Revision – Electricity (Year 12) – Mark Scheme

1.

(a) (three parallel resistors) give $\frac{1}{40}+\frac{1}{20}+\frac{1}{40}=\frac{1}{R}$ ✓

$R = 10\ (\Omega)$ ✓

10 Ω and 50 Ω in series gives 60 Ω ✓

(allow e.c.f. from value of R) (3)

(b) ($V = IR$ gives) $12 = I \times 60$ and $I = 0.2$ A ✓

(allow e.c.f. from (a)) (1)

(4)

2.

(a) only 30 Ω in the circuit ✓

(use of $V = IR$ gives) $6 = I \times 30$ and $I = 0.20$ A ✓ (2)

(b) two resistors in parallel gives $\frac{1}{R}=\frac{1}{60}+\frac{1}{30}$ ✓

and $R = 20\ (\Omega)$ ✓

total resistance = 20 + 30 = 50 (Ω) ✓

(allow C.E. for value of R)

$I = \frac{6}{50} = 0.12$ A ✓ (allow C.E. for total resistance) (4)

(6)

3.

(a)(i) $P = \frac{V^2}{R}$ gives $40 = \frac{144}{R_T}$ ✓

$R_T = 3.6\ \Omega$ ✓

[or $P = VI$ to give $I = 3.3$ (A) ✓ and $R = P/I^2 = 3.7\ \Omega$ (3.67 Ω) ✓]

(ii) three resistors in parallel ✓

$\frac{1}{R_T}=\frac{1}{R}+\frac{1}{R}+\frac{1}{R}=\frac{3}{R}$ ✓

$R = 3.6 \times 3 = 10.8\ (\Omega)$ ✓ (5)

(allow C.E. for R_T from (i))

(b) (use of $R = \frac{\rho l}{A}$ gives) $10.8 = \frac{4.0\times10^{-5} l}{2.6\times10^{-3}\times1.1\times10^{-3}}$ ✓

$l = \frac{10.8\times2.6\times10^{-3}\times1.1\times10^{-3}}{4.0\times10^{-5}}$ ✓

= 0.77 m ✓ (allow C.E for R from(a)(ii)) (3)

(8)

4.

The list gives some quantities and units. *Underline* those which are base quantities of the International (SI) System of units.

coulomb force <u>length</u> mole newton <u>temperature interval</u>

(2 marks)

Define the volt.

Volt = Joule/Coulomb or Watt/Ampere

(2 marks)

Use your definition to express the volt in terms of base units.

Volt = J/C

= kg m^2 s^{-2}/A s

= kg m^2 s^{-3} A^{-1}

(3 marks)

Explain the difference between scalar and vector quantities

Vector has magnitude and direction

Scalar has magnitude only

(2 marks)

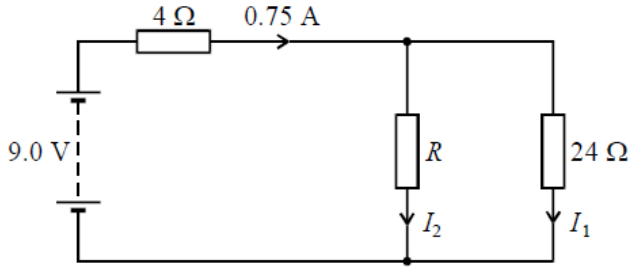
Is potential difference a scalar or vector quantity?

Scalar

(1 mark)

5.

The circuit shows a battery of negligible internal resistance connected to three resistors.



Calculate current I_1.

Voltage drop across 4Ω resistor = 3V (1)

I_2 = $\frac{(9\text{ V} - 3\text{ V})}{24\ \Omega}$ (1)

I_1 = 0.25 A (1)

(3 marks)

Calculate resistance R

I_2 = 0.75 A – 0.25 A = 0.50 A (1)

R = 6 V / 0.50 A = 12 Ω (1)

R = 12 Ω

(2 marks)

6.

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

symbols defined ✓

(ii) $R = \frac{\rho l}{A} = \frac{1.7 \times 10^{-8} \times 2}{\pi(0.4 \times 10^{-3})^2}$ ✓

$= 0.068\ (\Omega)$ ✓ (0.0676 Ω)

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

(allow e.c.f. from value of *R*) (5)

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

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

(iii) pd_{AC} = potential at A – potential at C ✓

$= (8 - 4) = 4\ \text{V}$ ✓

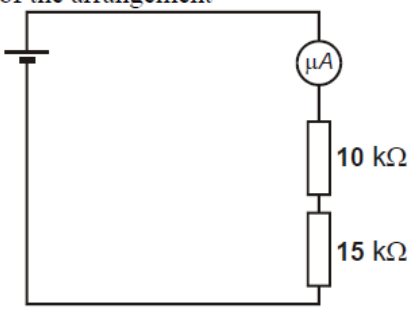
(allow e.c.f. from (i) and (ii)) (5)

(10)

7.

A cell of negligible internal resistance is connected in series with a microammeter of negligible resistance and two resistors of 10 kΩ and 15 kΩ. The current is 200 μA.

Draw a circuit diagram of the arrangement



(1 mark)

Calculate the e.m.f. of the cell.

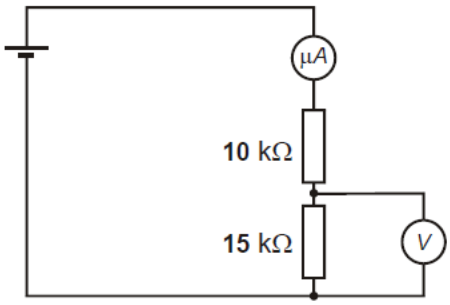
e.m.f. = (200 μA) × (2.5 kΩ)

= 5000 m(A Ω)

e.m.f. = 5.0 V

(2 marks)

Where a voltmeter is connected in parallel with the 15 kΩ resistor, the current in the microammeter increases to 250 μA. Sketch a diagram of the modified circuit.



(1 mark)

Calculate the resistance of the voltmeter.

Seris Resistance = 5.0 V / 250 μA = 20 kΩ

$$\frac{1}{R_V}+\frac{1}{15000}+\frac{1}{10000}$$

Resistance = R_v = 30 kΩ

(3 marks)

8.

(a)(i) energy provided by the battery ✓
per unit charge ✓
[or potential difference across battery ✓ when no current flows ✓]

(ii) when current flows, work is done inside the battery
to overcome the resistance (hence $V < \epsilon$) ✓
(or any correct alternative) *(3)*

(b)(i) suitable scale for I ✓
four correct points ✓ ✓
best straight line ✓

(ii) ($\epsilon = Ir + V$ gives) $V = -rI + \epsilon$ ✓
intercept = ϵ = 5 V ✓
gradient = (−)r ✓

$$= \frac{5}{0.35} = 14.(2)\ \Omega$$ ✓

(8)

(11)

9.

(a)(i) $\epsilon = I(R + r)$ ✓

(ii) $V_R = IR$ gives $V_R = \epsilon - Ir$ ✓ (2)

(b)(i) $P = VI$ gives $30 = 120\ I$ ✓
$I = 0.25$ A ✓

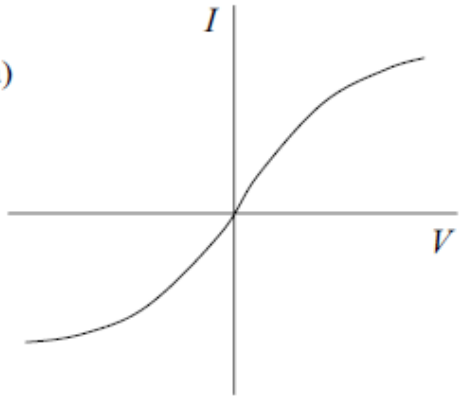
(ii) I through lamp = 0.25 (A) and p.d. across it = 240 V ✓
p.d. due to 1 cell = $1.5 - (0.25 \times 1.2) = 1.2$ (V) ✓
number of cells = $\frac{120}{1.2} = 100$ ✓
[or R_L given by $30 = 0.25^2 R_L$ and $R_L = 480\ (\Omega)$ ✓
$1.5n = 0.25(480 + 1.2n)$ ✓
$1.2n = 120$ and $n = 100$ ✓]

[or $\epsilon = V + Ir$ gives $1.5n = 120 + 0.25 \times 1.2n$ ✓ ✓
$n = 100$ ✓] (5)

(7)

10.

(a)



correct curve in positive quadrant ✓
correct curve in negative quadrant ✓
passing through origin ✓

(3)

(b) the current heats the filament ✓
(temperature rises) resistance increases ✓
pd. and current do not increase proportionally ✓
some reference to mirror image in negative quadrant ✓ max(3)

(c) diagram to show:
battery, variable resistance (or variable supply) and filament ✓
current sensor in series circuit ✓
voltage sensor across filament ✓
the two sensor boxes connected to datalogger ✓

method:
variable resistor or variable supply altered
[or choose recording interval] ✓
thus changing both V and I ✓ max(5)

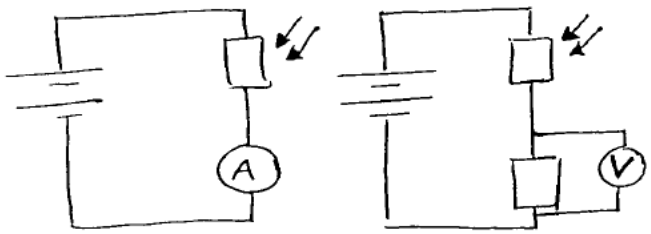
(11)

11.

A light-dependent resistor may be used with additional components to make a light meter. Sketch a diagram for a suitable circuit.

Examples

Examples



(–1) for each error in the diagram. Correct working circuit (2)

(2 marks)

Explain how your circuit works

R_L decreases with increasing incident light intensity (1)

Whence increase in A or V reading (1)

(2 marks)

12.

Define the term *resistivity*.

Either $\rho = \frac{RA}{l} or R = \frac{\rho l}{A}$ (1)

with symbols defined (1)

(2 marks)

The resistivity of copper is $1.7 \times 10^{-8}\ \Omega$ m. A copper wire is 0.6 m long and has a cross-sectional area of 1mm^2. Calculate its resistance.

Resistance = ($1.7 \times 10^{-8}\ \Omega$m) (1) $\frac{(0.6\ \text{m})}{1\times10^{-6}\ \text{m}^2}$ **(1)**

Resistance =10.2 mΩ (1)

(3 marks)

Two such wires as used to connect a lamp to a power supply of negligible internal resistance. The potential difference across the lamp is 12 V and its power is 36 W. Calculate the potential difference across each wire.

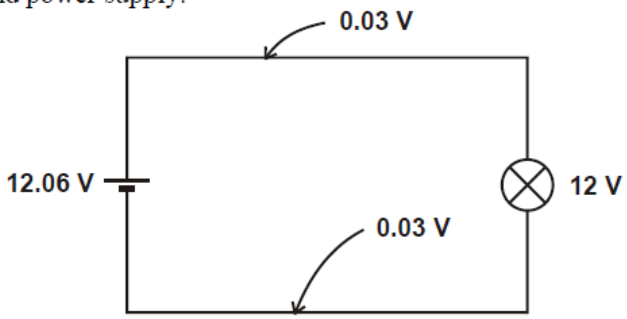
Current = 36 W/12 V = 3 (A) (1)

P.d = (3 A) × ($10.2 \times 10^{-3}\ \Omega$) (1)

Potential difference = 30.6 mV (1)

(3 marks)

Draw a circuit diagram of the above arrangement. Label the potential differences across the wires, lamp and power supply.



lamp (1)

both wires (1)

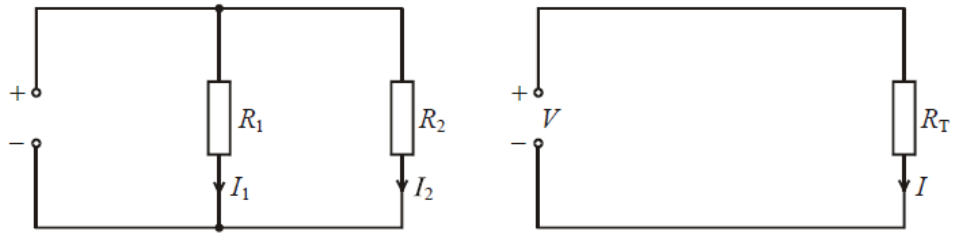
cell (1)

(Allow 12 V cell and 11.94 V across lamp)

(3 marks)

13.

The power supplies in the two circuits shown below are identical.



Write down the relationship between I_1, I_2 and I which must hold if the combined resistance of the parallel pair, R_1, and R_2, is to equal R_T.

$I = I_1 + I_2$

(1 mark)

Hence derive the formula for the equivalent resistance of two resistors connected in parallel.

From Ohm's law:

$I = V/R_T$ $I_1 = V/R_1$ $I_2 = V/R_2$ (1)

$\therefore V/R_T = V/R_1 + V/R_2$ (1)

and $1/R_T = 1/R_1 + 1/R_2$ (1)

(3 marks)

Use your formula to show that the resistance between the terminals of a low-resistance component is hardly changed when a high-resistance voltmeter is connected in parallel with it.

If $R_v >> R_{low}$ then $1/R_v >> 1/R_{low}$ (1)

and $R_T \approx R_{low}$ (1)

Allow method based on numerical example

(2 marks)
