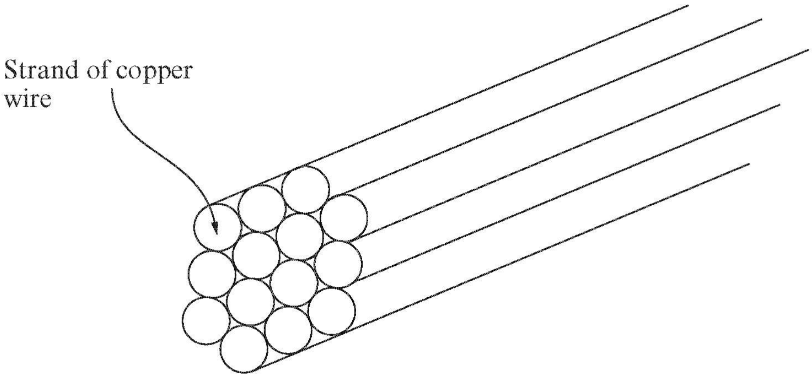
1.

(a) Starting from a relevant equation, show that the unit of resistivity is Ω m. [2]

(b) A cable consists of 14 strands of copper wire, each of **diameter** 1.3 mm.



(i) Show that the cross-sectional area of **one** strand of the copper wire is approximately 1.3×10^{-6} m^2. [1]

(ii) Hence calculate the resistance of one strand of length 20.0m. [1]
[Resistivity of copper = 1.7×10^{-8} Ω m].

(iii) Determine the combined resistance of the 14 strand cable. [2]

(iv) Showing your working clearly, calculate the ratio:

$$\frac{\text{Energy dissipated in one second in a } \textbf{single strand} \text{ carrying a current of } 3.0\,\text{A}}{\text{Energy dissipated in one second in the } \textbf{whole cable} \text{ carrying a current of } 3.0\,\text{A}}$$ [3]

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(v) Give an advantage of the 14 strand copper cable over

(I) a single strand copper cable of 1.3 mm diameter, [1]

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(II) a solid core cable of the same total cross-sectional area. [1]

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(iv) Showing your working clearly, calculate the ratio:

$$\frac{\text{Energy dissipated in one second in a } \textbf{single strand} \text{ carrying a current of } 3.0\,\text{A}}{\text{Energy dissipated in one second in the } \textbf{whole cable} \text{ carrying a current of } 3.0\,\text{A}}$$ [3]

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(v) Give an advantage of the 14 strand copper cable over

(I) a single strand copper cable of 1.3mm diameter, [1]

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(II) a solid core cable of the same total cross-sectional area. [1]

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2. *(a)* (i) The current in a wire depends on its **resistance**. Explain, in terms of free electrons, how this resistance arises when a potential difference is applied across the wire. [2]

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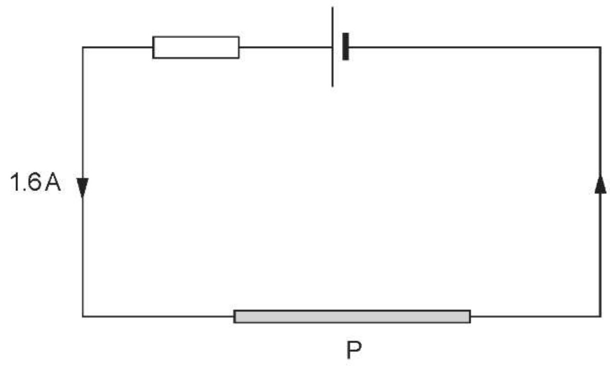
(ii) The wire (labelled P in the diagram) is connected to a fixed voltage source and a resistor to limit the current as shown. The wire is 0.4 m long and has a cross-sectional area of $2.0 \times 10^{-6}\,m^2$. When the current is 1.6 A it dissipates 1.8 J of energy in 1 minute. Calculate its resistivity. [4]



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(b) (i) The current, I, in a wire of cross-sectional area, A, is given by the formula:

$$I = nAve$$

Derive the formula. You may include a clearly labelled diagram. [4]

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(ii) Calculate the drift velocity of the free electrons in the wire in *(a)*(ii) when the current through it is 1.6 A. [$n = 6.4 \times 10^{28}\,\text{m}^{-3}$] [2]

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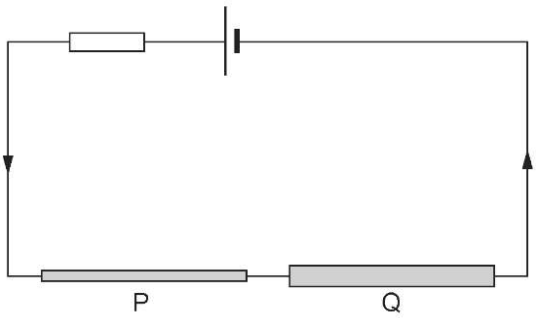
(iii) Wire P is now connected to another wire, Q, of the same material but with **twice** the cross-sectional area. The wires are connected to the same fixed voltage source and resistor.



Complete the following sentences by **circling the correct option** given in brackets.

(I) The current in the circuit containing both wires is **[less than 1.6 A] [equal to 1.6 A] [more than 1.6 A]**. [1]

(II) The current in P is **[less than] [the same as] [greater than]** the current in Q. [1]

(III) The electron drift velocity in Q is **[half] [the same as] [twice] [four times]** the electron drift velocity in P. [1]

3. *(a)* (i) State Ohm's law. [2]

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(ii) What can be said about the resistance of a conductor that obeys Ohm's law? [1]

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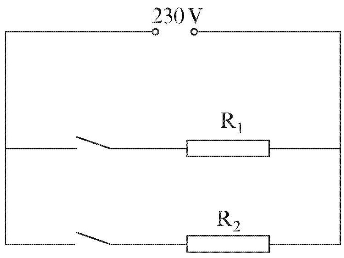
(b) The heating circuit of a hairdryer consists of two heating elements R_1 and R_2 connected in parallel as shown. The elements are made from wire of the same material of resistivity $95 \times 10^{-8}\,\Omega\text{m}$ and diameter $1.4 \times 10^{-4}\text{m}$.



(i) The length of wire used to make R_1 is 3.2 m. Show that the resistance of R_1 is approximately 200 Ω. [3]

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(ii) Calculate the power output from the heating circuit with only R_1 switched on. [1]

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(iii) With both elements switched on the **total resistance** is only a third of the resistance of R_1 on its own. Calculate the resistance of R_2. [3]

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(iv) Explain which element, R_1 **or** R_2, would provide the greater power output from the heating circuit. [2]

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(v) Calculate the total current with both elements switched on. [1]

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5. *(a)* (i) Draw a **labelled** diagram of the apparatus you would use to determine the relationship between the resistance and length of a metal wire. [3]

(ii) Sketch a graph of your expected results. [1]

(iii) Explain how you would use an accurately drawn graph of resistance against length, as well as any other measurements, to obtain a value for the *resistivity* of the metal in the wire. [3]

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(b) (i) A simple heater is made of a metallic wire of resistivity $48 \times 10^{-8}\,\Omega\text{m}$ and cross-sectional area $4.0 \times 10^{-8}\,\text{m}^2$. When it is in use the potential difference across the heater is 12.0V and its power is 32W. Calculate the length of the wire in the heater. [3]

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(ii) Calculate the drift velocity of the electrons in the wire when the heater is in use. [The number of free electrons per unit volume is $3.4 \times 10^{28}\,\text{m}^{-3}$ for the material in the wire.] [3]

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5. A power cable has a resistance of $11.2\,\Omega$ and is made of an alloy of aluminium of resistivity $2.8 \times 10^{-8}\,\Omega\,m$. It is used to link a power station to a town 160 km away.

(a) (i) Show that the cross-sectional area of the cable is $4.0 \times 10^{-4}\,m^2$. [1]

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(ii) Calculate the current in the cable given that the pd across it is 2.0 kV. [1]

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(iii) Calculate the mean drift velocity of the free electrons in the cable given that there are 6.0×10^{28} atoms per m^3 of aluminium and each atom contributes 3 free electrons. [3]

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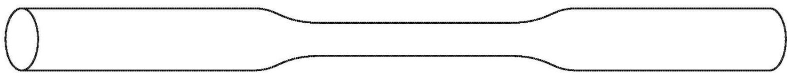
(b) A small portion of the cable is damaged. As a result its cross-sectional area is less than that of the rest of the cable, as shown in the diagram.



(i) State how the current in the thinner portion compares with the current in the rest of the cable. [1]

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(ii) State how the mean drift velocity of free electrons in the thinner portion compares with that in the rest of the cable. Justify your answer. [2]

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(iii) Hence suggest, in terms of particles, why the damaged part of the cable will be prone to overheating. [2]

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