A-Level Physics

Current-Voltage Characteristics

Mark Scheme

Time available: 64 minutes
Marks available: 51 marks

1. (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

$\rho = 2.1 \times 10^{-5}$ Ω 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]

2. (a) Acceptable line ✓

Condone one failure from the following list

A. Line straight up to point 8 (expect ruled but condone freehand drawing)
B. Line shows balance of points on each side of drawn line
C. Line goes within region of data cross
D. Appropriate continuous transition between line and curve
E. Beyond point 12 shows either curve of decreasing gradient OR straight line through points 12 to 15
F. Thin line and non-variable thickness
G. Line of acceptable quality, eg not hairy or kinked

Please annotate on CMI+

The line must intersect with the cross of the data point.

However, condone point 14 or 15 being off line of best fit for a smooth curve.

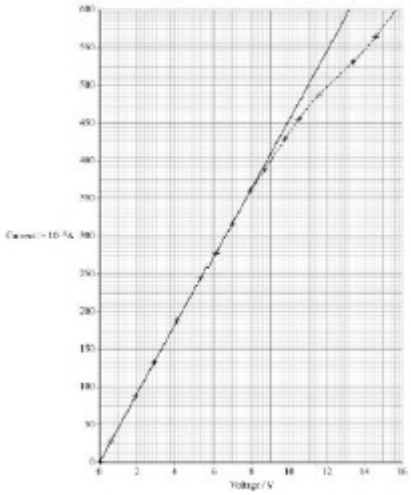
Condone partially erased and redrawn.

Do not allow double line under any circumstance.

Allow a curve with a slight inflection at point 14

(see example below)

Allow a split line where linear section has been extrapolated to the top of the grid e.g.



1

(b) Circle drawn around data point 9 (8, 360 × 10^{-3}) ✓

Condone circle drawn around

data point 10 (8.7, 390 × 10^{-3})

***provided that** linear section of line intersects with this cross.*

1

(c) Correct read off for voltage from candidate line $_1$✓

This voltage must be within one half-square of actual value.

Correct answer using $\left(\frac{\frac{their\ V}{0.55} - 22.2}{22.2}\right) \times 100$ $_2$✓

Penalise mid-calculation rounding.

Condone missing % sign;

2 or 3 significant figures for answer.

Penalise Physics Error of using gradient of tangent to determine the resistance.

2

(d) circuit **D** is correct $_1$✓

circuit **A** is incorrect because the ammeter is not measuring the current in **R**

OR
ammeter is not in series with R

OR
the ammeter is measuring the current in the power supply $_2$✓

circuit **B** is incorrect because the voltage range (shown in the data) cannot be produced

OR
cannot achieve voltage less than (about) 5 V $_3$✓

circuit **C** is incorrect because the voltmeter is not in parallel with **R**

OR
the voltmeter is not measuring the voltage across **R**

OR

the <u>voltmeter</u> reading equals emf minus voltage across **R** $_4$✓

Ignore unclear or incorrect explanation for MP1

$_2$✓ $_3$✓ and $_4$✓ are awarded for correct explanations not for a statement that a circuit is incorrect.

*for $_1$✓ accept implied answer that circuit **D** is correct if circuits **A**, **B** and **C** are <u>all</u> stated to be incorrect*

*for $_2$✓ any suggestion that in circuit **A** the voltmeter is in the wrong position forfeits the mark*

*Condone circuit **B** is incorrect "because the voltage cannot go down to zero" for $_3$✓.*

Or

*Condone circuit **B** is incorrect "there is less variation in voltage <u>because</u> the resistors are in series" $_3$✓.*

*for weak statements in MP2 and MP4 1 mark for 'circuit **A** is incorrect because <u>ammeter</u> is in wrong place' and 'circuit **C** is incorrect because <u>voltmeter</u> is in the wrong position'*

*If **A** / **B** / **C** is identified as correct then **MAX 2** for two statements that correctly explain why the others are unsuitable.*

*If no other marks awarded: **MAX 1** for "Circuit **B** is correct because the ammeter in <u>series</u> with resistor **R and** the voltmeter is in <u>parallel</u> with **R**".*

4

[8]

3. (a) An increase in current / voltage leads to an increase in temperature (more heat generated) ✓

Ignore 'of particles' in first mark

Do not condone 'particles' in second mark

This causes an increase in the movement of the lattice/ions/atoms ✓

And therefore an increase in the <u>rate</u> of collisions with electrons ✓

Allow more frequent collisions

So the resistance increases as shown by V / I changing/V not proportional to I (on the graph) ✓

Allow correct reference to gradient of I / V curve unless the answer suggests that this is the resistance or inverse of resistance.

Max 4

(b) 14.3 (Ω)

Allow range 14 to 15

but calculated answer must lie between 14 and 15

1

(c) Determination of pd across either filament or resistor from graph ✓

Pd across resistor can be calculated from resistance value in (b)

Eg V = 0.18 × 14.3 = 2.6

Determination of pd across the other component, and values added ✓

Use of V = IR to give 3.4 (V)

Allow ecf if either value is wrong allow 2 max

Or

Clear attempt to determine total resistance and multiply by 0.18 ✓

Condone small rounding error

(Resistance of lamp at 0.18A = 4.4 Ω)

Total resistance = 18.7 Ω ecf from 2,2 ✓

3.4 V (ecf from 2.2) ✓

Allow for small rounding errors (eg allow range 3.3 to 3.5)

3

(d) Determination of current through either filament or resistor from graph ✓

Allow calculation of resistor current using 4/(answer to 2.2)

Determination of current through the other component, and values added✓

(Current through resistor = 0.28 A

Current through filament = 0.36 A)

R = V/I = 4/ (0.28 + 0.36) = 6.25 (Ω)

If either value wrong allow 2 max

Condone small rounding errors.

Or

Calculation of filament resistance or statement of resistor resistance ✓

Resistance of filament = 11.1 (Ω)

Calculation of other resistance and use of parallel formula (allow ecf from part b) ✓

Either resistance gets the first mark

6.2 -6.3 (Ω) ✓

3

(e) Calculation of area, ignoring power of ten errors.

$A = 8.0 \times 10^{-10}\ m^2$

Correct resistivity 3.1×10^{-8} ✓

Allow ecf for A (for example use of d for r gives 3.2×10^{-11} for A and 1.2×10^{-7} for answer)

Ω m ✓

Some working must be shown for award of unit mark.

3

[14]

4. (a) correct general shape ✓

accurate plotting to within $\frac{1}{2}$ square ✓

2

(b) 12 (V) ✓, 30 (W) ✓

2

(c) $R = \left(\frac{6}{1.9}\right) = 3.2\ (\Omega)$ ✓

1

(d) Resistance increases ✓

Temperature increases ✓

More collisions / interaction of electrons with lattice ions ✓

Condone 'atoms', 'molecule'.

*Do **not** allow electron−electron collisions.*

3

(e) Can attain neither maximum nor minimum voltage ✓

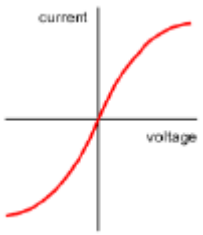
Explanation of either maximum OR minimum ✓

2

[10]

5.

(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]