LONDON SCIENCE COLLEGE

MARK SCHEME

PHYSICS

AS-Level

ELECTRICITY

TEST 3

Mark schemes

1 (a) power increases to a maximum / (up) to 3.0 (2.8 -3.4) Ω / / (up)to 3.0 W ✓
then decreases ✓

2

(b) (i) (*use of $P = I^2R$*)
when R = 0.8 Ω power = 1.95 W ✓
$1.9 = I^2 \times 0.8$ ✓
$I = \sqrt{2.375} = 1.5(4)$ (A) ✓

Range
1.9 - 2.0 W for power (first mark)
Current 1.5 – 1.6 A

3

(ii) (*use of $V = IR$*)
V = 1.54 × 0.8 ✓
V = 1.2 V ✓

CE from part (i)

2

(iii) (*use of $\varepsilon = V + Ir$*)
6.0 = 1.2 + 1.54 × r ✓
r = (6.0 – 1.2) / 1.54 = 3.1 (2.9 – 3.2)(Ω) ✓
use of maximum power theorem (quoted) as alternative method can get both marks i.e. read peak maximum from graph

CE from part (ii)

2

(c) power would decrease (as R increased) ✓
pd / voltage across R is now constant / equal to emf ✓
and so power proportional to 1 / R / inversely proportional to R OR
can quote $P = V^2 / R$ but only if scored second mark ✓

3

[12]

2 (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* $\rho = \frac{RA}{l}$)

ρ = 0.70 × π × 0.0005^2 / 4.8 ✓ = 1.1(5) × 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]

3 (a) (i) *(use of V=Ir)*
V= 4.2 × 1.5 ✓ = 6.3 (V)

1

(ii) pd = 12 − 6.3 = 5.7 V✓

NO CE from (i)

1

(iii) (*use of I = V / R*)
I = 5.7 / 2.0 = 2.8(5) A✓

CE from (ii)
(a(ii)/2.0)
accept 2.8 or 2.9

1

(iv) *I* = 4.2 – 2.85 = 1.3(5) A ✓

CE from (iii)
(4.2 −(a)(iii))
accept 1.3 or 1.4

1

(v) *R*= 5.7 / 1.35 =4.2 Ω ✓

CE from (iv)
(a(ii) / (a)(iv))
Accept range 4.4 to 4.1

1

(vi) $\frac{1}{R_{Parallel}} = \frac{1}{4.2} + \frac{1}{2.0} = 0.737$ ✓

CE from (a)(v)

$R_{parallel}$ = 1.35 **Ω**

second mark for adding internal resistance

R_{total} = 1.35 + 1.5✓ = 2.85 Ω
OR
R = 12/4.2 ✓
R= 2.85 Ω ✓

2

(b) (i)

resistor	Rate of energy dissipation (W)
1.5 Ω internal resistance	$4.2^2 \times 1.5 = 26.5$ ✓
2.0 Ω	$2.85^2 \times 2.0 = 16.2$ (15.68 − 16.82) ✓
R	$1.35^2 \times 4.2 = 7.7$ (7.1 − 8.2) ✓

CE from answers in (a) but not for first value

2.0: a(iii)^2×2

R: a(iv)^2×a(v)

3

(ii) energy provided by cell per second = 12 × 4.2 = <u>50.4</u> (W) ✓
energy dissipated in resistors per second = 26.5 + 16.2 + 7.7 = 50.4 ✓
(hence energy input per second equals energy output)

if not equal can score second mark if an appropriate comment

2

[12]

4 (a) (i) *(use of I = V / R)*

first mark for adding resistance values 90 k Ω

I = 6.0 / (50 000 + 35 000 + 5000) ✓ = 6.7×10^{-5} A ✓

accept 7×10^{-5} or dotted 6×10^{-5}

but not 7.0×10^{-5} and not 6.6×10^{-5}

2

(ii) $V = 6.7 \times 10^{-5} \times 5000$ ✓ = 0.33 (0.33 − 0.35) V ✓
OR
V = 5 / 90 × 6 ✓ = 0.33(V) ✓

CE from (i)
BALD answer full credit
0.3 OK and dotted 0.3

2

(b) resistance of LDR decreases ✓

need first mark before can qualify for second

reading increase because greater <u>proportion / share</u> of the voltage across R OR higher current ✓

2

(c) $I = 0.75 / 5000 = 1.5 \times 10^{-4}$ (A) ✓
(pd across LDR = 0.75 (V))
pd across variable resistor = 6.0 − 0.75 − 0.75 = 4.5 (V) ✓
$R = 4.5 / 1.5 \times 10^{-4} = 30\,000\ \Omega$ ✓
or
$I = 0.75 / 5000 = 1.5 \times 10^{-4}$ (A) ✓
$R_{total}I = 6.0 / 1.5 \times 10^{-4} = 40\,000\ \Omega$ ✓
$R = 40\,000 - 5000 - 5000 = 30\,000\ \Omega$ ✓

3

[9]

5 (a) potential divider formula used or current found to be 0.25 A

C1

A1

allow 1 s.f.

2.0 V

1.0 V (with working) gains 1 mark

2

(b) main current =1.2 V / 4 Ω = 0.3 (A)

C1

R_{total} = 1.8 V / 0.3 A = 6 Ω or I_8 = 0.225 (A)

C1

R_V = 24 Ω

A1

3

[5]

6 (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]

7 (a) (i) **$1/R_{total}$ = 1/(40)**✓+1/(10+5) ✓= 0.09167
R_{total} = 10.9 kΩ ✓

3

(ii) I = 12 / 10.9 k = 1.1 mA✓

1

(b)

position	pd / V
AC	6.0✓
DF	4.0✓
CD	2.0✓

C.E. for CD

3

(c) (i) AC: no change✓
constant pd across resistors / parallel branches(AE) ✓
no CE from first mark

2

(ii) DF: decreases ✓
as greater proportion of voltage across fixed / 10 k Ω resistor ✓

no CE from first mark

2

[11]

8 (a) (use of ρ=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]

9 **B**

[1]

10 **B**

[1]

11 **C**

[1]

12 **D**

[1]

13 **C**

[1]

14 **B**

[1]

15 C

[1]

16 B

[1]

Examiner reports

1 Candidates often find circuit analysis questions challenging if the power supply in the circuit has an internal resistance. This certainly proved to be the case in this exam.

Most candidates were able to interpret the graph in part (a) but when it came to the calculations in part (b) (i), only about half of the candidates appreciated that the pd across resistor R was not 6.0 V. This led them to calculate an incorrect value for current. They were allowed consequential error however, and this meant that higher marks were seen in parts (b) (ii) and (b) (iii).

Part (c) was answered very badly with only about 6% of candidates obtaining full marks and nearly 70% getting zero. The commonest mistake was the assumption that the new graph would have the same overall shape as the one shown in figure 2. Very few candidates seemed to appreciate that with negligible internal resistance, power would be inversely proportional to resistance.

2 Part (a) of this question required a definition of resistivity and many candidates did not recognise what was required by this command word. A lot of answers were vague with descriptions of what is meant by resistivity rather than a formal definition. The commonest mistake made by those who did give a definition was to refer to area rather than cross-sectional area. In part (a) (ii) a high proportion of candidates were aware that critical temperature was associated to superconductivity. Many however, lost a mark because their answers were not clear due to them making statements such as 'at the critical temperature a material becomes a superconductor' instead of 'at or below the critical temperature'.

The calculation in part (b) was done well although, as is usually the case with this type of question, it was quite common for the cross-sectional area to be calculated incorrectly. This was either because the surface area was calculated or the diameter was used as a radius. The unit for resistivity is one that is often given incorrectly with $\Omega\ m^{-1}$ being the most frequent erroneous answer.

3 Part (a) was highly structured and led candidates through a full circuit calculation in stages. This approach appeared to have helped them and more successful solutions were seen than has been the case in the past with this type of circuit.

The part that caused the most problems was (a) (ii) with a significant proportion of candidates not appreciating that the pd across the 2.0 Ω resistor was the same as that across resistor R. Candidates were however, not penalized when they carried their incorrect answer to subsequent parts and consequently the remaining calculations were often carried out successfully.

Part (b) proved to be much more demanding and only about half the candidates managed to complete the table for the rate of energy dissipation successfully.

The demonstration of energy conservation in part (b) (ii) provided an even greater challenge and only about a third of candidates provided a convincing analysis of energy conservation in the circuit. A fifth of candidates made no attempt at this part of the question.

4 This question on a potential divider circuit was a mixture of qualitative and quantitative. As is often the case with questions involving electric circuits, candidates coped better with quantitative parts. This was particularly true in part (a) where the calculation involved more than one stage.

Part (b) was not well done and only the strongest candidates manage to relate the changing light intensity to the voltmeter reading. A significant proportion of candidates were under the impression that increasing the light intensity increases the ldr resistance.

Part (c) did involve a calculation but this was much more challenging than part (a) because there were no intermediate stages. Only a third of candidates were able to calculate a correct value for the resistance of the variable resistor. The majority of those who were successful calculated the value using a ratio method rather than calculating the current and then using this value with the correct pd to find the resistance.

5 The majority of candidates correctly calculated the voltage in (a). Many used the same current as in (a) to do the calculation in (b); dividing the difference in the voltage across the resistor [between (a) and (b) = 0.2 V] by the current in (a) to give 0.8 Ω was a very common incorrect answer. Only a few candidates were able to perform the complete calculation to obtain a resistance of 24 Ω.

6 Most candidates made a good attempt at calculating the resistance of the wire but there were many mistakes with powers of ten and rearranging the equation. There were quite a large number of candidates using the radius as the cross-sectional area or using the wrong formula for the area of a circle. The same mistakes occurred when calculating the power dissipated – many either used an incorrect power of 10 for milliamps or else forgot the square the current.

Most candidates drew a creditable graph in (b); a minority showed a negative slope or a graph that did not have a transition temperature. A significant number of candidates believed that using superconductors simply reduced the power loss; although this is true it is more important that the power loss falls to zero (at the transition temperature). Many answered this by simply saying that the resistance was zero.

7 In this question candidates were required to analyse a bridge network of resistors. The calculation of the circuit resistance in part (a) proved to be reasonably straightforward with over two thirds of candidates scoring full marks. The only common error in weaker scripts was the combining of all the resistors as parallel resistors instead of combining the series branches first. The calculation of current in part (a) (ii) was done well and with consequential error applied, the majority of candidates were able to do this successfully.

Part (b) was not well answered and very few candidates were able to give correct answers for the voltmeter reading in the three positions. The position that proved the most challenging was the pd between C and D and it is clear that many candidates did not appreciate that this was found by subtracting the pd across D and F from the pd across C and E.

Part (c) was a qualitative question and previous papers suggest that candidates find these difficult. Only the very best candidates managed to get full marks in this section and it was the explanations of the effect on the voltmeter that proved to be the most challenging. For example over 60% of candidates appreciated that the pd across the thermistor decreased but only about 14% managed to explain why. A common mistake was to try and use current in explanations and this led them to conclude incorrectly that if current goes up then so does pd or that the increase in current cancels out the decrease in resistance. Very few used the constant 12 V across the parallel branches to justify their conclusions.

8 The first part of this question involved the use of the resistivity formula and many were able to do this successfully. In the vast majority of cases they were also able to calculate the current flowing in the lamp using the power formula.

Parts (b)(ii) and (iii) were answered less successfully and only about half of the candidates appreciated that the pd across the wires was found by multiplying their answer in part (a) by the answer in part (b)(i). In part (b)(iii) candidates were required to calculate the emf of the supply and this proved to be quite a challenge with only about 23% scripts obtaining full marks. Many answers gave values of less than 12 V.

Part (c) required a knowledge of the effects of internal resistance and this is a topic that has caused problems in the past. This time however, fewer confused answers were seen and full marks were relatively common.

9 Most students correctly identified B as the correct statement regarding superconductors. Distractor A proved a popular choice as many students are reluctant to recognise that superconductors have no resistance and prefer statements that suggest that superconductors have almost zero resistance.

10 40% of students selected the correct answer. The most popular distractor was C; students had difficulty dealing with the fact that doubling the radius quadrupled the cross-sectional area. Where students had supporting working, with the resistivity formula, they had usually performed the calculation correctly.

11 The low level of success here was surprising; less than 50% of students correctly identified the correct answer. In preparation for the exam, students would do well to be able to sketch all such graphs from memory, making any such graph instantly recognisable in questions like this.

12 Over 10% of students did not select any answer. It is important that students develop exam technique to include a final page check to ensure all questions have been seen. Only 35% of students selected the correct answer; this demonstrates a lack of familiarity with the properties of LDRs and potential divider circuits.