## 4.1 Making a globe light up

### Lesson outcomes

At the end of this activity students will be able to:

- describe the requirements for lighting an electric globe
- understand every electric circuit requires a source of electrical energy and a complete circuit.

### What ideas might your students already have?

- Students may not understand that electrical devices require a complete circuit to work. This relates to the belief that electricity is delivered to a device, such as a bulb, and used up.

### Key vocabulary

Electricity, voltage, positive and negative terminals, circuit.

### Each GROUP will require:

- small light bulb without bulb holder (2 V)
- plastic coated wires without the ends stripped
- 1.5 V battery
- pair of wire strippers for removing the plastic from the ends.

### Things to consider

This activity introduces electrical circuits. The minimal equipment ensures students can clearly see what constitutes the basic requirements of an electric circuit. This activity avoids using the usual power supply and bulbs in holders to remove black-box effects, so students see exactly what is required. Students will go on to use the more usual electrical equipment in subsequent activities.

### Lesson plan

**What to use:**

**Each GROUP will require:**

- spring balance (up to 1 kg or 10 N)
- string
- 2 pulleys to attach to end of bench
- 2 x 500 g masses with mass hanger

**What to do:**

**Step 1:** Give each group the basic equipment.

**Step 2:** Instruct the class to make the light bulb glow.

**Step 3:** When most groups have been successful, ask the whole class what was required.

**Suggested question/s:**

What were the minimum requirements for lighting your globe?

Wires had to be connected to the battery's *positive* and *negative* terminals. Explain these are indicated by plus and minus signs.

The wires had to be connected to two different parts of the globe. Electricity had to be able to flow in and out of the globe. *A complete circuit was required*.

Students should answer the ***Notebook*** questions.

## 4.2 Showing electric circuits

### Lesson outcomes

At the end of this activity students will be able to:

- interpret circuit symbols.

### Key vocabulary

Circuit, diagram, symbols

### Equipment list

**Each GROUP will require:**

- large sheet of paper
- marker pens
- Blu Tack to display poster.

### Teacher content information

This activity allows students to develop ownership and understanding of how we communicate with each other. They explore ideas and reach a common understanding. You may increase the number of symbols used (battery, bulb, wires, switch, buzzer, ammeter, electric motor).

However, symbols are not universally agreed and vary for different applications.

### Lesson plan

**Step 1:** Form groups of three or four and ask them to recall the last activity (lighting the globe) and to suggest a set of symbols to represent the equipment used. You may add more, such as a motor or meter. Students brainstorm ideas for symbols.

**Step 2:** Students write ideas on the paper (using their symbols) to represent the circuit and then perform a **Gallery Walk**.

**Step 3:** Encourage students to share their ideas from the walk. What were common features? Why?

**Step 4:** Compare students' ideas to the conventional table of symbols (*Student Guide* **Activity 4.3**). Discuss as a class why these symbols are standardised.

**Suggested questions:**

- Why did you use …?
- Is that the quickest way?
- Would you use … regularly?

**Follow up:**

- bingo activity to refresh memory of the symbols

## 4.3 Heating water with electricity

### Lesson outcomes

At the end of this activity students will be able to:

- explain how a circuit can be built to heat water
- understand most electric circuits transform some electrical energy to heat
- calculate the quantity of heat transformed in a circuit.

### Equipment list

**Each GROUP will require:**

- standard 12 V power supply
- electrical leads with alligator clips
- voltmeter (0 - 12 V)
- ammeter (0 - 5 A)
- 20 cm high-resistance wire (Eureka or Nichrome)
- large test tube for winding the heating coil
- tap water
- measuring cylinder
- foam cups
- thermometer (0 – 100 $^{o}$C).

### Things to consider

The success of this experiment depends on the efficiency with which the heat energy generated by the wire is transferred to the water. It is important that:

- as much of the wire as possible is immersed in the water as possible. Make sure that the whole coil is below the water surface. There will need to be a small stretch of wire out of the water for the electrical connections.
- the wire is not in contact with the Styrofoam, which could melt as the wire heats up.
- the loss of heat is minimised. This can be achieved by covering the cup with a piece of card or even paper.

### Teacher content information

Students are studying the electrical equivalence of heat. The relationship for heating water is:

**Power = V x I** (measured in Watts).

The high-resistance wires usually used are either Eureka (a nickel/copper alloy) or Nichrome (a nickel/chromium alloy).

**Lesson plan**

**Step 1:** Students examine the directions for setting up the circuit, as shown in the *Student Guide* **Activity 4.2**. Information about each component and its symbol is provided.

**Step 2:** Different groups should be assigned different voltages, ranging from 2 V to 12 V.

**Step 3:** Each group should carefully measure the temperature of 150 mL of water before and after running the experiment for 15 minutes.

**Step 4:** Each group should add their results to the table on the board (see below).

**Table of results**

| Voltage | Current | V x I<br>(Power in Watts) | Temp increase of 150 mL of water in 15 minutes. |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**Step 5:** Students should graph power against the temperature increase of 150 mL water in 15 minutes.

**Suggested questions:**

- Did the temperature increase of the water correspond to the power of your heater?
- What do you think would have happened to the temperature increase of the water if you had doubled the time of heating?

## 4.4 Build a motor

### Lesson outcomes

At the end of this activity students will be able to:

- build a model motor and describe its major components
- describe how electrical energy can be transformed into kinetic energy.

### Key vocabulary

Electricity, motor, coil, magnet.

### Equipment list

**Each GROUP will require:**

- two jumbo-sized paper clips
- 1.5 V battery
- rubber bands
- 2 m of fine, insulated, electrical wire
- super magnet (neodymium): can be purchased from Scientrific for about $14 .
- plasticine or Blu Tack
- large test tube for producing the coil.

### Things to consider

This activity requires students to closely follow the instructions in *Student Guide* **Activity 4.3**. Once they have produced a working motor they may be able to modify and improve it.

### Teacher content information

All electric motors run on the principle that a wire carrying an electric current will feel a force if it is in a magnetic field. This is called the motor effect. This effect is quite weak, however coiling the wire multiple times will aggregate the individual forces. The wire must be insulated before it is coiled. All electric motors must have, at least, a coil of insulated wire and a magnet. The magnet can be an electromagnet.

This model is a direct current (DC) motor. Shaving the ends of the wire produces the commutator, which switches the current on once each turn.

Most real motors are alternate current (AC) motors, running directly from the AC power supply. They simply require a sliding contact rather than a commutator.

**Lesson plan**

**Step 1:** Carefully wind the wire around the test tube about 15 times to produce your coil. It should be finely balanced to turn easily, but doesn't slip to one side.

**Step 2:** With scissors, carefully shave the insulated coating from the **same** side of each protruding wire.

**Step 3:** Shape each paper clip into a cradle as shown.

**Step 4:** With the rubber band, attach both paper clips to the battery terminals.

**Step 5:** Attach the magnet to the battery's steel jacket.

**Step 6:** Secure the apparatus to the table using plasticine.

**Step 7:** Place the coil in the cradle and start it with a nudge.

**Suggested questions:**

- Did your motor require a complete circuit?
- What energy transfer is your motor achieving?
- Did you know the electric motor was one of the most important inventions of all time? They are found everywhere.
- How many motors does your family own? This includes every device (large or small) where electricity makes something move. You should be able to find several.

## 4.5 Build a generator

### Lesson outcomes

At the end of this activity students will be able to:

- build a model generator and describe its major components.

### Key vocabulary

Generator, coil, magnet.

### Equipment list

**Each GROUP will require:**

- solenoid (each group could also produce their own coil with about 1-2 m of insulated wire)
- strong-bar magnet
- electric leads
- galvanometer or micro ammeter.

### Things to consider

This activity requires students to follow the instructions provided in the *Student Guide*. Students will see a small *generator effect* using a micro ammeter or galvanometer.

You can give students a more practical example using a bicycle dynamo. The problem with real, working generators, like motors, is that you can't see the inner workings.

### Teacher content information

The generator effect means any magnet moving near a conductor will produce a voltage. This is the basis for all large-scale electricity production (excluding solar cells). Every large power station uses turbines to create electricity. Various fuels, including coal, gas, or nuclear reactions are used to heat fluids, usually water, to produce steam to drive turbines. The Snowy Mountains Hydro-Electric Scheme uses water rushing down pipes (transferring gravitational potential energy to kinetic energy) to drive turbines.

### Lesson plan

**Step 1:** Connect the solenoid and the meter in a complete circuit.

**Step 2:** Quickly pass the bar magnet in and out of the coil. Watch the meter as you do.

**Step 3:** Hold the magnet in a stationary position inside the coil. Does the needle move now?

### Suggested questions:

- Did the meter needle move?
- Was the effect very large?
- What sort of energy is being transferred to electrical energy?

**General Idea:** electricity is always produced if a magnet moves near a conductor.

## 4.6 The lemon battery

### Lesson outcomes

At the end of this activity students will be able to:

- construct a battery made of lemons and copper and zinc electrodes.
- explain that the energy to power the battery ultimately comes from the chemical energy in the metal electrodes.

### What ideas might your students already have?

- A very common misconception is that this battery is powered by the lemon. In fact the chemical energy comes from the pure metals. A large amount of chemical or electrical energy was put in to produce the pure metals from their ores.

### Key vocabulary

Electrode, battery, LED (light emitting diode).

### Equipment list

**Each GROUP will require:**

- 4-6 lemons
- 4-6 pieces of copper and zinc, approximately 1 cm x 3 cm
- LED
- electrical leads with alligator clips
- tray for lemons.

### Things to consider

A typical LED requires around 2.2 V to light. A copper/zinc electric cell (in any appropriate electrolyte) can produce up to around 0.8 V). Hence at least three cells need to be connected in series to produce an appropriate overall voltage. We have found four in series is sufficient.

Connecting more of these in parallel should produce more current, but uses a lot of lemons.

Unlike light bulbs, LEDs have a particular polarity. Most have the negative electrode indicated by having the plastic case shaved off to produce a flat edge just above the negative electrode. If connected the wrong way, it won't light.

### Teacher content information

In this electric battery, the lemon is simply serving as the electrolyte. The energy to drive the system essentially comes from the zinc, which is oxidized, releasing electrons. Zinc dissolves into the juice forming a zinc solution. Electrons travel through the circuit to the copper. Mostly hydrogen is released at the copper. The hydrogen ions come from the acids in the lemon.

### Lesson plan

**Step 1:** Roll each lemon firmly on the table to release juice. You may have seen Jamie Oliver do this on a cooking show.

**Step 2:** Cut two slits in each lemon.

**Step 3:** Push one piece of copper and one piece of zinc into each lemon.

**Step 4:** Use the electric leads to connect the lemons in a circuit. You should connect the lemons one after the other, so that copper connects to zinc on the next lemon, and so on.

**Step 5:** Complete the circuit by connecting the LED.

**NOTE:** the pin under the flat side of the LED should connect to a zinc electrode.

**Step 6:** Experiment with different numbers of lemons in your circuit to find the optimum number.

**Discussion**

- You could try this experiment with other fruit or vegetables, or even with salty water.
- You could also try different combinations of metals.
- You could also use a voltmeter to check how much voltage you got from your battery.
- What energy conversion was happening in your lemon battery?
- Sketch your lemon battery in your ***Notebook***.
- Based on the information provided in the *Student Guide* **Activity 4.6** summarise where the energy to run your lemon battery came from.