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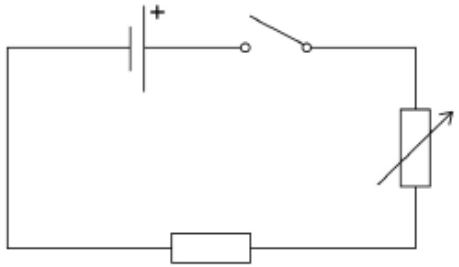
physics
aqa
Electricity
with solutions

0 1 A student investigated how the current in a resistor varies with the potential difference across the resistor.

Figure 1 shows part of the circuit used.

voltage

Figure 1



Series

parallel

0 1 . 1 The student connected an ammeter and a voltmeter into the circuit.

What is the correct way to connect the ammeter and the voltmeter into the circuit?

[1 mark]

Tick (✓) **one** box.

Ammeter	Voltmeter	
In parallel with the resistor	In series with the resistor	☐
In parallel with the cell	In series with the resistor	☐
In series with the resistor	In parallel with the resistor	☐
In series with the resistor	In parallel with the cell	☐

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0 1 . 2 The student increased the resistance of the variable resistor.

How did increasing the resistance affect the current in the circuit?

[1 mark]

current decreased

$V = I \times R$

$\frac{V}{R} = I$

Increase → R

I ← decrease

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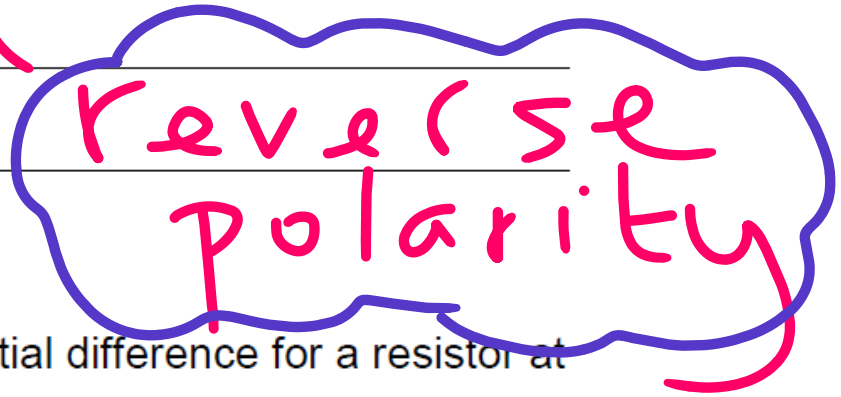
0 1 . 3 How should the student change the circuit to give negative values for current and potential difference?

[1 mark]

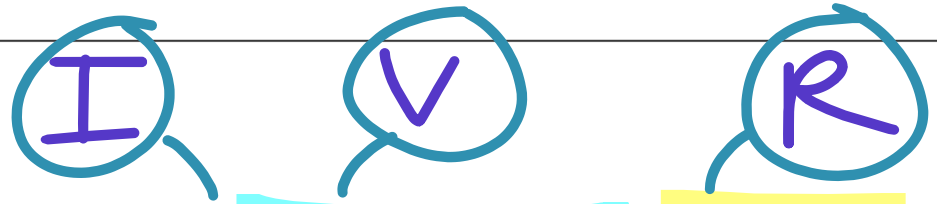
reverse the connections to the cell



0 1 . 4 Name the type of relationship between current and potential difference for a resistor at constant temperature.

[1 mark]

(directly) proportional



0 1 . 5 Write the equation which links current, potential difference and resistance.

[1 mark]

$V = I \times R$

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0 1 . 6 The current in the resistor was 0.12 A when the potential difference across the resistor was 3.0 V

Calculate the resistance of the resistor.

[3 marks]

$V = I \times R$

$R = \frac{V}{I} = \frac{3.0}{0.12} = 25\ \Omega$

Resistance = 25 Ω

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0 3 A hybrid car has an electric motor and a petrol engine.

0 3 . 2 The electric motor in the car is powered by a battery.

To charge the battery, the car is plugged into the mains supply at 230 V

The power used to charge the battery is 6.9 kW

Calculate the current used to charge the battery.

[4 marks]

V

P 6900W

I

$P = I \times V$ $I = \frac{P}{V} = \frac{6900}{230}$

So $I = 30A$

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0 3 . 3 Mains electricity is an ac supply.

Explain the difference between direct and alternating potential difference.

[2 marks]

direct potential difference is always in the same direction

alternating potential difference changes direction

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0 3 . 4 The cable used to connect the car to the mains electricity supply has a low resistance.

Explain why it is better to use a cable with a low resistance than to use a cable with a high resistance.

[2 marks]

(lower resistance gives) a greater current (for the same potential difference)

so the car battery can charge faster

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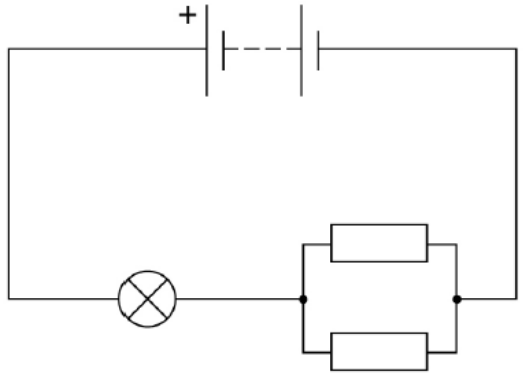
0 4 **Figure 2** shows a circuit that a student built.

Figure 2



0 4 . 1 The lamp has a resistance of 10 Ω

Each resistor has a resistance of 10 Ω

What is the total resistance of the circuit?

Tick (✓) **one** box.

- [ ] Between 20 and 30 Ω
- [ ] Exactly 20 Ω
- [ ] Exactly 30 Ω
- [x] Less than 20 Ω

Resistors in parallel

$R_T <$ smallest resistor

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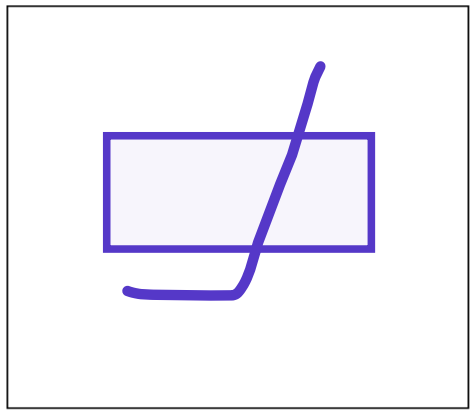
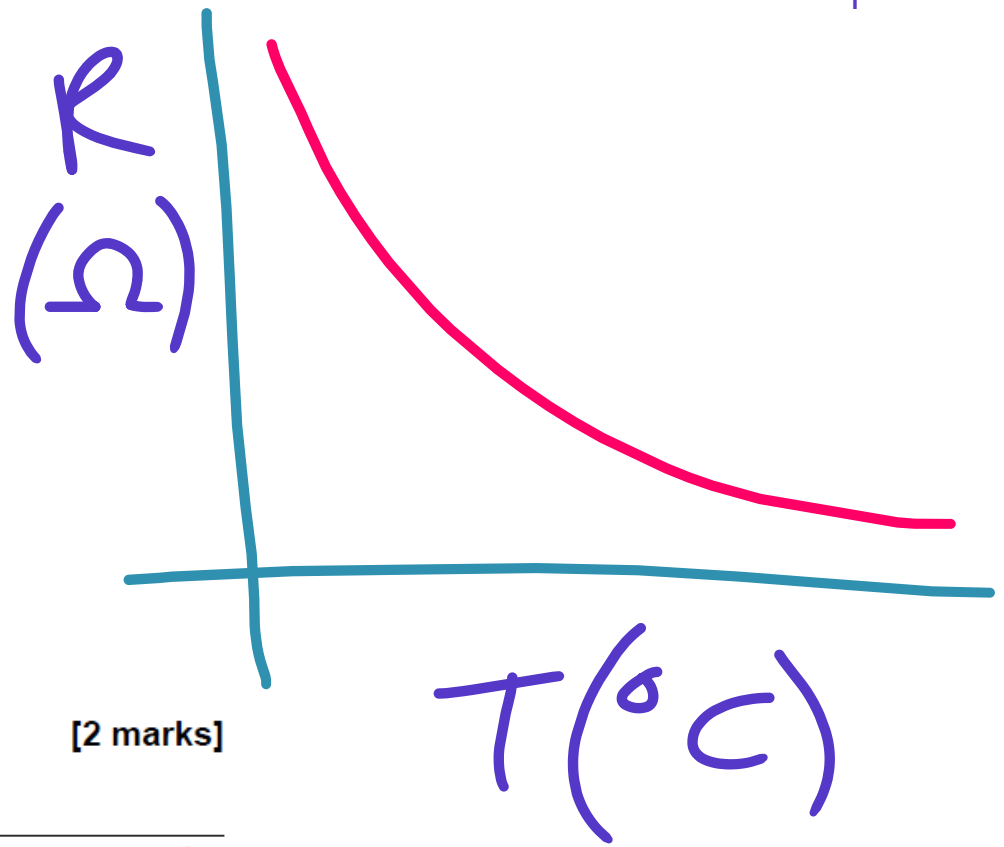
0 4 . 3 Draw the circuit symbol for a thermistor in the box below.

[1 mark]





0 4 . 4 The student increased the temperature of the thermistor.

Explain how the current in the thermistor changed.

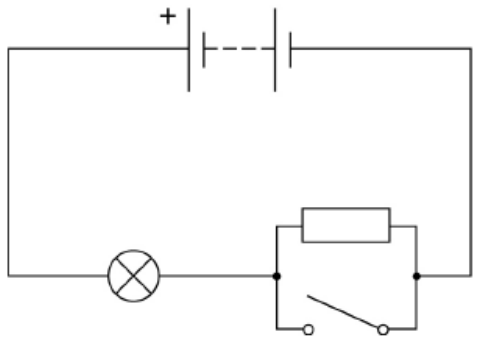
[2 marks]

the current increased

(because) the resistance (of the thermistor) decreased

0 4 . 5 **Figure 3** shows another circuit the student built.

Figure 3



Explain how the potential difference across the resistor and the lamp will change when the switch is closed.

[4 marks]

The resistor

the potential difference across the resistor becomes 0V because there is a short circuit across the resistor

The lamp

the potential difference across the lamp increases because the current increases

Current takes Path of least resistance

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0 1 Light bulbs are labelled with a power input.

Power
Same as
Energy per
unit time

0 1 . 1 What does power input mean?

[1 mark]

Tick (✓) **one** box.

- The charge transferred each second by the bulb. ☐
- The current through the bulb. ☐
- The energy transferred each second to the bulb. ☑
- The potential difference across the bulb. ☐

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0 1 . 2 Write down the equation which links current, potential difference and power.

[1 mark]

$P = I \times V$

0 1 . 3 A light bulb has a power input of 40 W — P

The mains potential difference is 230 V — V

Calculate the current in the light bulb. — I

[3 marks]

$P = I \times V$ $\quad I = \frac{P}{V} = \frac{40}{230}$

Current = 0·17 A

Light bulb	Total power input in watts	Useful power output in watts	Efficiency
P	6.0	5.4	0.90
Q	40	2.0	0.05
R	9.0	**X**	0.30

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0 1 . 4 Write down the equation which links efficiency, total power input and useful power output.

[1 mark]

efficiency = useful power output / total power input

0 1 . 5 Calculate the value of **X** in **Table 1**.

[3 marks]

$0.3 = \frac{\text{useful}}{9.0}$

$9.0 \times 0.3 = \text{useful}$

X = 2.7 W

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0 1 . 6 In addition to power input, light bulbs should also be labelled with the rate at which they emit visible light.

Suggest why.

[2 marks]

bulbs also transfer thermal energy

the efficiency of the light bulb also needs to be considered

0 6 **Figure 7** shows a person using an electric lawn mower.

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Figure 7

0 6 . 1 The lawn mower is connected to the mains electricity supply.

What is the frequency of the mains electricity supply in the UK?

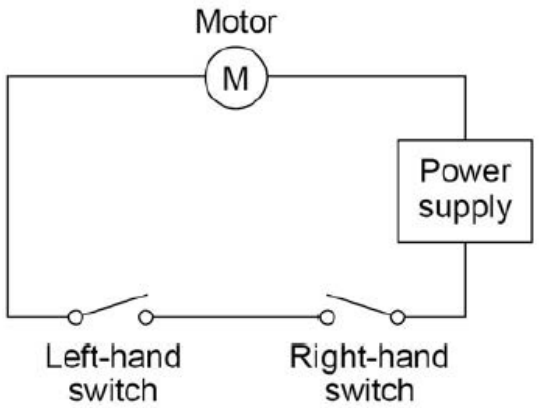
[2 marks]

Frequency = 50 Unit Hz

The lawn mower has a switch on each side of the handle.

Figure 8 shows the circuit diagram for the lawn mower.

Figure 8



0 6 . 2 The motor in the lawn mower can only be turned on when the person using it holds the handle of the lawn mower with both hands.

Explain why.

[2 marks]

(both) switches need to be closed / or on

~~to complete the series circuit~~

or

to allow charge to flow

or

~~so there is a current flowing in the circuit~~

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0 6 . 3 The power input to the motor is 1.8 kW

P

1800W

The resistance of the motor is 32 Ω

R

Calculate the current in the motor.

[3 marks]

I

$P = I^2 \times R$ so $I^2 = P / R$

$I^2 = \frac{1800}{32}$ so $I = \sqrt{1800/32}$

Current = 7.5 A

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P → 1500W

0 6 . 4 The useful power output from the motor is 1.5 kW

E

Calculate the time it takes for the motor to transfer 450 000 J of useful energy.

[3 marks]

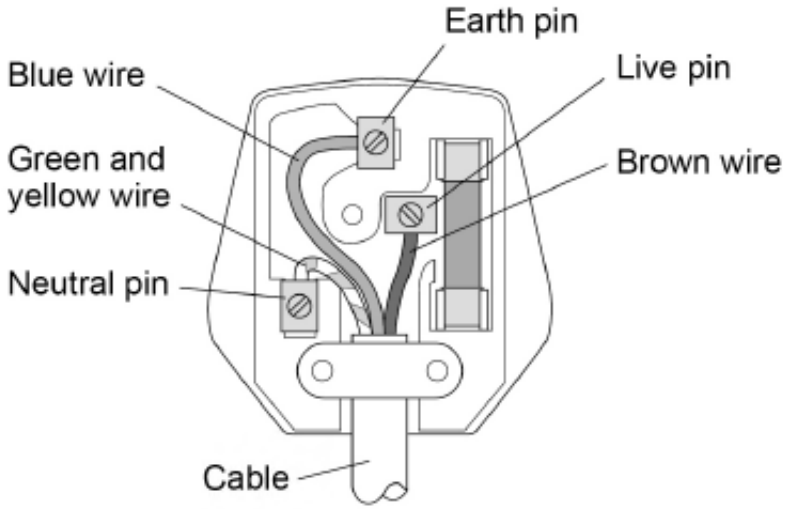
t

$E = P \times t$ $t = \frac{E}{P} = \frac{450000}{1500}$

Time = 300 seconds

0 1 **Figure 1** shows the inside of a plug.

Figure 1



0 1 . 1 The plug is **not** wired correctly.

What should be done to connect the wires in the plug correctly?

[1 mark]

swap the blue wire and the green and yellow wire

The correctly wired plug and cable connects a washing machine to the mains electricity supply.

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0 1 . 2 Give the potential difference and frequency of the mains electricity supply in the UK.

[2 marks]

The potential difference is 230 V

The frequency is 50 Hz

0 1 . 3 The washing machine is switched on.

What is the potential difference between the neutral wire and the earth wire?

[1 mark]

Potential difference = 0 V

0 1 . 4 The plug has a fuse.

Draw the circuit symbol for a fuse in the space below.

[1 mark]

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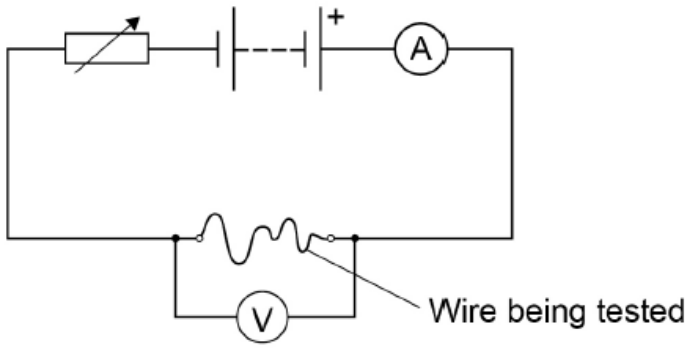
0 3 A student investigated how the resistance of a piece of wire varies with its length.

0 3 . 1 **Figure 2** shows the circuit used.

Figure 2



Explain why the student needed to adjust the variable resistor each time she changed the length of the wire.

[3 marks]

(the variable resistor) changes the resistance of the circuit
to keep the current the same
so the temperature of the wire is kept constant

0 3 . 2 The student recorded three measurements of the potential difference across a 0.10 m length of wire.

Table 1 shows the results.

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Table 1

Length in m	Potential difference in V			
	1	2	3	Mean
0.10	**X**	0.18	0.15	0.17

Calculate **X** in **Table 1**.

[2 marks]

$$\frac{X + 0.18 + 0.15}{3} = 0.17$$

$$X = 0.18$$

X = _____ V

0 3 . 3 **Figure 3** shows the results for five different lengths of the wire.

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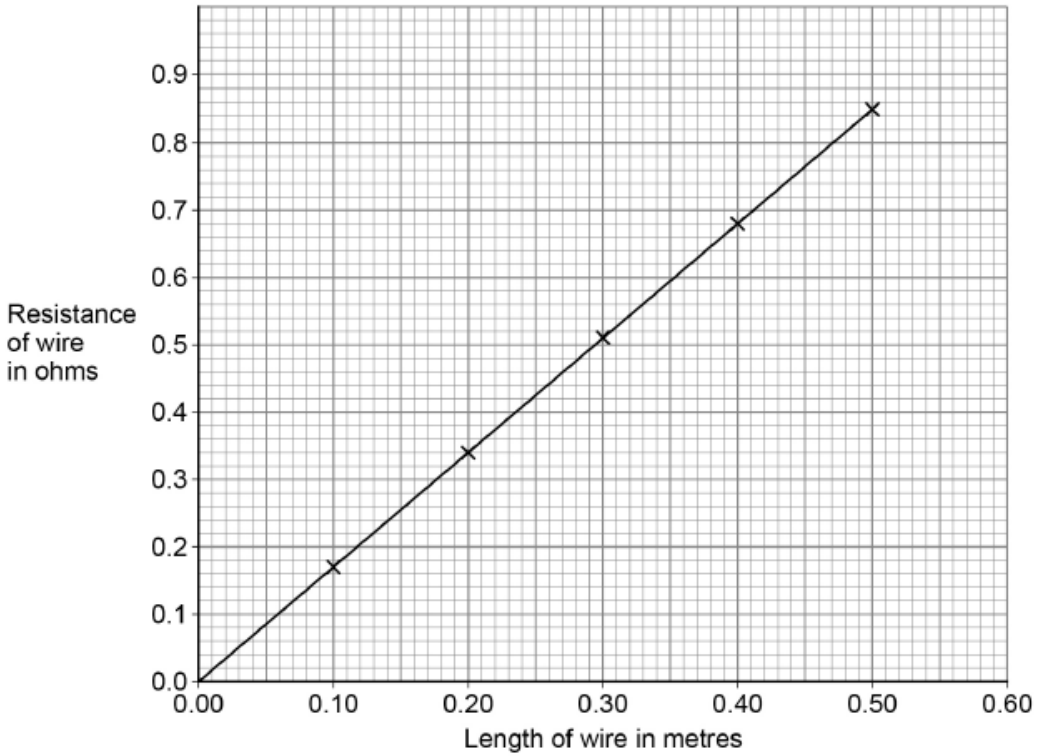
Figure 3



Describe the relationship between the length of the wire and the resistance of the wire.

[2 marks]

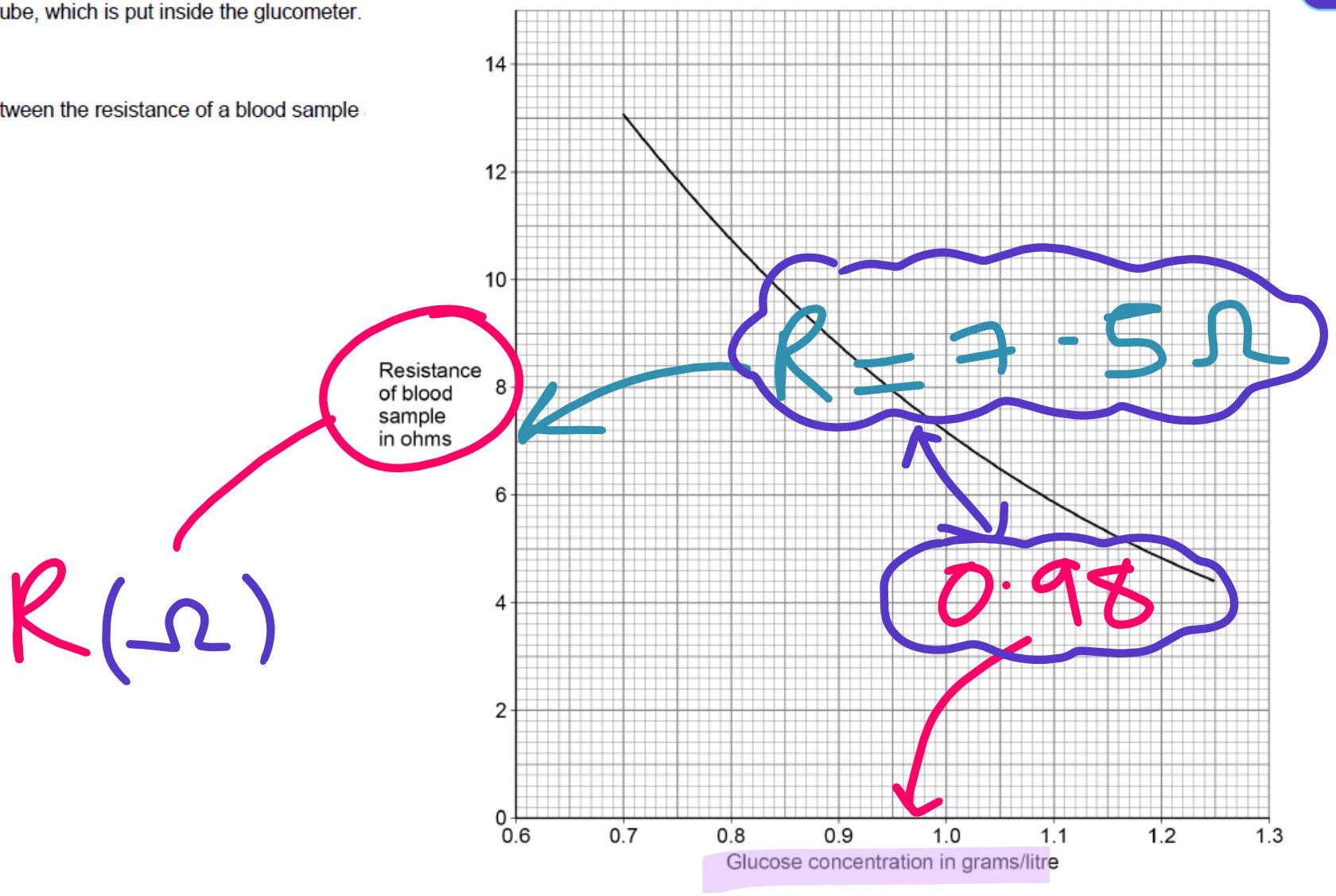
resistance is directly proportional to length

A glucometer uses the resistance of a blood sample to calculate the glucose concentration in a person's blood.

A blood sample is put into a small tube, which is put inside the glucometer. then acts like a resistance wire.

Figure 4 shows the relationship between the resistance of a blood sample glucose concentration.

Figure 4



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0 3 . 4 The glucometer applies a potential difference of 0.90 volts across a blood sample.

The glucose concentration of the blood sample is 0.98 grams/litre.

Determine the current in the blood sample.

[4 marks]

$R = 7.5$

$0.9 = I \times 7.5$

$I = \frac{0.9}{7.5}$

Current = 0.12 A

Use graph:

resistance = 7.5 (Ω)

$0.90 = I \times 7.5$

$I = \frac{0.90}{7.5}$

$I = 0.12$ (A)

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0 3 . 5 A new tube is used each time a blood sample is tested.

Explain why valid results are only obtained if each tube is identical.

[2 marks]

the length/width/volume (of the blood sample) affects the resistance of the blood sample so only glucose concentration affects resistance

0 3

An engineering company has invented pavement tiles that generate electricity as people walk on them.

Figure 3 shows someone walking on the pavement tiles.

Figure 3

Use the Physics Equations Sheet to answer questions **03.1** and **03.2**.

0 3 . 2 When a person walks on a tile, a potential difference of 40 V is induced across the tile.

The power output of the tile is 4.4 W.

P

V

Calculate the current in the tile.

I

[3 marks]

$P = I \times V$ $I = \frac{P}{V} = \frac{4.4}{40}$

$I = 0.11$

Current = 0.11 A

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0 3 . 4 The tiles are used to power LED lights in the pavement.

An LED light has a total power input of 4.0 W.

The efficiency of the LED light is 0.85

Calculate the useful power output of the LED light.

[3 marks]

$$\text{Eff} = \frac{\text{useful}}{\text{input}} \qquad 0.85 = \frac{\text{useful}}{4.0\text{W}}$$

$$= 0.85 \times 4.0 = 3.4$$

efficiency = $\frac{\text{useful power output}}{\text{total power input}}$

Useful power output = 3.4 W

0 6 **Figure 8** shows how electricity is supplied to consumers by the National Grid.

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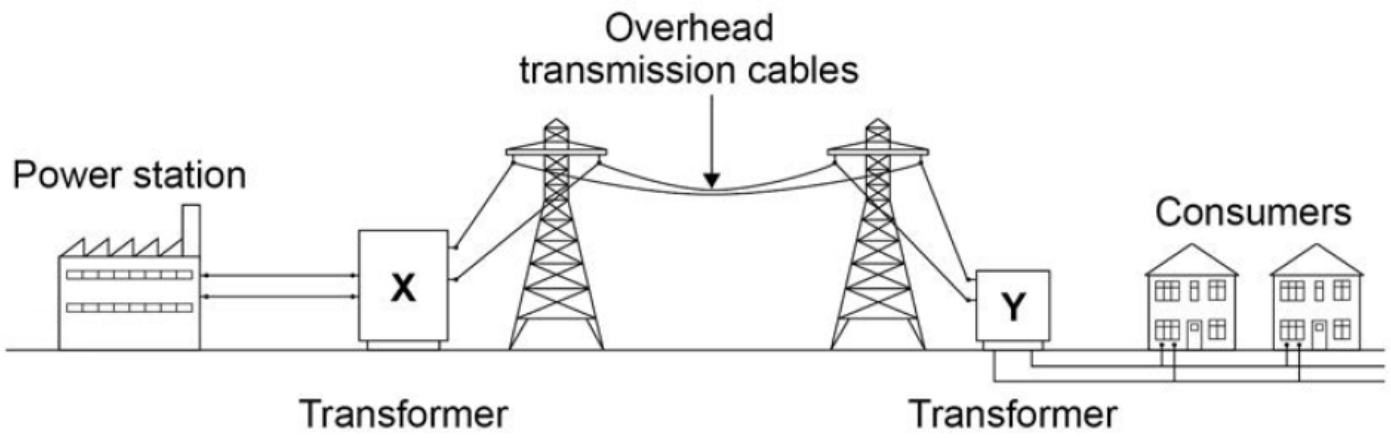
Figure 8



0 6 . 1 Explain why transformer **X** is used in the National Grid.

[4 marks]

transformer **X** increases potential difference

~~and decreases current~~

reducing (thermal) energy transfer to surroundings

or

~~reducing (thermal) energy transfer from transmission cables~~

increasing the efficiency (of power transmission)

0 6 . 3 The town of Hornsdale in Australia has electricity supplied by a huge battery.

On one day the battery transferred 3.24×10^{11} J of energy to the town.

The potential difference of the town's electricity supply is 230 V.

Calculate the charge flow to the town on this day.

Use the Physics Equations Sheet.

Give your answer to **3** significant figures.

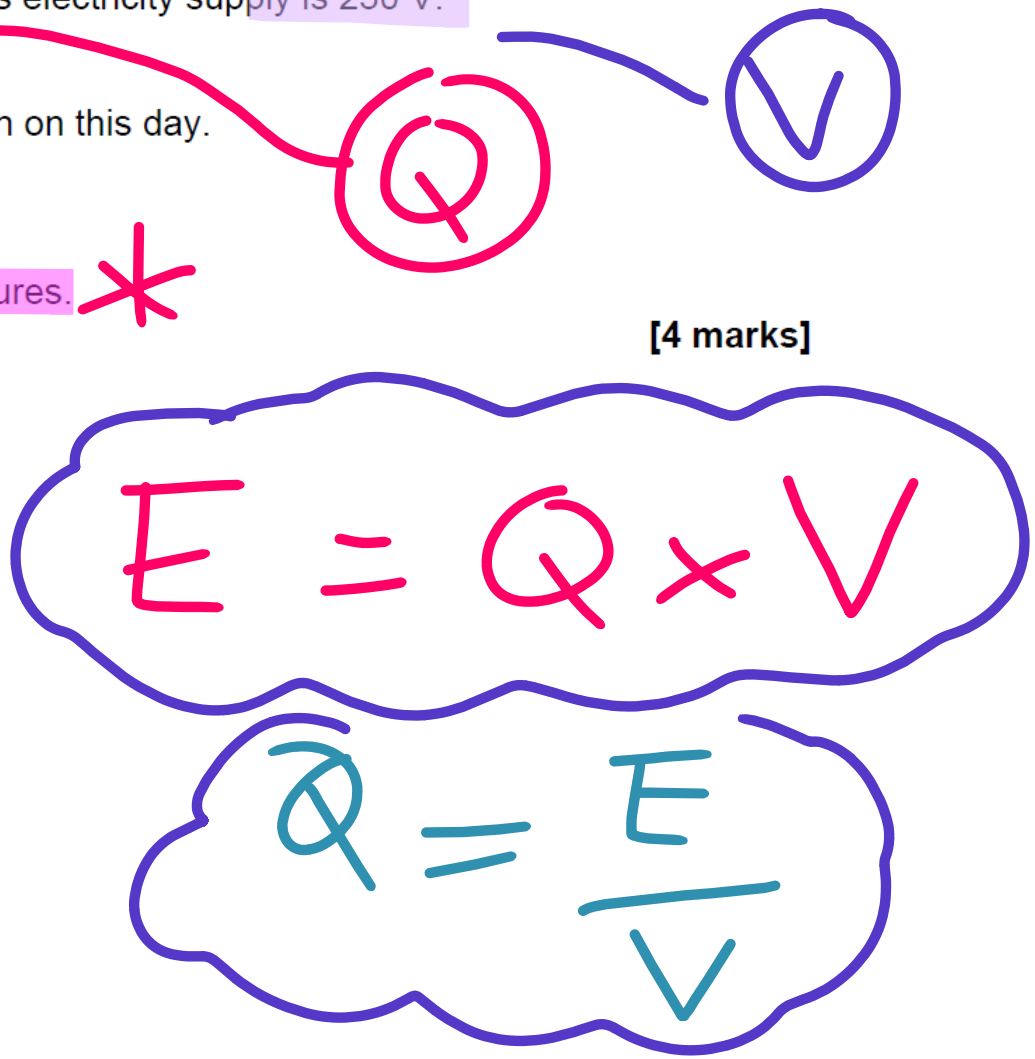
[4 marks]

$3.24 \times 10^{11} = Q \times 230$

$$Q = \frac{3.24 \times 10^{11}}{230}$$

$Q = 1\,408\,695\,652$ (C)

$Q = 1.41 \times 10^{9}$ (C)
or
$Q = 1\,410\,000\,000$ (C)



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1 1 **Figure 12** shows some hair straighteners.

Hair straighteners contain heating elements.

Figure 12

1 1 . 1 When the hair straighteners reach normal operating temperature, an LED turns on.

Draw the circuit symbol for an LED in the box.

[1 mark]

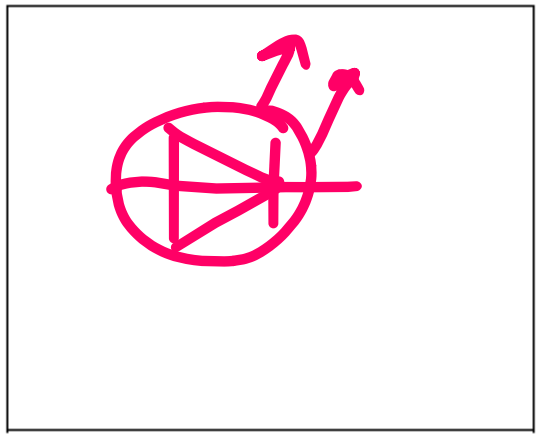

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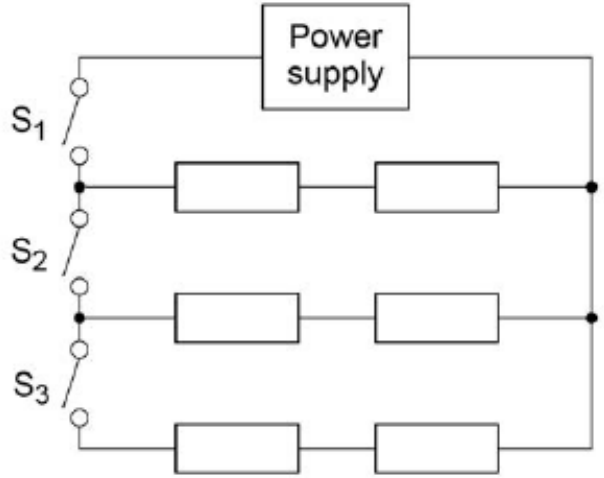
Figure 13 shows the circuit diagram for the hair straighteners.

Each resistor represents a heating element.

The power output of the hair straighteners can be changed by closing different switches.

Figure 13



1 1 . 2 Why do the hair straighteners **not** turn on when only switch S_2 is closed?

[1 mark]

there is a gap in the circuit

or

S1 needs to be closed to complete the circuit

or

S1 needs to be closed to turn the hair straighteners on

1 1 . 3 The hair straighteners have a maximum power output of 120 W.

P

The energy transferred to the hair straighteners to reach normal operating temperature is 3.6 kJ.

E

t

Calculate the time taken for the hair straighteners to reach normal operating temperature when operating at maximum power.

Use the Physics Equations Sheet.

[4 marks]

3600J

$E = p \times t$

so $t = \frac{E}{P} = \frac{3600}{120} = 30$

Time = 30 seconds

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