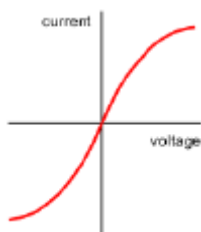


M1.

(a)



✓ ✓

*first mark for linear at origin and decreasing gradient in either quadrant (linear region can be very small)*  
*second mark for symmetry plus no dip at end or extended horizontal section at end*  
*straight line scores zero*

2

(b) (i) resistance (of filament lamp) increases ✓

1

(ii) filament lamp is a non-ohmic conductor as current is not (directly) proportional to voltage / resistance is not constant ✓

*proportionality can be shown using graph*

1

(c) either

circuit / total resistance increases ✓

(hence) current decreases and pd / voltage across R decreases ✓

OR

resistance of PQ combination increases ✓

(hence) greater share of pd / voltage across lamp P ✓

*implication that current is different in different parts of series circuits scores 0*

*implication that new total current is greater scores zero*  
*voltage flowing loses second mark*

2

(d) (i) (use of  $energy = VIt$ )

(energy converted by X =  $60 \times 120 \times 3600 =$ )  $2.59 \times 10^7$  J ✓

(energy converted by Y =  $11 \times 120 \times 3600 =$ )  $4.75 \times 10^6$  J ✓

*Accept answers to 1 sig. fig.*

2

- (ii) in lamps energy is wasted as heat / thermal energy ✓  
 specific lamp considered e.g. in lamp, X / filament lamp more energy is  
 wasted OR in X / filament lamp less energy is converted to light /  
 luminosity ✓

2

[10]

- M2.(a)** emf is the work done / energy transferred by a voltage source / battery / cell ✓ per  
unit charge ✓  
 OR  
 electrical energy transferred / converted / delivered / produced ✓  
 per unit charge ✓  
 OR  
 pd across terminals when no current flowing / open circuit ✓ ✓

*not in battery*

*accept word equation OR symbol equation with symbols  
 defined if done then must explain energy / work in equation  
 for first mark*

2

- (b) (i) by altering the (variable) resistor ✓

1

- (ii) reference to correct internal resistance ✓

*e.g. resistance of potato (cell)*

terminal pd = emf  $\square$  pd across internal resistance / lost volts ✓

pd / lost volts increases as current increases OR as (variable)

resistance decreases greater proportion / share of emf across internal  
 resistance ✓

*accept voltage for pd*

3

- (iii) draws best fit straight line and attempts to use gradient ✓

uses triangle with base at least 6 cm ✓

value in range 2600 – 2800 ( $\Omega$ ) ✓

3

*stand-alone last mark*

- (c) total emf is above 1.6 V ✓

but will not work as current not high enough / less than 20 mA ✓

2

[11]

M3.(a) Use of  $\rho=RA / l$

$$\text{cross sectional area} = \pi \times (3.7 \times 10^{-3})^2 = 4.3 \times 10^{-5} \text{ (m}^2\text{)} \checkmark$$

$$\rho = \frac{3.3 \times 4.3 \times 10^{-5}}{1000} \checkmark = 1.4(2) \times 10^{-7} \checkmark \Omega \text{ m} \checkmark$$

*area : lose first mark if use diameter as radius or fail to convert to m<sup>2</sup> (if both errors still only lose 1 mark)*

*CE area for next two marks but if uses diameter in place of area then lose first two marks*

*if leave length in km lose 2<sup>nd</sup> mark but CE for answer*

*UNIT stand-alone 4th mark*

4

- (b) (current in) steel wire (is less than the current in an) aluminium wire as it has a higher resistivity / resistance OR aluminium is better conductor  $\checkmark$   
the six aluminium wires are in parallel OR total cross-sectional area of aluminium is 6 times greater than steel wire  $\checkmark$   
each aluminium wire carries three times as much current as the (single) steel wire  $\checkmark$

3

- (c) resistance of 1 km of 6 Al cables in parallel =  $\frac{1.1}{6} = 0.183 \Omega \checkmark$

*if ignored the steel wire then can score first and third mark*

total resistance of the cable =  $0.174 \Omega \checkmark$

power loss per km =  $32.3 \text{ kW}$  (or  $30.7 \text{ kW}$  if they ignore the steel)  $\checkmark$

OR

power loss in 1 km of steel =  $1.70 \text{ kW} \checkmark$

power loss in 1 km each of Al cable =  $5.11 \text{ kW} \checkmark$

total power loss per km =  $32.4 \text{ kW}$  (or  $30.7 \text{ kW}$  if they ignore the steel)  $\checkmark$

OR

calculate current in steel wire and aluminium wire ( $22.7$  and  $68.2$ )  $\checkmark$

calculate power loss in aluminium wire and steel wire ( $1700$  and  $5115$ )  $\checkmark$

calculate total power loss ( $1700 + 6 \times 5115 = 32,4 \text{ kW}$ )  $\checkmark$

*accept range  $32 \text{ kW}$  to  $33 \text{ kW}$*

*if ignored steel wire*

*range for third mark is  $30 \text{ kW}$  to  $31 \text{ kW}$*

if wires treated as series resistors then zero

3  
[10]

M4.(a) (i) 5.1 and 7.1 ✓

*Exact answers only*

1

(ii) Both plotted points to nearest mm ✓  
Best line of fit to points ✓

*The line should be a straight line with approximately an equal number of points on either side of the line*

2

(iii) Large triangle drawn at least 8 cm × 8 cm ✓

Correct values read from graph ✓

Gradient value in range 0.190 to 0.210 to 2 or 3 sf ✓

3

(iv)  $(R = \frac{1}{\text{gradient}}) = 5.0 \Omega$  Must have unit ✓

*Allow ecf from gradient value*

**No sf penalty**

1

(b) (i) 5.04 ( $\Omega$ ) or 5.0 ( $\Omega$ ) s

(Allow also 5.06  $\Omega$  or 5.1  $\Omega$ , obtained by intermediate rounding up of 3.50<sup>2</sup>)

$$\text{From } R = \frac{V^2}{P}$$

1

(ii) (Uncertainty in  $V = 0.29\%$ )  
Uncertainty in  $V^2 = 0.57\%$ , 0.58% or 0.6% ✓

From uncertainty in  $V = 0.01 / 3.50 \times 100\%$

Uncertainty in  $P = 2.1\%$  ✓

From uncertainty in  $P = 0.05 / 2.43 \times 100\% = 2.1\%$

Uncertainty in  $R = 2.6\%$ , 2.7% or 3%

Answer to 1 or 2 sf only ✓

$2.1\% + \text{uncertainty in } V^2 (0.6\%) = 2.7\%$   
Allow ecf from incorrect uncertainty for  $V^2$  or  $P$

3

- (iii) (Absolute) uncertainty in  $R$  is  $(\pm) 0.14$  or just  $0.1 \Omega$  (using 2.6%)  
(or  $0.15$  or  $0.2 \Omega$  using 3%) ✓

*Must have unit ( $\Omega$ )*

*Must be to 1 or 2 sf and must be consistent with sf used from (ii)*

*No penalty for omitting  $\pm$  sign*

1

- (iv) Works out possible range of values of  $R$  based on uncertainty in (iii), e.g.  $R$  is in range  $5.0$  to  $5.2 \Omega$  using uncertainty of  $\pm 0.1 \Omega$  ✓

*No credit for statement to effect that the values are or are not consistent, without any reference to uncertainty*

*Allow ecf from (iii)*

Value from (a)(iv) is within the calculated range (or not depending on figures, allowing ecf) ✓

*Allow ecf from (a)(iv)*

2

[14]