Mark schemes

1 B

[1]

2 (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]

3 (a) 1 joule per coulomb (or equivalent)

B1

allow watt per amp

1

(b) (i) Use of potential divider formula

C1

allow 1 for 4.05 (V) or current of 2.25 (mA)

4.95 (V)

A1

2

(ii) reduced current

B1

1

(iii) use of parallel resistor formula

C1

leading to 1.72 (kΩ)

C1

pd = 4.4 (V)

A1

3

(iv) potential divider can provides sensitive control of current (from 0 - 1.1 mA)

B1

allow pot div can provide zero current ***and*** *variable resistor gives larger current*

variable resistor can provide larger current but cannot get near 0 A owtte

B1

2

[9]

4 (a) potential divider or potentiometer

B1

1

(b) minimum 4 (V)

B1

variable *R* 8 Ω

B1

max I 12 V

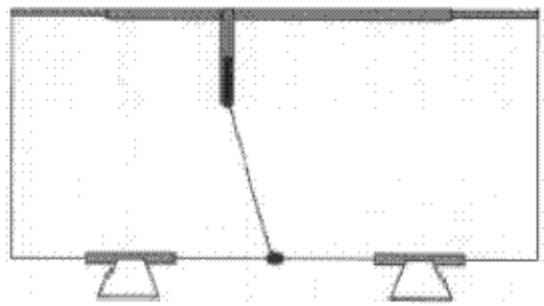
B1

variable *R* 0 (Ω)

B1

4

(c) (i)



B1

1

(ii) full amplitude/voltage/volume range in each speaker/only **limited range** in Figure 2

B1

Figure 2 circuit would have **different ranges** in each speaker

B1

allow arguments related to relative values of resistors and speakers

2

[8]

5 (a) (i) pd across resistor = 12 – 4.5 = 7.5 V

C1

1

(ii) I = (answer to (a) (i))/67 (allow 12/7.5/4.5 for this mark)

C1

0.110/0.112 (A)

A1

2

(b) (i) *360 + 67 (= 427) seen*

C1

$V = 12 \times 360/(360 + 67)$

C1

10.1 V

A1

3

(ii) substitution $P = V^2/R$ allow 360 Ω/67 Ω;
10 V, 10.1 V, 1.9 V, 2 V

C1

$1.9^2/67$

C1

0.053

C1

W or J s^{-1}

A1

4

(c) $1/R = 1/570 + 1/360$

C1

220 [Ω]

C1

total R = 287 Ω

C1

42/41.7 mA $4.2 \times 10^{-2}/4.17 \times 10^{-2}$

A1

4

(d) extra charge carriers released as temperature rises

B1

increased thermal agitation of atoms resists flow of charge carriers

B1

1st effect overwhelms 2nd

A1

3

[17]

6 (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 = 1.5×10^{-4} (A) ✓

(pd across LDR = 0.75 (V))

pd across variable resistor = 6.0 − 0.75 − 0.75 = 4.5 (V) ✓

R = 4.5 / 1.5×10^{-4} = 30 000 Ω ✓

or

I = 0.75 / 5000 = 1.5×10^{-4} (A) ✓

R_{total}l = 6.0 / 1.5×10^{-4} = 40 000 Ω ✓

R = 40 000 − 5000 − 5000 = 30 000 Ω ✓

3

[9]

7 (a) (i) (use of $V = IR$ gives) $V = I(R_1 + R_2)$ **(1)**

$$I = \frac{V}{R_1 + R_2} = \frac{9}{120 + 60} \textbf{ (1)}$$

= 50 mA ✓

(ii) V_{out} (= IR_2) = 0.05 × 60 = 3 V **(1)**

(allow C.E. for value of I from (i))

4

(b) (temperature increases, resistance decreases), total resistance decreases **(1)**
current increases **(1)**
voltage across R_2 increases **(1)**
[or R_2 has increased share of (total) resistance **(1)**
new current is same in both resistors **(1)** larger share of the 9 V **(1)**]

[or $V_{out} = V_{in} \dfrac{R_2}{R_1 + R_2}$ **(1)** R_1 decreases **(1)** V_{out} decreases **(1)**]

3

[7]

8 (a) (i) resistivity defined by $\rho = \dfrac{RA}{l}$ **(1)**

symbols defined $\dfrac{RA}{l}$

(ii) $R = \dfrac{\rho l}{A} = \dfrac{1.7 \times 10^{-8} \times 2}{\pi(0.4 \times 10^{-3})^2}$ **(1)**
= 0.068 (Ω) **(1)** (0.0676 Ω)

$I = \dfrac{1.5}{0.068}$ = 22 A **(1)** (22.2 A)

(allow e.c.f. from value of R)

(5)

(b) (i) pd$_{AB}$ = $\dfrac{2}{3}$ × 12 = 8 V **(1) (1)**

(ii) pd$_{BC}$ = ($\dfrac{1}{3}$ × 12) = 4 V **(1)**

(iii) pd$_{AC}$ = potential at A – potential at C **(1)**
= (8 – 4) = 4 V **(1)**
(allow e.c.f. from (i) and (ii))

(5)

[10]

9 (a) *potential divider*:

advantage: better control from 0 to maximum **(1)**

disadvantage: power wasted because lower half of resistor always carries current (or top half of resistor must be capable of carrying lower half current **and** bulb current) **(1)**

rheostat:

advantage: easier to connect **(1)**

disadvantage: minimum current through bulb never zero **(1)**

(4)

(b) (i) $V_{XB} = V_{lamp} = 2.0$ V $\therefore I_{XB} = \frac{2}{16/2} = 0.25$ A **(1)**

(ii) $I_{AX} = I_{XB} + I_{lamp}$, $I_{lamp} = I_{XB} = 0.25$ A, $\therefore I_{AX} = 0.5$ A **(1)**

(2)

[6]

10 (a) (i) current = emf / total resistance or $I = \frac{E}{R+r}$ **or** equivalent **C1**

current = 0.77 A **C1**

$V = 2.3(1)$ V **A1**

(**or** alternative approach using potential divider formula)

(3)

(ii) wider range of voltages available

from 0 to 10 V **or** since lower minimum voltage **B1**

(1)

(iii) resistance of lower part is reduced

(since 3 Ω resistor is in parallel with lower half of potentiometer)

or calculation of resistance = 2.5 Ω **B1**

so voltage across lower section is reduced or calculation of p.d. = 1.43 V **B1**

allow 1 for calculation of p.d using {3 / (3 + 15) × 10} = 1.67 V

(2)

(iv) point labelled at least $\frac{3}{4}$ of the way toward the top of the potentiometer (correct position is just over $\frac{9}{10}$ of the way up)

B1

(1)

(b) (i) power = V^2 / R **B1**

$V_1^2 / 9 = V_2^2 / 4$ with correct clear manipulation **A1**

or calculates V_1 (6 V) and V_2 (4 V) **C1**

calculates power in each resistor (4 W) showing them to be equal **A1**

(2)

(ii) 4(.0) W (c.a.o.) **B1**

NB not half of (10^2 / 13)

(1)

[10]

11 (a) [$V_1 = V \times R_1/(R_1 + R_2)$] C1

= 16 × 1200/2000 = 9.6 V A1

2

(b) LDR resistance drops B1

voltmeter reading decreases B1

because more conduction electrons/charge carriers released B1

3

[5]

Examiner reports

2 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.

3 Few candidates were able to define the volt correctly – most tried to use V = IR. In (b)(i) most candidates were able to apply the potential divider formula correctly to calculate the voltmeter reading.

A minority of candidates suggested that the benefit of using high resistances in potential dividers was to result in low currents in (b)(ii).

A high proportion of candidates answered (b)(iii) correctly by calculating the resistance of the parallel arrangement and then either applying the potential divider formula or else calculating the current and consequent potential difference. A significant minority of candidates failed to make any progress in this part and there were a number of blank answers.

In (b)(iv) few could make any creditworthy comment on the relative merits of a potential divider and series arrangement when controlling current. Only a very limited number of candidates were able to calculate the current range in the two circuits and thereby inform their comments – it was clear that this topic was not well understood.

4 In part (a), few than half the candidates identified this as potential divider circuit.

There were many correct responses to part (b) fairly straightforward question. A small minority gave the answers the wrong way round. Some knew that 12 V was likely to be the maximum without knowing when this would occur and some knew the resistor setting but were unable to calculate the voltages.

It was disappointing that more than half of the candidates were unable to complete the circuit in part (c) (i) correctly.

Few could make progress with part (c) (ii). Many thought that the circuit in Figure 6 would only enable the amplitude of one speaker to be changed. They did not appreciate that the voltage could not be made zero in the left hand loudspeaker or that the range of voltages available would be different in the two loudspeakers. Using the potentiometer both loudspeakers have the same range of voltages from zero to the maximum.

5 The level of attainment in this question that tested the electrical areas of the specification was very poor. Some candidates are clearly not comfortable with even the simplest problems tested here.

The pd in part (a) (i) was correctly identified by most candidates.

Answers to part (a) (ii) were very mixed and in general poor. Explanations were not adequate and the application of $V = IR$ confused.

20% of candidates did not attempt part (b) (i) and only 10% gave completely accurate answers. Both the understanding and application of the potential divider by candidates as poor.

Again many used poor physics that did not relate to the circuit in part (b) (ii). There was a misunderstanding as to which pd to use in the equation.

One-fifth of candidates offered no explanations to part (c). The essence of the question was a computation of the total resistance of a parallel resistor network. About half of candidates were able to negotiate this with comfort, but the remainder were usually able to quote the appropriate equation but not to get further with it.

Only the more able candidates gave a complete picture of the situation in part (d). To gain full credit candidates needed to recognise both the change in atomic vibration and the increase in charge carrier density as a result of temperature increase, but then to go on to state that the second effect outweighs the first.

6 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.

7 Part (a) provided the candidates with a reasonably easy four marks, and very few failed completely on the calculation. Usual errors such as units and arithmetic errors occurred but, in general, the candidates knew how to proceed with the calculation.

Part (b) required clear, logical thinking and sadly, the majority of candidates failed to gain the full three marks. Having been told in the question that the resistance of the sensor decreased with increasing temperature, many candidates simply wrote that the reading of the voltmeter would increase. Such a statement, although in itself correct, without any reasoning did not gain marks. Many candidate realised that the current in the circuit would decrease, but failed to go any further. The best approach seemed to be using the potential divider equation and candidates who tackled the question from this angle were usually awarded two or three marks.

8 Giving the relevant equation for resistivity in part (a)(i) was straightforward for the majority of candidates. Errors were quite common however in the calculation in part (ii). The usual error occurred in calculating the area of cross-section, e.g. by omitting the π or the factor 10^{-3} or not squaring the radius. These errors however were allowed to be carried forward and credit was given for subsequent calculations and although it often resulted in currents of the order of 10^7 A very few candidates made any comment on this unlikely value.

Part (b) was probably the worst answered section in the paper and very few candidates gained full credit. The basic problem seemed to be that candidates were under the impression that the 12 V was somehow split, resulting in 6 V across each chain of three resistors. Thus answers of 4 V and 2 V respectively for parts (i) and (ii) were common. Many candidates attempted to calculate the various potential differences but their mathematics was so confused that it was difficult to decide what approach they were taking. Answers to part (iii) usually bore no relation to the previous answers and was very often a matter of guesswork.

10 (a) (i) Many were unable to make any progress with this part. The only slight complication was the requirement to understand that the voltage is a minimum when the rheostat is set to 10 Ω but this usually seemed to be the least of the candidates' concerns. The formula quoted was often that for terminal p.d. that led nowhere. Some quoted the potential divider formula and were then unable to apply it. Other candidates worked out the circuit current and gave this as the minimum voltage.

(ii) Most answers to this part were very vague and relatively few acknowledged the fact that it was possible to vary the voltage from 0 V – 10 V. Some stated only that it 'increased the range' without further qualification. Some focused attention on the resistor giving 'finer control' but this would depend on the structure of the potentiometer (e.g. the resistance per unit length).

(iii) Although many stated that the 3 Ω resistor would be in parallel with 15 Ω of the potentiometer relatively few continued the argument to a satisfactory conclusion. Many assumed that the final situation was 3 Ω in series with 15 Ωand drew a conclusion from this which gained some credit. Although only a correct qualitative argument was required for full marks, the best candidates actually calculated the voltage correctly.

(iv) Many placed the new position toward the bottom of the potentiometer even after making progress to the correct explanation in part (iii). Generally this was not well done.

(b) (i) Many assumed the currents in the two components to be equal. Some who quoted the correct starting formula (V^2 / R) tried to determine the power dissipated and prove them to be the same. This was an acceptable approach but candidates were expected to use the actual voltages in their explanations rather than the ratio given.

(ii) There was a good proportion of correct answers but often, even when part (i) was correct, this part was wrong. A significant proportion calculated the total power using $10^2 / 13$ and then halved it.

11 (a) This question was well answered by large numbers of the entry.

(b) Thinking was confused in this question, however. About half the candidates could not correctly state or explain how the resistance of a light-dependent resistor varies with light intensity. Those who knew this often could not go on to state correctly how the voltmeter reading varies. Only rarely could a candidate write fluently in terms of the *ratio* of the resistance values in the potential divider. Explanations were usually on a much lower level and rarely went beyond: '*resistance goes down so the voltage drops*'.