# A-Level Physics

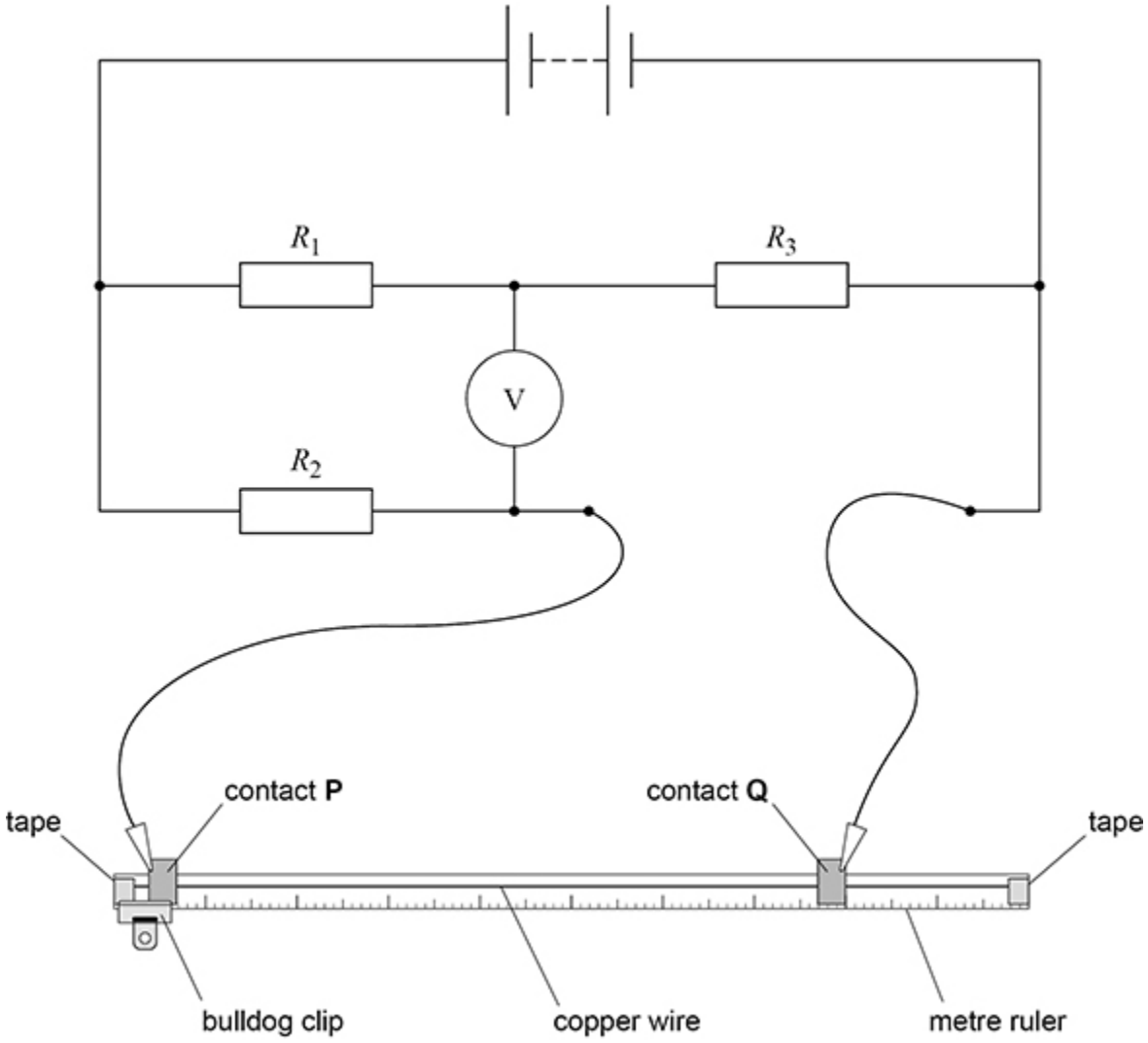
## Resistivity

## Question Paper

**Time available: 74 minutes**
**Marks available: 55 marks**

**1.** **Figure 1** shows a circuit used to find the resistance per unit length of a copper wire.

**Figure 1**

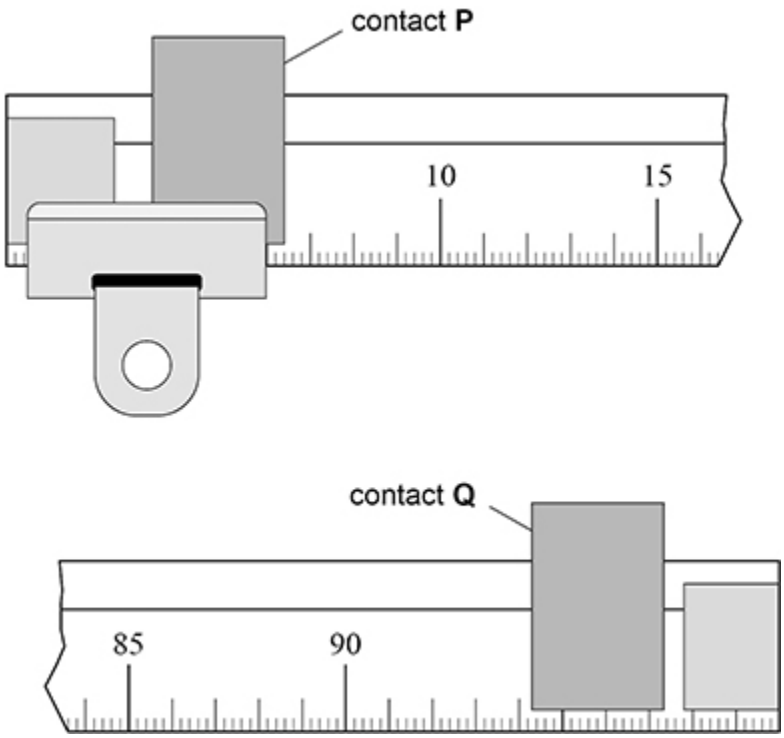



The copper wire is fixed with tape to a metre ruler that has $2\ \text{mm}$ graduations.
Contact **P** is placed on the wire close to one end of the ruler and held firmly in place using a bulldog clip.
When contact **Q** is placed on the wire as shown in **Figure 1** the voltmeter shows a non-zero reading.

**Q** is moved along the wire until the voltmeter reading is zero.

**Figure 2** shows enlarged views of the position of **P** and the new position of **Q**.

**Figure 2**




(a) Determine, in m, the length $x$ of copper wire between **P** and **Q**.

$x$ = _____ m

**(1)**

(b) When the voltmeter reading is zero:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

where $R_4$ is the resistance of the copper wire between **P** and **Q**.

Determine, in $\Omega\ \text{m}^{-1}$, the resistance per unit length of the copper wire.

$R_1 = 2.2\ \text{M}\Omega$
$R_2 = 3.9\ \text{k}\Omega$
$R_3 = 75\ \Omega$

resistance per unit length = _____ $\Omega\ \text{m}^{-1}$

**(2)**

(c) The diameter $d$ of the copper wire is approximately $0.4\ \text{mm}$.

Suggest:

- a suitable measuring instrument to accurately determine $d$
- how to reduce the effect of random error on the result for $d$.

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**(3)**

(d) Determine the resistivity $\rho$ of copper.

diameter $d$ of the copper wire = $0.38\ \text{mm}$

$\rho$ = _____ $\Omega\ \text{m}$

**(2)**

The copper wire is replaced with a constantan wire of diameter $0.38\ \text{mm}$.

$$\frac{\text{resistivity of constantan}}{\text{resistivity of copper}} = 30$$

(e) Suggest **one** change to the circuit to make the voltmeter read zero for the same value of $x$ as in part (a).

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**(1)**

(f) Calculate, in $\text{mm}$, the diameter of a constantan wire that has the **same** resistance per unit length as the copper wire.

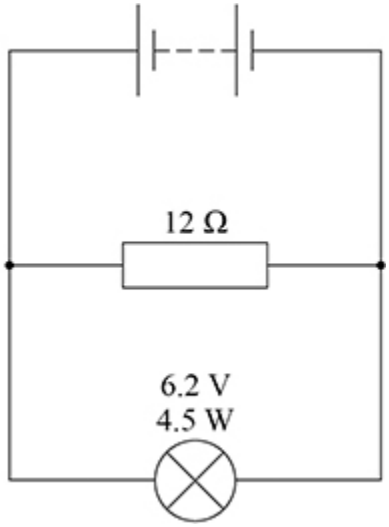
diameter = _____ $\text{mm}$

**(1)**

**(Total 10 marks)**

**2.** A student assembles the circuit in **Figure 1**.

**Figure 1**




The battery has an internal resistance of $2.5\ \Omega$.

(a) Show that the resistance of the $6.2\ \text{V}, 4.5\ \text{W}$ lamp at its working potential difference (pd) is about $9\ \Omega$.

**(1)**

(b) The terminal pd across the battery is $6.2\ \text{V}$.

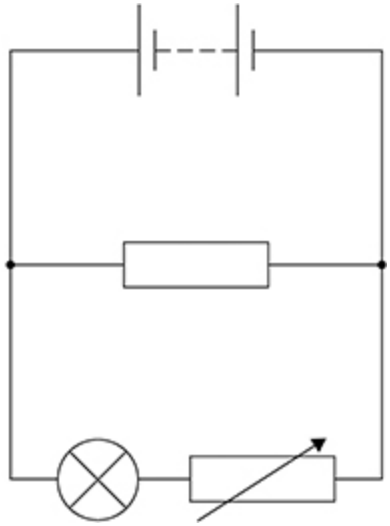
Calculate the emf of the battery.

emf = _____ V

**(3)**

The student makes a variable resistor to control the brightness of the lamp. **Figure 2** shows her circuit.

**Figure 2**



(c) She uses a resistance wire with a diameter of $0.19\ \text{mm}$ to make the variable resistor. A $5.0\ \text{m}$ length of this wire has a resistance of $9.0\ \Omega$.

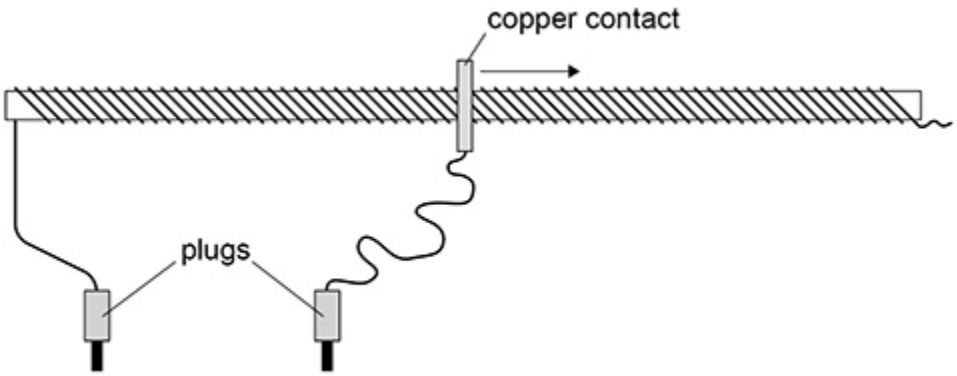
Calculate the resistivity of the wire.

resistivity = _____ $\Omega\ \text{m}$

**(3)**

(d) **Figure 3** shows the $5.0\ \text{m}$ length of wire wrapped around a tube to make the variable resistor.

**Figure 3**




Two plugs connect the variable resistor into the circuit. A moveable copper contact is used to vary the length of wire in series with the lamp.
When the contact is placed on the tube at one particular position, the lamp is dim.
The contact is then moved slowly to the right as shown in **Figure 3**.

Explain, without calculation, what happens to the brightness of the lamp as the contact is moved.

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**(2)**

(e) The student now makes a different circuit by connecting the variable resistor **in parallel** with the lamp.

The contact is returned to its original position on the tube as shown in **Figure 3** and the lamp is dim. The contact is again slowly moved to the right.

Explain, without calculation, what happens to the brightness of the lamp as the contact is moved.

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**(2)**

**(Total 11 marks)**

**3.** A battery of emf 7.4 V and negligible internal resistance is used to power a heating element inside a glove. The heating element has a resistance of 3.7 Ω.

(a) The designers state that the battery can produce a current of 2.0 A in the heating element for 240 minutes.

Calculate the energy dissipated in the heating element in this time.

energy dissipated = _____ J

**(3)**

(b) The length of the heating element needed is about 0.85 m.
The designer considers using a carbon fibre tape for the heating element.
The table gives information for the carbon fibre tape.

| **Cross-sectional area / $m^2$** | **Resistivity / Ω m** |
|---|---|
| $4.9 \times 10^{-6}$ | $2.0 \times 10^{-5}$ |

Deduce whether the carbon fibre tape is suitable for making the heating element for the glove.

**(2)**

(c) A light emitting diode (LED) is used to indicate that the switch in the glove is closed, as shown in **Figure 1**. Resistor R limits the current in the LED.

**Figure 1**

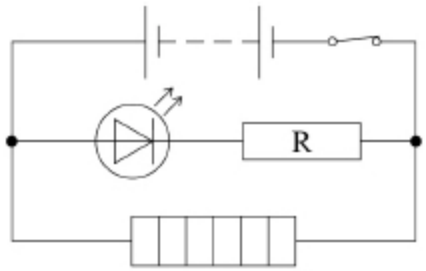
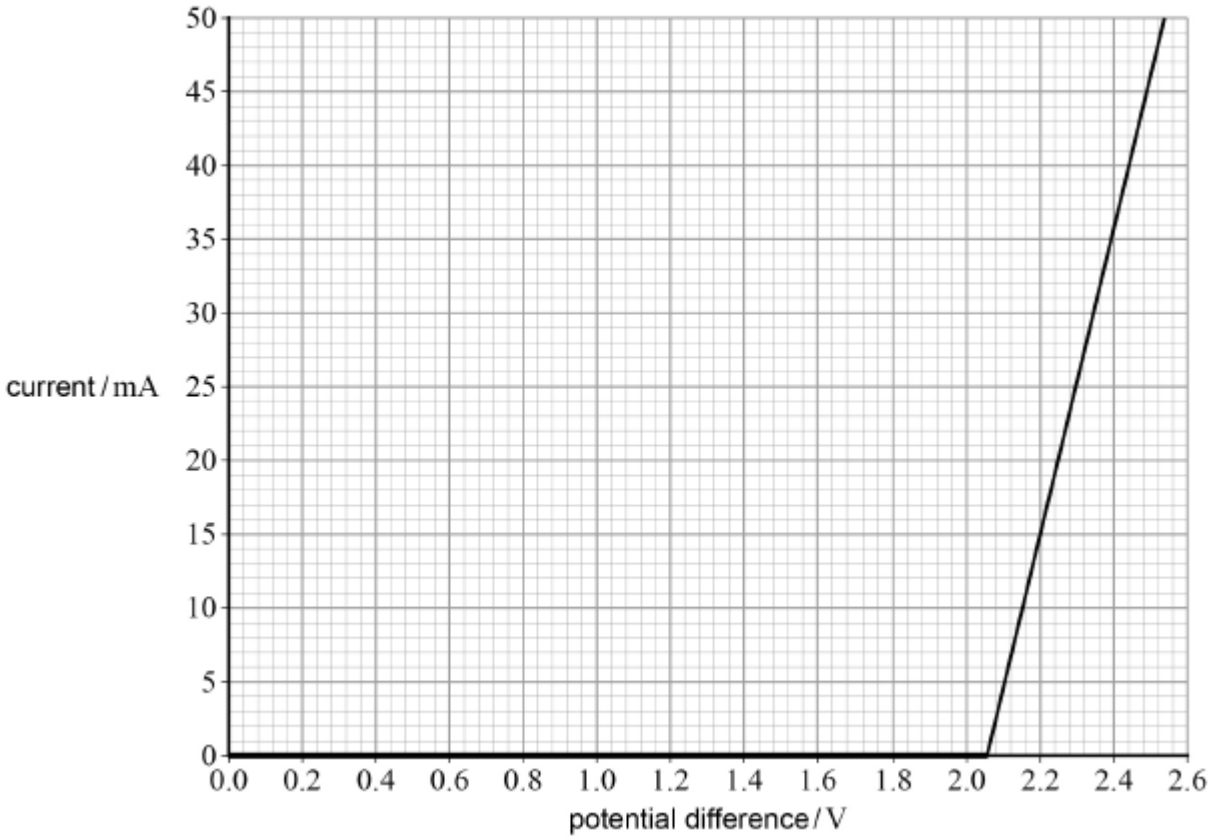



**Figure 2** shows part of the characteristic graph for the LED.

**Figure 2**



The circuit is designed so that the potential difference across the LED is 2.2 V when the switch is closed.

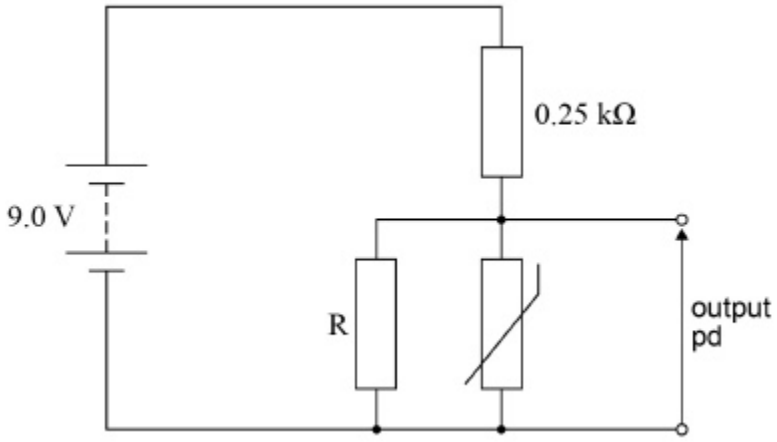
Calculate the resistance of R.

resistance = _____ Ω

**(4)**

**(Total 9 marks)**

**4.** The diagram shows a circuit designed by a student to monitor temperature changes.




The supply has negligible internal resistance and the thermistor has a resistance of 750 Ω at room temperature. The student wants the output potential difference (pd) at room temperature to be 5.0 V

(a) The 0.25 kΩ resistor is made of 50 turns of wire that is wound around a non-conducting cylinder of diameter 8.0 mm

Resistivity of the wire = $4.2 \times 10^{-7}$ Ω m

Determine the area of cross-section of the wire that has been used for the resistor.

area of cross-section = _____ $m^2$

**(3)**

(b) The student selects a resistor rated at 0.36 W for the 0.25 kΩ resistor in the diagram.

Determine whether this resistor is suitable.

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_____

_____

_____

_____

**(2)**

(c) Determine the value of R that the student should select.

Give your answer to an appropriate number of significant figures.

value of R = _____ Ω

**(5)**

(d) State and explain the effect on the output pd of increasing the temperature of the thermistor.

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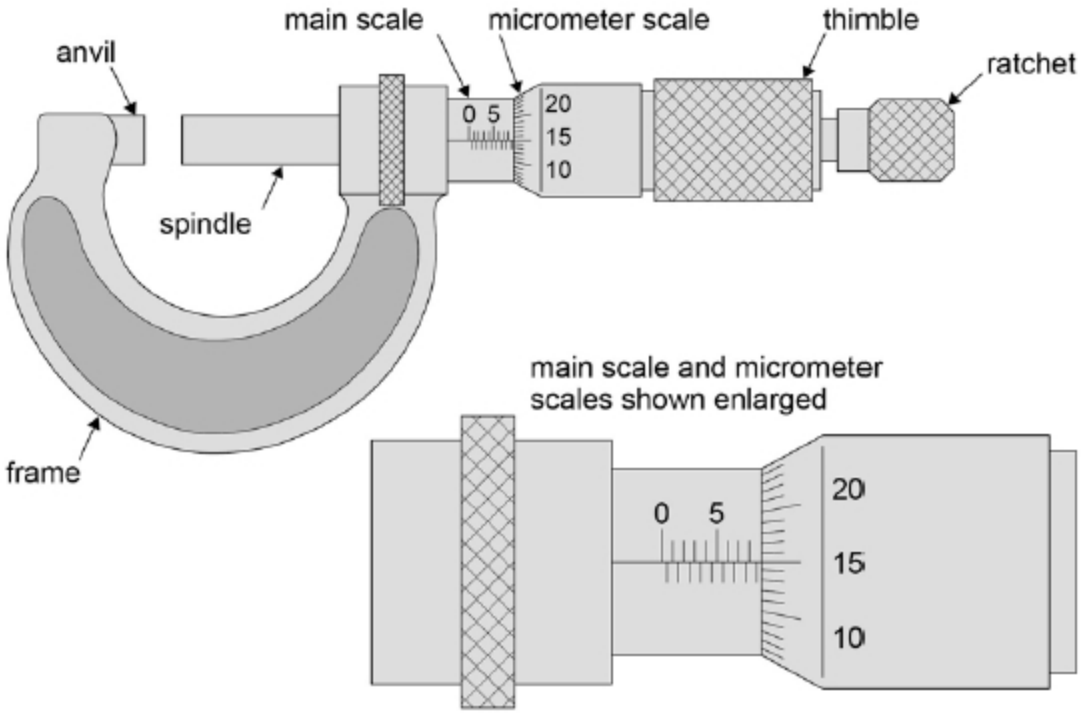
**(2)**

**(Total 12 marks)**

**5.** This question is about the determination of the resistivity of a wire.

**Figure 1** shows a micrometer screw gauge that is used to measure the diameter of the wire.

**Figure 1**




(a) State the resolution of the **main scale** on the micrometer in **Figure 1**.

resolution = _____mm

**(1)**

(b) Determine the distance between the anvil and the spindle of the micrometer in **Figure 1**. State any assumption you make.

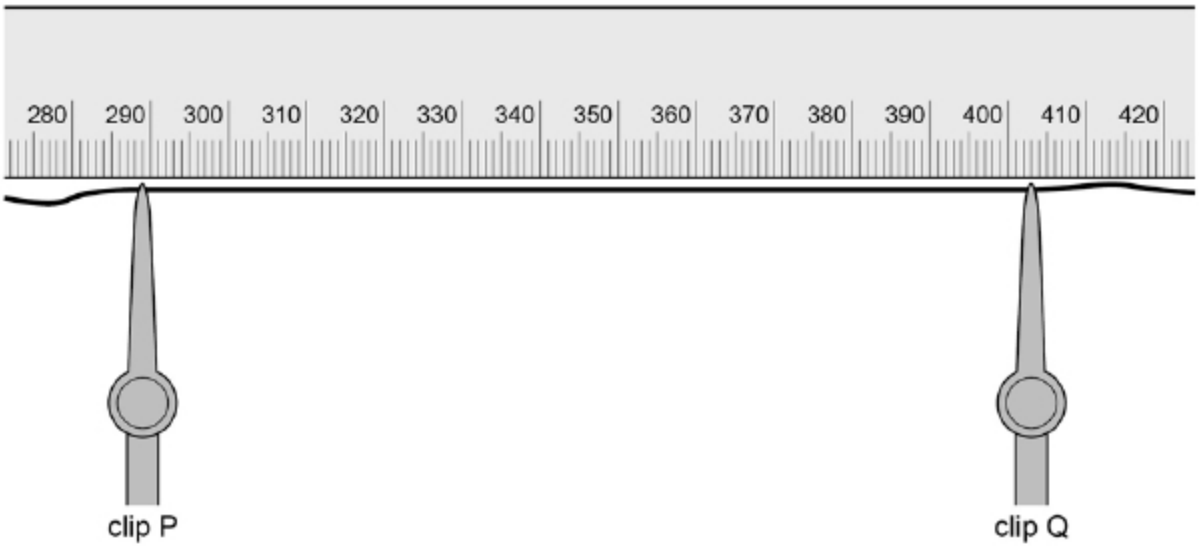
distance = _____mm

**(2)**

(c) A student must also determine the length $L$ of the wire between clips P and Q that will be connected into a circuit.

**Figure 2** shows the metre ruler being used to measure $L$.

**Figure 2**




Determine $L$

$L$ = _____ mm

**(1)**

(d) Calculate the percentage uncertainty in your result for $L$.

percentage uncertainty = _____ %

**(2)**

(e) State and explain what the student could have done to reduce uncertainty in the reading for $L$.

_____

_____

_____

**(1)**

(f) The student intends to make measurements that will allow her to determine the resistance of one metre of the wire. She uses an ohm-meter to measure the resistance $R$ for different lengths $L$ of the wire. The student's measurements are shown in the table below.

| ***L*/cm** | ***R*/Ω** | |
|---|---|---|
| 81.6 | 8.10 | |
| 72.2 | 7.19 | |
| 63.7 | 6.31 | |
| 58.7 | 5.85 | |
| 44.1 | 4.70 | |

Determine the value that the student should record for the resistance per metre of the wire.

Use the additional column in the table above to show how you arrived at your answer.

resistance of one metre of wire = _____ Ω

**(2)**

(g) Determine the resistivity of the wire. Give a suitable unit for your answer.

mean diameter of the wire = 0.376 mm

resistivity = _____ unit = _____

**(4)**

**(Total 13 marks)**