Current & Resistance MS

M1. (a) $R = \frac{\rho l}{A}$ **(1)**

$= \frac{1.7 \times 10^{-8} \times 1.4}{7.8 \times 10^{-7}}$ = 0.031 Ω **(1)** (0.0305 Ω)

2

(b) constant volume gives $l_1 A_1 = l_2 A_2$

[or $l_2 = 2l_1$ and $A_2 = A_1/2$] **(1)**

$R = \frac{\rho 2l}{A/2}$ $=4R$ **(1)**

[or calculation with l_2 = 2.8 (m) and A_2 = 3.9 (m^2) **(1)**]

gives R = 0.124 Ω **(1)**]

2

[4]

M2. (a) superconductivity means a material has zero resistivity/resistance **(1)**

resistivity decreases with temperature **or** idea of cooling **(1)**

becomes superconducting when you reach the critical/certain/ transition temperature **(1)**

3

(b) (i) (use of $R = \rho l/A$)

$0.075 = \rho \times 1/(2.28 \times 10^{-7})$ **(1)** (must see working or equation)

$R = 1.7 \times 10^{-8}$ **(1)** Ωm **(1)**

(ii) **max 3 from**

the resistance decreases (to zero) **(1)**

copper still has resistance **(1)**

but this is in parallel with filaments (which have zero resistance) **(1)**

hence **total** resistance is zero **(1)**

current goes through filaments **(1)**

6

[9]

M3. (a) (i) (use of $R = \rho l/A$)

$R = 4.0 \times 10^{-3} \times 0.060$ **(1)**/($\pi \times 0.012^2$) **(1)**

$R = 0.53$ (Ω) **(1)**

2 significant figures **(1)**

4

(ii) halving the diameter **will** increase resistance by factor of 4 or increasing the length by a factor of 4 will increase resistance by factor of 4 **(1)**

(hence) resistance will be 16 times greater **(1)**

2

(b) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

circuit must include:

voltmeter and ammeter connected correctly **(1)**

power supply with means of varying current **(1)**

2

QWC	descriptor	mark range
good-excellent	(i) Uses accurately appropriate grammar, spelling, punctuation and legibility. (ii) Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [may include bullet points and/or formulae or equations] An excellent candidate will have a working circuit diagram with correct description of measurements (including range of results) and processing. An excellent candidate uses a range of results and finds a mean value or uses a graphical method, eg *I*-*V* characteristics. They also mention precision eg use of vernier callipers.	**5-6**
modest-adequate	(i) Only a few errors. (ii) Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. An adequate candidate will have a working circuit and a description with only a few errors, eg do not consider precision. They have not taken a range of results and fail to realise that the diameter needs to be measured in several places.	**3-4**
poor-limited	(i) Several significant errors. (ii) Answer lacking structure, arguments not supported by evidence and contains limited information. Several significant errors, eg important measurement missed, incorrect circuit, no awareness of how to calculate resistivity.	**1-2**
incorrect, inappropriate or no response		**0**

The explanation expected in a good answer should include a coherent account of the procedure and include most of the following points.

- length with a ruler
- thickness/diameter with vernier callipers/micrometer
- measure voltage
- measure current
- calculate resistance
- use of graph, eg *I-V* or resistance against length
- use of diameter to calculate cross-sectional area
- mention of precision, eg vernier callipers or full scale readings for V and I
- flat metal electrodes at each end to improve connection

6

[14]

M4. (a) $R = \frac{\rho l}{A}$ **(1)**

ρ is resistivity, l is the length of the wire, A is the cross-sectional area **(1)**

2

(b) (i) $P = \frac{V^2}{R}$ **(1)**

$R = \frac{230^2}{500} = 106(\Omega)$ **(1)** (105.8 Ω)

$l = \left(\frac{RA}{\rho}\right) = \frac{105.8 \times 8.0 \times 10^{-8}}{1.1 \times 10^{-6}} = 7.7$ m **(1)** (7.69 m)

(allow C.E. for incorrect value of *R*)

(ii) in series, voltage across each < 230 V or pd shared **(1)**

∴ power (= V^2/R) is less than 500 W in each **(1)**

in parallel, voltage across each = 230 V **(1)**

∴ correct rating, ∴ conclusion **(1)**

[or, in series, high resistance or combined resistance **(1)**

∴ low current **(1)**

in parallel, resistance is lower, ∴ higher current **(1)**

more power, justified **(1)**]

max 6

[8]

M5. (a) $\rho = \frac{RA}{l}$ **(1)**

R = resistance (of wire), A = **cross-sectional** area,
l = length (of wire) **(1)**

2

(b) (i) $R = \frac{\rho l}{A} = \frac{4.0 \times 10^{-5} \times 30 \times 10^{-3}}{8 \times 10^{-3} \times 2 \times 10^{-6}}$ **(1)**

= 75 Ω **(1)**

(ii) length has decreased causing resistance to decrease **(1)**
area increased, causing resistance to decrease **(1)**
each changed by factor of 1.5×10^3 **(1)**

4
QWC 1

[6]

M6. (i) $I = \frac{\Delta Q}{\Delta t}$ [or $Q = It$] **(1)**

$Q = 40 \times 10^{-3} \times 3 \times 60 = 7.2$ C **(1)**

(ii) number of electrons = $\frac{7.2}{1.6 \times 10^{-19}} = 4.5 \times 10^{19}$ **(1)**

(allow C.E. for value of Q from (i**)**

(iii) $V = \frac{W}{Q}$ **(1)**

$= \frac{8.6}{7.2} = 1.2\,\text{V}$

(allow C.E. for value of *Q* from (i)

(iv) (use of *V* = *IR* gives) $R = \frac{1.2}{40 \times 10^{-3}} = 30\Omega$ **(1)**

(allow C.E. for value of *V* from (iii))

[6]

M7. (a) $I = \frac{\Delta Q}{\Delta t}\left(or\ I = \frac{Q}{t}\right)$ **(1)**

$\Delta Q = 0.25 \times 6 \times 60 = 90$ C **(1)**

2

(b) (i) $V = \frac{W}{Q}$ **(1)** [or *E* = *VIt*]

$= \frac{9.0 \times 10^4}{0.25 \times 20 \times 60 \times 60} = 5.0\,\text{V}$ **(1)**

(ii) (use of $P = \frac{W}{t}$ gives) $P = \frac{9.0 \times 10^4}{20 \times 60 \times 60} = 1.2(5)W$ **(1)**

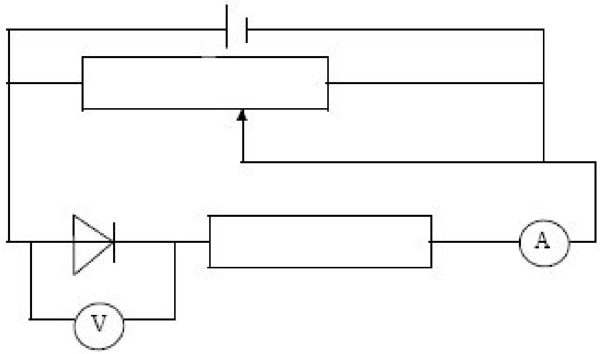
[or *P* = *IV* gives *P* = 0.25 × 5 = 1.2(5) W]

(allow C.E. in alternative method for value of *V* from (i))

3

[5]

M8. (a) (i)



suitable variable input (variable power supply or variable resistor) **(1)**

protective resistor **and** diode **forward** biased **(1)**

correct current **and** pd measuring devices **(1)**

3

(ii) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

QWC	descriptor	mark range
good-excellent	Uses accurately appropriate grammar, spelling, punctuation and legibility. Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [May include bullet points and/or formulae or equations]. Answer refers to at least 5 of the relevant points listed below.	**5-6**
modest-adequate	Only a few errors. Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. Answer refers to at least 3 or the relevant points listed below.	**3-4**
poor-limited	Several significant errors. Answer lacking structure, arguments not supported by evidence and contains limited information. Answer refers to no more than 2 of the relevant points.	**1-2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**

The explanation expected in a competent answer should include a coherent selection of the following physics ideas.

connect circuit up **(1)**

measure current (I) and pd/voltage (V) **(1)**

vary resistance/voltage **(1)**

obtain a range of results **(1)**

reverse connections to power supply (and repeat) **(1)**

plot a graph (of pd against current) **(1)**

mention of significance of 0.6V **or** disconnect between readings **or** change range on meters when doing reverse bias **(1)**

(b) (i) (use of $I = V/R$)

I = 12/8 **(1)**= 1.5A **(1)**

(ii) I = (12 – 0.65 **(1)**)/4 = 2.8 A **(1)** sig figs **(1)**

5

[14]

M9. (a) reverse mode: current zero or just negative at 50 -500 V **(1)**
sharp downward curve **(1)**

forward mode: current zero or just positive up to ≈ 0.7 V **(1)**
rapid increase of for small increase in V **(1)**

4

(b) at low V, I increases proportionally (or Ohm's law obeyed) **(1)**
(as V increases) greater I heats filament/wire
(or temp of filament/wire increases) **(1)**
resistance increases **(1)**
rate of increase of I with V decreases [or ref. to gradient = $1/R$] **(1)**
reference to same form of the curve in negative quadrant **(1)**

4

[8]

M10. (a) (i) battery, milliammeter, and wire in series **(1)** **(1)**
voltmeter across the wire **(1)**
variable resistor/potential divider in series **(1)**

(ii) alter variable resistor **(1)**
to obtain a series of values of *I* and *V* **(1)**

QWC 1

(iii) plot a graph of *V* against *I* **(1)**
gradient = *R* **(1)**

QWC 1

[or calculate *R* = *V*/*I* for <u>each reading</u> and take mean]

8

(b) (i) ($P = \frac{V^2}{R}$ gives) $1200 = \frac{230^2}{R}$

$R = 44.1\Omega$ **(1)**

(ii) $R = \frac{\rho l}{A}$ **(1)**

$l = \frac{44.1 \times 9.4 \times 10^{-8}}{1.1 \times 10^{-6}}$ **(1)**

= 3.8 m **(1)**

(allow C.E. for value of *R* in (i))

5

[13]

M11. (a) $R = \frac{\rho l}{A}$ **(1)**

$= \frac{1.7 \times 10^{-8} \times 1.4}{7.8 \times 10^{-7}}$ = 0.031 Ω **(1)** (0.0305 Ω)

2

(b) constant volume gives $l_1A_1 = l_2A_2$

[or $l_2 = 2l_1$ and $A_2 = A_1/2$] **(1)**

$R = \frac{\rho 2l}{A/2}$ $=4R$ **(1)**

[or calculation with l_2 = 2.8 (m) and A_2 = 3.9 (m^2) **(1)**]

gives R = 0.124 Ω **(1)**]

2

[4]