**Resistivity AQA booklet Name:**

**Q1.**          The wire in an electric heater has a resistance of 75 Ω. It is 9.5 m long and has a cross-sectional area of 1.4 × 10–7 m2.  
Calculate the resistivity of the material from which the wire is made.  
Give an appropriate unit for your answer.

resistivity ...........................................

**(Total 3 marks)**

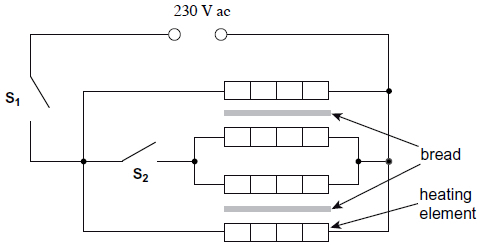
**Q2.**A cylindrical conductor of length *l*, diameter *D*, and resistivity *ρ* has a resistance *R*.

What is the resistance of another cylindrical conductor of length *l*, diameter  , and resistivity *ρ*?

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| --- | --- | --- | --- |
|  | **A** | 8*R* |  |
|  | **B** | 4*R* |  |
|  | **C** | 2*R* |  |
|  | **D** | *R* |  |

**(Total 1 mark)**

**Q4.**The diagram shows the circuit diagram for a two-slice electric toaster that is operated at a mains voltage of 230 V.



The toaster has four identical heating elements and has two settings: normal and low. On the normal setting both sides of the bread are toasted. On the low setting, only one side of the bread is toasted. The setting is controlled by switches **S1** and **S2**.

The table shows the position of each switch and the power for each setting.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Setting** | **S1** | **S2** | **Power / W** |
|  | Low | closed | open | 400 |
|  | Normal | closed | closed | 800 |

(a)     Calculate the current in **S2** when the normal setting is selected.

current ........................... A

**(2)**

(b)     (i)      Show that the resistance of **one** heating element is approximately 260 Ω when the toaster is operating at its working temperature.

**(2)**

(ii)     Calculate the total resistance when the normal setting is selected.

resistance ........................... Ω

**(2)**

(iii)     Each heating element is made of nichrome wire of diameter 0.15 mm.

The nichrome wire is wrapped around an insulating board.

Determine the length of nichrome wire needed to provide a resistance of 260 Ω.

resistivity of nichrome at the working temperature = 1.1 × 10−6 Ω m

length of wire ........................... m

**(3)**

(c)     Explain why the resistivity of the nichrome wire changes with temperature.

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**(3)**

**(Total 15 marks)**

**Q5.**          (a)     A metal wire of length 1.4 m has a uniform cross-sectional area = 7.8 × 10–7 m2. Calculate the resistance, *R*, of the wire.  
resistivity of the metal = 1.7 × 10–8 Ωm

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**(2)**

(b)     The wire is now stretched to twice its original length by a process that keeps its volume constant. If the resistivity of the metal of the wire remains constant, show that the resistance increases to 4*R*.

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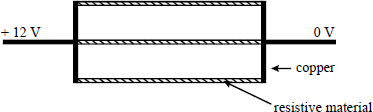
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**(2)**

**(Total 4 marks)**

**Q7.**A heating element, as used on the rear window of a car, consists of three strips of a resistive material, joined, as shown in the diagram, by strips of copper of negligible resistance. The voltage applied to the unit is 12 V and heat is generated at a rate of 40 W.



(a)     (i)      Calculate the total resistance of the element.

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(ii)     Hence show that the resistance of a single strip is about 11 Ω.

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**(5)**

(b)     If each strip is 2.6 mm wide and 1.1 mm thick, determine the length of each strip.

              resistivity of the resistive material = 4.0 × 10–5 Ω m

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**(3)**

**(Total 8 marks)**

**Q8.**          (a)     For a conductor in the form of a wire of uniform cross-sectional area, give an equation which relates its resistance to the resistivity of the material of the conductor. Define the symbols used in the equation.

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**(2)**

(b)     (i)      An electrical heating element, made from uniform nichrome wire, is required to dissipate 500 W when connected to the 230 V mains supply.   
The cross-sectional area of the wire is 8.0 × 10–8 m2. Calculate the length of   
nichrome wire required.

resistivity of nichrome = 1.1 × 10–6 Ω m

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(ii)     Two heating elements, each rated at 230 V, 500 W are connected to the 230 mains supply

(A) in series,   
(B) in parallel.

Explain why only one of the circuits will provide an output of 1 kW.

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**(6)**

**(Total 8 marks)**

**Q9.**(a)     (i)      Give the equation which relates the *electrical resistivity* of a conducting material to its *resistance*. Define the symbols in the equation.

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(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 × 10–8 Ω m

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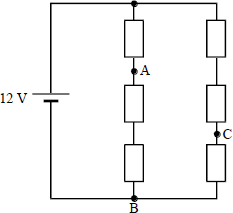
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**(5)**

(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.

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

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

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**(5)**

**(Total 10 marks)**

**Q11.**(a)     A sample of conducting putty is rolled into a cylinder which is 6.0 × 10–2 m long and has a radius of 1.2 × 10–2 m.

         resistivity of the putty = 4.0 × 10–3 Ωm.

Calculate the resistance between the ends of the cylinder of conducting putty.  
Your answer should be given to an appropriate number of significant figures.

answer = ...................................... Ω

**(4)**

(b)     Given the original cylinder of the conducting putty described in part (a), describe how you would use a voltmeter, ammeter and other standard laboratory equipment to determine a value for the resistivity of the putty.

Your description should include

•        a labelled circuit diagram,

•        details of the measurements you would make,

•        an account of how you would use your measurements to determine the result,

•        details of how to improve the precision of your measurements.

The quality of your written communication will be assessed in this question.

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**(8)**

**(Total 12 marks)**

**Resistivity and superconductivity AQA booklet 1 – Mark Scheme**

**M1.**          correct substitution of data in resistivity formula C1

          1.1(1) × 10–6 **(1)**           Ωm **(1)**

**[3]**

**M2.**B

**[1]**

**M4.**(a)     Correct substitution into P=VI 1.74 (A)

**2**

(b)     (i)      Correct substitution into R=V/I or V2/P or P/I2 264 (Ω)

*Allow correct use of parallel resistor equation*

**2**

(ii)     Use of 1/RT = 1/R1 + 1/R2 or R = V2/P 65 (66.1) (Ω)

**2**

(iii)     A = *π*(1.5 × 10−4)2/4 or *π*(7.5 × 10–5)2 or 1.767 × 10−8 (m2)

Substitution into l=RA/*ρ* 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 × 10−3/447 or 2.9 × 10−3/174 seen

6.5 (6.49) × 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]**

**M5.**          (a)     *R* =  **(1) ** = 0.031 Ω **(1)** (0.0305 Ω)

**2**

(b)     constant volume gives *l1A1 = l2A2* [or *l2* = 2*l1* and *A*2 *=* *A*1/2] **(1)**

*R* =  =*4R* **(1)** [or calculation with *l2* = 2.8 (m) and *A*2 = 3.9 (m2) **(1)**]

gives *R* = 0.124 Ω **(1)**]

**2**

**[4]**

**M7.**(a)     (i)      *P* =  gives 40  **(1)** *RT* = 3.6 Ω **(1)**   
[or *P* = *VI* to give *I* = 3.3 (A) **(1)** and *R* = *P* / *I*2 = 3.7 Ω (3.67 Ω) **(1)**]

(ii)     three resistors in parallel **(1) **

*R* = 3.6 × 3 = 10.8 (Ω) (1)                          (allow C.E. for *RT* from (i))

**5**

(b)     (use of *R* =  = gives) 10.8 =  **(1)**

*l* =  **(1)** = 0.77 m **(1)**    (allow C.E for *R* from (a)(ii)

**3**

**[8]**

**M8.**          (a)     R =  **(1)**

*ρ* is resistivity, *l* is the length of the wire, *A* is the cross-sectional area **(1)**

**2**

(b)     (i)      *P* =  **(1)** *R* =  = 106(Ω)**(1)** (105.8 Ω)

*l* =  =  = 7.7 m **(1)** (7.69 m)

(allow C.E. for incorrect value of *R* )

(ii)     in series, voltage across each < 230 V or pd shared **(1)**

****power (= *V*2/*R*) is less than 500 W in each **(1)**

in parallel, voltage across each = 230 V **(1)**

****correct rating, conclusion **(1)**

[or, in series, high resistance or combined resistance **(1)**

****low current **(1)**

in parallel, resistance is lower, higher current **(1)**

more power, justified **(1)**]

**max 6**

**[8]**

**M9.**(a)     (i)      resistivity defined by *ρ* =  **(1)** symbols defined 

(ii)      = 0.068 (Ω) **(1)**      (0.0676 Ω)

*I* =  = 22 A **(1)**      (22.2 A)          (allow e.c.f. from value of *R*)

**(5)**

(b)     (i)      pdAB =  × 12 = 8 V **(1) (1)**

(ii)     pdBC = ( × 12) = 4 V **(1)**

(iii)    pdAC = potential at A – potential at C **(1)**       = (8 – 4) = 4 V **(1)**(allow e.c.f. from (i) and (ii))

**(5)**

**[10]**

**M11.**(a)           (use of *R* = *ρl*/*A*) *R* = 4.0 × 10–3 × 0.060 **(1)**/(π × 0.0122) **(1)**

*R* = 0.53 (Ω) **(1)** 2 significant figures **(1)**

**4**

(b)     the mark scheme for this part of the question includes an overall  
assessment for the Quality of Written Communication

circuit must include:

voltmeter and ammeter connected correctly **(1)**

power supply with means of varying current **(1)**

**2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **QWC** | **descriptor** | **mark range** |
|  | good-excellent | (i)    Uses accurately appropriate grammar, spelling, punctuation and legibility.  (ii)    Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [may include bullet points and/or formulae or equations]  An excellent candidate will have a working circuit diagram with correct description of measurements (including range of results) and processing. An excellent candidate uses a range of results and finds a mean value or uses a graphical method, eg *I*-*V* characteristics. They also mention precision eg use of vernier callipers. | **5**-**6** |
|  | modest- adequate | (i)    Only a few errors.  (ii)   Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples.  An adequate candidate will have a working circuit and a description with only a few errors, eg do not consider precision. They have not taken a range of results and fail to realise that the diameter needs to be measured in several places. | **3**-**4** |
|  | poor- limited | (i)    Several significant errors.  (ii)    Answer lacking structure, arguments not supported by evidence and contains limited information.  Several significant errors, eg important measurement missed, incorrect circuit, no awareness of how to calculate resistivity. | **1**-**2** |
|  | incorrect, inappropriate or no response |  | **0** |

The explanation expected in a good answer should include a coherent  
account of the procedure and include most of the following points.

•        length with a ruler

•        thickness/diameter with vernier callipers/micrometer

•        measure voltage

•        measure current

•        calculate resistance

•        use of graph, eg *I*-*V* or resistance against length

•        use of diameter to calculate cross-sectional area

•        mention of precision, eg vernier callipers or full scale readings  
for V and I

•        flat metal electrodes at each end to improve connection

**6**

**[12]**