AQA A-LEVEL PHYSICS · 7408

# PHYSICS



EXAM QUESTION PACK

## 3.5.1 CURRENT ELECTRICITY

| SCORE | PERCENTAGE |
| --- | --- |
| /315 | % |

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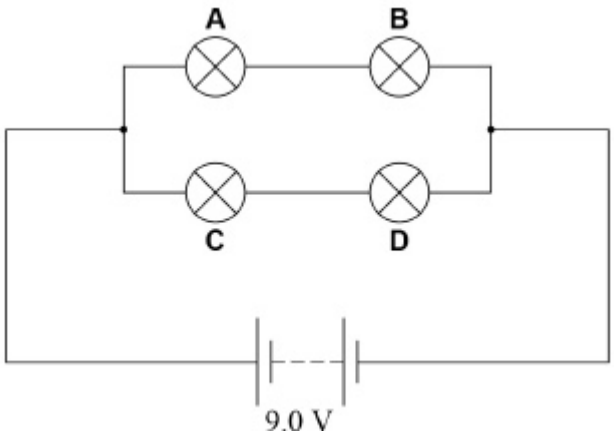
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## Q1.

A student connects four lamps **A**, **B**, **C** and **D** in the circuit shown in **Figure 1**.
The battery has an emf of 9.0 V and negligible internal resistance.

**Figure 1**




(a) The table shows the operating conditions for the lamps when they are at normal brightness.

| Lamps | Operating voltage / V | Power / W |
|---|---|---|
| **A** and **C** | 6.0 | 6.0 |
| **B** and **D** | 3.5 | 4.1 |

The student observes that **two** of the lamps are at their normal brightness.
Assume that any changes in resistance of the lamps are negligible.

Determine which **two** lamps are at their normal brightness.

Use calculations to support your answer.

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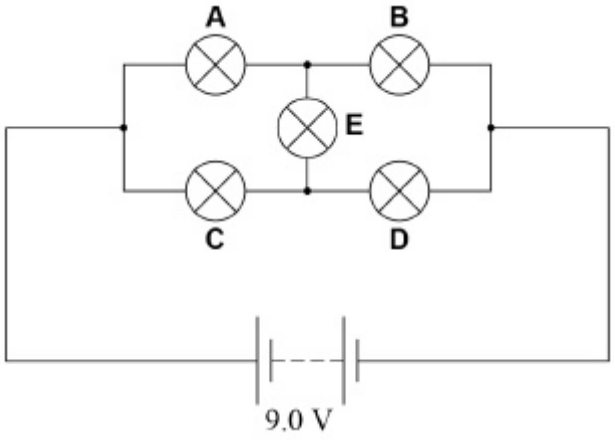
**(4)**

(b) The student connects another lamp **E** in the circuit as shown in **Figure 2**.
Lamp **E** is identical to lamps **A** and **C**.

**Figure 2**



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Explain what the student would observe regarding the brightness of the lamps.

Refer to potential differences across lamp **E** in your answer.

**(3)**

(c) Lamp **B** in **Figure 2** fails so that it no longer conducts. This change does not affect the resistance of the other lamps.

Deduce the effect on the current in the battery.

Use calculations to support your answer.



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**(3)**

**(Total 10 marks)**

## Q2.

A radioactive source emits alpha particles each with $8.1 \times 10^{-13}$ J of kinetic energy.

(a) Show that the velocity of an alpha particle with kinetic energy $8.1 \times 10^{-13}$ J is approximately $2 \times 10^{7}$ m s$^{-1}$

specific charge of an alpha particle = $4.81 \times 10^{7}$ C kg$^{-1}$

_____

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_____

**(2)**

(b) The alpha particles travel through air in straight lines with a range of 3.5 cm

Calculate the average force exerted on an alpha particle as it is stopped by the air.

average force = _____ N

**(2)**

(c) An alpha particle transfers all its kinetic energy to air molecules and produces $5.1 \times 10^{4}$ ions per centimetre over its range of 3.5 cm

Calculate the average ionisation energy, in eV, of a molecule of air.

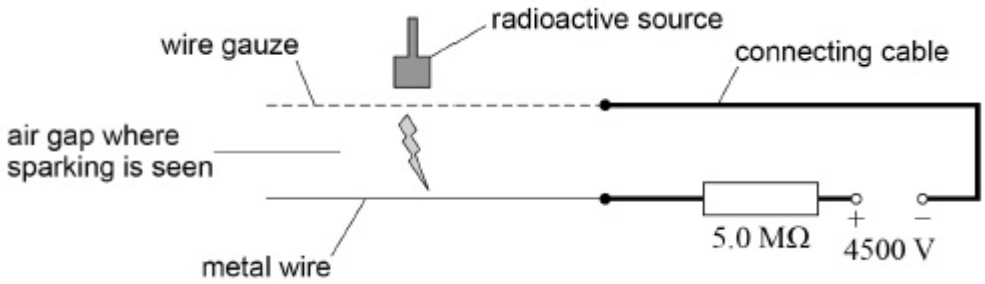


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ionisation energy = _____ eV

**(3)**

(d) A spark counter consists of a wire gauze separated from a metal wire by a small air gap. A power supply with an output of 4500 V is connected in series with a 5.0 MΩ resistor and the spark counter as shown in the diagram. When the radioactive source is moved close to the wire gauze, sparking is seen in the air gap.




Sparks are produced when alpha particles produce ionisation in the air gap.

One ionisation event produces a current of 0.85 mA for a time of 1.2 ns

Calculate the number of charge carriers that pass a point in the connecting cable during this ionisation event.

number of charge carriers = _____

**(2)**

(e) The radioactive source was positioned 10 cm above the wire gauze before being moved slowly towards the wire gauze leading to the ionisation event in part **(d)**.

Discuss how the potential difference across the air gap varied as the radioactive source was moved over this distance.

Assume the power supply has negligible internal resistance.



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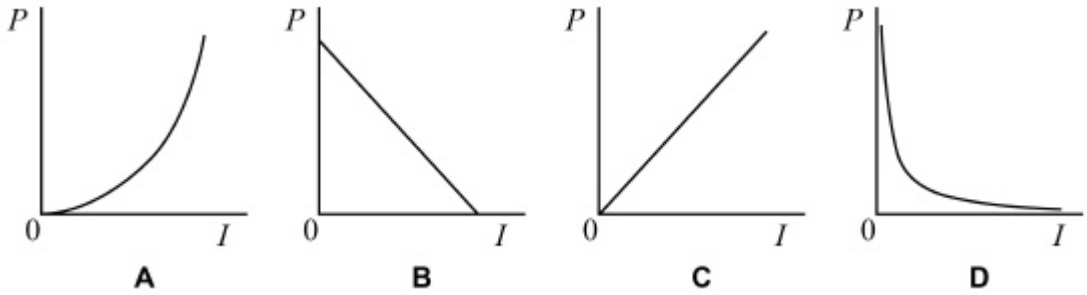
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**(3)**

**(Total 12 marks)**

## Q3.

Which graph shows how power dissipated $P$ varies with current $I$ in a component that obeys Ohm's law?




**A** ⬭

**B** ⬭

**C** ⬭

**D** ⬭

**(Total 1 mark)**

## Q4.

1.0 kilowatt-hour (kW h) is equivalent to

**A** $6.3 \times 10^{18}$ eV ⬭

**B** $6.3 \times 10^{21}$ eV ⬭

**C** $2.3 \times 10^{22}$ eV ⬭

**D** $2.3 \times 10^{25}$ eV ⬭

**(Total 1 mark)**

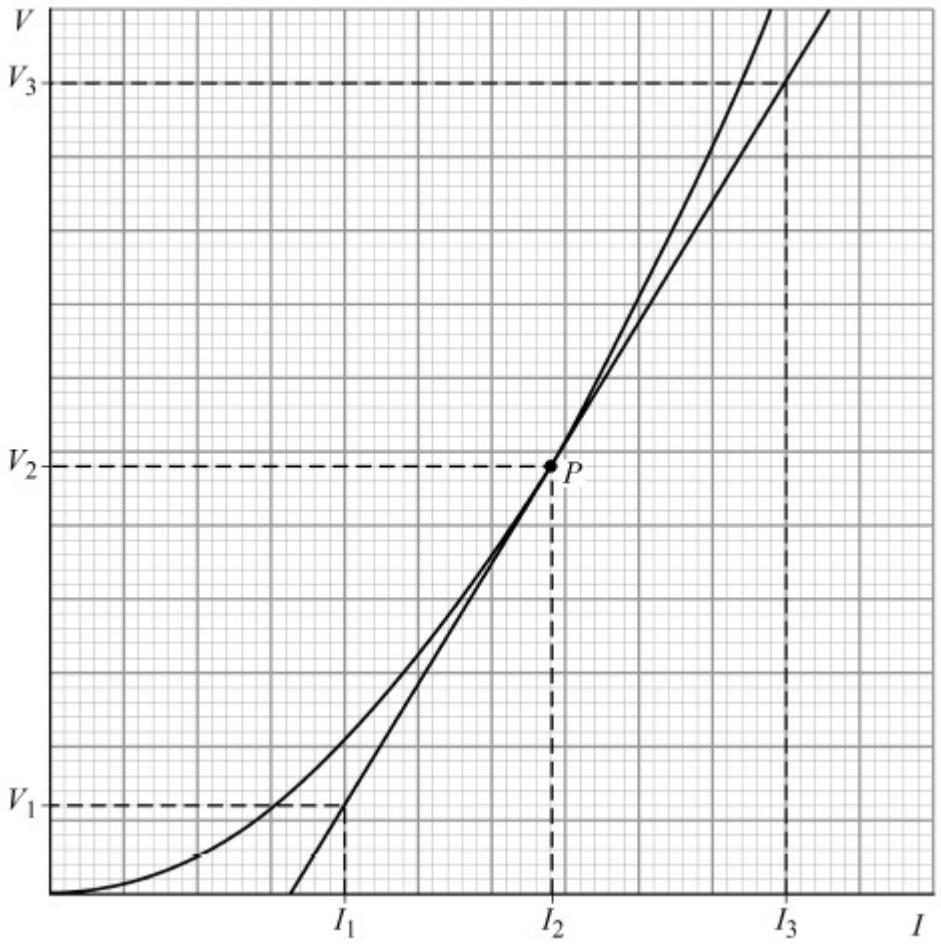
## Q5.

The graph shows how the potential difference $V$ across an electrical component varies with current $I$ in the component.

A tangent has been drawn on the curve at point $P$ for a current of $I_2$.



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What is the resistance of the electrical component when the current in the component is $I_2$?

**A** $\frac{V_3 - V_1}{2I_2}$ ⬭

**B** $\frac{V_3 - V_1}{I_3 - I_1}$ ⬭

**C** $\frac{V_2}{I_2}$ ⬭

**D** $\frac{2V_2}{I_2 - I_1}$ ⬭

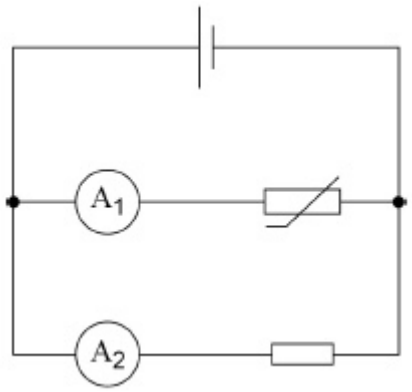
**(Total 1 mark)**

## Q6.

A circuit consists of a cell, a thermistor, a fixed resistor and two ammeters.



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The cell has a constant electromotive force and negligible internal resistance. Readings from the two ammeters are taken.

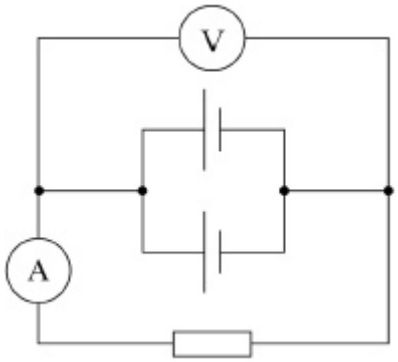
Which row describes what happens to the current in each ammeter when the temperature of the thermistor decreases?

| | **Current in ammeter $A_1$** | **Current in ammeter $A_2$** | |
|---|---|---|---|
| **A** | Decreases | Unchanged | ⬭ |
| **B** | Decreases | Increases | ⬭ |
| **C** | Increases | Decreases | ⬭ |
| **D** | Increases | Unchanged | ⬭ |

**(Total 1 mark)**

## Q7.

A circuit consists of two identical cells, a resistor, an ammeter and a voltmeter. The cells each have an emf of 3.0 V and the resistor has a resistance of 12 Ω
The cells have negligible internal resistance.




Which row shows the readings on the voltmeter and ammeter?

| | **Voltage / V** | **Current / A** | |
|---|---|---|---|
| **A** | 3.0 | 0.25 | ⬭ |



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| | | | |
|---|---|---|---|
| **B** | 3.0 | 0.50 | ⬭ |
| **C** | 6.0 | 0.25 | ⬭ |
| **D** | 6.0 | 0.50 | ⬭ |

**(Total 1 mark)**

## Q8.

Which is equivalent to the ohm?

**A** J $C^{-2}$ $s^{-1}$ ⬭

**B** J $C^{-2}$ s ⬭

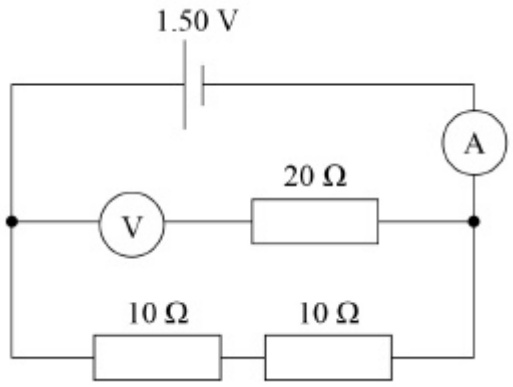
**C** J s ⬭

**D** J $s^{-1}$ ⬭

**(Total 1 mark)**

## Q9.

The circuit shows a cell with negligible internal resistance connected in a circuit with three resistors, an ammeter and a voltmeter.




Which row shows the readings on the ammeter and voltmeter?

| | **Current / A** | **Voltage / V** | |
|---|---|---|---|
| **A** | 0.075 | 0.75 | ⬭ |
| **B** | 0.075 | 1.50 | ⬭ |
| **C** | 0.150 | 0.75 | ⬭ |
| **D** | 0.150 | 1.50 | ⬭ |

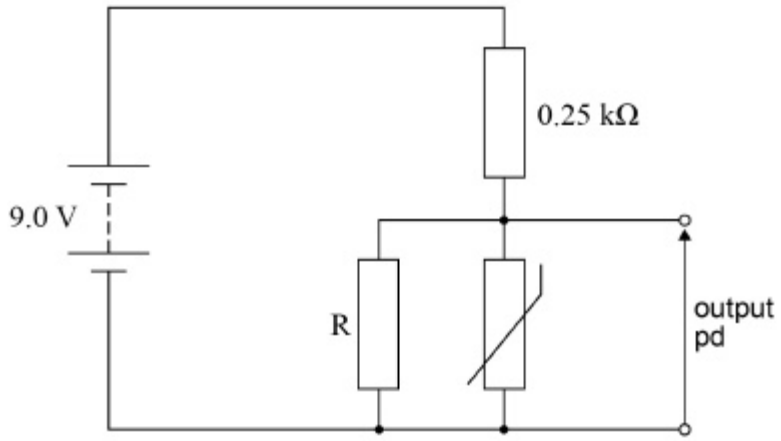
**(Total 1 mark)**



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## Q10.

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.

_____

_____

_____

_____

_____

**(2)**

**(Total 12 marks)**

## Q11.

A student carries out an experiment to determine the resistivity of a metal wire.
She determines the resistance from measurements of potential difference between the ends of the wire and the corresponding current. She measures the length of the wire with a ruler and the diameter of the wire using a micrometer. Each measurement is made with an uncertainty of 1%

Which measurement gives the largest uncertainty in the calculated value of the resistivity?

**A** current ⬭

**B** diameter ⬭

**C** length ⬭



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**D** potential difference ⬭

**(Total 1 mark)**

## Q12.

A gas containing doubly-charged ions flows to give an electric current of 0.64 A

How many ions pass a point in 1.0 minute?

**A** $2.0 \times 10^{18}$ ⬭

**B** $4.0 \times 10^{18}$ ⬭

**C** $1.2 \times 10^{20}$ ⬭

**D** $2.4 \times 10^{20}$ ⬭

**(Total 1 mark)**

## Q13.

A mobile phone operates at a constant power of 200 mW
It has a 3.7 V lithium-ion battery that has a charge capacity of 9400 C

What is the time taken for the battery to discharge completely?

**A** 2 hours ⬭

**B** 48 hours ⬭

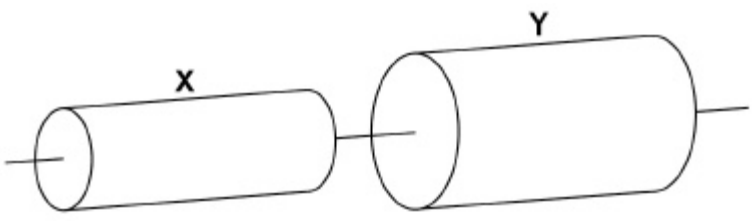
**C** 120 hours ⬭

**D** 140 hours ⬭

**(Total 1 mark)**

## Q14.

The two resistors shown are both uniform cylinders of equal length made from the same conducting putty.




The diameter of **Y** is twice that of **X**. The resistance of **Y** is $R$.

What is the total resistance of the combination?



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**A** $\frac{4R}{5}$ ⬭

**B** $3R$ ⬭

**C** $4R$ ⬭

**D** $5R$ ⬭

**(Total 1 mark)**

## Q15.

A voltmeter is used to measure potential difference for a component **X**.

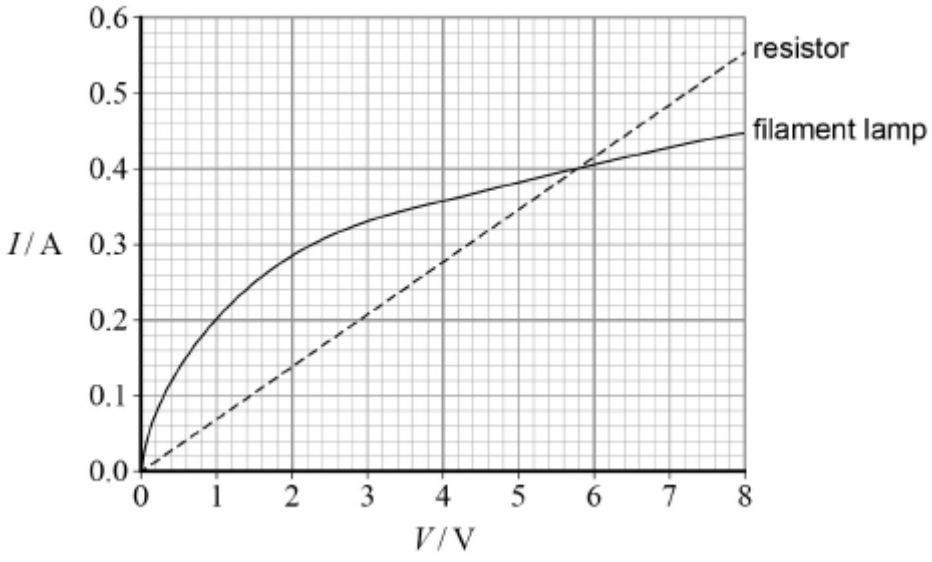
Which row gives the position and ideal resistance for the voltmeter?

| | Position | Ideal resistance | |
|---|---|---|---|
| **A** | in series with X | infinite | ⬭ |
| **B** | in series with X | zero | ⬭ |
| **C** | in parallel with X | infinite | ⬭ |
| **D** | in parallel with X | zero | ⬭ |

**(Total 1 mark)**

## Q16.

The graph below shows the current–voltage ($I$–$V$) characteristics for a resistor and a filament lamp.




(a) Explain, in terms of electron motion, why the $I$–$V$ characteristic for the filament lamp is a curve.



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**(4)**

(b) Determine the resistance of the resistor.

resistance = _____ Ω

**(1)**

(c) The resistor and the filament lamp are connected in series with a supply of variable emf and negligible internal resistance.

Determine the emf that produces a current of 0.18 A in the circuit.

emf = _____ $V$

**(3)**

(d) The resistor and filament lamp are now connected in parallel.

Determine the resistance of the parallel combination when the emf of the supply is adjusted to be 4.0 V.

resistance = _____ Ω

**(3)**



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(e) The resistance of the filament lamp at its working temperature is 14 Ω.

The filament has a length of 0.36 m and a diameter of 32 μm.

Calculate the resistivity of the metal that is used for the filament when the lamp is at its working temperature.

Give an appropriate unit for your answer.

resistivity = _____ unit _____

**(3)**

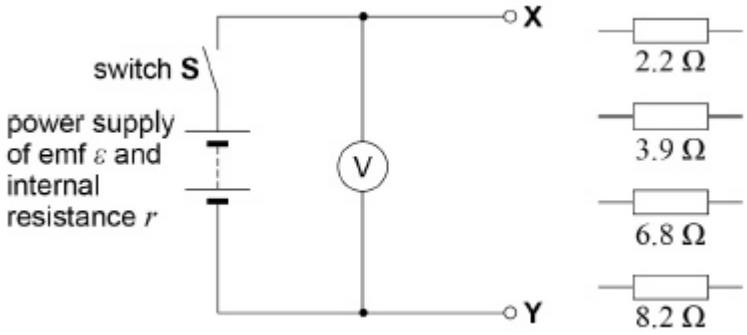
**(Total 14 marks)**

## Q17.

This question is about an experiment to determine the internal resistance of a power supply.

A student is given the circuit and the four resistors of known resistance shown in **Figure 1**.

**Figure 1**




The student can change the external resistance $R$ of the circuit between terminals **X** and **Y**. This is done by connecting different combinations of **two** resistors in series or in parallel between **X** and **Y**.
This method can produce **12 different values** for $R$.

(a) Calculate the largest value of $R$ that the student can obtain using **two** resistors.

largest value of $R$ = _____ Ω

**(1)**



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(b) Calculate the smallest value of $R$ that the student can obtain using **two** resistors.

smallest value of $R$ = _____ Ω

**(2)**

(c) With switch **S** closed (in the on position) and no resistors connected between **X** and **Y** the voltmeter reading $V$ is 1.62 V.

The student concludes that this voltmeter reading equals the emf $\varepsilon$ of the power supply.

State why the student's conclusion that $\varepsilon$ = 1.62 V was correct.

_____

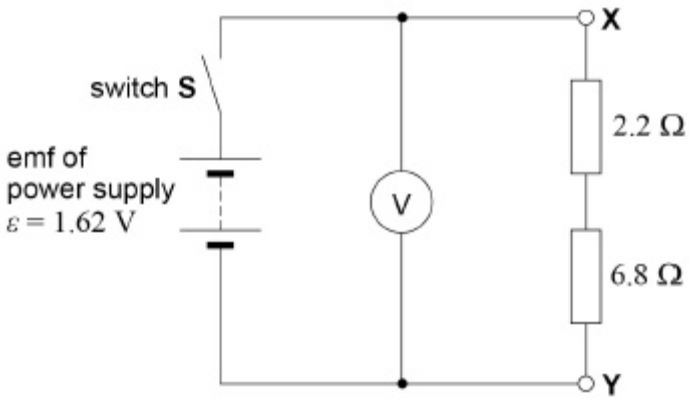
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**(1)**

(d) **Figure 2** shows one particular combination and arrangement of two resistors that the student could use.

**Figure 2**




When **S** is closed the voltmeter reading $V$ is 1.14 V.

Explain why $V$ is less than 1.62 V when **S** is closed.

_____

_____

_____

**(1)**

(e) It can be shown that

$$\varepsilon - V = r \times \frac{V}{R}$$



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where $r$ is the internal resistance of the power supply.

Determine ($\varepsilon$ – V ) and $\frac{V}{R}$ for this circuit using the data given in part (d).

($\varepsilon - V$) = _____ V

$\frac{V}{R}$ = _____ V $\Omega^{-1}$

**(1)**

(f) The student obtains values of $V$ for five further different values of $R$.

These data were used to produce the graph of ($\varepsilon - V$) against $\frac{V}{R}$ in **Figure 3**.

Plot the point you determined in part (e) on **Figure 3** and add a suitable best-fit line.

**(1)**

(g) Use **Figure 3** to determine $r$.

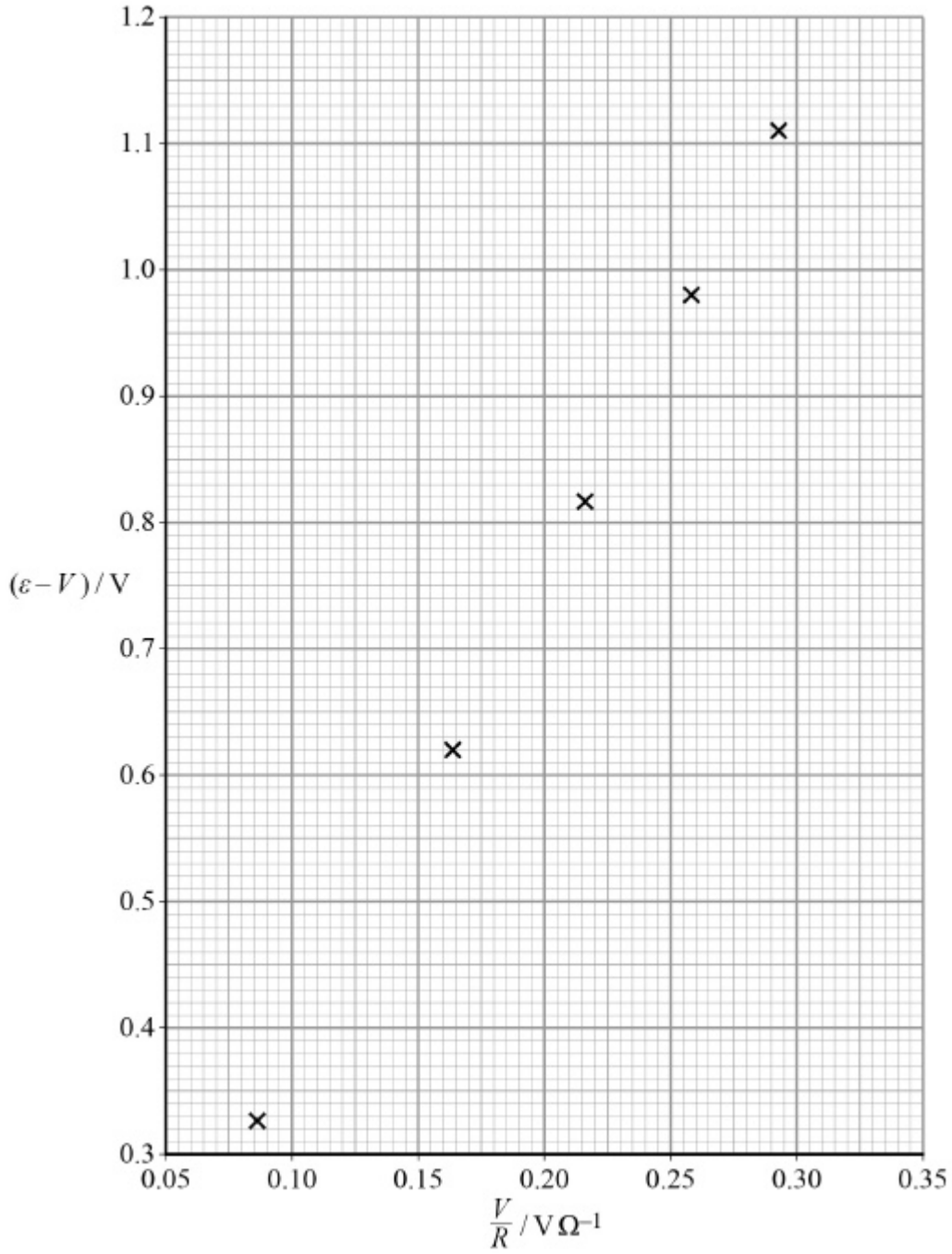
$r$ = _____ Ω

**(2)**

**Figure 3**



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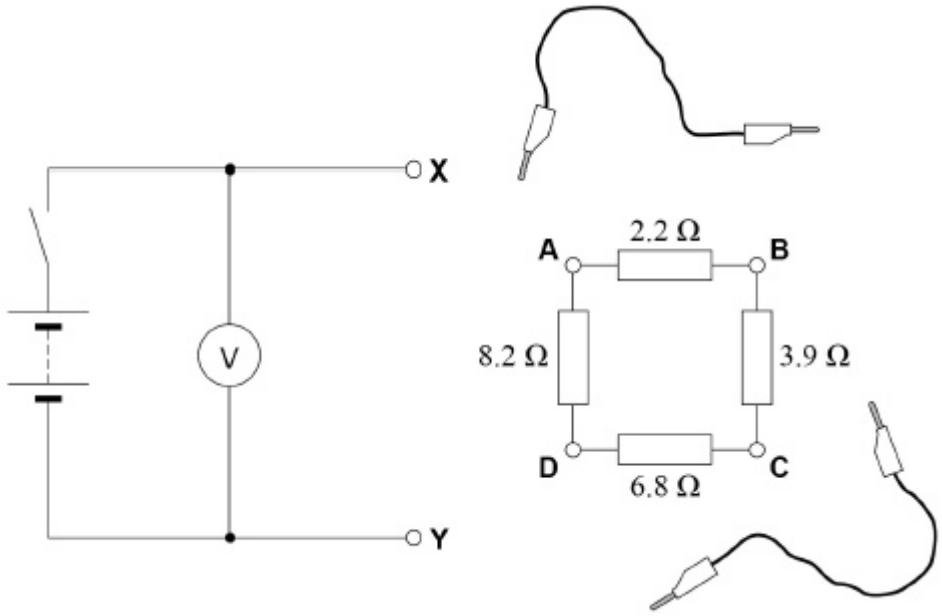



(h) **Figure 4** shows a different method for varying the resistance $R$ described in part (a).

**Figure 4**



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The four resistors are connected in a loop with sockets **A**, **B**, **C** and **D** at each junction. Two leads are used to connect the resistor loop to **X** and **Y**.

Discuss whether this method is an improvement over the method described in part (a). In your answer, you should refer to the number of different values that can be obtained for $R$.

**(2)**

**(Total 11 marks)**

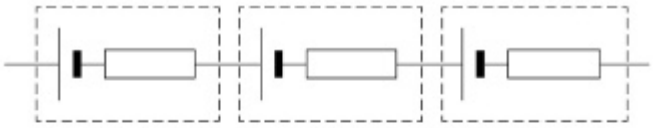
## Q18.

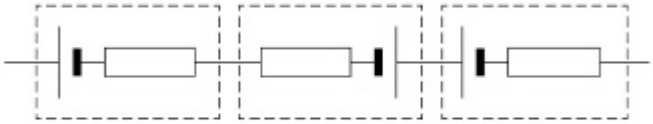
Three cells each have an emf $\varepsilon$ = 1.5 V and an internal resistance $r$ = 0.6 Ω.

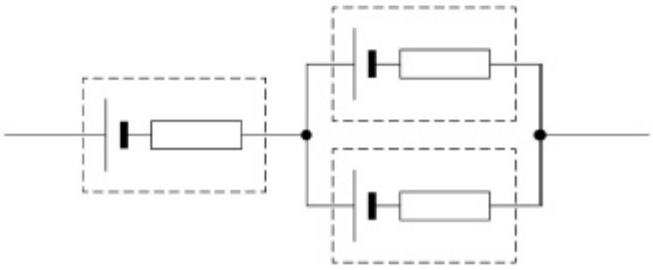
Which combination of these cells will deliver a total emf of 1.5 V and a maximum current of 7.5 A?

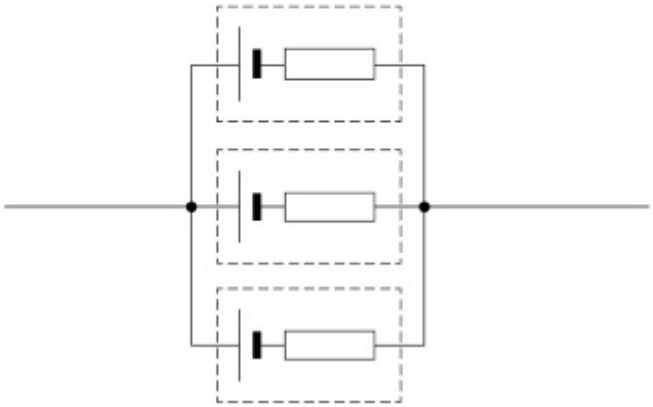


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A 

B 

C 

D 

A ☐

B ☐

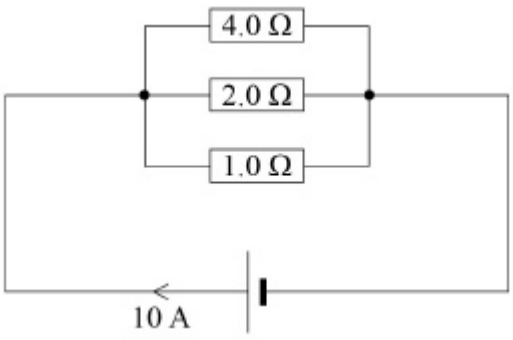
C ☐

D ☐

**(Total 1 mark)**

## Q19.

The current in the cell is 10 A as shown.






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What is the current in the 2.0 Ω resistor?

**A** 0.35 A ⬭

**B** 2.86 A ⬭

**C** 3.50 A ⬭

**D** 7.14 A ⬭

**(Total 1 mark)**

## Q20.

A battery of negligible internal resistance and an emf of 12 V is connected in series with a heating element. The heating element has a resistance of 6.5 Ω when in operation.

What is the energy transferred by the heating element when operating for 5 minutes?

**A** 111 J ⬭

**B** 390 J ⬭

**C** 6650 J ⬭

**D** 23 400 J ⬭

**(Total 1 mark)**

## Q21.

Which statement about superconductors is correct?

**A** When a material becomes a superconductor, its resistivity is almost zero. ⬭

**B** The temperature at which a material becomes a superconductor is called the critical temperature. ⬭

**C** When current passes through a superconductor the pd across it becomes a maximum. ⬭

**D** Copper is a superconductor at room temperature. ⬭

**(Total 1 mark)**

## Q22.

A wire has a resistance $R$.

What is the resistance when both the length and radius of the wire are doubled?

**A** $\frac{R}{4}$ ⬭



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**B** $\frac{R}{2}$ ⬭

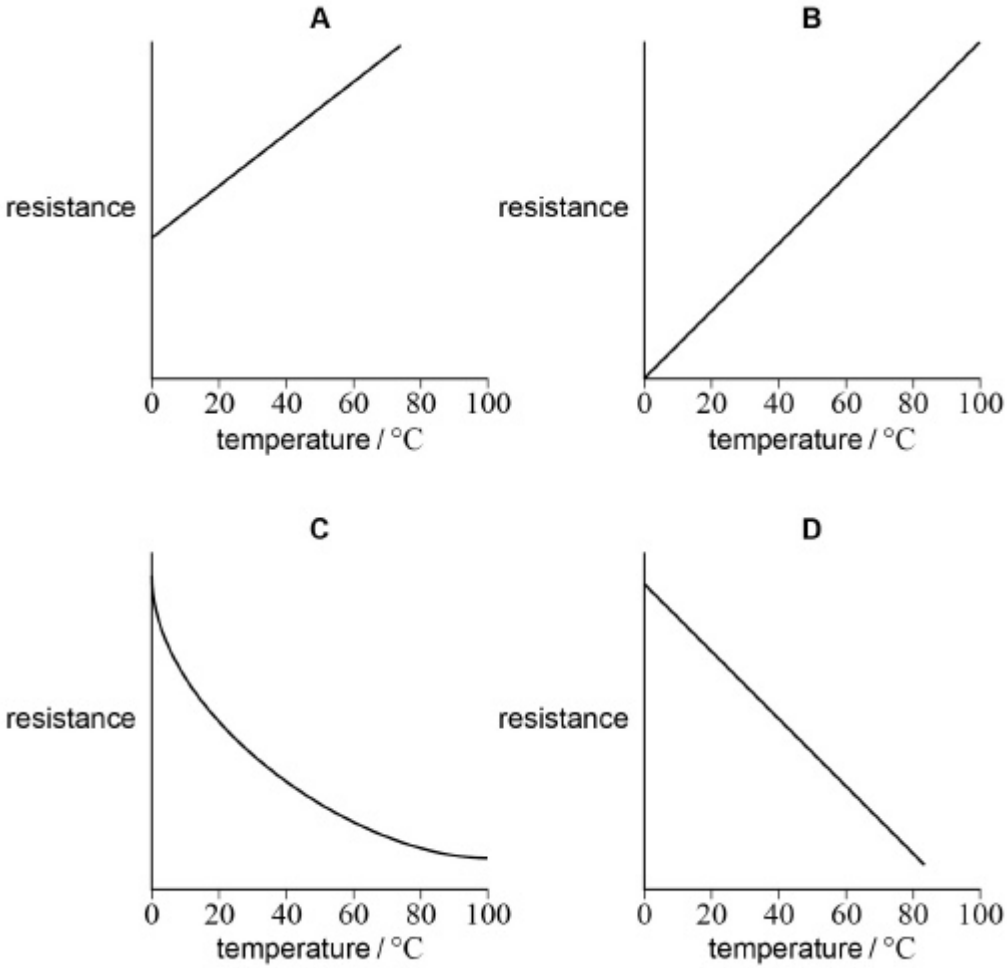
**C** $2R$ ⬭

**D** $4R$ ⬭

**(Total 1 mark)**

## Q23.

Which graph shows the variation of the resistance with temperature for an ntc thermistor?




**A** ⬭

**B** ⬭

**C** ⬭

**D** ⬭

**(Total 1 mark)**

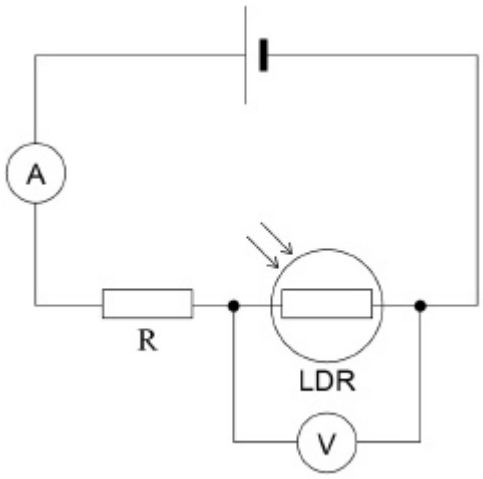
## Q24.

The figure shows a light dependent resistor (LDR) and fixed resistor R connected in series



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across a cell. The internal resistance of the cell is negligible.




Which row shows how the readings on the ammeter and the voltmeter change when the light intensity incident on the LDR is increased?

| | Ammeter reading | Voltmeter reading | |
|---|---|---|---|
| **A** | decreases | increases | ⬭ |
| **B** | decreases | decreases | ⬭ |
| **C** | increases | increases | ⬭ |
| **D** | increases | decreases | ⬭ |

**(Total 1 mark)**

## Q25.

An engineer wants to use solar cells to provide energy for a filament lamp in a road sign.

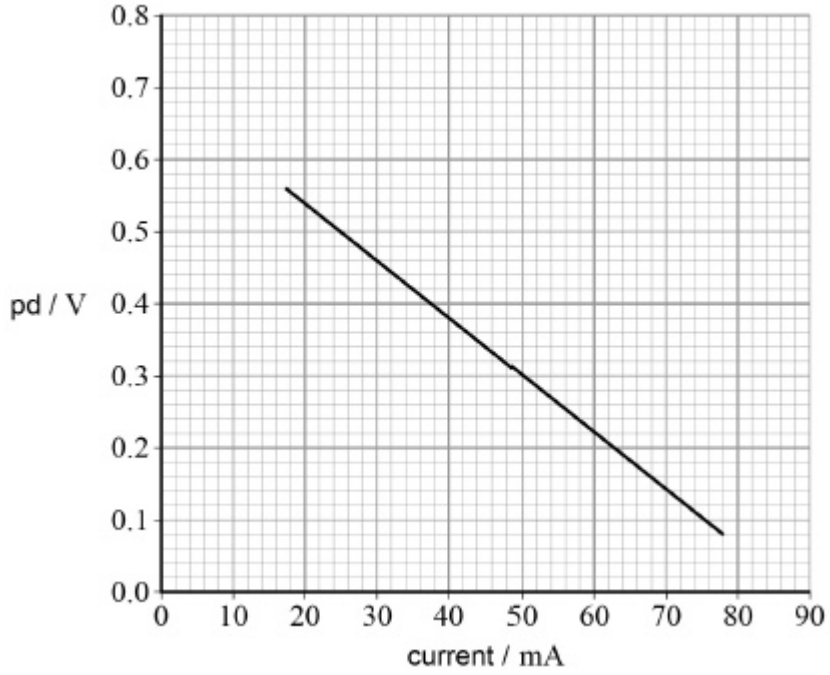
The engineer first investigates the emf and internal resistance of a solar cell under typical operating conditions.

The engineer determines how the potential difference across the solar cell varies with current. The results are shown in the graph in **Figure 1**.

**Figure 1**



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The engineer uses the graph to deduce that when operating in typical conditions a single solar cell produces an emf of 0.70 V and has an internal resistance of 8.0 Ω.

(a) Explain how the engineer uses the graph to obtain the values for the emf and internal resistance of the solar cell.

**(2)**

(b) To operate effectively the lamp in the road sign needs a minimum current of 75 mA. At this current the resistance of the filament lamp is 6.0 Ω.

The engineer proposes to try the two circuits shown in **Figure 2** and **Figure 3**.

**Figure 2**



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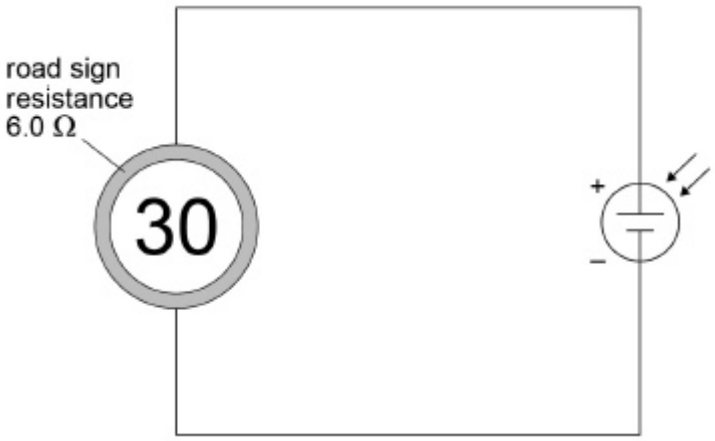
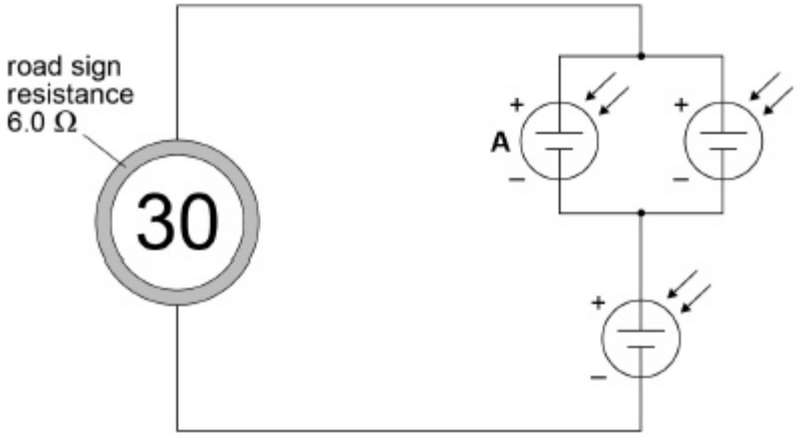



**Figure 3**




Deduce, using calculations, whether the circuits in **Figure 2** and **Figure 3** are suitable for this application.

**(4)**

(c) Solar cells convert solar energy to useful electrical energy in the road sign with an efficiency of 4.0%.
The solar-cell supply used by the engineer has a total surface area of 32 $cm^2$.

Calculate the minimum intensity, in W $m^{-2}$, of the sunlight needed to provide the minimum current of 75 mA to the road sign when it has a resistance of 6.0 Ω.



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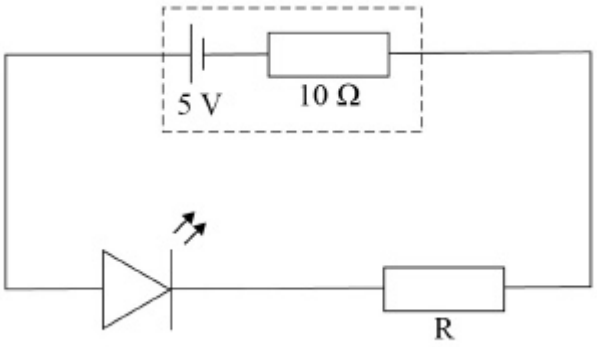
intensity = _____ W $m^{-2}$

**(3)**

**(Total 9 marks)**

## Q26.

In the circuit below, the potential difference across the light emitting diode (LED) is 1.8 V when it is emitting light.




The current in the circuit is 20 mA.

What is the value of the resistor R?

**A** 80 Ω ⬭

**B** 90 Ω ⬭

**C** 150 Ω ⬭

**D** 160 Ω ⬭

**(Total 1 mark)**

## Q27.

The combined resistance of $n$ identical resistors connected in parallel is $R_n$.

Which statement correctly describes the variation of $R_n$ as $n$ increases?

**A** $R_n$ decreases linearly as $n$ increases ⬭

**B** $R_n$ decreases non-linearly as $n$ increases ⬭

**C** $R_n$ increases linearly as $n$ increases ⬭

**D** $R_n$ increases non-linearly as $n$ increases ⬭

**(Total 1 mark)**

## Q28.

The table shows the resistivity, length and cross-sectional area of wires P and Q.



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| | resistivity | length | cross-sectional area |
|---|---|---|---|
| wire P | $\rho$ | $L$ | $A$ |
| wire Q | $\frac{\rho}{4}$ | $L$ | $\frac{A}{2}$ |

The resistance of wire P is $R$.

What is the total resistance of the wires when they are connected in parallel?

**A** $\frac{R}{9}$ ⬭

**B** $\frac{R}{3}$ ⬭

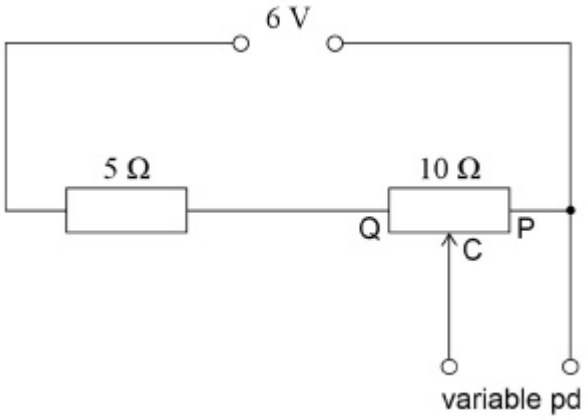
**C** $\frac{2R}{3}$ ⬭

**D** $\frac{3R}{2}$ ⬭

**(Total 1 mark)**

## Q29.

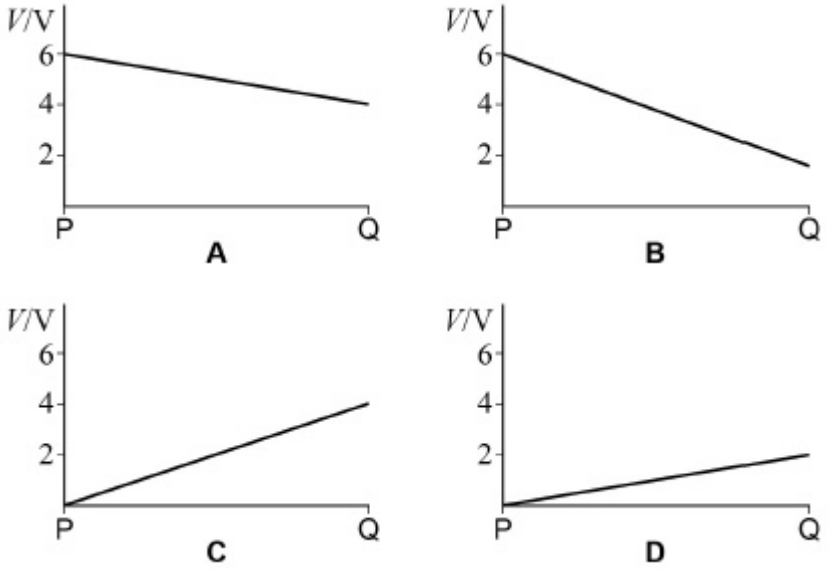
The circuit shown is used to supply a variable potential difference (pd) to another circuit.




Which graph shows how the pd supplied $V$ varies as the moving contact C is moved from position P to position Q?



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**A** ⬭

**B** ⬭

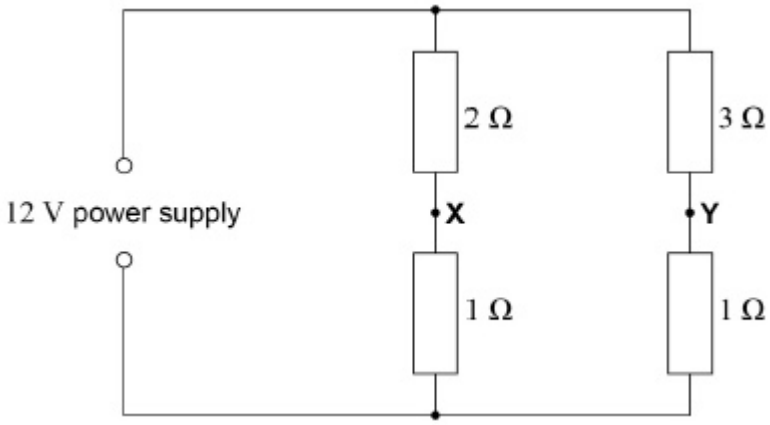
**C** ⬭

**D** ⬭

**(Total 1 mark)**

## Q30.

In this resistor network, the emf of the supply is 12 V and it has negligible internal resistance.




What is the reading on a voltmeter connected between points **X** and **Y**?

**A** 0 V ⬭

**B** 1 V ⬭

**C** 3 V ⬭



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**D** 4 V ⬭

**(Total 1 mark)**

## Q31.

The mean power dissipated in a resistor is 47.5 μW when the root mean square (rms) voltage across the resistor is 150 mV.

What is the peak current in the resistor?

**A** $2.3 \times 10^{-4}$ A ⬭

**B** $4.5 \times 10^{-4}$ A ⬭

**C** $2.3 \times 10^{3}$ A ⬭

**D** $4.5 \times 10^{3}$ A ⬭

**(Total 1 mark)**

## Q32.

The National Grid is used to transfer electrical energy from power stations to consumers.

What conditions for the transmission voltage and the transmission current give the most efficient transfer of energy through the National Grid?

| | **Transmission voltage** | **Transmission current** | |
|---|---|---|---|
| **A** | High | High | ⬭ |
| **B** | High | Low | ⬭ |
| **C** | Low | High | ⬭ |
| **D** | Low | Low | ⬭ |

**(Total 1 mark)**

## Q33.

A mains transformer has a primary coil of 2500 turns and a secondary coil of 130 turns.
The primary coil is connected to a mains supply where $V_{rms}$ is 230 V.
The secondary coil is connected to a lamp of resistance 6.0 Ω.
The transformer is 100% efficient.

What is the peak power dissipated in the lamp?

**A** 12 W ⬭

**B** 24 W ⬭

**C** 48 W ⬭



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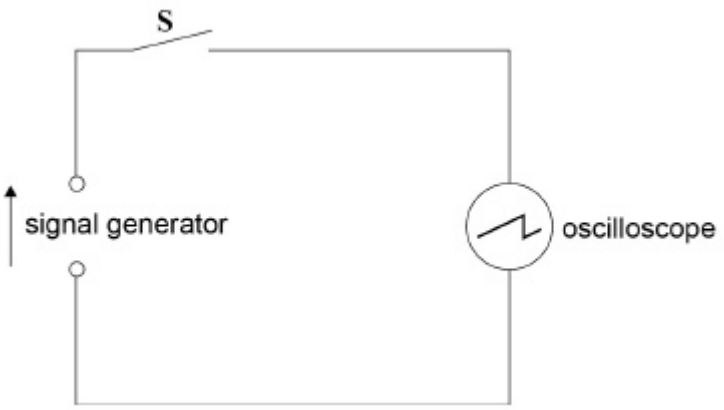
**D** 96 W

**(Total 1 mark)**

## Q34.

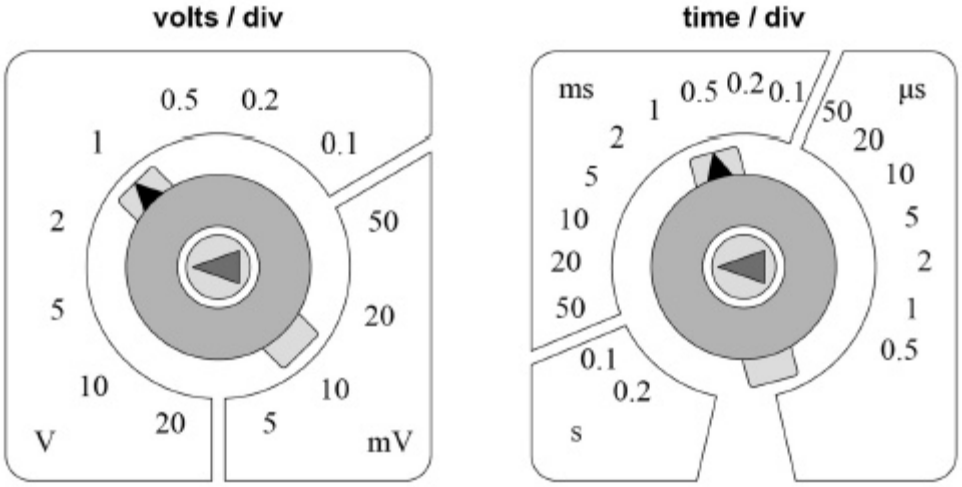
A signal generator is connected to an oscilloscope, as shown in **Figure 1**.

**Figure 1**




The Y-voltage gain and time-base settings of the oscilloscope are shown in **Figure 2**.

**Figure 2**




When switch **S** is open (off) the oscilloscope displays the waveform shown in **Figure 3**.

When **S** is closed (on) the oscilloscope displays the waveform shown in **Figure 4**.

(a) Determine the peak-to-peak voltage $V$ of the waveform shown in **Figure 4**.

$V$ = _____ V

**(1)**



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(b) Determine the frequency $f$ of the waveform shown in **Figure 4**.

$f$ = _____ Hz

**(2)**

**Figure 3**

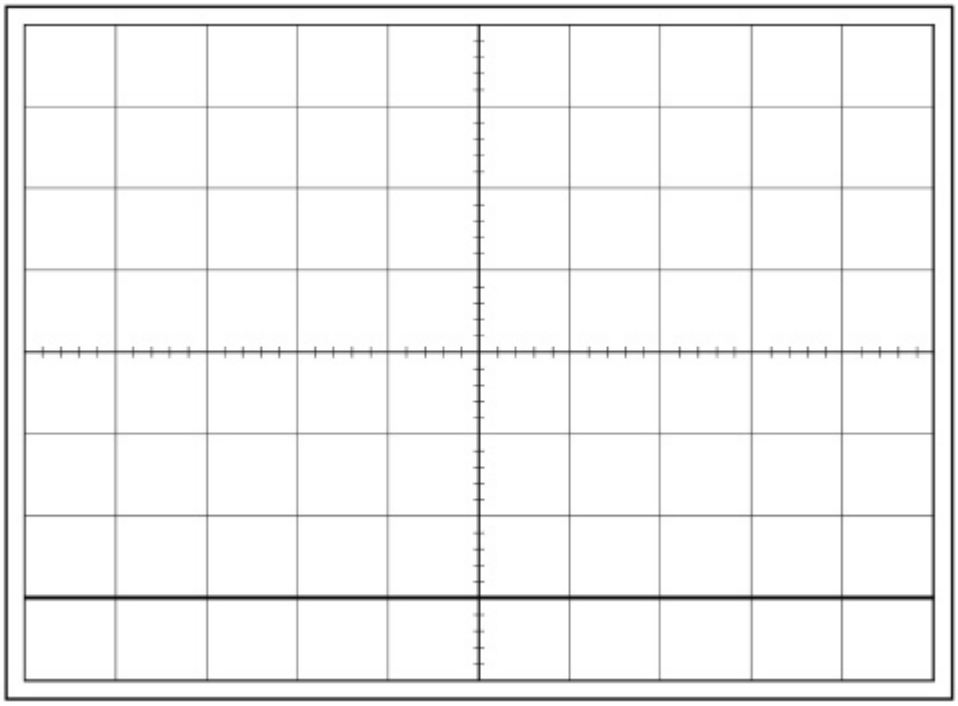
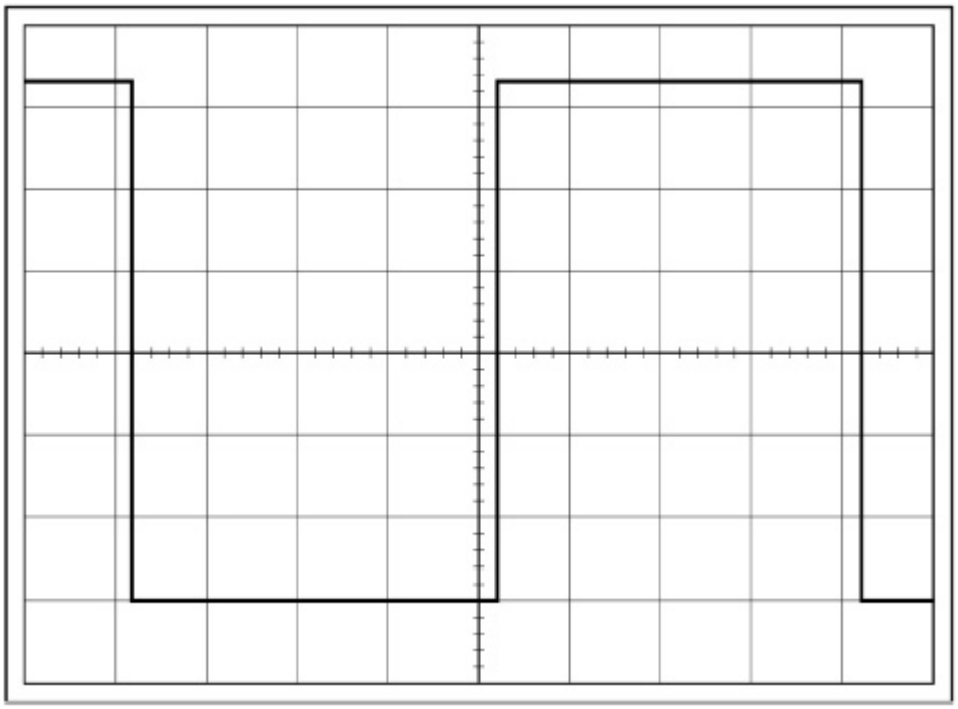


**Figure 4**

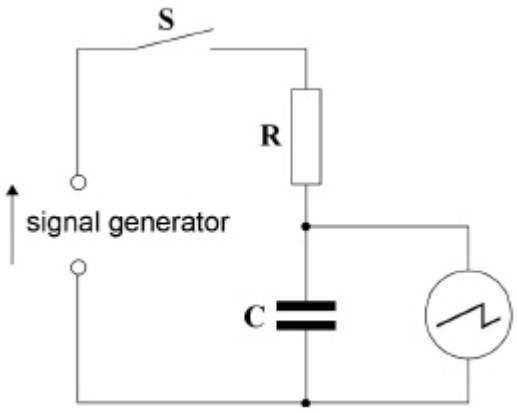




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(c) **Figure 5** shows the signal generator connected in series with a resistor **R** and a capacitor **C**.

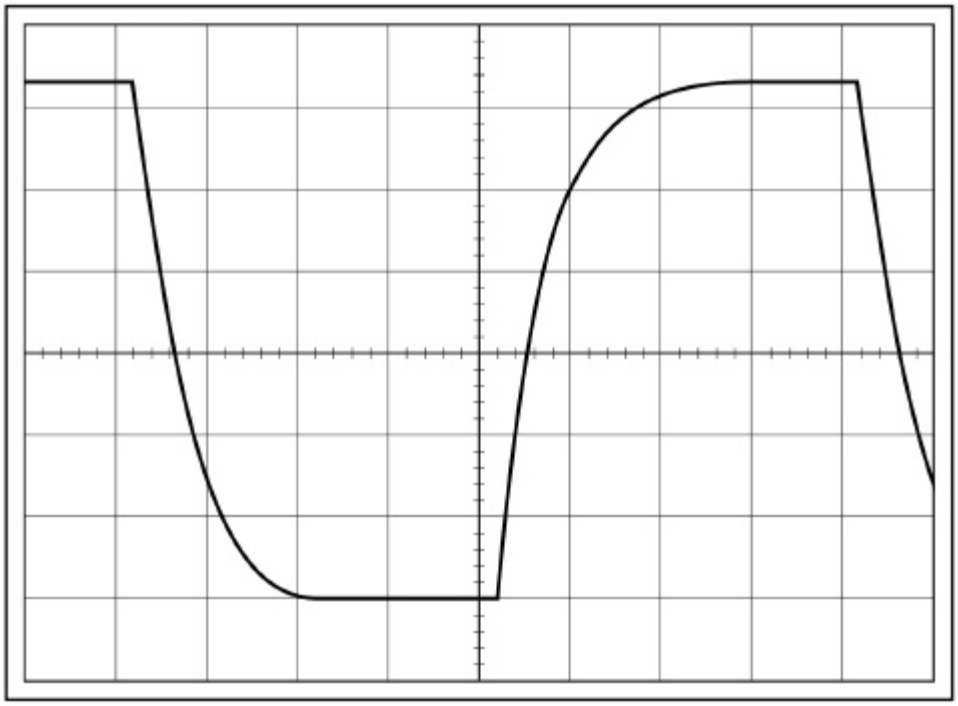
**Figure 5**




The oscilloscope is connected across the capacitor.
The Y-voltage gain and time-base settings are still the same as shown in **Figure 2**.

When **S** is closed (on) the oscilloscope displays the waveform shown in **Figure 6**.

**Figure 6**



Determine the time constant of the circuit in **Figure 5**.



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time constant = _____ s

**(2)**

(d) A student suggests that setting the time-base to 0.2 ms division$^{-1}$ might reduce uncertainty in the determination of the time constant.

State and explain any possible advantage or disadvantage in making this suggested adjustment.

_____

_____

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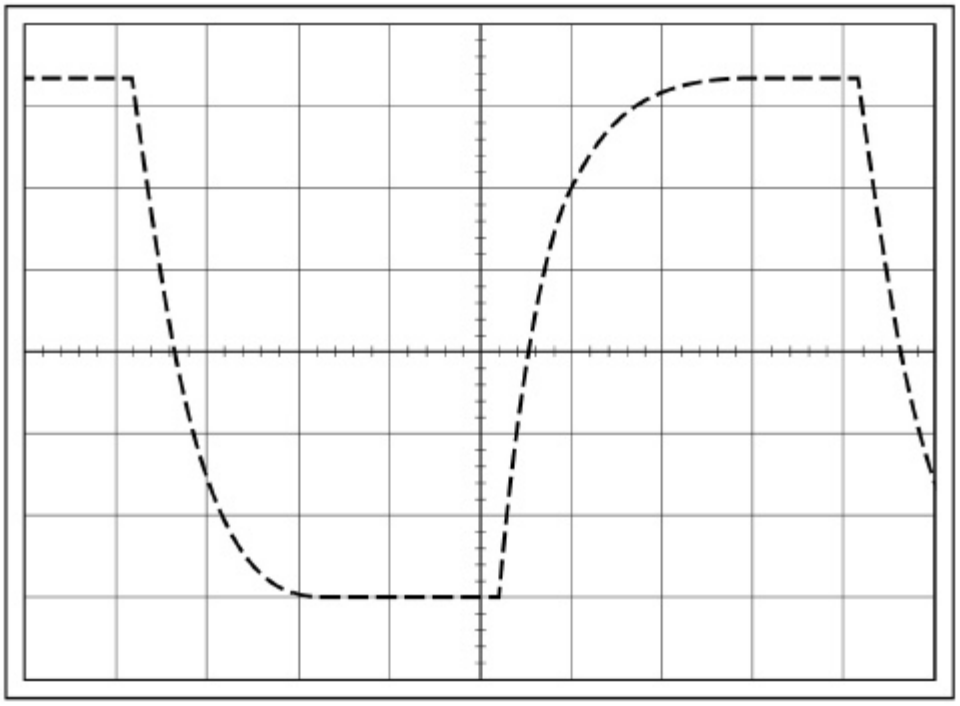
**(3)**

(e) The student connects an identical resistor in parallel with **R** and uses the oscilloscope to display the waveform across **C**.

Draw on **Figure 7** the waveform you expect the student to see.

The waveform of **Figure 6** is shown as a dashed line to help you show how the waveform changes.

**Figure 7**





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Explain the change in the waveform.

_____

_____

_____

_____

_____

_____

**(2)**

(f) **Figure 8a** is a graph of voltage against time showing the output of the signal generator. **Figure 8b** shows the voltage across **C** during the same time interval.

The student interchanges the positions of **R** and **C** and connects the oscilloscope across **R**.

Complete **Figure 8c** to draw the voltage across R during the time interval.

**Figure 8a**

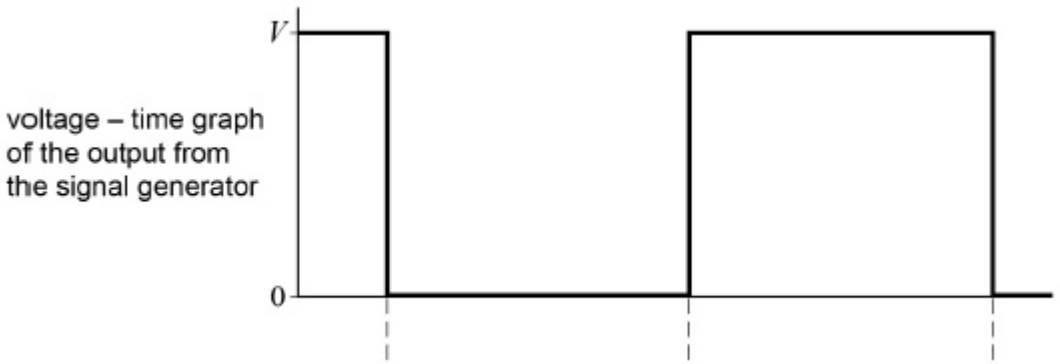



**Figure 8b**

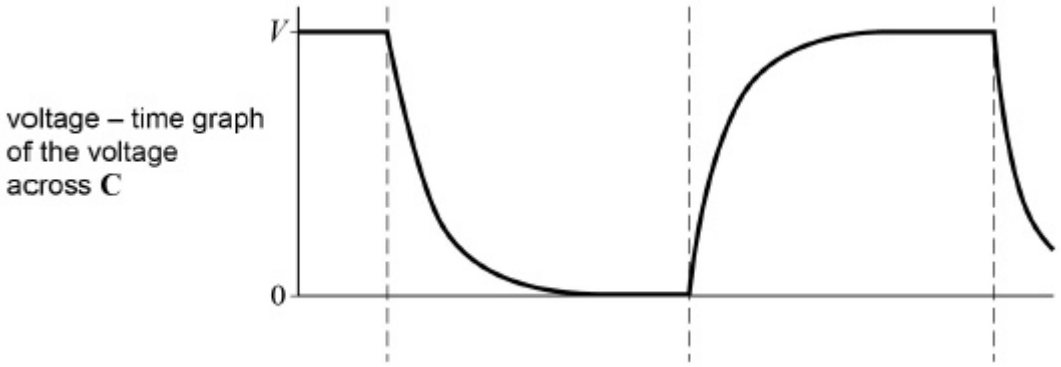
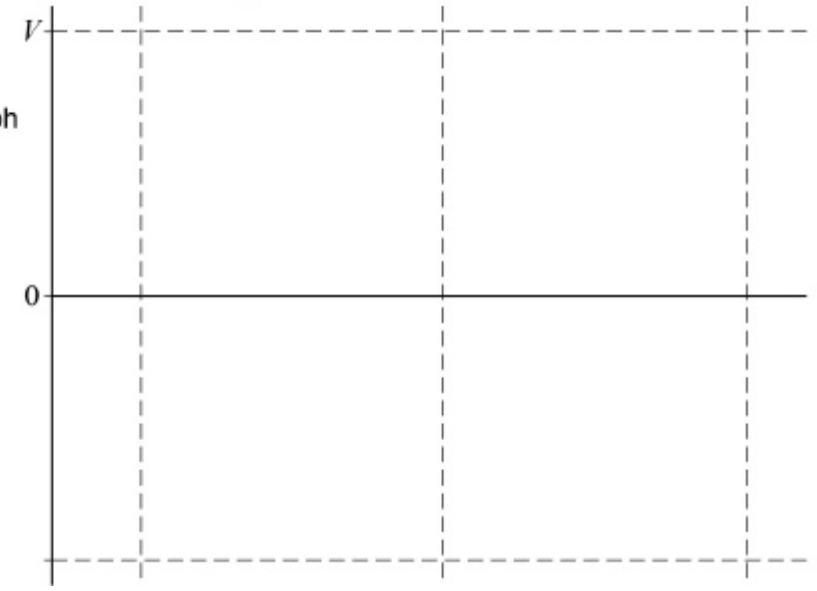



**Figure 8c**



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voltage – time graph of the voltage across **R**




**(2)**

(g) State and explain what changes, if any, the student needs to make to the settings of the oscilloscope so the waveform across **R** is fully displayed.

_____

_____

_____

_____

_____

_____

_____

_____

**(2)**

**(Total 14 marks)**

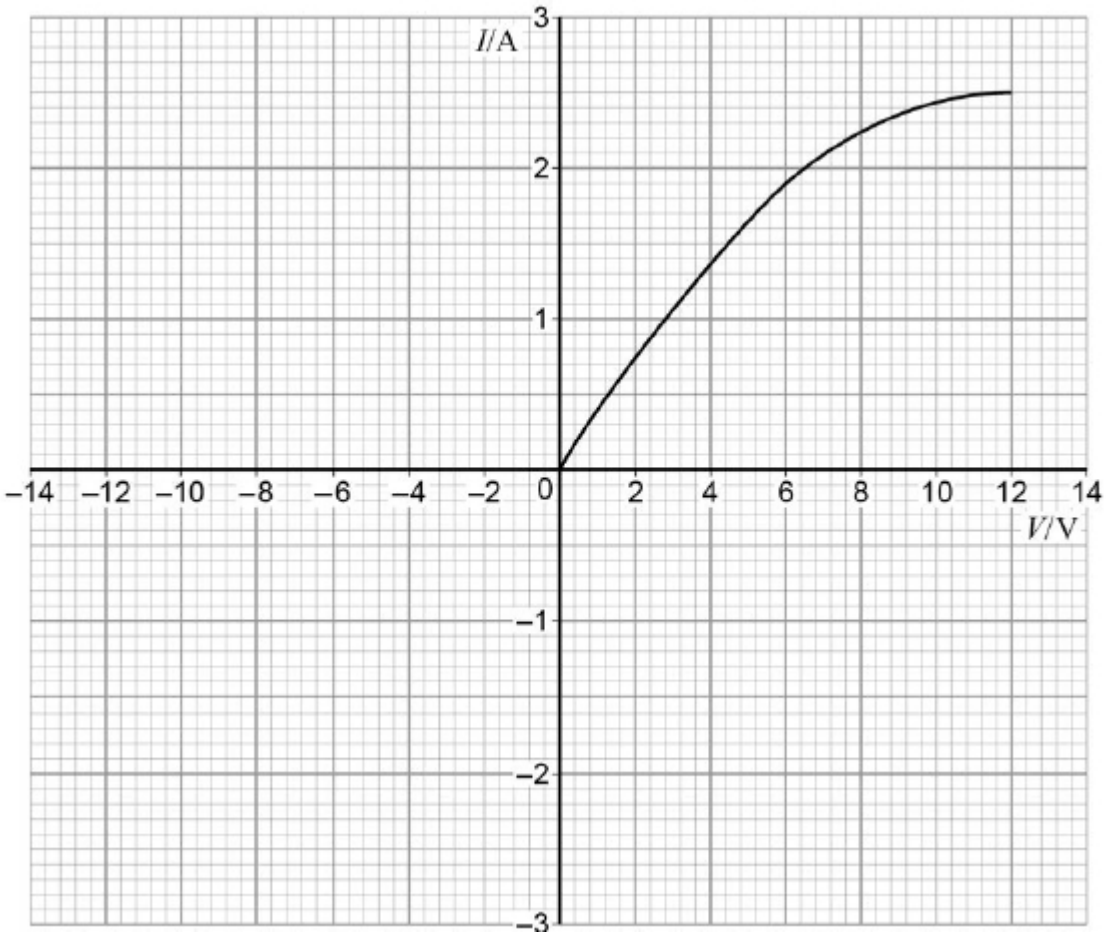
## Q35.

**Figure 1** shows the current–voltage ($I-V$) characteristic of the lamp used in a car headlight up to its working voltage.

**Figure 1**



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(a) Draw on **Figure 1** the characteristic that would be obtained with the connections to the supply reversed.

**(2)**

(b) Lamps are marked with their working voltage and the power used at this voltage. For example, a lamp for use in a torch may be marked 2.5 V 0.3 W.

Deduce the marking on the lamp for the car headlight.

lamp marking =_____ V _____ W

**(2)**

(c) Determine the resistance of the lamp when the potential difference (pd) across it is half the working voltage.



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resistance _____ Ω

**(1)**

(d) Explain, without further calculation, how the resistance of the lamp varies as the voltage across it is increased from zero to its working voltage.

_____

_____

_____

_____

_____

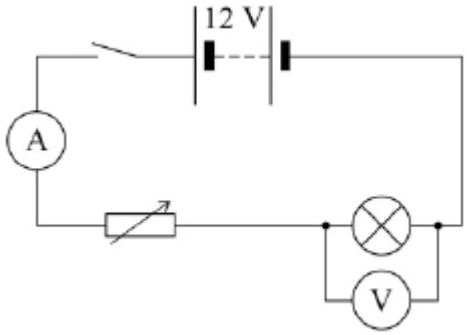
_____

_____

**(3)**

(e) A student suggests that the circuit shown in **Figure 2** is suitable for collecting data to draw the *I*−*V* characteristic of the lamp up to its working voltage. The maximum resistance of the variable resistor is 6.0 Ω and the internal resistance of the power supply is 2.0 Ω. The resistance of the ammeter is negligible.

**Figure 2**




Discuss the limitations of this circuit when used to collect the data for the characteristic.

_____

_____

_____

_____

**(2)**

**(Total 10 marks)**

## Q36.

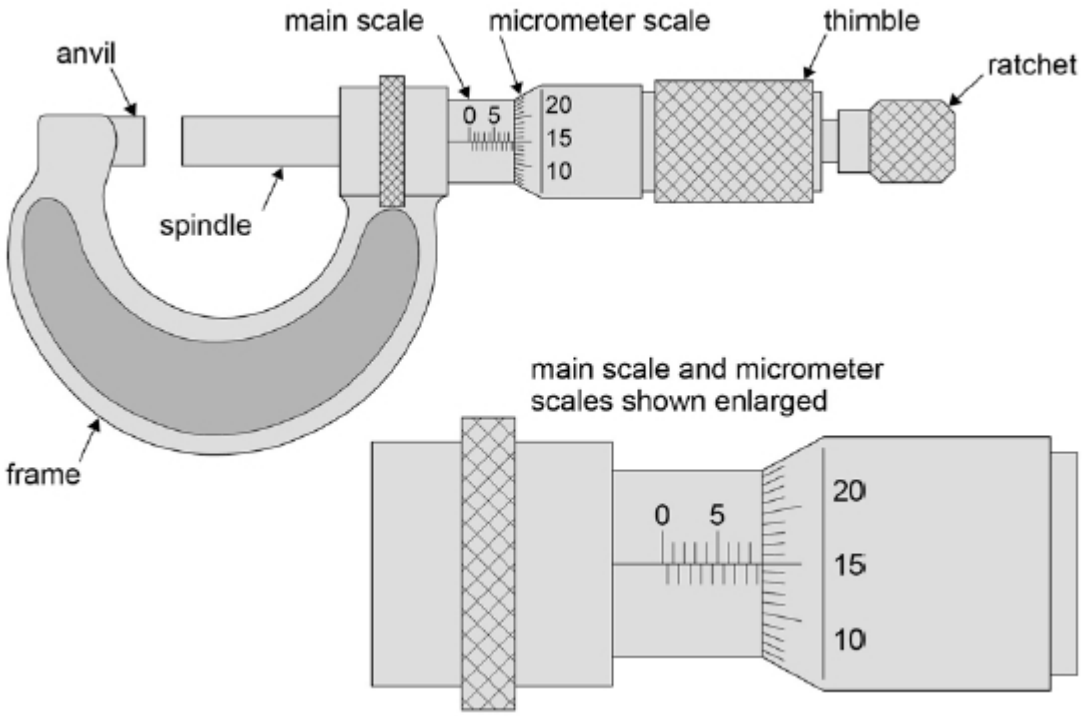
This question is about the determination of the resistivity of a wire.



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**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)**

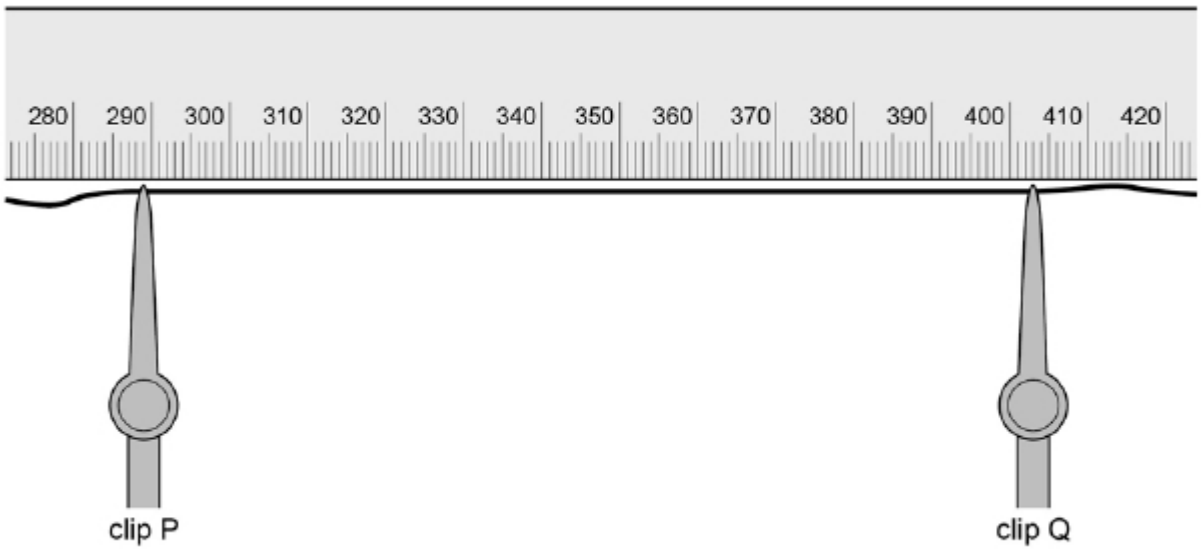
(c) A student must also determine the length $L$ of the wire between clips P and Q that will be connected into a circuit.



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**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 $L$.

_____

_____

_____



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**(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)**

## Q37.

The units of physical quantities can be expressed in terms of the fundamental (base) units of the SI system. In which line in the table are the fundamental units correctly matched to



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the physical quantity?

| | Physical quantity | Fundamental units | |
|---|---|---|---|
| **A** | charge | A $s^{-1}$ | ⊙ |
| **B** | power | kg $m^2$ $s^{-3}$ | ⊙ |
| **C** | potential difference | kg $m^2$ s $A^{-1}$ | ⊙ |
| **D** | energy | kg $m^2$ $s^{-1}$ | ⊙ |

**(Total 1 mark)**

## Q38.

When the temperature of a copper wire increases, its ability to conduct electricity

**A** remains the same. ⊙

**B** increases. ⊙

**C** decreases. ⊙

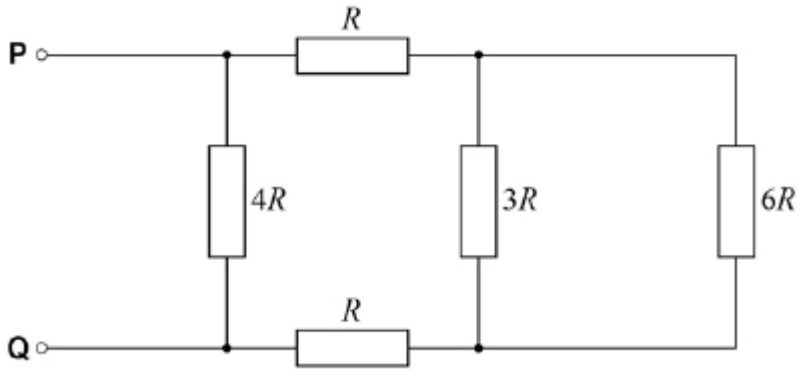
**D** remains the same at first and then increases. ⊙

**(Total 1 mark)**

## Q39.

The diagram shows a network of resistors connected between the terminals **P** and **Q**.

The resistance of each resistor is shown.




What is the effective resistance between **P** and **Q**?

**A** $R$ ⊙

**B** $2R$ ⊙



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**C** $3R$ ⬭

**D** $4R$ ⬭

**(Total 1 mark)**

## Q40.

A metal wire has a length $l$ and a cross-sectional area $A$. When a potential difference $V$ is applied to the wire, there is a current $I$ in the wire.

What is the resistivity of the wire?

**A** $\frac{IA}{Vl}$ ⬭

**B** $\frac{VA}{Il}$ ⬭

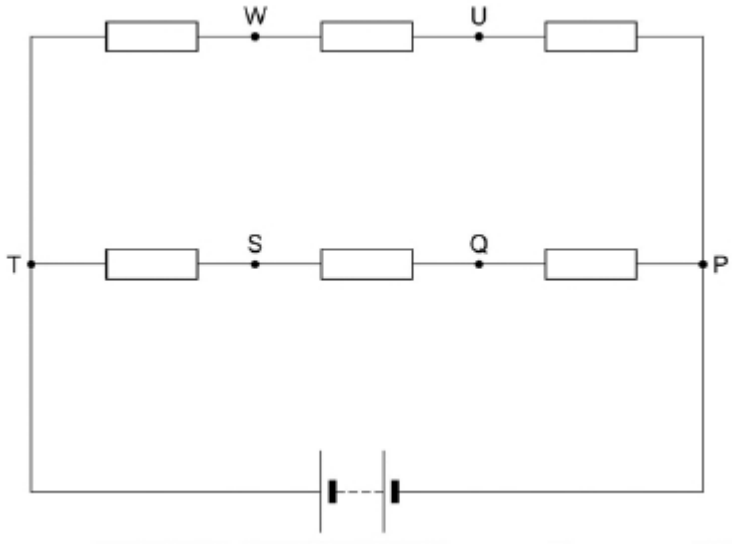
**C** $\frac{Il}{VA}$ ⬭

**D** $\frac{Vl}{IA}$ ⬭

**(Total 1 mark)**

## Q41.

In the circuit shown below, each of the resistors has the same resistance.




A voltmeter with very high resistance is connected between two points in the circuit.

Between which two points of connection would the voltmeter read zero?

**A** Q and U ⬭



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**B** P and T ⬭

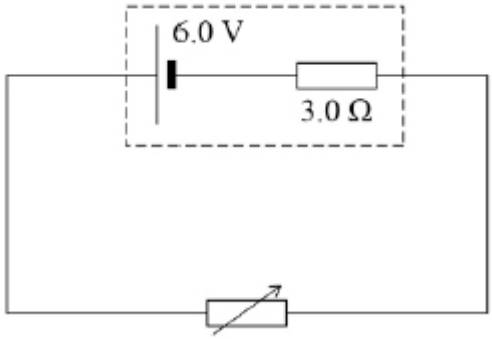
**C** Q and W ⬭

**D** S and U ⬭

**(Total 1 mark)**

## Q42.

The cell in the following circuit has an emf (electromotive force) of 6.0 V and an internal resistance of 3.0 Ω. The resistance of the variable resistor is set to 12 Ω.




How much electrical energy is converted into thermal energy **within the cell** in 1 minute?

**A** 0.48 J ⬭

**B** 29 J ⬭

**C** 45 J ⬭

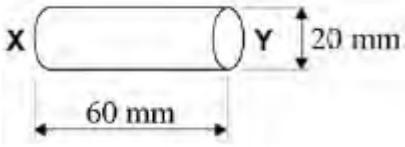
**D** 144 J ⬭

**(Total 1 mark)**

## Q43.

**Figure 1** shows a cylinder of conducting putty which is 60 mm long and 20 mm in diameter.

**Figure 1**




(a) The conducting putty obeys Ohm's law.

State Ohm's law.

_____

_____



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**(1)**

(b) A 1.50 V dc supply of negligible internal resistance is connected across the ends **X** and **Y** of the cylinder of putty. The resistance of the cylinder of putty is 20.0 Ω.

Calculate, in mA, the current in the putty.

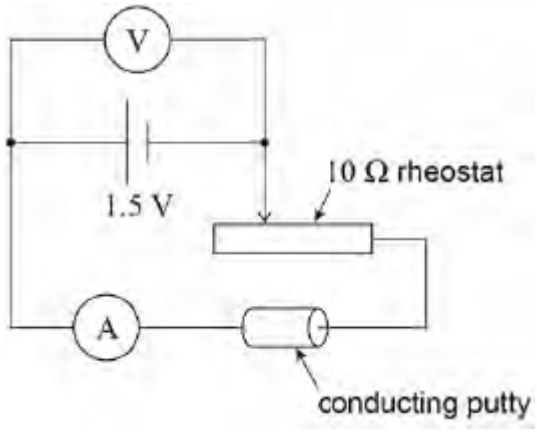
current = _____ mA

**(1)**

(c) A student suggests an arrangement for demonstrating that the putty obeys Ohm's law.

Discuss any problems that make the circuit and components shown in **Figure 2** unsuitable for this purpose.

**Figure 2**






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_____

_____

_____

**(4)**

(d) Show that the resistivity ρ of the putty can be calculated using the formula

$$\rho = \frac{R}{l^2} \times \textit{volume of the cylinder}$$

where $R$ is the resistance of the cylinder and $l$ is the length of the cylinder.

**(1)**

(e) Calculate, using the formula in part **(d)**, the resistivity of the putty. Give an appropriate unit for your answer.

resistivity = _____ unit = _____

**(3)**

**(Total 10 marks)**

## Q44.

When a constant potential difference (pd) is applied across the ends of a uniform wire there is a current $I$ in the wire.

The wire is replaced by one made from the same material, but of double the length and double the diameter. The same pd is applied across the ends.

What is the new current?

**A** $4I$ ⬭

**B** $2I$ ⬭

**C** $\frac{I}{2}$ ⬭

**D** $\frac{I}{4}$ ⬭

**(Total 1 mark)**



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## Q45.

A pd $V$ is applied across a resistor. Another identical resistor is then connected in series with it and the same pd $V$ is applied across the combination.

Which statement is **incorrect**?

**A** The total resistance is doubled. ⊙

**B** The pd across one resistor is $\frac{V}{2}$. ⊙

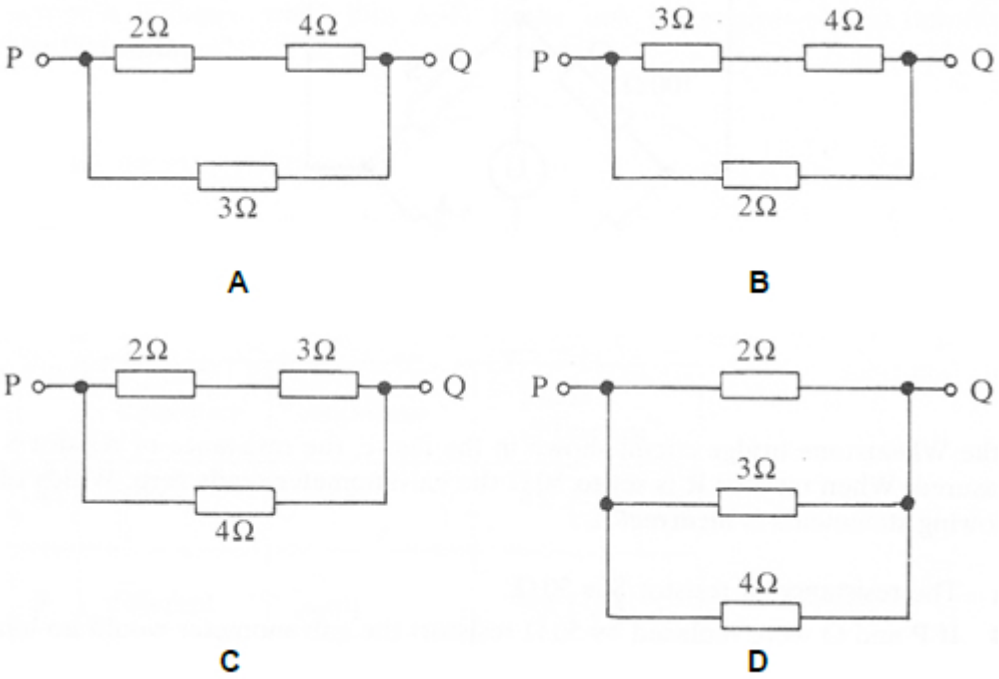
**C** The current in the resistors is halved. ⊙

**D** The power dissipated in one resistor is halved. ⊙

**(Total 1 mark)**

## Q46.

Which resistor arrangement has the greatest value of resistance?




**A** ⊙

**B** ⊙

**C** ⊙

**D** ⊙

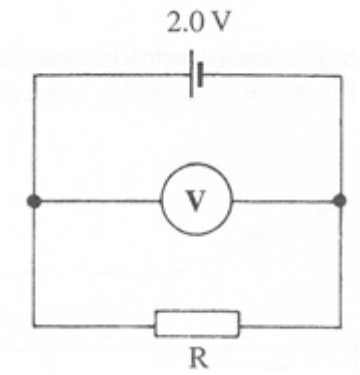
**(Total 1 mark)**



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## Q47.

The cell in the following circuit has an emf of 2.0 V and an internal resistance of 1.0 Ω.




The digital voltmeter reads 1.6 V. What is the resistance of R?

**A** 0.4 Ω ⬭

**B** 1.0 Ω ⬭

**C** 2.0 Ω ⬭

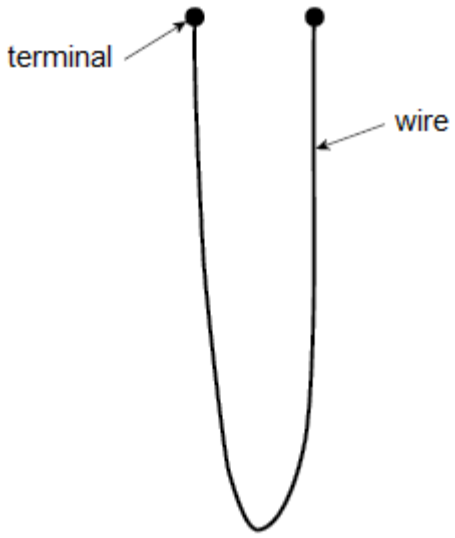
**D** 4.0 Ω ⬭

**(Total 1 mark)**

## Q60.

A wire probe is used to measure the rate of corrosion in a pipe carrying a corrosive liquid. The probe is made from the same metal as the pipe. **Figure 1** shows the probe. The rate of corrosion of the wire in the probe is the same as in the pipe.

**Figure 1**




(a) The wire in an unused probe has a resistance of 0.070 Ω and a length of 0.50 m.

Calculate the diameter of the wire.



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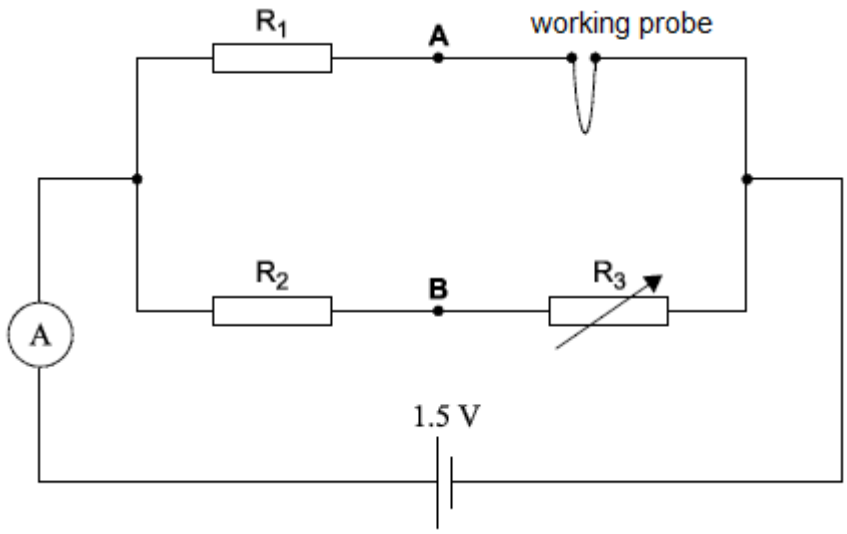
resistivity of metal in the wire = $9.7 \times 10^{-8}$ Ω m

diameter = _____ m

**(3)**

(b) In order to measure the resistance of a used working probe, it is connected in the circuit shown in **Figure 2**.

**Figure 2**




When $R_3$ is adjusted to a particular value the current in the cell is 0.66 A.

Calculate the total resistance of the circuit.
You may assume that the cell has a negligible internal resistance.

resistance = _____ Ω

**(1)**

(c) The resistance of $R_2$ is 22 Ω and the resistance of $R_3$ is 1.2 Ω.

Calculate the current in $R_3$.



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current = _____ A

**(1)**

(d) Calculate the resistance of the probe when the resistance of $R_1$ is 2.4 Ω.

resistance = _____ Ω

**(3)**

(e) Calculate the percentage change in the diameter of the probe when its resistance increases by 1.6 %.

percentage change = _____ %

**(2)**

(f) A voltmeter is connected between points **A** and **B** in the circuit and $R_3$ stays at 1.2 Ω.

Explain, without calculation, why the reading on the voltmeter does not change when the cell in the circuit is replaced with another cell of the same emf but a significant internal resistance.

_____

_____

_____

_____

_____

**(2)**

**(Total 12 marks)**

## Q61.

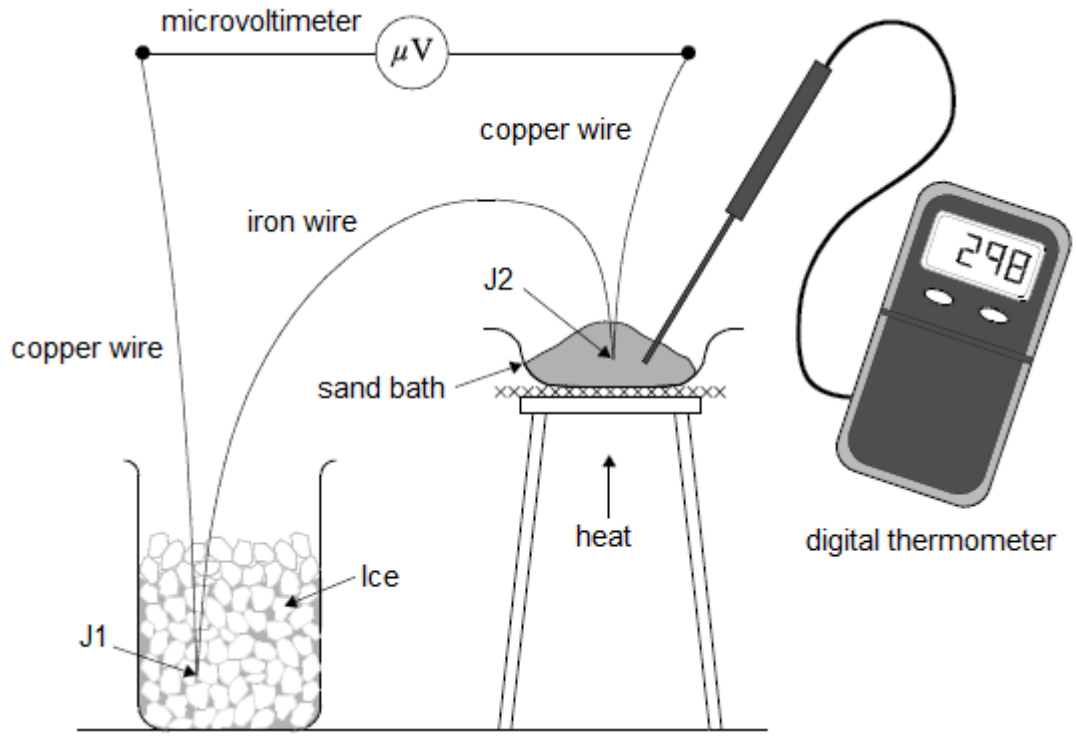
Lengths of copper and iron wire are joined together to form junctions J1 and J2. When J1 and J2 are at different temperatures an emf $\varepsilon$ is generated between them. This emf is measured using a microvoltmeter.

**Figure 1** shows J1 kept at 0 °C while J2 is heated in a sand bath to a temperature $\theta$ measured by a digital thermometer.



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**Figure 1**




An experiment is carried out to determine how $\varepsilon$ depends on $\theta$.

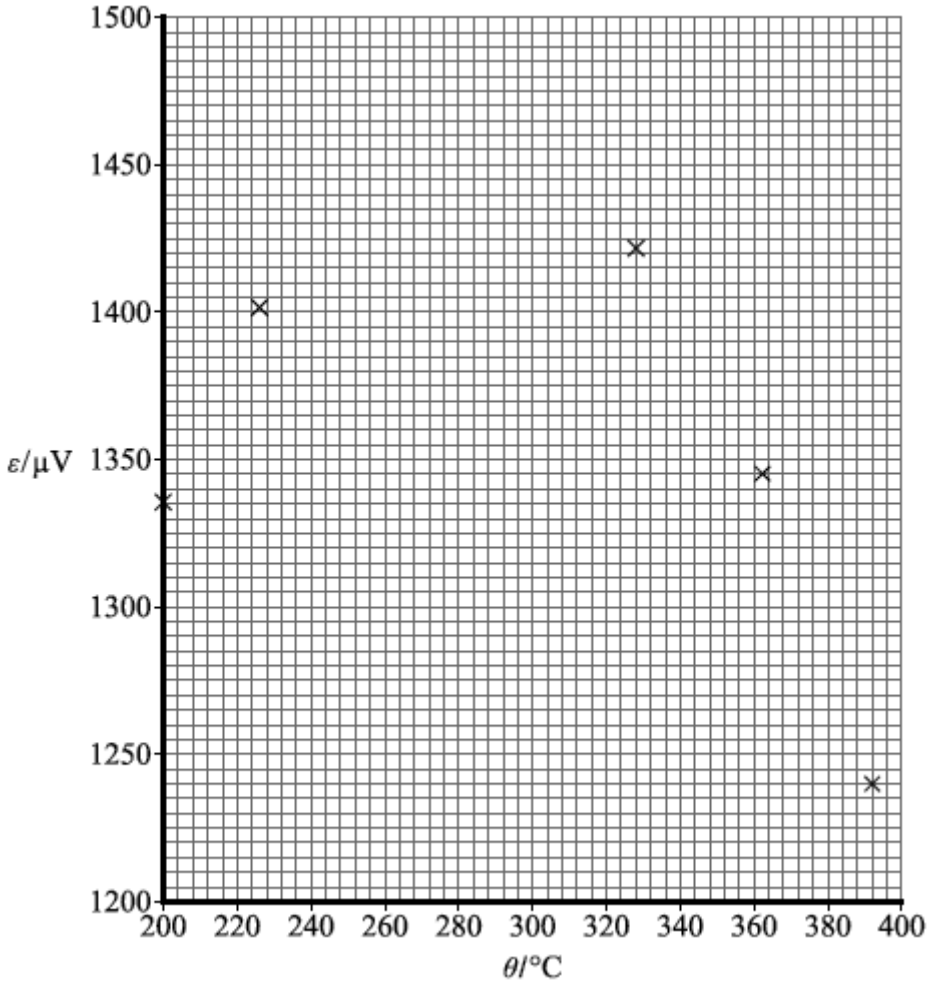
The results of the experiment are shown in the table below and a graph of the data is shown in **Figure 2**.

| $\theta$ / °C | $\varepsilon$ / μV |
|---|---|
| 200 | 1336 |
| 226 | 1402 |
| 258 | 1450 |
| 298 | 1456 |
| 328 | 1423 |
| 362 | 1345 |
| 392 | 1241 |

**Figure 2**



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(a) Plot the points corresponding to $\theta$ = 258 °C and $\theta$ = 298 °C on **Figure 2**.

**(1)**

(b) Draw a suitable best fit line on **Figure 2**.

**(1)**

(c) Determine the maximum value of $\varepsilon$.

maximum value of $\varepsilon$ = _____ μV

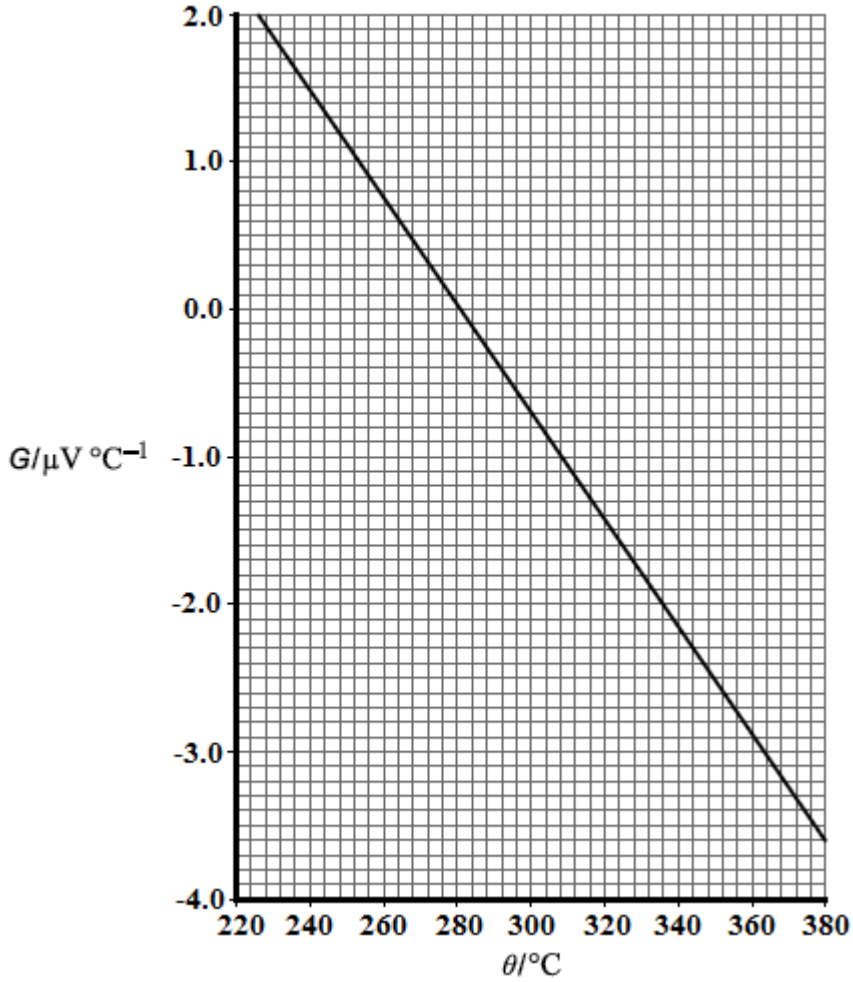
**(1)**

(d) The gradient *G* of the graph in **Figure 2** is measured for values of $\theta$ between 220 °C and 380 °C. A graph of *G* against $\theta$ is plotted in **Figure 3**.

**Figure 3**



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The neutral temperature $\theta_n$ is the temperature corresponding to the maximum value of $\varepsilon$. $\theta_n$ can be determined using either **Figure 2** or **Figure 3**.

Explain why a more accurate result for $\theta_n$ may be obtained using **Figure 3**.

**(1)**

(e) It can be shown that $G$ is given by

$$G = \beta\theta + \alpha$$

where $\alpha$ and $\beta$ are constants.

Determine $\alpha$.



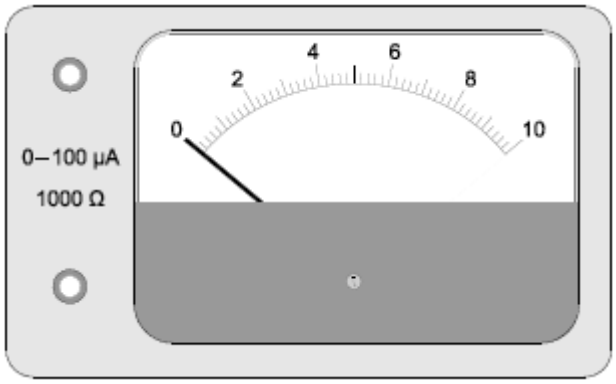
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$\alpha$ = _____ μV °C$^{-1}$

**(2)**

(f) A student decides to carry out a similar experiment. The student thinks the meter in **Figure 4** could be used as the microvoltmeter to measure $\varepsilon$.

**Figure 4**




When this meter indicates a maximum reading and the needle points to the right-hand end of the scale (full-scale deflection), the current in the meter is 100 μA. The meter has a resistance of 1000 Ω.

Calculate the full-scale deflection of this meter when used as a microvoltmeter.

full-scale deflection = _____ μV

**(1)**

(g) The scale on the meter has 50 divisions between zero and full-scale deflection.

Discuss why this meter is not suitable for carrying out the experiment.

_____

_____

_____

_____

_____

_____

**(2)**



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**(Total 9 marks)**

## Q62.

A Radioisotope Thermonuclear Generator (RTG) is a device that uses some of the energy from radioactive decay to generate electricity. The Mars rover Curiosity includes an RTG that contains plutonium-238. The plutonium undergoes alpha decay and some of the energy is used to generate about 100 W of electrical power.

(a) Complete the equation for the alpha decay of plutonium-238.

$$^{238}_{94}\mathrm{Pu} \rightarrow \ _____{92}\mathrm{U} + \frac{____}{____}\alpha$$

**(2)**

(b) Only 6% of the energy from the decay is used to generate electricity.

Calculate the rate at which energy is transferred from the decay of plutonium-238 on Curiosity.

rate of energy transfer = _____ W

**(1)**

(c) The RTG has a constant output voltage of 32 V.

Calculate the current when the output power is 100 W.

current = _____ A

**(1)**

(d) Calculate the maximum number of components, each of resistance 45 Ω, that can be connected in parallel across the RTG before the maximum output power is reached.



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number of components = _____

**(2)**

(e) The alternative to using an RTG is to use a solar panel.
A typical solar panel installation on a house roof in the UK provides about 1000 kW h of electricity each year.

Calculate the average electrical power output of the installation.

average power output = _____ W

**(2)**

(f) The maximum intensity of the sunlight on the surface of Mars at its equator is similar to that in the UK.

Estimate, using your answer to **part (e)**, the area of the solar panel needed to provide an average power output of 100 W on Mars. Give your answer to an appropriate order of magnitude.

order of magnitude of area = _____ $m^2$

**(1)**

**(Total 9 marks)**

## Q63.

The current in a wire is 20 mA.

How many electrons pass a point in the wire in 2 minutes?

**A** $2.5 \times 10^{17}$ ⬭

**B** $1.5 \times 10^{19}$ ⬭

**C** $2.5 \times 10^{20}$ ⬭

**D** $1.5 \times 10^{22}$ ⬭

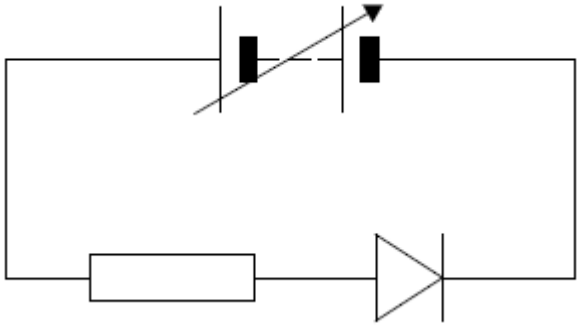
**(Total 1 mark)**

## Q64.

A resistor and diode are connected in series with a variable power supply as shown in the diagram.

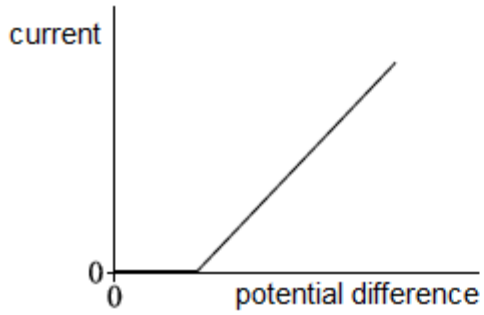


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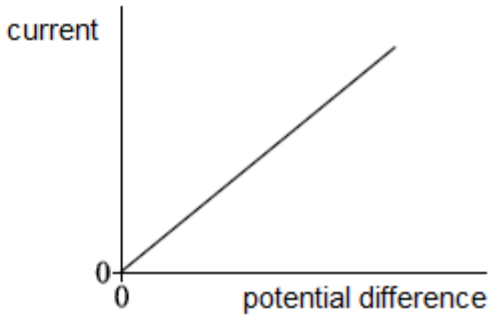


Which best shows the characteristic for the combination of the resistor and diode?

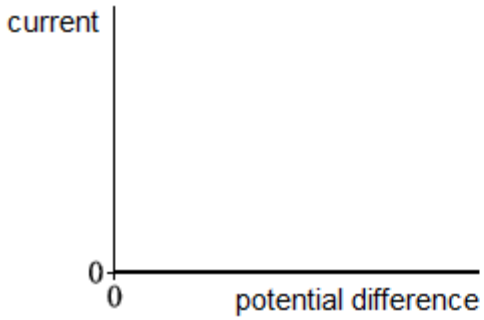
**A**



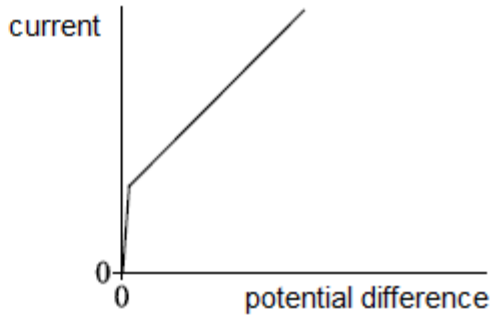

**B**




**C**




**D**




**A** ⬭

**B** ⬭

**C** ⬭

**D** ⬭

**(Total 1 mark)**

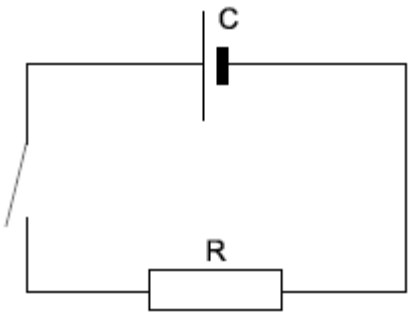
## Q65.

A cell C of negligible resistance and a switch are in series with a resistor R. The switch is moved to the on (closed) position for a time $t$.

Which change reduces the amount of charge flowing through R in time $t$?



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**A** add an identical cell in parallel with C ⬭

**B** add an identical cell in series with C ⬭

**C** add a second resistor in series with R ⬭

**D** add a second resistor in parallel with R ⬭

**(Total 1 mark)**

## Q66.

The National Grid uses high-voltage transmission lines to carry electrical power around the UK. A particular transmission line delivers 800 MW of power at 132 kV to the user. It loses 1% of the transmitted power as heat.

What is the resistance of the transmission line?

**A** 0.2 Ω ⬭

**B** 6 Ω ⬭

**C** 20 Ω ⬭

**D** 2000 Ω ⬭

**(Total 1 mark)**

## Q67.

A potential divider circuit consists of a battery connected across a thermistor and variable resistor in series.

Which of the following causes the potential difference (pd) across the thermistor to increase?

**A** increasing the temperature of the thermistor ⬭

**B** increasing the resistance of the variable resistor ⬭

**C** reducing the emf of the battery ⬭

**D** adding a resistor across the variable ⬭



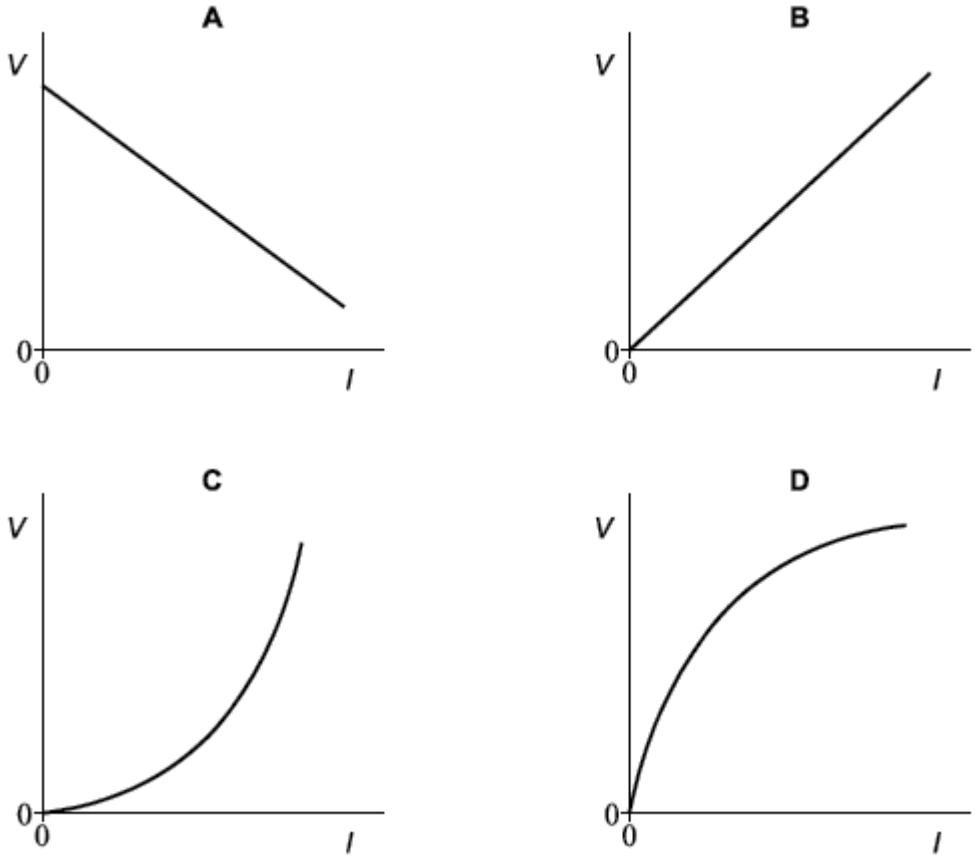
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resistor

**(Total 1 mark)**

## Q68.

A student investigates how the potential difference *V* across the terminals of a cell varies with the current *I* in the cell.




Which graph correctly shows how *V* varies with *I*?

**A** ⬭

**B** ⬭

**C** ⬭

**D** ⬭

**(Total 1 mark)**

## Q69.

A battery is connected to a 10 Ω resistor and a switch in series. A voltmeter is connected across the battery. When the switch is open (off) the voltmeter reads 1.45 V. When the switch is closed the reading is 1.26 V.

What is the internal resistance of the battery?



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**A** 0.66 Ω ⬭

**B** 0.76 Ω ⬭

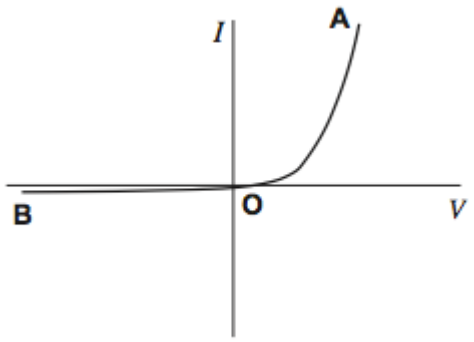
**C** 1.3 Ω ⬭

**D** 1.5 Ω ⬭

**(Total 1 mark)**

## Q70.

(a) The graph shows the current–voltage ($I$–$V$) characteristic curve for a semiconductor diode.




In order to produce this characteristic a student is given suitable equipment including an ammeter and a voltmeter.

(i) Draw a labelled circuit diagram of the apparatus that the student could use to obtain the part of the characteristic from **O** to **A**.

**(2)**

(ii) Describe how the student could use the circuit in part (a)(i) to obtain sufficient measurements to draw the part of the characteristic from **O** to **A**. Your account should include:

- details of how different readings of $I$ and $V$ are obtained
- a consideration of safety precautions when using the diode
- a discussion of the range and number of measurements that need to be taken
- a discussion of the advantages of using a data logger to obtain the measurements.

The quality of your written communication will be assessed in your answer.



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**(6)**

(iii) Suggest how the circuit you drew in part (a)(i) could be modified to obtain the characteristic from **O** to **B**.

**(1)**

(b) The student wants to find out how the resistance of the diode changes between **O** and **A**.

(i) Describe how the student could use the characteristic to determine how the resistance varies as the potential difference (pd) between **O** and **A** increases.

**(2)**

(ii) State how you would expect the resistance of the diode to vary as the pd increases.

**(1)**

**(Total 12 marks)**



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## Q71.

An electric oven is connected to a 230 V root mean square (rms) mains supply using a cable of negligible resistance.

(a) (i) Calculate the peak-to-peak voltage of the mains supply.

peak-to-peak voltage = _____ V

**(2)**

(ii) The resistance of the heating element in the oven at its working temperature is 12 Ω.

Calculate the power dissipated by the heating element in the oven.
Give your answer to an appropriate number of significant figures.

power = _____ W

**(3)**

(b) In practice the resistance of the cable connecting the oven to the mains supply is not negligible. Each of the **two** wires connecting the heating element to the mains electricity supply has a length of 3.15 m. Each metre of wire has a resistance of 0.0150 Ω.

(i) Explain why the rms voltage across the heating element in the oven will be less than 230 V.

_____

_____

_____

_____

**(2)**

(ii) Calculate the rms voltage across the heating element in the oven when it is at its working temperature.

rms voltage = _____ V

**(3)**

(iii) Calculate the average power wasted in the cable due to the heating effect of



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the electric current.

average power = _____ W

**(2)**

(iv) State **two** reasons why it is important that the cable has a low resistance.

1. _____

_____

_____

2. _____

_____

_____

**(2)**

**(Total 14 marks)**

## Q72.

**Figure 1** shows a circuit that includes an oscilloscope used to find the internal resistance $r$ of a battery.

**Figure 1**

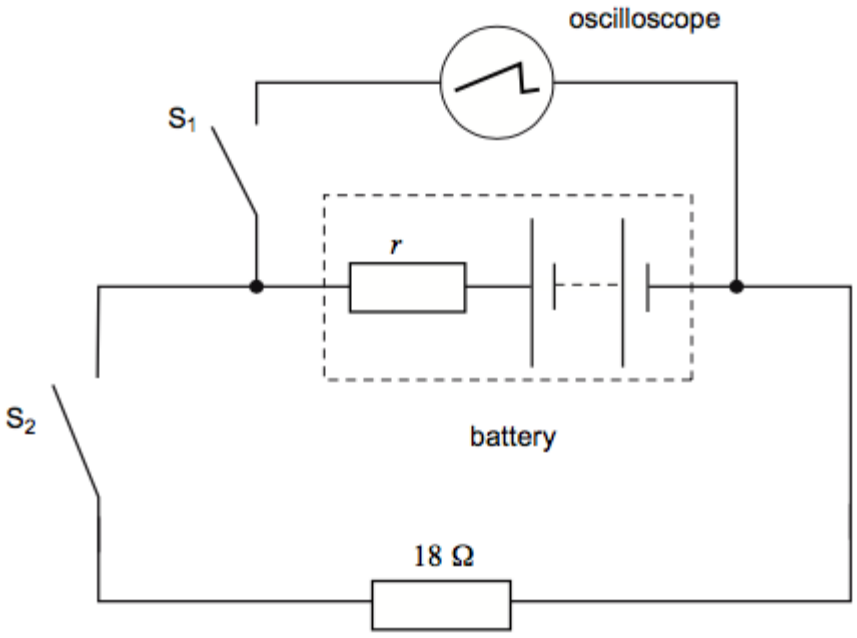
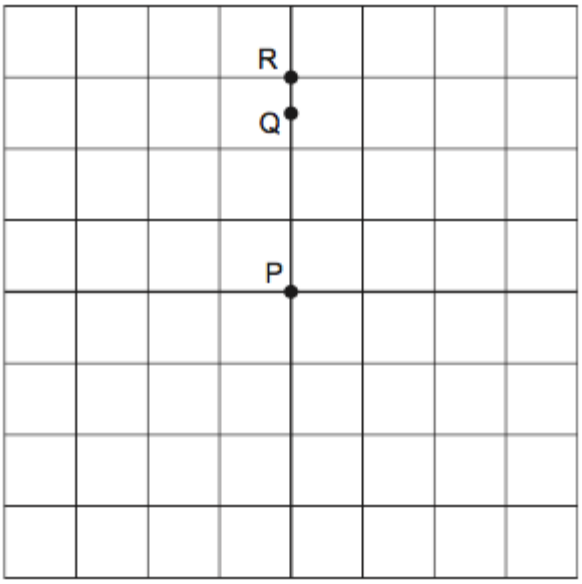



**Figure 2** represents the screen of the oscilloscope. With switches $S_1$ and $S_2$ open, a bright spot is seen on the screen at P.



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**Figure 2**




The vertical sensitivity of the oscilloscope is set at 2.0 V per division.

(a) Explain why the oscilloscope shows a bright spot rather than a horizontal line.

_____

_____

**(1)**

(b) When switch $S_1$ is closed, the spot moves to R.

(i) State the electrical property of the battery represented by the deflection PR.

_____

_____

**(1)**

(ii) Determine the value of the electrical quantity represented by the deflection PR.

electrical quantity = _____

**(1)**

(c) With switch $S_1$ kept closed, switch $S_2$ is also closed. The spot moves to Q.

Explain why the spot moves from R to Q.

_____

_____



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_____

_____

_____

**(3)**

(d) Calculate the current in the battery when both switches are closed.

current = _____ A

**(2)**

(e) Calculate the internal resistance of the battery.

internal resistance = _____ Ω

**(2)**

**(Total 10 marks)**

## Q73.

State what is meant by a superconductor.

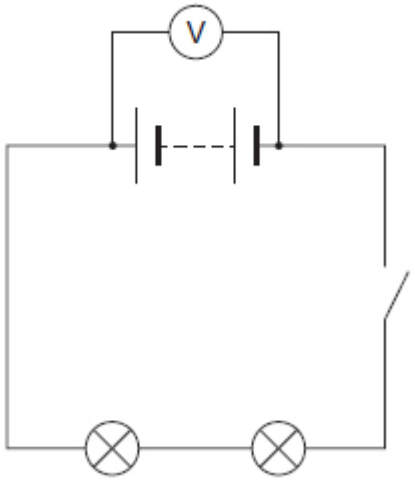
_____

_____

**(Total 1 mark)**

## Q74.

The diagram shows an electrical circuit in a car. A voltmeter of very high resistance is used to measure the potential difference across the terminals of the battery.






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(a) Define potential difference.

_____

_____

**(1)**

(b) Explain how and why the voltmeter reading changes when the switch is closed.

_____

_____

_____

_____

_____

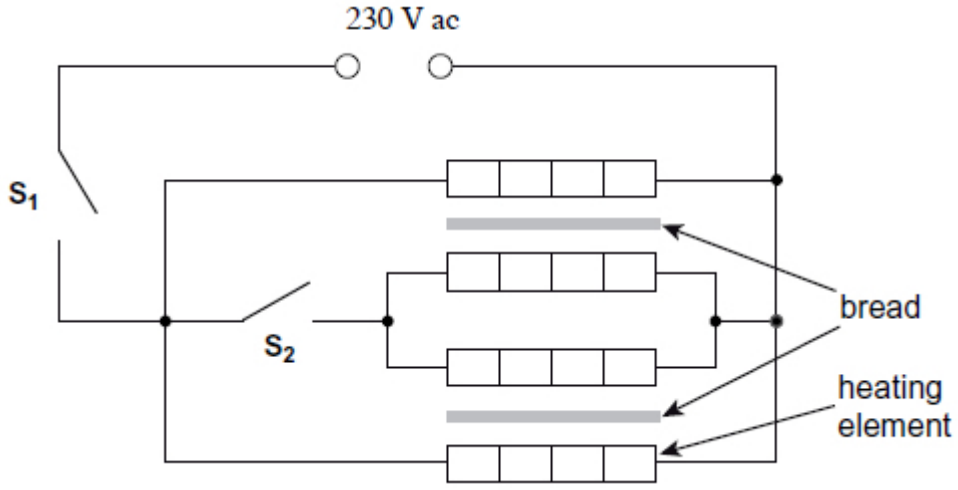
_____

**(3)**

**(Total 4 marks)**

## Q75.

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 **$S_1$** and **$S_2$**.

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

| **Setting** | **$S_1$** | **$S_2$** | **Power / W** |
|---|---|---|---|
| Low | closed | open | 400 |
| Normal | closed | closed | 800 |

(a) Calculate the current in **$S_2$** when the normal setting is selected.



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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 = $1.1 \times 10^{-6}$ Ω m

length of wire _____ m

**(3)**

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

_____

_____

_____

_____

_____

**(3)**

(d) The nichrome wire has an equilibrium temperature of 174°C when the toaster is operating.

Calculate the peak wavelength of the electromagnetic radiation emitted by the wire.

Give your answer to an appropriate number of significant figures.



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peak wavelength _____ m

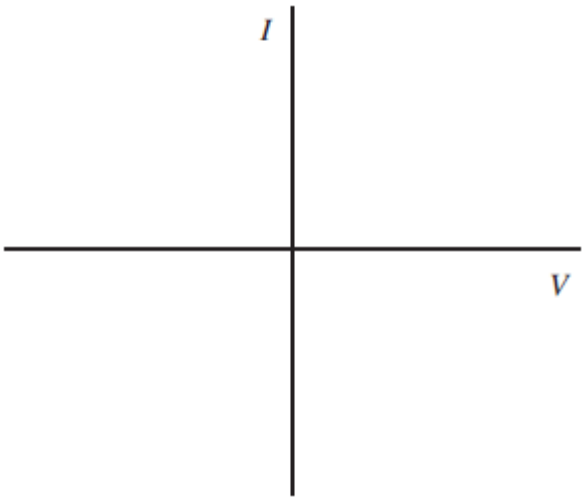
**(3)**

**(Total 15 marks)**

## Q76.

(a) Sketch, on **Figure 1**, the current−voltage ($IV$) characteristic for a filament lamp for currents up to its working power.

**Figure 1**




**(2)**

(b) (i) State what happens to the resistance of the filament lamp as the current increases.

_____

**(1)**

(ii) State and explain whether a filament lamp is an ohmic or non−ohmic conductor up to its working power.

_____

_____

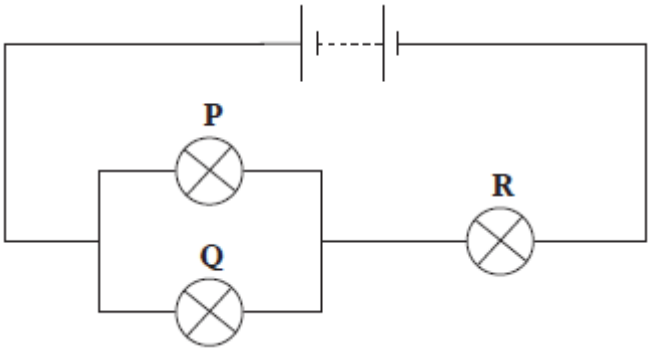
**(1)**

(c) Three identical filament lamps, **P**, **Q** and **R** are connected in the circuit shown in **Figure 2**.

**Figure 2**.



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The filament in lamp **Q** melts so that it no longer conducts. Explain why lamp **P** becomes brighter and lamp **R** becomes dimmer.

_____

_____

_____

_____

_____

_____

**(2)**

(d) A filament lamp, **X**, is rated at 60 W 230 V. Another type of lamp, **Y**, described as 'energy saving' has the same light intensity output but is rated at 11 W 230 V.

(i) Calculate the electrical energy converted by each lamp if both are on for 4 hours a day for a period of 30 days.

electrical energy converted by **X** = _____ J

electrical energy converted by **Y** = _____ J

**(2)**

(ii) Suggest why the two lamps can have different power ratings but have the same light intensity output.

_____

_____



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_____

_____

_____

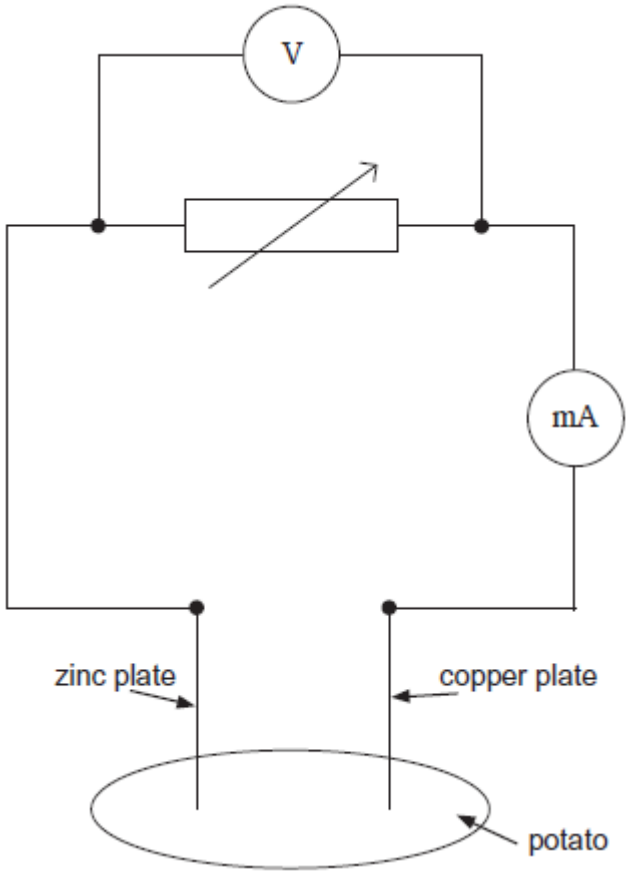
**(2)**

**(Total 10 marks)**

## Q77.

A 'potato cell' is formed by inserting a copper plate and a zinc plate into a potato. The circuit shown in **Figure 1** is used in an investigation to determine the electromotive force and internal resistance of the potato cell.

**Figure 1**




(a) State what is meant by electromotive force.

_____

_____

_____

_____

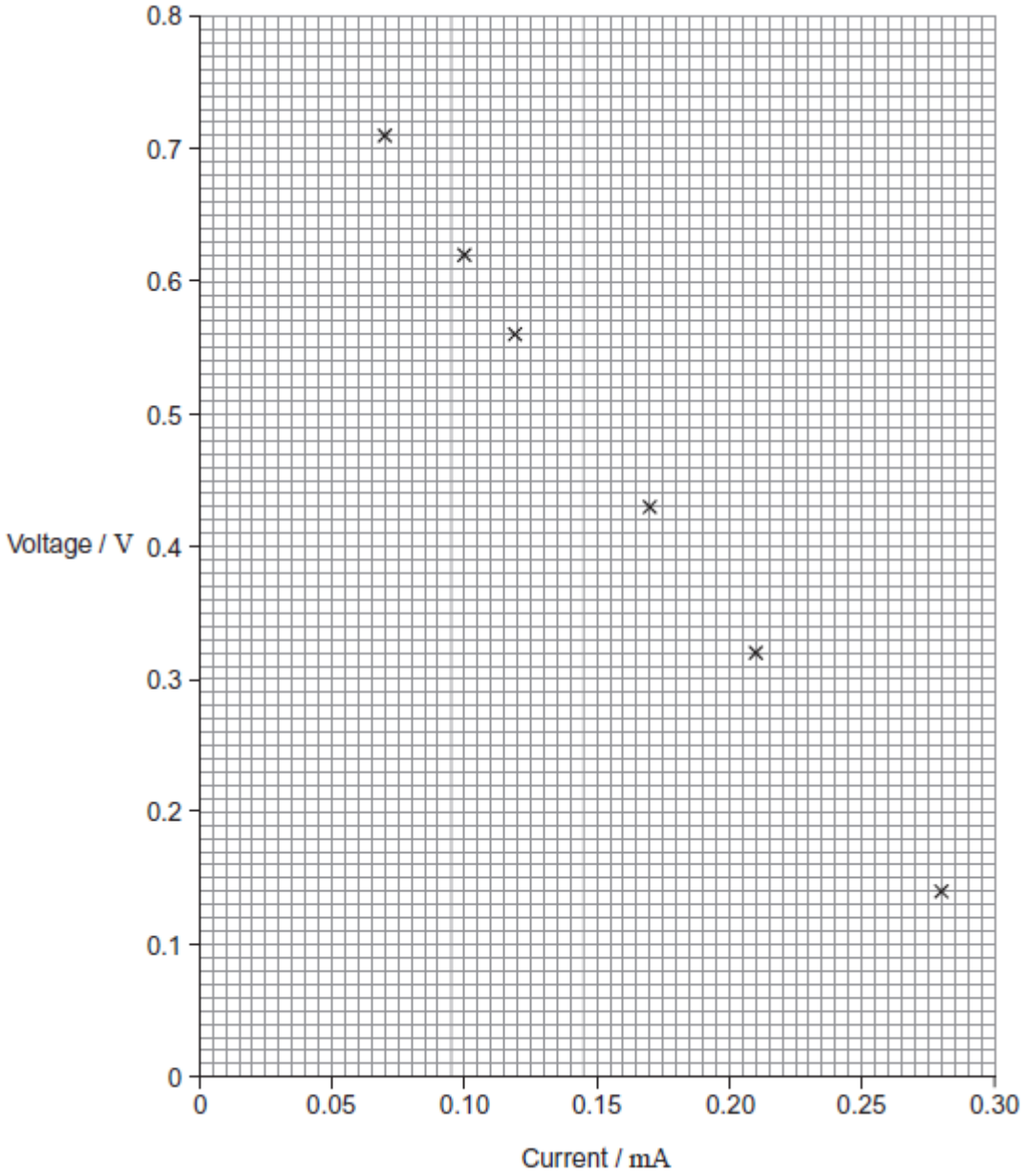
**(2)**

(b) The plotted points on **Figure 2** show the data for current and voltage that were obtained in the investigation.



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**Figure 2**




(i) Suggest what was done to obtain the data for the plotted points.

_____

_____

_____

_____

**(1)**

(ii) The electromotive force (emf) of the potato cell is 0.89 V. Explain why the voltages plotted on **Figure 2** are always less than this and why the difference between the emf and the plotted voltage becomes larger with increasing current.

_____



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_____

_____

_____

_____

_____

_____

**(3)**

(iii) Use **Figure 2** to determine the internal resistance of the potato cell.

internal resistance = _____ Ω

**(3)**

(c) A student decides to use two potato cells in series as a power supply for a light emitting diode (LED). In order for the LED to work as required, it needs a voltage of at least 1.6 V and a current of 20 mA.

Explain whether the LED will work as required.

_____

_____

_____

_____

_____

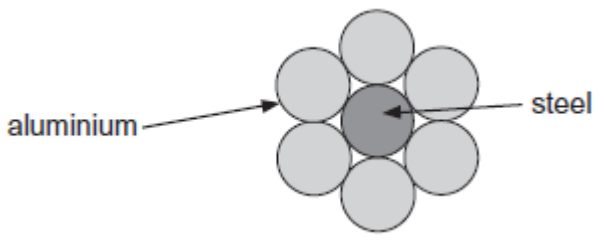
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**(2)**

**(Total 11 marks)**

## Q78.

A cable used in high-voltage power transmission consists of six aluminium wires surrounding a steel wire. A cross-section is shown below.






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The resistance of a length of 1.0 km of the steel wire is 3.3 Ω. The resistance of a length of 1.0 km of **one** of the aluminium wires is 1.1 Ω.

(a) The steel wire has a diameter of 7.4 mm.
Calculate the resistivity of steel. State an appropriate unit.

resistivity = _____ unit _____

**(4)**

(b) Explain why only a small percentage of the total current in the cable passes through the steel wire.

_____

_____

_____

_____

_____

_____

_____

**(3)**

(c) The potential difference across a length of 1.0 km of the cable is 75 V.

Calculate the total power loss for a 1.0 km length of cable.

Total power loss _____ W

**(3)**

**(Total 10 marks)**

## Q79.

(a) (i) Describe how you would make a direct measurement of the emf $\mathcal{E}$ of a cell, stating the type of meter you would use.

_____

_____

**(1)**



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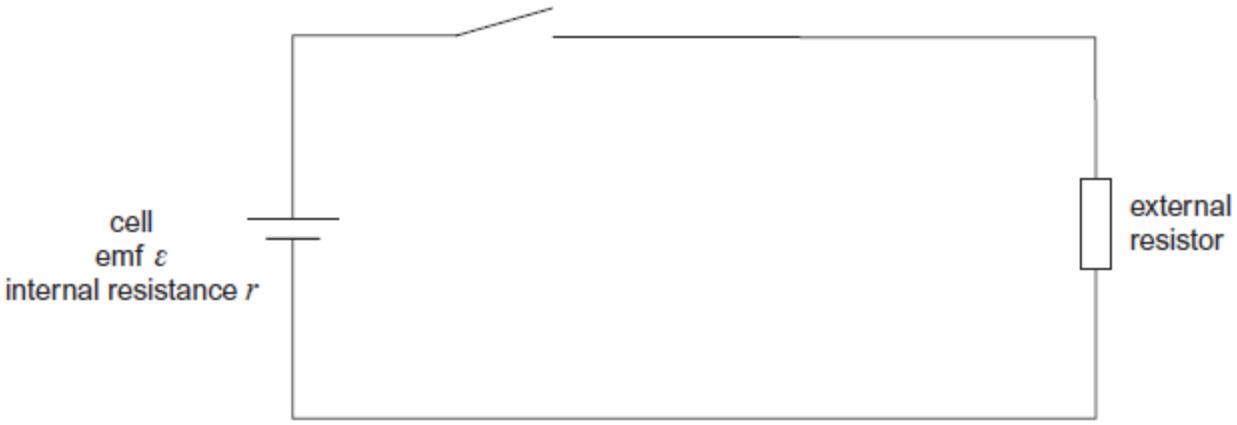
(ii) Explain why this meter must have a very high resistance.

_____

_____

**(1)**

(b) A student is provided with the circuit shown in the diagram below.




The student wishes to determine the efficiency of this circuit.

In this circuit, useful power is dissipated in the external resistor. The total power input is the power produced by the battery.

$$\text{Efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

The efficiency can be determined using two readings from a voltmeter.

(i) Show that the efficiency = $\frac{V}{\varepsilon}$ where $\varepsilon$ is the emf of the cell

and $V$ is the potential difference across the external resistor.

**(1)**

(ii) Add a voltmeter to the diagram and explain how you would use this new circuit to take readings of $\varepsilon$ and $V$.

_____

_____

_____

**(2)**



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(c) Describe how you would obtain a set of readings to investigate the relationship between efficiency and the resistance of the external resistor. State any precautions you would take to ensure your readings were reliable.

**(2)**

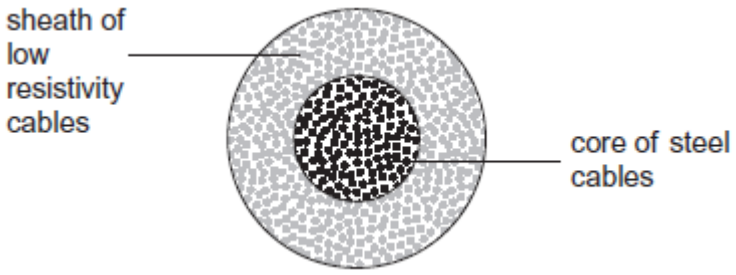
(d) State and explain how you would expect the efficiency to vary as the value of $R$ is increased.

**(2)**

**(Total 9 marks)**

## Q80.

The overhead cables used to transmit electrical power by the National Grid usually consist of a central core of steel cables surrounded by a sheath of cables of low resistivity material, such as aluminium.




What is the main purpose of the steel core?

**A** To force more current into the outer sheath.



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**B** To provide additional current paths through the cables.

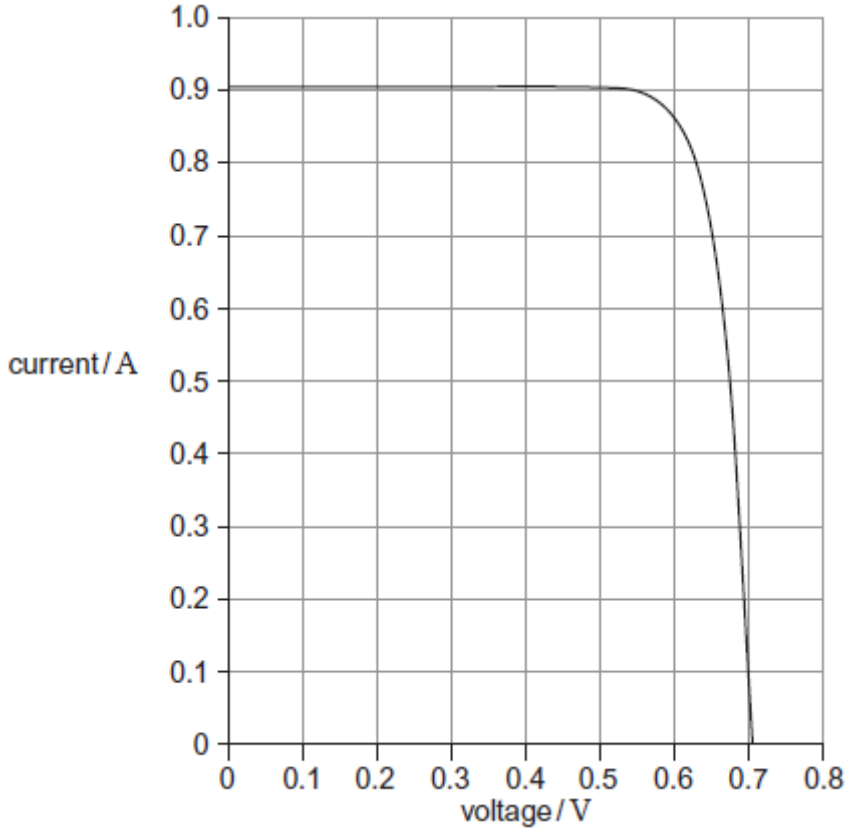
**C** To reduce the power lost from the cables.

**D** To increase the mechanical strength of the cables.

**(Total 1 mark)**

## Q81.

The graph shows the current−voltage characteristic of the output from a solar cell when light of intensity 450 W $m^{-2}$ is incident on it.




(a) (i) Using data from the graph above estimate the **maximum** power output from the solar cell.

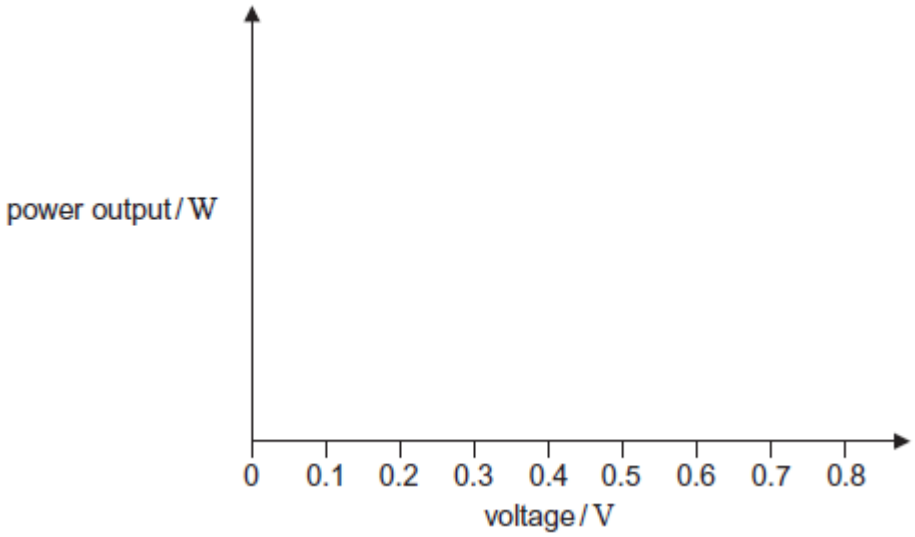
**maximum** power _____ W

**(2)**

(ii) Sketch, on the axes below, a graph to show how the power output varies with voltage for this solar cell for the same incident light intensity.



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**(2)**

(iii) When the light intensity is 450 W $m^{-2}$ the cell has an efficiency of 0.15 at the maximum power.

Calculate the area of the solar cell.

area _____ $m^2$

**(3)**

(b) A manufacturer has a supply of solar cells that each have an electromotive force (emf) of 0.70 V and an internal resistance of 0.78 Ω when delivering maximum power.

(i) Explain what is meant by an emf of 0.70 V.

_____

_____

**(1)**

(ii) The manufacturer uses a number of these solar cells in an array to make a power supply that has an emf of 14 V and an internal resistance of 3.9 Ω when delivering maximum power.

Describe and explain the arrangement of cells the manufacturer has to use in this array. Go on to calculate the number of cells the manufacturer needs to make the power supply.

_____

_____



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number of cells _____

**(4)**

(c) Communications satellites use solar cells to generate electrical power. Discuss why solar cells are appropriate for this task.

Your answer should refer to:

- any additional features that would be needed to ensure that the satellite's electrical systems operate continuously
- whether solar cell arrays are appropriate for space probes that travel to the edge of the solar system.

The quality of your written communication will be assessed in your answer.

**(6)**

**(Total 18 marks)**

## Q245.

According to semiconductor theory, the forward voltage across a silicon diode increases linearly with temperature, so long as the current through the diode remains constant.

When a current of 1 mA passes through a particular diode, a student measures a forward



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voltage of 0.619 V at 0 °C and 0.718 V at 100 °C.

(a) Show, using a calculation, that the change in voltage per °C is approximately $10^{-3}$ V / °C.

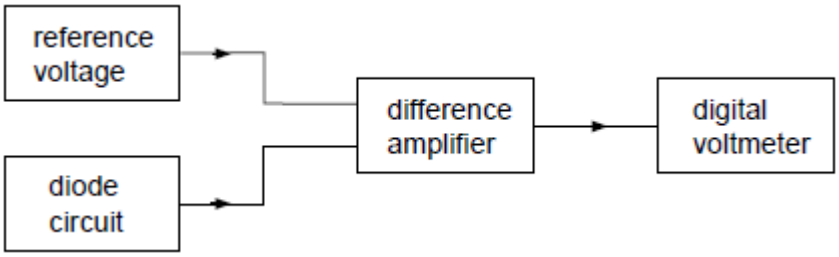
_____

_____

**(1)**

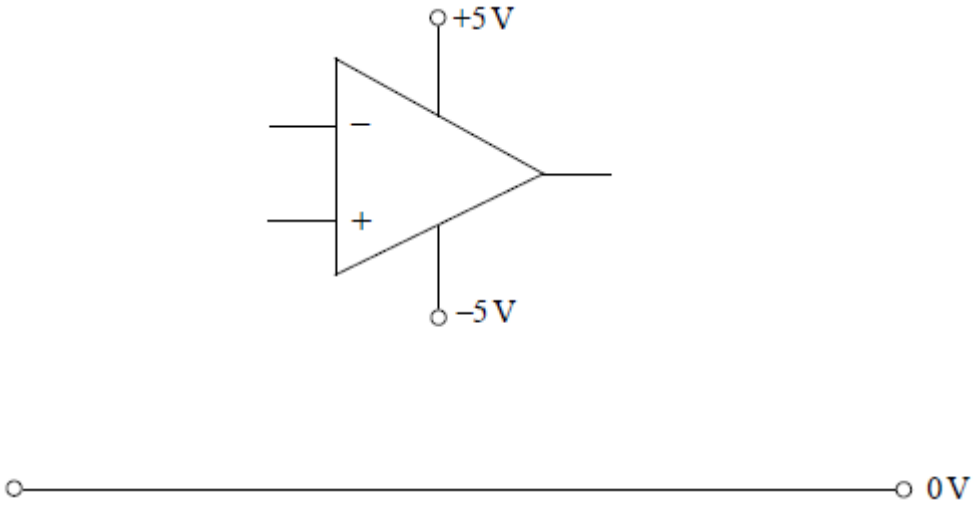
(b) The student decides to use this diode for a room thermometer project and devises the system diagram in **Figure 1**.

**Figure 1**




Complete the circuit diagram in **Figure 2** for a difference amplifier by adding **four** resistors.

**Figure 2**




**(4)**

(c) The output display for the room thermometer is a 0 to 5 V digital voltmeter that represents temperatures from 0 °C to 50 °C.
Show, using a calculation, that the difference amplifier needs to have a voltage gain of 100.

_____

_____

_____

**(3)**



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(d) The student uses 15 kΩ input resistors in his difference amplifier.
Calculate the value that both the other resistors must have to produce a voltage gain of 100.

_____

_____

_____

**(3)**

**(Total 11 marks)**



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