M1.(a) Use of *$\rho = RA / l$)*

cross sectional area= × $(3.7 \times 10^{-3})^2 = 4.3 \times 10^{-5}$ (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 2nd 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 parallel OR total 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]

M2.D

[1]

M3.B

[1]

M4.D

[1]

M5.(a) (i) resistivity is defined as

$$\rho = \frac{RA}{l}$$

where *R* is the resistance of the material of length *l* ✓
and <u>cross-sectional</u> area *A* ✓

2

(ii) <u>below</u> the critical temperature / maximum temperature which resistivity / resistance ✓
is zero / becomes superconductor ✓

Any reference to negligible / small / very low resistance loses second mark

2

(b) (*use of* $\rho = \frac{RA}{l}$)

$\rho = 0.70 \times \pi \times 0.0005^2 / 4.8$ ✓ $= 1.1(5) \times 10^{-7}$ (1.1 – 1.2) ✓ ✓ Ω m ✓

First mark for substitution R and l
Lose 1 mark if diameter used as radius and answer is 4

times too big (4.4 – 4.8) OR if power of ten error

4

[8]

M6.(a) (i) calculated cross-sectional area = 1.54×10^{-6} (m^2) or *correct substitution*

C1

1.6×10^{-3} (treating r as A) gains 2

into resistivity equation *with incorrect powers of ten correct substitution*

C1

into resistivity equation *with correct powers of ten*

0.73 (Ω)

A1

3

(ii) Sub into $I^2 R$ irrespective of power of 10 [ecf from (a)(i)]

C1

2.96×10^{-4} (W)

A1

2

(b) line with positive slope (linear or curve)

B1

knee and vertical line shown in first 2 / 3 on temperature axis

B1

resistivity falling to zero above 0 K

B1

3

(c) (with no resistance there can be) no power loss

B1

1
[9]

M7.(a) (use of $\rho = RA / l$)

$R = 1.7 \times 10^{-7} \times 0.75 / 1.3 \times 10^{-7}$ ✓

$R = 0.98\ \Omega$ ✓

First mark for sub. and rearranging of equation.
Bald 0.98 gets both marks
Final answer correct to 2 or more sig. figs.

2

(b) (i) *(use of P=VI) I*= 2.08 A

1

(ii) V=2.08 × 0.98 = 2.04 V

C.E. from (a) and (b)(i)

1

(iii) emf = 12 + 2 ✓ × 2.04 = 16.1 V ✓

C.E. from (b)(ii)
If only use one wire then C.E. for second mark

2

(c) lamp would be less bright ✓
as energy / power now wasted in internal resistance / battery
OR terminal pd less
OR current lower (due to greater resistance) ✓

No C.E. from first mark

2
[8]

M8. (a) no resistance

M1

(at or) below critical temperature

A1

alternative:

allow a labelled diagram which indicates features, allow T_c for transition temp in diagram

2

(b) **Use**

eg mri scanner, transformer, generator, maglev train, particle accelerators, microchips, computers, energy storage with detail

B1

Reason

eg **strong** magnetic field, no energy dissipation (mri scanner / maglev / particle accelerator)
higher (processing) speeds, smaller, no
energy dissipation

(microchip / computer)

B1

smaller, no energy dissipation, no fire risk (transformer / generator)
no energy dissipation (power transmission / energy storage with detail)

2

[4]

M9. (a) correct substitution into $P = V^2/R$
(condone power of 10 error)

C1

R = 2.62 (Ω) = 144/55 = $12^2/55$

C1

correct substitution into ρ= RA/L
(condone error on R and/or power of 10 errors)

C1

resistivity = 9.9(5) × 10^{-7} (range 9.9 to 9.95 × 10^{-7})

A1

unit = Ω m

B1

5

(b) (i) joules per coulomb (of charge)/work done per unit charge (treat reference to force as neutral)

M1

where charge moved (whole way) round circuit

A1

2

(ii) lost volts = 0.1 (V) or 0.1 seen as voltage

C1

r = 0.011 to 1.09×10^{-2} (Ω)

A1

2

(c) brightness decreases

B1

increased current (in circuit/battery)

B1

increased lost volts leading to decreased pd across bulb or decreased terminal pd

B1

3

[12]