predictions (what you think would happen) using your knowledge gained from Activity 8.

a) Predict what would happen if you actually connected a 2.5V, 0.3A torch light with a 9V battery.

____

____

b) Predict what would happen if some 0.3A fuse wire was included in the torch circuit and then connected to the 9V battery.

____

____

2. Electric stoves use large currents.

Assess why they need thick wiring and large amp fuses or circuit breakers.

____

____

____

____

Lesson 4: Resistance, current and voltage

1. a) State Ohm's Law, in words and using a formula.

____

____

____

b) Complete the following table

Voltage	**Current**	**Resistance**
constant		increased
increased		constant

c) Use the information below to answer the following questions.

Currents used by Appliances

Appliance	**Current (I)** measured in amps (A)
light globe in a room	0.4 A
electric jug	12 A

i) Calculate the resistance of the light globe. Remember in Australian homes the power point Voltage (V) = 240 V.
Show your working.

____

____

____

ii) Would the light or the electric jug produce more heat in a household electric circuit?

____

iii) Would a light circuit or a kitchen power point circuit require the greater amp circuit breaker or fuse? (You may wish to refer to Lesson 2).

____

2. Discuss the benefits and risks of using CFLs.

____

____

____

____

3. Evaluate how using the following would be good for the environment:

   a) LED lights

   ____

   ____

   b) using appliances with four star energy ratings

   ____

   ____