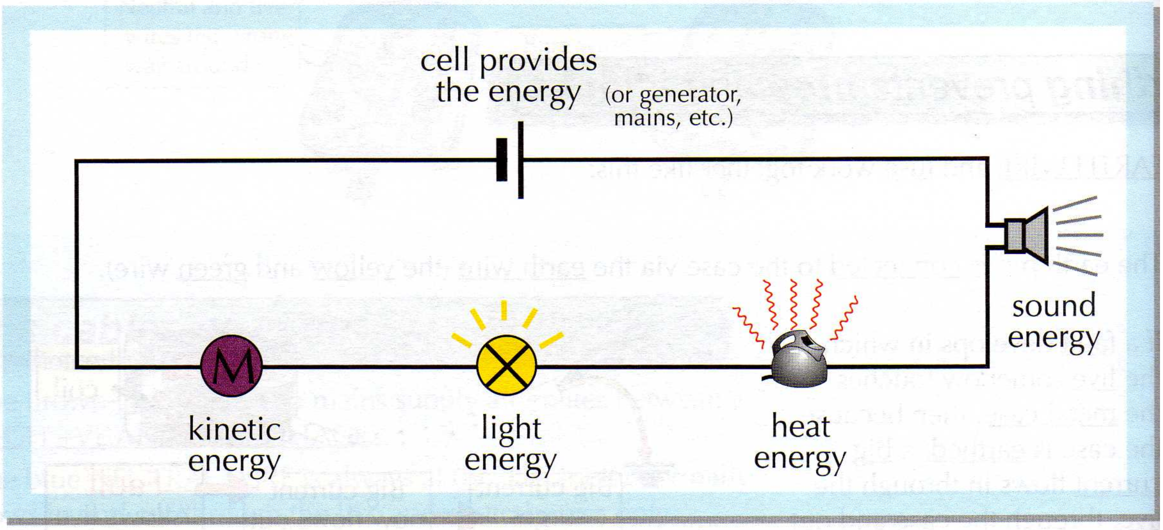
Energy and Power in Circuits

You can look at electrical circuits in two ways. The first is in terms of a voltage pushing the current round and the resistances opposing the flow, as on page 91. The other way of looking at circuits is in terms of energy transfer. Learn them both and be ready to tackle questions about either.

Energy is transferred from cells and other sources

Anything which supplies electricity is also supplying energy.
So cells, batteries, generators, etc. all transfer energy to components in the circuit:

Motion: motors   Light: light bulbs   Heat: Hairdryers/kettles   Sound: speakers



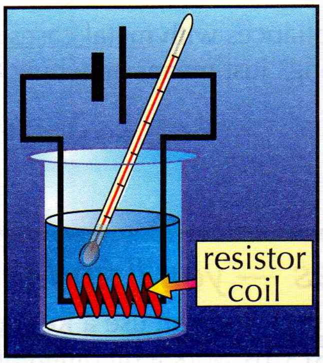
All resistors produce heat when a current flows through them

1) Whenever a current flows through anything with electrical resistance (which is pretty well everything) then electrical energy is converted into heat energy.

2) The more current that flows, the more heat is produced.

3) A bigger voltage means more heating because it pushes more current through.

4) You can measure the amount of heat produced by putting a resistor in a known amount of water, or inside a solid block, and measuring the increase in temperature.



Energy and Power in Circuits

...you how much energy a device transfers per second.

...ngs of appliances

...ight bulb converts electrical energy into light and has ...ower rating of 100 watts (W), which means it transfers ...0 joules/second.

A kettle converts electrical energy into heat and has a power rating of 2.5 kW, transferring 2500 joules/second.

...gy transferred by an appliance depends on how long it is on for and on its power rating. ...or energy

ENERGY = POWER × TIME **(E = P × t)**

...e, if the kettle above is left on for five minutes, the energy ... by the kettle in this time is:

...00 = 750 000 J = 750 kJ. (5 minutes = 300 seconds)

...al power and fuse ratings

...mula for electrical power is:

...VER = VOLTAGE × CURRENT **(P = V × I)**

$\frac{P}{V \times I}$

...lectrical goods show their power rating and voltage rating. To work out the ...eeded, you need to work out the current that the item will normally use:

...mple:

...hairdryer is rated at 230 V, 1 kW. Find the fuse needed.

...swer: I = P/V = 1000/230 = 4.3 A.

...rmally, the fuse should be rated just a bit higher than the normal current, ...a 5 amp fuse is ideal for this one.

...just pick the nearest fuse value — a lower one is no good

...K, you can usually get fuses rated at 3 A, 5 A or 13 A, and that's about it. You should bear tha... ...hen you're working out fuse ratings. If you find you need a 10.73 A fuse — tough.

Charge, Voltage and Energy

Total charge *through a circuit depends on* ***current*** *and* ***time***

1) Current is the flow of electrical charge (in coulombs, C) around a circuit.
2) When a current (I) flows past a point in a circuit for a time (t) then the charge (Q) that has passed is given by:

total charge (C) = current (A) × time (s)

3) More charge passes around the circuit when a bigger current flows.

Example:

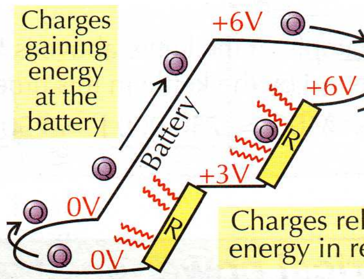
A battery charger passes a current of 2.5 A through a cell for a period of 4 hours. How much charge does the charger transfer to the cell in total?

Answer: $Q = I \times t = 2.5 \times (4 \times 60 \times 60) = 36\,000$ C (36 kC).

Voltage *is the* ***energy*** *transferred per* ***charge passed***

1) When an electrical charge (Q) goes through a change in voltage (V), then energy (E) is transferred.
2) Energy is supplied to the charge at the power source to 'raise' it through a voltage.
3) The charge gives up this energy when it 'falls' through any voltage drop in components elsewhere in the circuit.

The formula is really simple:



energy transformed = charge × potential difference

4) The bigger the change in voltage (or P.D.), the more energy is transferred for a given amount of charge passing through the circuit.

5) That means that a battery with a bigger voltage will supply more energy to the circuit for ev coulomb of charge which flows round it, because the charge is raised up 'higher' at the star (see above diagram) — and as the diagram shows, more energy will be dissipated in the cir

Example:

A motor is attached to a 3 V battery. If a current of 0.8 A flows through the motor for 3 minu
a) Calculate the total charge passed.
b) Calculate the energy transformed by the motor.
c) Explain why the kinetic energy output of the motor will be less than your answer to b).

Answer: a) Using the formula above, $Q = I \times t = 0.8 \times (3 \times 60) = 144$ C.

b) Use $E = Q \times V = 144 \times 3 = 432$ J.

c) The motor won't be 100% efficient. Some energy will be transformed into sound and h

Warm-Up and Exam Questions

You're well over half way through this section now. Check you can do the straightforward stuff with this warm-up, then have a go at the exam questions below.

Warm-Up Questions

1) Which of the live, neutral or earth wires is always at 0 volts?
2) Why is the case of a plug usually made out of plastic?
3) What energy transformation occurs when electric current flows through a resistor?
4) What is the name for the rate at which electrical charge flows round a circuit?
5) What is the equation linking Q, V and E?

Exam Questions

1 (a) What colour are each of the following wires in an electric plug?

(i) live

(ii) neutral

(iii) earth

(3 marks)

(b) Which two wires usually carry the same current?

(1 mark)

(c) What type of safety device contains a wire that is designed to melt when the current passing through it goes above a certain value?

(1 mark)

2 A domestic appliance has a plug containing live, neutral and earth wires and a fuse, all correctly wired to the household circuit.

(a) Describe the current that flows in each of the wires in the following situations:

(i) normal operation

(ii) the instant after the live wire has come into contact with the metal cover

(iii) after the fuse has blown

(3 marks)

(b) If there were no earth wire or fuse present and a person touched the live wire, what path would the current take?

(1 mark)

3 A current of 0.5 A passes through a torch bulb. The torch is powered by a 3 V battery.

(a) What is the power of the torch?

(2 marks)

(b) If the torch is on for half an hour, how much charge has passed through the battery?

(2 marks)

(c) How much electrical energy does the bulb transfer in half an hour?

(2 marks)