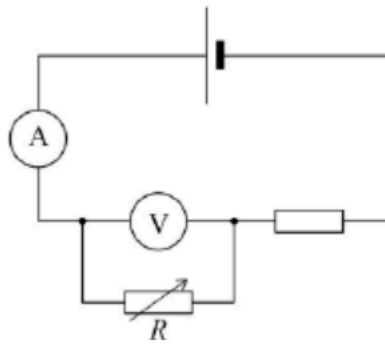


1

In the circuit shown in the diagram the cell has negligible internal resistance.



What happens to the reading of both meters when the resistance of R is decreased?

	Reading of ammeter	Reading of voltmeter	
A	increases	increases	☐
B	increases	decreases	☐
C	decreases	increases	☐
D	unchanged	decreases	☐

(Total 1 mark)

2

A potential divider circuit consists of a battery connected across a thermistor and variable resistor in series.

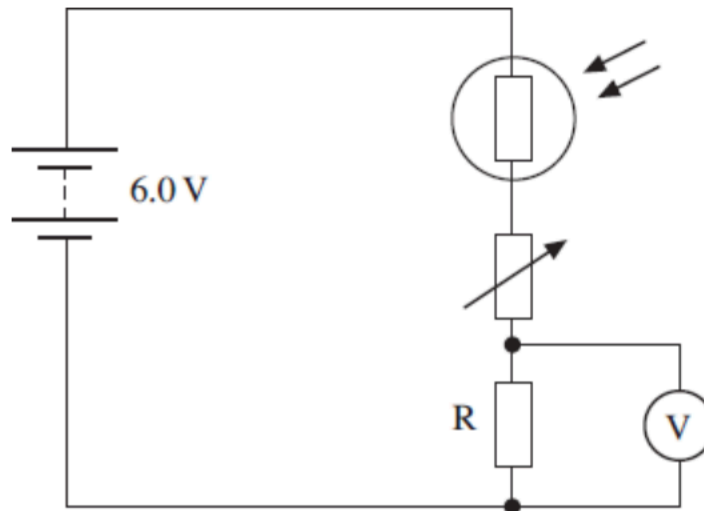
Which of the following causes the potential difference (pd) across the thermistor to increase?

- A** increasing the temperature of the thermistor ☐
- B** increasing the resistance of the variable resistor ☐
- C** reducing the emf of the battery ☐
- D** adding a resistor across the variable resistor ☐

(Total 1 mark)

3

The circuit diagram below shows a 6.0 V battery of negligible internal resistance connected in series to a light dependent resistor (LDR), a variable resistor and a fixed resistor, R.



- (a) For a particular light intensity the resistance of the LDR is $50\text{ k}\Omega$. The resistance of R is $5.0\text{ k}\Omega$ and the variable resistor is set to a value of $35\text{ k}\Omega$.

- (i) Calculate the current in the circuit.

current _____ A

(2)

- (ii) Calculate the reading on the voltmeter.

voltmeter reading _____ V

(2)

- (b) State and explain what happens to the reading on the voltmeter if the intensity of the light incident on the LDR increases.

(2)

- (c) For a certain application at a particular light intensity the pd across R needs to be 0.75 V. The resistance of the LDR at this intensity is 5.0 k Ω .

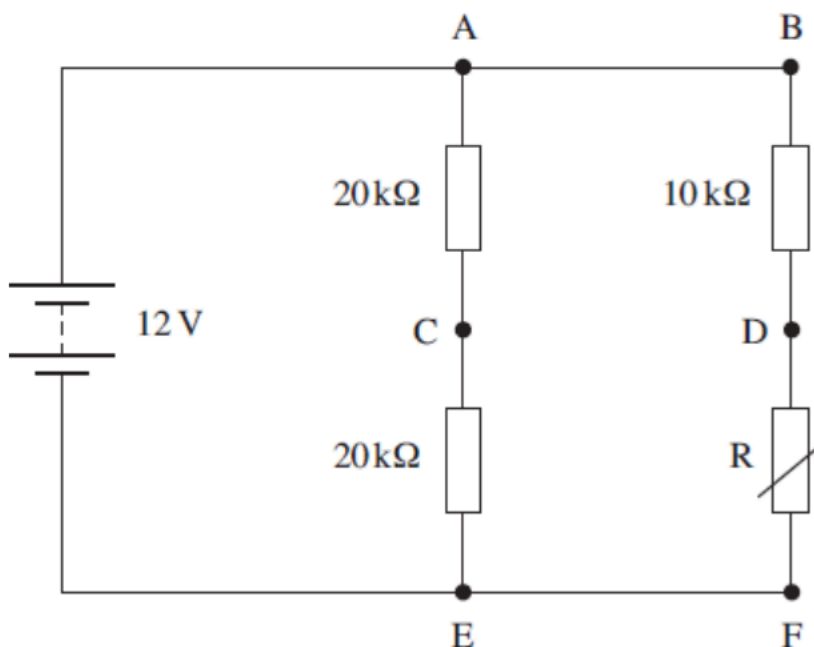
Calculate the required resistance of the variable resistor in this situation.

resistance _____ Ω

(3)

(Total 9 marks)

- 4** The circuit diagram below shows a 12 V battery of negligible internal resistance connected to a combination of three resistors and a thermistor.



- (a) When the resistance of the thermistor is 5.0 k Ω
- (i) calculate the total resistance of the circuit,

total resistance = _____ k Ω

(3)

- (ii) calculate the current in the battery.

current = _____ mA

(1)

- (b) A high-resistance voltmeter is used to measure the potential difference (pd) between points A-C, D-F and C-D in turn.
Complete the following table indicating the reading of the voltmeter at each of the three positions.

voltmeter position	pd / V
A-C	
D-F	
C-D	

(3)

- (c) The thermistor is heated so that its resistance decreases. State and explain the effect this has on the voltmeter reading in the following positions.

- (i) A-C _____

(2)

- (ii) D-F _____

(2)

(Total 11 marks)

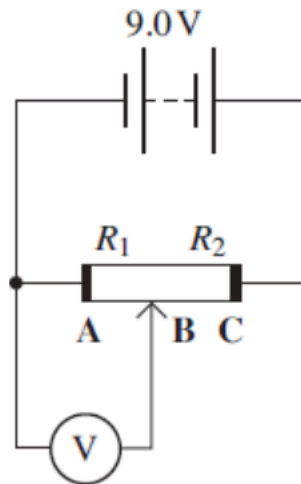
5

- (a) Define the volt.

(1)

- (b) To test the potential differences in a potential divider circuit, a student sets up the circuit of **Figure 1**. R_1 is the resistance of section **AB** and R_2 that of section **BC** of the potential divider. The battery has an emf of 9.0 V and negligible internal resistance

Figure 1



- (i) Calculate the voltmeter reading when $R_1 = 2.2 \text{ k}\Omega$ and $R_2 = 1.8 \text{ k}\Omega$. Assume that the voltmeter has infinite resistance.

voltmeter reading _____ V

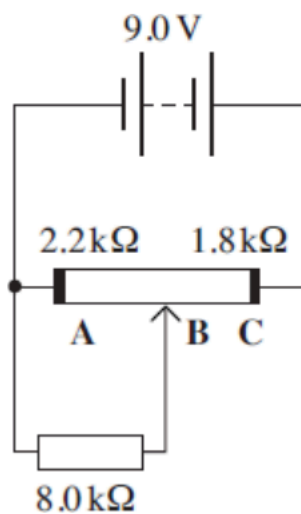
(2)

- (ii) State the benefit of using a high value of resistance in potential divider circuits.

(1)

- (iii) An $8.0\text{ k}\Omega$ resistor is connected in the circuit to replace the voltmeter in **Figure 1**. This is shown in **Figure 2**.

Figure 2



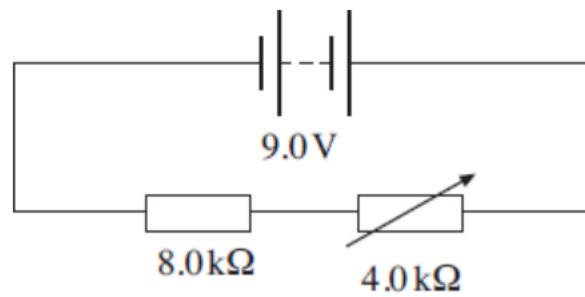
Calculate the potential difference across this resistor when the sliding contact **B** is in the position shown in **Figure 2**.

potential difference _____ V

(3)

- (iv) The $8.0\text{ k}\Omega$ resistor is now connected in a circuit with a $4.0\text{ k}\Omega$ variable resistor as shown in **Figure 3**.

Figure 3

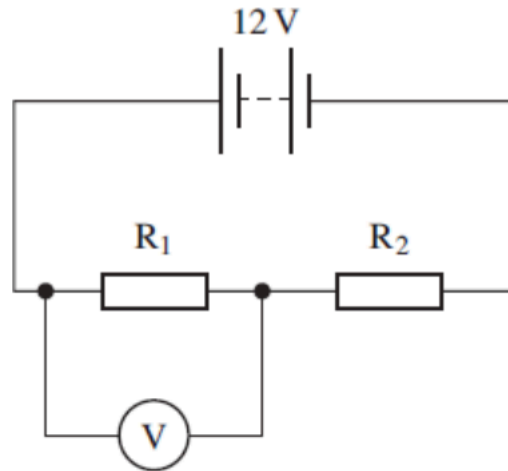


Compare this arrangement for controlling the current in the $8.0\text{ k}\Omega$ resistor with the potential divider arrangement in **Figure 2**.

(2)
(Total 9 marks)

6

The figure below shows two resistors, R_1 and R_2 , connected in series with a battery of emf 12 V and negligible internal resistance.



(a) The reading on the voltmeter is 8.0 V and the resistance of R_2 is 60 Ω .

(i) Calculate the current in the circuit.

answer = _____ A

(2)

(ii) Calculate the resistance of R_1 .

answer = _____ Ω

(1)

(iii) Calculate the charge passing through the battery in 2.0 minutes. Give an appropriate unit for your answer.

answer = _____ unit = _____

(2)

- (b) In the circuit shown in the figure above R_2 is replaced with a thermistor. State and explain what will happen to the reading on the voltmeter as the temperature of the thermistor increases.

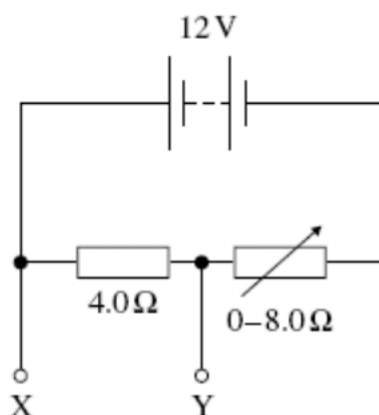
(3)

(Total 8 marks)

7

Figure 1 shows an electrical circuit that contains a $4.0\ \Omega$ resistor, a $0 - 8.0\ \Omega$ variable resistor and a $12\ \text{V}$ power supply with negligible internal resistance.

Figure 1



- (a) State the name given to this type of circuit.

(1)

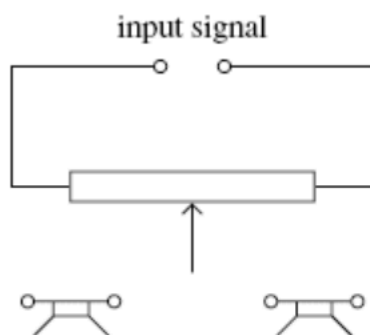
- (b) Calculate the minimum and maximum potential differences that can be obtained across XY. State the corresponding values of the resistance of the variable resistor.

minimum pd _____ V when the resistance of the variable resistor is _____ Ω

maximum pd _____ V when the resistance of the variable resistor is _____ Ω

(4)

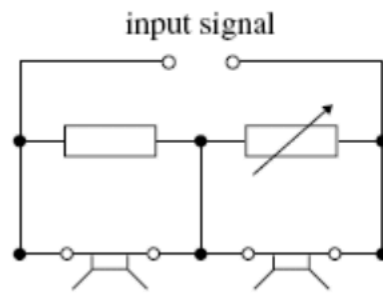
- (c) (i) Complete the circuit diagram to show how a potentiometer (variable resistor) can be connected so that the relative loudness of the sound from two loudspeakers can be adjusted.



(1)

- (ii) Explain the advantage of using a potentiometer over the two-resistor arrangement in **Figure 2** for this purpose.

Figure 2



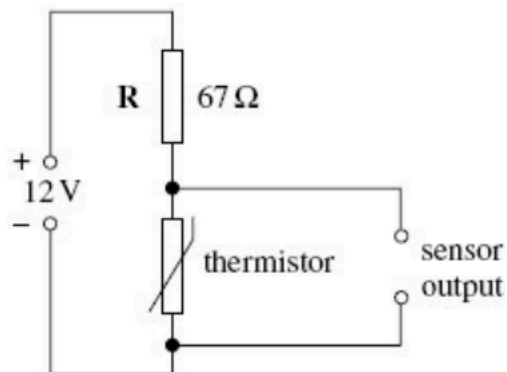
(2)

(Total 8 marks)

8

Figure 1 shows a circuit that can be used to sense temperature changes. Sensing is possible because the potential difference across the thermistor changes as the temperature changes.

Figure 1



The power supply has a negligible internal resistance and the resistor **R** has a resistance of $67\ \Omega$.

(a) When the thermistor is at a high temperature the potential difference across it is 4.5 V.

(i) Calculate the potential difference across **R**.

potential difference _____ V

(1)

(ii) Calculate the current in the circuit.

current _____ A

(2)

(b) (i) The temperature of the thermistor changes to 25 °C and its resistance becomes 360 Ω.

Show that the potential difference across the thermistor at 25 °C is about 10 V.

(3)

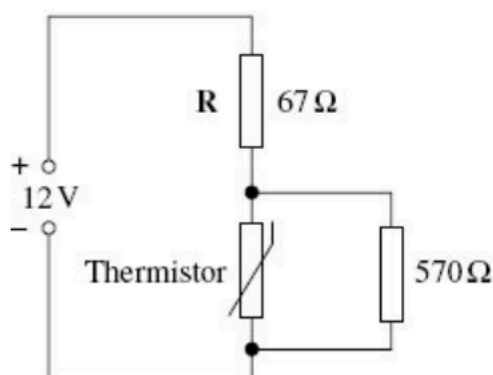
(ii) Calculate the power dissipated in the resistor **R** when the thermistor temperature is 25 °C, giving an appropriate unit for your answer.

power dissipated _____

(4)

- (c) The circuit is modified as shown in **Figure 2**. A resistor of resistance $570\ \Omega$ is connected in parallel with the thermistor.

Figure 2



For the circuit in **Figure 2** calculate the current in the $67\ \Omega$ resistor when the thermistor temperature is $25\ ^\circ\text{C}$.

current in $67\ \Omega$ resistor _____ A

(4)

- (d) Explain, in terms of charge carriers, why the resistance of the thermistor decreases as the temperature rises.

(3)

(Total 17 marks)

9

(a) A student is given three resistors of resistance $3.0\ \Omega$, $4.0\ \Omega$ and $6.0\ \Omega$ respectively.

(i) Draw the arrangement, using all three resistors, which will give the largest resistance.

(ii) Calculate the resistance of the arrangement you have drawn.

(iii) Draw the arrangement, using all three resistors, which will give the smallest resistance.

(iv) Calculate the resistance of the arrangement you have drawn.

(5)

- (b) The three resistors are now connected to a battery of emf 12 V and negligible internal resistance, as shown in **Figure 1**.

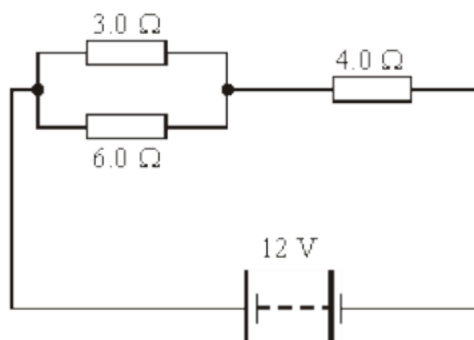


Figure 1

- (i) Calculate the total resistance in the circuit.

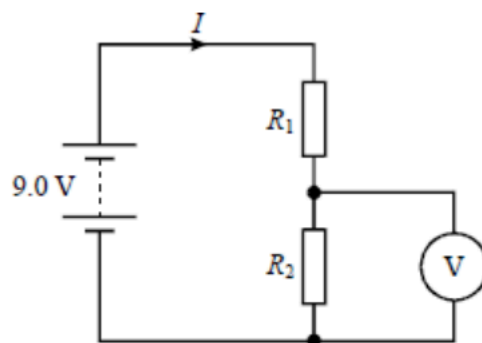
- (ii) Calculate the voltage across the 6.0 Ω resistor.

(4)

(Total 9 marks)

10

In the circuit shown, the battery has negligible internal resistance.



- (a) (i) If the emf of the battery = 9.0 V, $R_1 = 120\ \Omega$ and $R_2 = 60\ \Omega$, calculate the current I flowing in the circuit.

- (ii) Calculate the voltage reading on the voltmeter.

(4)

- (b) The circuit shown in the diagram acts as a potential divider. The circuit is now modified by replacing R_1 with a temperature sensor, whose resistance decreases as the temperature increases.

Explain whether the reading on the voltmeter increases or decreases as the temperature increases from a low value.

(3)

(Total 7 marks)

11

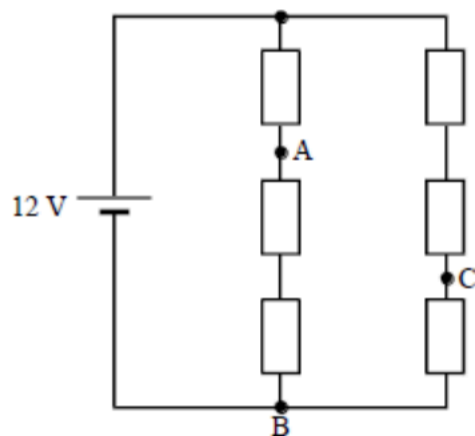
- (a) (i) Give the equation which relates the *electrical resistivity* of a conducting material to its *resistance*. Define the symbols in the equation.

- (ii) A potential difference of 1.5 V exists across the ends of a copper wire of length 2.0 m and uniform radius 0.40 mm. Calculate the current in the wire.

resistivity of copper = $1.7 \times 10^{-8} \Omega \text{ m}$

(5)

- (b) In the circuit shown, each resistor has the same resistance. The battery has an e.m.f. of 12 V and negligible internal resistance.



- (i) Calculate the potential difference between A and B.

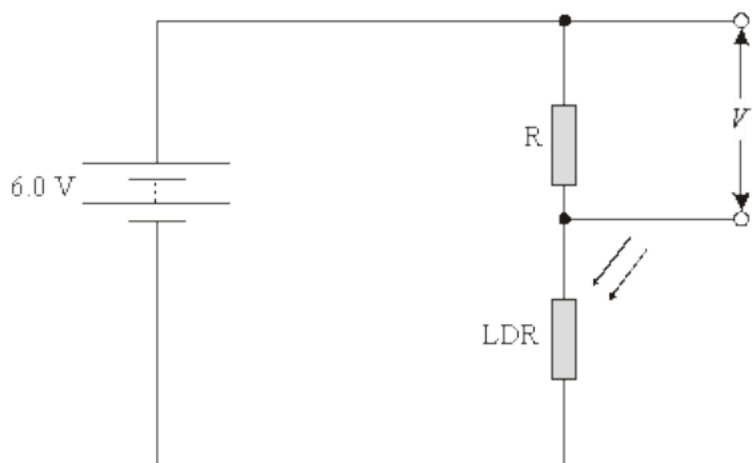
- (ii) Calculate the potential difference between B and C.

- (iii) A high resistance voltmeter is connected between A and C. What is the reading on the voltmeter?

(5)
(Total 10 marks)

12

The figure below shows a simple light sensing circuit. When the output voltage V falls below 2.0 V, this acts as a signal which switches on a safety lamp. The LDR has a resistance of $1.25 \text{ k}\Omega$ when it is fully illuminated and $105 \text{ k}\Omega$ when it is in the dark. The battery has an emf of 6.0 V and negligible internal resistance.



- (a) (i) Show that the safety light will come on when it is dark if resistor R has the value $50 \text{ k}\Omega$.
- (ii) Calculate V when the LDR is fully illuminated and the value of R is $50 \text{ k}\Omega$.

$V =$ _____

(5)

- (b) Draw a diagram for a circuit, using the same LDR and battery, which would produce an output signal which *increases* to 3.0 V when the LDR is in the dark.

(2)

(Total 7 marks)

13

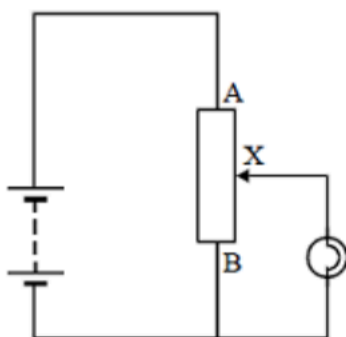


Figure 1

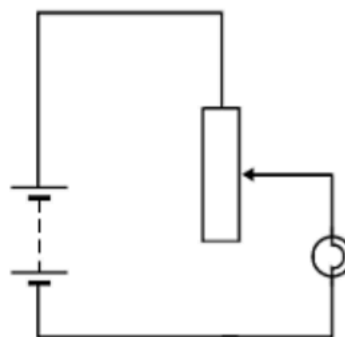


Figure 2

- (a) The current flowing through a torch bulb can be controlled by a variable resistor using either of the two circuit arrangements shown above. **Figure 1** is called a potential divider arrangement and **Figure 2** may be called a rheostat arrangement. For each of these two methods explain **one** advantage and **one** disadvantage.

potential divider

advantage _____

disadvantage _____

rheostat

advantage _____

disadvantage _____

(4)

- (b) In **Figure 1**, the variable resistor has a total resistance of $16\ \Omega$. When the slider of the variable resistor is set at X, exactly mid-way along AB, the bulb works according to its specification of $2.0\ \text{V}$, $500\ \text{mW}$. Calculate

- (i) the current through section XB of the variable resistance,

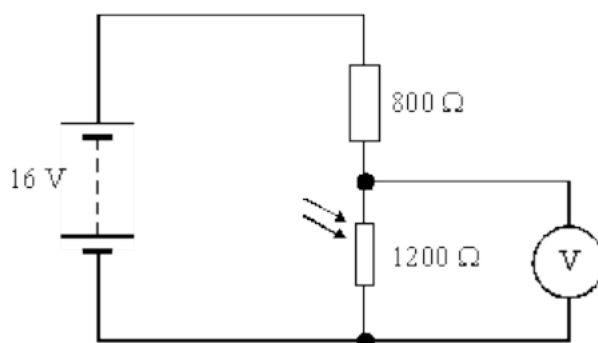
- (ii) the current through section AX of the variable resistance.

(2)

(Total 6 marks)

14

The diagram below shows a potential divider consisting of a resistor in series with a light dependent resistor. The voltmeter connected in parallel with the light dependent resistor has an infinite resistance. The battery has an emf of $16\ \text{V}$ with a negligible internal resistance.



- (a) Calculate the reading on the voltmeter when the light dependent resistor has a resistance of $1200\ \Omega$.

Voltmeter reading _____

(2)

- (b) The light intensity in the room is increased. State and explain what happens to the resistance of the LDR and the reading on the voltmeter.

(3)

(Total 5 marks)

15

- (a) **Figure 1** and **Figure 2** show two circuits that may be used for controlling the voltage across a $3.0\ \Omega$ resistor. In each circuit the supply has an e.m.f. E of $10\ \text{V}$ and negligible internal resistance.

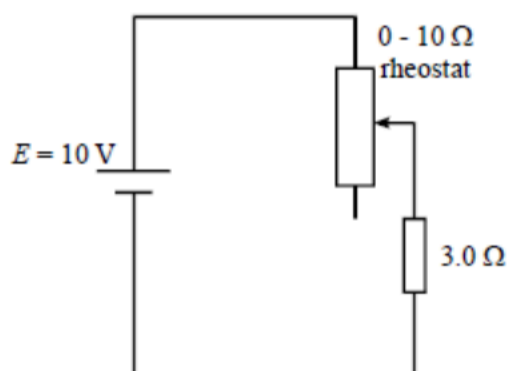


Figure 1

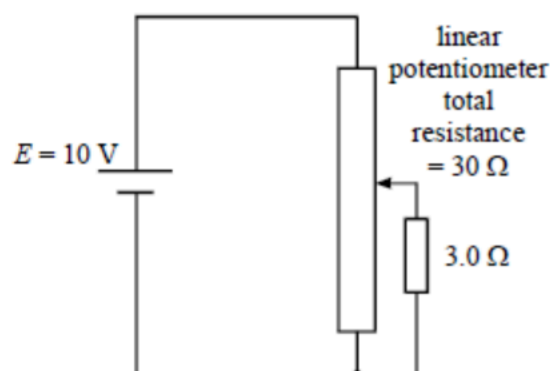


Figure 2

- (i) Calculate the minimum voltage which can exist across the $3.0\ \Omega$ resistor using the circuit shown in **Figure 1**.

(3)

- (ii) State **one** advantage of using the circuit shown in **Figure 2** for controlling the voltage across the $3.0\ \Omega$ resistor.

(1)

- (iii) The total resistance of the potentiometer wire in **Figure 2** is $30\ \Omega$. Explain why the voltage across the $3.0\ \Omega$ resistor would not be half of the maximum when the slider of the potentiometer is half-way along the wire, as shown in **Figure 2**.

(2)

- (iv) Label with a letter **P** the approximate position of the slider in **Figure 2**, when the voltage across the $3.0\ \Omega$ resistor is about half the maximum possible.

(1)

- (b) The circuit in **Figure 3** is used to balance the power dissipated by two components that have different resistances. This is achieved by adjusting the position of S.

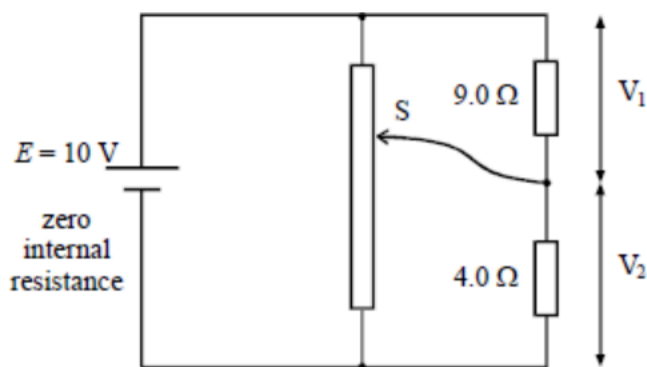


Figure 3

- (i) Show that for the power dissipation to be the same, the ratio $V_1/V_2 = 3/2$.

(2)

- (ii) Calculate the power dissipated by **one** of the components when they are balanced.

(1)

(Total 10 marks)

Mark schemes

1	B	[1]
2	D	
3	(a) (i) (use of $I = V / R$) first mark for adding resistance values 90 k Ω	[1]
	$I = 6.0 / (50\,000 + 35\,000 + 5000) \checkmark = 6.7 \times 10^{-5} \text{ A} \checkmark$ accept 7×10^{-5} or dotted 6×10^{-5} but not 7.0×10^{-5} and not 6.6×10^{-5}	
	(ii) $V = 6.7 \times 10^{-5} \times 5000 \checkmark = 0.33 \text{ (} 0.33 - 0.35 \text{) V} \checkmark$ OR $V = 5 / 90 \times 6 \checkmark = 0.33 \text{ (V)} \checkmark$ CE from (i) BALD answer full credit 0.3 OK and dotted 0.3	2
	(b) resistance of LDR decreases $\checkmark$ need first mark before can qualify for second	2
	reading increase because greater <u>proportion / share</u> of the voltage across R OR higher current $\checkmark$	2
	(c) $I = 0.75 / 5000 = 1.5 \times 10^{-4} \text{ (A)} \checkmark$ (pd across LDR = 0.75 (V)) pd across variable resistor = $6.0 - 0.75 - 0.75 = 4.5 \text{ (V)} \checkmark$ $R = 4.5 / 1.5 \times 10^{-4} = 30\,000 \Omega \checkmark$ or $I = 0.75 / 5000 = 1.5 \times 10^{-4} \text{ (A)} \checkmark$ $R_{\text{total}} I = 6.0 / 1.5 \times 10^{-4} = 40\,000 \Omega \checkmark$ $R = 40\,000 - 5000 - 5000 = 30\,000 \Omega \checkmark$	3
4	(a) (i) $1/R_{\text{total}} = 1/(40) \checkmark + 1/(10+5) \checkmark = 0.09167$ $R_{\text{total}} = 10.9 \text{ k}\Omega \checkmark$	[9]
	(ii) $I = 12 / 10.9 \text{ k} = 1.1 \text{ mA} \checkmark$	
		3
		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]

5

- (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 (k Ω)

C1

pd = 4.4 (V)

A1

(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]

6

(a) (i) *(use of $V = IR$)*

$$I = (12-8) / 60 \checkmark = 0.067 \text{ Or } 0.066(\text{A}) \checkmark$$

2

(ii) *(use of $V = IR$)*

$$R = 8/0.067 = 120 (\Omega) \checkmark$$

1

(iii) *(use of $Q = It$)*

$$Q = 0.067 \times 120 = 8.0 \checkmark \text{ C } \checkmark$$

2

(b) reading will increase $\checkmark$

resistance (of thermistor) decreases (as temperature increases) $\checkmark$

current in circuit increase (so pd across R_1 increases) OR correct potential divider argument $\checkmark$

3

[8]

7

(a) potential divider or potentiometer

B1

1

(b) minimum 4 (V)

B1

variable R 8 Ω

B1

max I 12 V

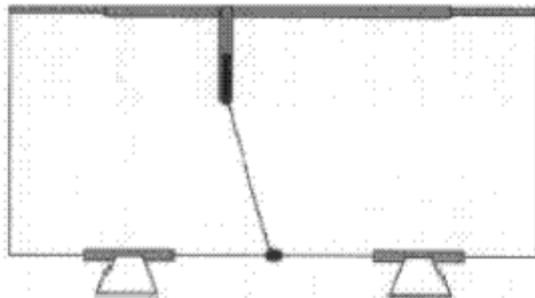
B1

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]

8

(a) (i) pd across resistor = $12 - 4.5 = 7.5$ V

C1

1

(ii) $I = (\text{answer to (a) (i)})/67$ (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 $R = 287 \Omega$

C1

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

A1

- (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]

9

- (a) (i) three resistors in series (1)
 (ii) $R = 3.0 + 4.0 + 6.0 = 13 \Omega$ (1)
 (iii) three resistors in parallel (1)

(iv) $\frac{1}{R} = \frac{1}{3} + \frac{1}{4} + \frac{1}{6} = \frac{9}{12}$ (1)

$R = 1.3 \Omega$ (1)

5

- (b) (i) two resistors in parallel give $\frac{1}{R'} = \frac{1}{3} + \frac{1}{6}$ and $R' = 2.0 \Omega$ (1)

total resistance = $(2 + 4) = 6.0 \Omega$ (1)

4

- (ii) divide the emf in the ratio of 2 : 4 (1)
 to give 4.0 V (1)
 [or any suitable method]

[9]

10

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

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

= 50 mA ✓

- (ii) $V_{\text{out}} (= IR_2) = 0.05 \times 60 = 3 \text{ V}$ (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 $V_{\text{out}} = V_{\text{in}} \frac{R_2}{R_1 + R_2}$ (1) R_1 decreases (1) V_{out} decreases (1)]

3

[7]

11

- (a) (i) resistivity defined by $\rho = \frac{RA}{l}$ (1)

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

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

$I = \frac{1.5}{0.068} = 22 \text{ A}$ (1) (22.2 A)

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

(5)

(b) (i) $\text{pd}_{\text{AB}} = \frac{2}{3} \times 12 = 8 \text{ V}$ (1) (1)

(ii) $\text{pd}_{\text{BC}} = (\frac{1}{3} \times 12) = 4 \text{ V}$ (1)

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

(5)

[10]

12

- (a) (i) $V/50 = 6/155$ or equivalent method

B1

$$V = 1.94 \text{ V}$$

B1

or $R/105 = 2/4$

or equivalent method

B1

$$R = 52.5 \text{ k}\Omega$$

B1

5

correct conclusion based on correct R
or V ($V < 2$, $R > 50$)

B1

- (ii) $V/6.0 = 50/(50 + 1.25)$

C1

$$V = 5.85 \text{ V}$$

A1

- (b) **potential divider** circuit with
battery, LDR and **105 k Ω** in series

B1

V_{out} clearly shown across the LDR

B1

2

[7]

13

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

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

(2)

[6]

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

C1

$$= 16 \times 1200 / 2000 = 9.6 \text{ V}$$

A1

2

(b) LDR resistance drops

B1

voltmeter reading decreases

B1

because more conduction electrons/charge carriers released

B1

3

[5]

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

C1

$$\text{current} = 0.77 \text{ A}$$

C1

$$V = 2.3(1) \text{ V}$$

A1

(or alternative approach using potential divider formula)

(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 $\{3 / (3 + 15) \times 10\} = 1.67$ 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

(2)

(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]