Electricity 4

Name: _____

Class: _____

Date: _____

Time: **66 minutes**

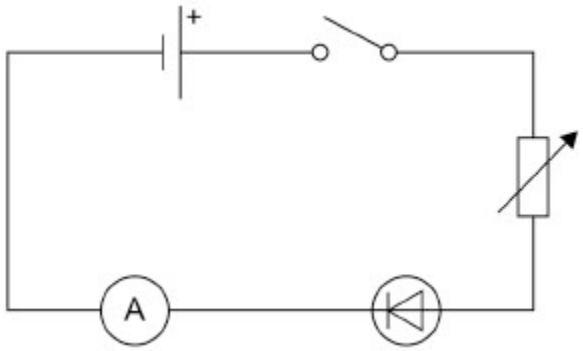
Marks: **61 marks**

Comments:

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

Figure 1 shows an incomplete diagram of the circuit used.

Figure 1



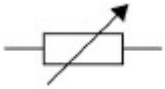
(a) The student measured the potential difference across the diode.

Complete **Figure 1** by adding the symbol for a voltmeter in the correct position.

(2)

(b) Which component should the student adjust to change the potential difference across the diode?

Tick (✓) **one** box.

 ☐

☐

☐

(1)

The student measured the current three times for each value of potential difference.

(c) Complete the sentence.

Choose the answer from the box.

random	systematic	zero

When the potential difference was 1.50 V the current measurements varied between 0.95 A and 1.08 A. This was caused by _____ errors.

(1)

(d) For one value of potential difference, the measurements of current were:

0.27 A 0.32 A 0.31 A

Calculate the mean current.

_____

_____

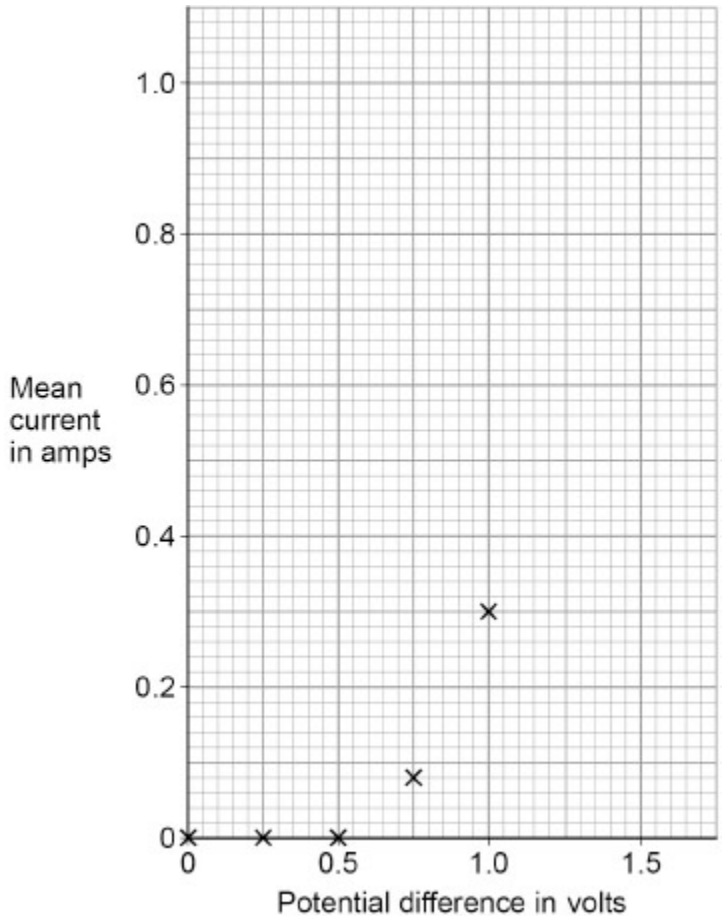
_____

Mean current = _____ A

(2)

Figure 2 shows some of the results.

Figure 2



(e) The table below shows the results when the potential difference was greater than 1.00 V.

Potential difference in volts	Mean current in amps
1.25	0.60
1.50	1.00

Complete **Figure 2**.

You should:

- plot the results from the table above
- draw a line of best fit.

(2)

(f) Complete the sentence.

Choose the answer from the box.

directly proportional	**inversely proportional**	**non-linear**

Figure 2 shows that the relationship between potential difference and current for the diode is _____ .

(1)

(g) The student adjusted the circuit so that the current in the diode was 1.00 A.

The student then reversed the connections to the diode.

What happened to the current in the diode when the connections were reversed?

Tick (✓) **one** box.

The current decreased to 0.00 A. ☐

The current remained at 1.00 A. ☐

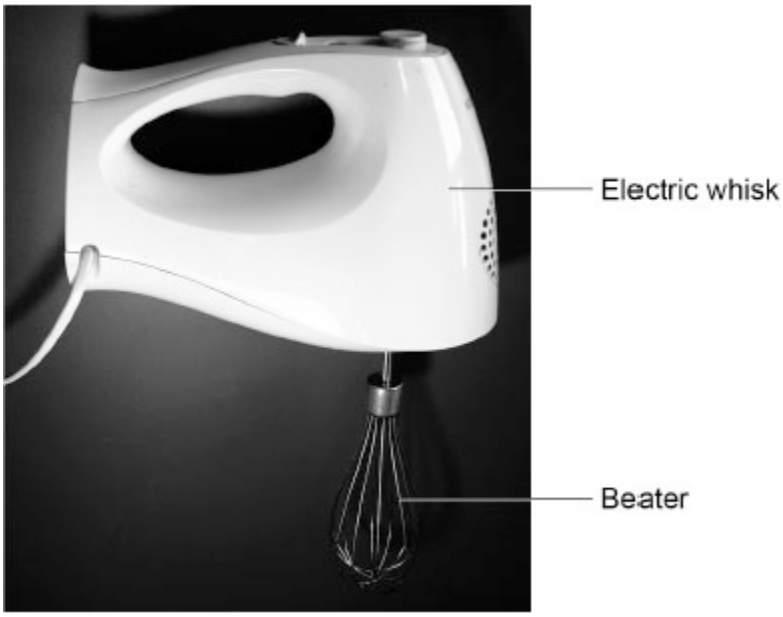
The current increased to 2.00 A. ☐

(1)

(Total 10 marks)

2. The figure below shows an electric whisk that plugs into the mains electricity supply.

The whisk can mix food by spinning a beater.



(a) Give **two** energy stores that increase when the whisk is switched on.

1 _____

_____

2 _____

_____

(2)

Use the Physics Equations Sheet to answer parts (b) and (c).

(b) Work is done by the whisk when it is used to mix food.

Write down the equation that links power (*P*), time (*t*) and work done (*W*).

_____

(1)

(c) The power output of the whisk is 92 W.

Calculate the time for the whisk to do 23 000 J of work.

_____

_____

_____

_____

_____

Time = _____ s

(3)

Use the Physics Equations Sheet to answer parts (d) and (e).

(d) Which equation links current (*I*), power (*P*) and resistance (*R*)?

Tick (✓) **one** box.

$P = \frac{I}{R^2}$ ☐

$P = I R^2$ ☐

$P = \frac{I^2}{R}$ ☐

$P = I^2 R$ ☐

(1)

(e) The current in the whisk is 500 mA.

The resistance of the whisk is 640 Ω.

Calculate the power of the whisk.

_____

_____

_____

_____

_____

Power = _____ W

(3)

The whisk has several settings that allow the beater to spin at different speeds.

A faster beater speed needs a greater power input from the mains electricity supply.

(f) What is the potential difference between the live wire and neutral wire in the mains electricity supply?

_____ V

(1)

(g) Changing the beater speed does **not** change the potential difference between the live wire and neutral wire.

The power input to the whisk changes because the current in the whisk changes.

Complete the sentence.

When the beater speed increases, the current in the whisk increases because the

resistance of the whisk _____ .

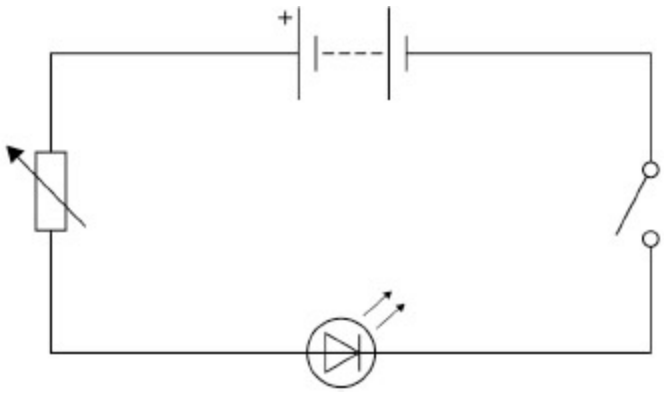
(1)

(Total 12 marks)

3. A student investigated how the current in a red LED varies with the potential difference across the LED.

Figure 1 shows an incomplete diagram of the circuit used.

Figure 1



(a) Complete **Figure 1** to show how the student should have connected a voltmeter and an ammeter into the circuit.

Use the correct circuit symbols.

(2)

(b) The potential difference across the battery was +2.6 V.

The student varied the potential difference across the LED between –2.6 V and +2.6 V.

Describe how the student should have adjusted the circuit to vary the potential difference across this range.

_____

_____

_____

_____

(2)

(c) The table below shows the results when the potential difference across the LED had positive values.

Potential difference in volts	0.0	1.0	1.8	2.0	2.2	2.4	2.6
Current in milliamps	0	0	0	5	19	41	69

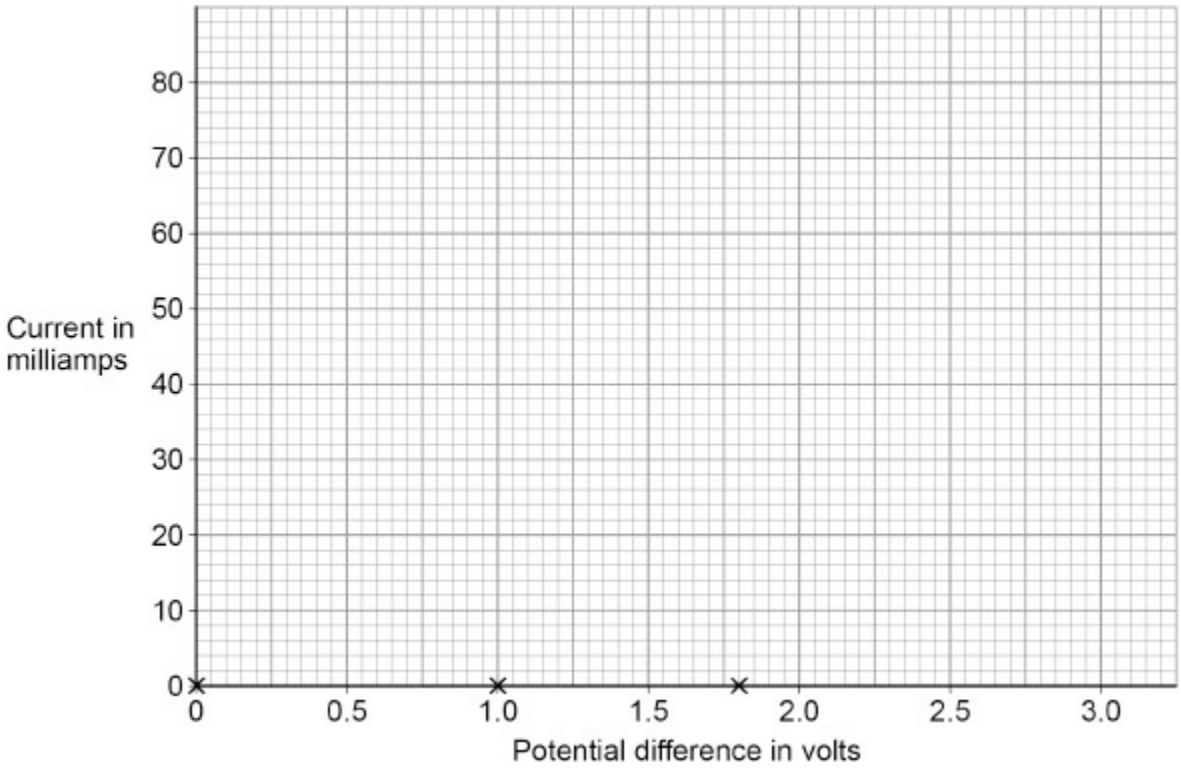
Figure 2 shows a graph of current against potential difference.

Complete **Figure 2**.

You should:

- plot the remaining points from above table
- draw a line of best fit.

Figure 2



(3)

(d) Explain what happens to the current in the LED when the potential difference across the LED is negative.

_____

_____

_____

_____

(2)

(e) A second student did the investigation using a blue LED.

The results for both the red LED and the blue LED showed the same pattern.

What conclusion can be made about the investigation?

Tick (✓) **one** box.

The investigation is repeatable. ☐

The investigation is reproducible. ☐

The results were accurate. ☐

(1)

(f) The relationship between current and potential difference for an LED is non-linear.

Which of the following always shows a linear relationship between current and potential difference?

Tick (✓) **one** box.

Filament lamp ☐

LDR ☐

Resistor at constant temperature ☐

Thermistor ☐

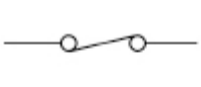
(1)

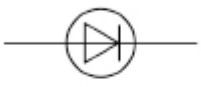
(Total 11 marks)

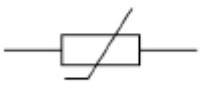
4. A gardener wanted to build an electrical circuit to monitor the temperature in a greenhouse.

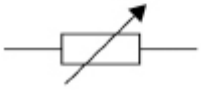
(a) Which symbol represents an electrical component with a resistance that decreases as its temperature increases?

Tick (✓) **one** box.

 ☐

 ☐

 ☐

 ☐

(1)

(b) When the resistance of an electrical circuit decreases, the current in the circuit increases.

Complete the sentence.

Choose the answer from the box.

charge	**energy**	**potential difference**	**power**

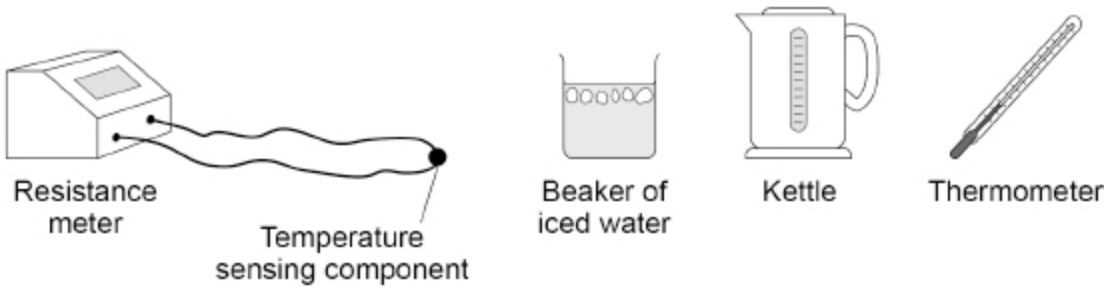
Electrical current is a flow of _____.

(1)

(c) The gardener wanted to find how the resistance of the component varies with temperature.

Figure 1 shows the equipment used by the gardener.

Figure 1



The resistance meter displays the resistance of the component.

Plan a method the gardener could use to find how the resistance of the component varies with temperature.

_____

_____

_____

_____

_____

_____

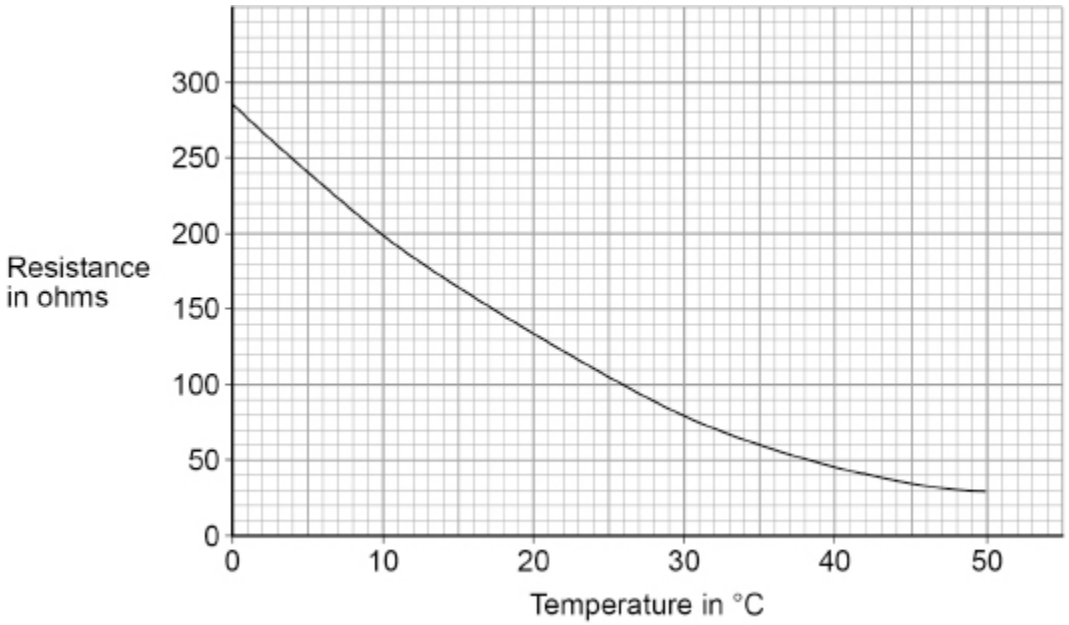
_____

_____

(4)

Figure 2 shows how the resistance of the component varies with temperature.

Figure 2



(d) Complete the sentence.

Choose the answer from the box.

linear	**non-linear**	**directly proportional**

The relationship between the temperature and the resistance of the component

is _____.

(1)

(e) The temperature in the greenhouse changed from 10 °C to 30 °C.

Determine the change in resistance of the component between these temperatures.

Use **Figure 2**.

_____

_____

_____

Change in resistance = _____ Ω

(2)

The gardener builds a circuit that switches a heater on when the greenhouse gets too cold.

Use the Physics Equations Sheet to answer parts (f) and (g).

(f) Write down the equation that links current (*I*), potential difference (*V*) and power (*P*).

_____

_____

(1)

(g) The power of the heater is 2900 W.

The potential difference across the heater is 230 V.

Calculate the current in the heater.

_____

_____

_____

_____

_____

Current = _____ A

(3)

(Total 13 marks)

5. Body analysis scales use the electrical resistance of a person's legs to estimate the percentage of water in the person's body.

Figure 1 shows body analysis scales.

Figure 1

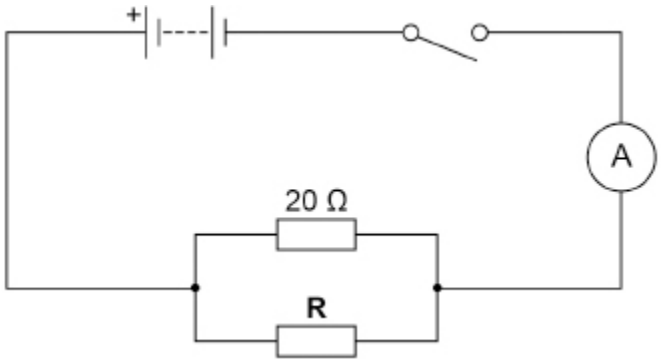
The person's legs contain both solid tissue and water.

A student used resistors to model the solid tissue and water.

The student connected a 20 Ω resistor in parallel with a resistor, **R**.

Figure 2 shows the circuit diagram.

Figure 2



(a) To determine the total resistance of both resistors, a voltmeter must be connected into the circuit.

Complete **Figure 2** to show where the voltmeter should be connected.

(1)

(b) The student calculated the total resistance of the two resistors.

The student's answer was 26 Ω.

Explain why the student's answer **cannot** be correct.

_____

_____

_____

_____

(2)

Use the Physics Equations Sheet to answer parts (c) and (d).

(c) Write down the equation that links current (*I*), resistance (*R*) and potential difference (*V*).

_____

_____

(1)

(d) When the total resistance of the resistors was 7.5 Ω the current in the circuit was 480 mA.

Calculate the potential difference across the two resistors.

_____

_____

_____

_____

_____

Potential difference = _____ V

(3)

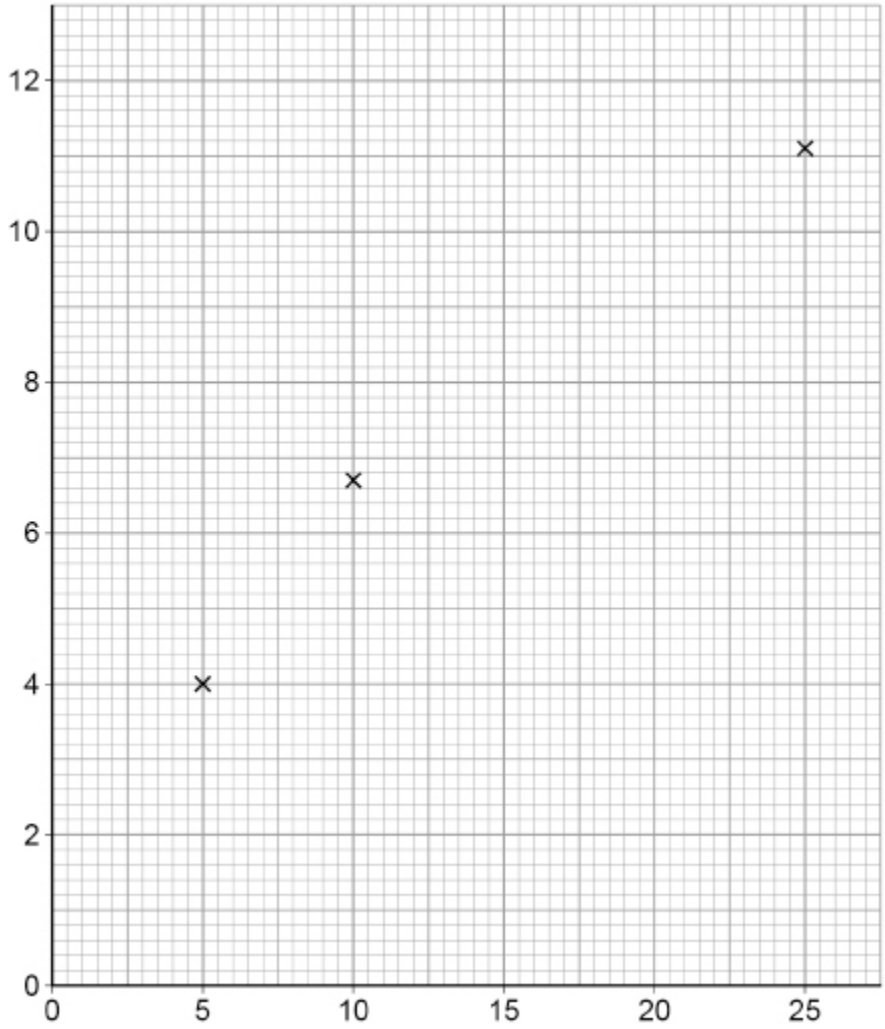
The student investigated how the resistance of **R** affected the total resistance of the circuit.

The table below shows the results.

Resistance of R in ohms	**Total resistance of the circuit in ohms**
5.0	4.0
10.0	6.7
15.0	8.6
20.0	10.0
25.0	11.1

Some of the results are plotted in **Figure 3**.

Figure 3



(e) Complete **Figure 3**.

You should:

- label both axes
- plot the two remaining values from the table above
- draw the line of best fit.

(3)

(f) What resistance of **R** would give a total resistance of 4.4 Ω?

Use **Figure 3**.

Resistance of **R** = _____ Ω

(1)

The body analysis scales initially show a reading of 0.0 kg.

When the student steps onto the scales the reading is 64.8 kg.

The student steps off the scales and then immediately steps back on.

The scales now show a reading of 64.1 kg.

(g) Complete the sentence.

The difference between the two values given by the scales is due

to a _____ error.

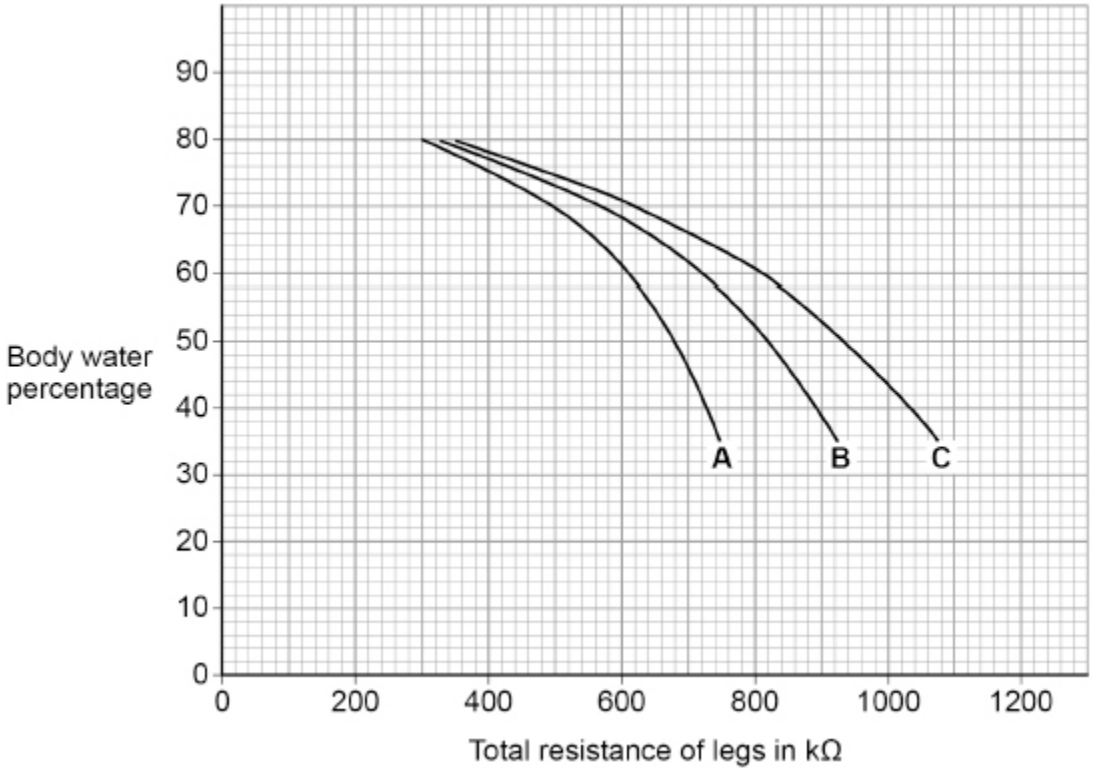
(1)

(h) The height of the student is programmed into the scales.

The scales place the student into a category, **A**, **B** or **C**, based on height and mass.

Figure 4 shows how the scales use the category and the total resistance of the legs to determine the body water percentage.

Figure 4



The total resistance of the student's legs is 600 kΩ. A healthy body water percentage is between 45% and 65%.

The different measurements of the mass of the student mean that the student could be in either category **A** or category **B**.

Evaluate if the student has a healthy body water percentage.

_____

_____

_____

_____

_____

_____

(3)

(Total 15 marks)

Mark schemes

1.

(a) voltmeter symbol correct

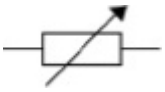
1

voltmeter connected across diode

allow voltmeter connected across diode and ammeter

1

(b)



1

(c) random

1

(d)

$$\frac{0.27 + 0.32 + 0.31}{3}$$

1

0.3 (A)

allow 0.30 (A)

1

(e) both points plotted correctly

allow a tolerance of ± ½ small square

1

line of best fit

ignore line before 0.5 V

1

(f) non-linear

1

(g) the current decreased to 0.00 A

1

[10]

2.

(a) kinetic energy (of the beater / food)

ignore sound

1

internal / thermal energy (of the surroundings / whisk / food)

1

(b)

$$\text{power} = \frac{\text{work done}}{\text{time}}$$

or

$$P = \frac{W}{t}$$

1

(c)

$$92 = \frac{23\,000}{\text{time}}$$

1

$$\text{time} = \frac{23\,000}{92}$$

1

250 (s)

1

(d) $P = I^2 R$

1

(e) $I = 0.500$ A

1

$P = 0.500^2 \times 640$

allow a correct substitution of an incorrectly / not converted current

1

$P = 160$ (W)

allow a correct calculation using an incorrectly / not converted current

1

(f) 230 (V)

1

(g) decreases

1

[12]

3. (a) correct symbol for voltmeter connected across LED

1

correct symbol for ammeter in series with LED

1

(b) change the number of cells in the battery

allow use batteries with different potential differences

allow adjust the variable resistor

allow adjust the potential difference across the power supply

1

reverse the connections to the LED / battery

allow reverse the connections to the power supply

1

(c) 4 points plotted correctly

allow a tolerance of ± ½ small square

*allow **1** mark for 3 points plotted correctly*

2

line of best fit

ignore line before 1.8 V

1

(d) the current is zero

allow the current stops

1

because the LED / diode has a very high resistance (in the reverse direction)

allow because the LED / diode only allows current in one direction

1

(e) the investigation is reproducible

1

(f) resistor at constant temperature

1

[11]

4. (a)

1

(b) charge

1

(c) place the component / thermistor in the water / beaker

1

record the temperature (of the water) using the thermometer

allow place the thermometer in the water / beaker and record the temperature

1

record / measure the resistance (using the resistance meter)

1

change the temperature of the water (using the kettle) and repeat the measurements (of temperature and resistance)

1

(d) non-linear

1

(e) (resistance changes from) 200 (Ω) to 80 (Ω)

1

change in resistance = 120 (Ω)

1

(f) power = potential difference × current

or

$P = V I$

1

(g) $2900 = 230 \times I$

1

$I = \frac{2900}{230}$

1

I = 12.6... (A)

allow 13 (A)

1

[13]

5. (a) voltmeter symbol correct and connected across the resistors

1

(b) the total resistance must be less than 20 Ω

allow the total resistance cannot be more than 20 Ω

1

because the total resistance of the resistors (in parallel) is less than the resistance of the smallest resistor

allow the total resistance of the resistors (in parallel) is less than either resistor

1

(c) potential difference = current × resistance

or

$V = IR$

1

(d) 480 mA = 0.48 A

1

$V = 0.48 \times 7.5$

allow a correct substitution of an incorrectly / not converted value for current

1

$V = 3.6$ (V)

allow an answer consistent with their incorrectly / not converted value for current

1

(e) x-axis labelled Resistance of R in Ω **and** y-axis labelled Total resistance (of resistors) in Ω

1

both points plotted correctly

points must be plotted within ½ small square

1

curved line of best fit drawn

allow a line of best fit which ignores an outlier

1

(f) reading from graph consistent with their line of best fit

allow an answer within ½ small square

1

(g) random

1

(h) in category A the body water percentage is 61%

allow a value for A between 60% and 62%

1

in category B the body water percentage is 68%

1

if in category A they have a healthy body water percentage **and** if in category B they have an unhealthy body water percentage

1

[15]