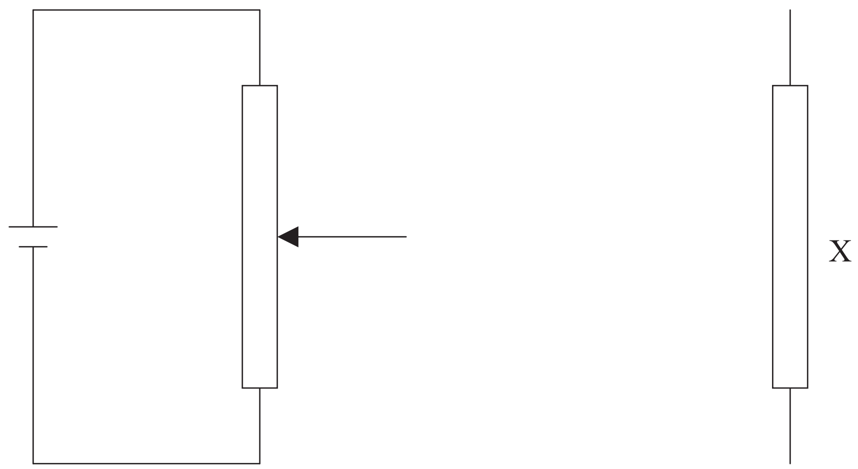
A3. (a) Draw the complete diagram of the circuit that uses a potential divider, ammeter, voltmeter and cell to measure the current-voltage characteristics for component X. *[3]*



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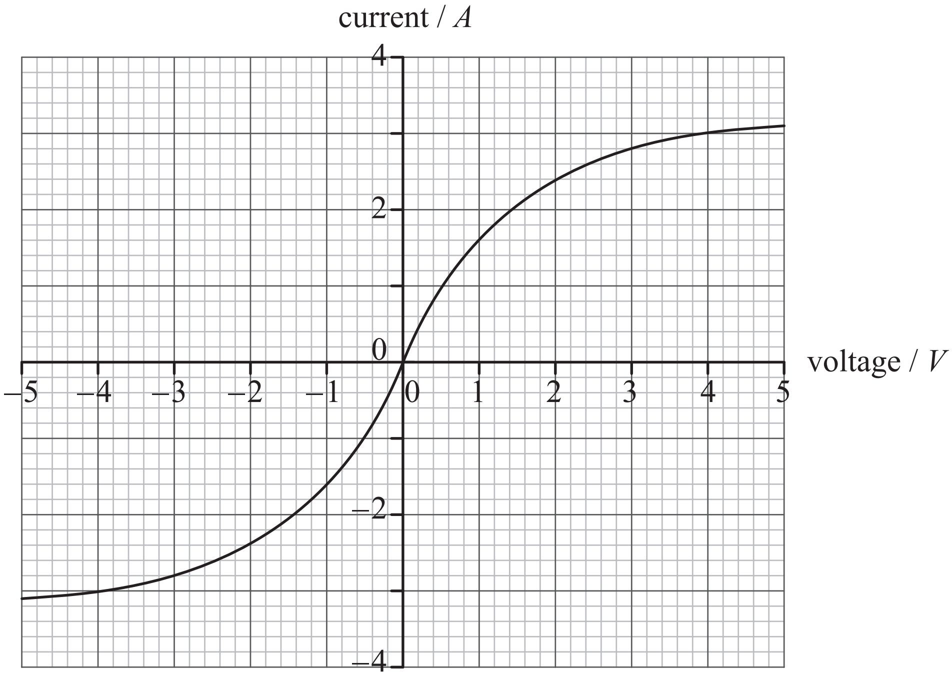
(Question A3 continued)

(b) The graph shows the current-voltage characteristics for the component X.



Component X is now connected across the terminals of a cell of emf 2.0 V and negligible internal resistance. Use the graph to show that the resistance of X is 0.83 Ω. *[2]*

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(c) A resistor of constant resistance 1.0 Ω is connected in series with the cell in (b) and with X. Use the graph to deduce that the current in the circuit is 1.3 A. *[3]*

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(Question B2 continued)

Part 2 Electrical resistance and electric circuits

(a) Define *resistance* and state Ohm's law. *[2]*

Resistance: . . . .

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Ohm's law: . . . .

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(b) A resistor made from a metal oxide has a resistance of 1.5 Ω. The resistor is in the form of a cylinder of length 2.2×10^{-2} m and radius 1.2×10^{-3} m. Calculate the resistivity of the metal oxide. *[2]*

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(c) The manufacturer of the resistor in (b) guarantees its resistance to be within ±10% of 1.5 Ω provided the power dissipation in the resistor does not exceed 1.0 W. Calculate the maximum current in the resistor for the power dissipation to be equal to 1.0 W. *[2]*

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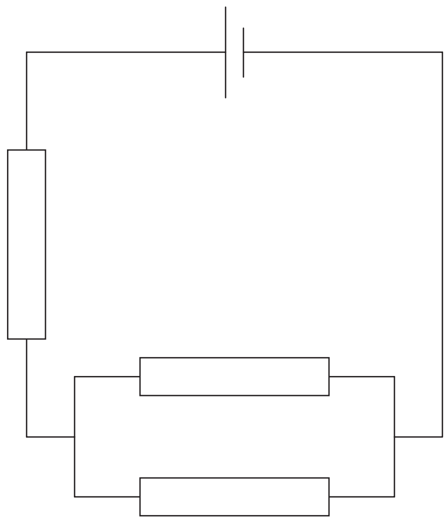
(Question B2, part 2 continued)

(d) The resistance of each of the resistors in the circuit below is measured to be 1.5 Ω with an accuracy of ±10 %.



The cell has an emf of 2.0 V and negligible internal resistance.

(i) Define *emf*. *[1]*

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(ii) Determine the minimum and the maximum power that could be dissipated in this circuit. *[3]*

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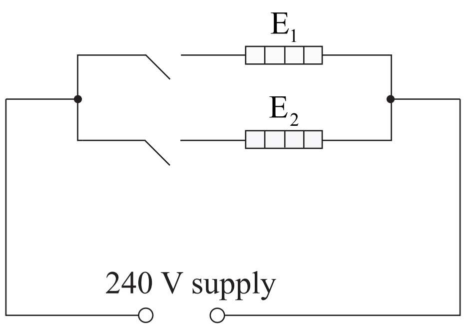
B3. This question is in **two** parts. **Part 1** is about an electrical heater. **Part 2** is about heating a liquid.

Part 1 Electrical heater

An electrical heater consists of two heating elements E_1 and E_2. The elements are connected in parallel. Each element has a switch and is connected to a supply of emf 240 V. The supply has negligible internal resistance.



Element E_1 is made from wire that has a cross-sectional area of $6.8\times10^{-8}\,m^2$. The resistivity of the wire at the operating temperature of the element is $1.1\times10^{-6}\,\Omega\,m$.

(a) (i) The total length of wire is 4.5 m. Show that the resistance of E_1 is 73 Ω. *[1]*

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(ii) Calculate the power output of E_1 with only this element connected to the supply. *[2]*

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(iii) Element E_2 is made of wire of the same cross-section and material as E_1. The length of wire used to make E_2 is 1.5 m. Determine the total power output when both E_1 and E_2 are connected to the supply. *[3]*

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(This question continues on the following page)

(Question B3, part 1 continued)

(iv) With reference to the power output, explain why it would be inappropriate to connect the heating elements in series. *[3]*

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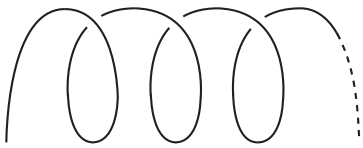
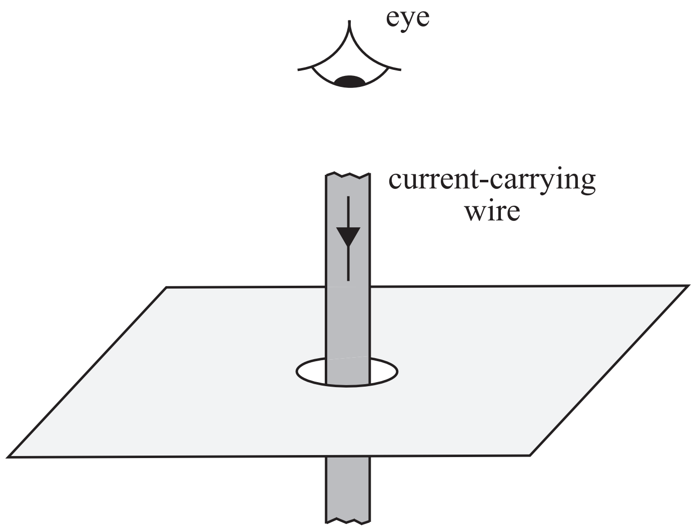
(b) Each element in the electrical heater is wound as a coil as shown.



Each turn of the coil may be considered to act as a current-carrying long straight wire.

(i) On the diagram, draw the magnetic field around a current-carrying long straight wire. The arrow shows the direction of the current. *[3]*



(ii) State **and** explain whether the turns of wire will attract or repel one another. *[3]*

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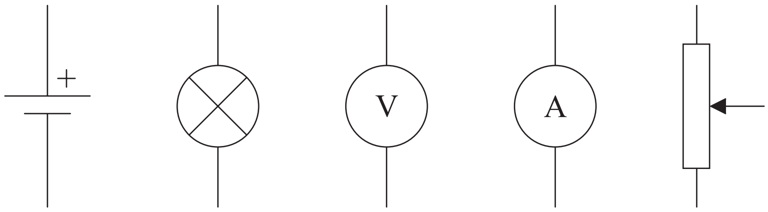
(This question continues on the following page)

(Question B2 continued)

Part 2 Electric circuits

The components shown below are to be connected in a circuit to investigate how the current *I* in a tungsten filament lamp varies with the potential difference *V* across it.

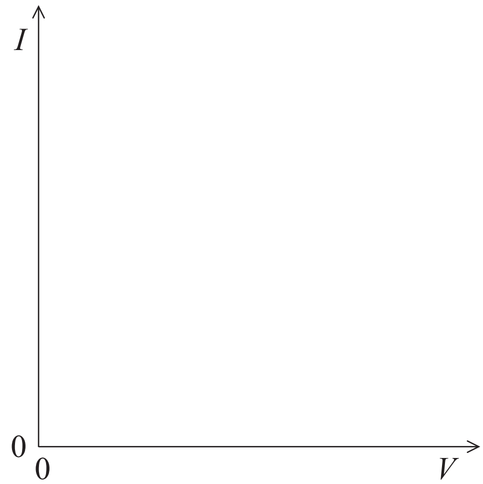


(a) Construct a circuit diagram to show how these components should be connected together in order to obtain as large a range as possible for values of potential difference across the lamp. *[4]*

(This question continues on the following page)

(Question B2, part 2 continued)

(b) On the axes, sketch a graph of I against V for a filament lamp in the range $V=0$ to its normal working voltage. *[2]*



(c) The lamp is marked with the symbols "1.25 V, 300 mW". Calculate the current in the filament when it is working normally. *[1]*

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(d) The resistivity of tungsten at the lamp's working temperature is $4\times10^{-7}\ \Omega\,\text{m}$. The total length of the tungsten filament is 0.80 m. Estimate the radius of the filament. *[4]*

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(e) The cell is connected to two identical lamps connected in parallel. The lamps are rated at 1.25 V, 300 mW. The cell has an emf of 1.5 V and an internal resistance of 1.2 Ω. Determine whether the lamps will light normally. *[4]*

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A2. This question is about electrical resistance.

(a) A heating coil is to be made of wire of diameter 3.5×10^{-4} m. The heater is to dissipate 980 W when connected to a 230 V d.c. supply. The material of the wire has resistivity $1.3 \times 10^{-6}\,\Omega$ m at the working temperature of the heater.

(i) Define *electrical resistance*. *[1]*

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(ii) Calculate the resistance of the heating coil at its normal working temperature. *[2]*

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(iii) Show that the length of wire needed to make the heating coil is approximately 4 m. *[2]*

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(This question continues on the following page)