M1. (a) \[ V = 0.10 \times 45 \]  
\[ 4.5 \text{ (V)} \]  

(b) \[ R = \frac{12}{0.10} \]  
\[ \text{total resistance} = 120 \text{ (Ω)} \]  
\[ R = 120 - 105 = 15 \text{ (Ω)} \]  

(c) \[ \text{(total) resistance decreases} \]  
\[ \text{(so) current increases} \]  

[7]
M2. (a) (i) also double

\[ increases \text{ is insufficient} \]

(ii) variable resistor

\[ \text{accept rheostat / potentiometer} \]

(b) (i) the data / results / variables are continuous

\[ \text{accept data / results / variables are not categoric / discrete} \]

(ii) misreading the ammeter

\[ \text{do not accept misreading the meter / results} \]
\[ \text{do not accept misreading the ammeter and / or voltmeter reading / human error is insufficient} \]

(iii) straight line from the origin drawn passing close / through points at 1 V, 5 V, 6 V and ignoring anomalous point

\[ \text{do not accept line drawn ‘dot-to-dot’} \]

(iv) yes

\[ \text{mark is for the reason} \]

\[ \text{supports prediction or (straight) line passes through the origin} \]
\[ \text{accept a mathematical argument, eg when p.d. went from 2 to 4 the current went from 0.3 to 0.6} \]
\[ \text{it’s directly proportional is insufficient} \]
M3. (a) decreases

(b) a filament bulb

*allow bulb*

an LED

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response.

0 marks
No relevant content.

Level 1 (1−2 marks)
There is a basic description of the method. This is incomplete and would not lead to any useful results.

Level 2 (3−4 marks)
There is a description of the method which is almost complete with a few minor omissions and would lead to some results.

Level 3 (5−6 marks)
There is a detailed description of the method which would lead to valid results. To gain full marks an answer including graph, or another appropriate representation of results, must be given.

examples of the physics points made in the response:

• read V and I
• read temperature
• apply heat
  *allow hot water to cool*
• read V and I at least one other temperature
• determine R from V / I
• range of temperatures above 50 °C

extra detail:
• use thermometer to read temperature at regular intervals of temperature
• remove source of heat and stir before taking readings
• details of attaining 0 °C or 100 °C
• last reading taken while boiling
• graph of R against T
• at least 3 different temperatures

(d) (i) \( Q \)

(ii) \( (80, 3.18) \)

(iii) any one from:

- measurement of \( V \) too small
- measurement of \( I \) too big
- incorrect calculation of \( R \)
- thermometer misread
  
  allow misread meter
  
  ignore any references to an error that is systematic

(iv) any two from:

- not portable
  
  allow requires a lot of equipment allow takes time to set up

- needs an electrical supply

- cannot be read directly
  
  accept it is more difficult to read compared to liquid-in-glass
M4. (a) (i) ammeter symbol correct and drawn in series

\[ \text{\(\text{A}\)} \]

*accept* 
*do not accept lower case a*

voltmeter symbol correct and drawn in parallel with the material

*do not accept*

(ii) adjust / use the variable resistor

*accept change the resistance*

or change the number of cells

*accept battery for cell*

*accept change the pd / accept change the voltage*

*accept increase / decrease for change*

(b) (i) 37.5 (Ω)

*accept answer between 36 and 39 inclusive*

(ii) 5.6(25) or their (b)(i) × 0.15

*allow 1 mark for correct substitution ie 37.5 or their (b)(i) × 0.15 provided no subsequent step shown*

(c) (i) the thicker the putty the lower the resistance

*answer must be comparative* 
*accept the converse*

(ii) any one from:

*measuring length incorrectly*

*accept may be different length*
• measuring current incorrectly
  *do not accept different currents*

• measuring voltage incorrectly
  *do not accept different voltage*

• ammeter / voltmeter incorrectly calibrated

• thickness of putty not uniform
  *do not accept pieces of putty not the same unless qualified*

• meter has a zero error
  *do not accept systematic / random error*
  accept any sensible source of error eg putty at different temperatures
  *do not accept human error without an explanation*
  *do not accept amount of putty not same*
M5. (a) (i) to obtain a range of p.d. values
accept increase / decrease current / p.d. / voltage / resistance
accept to change / control the current / p.d. / voltage / resistance
to provide resistance is insufficient
a variable resistor is insufficient
do not accept electricity for current

(ii) temperature of the bulb increases
accept bulb gets hot(ter)
accept answers correctly
expressed in terms of collisions between (free) electrons and ions / atoms
bulb gets brighter is insufficient

(iii) 36
allow 1 mark for correct substitution, ie 12 × 3 provided no subsequent step shown

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a ‘best-fit’ approach to the marking.

0 marks No relevant content.

Level 1 (1-2 marks) There is a basic comparison of either a cost aspect or an energy efficiency aspect.

Level 2 (3-4 marks) There is a clear comparison of either the cost aspect or
energy efficiency aspect OR a basic comparison of both cost and energy efficiency aspects.

**Level 3 (5-6 marks)** There is a detailed comparison of both the cost aspect and the energy efficiency aspect.

For full marks the comparisons made should support a conclusion as to which type of bulb is preferable.

**Examples of the points made in the response:**

**cost**

- halogen are cheaper to buy
  
  *simply giving cost figures is insufficient*

- 6 halogen lamps cost the same as one LED

- LEDs last longer

- need to buy 18 / more halogen lamps to last the same time as one LED

- 18 halogens cost £35.10

- costs more to run a halogen than LED

- LED has lower maintenance cost (where many used, eg large departmental store lighting)

**energy efficiency**

- LED works using a smaller current

- LED wastes less energy

- LEDs are more efficient

- LED is 22% more energy efficient

- LED produces less heat

- LED requires smaller input (power) for same output (power)
M6. (a) (i) live

(ii) react faster

(iii) live and neutral

(b) (i) ammeter

to measure current

accept to measure amps

plus any one from:

• variable resistor (1)
to vary current (1)

accept variable power supply
accept change or control

• switch (1)
to stop apparatus getting hot / protect battery
or
to reset equipment (1)

• fuse (1)
to break circuit if current is too big (1)

(ii) any two from:

• use smaller mass(es)
• move mass closer to pivot
• reduce gap between coil and rocker
• more turns (on coil) coil / loop
• iron core in coil

accept use smaller weight(s)