A-Level Physics

Resistivity

Mark Scheme

Time available: 74 minutes
Marks available: 55 marks

1. (a) x = 0.879 m ✓

CAO;

*read-offs from **Figure 2** should be 0.064 (m) at **P** and 0.943 (m) at **Q***

1

(b) substitution into equation to determine R_4;

evaluates $\frac{\text{their } R_4}{\text{their (a)}}$ 1 ✓

evaluates $\frac{\text{correct } R_4}{\text{their (a)}}$ 2 ✓

correct answer 0.15(1) (Ω m^{-1}) earns both marks

for 1✓ insist on seeing full substitution; allow POT errors

for 2✓ use of correct R_4 (0.13(3));

allow POT error in their x

2

(c) micrometer screw gauge

OR

digital (vernier) callipers 1✓

repeat readings at different points (along the wire)

OR

repeat readings in different directions / orientations

OR

repeat readings AND reject / discard anomalies 2✓

calculate average / mean (from repeated readings) 3✓

for 1✓ allow 'micrometer' or 'screw gauge';

allow travelling microscope;

reject '(vernier) callipers'

for 3✓ some mention of repeat (readings) or wtte must be seen somewhere in body of answer

3

(d) use of $A = \frac{\pi d^2}{4}$ $_1$✓

ρ = their **(b)** × 1.1(3) × 10^{-7} (Ω m) $_2$✓

correct answer (rounding to) 1.7 × 10^{-8} (Ω m^{-1}) earns both marks

for $_1$✓ allow POT in d;

either $A = \frac{\pi \times 0.38^2}{4}$ OR $A = \pi \times 0.19^2$ ***OR***

A = 1.1(3) (× 10^{-7}) seen

for $_2$✓ allow ECF for POT in their ***(b)***

2

(e) decrease R_1 / 2.2 MΩ by a factor of 30

OR

increase R_2 / 3.9 kΩ by a factor of 30

OR

increase R_3 / 75 Ω by a factor of 30 ✓

unless quantitative change identified, must give new resistance, eg

(new) R_1 is 73.3 / 73 kΩ / 7.3 × 10^4 Ω etc

(new) R_2 is 117 / 120 kΩ / 1.2 × 10^5 Ω etc

(new) R_3 is 2.25 / 2.3 kΩ / 2.3 × 10^2 Ω etc

1

(f) diameter = 2.08 OR 2.1 (mm) $_1$✓

allow > 3 sf rounding to 2.08 (mm)

Allow ecf from ***(b)***

1

[10]

2. (a) Use of power equation

OR

Power equation and $V = IR$

To give R = 8.5 (Ω) ✓

1

(b) Calculation of parallel pair resistance = 5.0 Ω ✓

Calculation of circuit current = 6.2 / 5.0 = 1.24 A

emf = terminal pd + Ir = 6.2 + (1.24 × 2.5) ✓

9.3 V ✓

*Allow ecf from **(a)***
Allow alternative methods

3

(c) A = π (d / 2)^2 = 2.84 × 10^{-8} ✓

Use of resistivity equation = RA/l ✓

To give 5.0 × 10^{-8} ✓

Allow POT error in MP1
And MP2

3

(d) Resistance increases ✓

Reduces current through lamp

Lamp dimmer ✓

2

(e) (Resistance increases)

Reduces current in battery ✓

Reduces lost volts and increases terminal pd

lamp brighter. ✓

Give 1 max for arguments dealing with initial dimming of bulb when wire attached.

2

[11]

3. (a) Use of $P=VI$ *or* $P=I^2R$ or P = $\frac{V^2}{R}$ ✓

Use of $\Delta W=P\Delta t$ ✓

OR

Use of $\Delta Q=I\Delta t$ ✓

Use of $W=VQ$ ✓

2.1 × 10^5 (J) ✓

2 marks if time not converted to seconds (3600 J)

3

(b) Use of ρ = $\rho = \frac{RA}{L}$ ✓

0.91 (m) + appropriate conclusion ✓

Allow calculation of R, ρ or A assuming 0.85 m length, and conclusion for second mark:

R = 3.5 Ω

$A = 4.6 \times 10^{-6}\ m^2$

$\rho = 2.1 \times 10^{-5}\ \Omega\ m$

2

(c) 350 (Ω) ✓

Full marks for correct answer

Max 3 from: ✓ ✓ ✓

15 (mA) read from graph

Allow 14.5 to 15.5

Conversion to A

pd across resistor = 7.4 – 2.2 = 5.2 V

Use of $R = \frac{V}{I}$

Do not allow gradient calculation for R.

4

[9]

4. (a) Length of resistance wire = $50 \times 2 \times 3.14 \times 4 \times 10^{-3}$ = 1.26 m ✓

or $50 \times 3.14 \times 8 \times 10^{-3}$

1

Substitution of data in resistance formula

or $A = \rho L/R$ seen ✓

ecf for incorrect length from attempt at a calculation

1

Area of cross section = 2.1(1) × 10^{-9} (m^2) ✓

1

(b) Maximum possible pd across 0.25 kΩ is 9 V ✓

1

(Max power dissipated) = $9^2/250$ = 0.32 W so resistor is suitable ✓

1

OR

When resistor dissipates maximum power

$V^2 = 0.36 \times 250$ so max $V = 9.5$ V ✓

This is higher than the supply pd so this power dissipation so will not be reached ✓

OR

Power dissipated when output is 5 V = $4^2/250 = 0.064$ W ✓

Which is below the max power dissipation of 0.36 W ✓

$9^2/250 = 0.32$ W with incorrect conclusion scores 1

Second mark implies the first

$9^2/0.36 = 225\ \Omega$ alone is not a useful calculation in the context. Still need to explain the effect of using the 250 Ω

First mark is for a valid useful calculation

(c) Use of potential divider formula to determine resistance of parallel combination ✓

0.313 kΩ ✓

Use of equation for resistors in parallel ✓

540 Ω ✓

Alternative to find resistance of combination

Current in circuit at room temp = 4/250 = 16 mA ✓

Resistance of combination = 5/16mA = 313 Ω ✓

OR

$$\frac{V_{combination}}{V_{250}} = \frac{R_{combination}}{250}$$

$$\frac{5}{4} = \frac{R_{combination}}{250}$$

$R_{combination} = 313\ \Omega$

OR

Current in circuit at room temp = 4/250 = 16 mA ✓

Current in thermistor = 5/750 = 6.7 mA ✓

Current in R = 9.3 mA ✓

R = 5/9.3 = 540 Ω ✓

2sf answer ✓

(only allowed with some relevant working leading to a resistor value)

Max 5

(d) Resistance of thermistor decreases ✓

Output pd decreases since

resistance of the parallel combination /circuit decreases

1

OR

lower proportion of pd across the parallel combination (or higher proportion across 250Ω)

OR

higher current so greater pd across the 0.25 k resistor ✓

Accept correct consequences for R increasing with temperature for 1 mark

1

[12]

5.

(a) 0.5 mm [0.05 cm, 0.0005 m] ✓

only acceptable answers

1

(b) 8.65 mm [0.865 cm, 0.00865 m] $_1$✓

the micrometer reads zero when the jaws are closed $_2$✓

only 3sf answers are acceptable for $_1$✓

accept no zero error for $_2$✓

2

(c) L = (403 − 289 =) 114 mm ✓

1

(d) absolute uncertainty = 1 mm $_1$✓

percentage uncertainty = $\frac{1}{114} \times 100 = 0.88\%_2$✓

accept 2 mm for ab. uncertainty $_1$✓

allow ecf for wrong L and / or wrong ΔL

accept 1.75%

2

(e) should move wire directly over / closer to scale on the ruler to avoid parallax error ✓

both statement and explanation required for this mark

1

(f) five values of R/L correct, recorded to 3 sf [last row to 3sf or 4sf]; accept values in Ω cm^{-1} ✓

mean based on first four rows only; result 9.94 Ω m^{-1} [9.94 × 10^{-2} Ω cm^{-1}] ✓

L/cm	R/Ω	$(R/L)\Omega$m^{-1}
81.6	8.10	9.93
72.2	7.19	9.96
63.7	6.31	9.91
58.7	5.85	9.97
44.1	4.70	10.66 (10.7)

2

(g) cross-sectional area = $\frac{\pi d^2}{4}$ $_1$✓

resistivity from $\frac{R}{L} \times A$, correct substitution of result from 01.6 $_2$✓

1.10 × 10^{-6} $_3$ ✓

Ω m $_4$✓

resistivity from $\frac{R}{L} \times \frac{\pi d^2}{4}$ earns $_{12}$✓✓

allow $_2$✓ if $\frac{R}{L}$ value is not based on mean or on a mean from all five rows of table in 01.6

condone 1.12 × 10^{-6} for $_3$✓ if fifth row in 01.6 was not rejected

withhold $_3$✓ for POT error

4

[13]