Access Tuition

A-Level Physics

Potential Dividers

Mark Scheme

Time available: 77 minutes
Marks available: 58 marks

Mark schemes

1. (a) Use of

$$V_0 = \frac{R_1}{R_1 + R_2} \times V_{in}$$

OR

$V_1 : V_2 = R_1 : R_2$ ✓

(R =) 1.7 (Ω) ✓

Alternative MP1:

pd across the variable resistor = 11.25 V

OR

current = 0.45 A

2

(b) use of $V = IR$ ✓

(R =) 4.7 (Ω) ✓

2

(c) Temperature increases so resistance increases ✓

Vibration of the lattice ions increases (with temperature) ✓

More collisions between the (conduction) electrons and the lattice ions (at higher temperature) ✓

3

(d) use of $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓

(R =) 4.8 (Ω) ✓

Alternative MP1:

determines I_T current in battery (I_T = 2.48 A) ***and*** *uses $V = IR$*

2

(e) use of $P = \frac{V^2}{R}$ ✓

(P =) 30 (W) ✓

Ecf from ***(d)***

2

(f) Voltage range is wider 0–12 V (in Figure 4's circuit)

OR

bulb won't light at lower range so control is unaffected ✓

Efficiency is less because more power dissipated in Figure 4 (for any particular voltage across the lamp compared to this voltage across the lamp in Figure 2) ✓

At any voltage across the lamp there is always 12 V across the resistor in Fig 4 which produces heating whereas only the remaining portion of 12 V is across the resistor in Fig 2 ✓

3

[14]

2. (a) R_{LDR} without light = 300 kΩ ✓

$I = \frac{V}{R} = \frac{5}{310 \times 10^3}$ = 16.1 × 10^{-6} A ✓

Allow ecf for their R

2

(b) V with without light = IR = 16.1 × 10^{-6} × 300 × 10^{3} = 4.84 V✓

*ecf from **(a)***

Allow 92–100 kΩ

With light $V = \left(\frac{93}{93+10}\right)$ × 5.0 = 4.51 V ✓

Conclusion and calculate of change in voltage and comparison with 1.25 V✓

4.8 – 4.5 = 0.3 V so no.

Allow 1 sf (allow ecf)

3

[5]

3. (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.

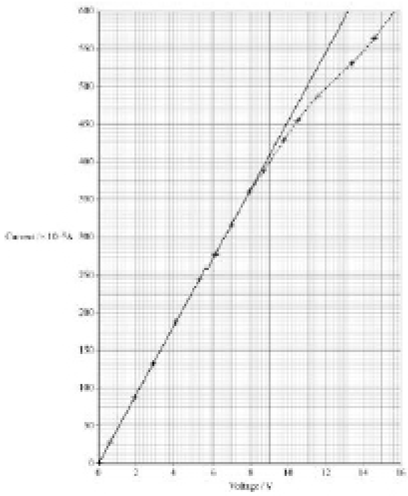
Condone partially erased and redrawn.

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

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 voltmeter 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 all 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 because the resistors are in series" $_3$✓.*

*for weak statements in MP2 and MP4 1 mark for 'circuit **A** is incorrect because ammeter is in wrong place' and 'circuit **C** is incorrect because voltmeter 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 series with resistor **R and** the voltmeter is in parallel with **R**".*

4

[8]

4. (a) resistance of lamp B and D = $3.5^2/4.1 = 3.0$ (2.98)(Ω) ✓
resistance of lamp A and C = $6.0^2/6.0 = 6.0$ (Ω) ✓
pd across lamp B and lamp D = 3/9 × 9.0 = 3.0 (V) OR pd across lamp A and C = 6.0 (V) ✓
hence A and C normal brightness ✓

Can justify in terms of current i.e. current needed by A and C is 1 A provided resistance values calculated

Must have some correct working for conclusion mark

1
1
1
1

(b) the pd across new lamp = 0 / E does not light ✓
no current in E ✓
other lamps are not affected ✓
because the current in the lamps/pd across lamps does not change ✓

2nd and 3rd marks conditional on 1st mark

1
1
1
(MAX 3)

(c) in first circuit current in battery = 9.0/4.5 = 2.0 A ✓
in second circuit current in battery = 9.0/7 = 1.2857 A ✓
hence current in battery decreases ✓

Allow ecf from (a)

Original current = 2A can come from (a) and score here

If say circuit resistance increases so current decreases and no other marks awarded score 1 mark

1
1
1

[10]

5. (a) Length of resistance wire = $50 \times 2 \times 3.14 \times 4 \times 10^{-3} = 1.26$ m ✓

or $50 \times 3.14 \times 8 \times 10^{-3}$

1

Substitution of data in resistance formula

or $A = \rho L/R$ seen ✓

ecf for incorrect length from attempt at a calculation

1

Area of cross section = $2.1(1) \times 10^{-9}$ (m^2) ✓

1

(b) Maximum possible pd across 0.25 kΩ is 9 V ✓

1

(Max power dissipated) = $9^2/250 = 0.32$ W so resistor is suitable ✓

1

OR

When resistor dissipates maximum power

$V^2 = 0.36 \times 250$ so max $V = 9.5$ V ✓

This is higher than the supply pd so this power dissipation so will not be reached ✓

OR

Power dissipated when output is 5 V = $4^2/250 = 0.064$ W ✓

Which is below the max power dissipation of 0.36 W ✓

$9^2/250 = 0.32$ W with incorrect conclusion scores 1

Second mark implies the first

$9^2/0.36 = 225\ \Omega$ alone is not a useful calculation in the context. Still need to explain the effect of using the 250 Ω

First mark is for a valid useful calculation

(c) Use of potential divider formula to determine resistance of parallel combination ✓

0.313 kΩ ✓

Use of equation for resistors in parallel ✓

540 Ω ✓

Alternative to find resistance of combination

Current in circuit at room temp = 4/250 = 16 mA ✓

Resistance of combination = 5/16mA = 313 Ω ✓

OR

$$\frac{V_{combination}}{V_{250}} = \frac{R_{combination}}{250}$$

$$\frac{5}{4} = \frac{R_{combination}}{250}$$

$R_{combination} = 313\ \Omega$

OR

Current in circuit at room temp = 4/250 = 16 mA ✓

Current in thermistor = 5/750 = 6.7 mA ✓

Current in R = 9.3 mA ✓

R = 5/9.3 = 540 Ω ✓

2sf answer ✓

(only allowed with some relevant working leading to a resistor value)

Max 5

(d) Resistance of <u>thermistor</u> decreases ✓

<u>Output pd decreases since</u>

resistance of the parallel combination /circuit decreases

1

OR

lower proportion of pd across the parallel combination (or higher proportion across 250Ω)

OR

higher current so greater pd across the 0.25 k resistor ✓

Accept correct consequences for R increasing with temperature for 1 mark

1

[12]

6. (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 $V = \dfrac{R_1 \times V_{tot}}{R_1 + R_2}$ ✓

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]