A-Level Physics

Basics of Electricity

Mark Scheme

Time available: 59 minutes
Marks available: 49 marks

1. (a) **Method 1:**

Attempts to determine area under curve / by counting squares $_1$✓

Multiplies their (total) area (or charge) by 24 (V) $_2$✓

240 (J) $_3$✓

Allow POT error on area of square in $_1$✓ and $_2$✓

*Evidence seen by calculations **or** from counting squares **or** from division of area into **at least two** recognisable geometrical shapes (triangles, rectangles, trapezia)*

answer in range 220 J to 264 J

Method 2:

Attempt to determine average current (over first 200 ms in range 45 A to 55 A) $_1$✓

Use of $E = I \times V \times t$ $_2$✓

240 (J) $_3$✓

Substitutes current value (or Δ current) with t = 200 ms and V = 24 V. Condone POT

Allow as two stage Q=It and E=QV

*Or $P = VI$ **and** $E = Pt$*

answer in range 220 J to 264 J

3

(b) (KE (gained) =) 65(.0) (J) **or**

(PE (gained) =) 58(.3) (J) $_1$✓

Use of efficiency = $\frac{\text{an output energy}}{\text{ans from part 04.1}}$

Allow output energy = 65 /58/ 120 /123 or candidate ke + pe

or (total output = 65 + 58 =) 123 (J) $_2$✓

Allow ecf from (a) for all 3 marks.

(Efficiency =) 0.51 or 51% $_3$✓

Answer to at least 2 sf. Range is 0.467 to 0.56 (46.7 % to 56 %)

3

(c) Heating occurs / temperature increases when there is a current (in the thermistor) (due to I^2R) $_1$✓

(When the temperature increases) the resistance of thermistor decreases (whereas fixed resistor remains high) $_2$✓

(Lower resistance from thermistor means) less wasted power $_3$✓

OR

(Lower resistance from thermistor means) more pd dropped across the motor (less wasted voltage) $_3$✓

Alternatively: (Lower resistance from the thermistor means) less voltage drop across thermistor $_3$✓

3

[9]

2. (a) The current through a conductor between two points is directly proportional to the potential difference across the two points

(provided the temperature remains constant) ✓

Or ratio of voltage / current is constant

1

(b) 75 (mA) ✓

1

(c) ***MAX 4***

voltmeter position is incorrect because it is across the cell✓

voltmeter should be connected across the putty✓

the 10 Ω resistor is not suitable to control the current✓

because its resistance is only half that of the putty✓

pd range is 1.0 to 1.5 V, this is insufficient for experiment✓

MAX 4

(d) Substitution of $V = A \times l$ into $\rho = \frac{R \times A}{l}$ ✓

(leading to $\rho = \frac{RV}{l^2}$)

Complete argument needed

1

(e) $V = 60 \times 10^{-3} \times \pi \times (10 \times 10^{-3})^2$

$(= 1.88 \times 10^{-5}\ m^3)$ ✓

$\rho = 20 \times 1.88 \times 10^{-5} / (60 \times 10^{-3})^2$

= 0.10 ✓Ωm ✓

Will not gain this mark only if POT error correctly followed through.
Stand alone unit mark

3

[10]

3.

(a) $I_3 = I_1 + I_2$ ✓

1

(b) 10 V ✓

1

(c) $I_2 = (12 - 10) / 10$ ✓

Allow ce for 10 V

1

= 0.2 A ✓

The first mark is for the pd
The second is for the final answer

1

(d) pd across R_2 increases

As R_1 increases, pd across R_1 increases as pd = $I_1 R_1$ ✓

First mark is for identifying that pd across R_1 increases (from zero).

1

pd across R_3 = 10 V – pd across R_1

Therefore pd across R_3 decreases ✓

Second mark is for identifying that pd across R_3 must decrease

1

pd across R_2 = 12 – pd across R_3

Therefore pd across R_2 increases ✓

Third mark is for identifying that this means pd across R2 must increase

1

[7]

4.

(a) Correct substitution into P=VI
1.74 (A)

2

(b) (i) Correct substitution into $R=V/I$ or V^2/P or P/I^2
264 (Ω)

Allow correct use of parallel resistor equation

2

(ii) Use of $1/R_T = 1/R_1 + 1/R_2$ or $R = V^2/P$
65 (66.1) (Ω)

2

(iii) $A = \pi(1.5 \times 10^{-4})^2/4$ or $\pi(7.5 \times 10^{-5})^2$ or 1.767×10^{-8} (m^2)
Substitution into $l=RA/\rho$ with their area
4.2 (4.18) (m)

2 marks for 17 (m), using of d instead of r

3

(c) Resistivity / resistance increases with increasing temperature
(Lattice) ions vibrate with greater amplitude
Rate of movement of charge carriers / electrons (along wire) reduced (for given pd)

ORA

Condone atoms for ions.

Accept "vibrate more".

Accept more frequent collisions occur between electrons and ions owtte

3

(d) $2.9 \times 10^{-3}/447$ or $2.9 \times 10^{-3}/174$ seen
$6.5 (6.49) \times 10^{-6}$ (m)
Correct answer given to 2 sig fig

Condone use of 174 for T for C1 and B1 marks

Allow 3 sig fig answer if 2.90×10^{-3} used

3

[15]

5. (a) emf is the work done / energy transferred by a voltage source / battery / cell ✓per <u>unit</u> charge✓
OR
electrical energy transferred / converted / delivered / produced✓
per <u>unit</u> charge✓
OR
pd across terminals when no current flowing / open circuit✓✓

not <u>in</u> battery

accept word equation OR symbol equation with symbols defined if done then must explain energy / work in equation for first mark

2

(b) (i) by altering the (variable) <u>resistor</u>✓

1

(ii) reference to correct internal resistance✓

e.g. resistance of potato (cell)

terminal pd = emf – pd across internal resistance / lost volts✓

pd / lost volts increases as current increases OR as (variable) resistance decreases greater proportion / share of emf across internal resistance✓

accept voltage for pd

3

(iii) draws best fit straight line and attempts to use gradient✓

uses triangle with base at least 6 cm✓

value in range 2600 – 2800 (Ω)✓

3

stand-alone last mark

(c) total emf is above 1.6 V✓

but will not work as current not high enough / less than 20 mA✓

2

[11]