MARK SCHEME

PHYSICS

AS-Level

ELECTRICITY

TEST 1

Mark schemes

1

(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 <u>*zero*</u> *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 <u>parallax</u> 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 <u>first four</u> rows only; result 9.94 Ω m^{-1} [9.94×10^{-2} Ω cm^{-1}] ✓

L/cm	*R*/Ω	(*R*/*L*)Ωm^{-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]

2 (a) A combination of resistors in series connected across a voltage source (to produce a required pd) ✓

Reference to splitting (not dividing) pd

1

(b) When R increases, pd across R increases ✓

Pd across R + pd across T = supply pd ✓

So pd across T / voltmeter reading decreases ✓

Alternative:

Use of $V = \frac{R_1 \times V_{tot}}{R_1 + R_2}$ ✓

V_{tot} and R_2 remain constant ✓

So V increases when R_1 increases ✓

3

(c) At higher temp, resistance of T is lower ✓

1

So circuit resistance is lower, so current / ammeter reading increases ✓

1

(d) Resistance of T = 2500 Ω

Current through T = V / R = 3 / 2500 = 1.2×10^{-3} A ✓

(Allow alternative using $V_1/R_1 = V_2/R_2$)

pd across R = 12 − 3 = 9 V

The first mark is working out the current 1

Resistance of R = V / I = 9 / 1.2×10^{-3} = 7500 Ω✓

The second mark is for the final answer 1

(e) Connect the alarm across R instead of across T ✓

allow: use a thermistor with a ptc instead of ntc. 1

[9]

3 (a) Peak power = 107 / 108 mW and load resistance = 290 / 310 Ω ✓ 1

Use of power = I^2R with candidate values✓ 1

0.0186 – 0.0193 A ✓ 1

(b) Area of cell = 36 x 10^{-4} m^2 and solar power arriving = 730 × (an area)✓ 1

$\frac{0.108}{2.63}$ seen✓ 1

0.041 (correct answer only; lose if ratio given unit) ✓ 1

(c) energy of one photon = $\frac{hc}{\lambda}$ = 4.0×10^{-19}J✓ 1

Number of photons = $\frac{730 \times 36 \times 10^{-4}}{4.0 \times 10^{-19}}$ = 6.6×10^{18} s^{-1}✓ 1

(d) **Two** from

Intensity of the sun at the Earth's surface
Average position of the sun
Efficiency of the panel
Power output of 1 panel
Weather conditions at the installation=
✓✓

Allow other valid physics answers=

2

[10]

4 (a) $I_3 = I_1 + I_2$ ✓

1

(b) 10 V ✓

1

(c) I_2 = (12 – 10) / 10 ✓

Allow ce for 10 V

1

= 0.2 A ✓

The first mark is for the pd

The second is for the final answer

1

(d) pd across R_2 increases

As R_1 increases, pd across R_1 increases as pd = I_1 R_1 ✓

First mark is for identifying that pd across R_1 increases (from zero).

1

pd across R_3 = 10 V – pd across R_1

Therefore pd across R_3 decreases ✓

Second mark is for identifying that pd across R_3 must decrease

1

pd across R_2 = 12 – pd across R_3

Therefore pd across R_2 increases ✓

Third mark is for identifying that this means pd across R2 must increase

1

[7]

5

(a) *(use of $R = \rho l/A$)*

$A = 9.7 \times 10^{-8} \times 0.50/0.070$ ✓

1

$A = 6.929 \times 10^{-7}$ (m^2) ✓

1

diameter = $\sqrt{(6.929 \times 10^{-7} \times 4/\pi)} = 9.4 \times 10^{-4}$ (m) ✓

CE for third mark if incorrect area

1

(b) R = 1.5/0.66 = 2.3(Ω) (2.27) ✓

1

(c) *(use of V = IR)*

I = 1.5/(22 + 1.2) = 0.065✓(A) (0.0647) ✓

1

(d) current in R_1 = 0.66 − 0.0647 = 0.595 (A) ✓

CE from 4.2/4.3

1

resistance of R_1 and probe = 1.5/0.595 = 2.52 (Ω) ✓

alternative method: 1/2.3 = 1/23.2 + 1/(R_{probe} + 2.4) ✓

1

resistance of probe = 2.52 − 2.4 = 0.12 (Ω) ✓

correct rearrangement ✓

range 0.1 – 0.15 ✓

accept 1 sig. fig. for final answer

1

(e) cross-sectional area must decrease OR R α 1/A

indicated by downward arrow or negative sign which can be seen on answer line

1

area decreases by 1.6% hence diameter must decrease by 0.8% ✓

accept 1%

1

(f) ANY TWO FROM

correct reference to lost volts OR terminal pd OR reduced current ✓

reference to resistors not changing OR resistors constant ratio ✓

reference to voltmeter having high/infinite resistance (so not affecting circuit) ✓

reference to pd between AB being (very) small (due to closeness of resistance ratios in each arm) ✓

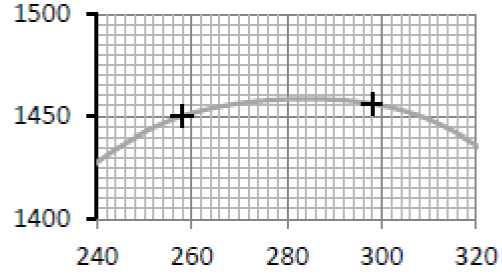
voltmeter (may not be) sensitive enough ✓

1

1

[12]

6 (a) 2 missing points plotted, each to nearest 1 mm (half a grid square); points marked + or × or ⊙; reject thick points, blobs or uncircled dots ✓



1

(b) continuous smooth best fit line through all 7 points to 1 mm ✓

allow mis-plotted points to be treated as anomalies; multiple lines or points of inflexion lose the mark

1

(c) candidate's value from Figure 2 ± ½ grid square ✓

if multiple lines are drawn condone value if ± ½ grid square of all lines

1

(d) finding θ_N from Figure 3 is easy since the result is read off where $G = 0$ $_1$✓
or
finding θ_N from Figure 2 is difficult since θ has a range of values for which ε is a maximum $_2$✓

accept evidence that $G = 0$ used shown on Figure 3; physics error about how Figure 3 used means no credit for any further valid comment about Figure 2

accept 'curve is shallow at peak' for $_2$✓

MAX 1

(e) method:
correctly determines gradient of Figure 3 or uses gradient result with any point on line to determine (vertical) intercept $_1$✓

result in range 9.8 to 10.9 $_2$✓

gradient values in the range −0.040 to −0.034 for $_1$✓ (minus sign essential)

for $_1$✓ allow the substitution of at least one pair of correct values of G and θ into $G = \beta\theta + \alpha$ to obtain α using simultaneous equations

condone 2sf '10' for $_2$✓

2

(f) full scale pd = 100 × 1000 = 100000 or 10^5 μV ✓

allow 100 mV or 0.1 V if μV deleted from answer line ✓

1

(g) idea that resolution of the meter is not satisfactory $_1$✓
because the largest pd that will be measured is less than 1500 μV
OR
only uses 1.5% of the range
OR
pd across meter at full-scale deflection ÷ divisions = $\frac{10^5}{50}$ = 2000 μV
per division $_2$✓

condone use of 'sensitivity' or 'precision' for 'resolution'; ignore 'meter is not accurate'

allow 'hard to tell different readings apart'

for $_2$✓ allow ce for incorrect 02.6

allow 'unable to measure to nearest micro volt'

allow 'resolution of scale should be 1 μV'

2

[9]

7 (a) time base is (switched) off ✓
TO for y-input switched off

not affected by x plates because these plates are not switched on

1

(b) (i) emf (of battery) ✓

not just terminal pd

TO applied for non-emf statements

Allow explanation of emf

1

(ii) (emf = 3 × 2.0 =) 6.0 V ✓

penalise 1 sf

1

(c) Because the pd across the y plates has decreased ✓

there is a current (in the battery) ✓

there is a pd / voltage across the internal resistance **or** there are (now) lost volts ✓

terminal pd decreases **or** terminal pd now less than emf **or** $IR = \varepsilon - Ir$ ✓

3

(d) *V*= 2.5 × 2.0 = 5 V
or (use of V=IR) by I = their incorrect voltage ÷18 ✓

Must see I as subject or their working leading to answer line for use of

I=0.28(A) ✓ cao

2

(e) (use of $\varepsilon = IR + Ir$)

6.0 = 2.5 × 2.0 + 0.28× r

$$r = \frac{\varepsilon - IR}{I}$$

or correct rearrangement to make r subject

or sets $R_{(T)} = \frac{\varepsilon}{0.28}$ = 21.2 or 21.4 (ohms) with subject seen

or $\frac{1}{0.28}$ ✓

r = 3.4 to 3.6 Ω ✓

Ecf for I *and* V ecf ans $= \frac{6 - \text{their V}}{\text{their I}}$

2

[10]

8 **B**

[1]

9 **B**

[1]

10 **B**

[1]

11 **B**

[1]

12 **D**

[1]

13 **C**

[1]

Examiner reports

5 Experience from past physics exams at this level indicates that students are better at answering quantitative questions involving electric circuits and this is supported by evidence from this question where the calculations were frequently done well. Part (a) required students to calculate the diameter of the wire and a high proportion of students were able to do this successfully. Full marks were obtained by over 70% of students. There was more variation in parts (b), (c) and (d). While the majority of students were able to calculate the resistance of the circuit, analysing the parallel arrangement was more discriminating. In particular, calculating the resistance of the probe proved challenging. A common mistake was the assumption that the current divided equally in the two branches and therefore the current in the probe was the same as that calculated for R3. Many students found (e) difficult and tried to determine the percentage change in diameter using extended calculations which frequently led to arithmetic errors. The first mark was for recognition that the diameter must decreases and any indication of this such as a downward arrow or negative sign was accepted. The marks obtained for part (f) were disappointing in spite of the mark scheme being expanded to accept a greater range of answers. Very few students picked up that the question referred to the voltmeter reading rather than the pd between A and B. The first marking point was for explaining the effect the internal resistance would have on the circuit by for example reducing the current or terminal pd. The second mark was for a sensible suggestion explaining why the voltmeter reading did not change such as realizing that the closeness of the resistance ratios would make the pd being measured very small. Having the bridge circuit slightly off balance did mean that a comment on the high resistance of the voltmeter was relevant and some did identify this point.

6 (a) Students should expect to be required to interpolate between grid lines when plotting points. Most students were able to do this satisfactorily, but errors reading the ε scale were surprisingly common. Another issue was associated with the style of point used. The standard has been long established in the legacy EMPA and ISA tests: thick points or blobs were not accepted.

(b) Thick, discontinuous, faint or straight lines forfeited this mark. Whilst some excellent lines were seen in answer to this question, some lines were thick enough to obscure the points. The line was expected to pass within half a grid square of all of the points. It was common to see careless drawing near the last point (392,1241), which lost the mark. Where it was clear that the points were incorrectly plotted far from the trend line it is surprising that students did not go back and check their answer to (a).

(c) An error was carried forward from their answer to (b) and most students were able to read the maximum correctly to half a grid square. However, it was common to see 1456 (the maximum in the table) even when the line on the graph did not support this value. 1335 was a common incorrect answer, suggesting that students were treating the ε axis as a number line.

(d) This question discriminated in favour of those who could write without ambiguity. Examiners were looking for an answer that explained that θ_n could be found from figure 3 simply by reading off where the value of G was zero (280 °C). Answers that discussed the difficulty of reading the value from figure 2 as there is a range of values for which ε is at, or close to, a maximum, also gained credit. Unfortunately many students implied that the gradient of figure 3 was easier to measure, or stated that finding where the gradient was zero was easier on figure 3 (seeming to suggest that there is such a point on figure 3). Some erroneously wrote about the relative difficulties of reading a point from a straight line rather than a curve. It was also relatively common to see comments referring to the different scale ranges in the two diagrams.

(e) Many very good answers to this question were seen, clearly demonstrating an understanding of the equation of a straight line and an ability to obtain data, such as the gradient, from a graph. An alternative acceptable approach was to use the values from two points and solve the two simultaneous equations produced. Many students incorrectly thought α was the value of G where the line touched the y-axis, and extrapolated the line back and extended the axis to find this point. Others mistakenly took α to be the gradient.

(f) Although many correct answers were seen, some suggested that several students were unfamiliar with the term “full scale deflection”, despite this being defined in the question. Others did not spot the μ on the answer line, writing down a value of 0.1 without changing the unit to match.

(g) There were many answers expressed so poorly that credit could not be given. Common examples were “the scale is too large”, “the divisions are not small enough” and “the scale does not have enough divisions”. Discussions related to accuracy gained no credit either. The best answers made it clear that the resolution of the meter was unsatisfactory, supporting this with a relevant calculation, such as the change in pd represented by one division (2000 μV). There was consideration made for answers based on an incorrect answer to (f). For example, those who had calculated the full-scale deflection to be 0., could gain credit for arguing that the range of the meter was inadequate. Several unsuccessfully argued that it was the susceptibility of the analogue meter to parallax error which made it unsuitable.

7 Students enjoyed success in part (a) and (b)(i) but the requirement for two significant figures in the answer to part (b)(ii) meant many students failed to get this mark. Students need to be aware of the number of significant figures used in data provided and to ensure that their answer agrees with this.

Part (c) proved difficult, this may have been due to the inclusion of the oscilloscope making many students doubt their knowledge of this topic. It was surprising to see the number of students who stated that when switch S2 was closed that the resistance increased causing the current to decrease. These students had a very limited understanding of basic circuit theory never mind being able to produce a reasonable answer involving internal resistance and lost volts. Many other students were able to state that the reading on the oscilloscope decreased but they were unsure of the reason why this happened.

As with the other calculations in the paper, grade A students dealt competently with parts (d) and (e). Lower grade students were unsure about how to determine the current in the battery, choosing to divide 6 V by 18 ohms was common here. Lower standard working in part (e) was often muddled and hard to follow due to the number of mistakes made in part (d); these students often confused terminal pd with emf and had no real idea about how to make headway in this part of the question.

8 This question tested students' knowledge of formulae, units and their ability to rearrange. Over 30% were able to identify the correct answer. There were a number of pitfalls along the way and many students did not manage to deal with the s^{-1} in Cs^{-1} (the unit for the ampère); in this case they selected distractor A.

9 This question proved a challenge (28.3% correct); the most common incorrect answer selected was distractor C. These students reasoned that the pd must be divided between the voltmeter and the 20 Ω resistor in a 1:1 ratio despite the voltmeter having an infinite resistance. Similarly, they were unaware that the total resistance in the circuit was 20 Ω rather than 10 Ω.

10 46.6% correct

11 75.4% correct

12 46.1% correct

13 76.3% correct