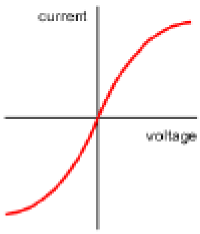
M1.

(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 × 120 × 3600 =) 2.59×10^7 J ✓
(energy converted by Y = 11 × 120 × 3600 =) 4.75×10^6 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 <u>unit</u> charge ✓
OR
electrical energy transferred / converted / delivered / produced ✓
per <u>unit</u> charge ✓
OR
pd across terminals when no current flowing / open circuit ✓ ✓

not <u>in</u> 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) <u>resistor</u> ✓

1

(ii) reference to correct internal resistance ✓

e.g. resistance of potato (cell)

terminal pd = emf − 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 (Ω) ✓

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 $\rho = RA / l$)

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

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

area : lose first mark if use diameter as radius or fail to convert to m^2 (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^{nd} 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✓

the six aluminium wires are in <u>parallel</u> OR <u>total</u> cross-sectional area of aluminium is 6 times greater than steel wire✓

each aluminium wire carries three times as much current as the (single) steel wire✓

3

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

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

total resistance of the cable = 0.174 Ω✓

power loss per km = 32.3 kW (or 30.7 kW if they ignore the steel)✓

OR

power loss in 1 km of steel = 1.70kW✓

power loss in 1 km each of Al cable = 5.11 kW✓

total power loss per km = 32.4 kW (or 30.7 kW if they ignore the steel)✓

OR

calculate current in steel wire and aluminium wire (22.7 and 68.2) ✓

calculate power loss in aluminium wire and steel wire (1700 and 5115) ✓

calculate total power loss (1700 + 6 × 5115 = 32,4 kW) ✓

accept range 32 kW to 33 kW

if ignored steel wire
range for third mark is 30 kW to 31 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 Ω Must have unit ✓

Allow ecf from gradient value

No sf penalty

1

(b) (i) 5.04 (Ω) or 5.0 (Ω) ✓

(Allow also 5.06 Ω or 5.1 Ω, obtained by intermediate rounding up of 3.50^2)

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 × 100%

Uncertainty in P = 2.1% ✓

From uncertainty in P = 0.05 / 2.43 × 100% = 2.1%

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

Answer to 1 or 2 sf only ✓

2.1 % + uncty in V^2 (0.6%) = 2.7%
Allow ecf from incorrect uncertainty for V^2 or P

3

(iii) (Absolute) uncertainty in *R* is (±) 0.14 or just 0.1 Ω (using 2.6%) (or 0.15 or 0.2 Ω using 3%) ✓

Must have unit (Ω)
Must be to 1 or 2 sf and must be consistent with sf used from (ii)
No penalty for omitting ± 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 Ω using uncertainty of ± 0.1 Ω ✓

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]