PEARSON EDEXCEL A-LEVEL PHYSICS · 9PH0

PHYSICS



EXAM QUESTION PACK

TOPIC 3: ELECTRIC CIRCUITS

ELECTRICAL CIRCUITS AND INTERNAL RESISTANCE

SCORE	PERCENTAGE
/450	%

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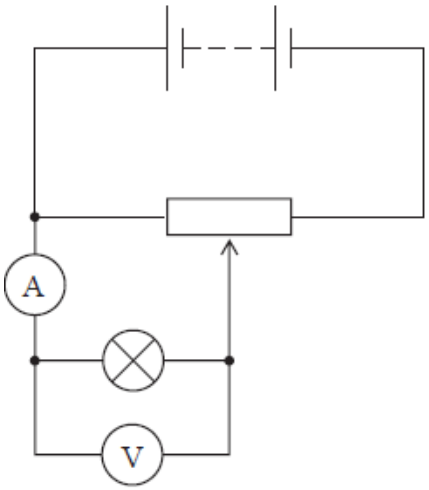
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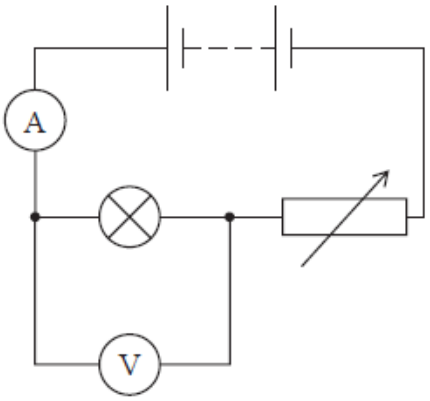
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Q1.

A student is planning to collect data to produce a current-potential difference graph for a filament lamp. Her teacher suggests two circuits that she could use.



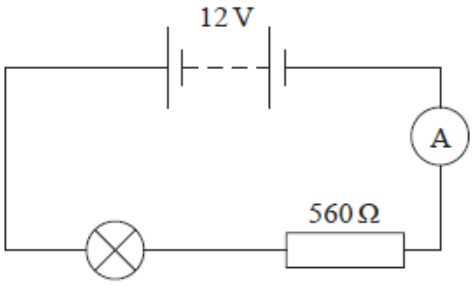
Circuit 1



Circuit 2

Circuit 1 uses a potential divider and circuit 2 uses a variable resistor to vary the potential difference across the filament lamp.

The student sets up the following circuit with the filament lamp. The battery has negligible internal resistance.



(i) The reading on the ammeter is 17.5 mA.

Calculate the value of the potential difference (p.d.) across the filament lamp.

(2)

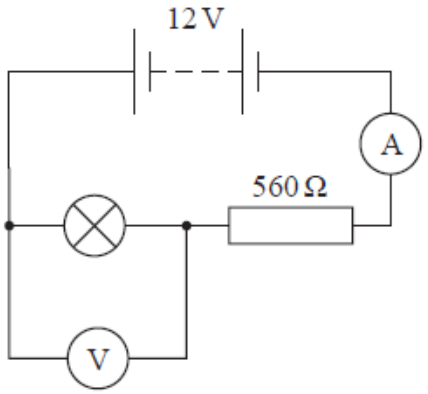
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pd across filament lamp = ...

(ii) When a voltmeter with a resistance of 1.5 kΩ is connected as shown, the p.d. across the filament lamp decreases.



Explain why the p.d. across the filament lamp decreases.

(3)

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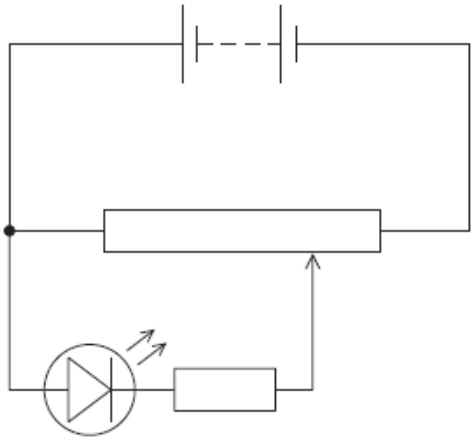
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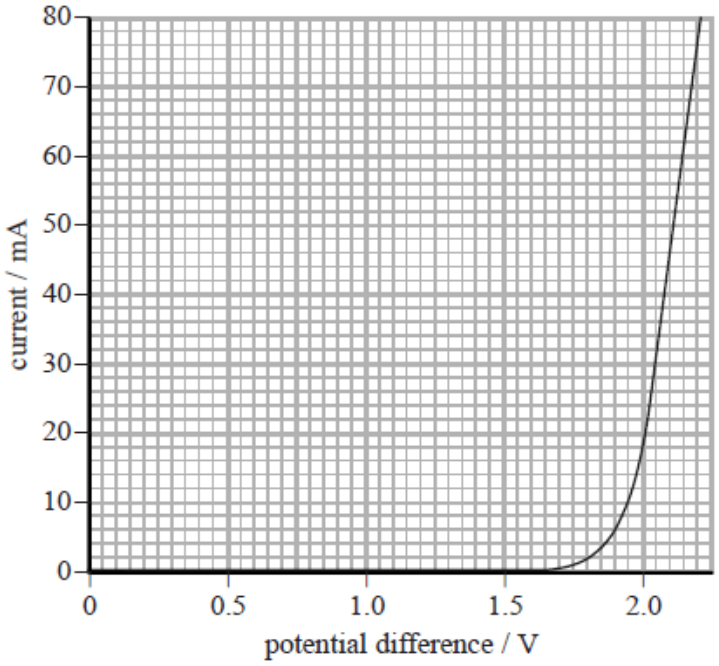
(Total for question = 5 marks)

Q2.

A student wanted to plot a graph of current against potential difference for a light emitting diode (LED). He used the circuit shown.



The graph of current against potential difference obtained by the student is shown.



(i) The student wrote the following conclusion.

"The graph shows that in general the LED is not an ohmic conductor. However, for potential differences greater than +2 V, Ohm's law is obeyed since the graph is linear in this region."

Criticise the student's conclusion.

(2)

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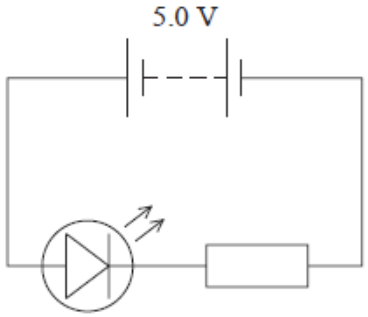
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(ii) The student used the LED with a 5.0 V power supply as shown in the circuit.



To be lit to normal brightness the current through the LED must be 18 mA.

Calculate the resistance of the resistor needed in the circuit.

(4)

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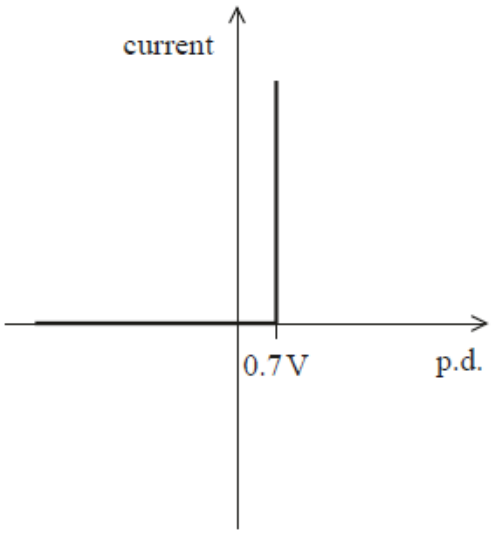
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Resistance = ...

(Total for question = 6 marks)

Q3.

The graph shows how current varies with potential difference (p.d.) for an ideal diode.



An alternating p.d. V_{IN} has a peak value of 3.4 V.

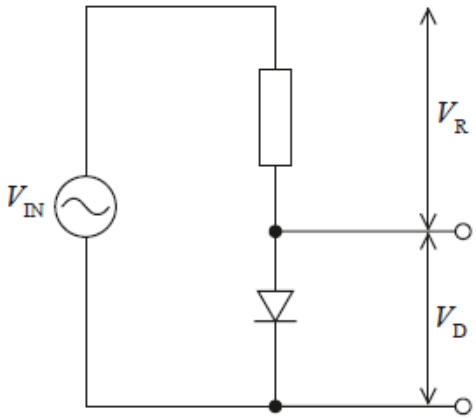
(i) Calculate the r.m.s. value.

(2)

.....

r.m.s. value = ...

(ii) V_{IN} is applied to a diode and resistor as shown.



The p.d. across the resistor is V_R and the p.d. across the diode is V_D. V_D is the output.

Explain why $V_{IN} = V_R + V_D$ at any given time.

(2)

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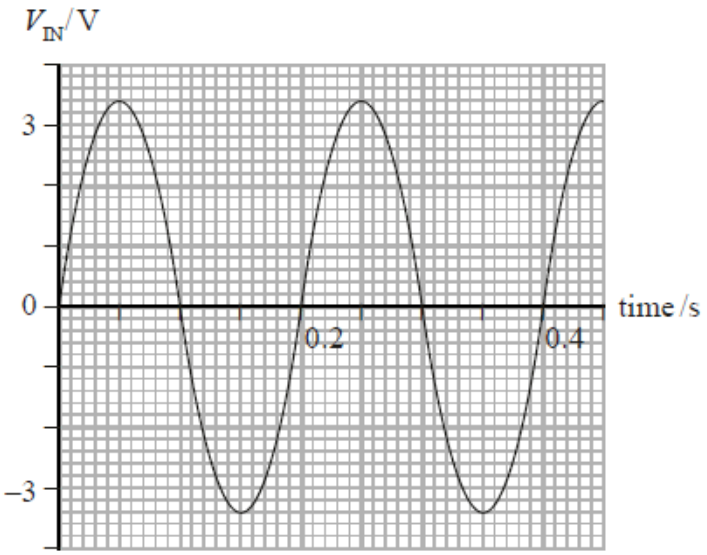
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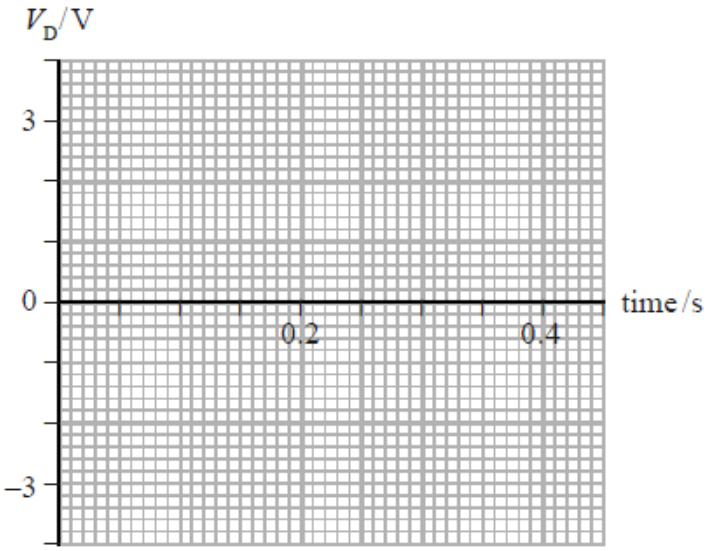
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(iii) The graph shows how V_{IN} varies with time.

Sketch a graph of V_D against time using the axes provided below.

(3)

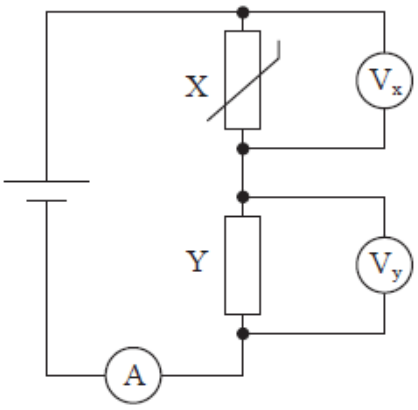




(Total for question = 7 marks)

Q4.

The diagram shows a potential divider circuit that contains a negative temperature coefficient thermistor.



The temperature of the room containing the circuit increases.

Select the row of the table that correctly shows the changes in readings on the meters.

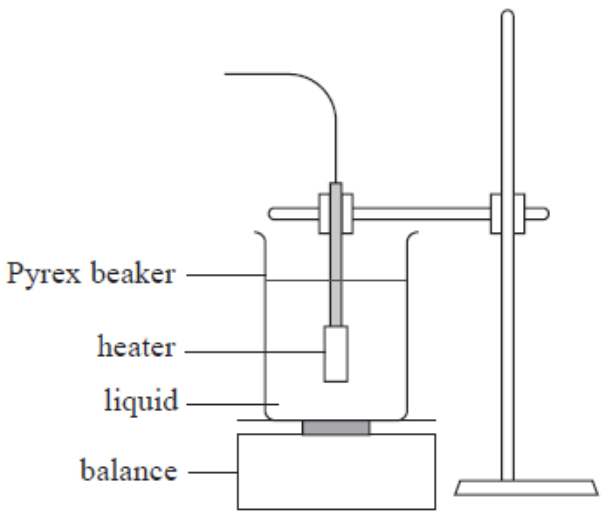
	V_x	V_y	A
☐ **A**	decrease	increase	decrease
☐ **B**	decrease	increase	increase
☐ **C**	increase	decrease	decrease
☐ **D**	increase	decrease	increase

(Total for question = 1 mark)

Q5.

A student determined the latent heat of vaporisation of a liquid using an electrical heater to boil the liquid in a Pyrex beaker.

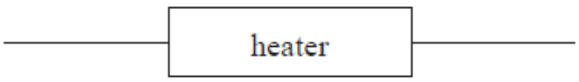
The apparatus used is shown below.



She connected the heater into a circuit and took measurements of the potential difference *V* and the current *I* for the heater.

Complete the circuit diagram to show a suitable circuit.

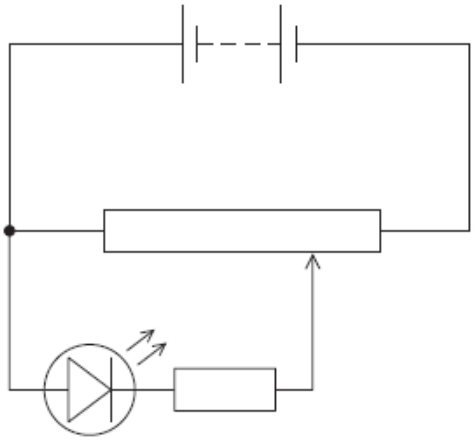
(2)



(Total for question = 2 marks)

Q6.

A student wanted to plot a graph of current against potential difference for a light emitting diode (LED). He used the circuit shown.



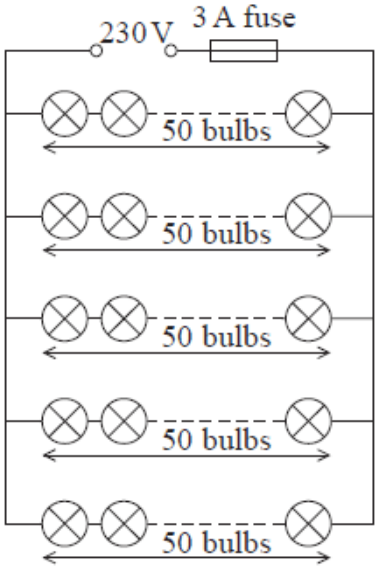
Add an ammeter and a voltmeter to the circuit diagram that would enable the data to be collected.

(1)

(Total for question = 1 mark)

Q7.

A set of festive lights is made up of five parallel strands of filament bulbs. Each strand contains 50 bulbs in series as shown.



(a) When a bulb is working normally its resistance is 8.0 Ω. If the filament of the bulb breaks, the lamp is designed to still conduct and its resistance becomes 3.0 Ω.

(i) The filament of one bulb on a strand breaks.
By considering the effect this has on the remaining bulbs in that strand, explain why it is recommended that broken bulbs are replaced as soon as possible.

(3)

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(ii) The set of festive lights are fitted with a 3 A fuse. Five bulbs in one strand break.

Determine whether the fuse blows.

(3)

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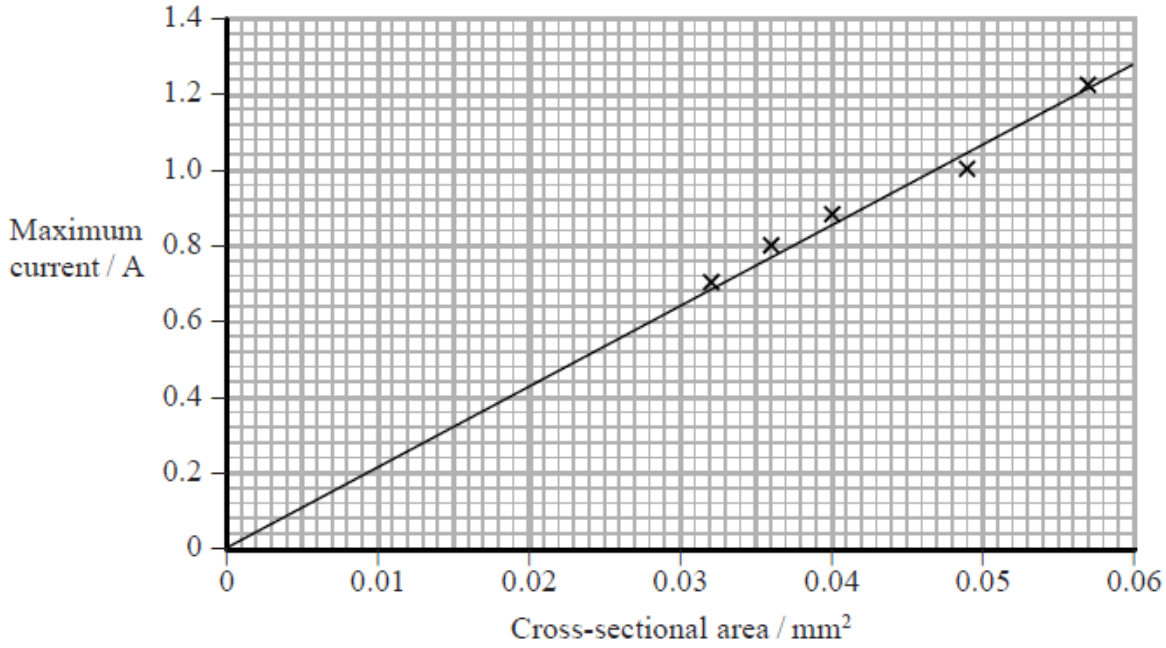
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(b) A student investigates how the cross-sectional area of a fuse wire affects the current at

which the fuse blows. She uses pieces of wire of the same material and length, but different cross-sectional areas. She steadily increases the current through each piece of wire and records the maximum current through the wire before it breaks.

She then plots a graph of maximum current against cross-sectional area.



(i) Describe how the student should determine the cross-sectional area of the wire.

(3)

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(ii) State the relationship between the maximum current and the cross-sectional area of the wire.

(1)

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(iii) The student chooses a piece of wire, of the same material and length as used in the investigation. The piece of wire has a diameter of 0.40 mm.

Use the graph to determine whether the piece of wire is suitable to use as the 3A fuse wire for the set of festive lights.

(4)

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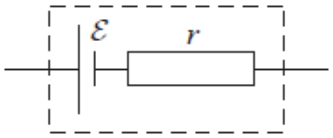
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(Total for question = 14 marks)

Q8.

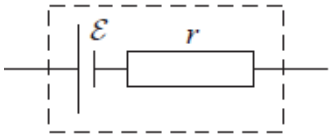
A cell may be represented as an e.m.f. ε in series with an internal resistance r.



A student used the relationship $V = \varepsilon - Ir$ and a graphical method to determine ε and r.
She connected a cell in a circuit and took a series of measurements of the current I in the cell and the potential difference V across the terminals of the cell.

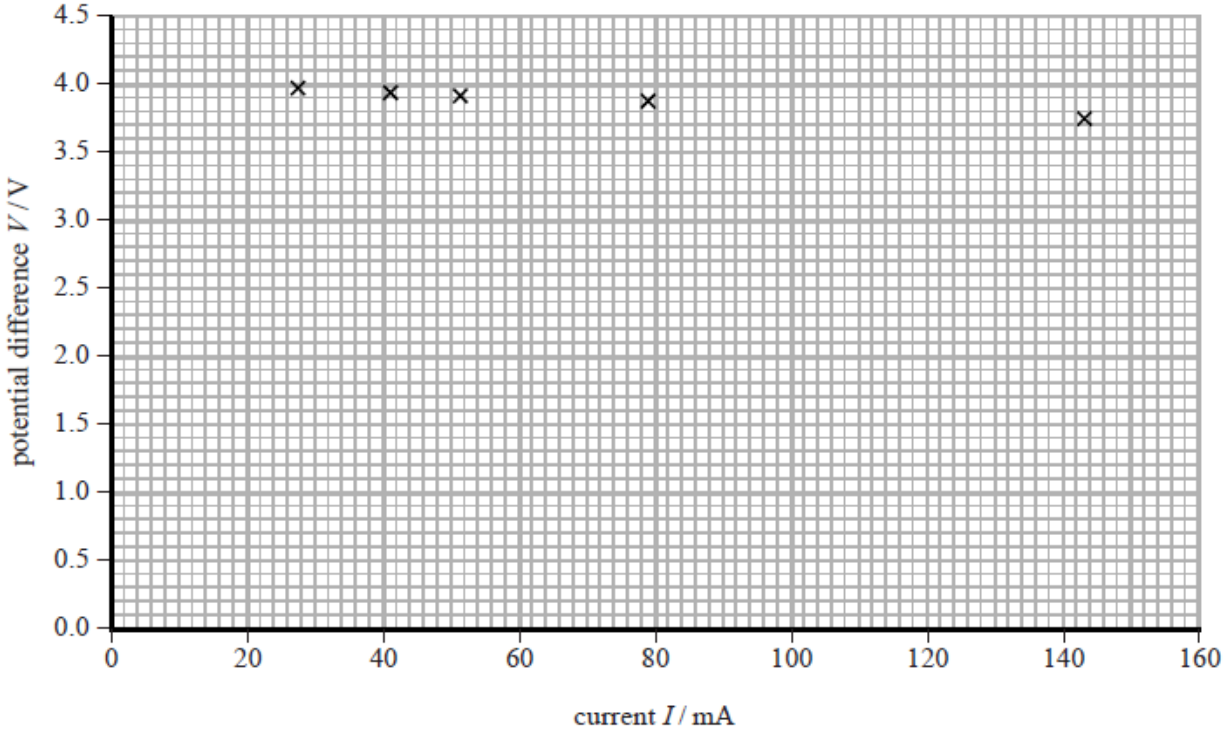
(a) Complete a circuit diagram of a circuit she could have used.

(2)



(b) The student's measurements are shown in the table and plotted on the graph.

I / mA	V / V
27.5	3.97
41.0	3.94
51.6	3.90
78.6	3.88
143.0	3.75



Determine values for ε and r from the graph and show how you obtained your answers.

(4)

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ε = ...

r = ...

(c) Explain how the graph could be constructed to obtain better values for ε and r.

(2)

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Q9.

When electromagnetic radiation is incident on a metal plate, electrons may be emitted.

(a) State what is meant by threshold frequency.

(1)

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(b) Calculate the threshold frequency for a metal with a work function of 2.28 eV.

(3)

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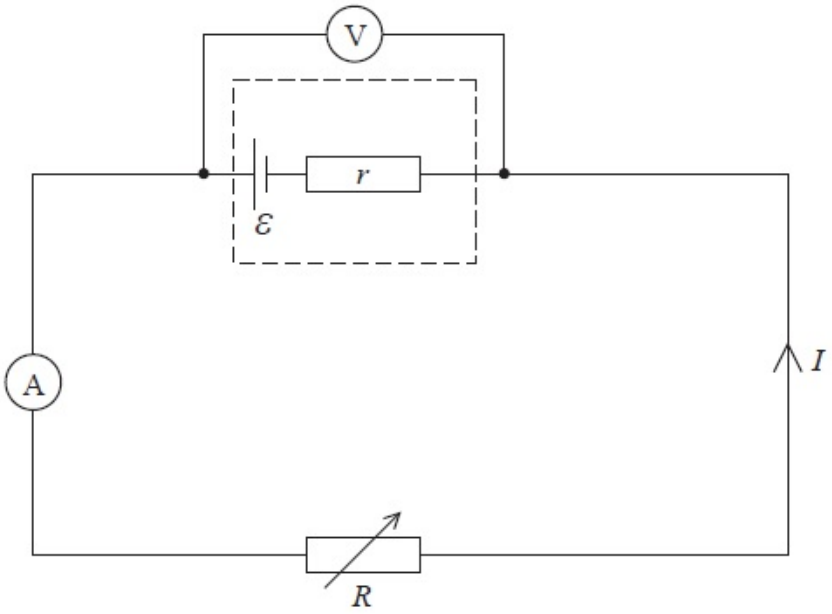
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Threshold frequency = ...

(Total for question = 4 marks)

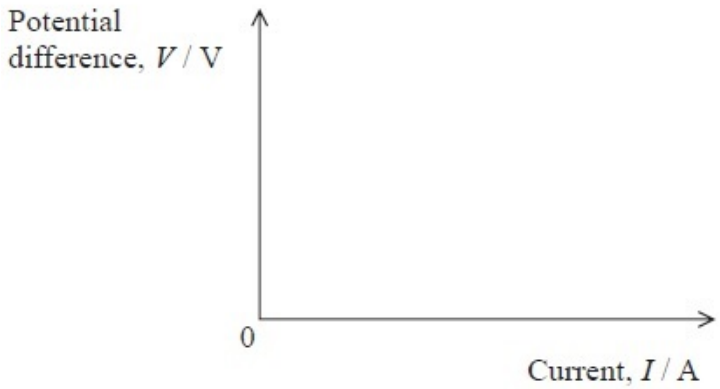
Q10. The diagram shows a circuit which may be used to find the emf ε and internal resistance r of a cell.



(a) As the resistance *R* of the variable resistor is varied, values of the current *I* in the circuit and the terminal potential difference *V* across the cell are recorded.

Sketch the graph of *V* against *I* and explain how it may be used to determine *ε* and *r*.

(5)



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*(b) We usually assume that ammeters have negligible resistance and voltmeters have infinite resistance.

The determination of *ε* and *r* is not affected by using an ammeter with non-negligible resistance but is affected by using a voltmeter with a low resistance.

Explain why.

(4)

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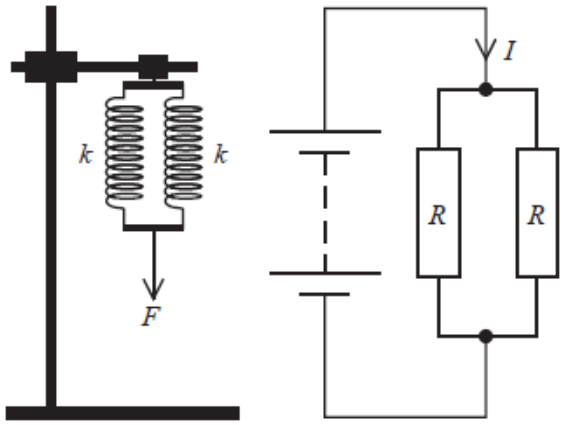
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(Total for Question = 9 marks)

Q11.

A student is experimenting with different combinations of springs and recalls that in physics it is often possible to model different physical situations in similar ways.

The student suggests that a parallel combination of springs could be a model for a parallel combination of resistors in a circuit.



Derive an expression for the effective resistance R_{eff} of two resistors R_1 and R_2 connected in parallel in a circuit.

(3)

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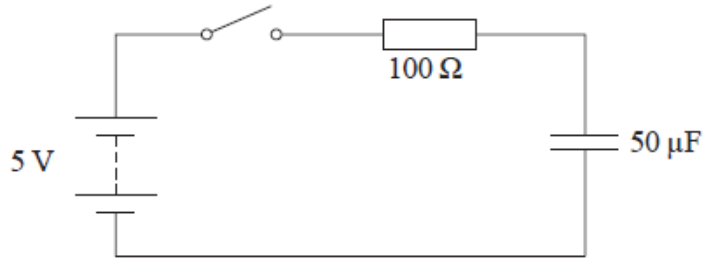
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(Total for question = 3 marks)

Q12.

A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



Describe what happens to the potential difference across the resistor and the potential difference across the capacitor after the switch is closed.

(4)

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(Total for question = 4 marks)

Q13.

A student is taking measurements in order to determine the resistance of a component in a

circuit. He connects a voltmeter in parallel with the component and an ammeter in series with the component.

Explain why the voltmeter should have a very high resistance.

(2)

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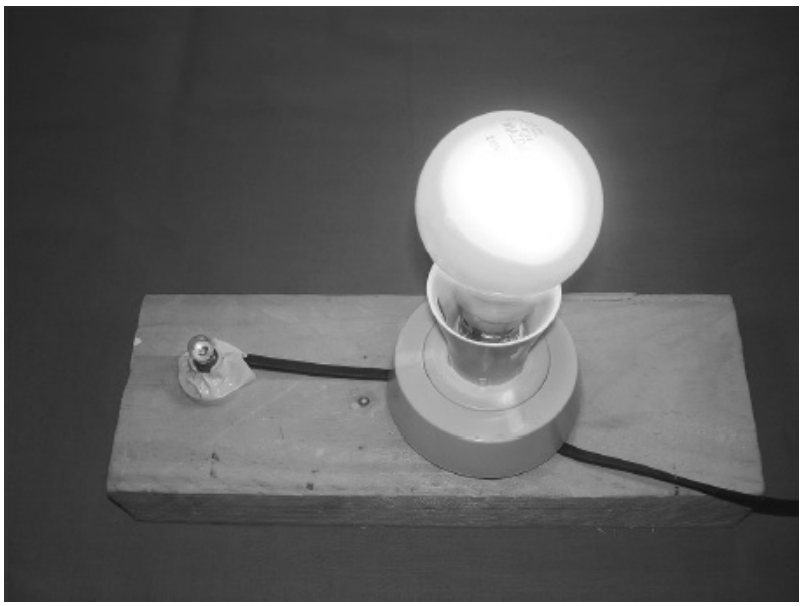
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(Total for question = 2 marks)

Q14. The photograph shows a piece of apparatus in which a mains light bulb and a torch bulb are both connected to the mains.



Students were surprised to see both bulbs shining normally when the apparatus was switched on.

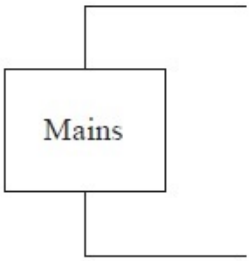
It is impossible to tell from looking at the apparatus whether the bulbs are connected in series or in parallel.

To test this, the apparatus was switched off and the mains bulb was removed. When it was switched on again the torch bulb did not light up. When this was repeated, removing the torch bulb, the mains bulb did not light up.

When the circuit was tried again with both bulbs, they still operated normally.

(a) Complete the circuit diagram to show how the bulbs are connected and explain why they must be connected in this way and not the alternative.

(3)



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(b) The mains bulb is marked 40 W, 230 V.

(i) Show that the current in the mains bulb is about 0.2 A when it is operating normally.

(2)

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(ii) Calculate the resistance of the mains bulb when it is operating normally.

(2)

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Resistance = ...

(iii) The torch bulb is marked 2.5 V, 0.20 A.

Calculate the resistance of the torch bulb when it is operating normally.

(2)

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Resistance = ...

(c) Explain, with reference to both current and potential difference, why it is possible to operate both bulbs at the same time from the same power supply.

(2)

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(d) Earlier in the question you were asked to calculate the resistances of the bulbs when operating normally.

Explain the effect on the resistances of the bulbs if they are operated at a much smaller current so that neither bulb lights up.

(4)

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(Total for Question = 15 marks)

Q15. Explain why an ammeter

- must be placed in series to measure current through a component
- must have a very low resistance.

(3)

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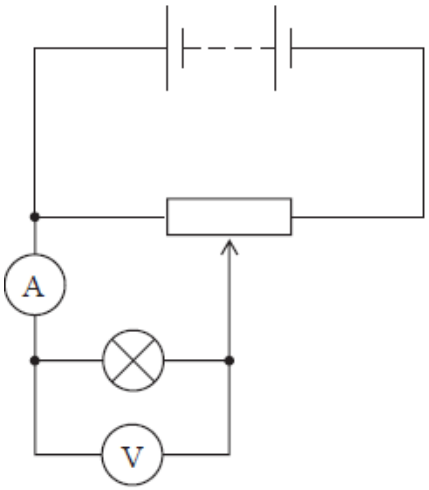
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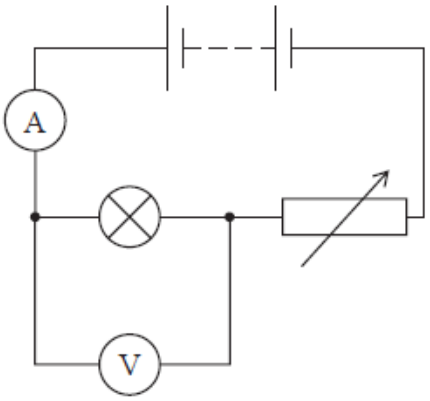
(Total for Question = 3 marks)

Q1.

A student is planning to collect data to produce a current-potential difference graph for a filament lamp. Her teacher suggests two circuits that she could use.



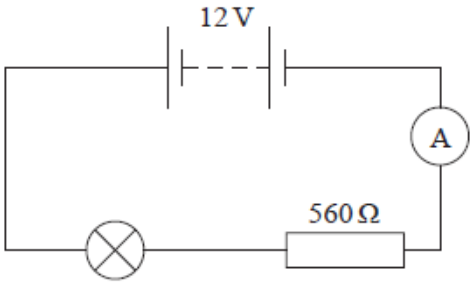
Circuit 1



Circuit 2

Circuit 1 uses a potential divider and circuit 2 uses a variable resistor to vary the potential difference across the filament lamp.

The student sets up the following circuit with the filament lamp. The battery has negligible internal resistance.



(i) The reading on the ammeter is 17.5 mA.

Calculate the value of the potential difference (p.d.) across the filament lamp.

(2)

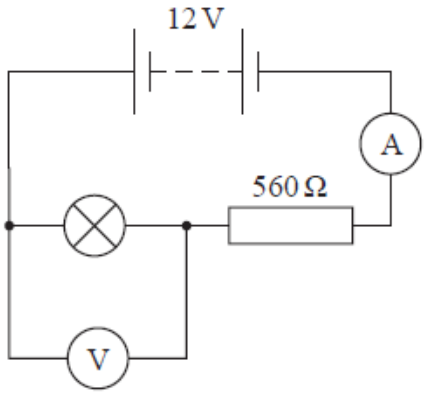
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pd across filament lamp = ...

(ii) When a voltmeter with a resistance of 1.5 kΩ is connected as shown, the p.d. across the filament lamp decreases.



Explain why the p.d. across the filament lamp decreases.

(3)

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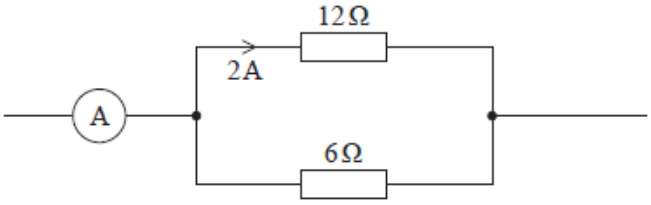
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(Total for question = 5 marks)

Q2.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Part of an electric circuit is shown.



What is the current shown by the ammeter?

☒ **A** 3 A

☒ **B** 4 A

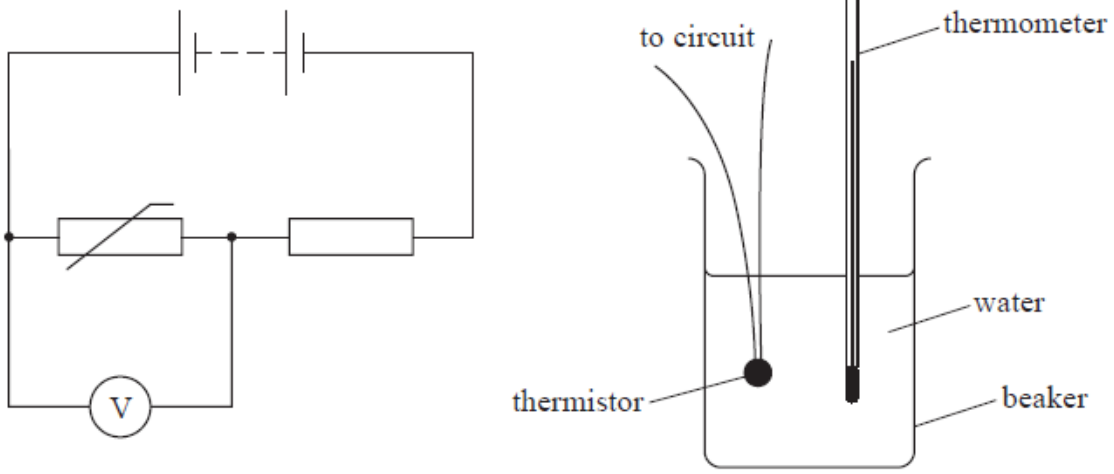
☒ **C** 5 A

☒ **D** 6 A

(Total for question = 1 mark)

Q3.

A student carried out an experiment to calibrate a thermistor. She connected the thermistor in series with a resistor and a power supply as shown. Then she placed the thermistor in a beaker of hot water and used a thermometer to record the temperature θ of the water.



The student recorded θ and corresponding values of the reading V on the voltmeter as the water cooled.

Explain, making reference to charge carriers, why V increased as the water cooled.

(3)

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(Total for question = 3 marks)

Q4.

Analogue ammeters were used before digital meters became widely available.

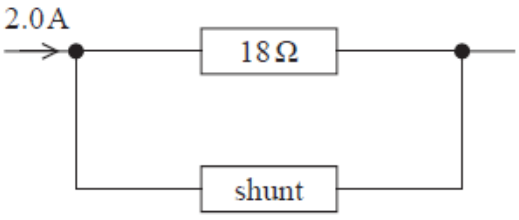
The analogue ammeter shown will measure a maximum current of 1.0 mA and has a resistance of 18 Ω.



(Source: © David J. Green/Alamy Stock Photo)

The analogue ammeter can be adapted to measure a larger current by adding a resistor, known as a shunt, in parallel with the ammeter. The arrangement is shown below.

The analogue ammeter is represented by the 18 Ω resistor.



The maximum current through the 18 Ω resistor remains as 1.0 mA.

Show that the shunt would need to have a resistance of about 0.01 Ω to adapt this ammeter to read up to a maximum current of 2.0 A.

(3)

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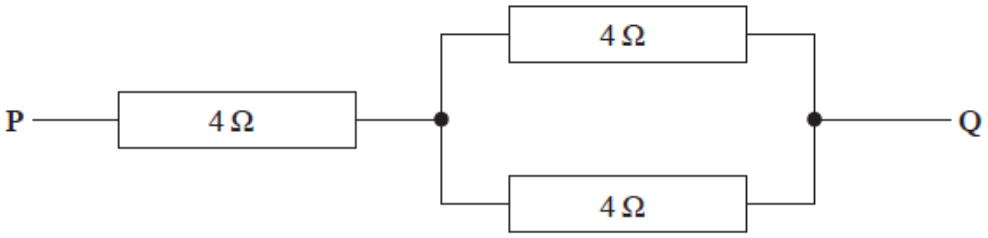
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(Total for question = 3 marks)

Q5.

The diagram shows a combination of three identical resistors.



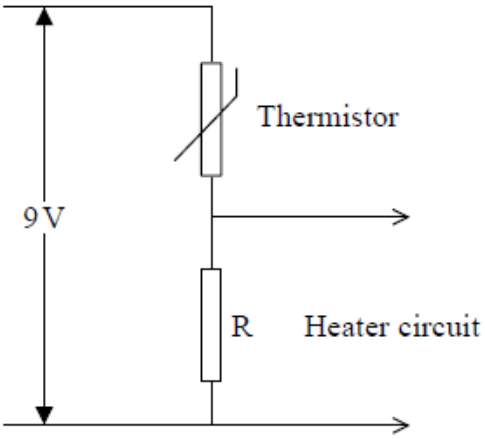
What is the combined resistance between P and Q?

- ☒ **A** 4 Ω
- ☒ **B** 6 Ω
- ☒ **C** 8 Ω
- ☒ **D** 12 Ω

(Total for question = 1 mark)

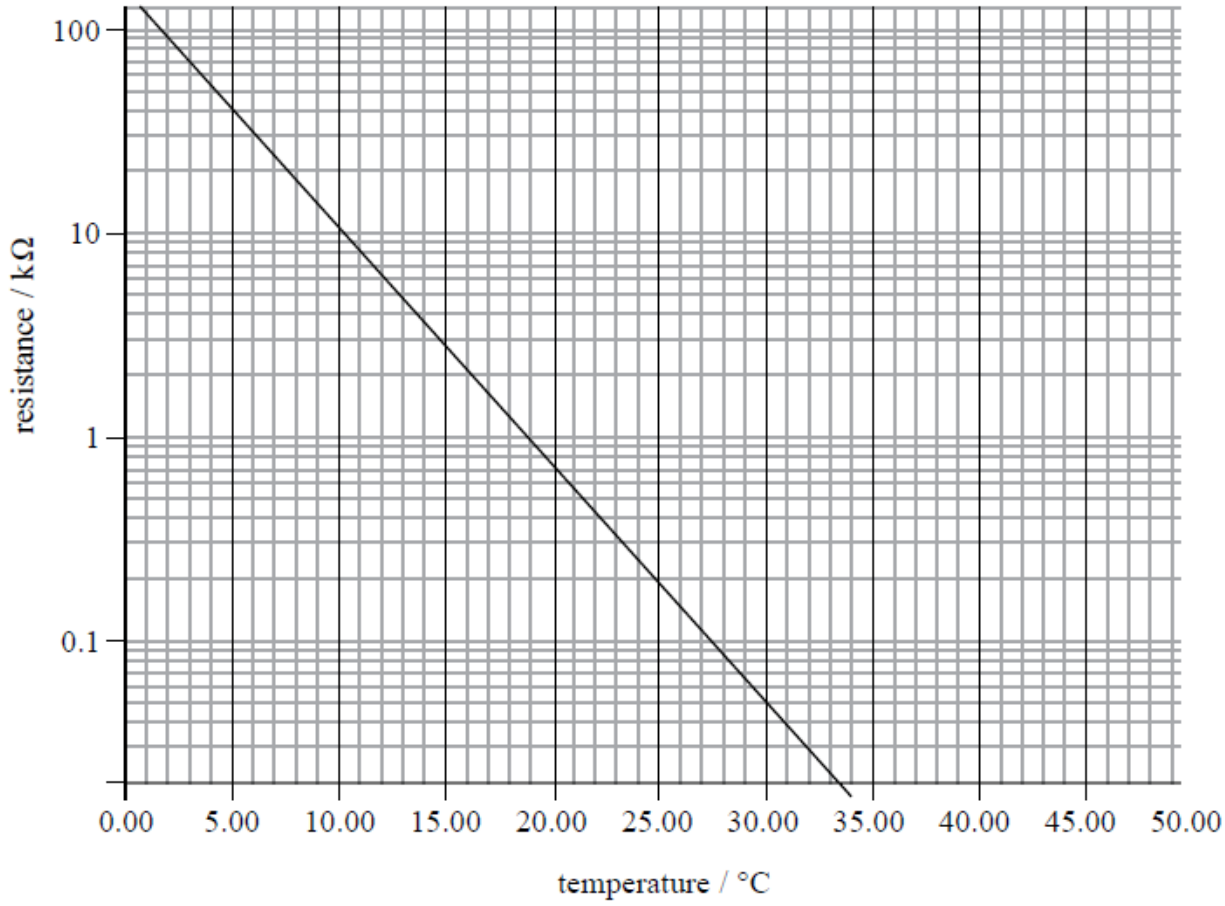
Q6.

A thermistor can be used to control a heater. When the temperature falls below a certain value the heater is switched on. The thermistor is connected in series with a fixed resistor R in a potential divider circuit as shown.



The heater circuit is connected across R and will switch on when the potential difference across it is above 5.5 V.

The variation of resistance of the thermistor R_T with temperature is shown on the graph.



(Source: http://reviseomatic.org/help/e-resistors/ThermistorLogGraph.gif)

The heater switches on when the temperature falls below 20 °C.

Calculate the resistance of the fixed resistor R.

(3)

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Resistance= .....

(Total for question = 3 marks)

Q7.

A student is deriving an equation for the total resistance of resistors in series.

She writes the following steps but does not justify them.

Step 1 $V = V_1 + V_2$
Step 2 $but\ V = IR$
Step 3 $so\ IR = I_1R_1 + I_2R_2$
Step 4 $but\ I = I_1 = I_2$
Step 5 $Therefore\ R = R_1 + R_2$

Which step is justified using conservation of charge?

(1)

☒ **A** Step 1

☒ **B** Step 2

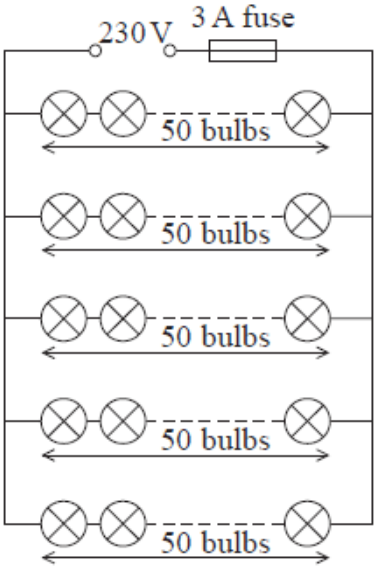
☒ **C** Step 3

☒ **D** Step 4

(Total for question = 1 mark)

Q8.

A set of festive lights is made up of five parallel strands of filament bulbs. Each strand contains 50 bulbs in series as shown.



(a) When a bulb is working normally its resistance is 8.0 Ω. If the filament of the bulb breaks, the lamp is designed to still conduct and its resistance becomes 3.0 Ω.

(i) The filament of one bulb on a strand breaks.
By considering the effect this has on the remaining bulbs in that strand, explain why it is recommended that broken bulbs are replaced as soon as possible.

(3)

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(ii) The set of festive lights are fitted with a 3 A fuse. Five bulbs in one strand break.

Determine whether the fuse blows.

(3)

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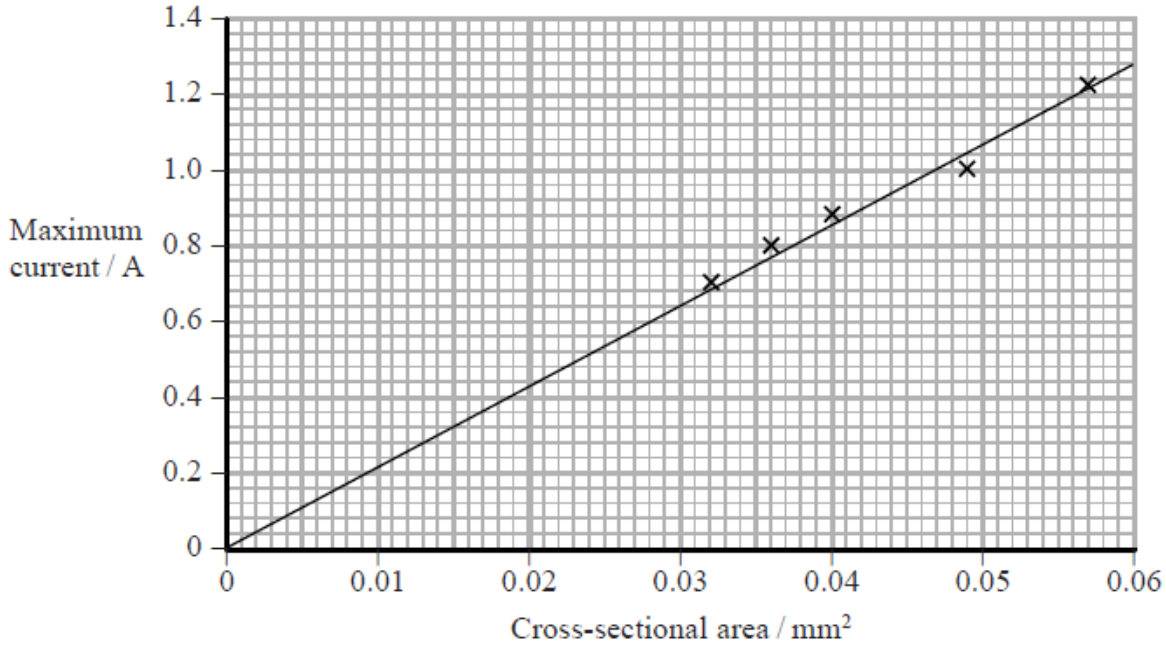
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(b) A student investigates how the cross-sectional area of a fuse wire affects the current at

which the fuse blows. She uses pieces of wire of the same material and length, but different cross-sectional areas. She steadily increases the current through each piece of wire and records the maximum current through the wire before it breaks.

She then plots a graph of maximum current against cross-sectional area.



(i) Describe how the student should determine the cross-sectional area of the wire.

(3)

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(ii) State the relationship between the maximum current and the cross-sectional area of the wire.

(1)

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(iii) The student chooses a piece of wire, of the same material and length as used in the investigation. The piece of wire has a diameter of 0.40 mm.

Use the graph to determine whether the piece of wire is suitable to use as the 3A fuse wire for the set of festive lights.

(4)

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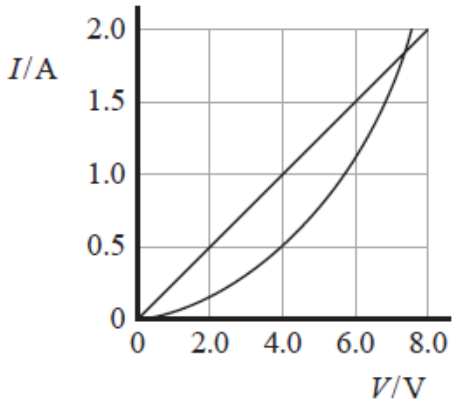
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(Total for question = 14 marks)

Q9.

The current-potential difference graphs for a resistor and a thermistor are shown.



The resistor and thermistor are connected in series to a 6 V battery.

What is the current, in amps, in the resistor?

(1)

☒ **A** 0.5

☒ **B** 1.0

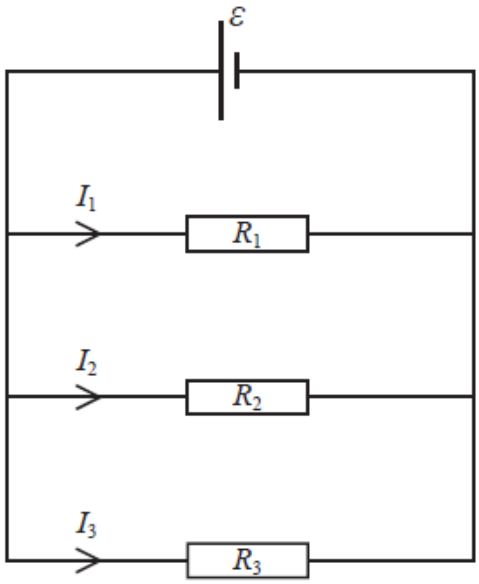
☒ **C** 1.5

☒ **D** 2.0

(Total for question = 1 mark)

Q10.

Three resistors, of resistance R_1, R_2 and R_3 respectively, are connected in parallel across a cell. The cell has negligible internal resistance and electromotive force ε.



Use the principle of conservation of charge to show that the total resistance R_T of the three resistors can be found using the expression

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

(3)

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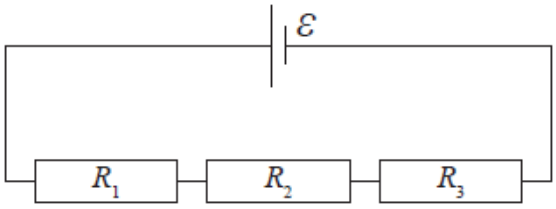
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(Total for question = 3 marks)

Q11.

Three resistors, of resistance R_1, R_2 and R_3, are connected in series across a cell. The cell has electromotive force (e.m.f.) ε with negligible internal resistance. The current through the cell is I.



Derive the formula for the total resistance R_T of the circuit in terms of R_1, R_2 and R_3.

(3)

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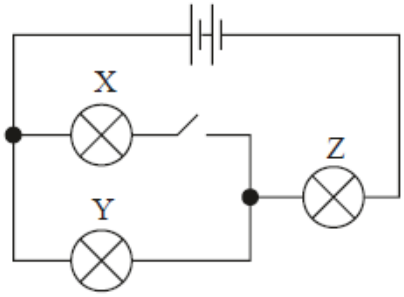
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(Total for question = 3 marks)

Q12.

A circuit consists of three identical 1.5 V bulbs connected to two 1.5 V cells.



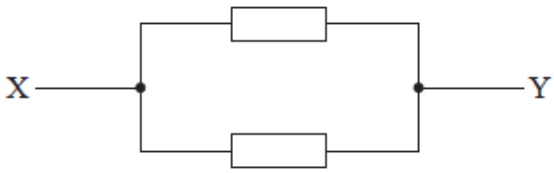
The switch is closed.
Which row describes the change in brightness of bulb Y and bulb Z?

	Y	Z
☒ **A**	brighter	brighter
☒ **B**	brighter	dimmer
☒ **C**	dimmer	brighter
☒ **D**	dimmer	dimmer

(Total for question = 1 mark)

Q13.

The two resistors shown each have resistance *R*.



Which expression gives the correct resistance between point X and point Y?

(1)

☒ **A** $\frac{R}{2}$

☒ **B** R

☒ **C** $2R$

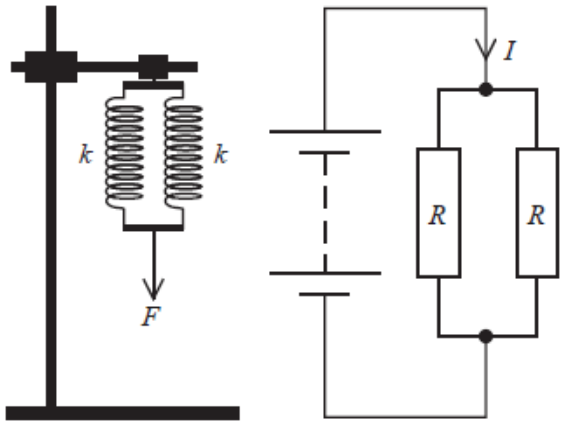
☒ **D** R^2

(Total for question = 1 mark)

Q14.

A student is experimenting with different combinations of springs and recalls that in physics it is often possible to model different physical situations in similar ways.

The student suggests that a parallel combination of springs could be a model for a parallel combination of resistors in a circuit.



Derive an expression for the effective resistance R_{eff} of two resistors R_1 and R_2 connected in parallel in a circuit.

(3)

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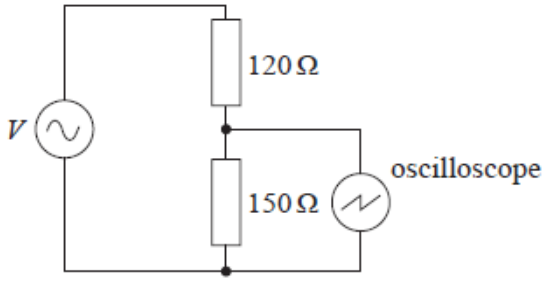
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(Total for question = 3 marks)

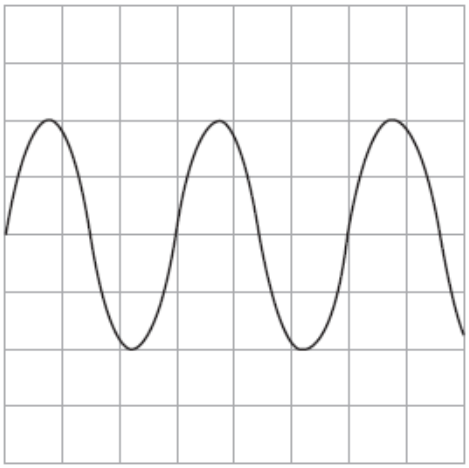
Q15.

A student connected the output from a source of alternating potential difference (p.d.) to a series resistor combination.

She connected an oscilloscope across the 150 Ω resistor as shown.



The trace obtained on the oscilloscope is shown below.



(i) Determine the peak p.d. across the 150 Ω resistor.

y-sensitivity of oscilloscope = 2.0 V per division

(2)

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Peak p.d. across 150 Ω resistor = ...

(ii) Calculate the root mean square (r.m.s.) value of the current in the circuit.

(3)

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r.m.s. value of current = ...

(iii) Calculate the power dissipated in the circuit.

(3)

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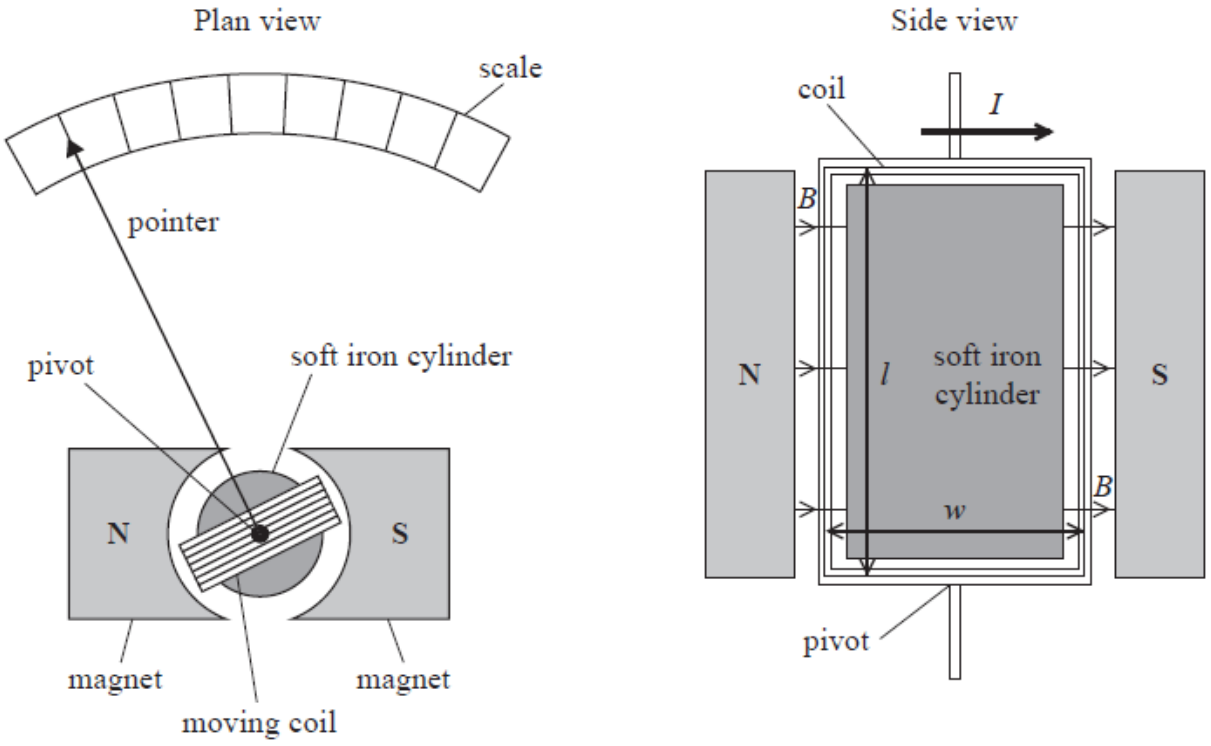
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Power dissipated in circuit = ...

(Total for question = 8 marks)

Q16.

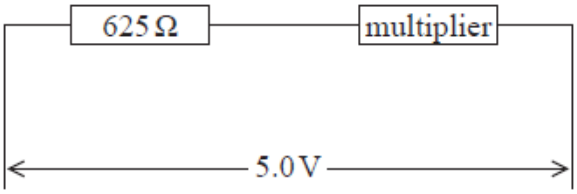
The diagrams show the plan view and side view of a moving coil ammeter.



An ammeter of this type has a resistance of 625 Ω and will measure a maximum current of 1.6 mA.

The ammeter can be adapted to measure potential difference by adding a resistor in series with the ammeter. This resistor is known as a multiplier.

The ammeter is adapted so that it can measure potential differences up to 5.0 V as shown.



The following multipliers are available:

200 Ω 2500 Ω 3125 Ω 3750 Ω

Deduce which multiplier should be used.

(3)

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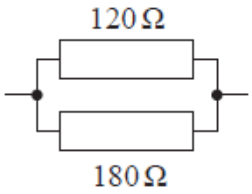
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(Total for question = 3 marks)

Q17.

Two resistors are connected as shown.



Show that the resistance of the combination is about 70 Ω.

(2)

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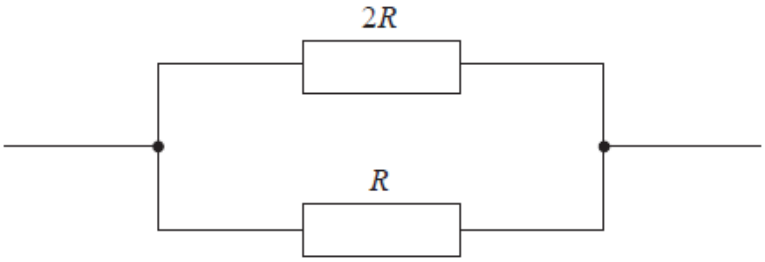
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(Total for question = 2 marks)

Q18.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Part of an electric circuit consists of two resistors. One resistor has a resistance $2R$ and the other resistor has a resistance R as shown.



Which of the following is the equivalent resistance of this combination?

☒ **A** $\frac{R}{3}$

☒ **B** $\frac{2R}{3}$

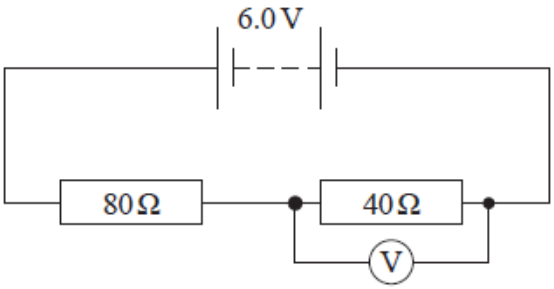
☒ **C** $\frac{3R}{2}$

☒ **D** $3R$

(Total for question = 1 mark)

Q19.

The circuit diagram shows two resistors in series across a battery of e.m.f. 6.0 V and negligible internal resistance. A voltmeter with low resistance is connected across the 40 Ω resistor.



The reading on the voltmeter is 1.8 V.

Calculate the resistance of the voltmeter.

(3)

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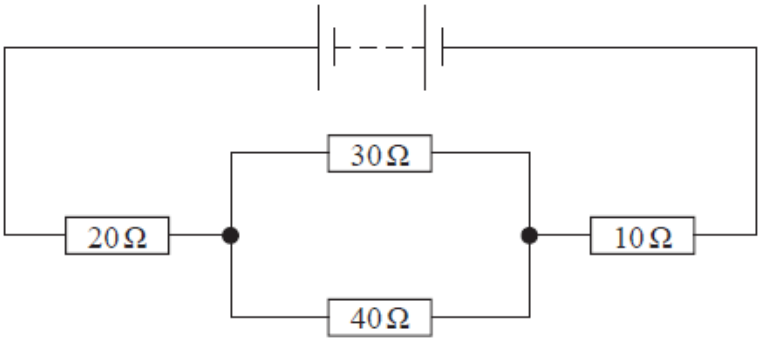
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Resistance of voltmeter = ...

(Total for question = 3 marks)

Q20.

A circuit was constructed as shown.



Calculate the total resistance of the resistors in the circuit.

(3)

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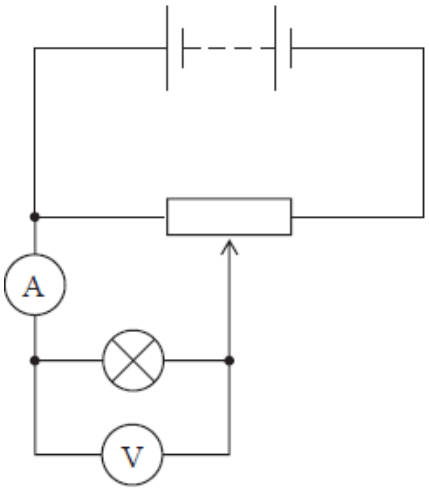
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Total resistance = ...

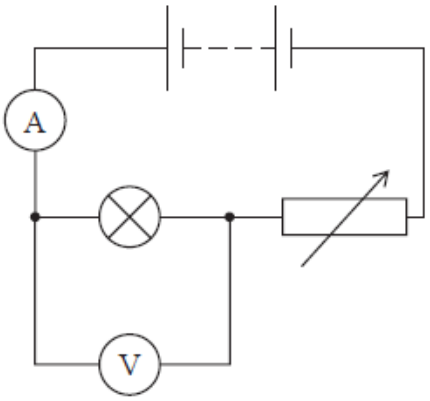
(Total for question = 3 marks)

Q1.

A student is planning to collect data to produce a current-potential difference graph for a filament lamp. Her teacher suggests two circuits that she could use.



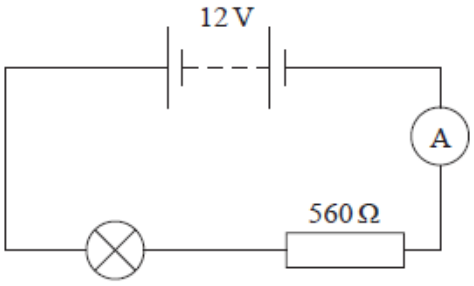
Circuit 1



Circuit 2

Circuit 1 uses a potential divider and circuit 2 uses a variable resistor to vary the potential difference across the filament lamp.

The student sets up the following circuit with the filament lamp. The battery has negligible internal resistance.



(i) The reading on the ammeter is 17.5 mA.

Calculate the value of the potential difference (p.d.) across the filament lamp.

(2)

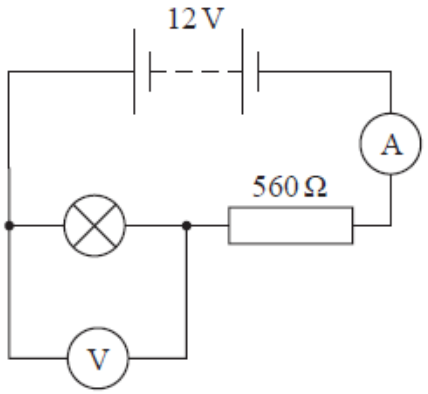
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pd across filament lamp = ...

(ii) When a voltmeter with a resistance of 1.5 kΩ is connected as shown, the p.d. across the filament lamp decreases.



Explain why the p.d. across the filament lamp decreases.

(3)

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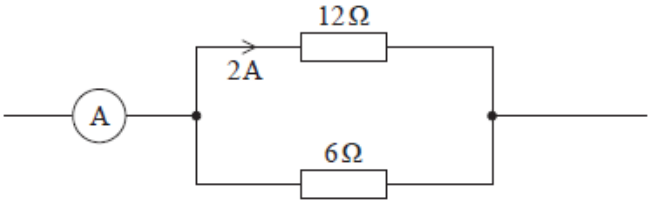
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(Total for question = 5 marks)

Q2.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Part of an electric circuit is shown.



What is the current shown by the ammeter?

☒ **A** 3 A

☒ **B** 4 A

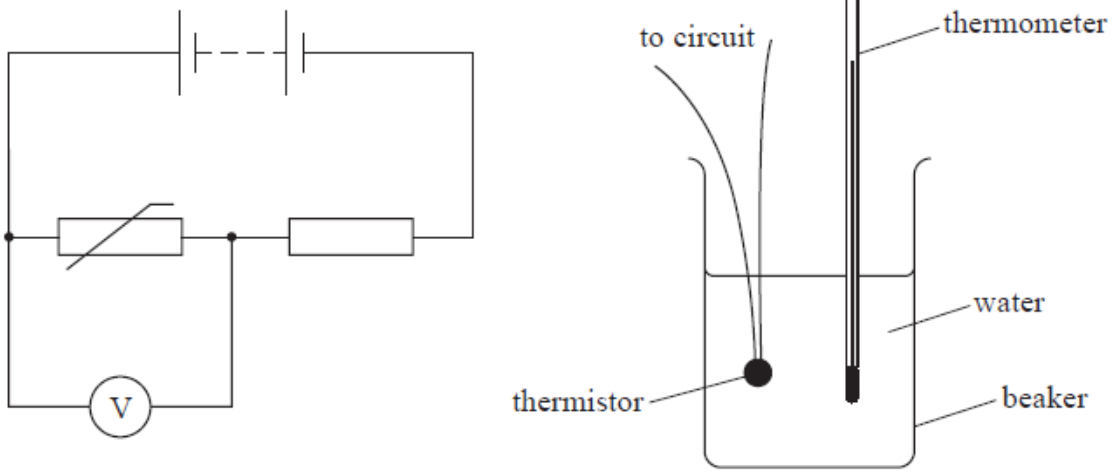
☒ **C** 5 A

☒ **D** 6 A

(Total for question = 1 mark)

Q3.

A student carried out an experiment to calibrate a thermistor. She connected the thermistor in series with a resistor and a power supply as shown. Then she placed the thermistor in a beaker of hot water and used a thermometer to record the temperature θ of the water.



The student recorded θ and corresponding values of the reading V on the voltmeter as the water cooled.

Explain, making reference to charge carriers, why V increased as the water cooled.

(3)

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(Total for question = 3 marks)

Q4.

Analogue ammeters were used before digital meters became widely available.

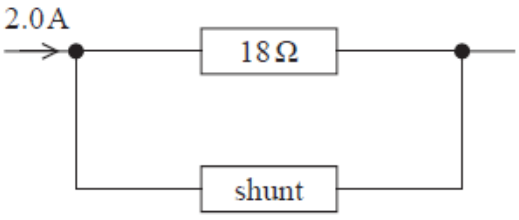
The analogue ammeter shown will measure a maximum current of 1.0 mA and has a resistance of 18 Ω.



(Source: © David J. Green/Alamy Stock Photo)

The analogue ammeter can be adapted to measure a larger current by adding a resistor, known as a shunt, in parallel with the ammeter. The arrangement is shown below.

The analogue ammeter is represented by the 18 Ω resistor.



The maximum current through the 18 Ω resistor remains as 1.0 mA.

Show that the shunt would need to have a resistance of about 0.01 Ω to adapt this ammeter to read up to a maximum current of 2.0 A.

(3)

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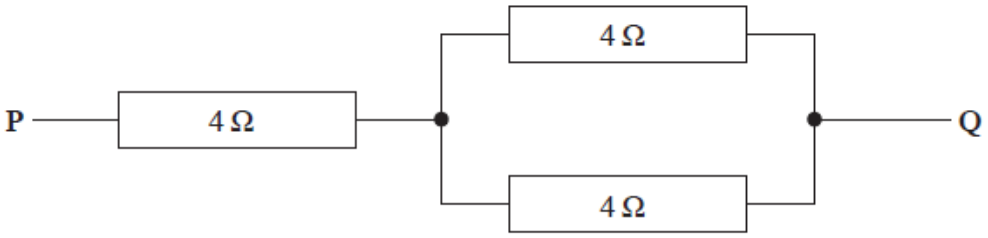
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(Total for question = 3 marks)

Q5.

The diagram shows a combination of three identical resistors.



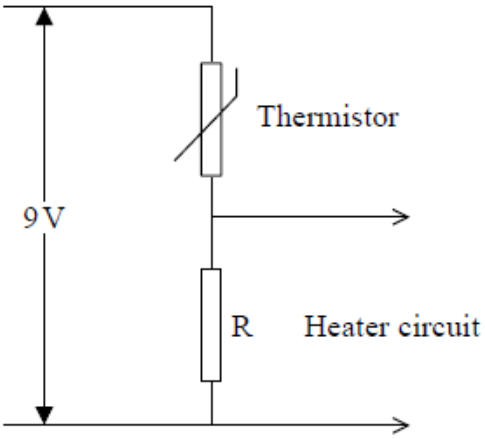
What is the combined resistance between P and Q?

- ☒ **A** 4 Ω
- ☒ **B** 6 Ω
- ☒ **C** 8 Ω
- ☒ **D** 12 Ω

(Total for question = 1 mark)

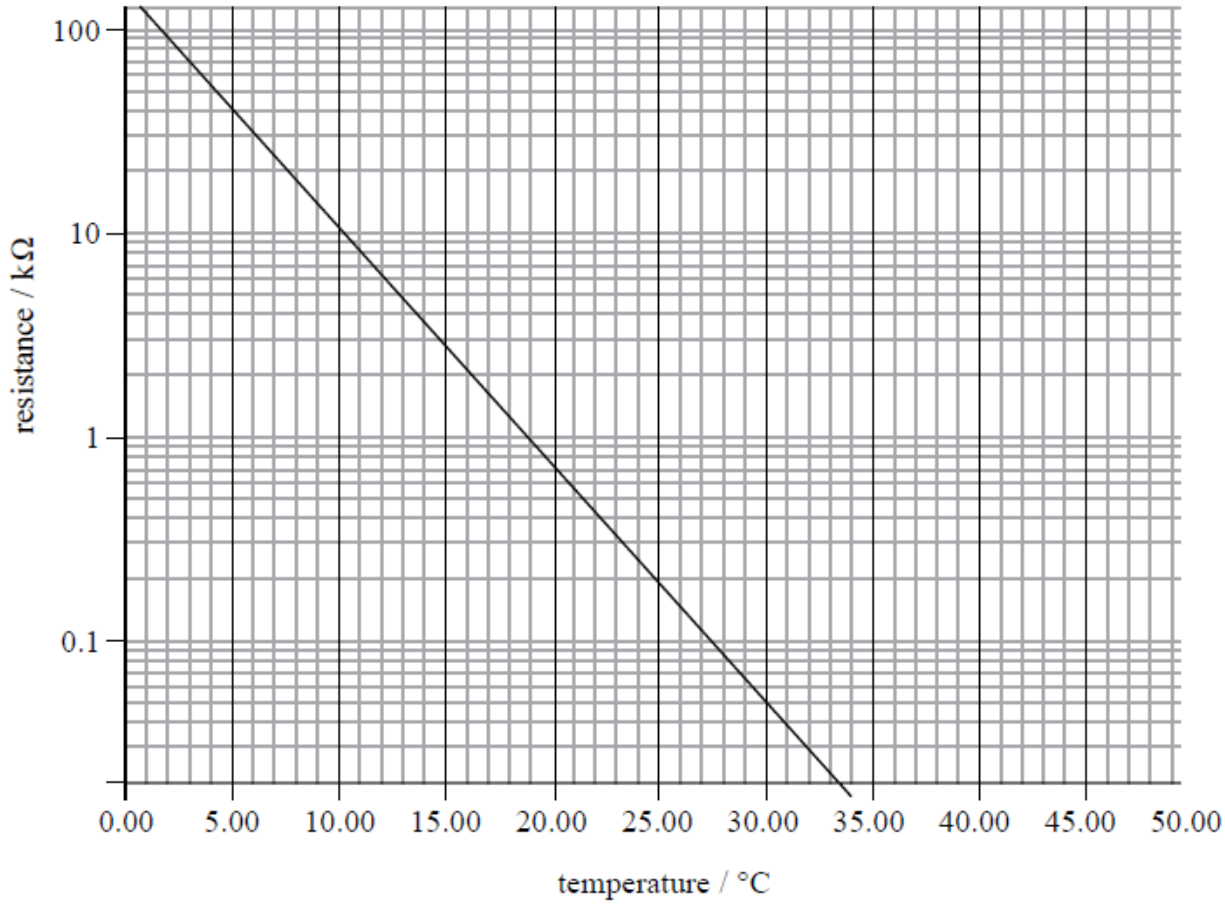
Q6.

A thermistor can be used to control a heater. When the temperature falls below a certain value the heater is switched on. The thermistor is connected in series with a fixed resistor R in a potential divider circuit as shown.



The heater circuit is connected across R and will switch on when the potential difference across it is above 5.5 V.

The variation of resistance of the thermistor R_T with temperature is shown on the graph.



(Source: http://reviseomatic.org/help/e-resistors/ThermistorLogGraph.gif)

The heater switches on when the temperature falls below 20 °C.

Calculate the resistance of the fixed resistor R.

(3)

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Resistance= .....

(Total for question = 3 marks)

Q7.

A student is deriving an equation for the total resistance of resistors in series.

She writes the following steps but does not justify them.

Step 1 $V = V_1 + V_2$
Step 2 $but\ V = IR$
Step 3 $so\ IR = I_1R_1 + I_2R_2$
Step 4 $but\ I = I_1 = I_2$
Step 5 $Therefore\ R = R_1 + R_2$

Which step is justified using conservation of charge?

(1)

☒ **A** Step 1

☒ **B** Step 2

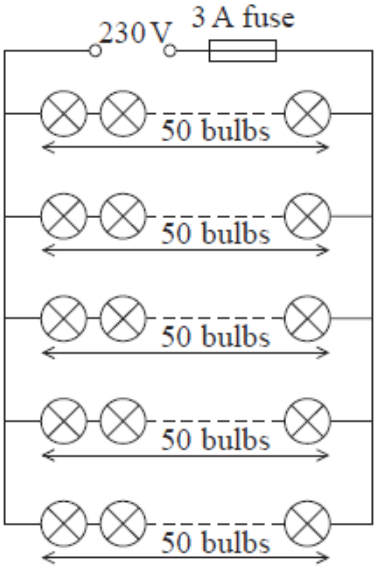
☒ **C** Step 3

☒ **D** Step 4

(Total for question = 1 mark)

Q8.

A set of festive lights is made up of five parallel strands of filament bulbs. Each strand contains 50 bulbs in series as shown.



(a) When a bulb is working normally its resistance is 8.0 Ω. If the filament of the bulb breaks, the lamp is designed to still conduct and its resistance becomes 3.0 Ω.

(i) The filament of one bulb on a strand breaks.
By considering the effect this has on the remaining bulbs in that strand, explain why it is recommended that broken bulbs are replaced as soon as possible.

(3)

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(ii) The set of festive lights are fitted with a 3 A fuse. Five bulbs in one strand break.

Determine whether the fuse blows.

(3)

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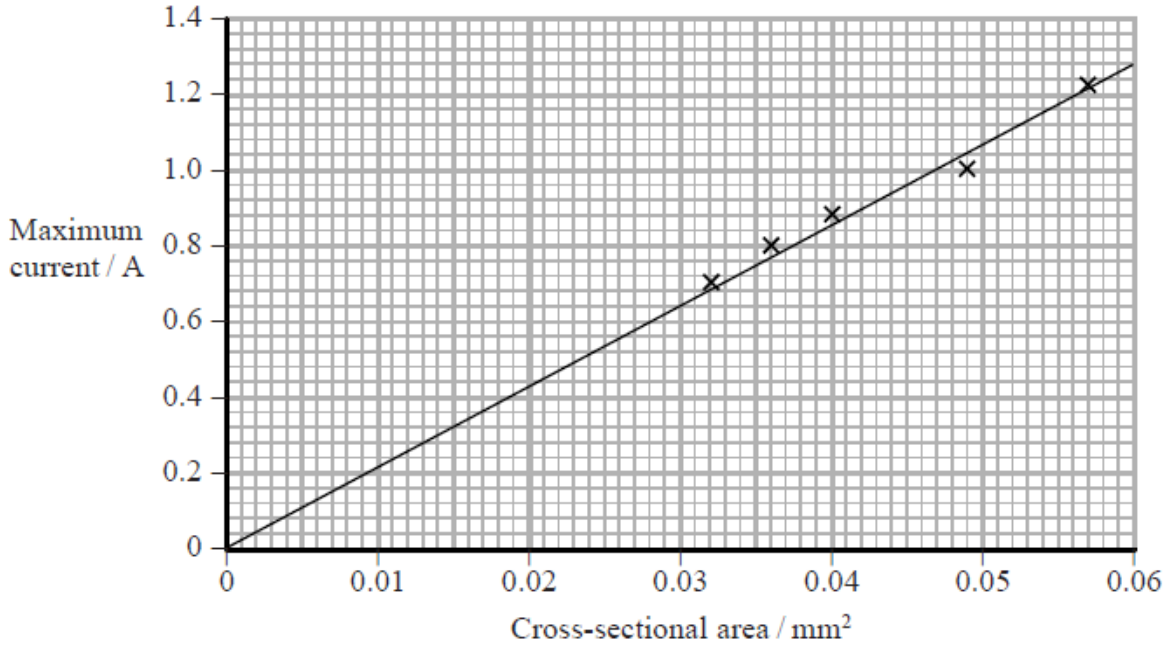
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(b) A student investigates how the cross-sectional area of a fuse wire affects the current at

which the fuse blows. She uses pieces of wire of the same material and length, but different cross-sectional areas. She steadily increases the current through each piece of wire and records the maximum current through the wire before it breaks.

She then plots a graph of maximum current against cross-sectional area.



(i) Describe how the student should determine the cross-sectional area of the wire.

(3)

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(ii) State the relationship between the maximum current and the cross-sectional area of the wire.

(1)

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(iii) The student chooses a piece of wire, of the same material and length as used in the investigation. The piece of wire has a diameter of 0.40 mm.

Use the graph to determine whether the piece of wire is suitable to use as the 3A fuse wire for the set of festive lights.

(4)

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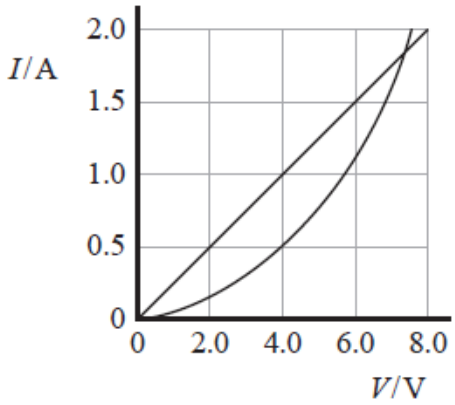
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(Total for question = 14 marks)

Q9.

The current-potential difference graphs for a resistor and a thermistor are shown.



The resistor and thermistor are connected in series to a 6 V battery.

What is the current, in amps, in the resistor?

(1)

☒ **A** 0.5

☒ **B** 1.0

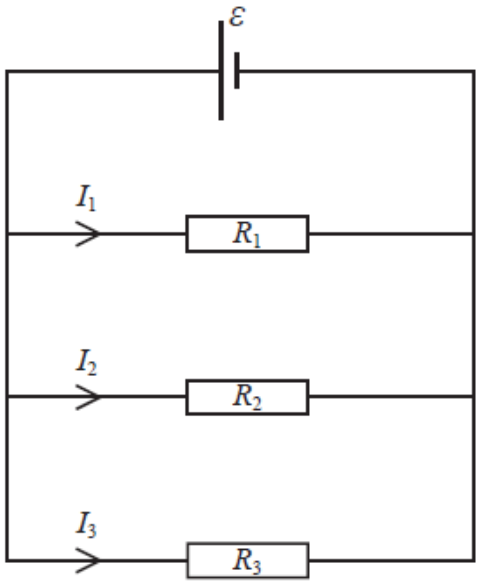
☒ **C** 1.5

☒ **D** 2.0

(Total for question = 1 mark)

Q10.

Three resistors, of resistance R_1, R_2 and R_3 respectively, are connected in parallel across a cell. The cell has negligible internal resistance and electromotive force ε.



Use the principle of conservation of charge to show that the total resistance R_T of the three resistors can be found using the expression

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

(3)

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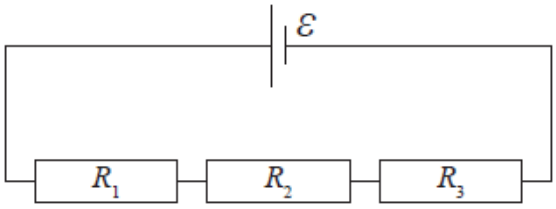
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(Total for question = 3 marks)

Q11.

Three resistors, of resistance R_1, R_2 and R_3, are connected in series across a cell. The cell has electromotive force (e.m.f.) ε with negligible internal resistance. The current through the cell is I.



Derive the formula for the total resistance R_T of the circuit in terms of R_1, R_2 and R_3.

(3)

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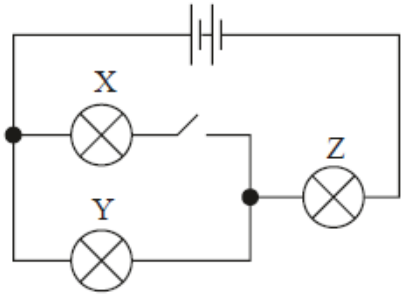
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(Total for question = 3 marks)

Q12.

A circuit consists of three identical 1.5 V bulbs connected to two 1.5 V cells.



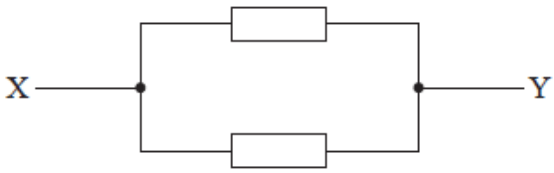
The switch is closed.
Which row describes the change in brightness of bulb Y and bulb Z?

	Y	Z
☒ **A**	brighter	brighter
☒ **B**	brighter	dimmer
☒ **C**	dimmer	brighter
☒ **D**	dimmer	dimmer

(Total for question = 1 mark)

Q13.

The two resistors shown each have resistance *R*.



Which expression gives the correct resistance between point X and point Y?

(1)

☒ **A** $\frac{R}{2}$

☒ **B** R

☒ **C** $2R$

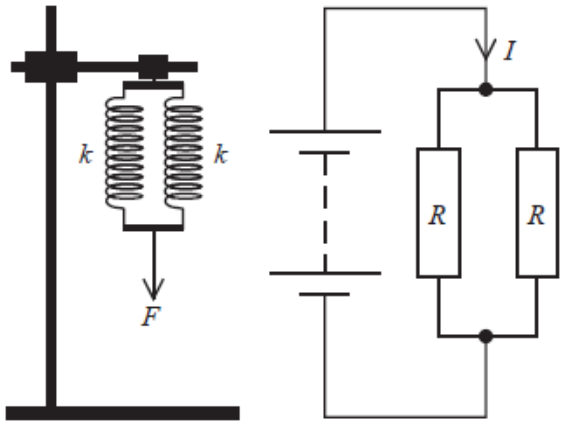
☒ **D** R^2

(Total for question = 1 mark)

Q14.

A student is experimenting with different combinations of springs and recalls that in physics it is often possible to model different physical situations in similar ways.

The student suggests that a parallel combination of springs could be a model for a parallel combination of resistors in a circuit.



Derive an expression for the effective resistance R_{eff} of two resistors R_1 and R_2 connected in parallel in a circuit.

(3)

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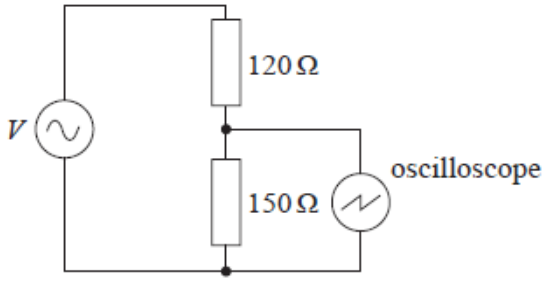
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(Total for question = 3 marks)

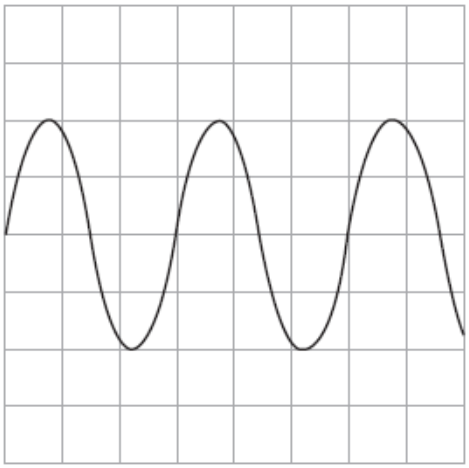
Q15.

A student connected the output from a source of alternating potential difference (p.d.) to a series resistor combination.

She connected an oscilloscope across the 150 Ω resistor as shown.



The trace obtained on the oscilloscope is shown below.



(i) Determine the peak p.d. across the 150 Ω resistor.

y-sensitivity of oscilloscope = 2.0 V per division

(2)

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Peak p.d. across 150 Ω resistor = ...

(ii) Calculate the root mean square (r.m.s.) value of the current in the circuit.

(3)

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r.m.s. value of current = ...

(iii) Calculate the power dissipated in the circuit.

(3)

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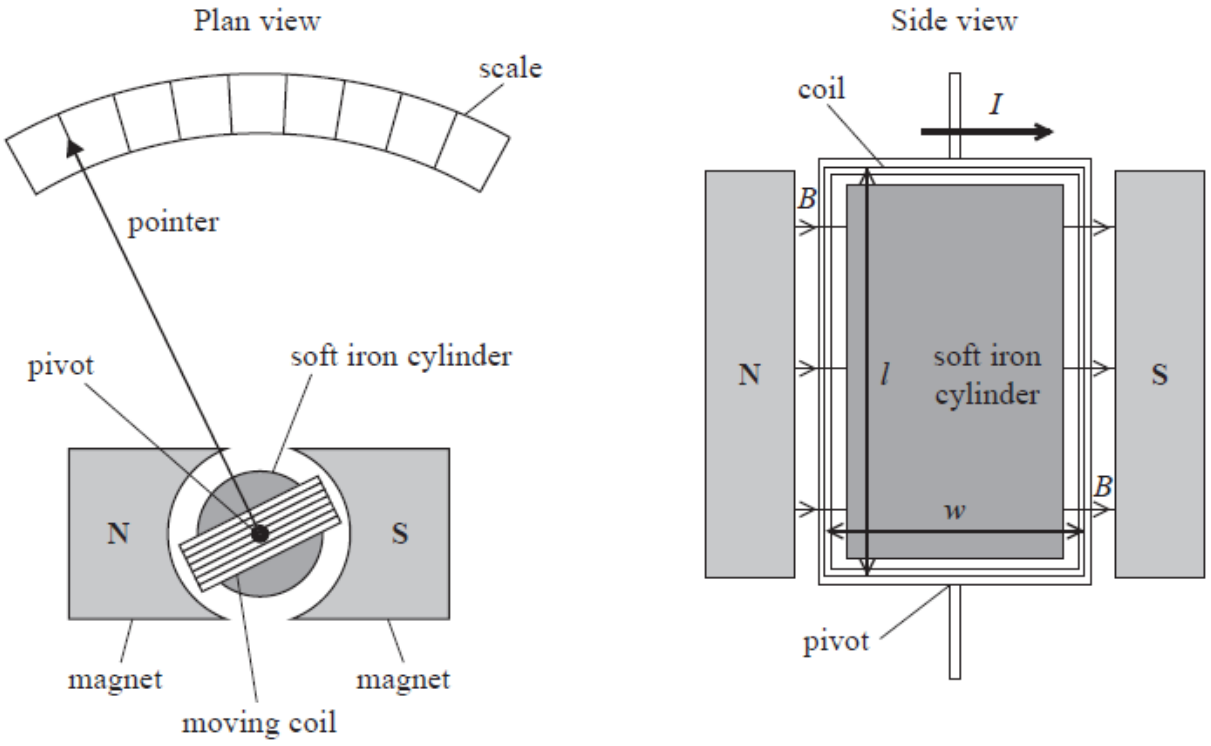
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Power dissipated in circuit = ...

(Total for question = 8 marks)

Q16.

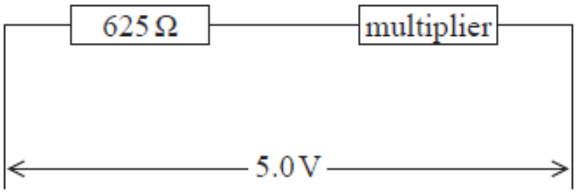
The diagrams show the plan view and side view of a moving coil ammeter.



An ammeter of this type has a resistance of 625 Ω and will measure a maximum current of 1.6 mA.

The ammeter can be adapted to measure potential difference by adding a resistor in series with the ammeter. This resistor is known as a multiplier.

The ammeter is adapted so that it can measure potential differences up to 5.0 V as shown.



The following multipliers are available:

200 Ω 2500 Ω 3125 Ω 3750 Ω

Deduce which multiplier should be used.

(3)

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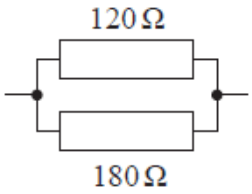
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(Total for question = 3 marks)

Q17.

Two resistors are connected as shown.



Show that the resistance of the combination is about 70 Ω.

(2)

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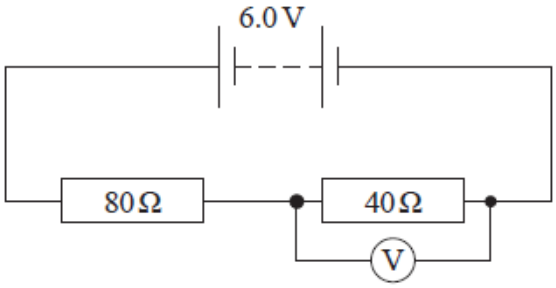
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(Total for question = 2 marks)

Q18.

The circuit diagram shows two resistors in series across a battery of e.m.f. 6.0 V and negligible internal resistance. A voltmeter with low resistance is connected across the 40 Ω resistor.



The reading on the voltmeter is 1.8 V.

Calculate the resistance of the voltmeter.

(3)

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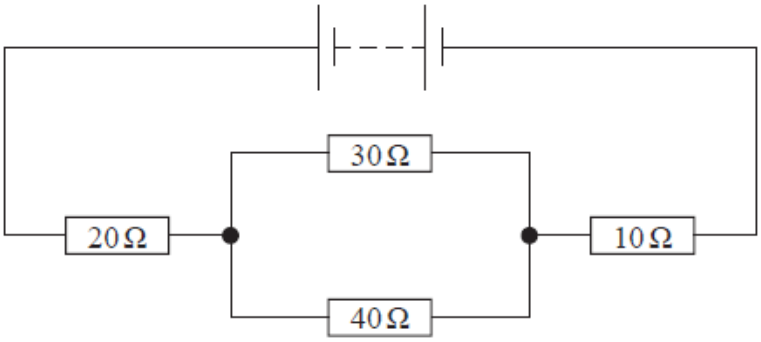
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Resistance of voltmeter = ...

(Total for question = 3 marks)

Q19.

A circuit was constructed as shown.



Calculate the total resistance of the resistors in the circuit.

(3)

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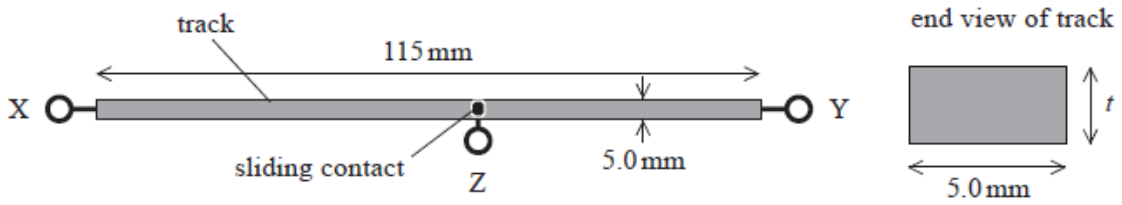
Total resistance = ...

(Total for question = 3 marks)

$\therefore V_{V_{LED}} = (12 - 9.8)V = 2.2\ V$

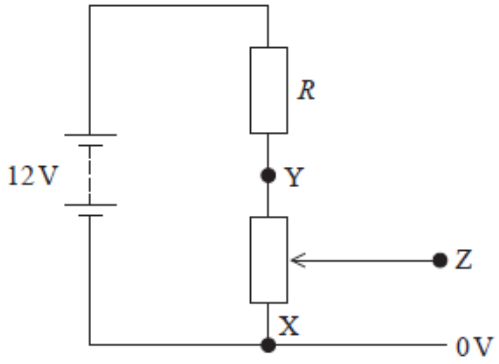
Q1.

A potential divider circuit may contain a component known as a potentiometer. One type of potentiometer consists of a track with terminals X and Y at either end. There is a sliding contact that can move along the track connected to a terminal Z as shown.



The length of the track is 115 mm and the width is 5.0 mm.

The potentiometer is used to monitor the displacement of a moving tool on a machine in a production line. The tool is attached to the sliding contact. The potentiometer is connected to a resistor of resistance *R* and a potential difference is applied as shown. The tool moves through a maximum displacement of 60 mm from end X, producing a maximum potential difference of 5.0 V between Z and X.



(i) Show that the potential difference between X and Y is about 10 V.

(2)

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(ii) Calculate the value of *R*.

(3)

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R = ...

(iii) When the circuit is assembled, using the correctly calculated resistance value and a battery of e.m.f. 12 V, it is found that the maximum output from the potentiometer is slightly less than 5.0 V.

Explain why the maximum output is slightly less than predicted.

(3)

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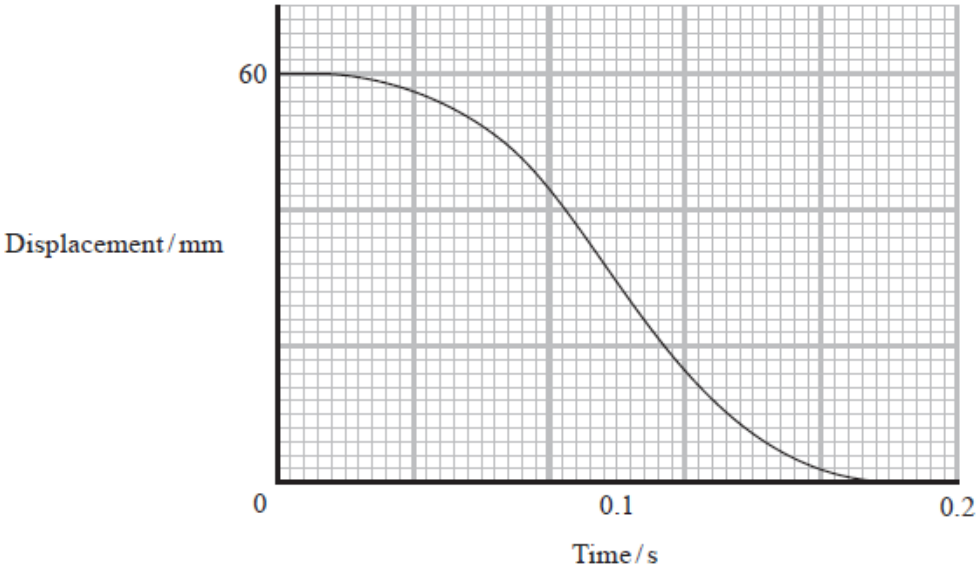
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(iv) The tool on the machine should not travel with a speed any larger than 0.8 m s^{-1} .

The graph shows how the displacement varies with time for the downward stroke of the moving tool.



Deduce whether this speed is exceeded by the moving tool.

(4)

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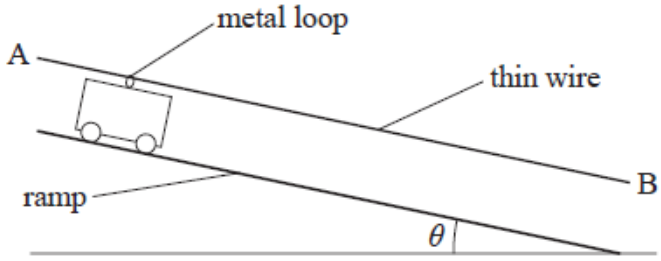
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(Total for question = 12 marks)

Q2.

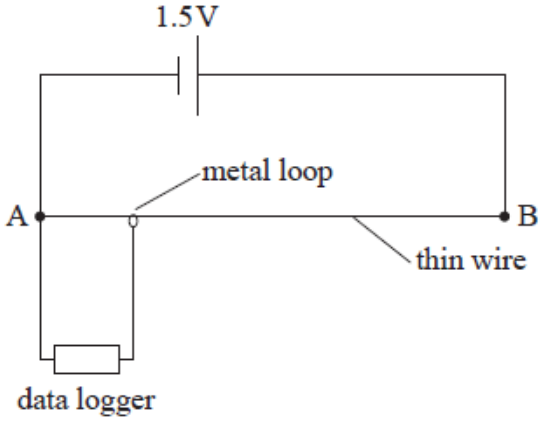
A student investigates the motion of a friction-free trolley down a ramp. On the top of the trolley there is a metal loop which makes contact with a length of thin resistance wire, AB, fixed above the ramp. The resistance wire has a uniform diameter.

The trolley accelerates down the ramp and the metal loop stays in contact with the wire along the full length of the ramp.



The student uses a protractor to measure the angle θ between the ramp and the horizontal and records a value of 4° with an uncertainty of ±1°.

(a) The two ends of the wire are connected to a 1.5 V cell. A data logger, set to measure potential difference, is connected to the metal loop and to the negative terminal of the cell.



Explain how the potential difference recorded by the data logger will vary as the loop moves

along the length of the
wire AB.

(3)

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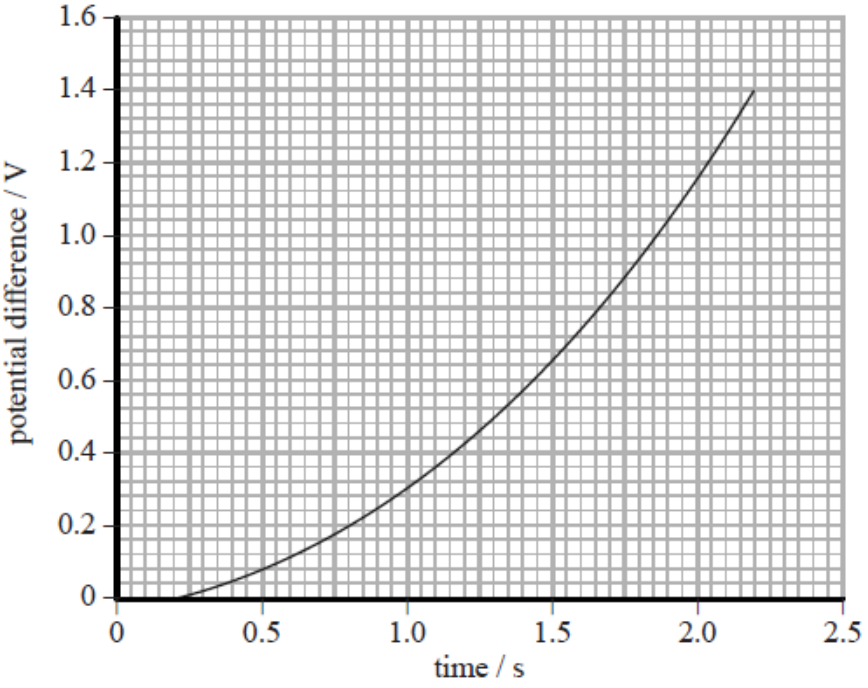
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(b) The graph shows the data obtained from the data logger.



Determine the velocity of the trolley at 1.5 s.

1.5 V represents a distance of 2.00 m.

(4)

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Velocity = ...

(c) The student calculated the velocity of the trolley at 2.0 s to be 1.5 m s^{-1}.

By considering the acceleration of the trolley, determine whether the student's measurement of θ was within the uncertainty quoted.

(4)

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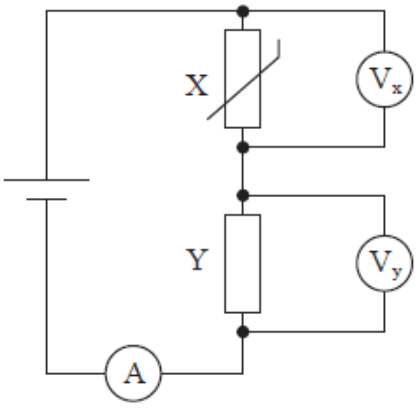
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(Total for question = 11 marks)

Q3.

The diagram shows a potential divider circuit that contains a negative temperature coefficient thermistor.



The temperature of the room containing the circuit increases.

Select the row of the table that correctly shows the changes in readings on the meters.

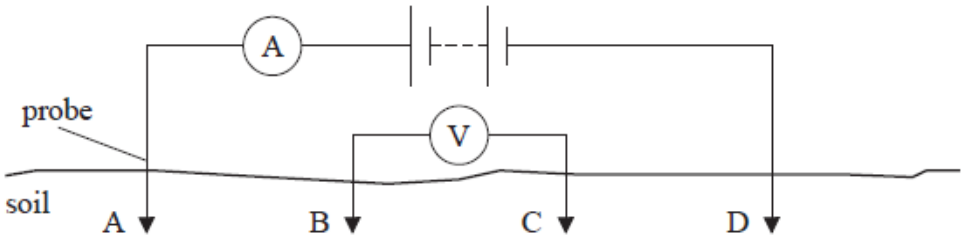
	V_x	V_y	A
☐ A	decrease	increase	decrease
☐ B	decrease	increase	increase
☐ C	increase	decrease	decrease
☐ D	increase	decrease	increase

(Total for question = 1 mark)

Q4.

Archaeologists use resistivity surveying of soil to search for the remains of buildings and settlements under the ground.

A basic arrangement that can be used to determine the resistivity of a region of soil is shown.



Probes are placed at positions A and D so that the length AD of soil forms part of the circuit. The ammeter measures the current through the soil.

A second pair of probes connected to a voltmeter is placed at positions B and C.
This measures the potential difference between positions B and C in the soil.

Explain how the reading on the voltmeter will change if the length BC increases.

(2)

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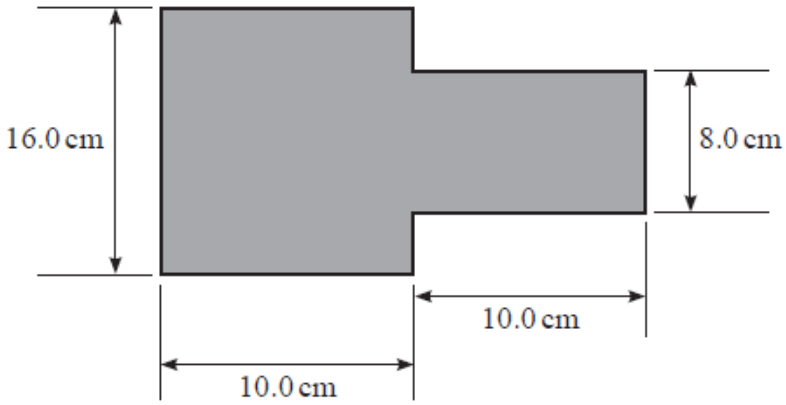
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(Total for question = 2 marks)

Q5.

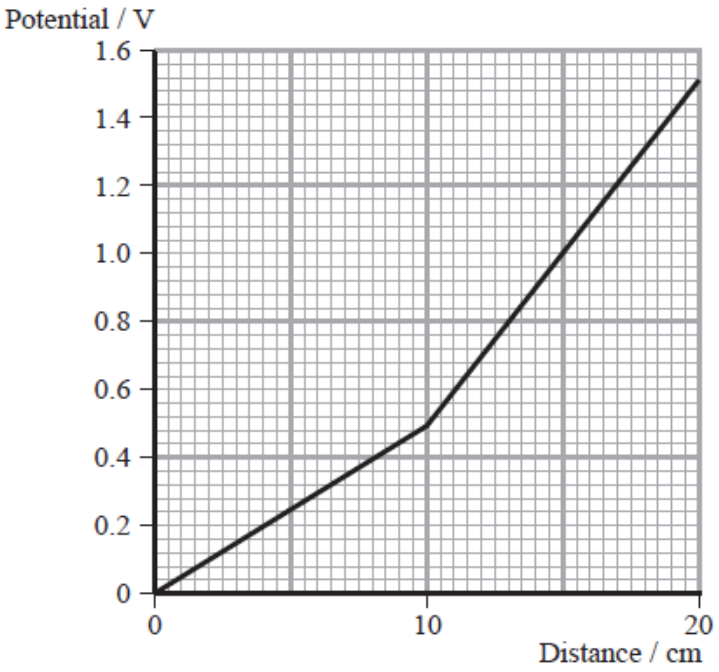
*****Carbon paper is an electrically conducting paper. A student cut a sheet of this paper into the shape shown, to carry out an investigation.



The student followed the procedure below to set up a potential divider circuit:

- connect the 16 cm and 8 cm wide ends to a 1.5 V cell
- connect the 16 cm wide end to the negative (0 V) terminal of the cell
- connect a voltmeter so that it measures the potential at a point 15 cm from the 16 cm wide end.

The following graph was plotted from an investigation in which the potential was measured at various distances from the 16.0 cm wide end of the shape.



Explain the shape of this graph.

(6)

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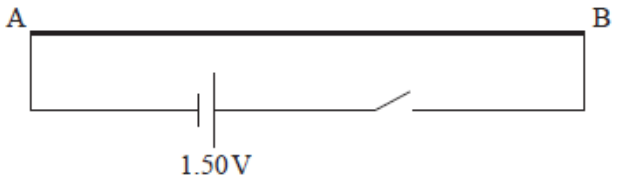
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(Total for question = 6 marks)

Q6.

A "metre bridge" is a circuit which can be used to measure an unknown resistance accurately. The metre bridge includes a metre length of nichrome wire.

This metre length of wire, labelled AB, is connected to a 1.50 V cell of negligible internal resistance and a switch as shown.



(i) Explain how the potential along this wire varies with distance from A when the switch is closed.

(2)

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(ii) Show that the potential difference between A and a point 75.0 cm along the wire from A is about 1.1 V.

(2)

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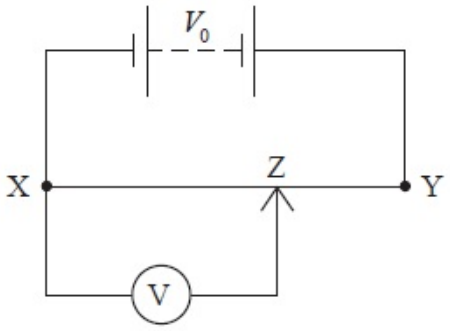
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(Total for question = 4 marks)

Q7. The diagram shows a uniform wire XY across which a potential difference V_0 is applied.



Which of the following correctly shows the output potential difference across XZ?

☒ **A** $V = \frac{XY}{XZ}V_0$

☒ **B** $V = \frac{XZ}{XY}V_0$

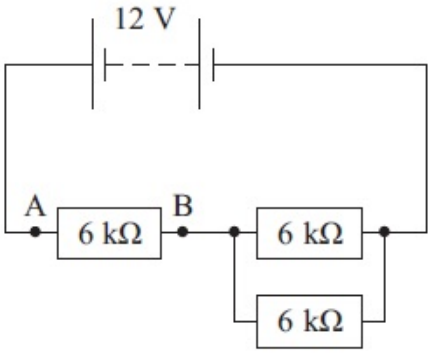
☒ **C** $V = \frac{XZ}{ZY}V_0$

☒ **D** $V = \frac{ZY}{XY}V_0$

(Total for Question = 1 mark)

Q8.

A combination of resistors is connected to a 12 V supply of negligible internal resistance.



The potential difference between points A and B is

☒ **A** 4 V

☒ **B** 6 V

☒ **C** 8 V

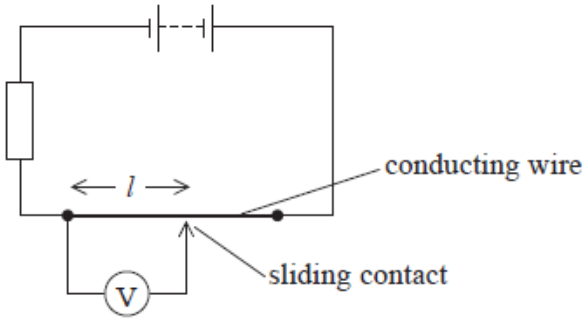
☒ **D** 12 V

(Total for question = 1 marks)

Q9.

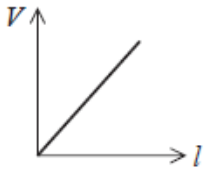
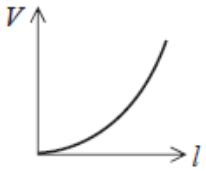
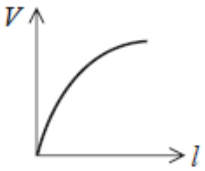
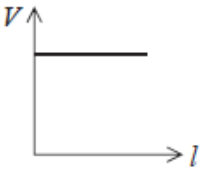
A student set up the circuit below and moved a sliding contact along a uniform conducting wire.

The student recorded the potential difference *V* across each length of wire *l* under test.



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

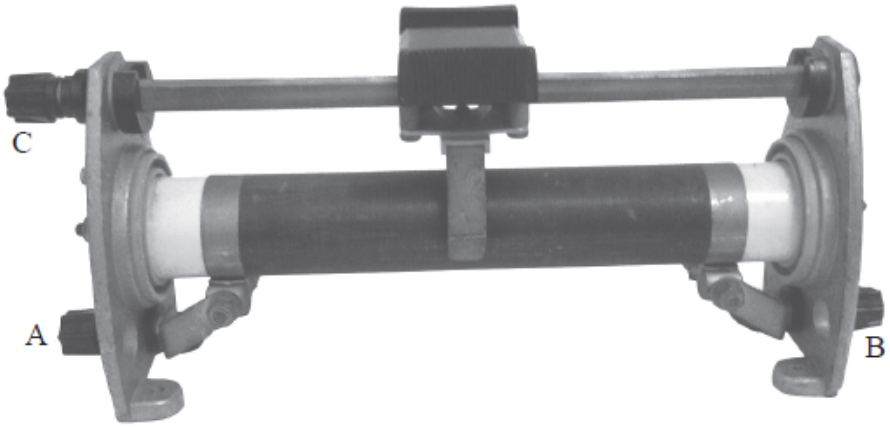
(1)

			
☒ **A**	☒ **B**	☒ **C**	☒ **D**

(Total for question = 1 mark)

Q10.

Photograph 1 shows a rheostat (a variable resistor).

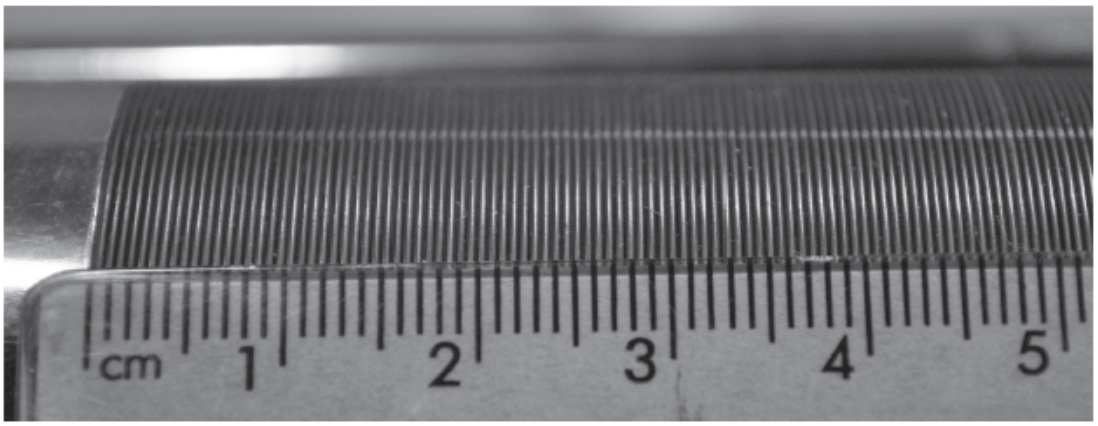


Photograph 1

The rheostat is made of a long resistance wire coiled around an insulating cylinder. The turns of wire are also separated from each other by insulation of negligible thickness. The ends of the wire are connected to the sockets A and B at either end and there is a sliding contact in the centre connected to the socket C. The resistance between A and C is varied by moving the sliding contact.

(a) A student decides to determine the resistivity of the material from which the wire is made by measuring the dimensions of the wire and its resistance.

Photograph 2 shows a section of the rheostat and a scale.



Photograph 2

(i) Take measurements from the photograph and use them to show that the cross-sectional area of the wire is about 2×10^{-7} m^2.

(3)

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(ii) Calculate the resistivity of the material from which the wire is made.

resistance of wire = 22 Ω

length of wire = 12 m

(3)

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Resistivity = ...

(iii) Suggest an advantage for the student of using a photograph rather than taking direct measurements.

(1)

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(b) The coil of the rheostat is 10.2 cm long. A potential difference of 12 V is applied across AB and the slider C is 7.0 cm from the end of the coil near A.

(2)

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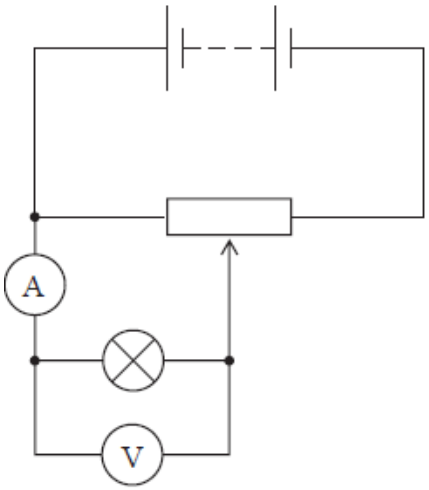
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Potential difference = ...

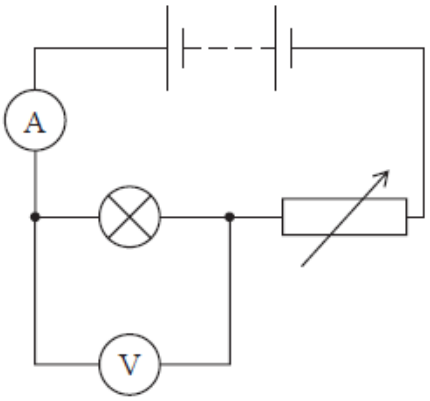
(Total for question = 9 marks)

Q1.

A student is planning to collect data to produce a current-potential difference graph for a filament lamp. Her teacher suggests two circuits that she could use.



Circuit 1



Circuit 2

Circuit 1 uses a potential divider and circuit 2 uses a variable resistor to vary the potential difference across the filament lamp.

*Discuss the suitability of each circuit to collect the data.

(6)

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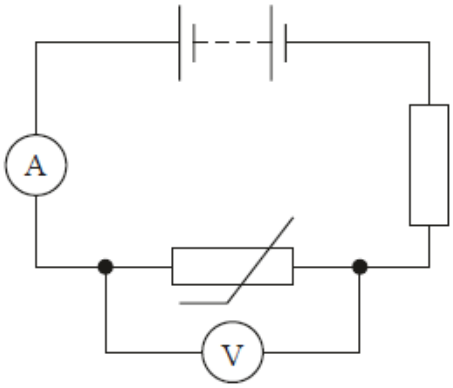
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(Total for question = 6 marks)

Q2.

A student investigated the effect of temperature on the resistance of a thermistor, using the circuit shown.



A negative temperature coefficient thermistor was used in this circuit.

With reference to the charge carriers in the thermistor, explain what happens to the p.d. across the thermistor as the temperature increases.

(3)

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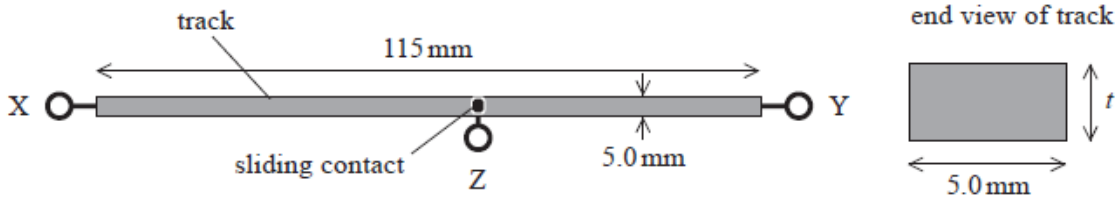
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(Total for question = 3 marks)

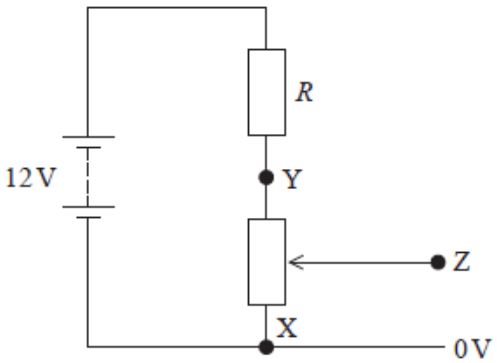
Q3.

A potential divider circuit may contain a component known as a potentiometer. One type of potentiometer consists of a track with terminals X and Y at either end. There is a sliding contact that can move along the track connected to a terminal Z as shown.



The length of the track is 115 mm and the width is 5.0 mm.

The potentiometer is used to monitor the displacement of a moving tool on a machine in a production line. The tool is attached to the sliding contact. The potentiometer is connected to a resistor of resistance *R* and a potential difference is applied as shown. The tool moves through a maximum displacement of 60 mm from end X, producing a maximum potential difference of 5.0 V between Z and X.



(i) Show that the potential difference between X and Y is about 10 V.

(2)

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(ii) Calculate the value of *R*.

(3)

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R = ...

(iii) When the circuit is assembled, using the correctly calculated resistance value and a battery of e.m.f. 12 V, it is found that the maximum output from the potentiometer is slightly less than 5.0 V.

Explain why the maximum output is slightly less than predicted.

(3)

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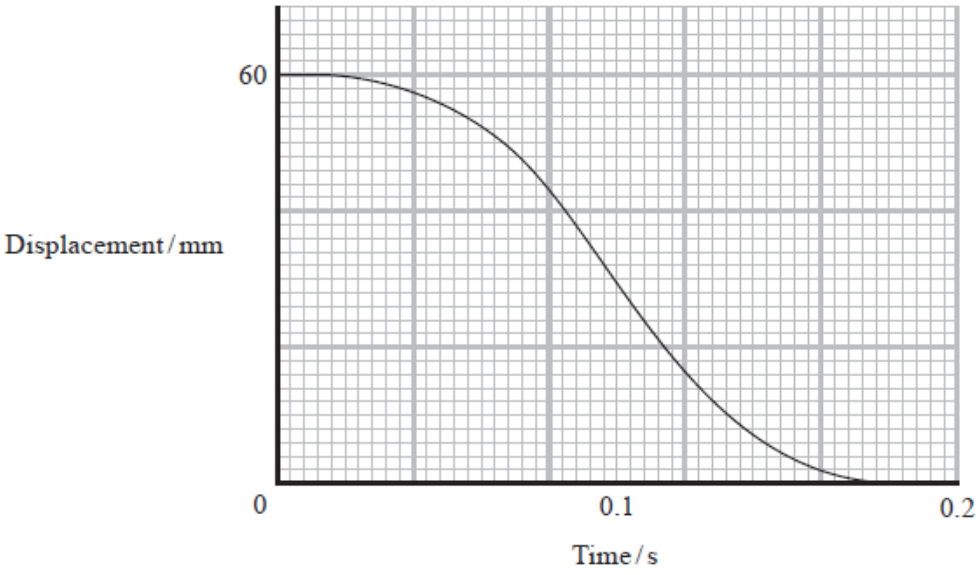
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(iv) The tool on the machine should not travel with a speed any larger than 0.8 m s^{-1} .

The graph shows how the displacement varies with time for the downward stroke of the moving tool.



Deduce whether this speed is exceeded by the moving tool.

(4)

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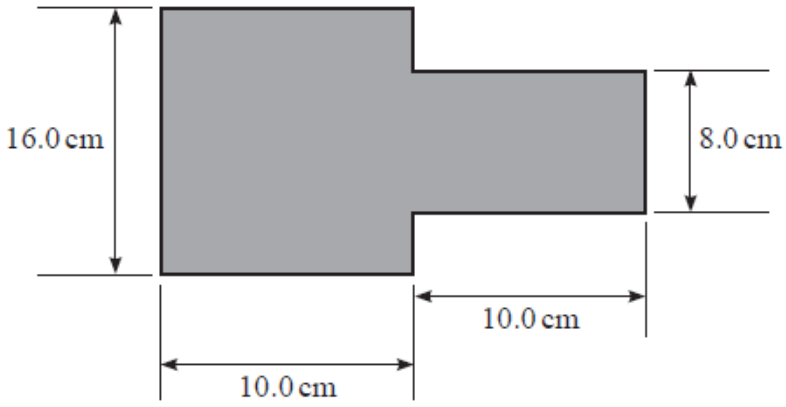
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(Total for question = 12 marks)

Q4.

Carbon paper is an electrically conducting paper. A student cut a sheet of this paper into the shape shown, to carry out an investigation.

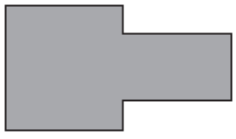


The student followed the procedure below to set up a potential divider circuit:

- connect the 16 cm and 8 cm wide ends to a 1.5 V cell
- connect the 16 cm wide end to the negative (0 V) terminal of the cell
- connect a voltmeter so that it measures the potential at a point 15 cm from the 16 cm wide end.

Add a circuit diagram to the diagram below to show how the carbon paper is connected.

(2)

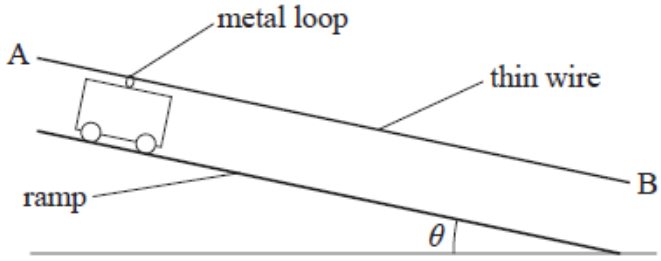


(Total for question = 2 marks)

Q5.

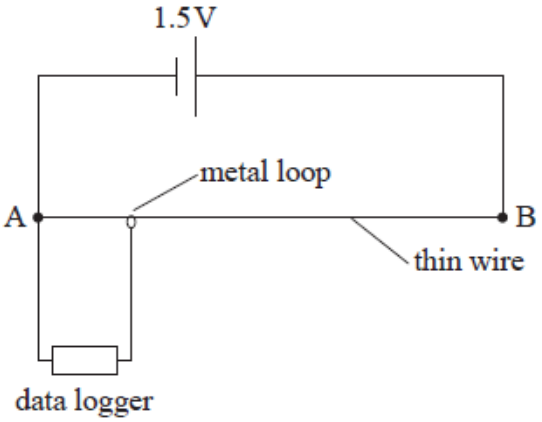
A student investigates the motion of a friction-free trolley down a ramp. On the top of the trolley there is a metal loop which makes contact with a length of thin resistance wire, AB, fixed above the ramp. The resistance wire has a uniform diameter.

The trolley accelerates down the ramp and the metal loop stays in contact with the wire along the full length of the ramp.



The student uses a protractor to measure the angle θ between the ramp and the horizontal and records a value of 4° with an uncertainty of ±1°.

(a) The two ends of the wire are connected to a 1.5 V cell. A data logger, set to measure potential difference, is connected to the metal loop and to the negative terminal of the cell.



Explain how the potential difference recorded by the data logger will vary as the loop moves along the length of the
wire AB.

(3)

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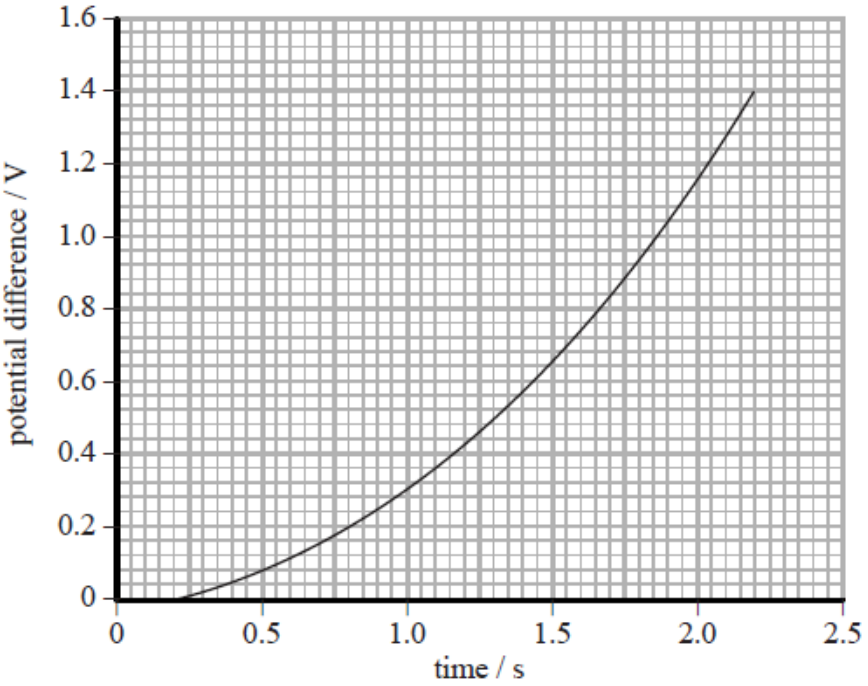
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(b) The graph shows the data obtained from the data logger.



Determine the velocity of the trolley at 1.5 s.

1.5 V represents a distance of 2.00 m.

(4)

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Velocity = ...

(c) The student calculated the velocity of the trolley at 2.0 s to be 1.5 m s^{-1}.

By considering the acceleration of the trolley, determine whether the student's measurement of θ was within the uncertainty quoted.

(4)

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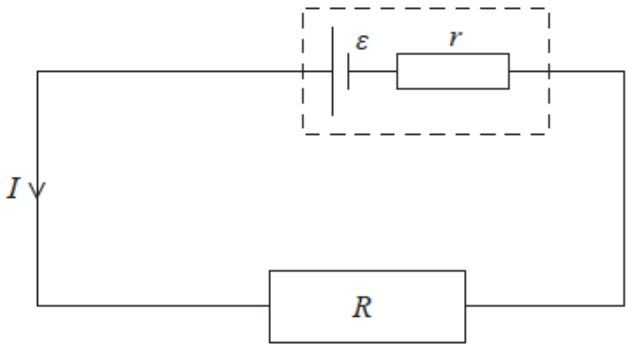
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(Total for question = 11 marks)

Q6.

The diagram represents a resistor of resistance R in a series circuit with a cell of e.m.f. ε and internal resistance r.



Which of the following correctly gives the potential difference V across the internal resistance?

☒ **A** $V = \dfrac{\varepsilon(R+r)}{r}$

☒ **B** $V = \dfrac{\varepsilon R}{R+r}$

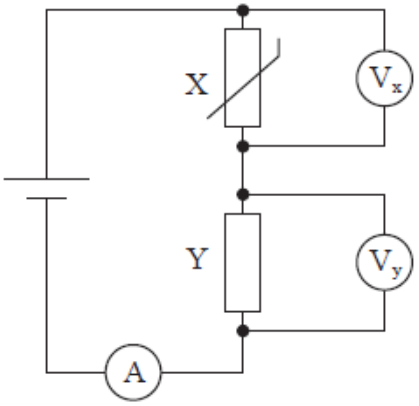
☒ **C** $V = \dfrac{\varepsilon(R+r)}{R}$

☒ **D** $V = \dfrac{\varepsilon r}{(R+r)}$

(Total for question = 1 mark)

Q7.

The diagram shows a potential divider circuit that contains a negative temperature coefficient thermistor.



The temperature of the room containing the circuit increases.

Select the row of the table that correctly shows the changes in readings on the meters.

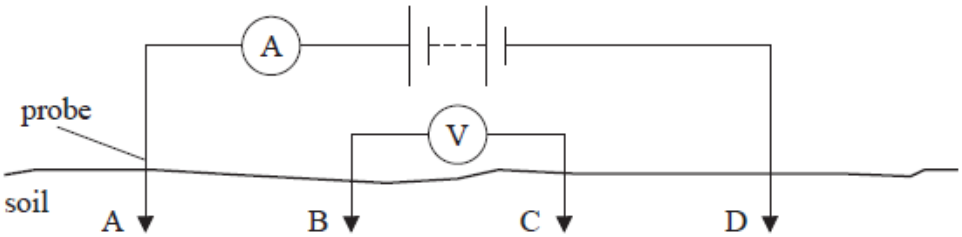
	V_x	V_y	A
☐ **A**	decrease	increase	decrease
☐ **B**	decrease	increase	increase
☐ **C**	increase	decrease	decrease
☐ **D**	increase	decrease	increase

(Total for question = 1 mark)

Q8.

Archaeologists use resistivity surveying of soil to search for the remains of buildings and settlements under the ground.

A basic arrangement that can be used to determine the resistivity of a region of soil is shown.



Probes are placed at positions A and D so that the length AD of soil forms part of the circuit.
The ammeter measures the current through the soil.

A second pair of probes connected to a voltmeter is placed at positions B and C.
This measures the potential difference between positions B and C in the soil.

Explain how the reading on the voltmeter will change if the length BC increases.

(2)

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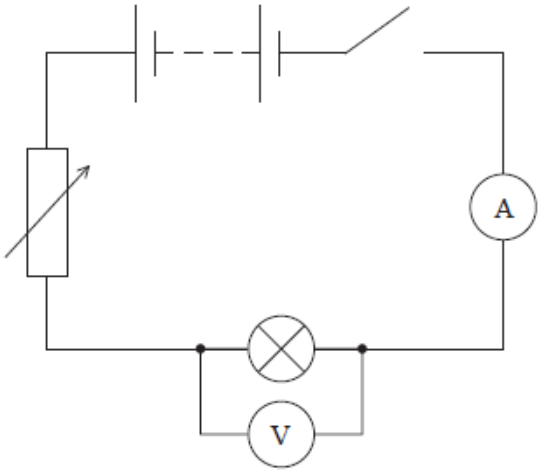
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(Total for question = 2 marks)

Q9.

A student set up the circuit shown and measured the current *I* through the filament lamp for a range of values of potential difference (p.d.) *V*.



The student's data is shown in the table.

V / V	I / A
3.0	0.6
4.0	0.75
6.0	1.00
8.0	1.20
10.0	1.35
12.0	1.5

Using the circuit shown the student was unable to obtain data for p.d.s less than 2.5 V.

Draw a diagram of a circuit the student could have used to enable a full range of p.d.s from 0 to 12 V to be investigated.

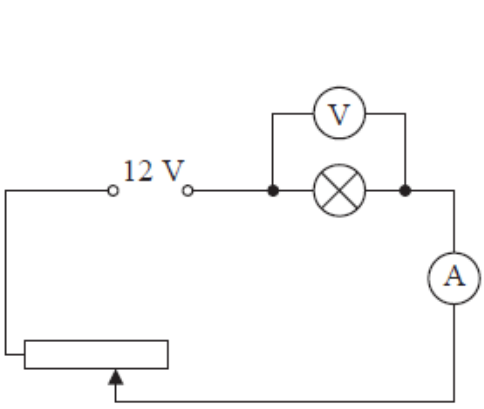
(2)

(Total for question = 2 marks)

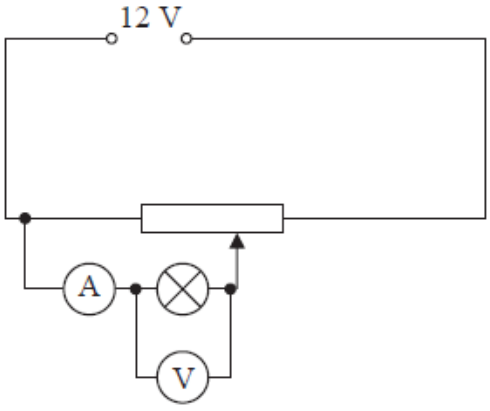
Q10.

Students are investigating how the current through a filament lamp depends upon the potential difference across the lamp. They are provided with a power supply of 12 V and a variable resistor.

Two students set up different circuits as shown.



Circuit A



Circuit B

Evaluate the effectiveness of the circuit used by each student in obtaining data for a current-potential difference characteristic graph. Assume that the voltmeters have infinite resistance.

(5)

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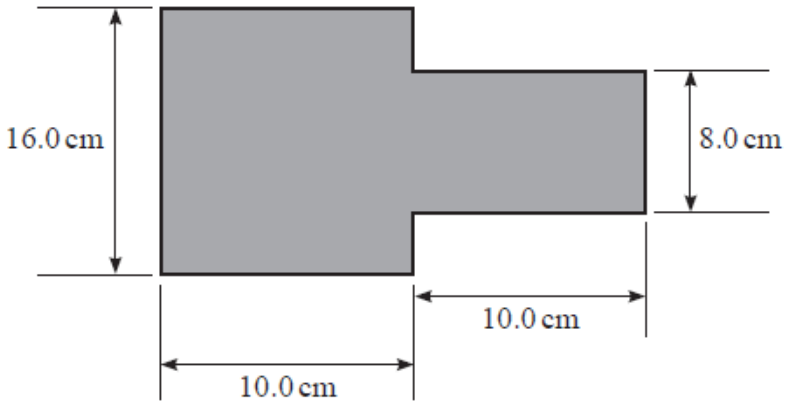
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(Total for question = 5 marks)

Q11.

*****Carbon paper is an electrically conducting paper. A student cut a sheet of this paper into the shape shown, to carry out an investigation.

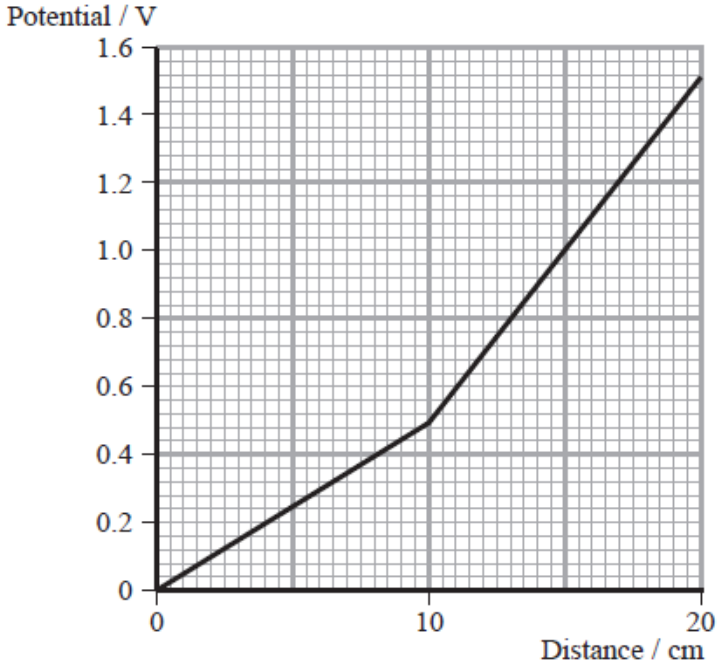


The student followed the procedure below to set up a potential divider circuit:

- connect the 16 cm and 8 cm wide ends to a 1.5 V cell
- connect the 16 cm wide end to the negative (0 V) terminal of the cell

- connect a voltmeter so that it measures the potential at a point 15 cm from the 16 cm wide end.

The following graph was plotted from an investigation in which the potential was measured at various distances from the 16.0 cm wide end of the shape.



Explain the shape of this graph.

(6)

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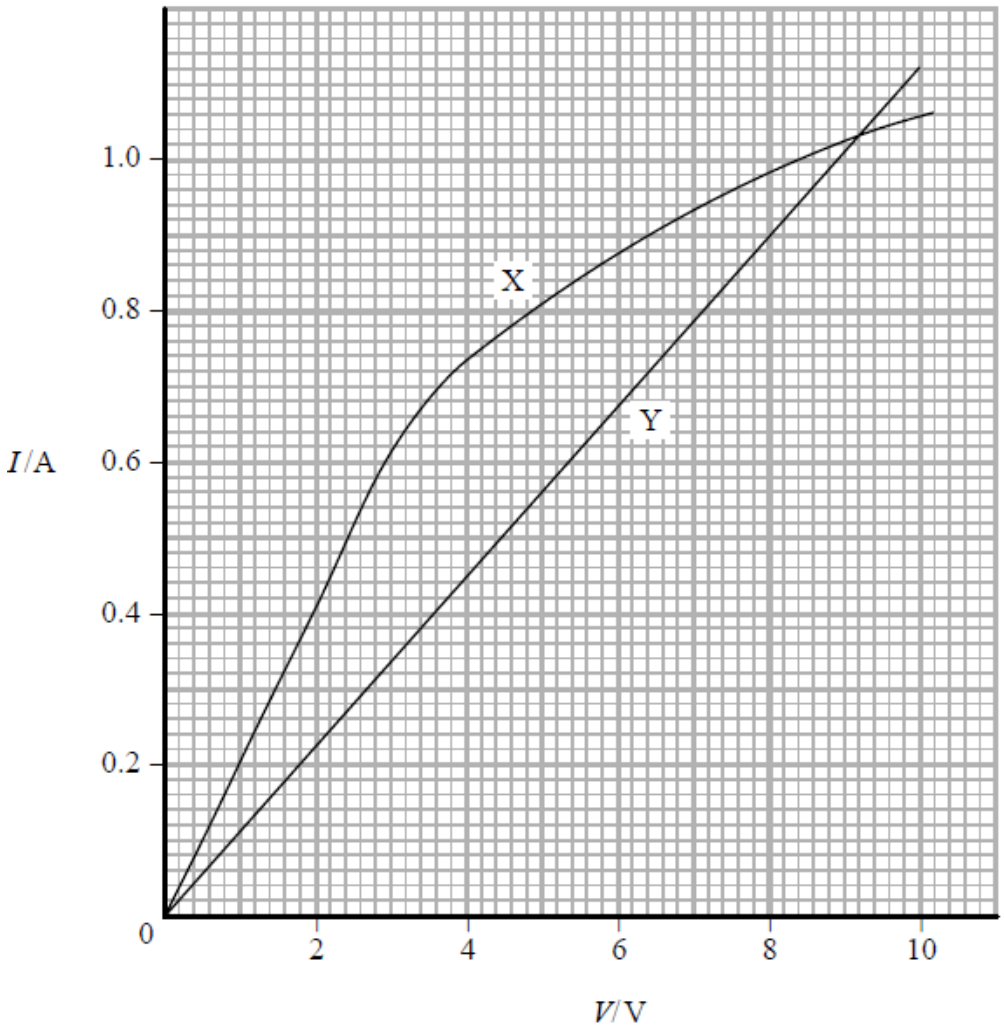
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(Total for question = 6 marks)

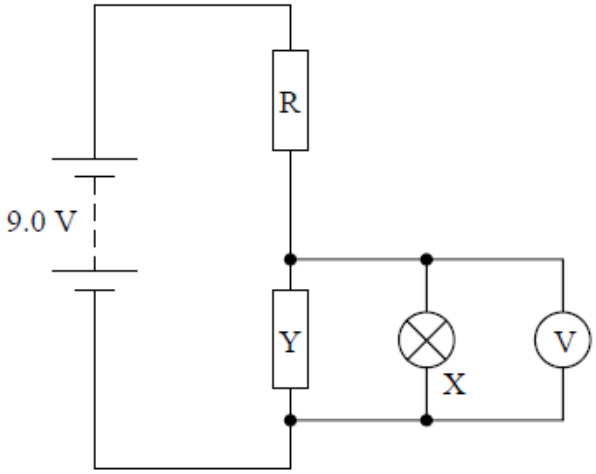
Q12.

The graph shows the variation of current *I* with potential difference *V* for two electrical components X and Y.

X is a filament bulb and Y is a fixed resistor.



A potential divider circuit consisting of components X and Y is connected to a 9.0 V supply in series with a fixed resistor R as shown. The supply has a negligible internal resistance.



The reading on the voltmeter is 3.0 V.

(i) Determine the current in the fixed resistor R.

(2)

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Current in the fixed resistor R = ...

(ii) Component X is removed from the circuit.

Explain, without further calculation, how this would change the voltmeter reading.

(3)

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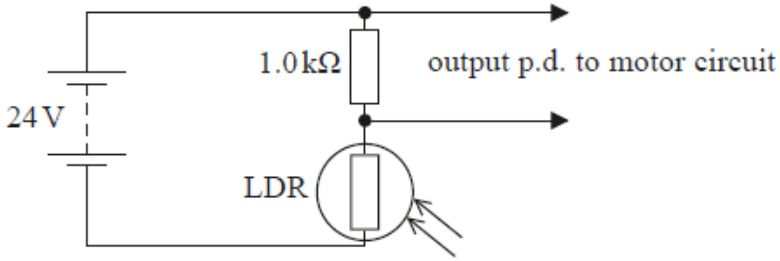
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(Total for question = 5 marks)

Q13.

A solar panel uses electromagnetic radiation from the Sun to generate electricity.
In one installation a sensor in the solar panel measures the intensity of radiation arriving from different directions. A motor rotates the solar panel so that it always faces the brightest part of the sky.

The circuit diagram shows how a light dependent resistor (LDR) can be used to produce an output potential difference (p.d.) that is dependent on the intensity of light. This output p.d. is connected to a motor circuit that operates the movement of the solar panel.



Initially the motor is switched off. The light intensity increases and the resistance of the LDR decreases to 750 Ω.

The motor switches on when the output p.d. is above 13 V.

Deduce whether this change in light intensity causes the motor to switch on.

(3)

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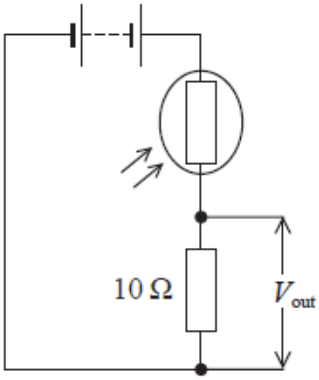
(Total for question = 3 marks)

Q14.

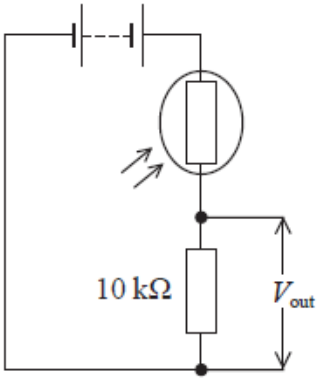
When a light dependent resistor is illuminated, its resistance falls from 1000 kΩ to 0.1kΩ.

The light dependent resistor is connected in series with a fixed resistor.

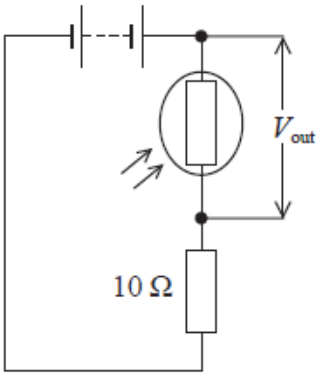
Which of the circuits shown would produce the greatest output potential difference V_{out} when illuminated?



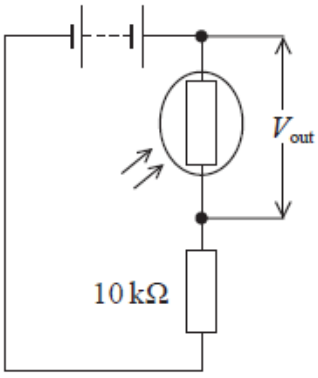
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(Total for question = 1 mark)

Q15.

A series circuit consists of two resistors with resistances R_1 and R_2 and a battery of potential difference V.

Which of the following gives the potential difference across the resistor with resistance R_2?

(1)

☐ **A** $\frac{R_1}{R_2} V$

☐ **B** $\frac{R_2}{R_1} V$

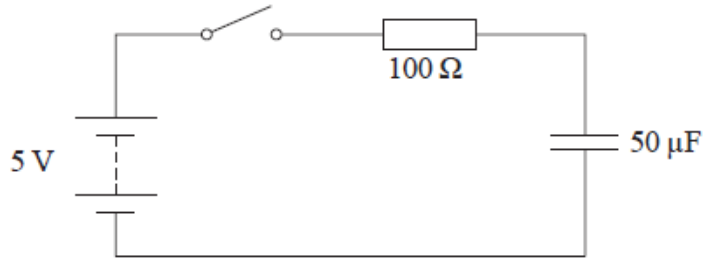
☐ **C** $\frac{R_1}{R_1 + R_2} V$

☐ **D** $\frac{R_2}{R_1 + R_2} V$

(Total for question = 1 mark)

Q16.

A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



Describe what happens to the potential difference across the resistor and the potential difference across the capacitor after the switch is closed.

(4)

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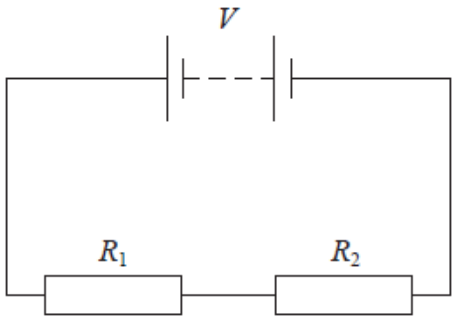
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(Total for question = 4 marks)

Q17.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Two resistors of resistance R_1 and R_2 are connected to a battery as shown.
The terminal potential difference of the battery is V.



Which of the following gives the potential difference across the resistor of resistance R_1?

☒ **A** $\frac{R_1}{R_2} \times V$

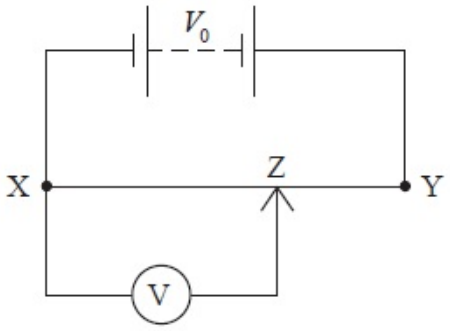
☒ **B** $\frac{R_1}{R_1 + R_2} \times V$

☒ **C** $\frac{R_2}{R_1} \times V$

☒ **D** $\frac{R_2}{R_1 + R_2} \times V$

(Total for question = 1 mark)

Q18. The diagram shows a uniform wire XY across which a potential difference V_0 is applied.



Which of the following correctly shows the output potential difference across XZ?

☒ **A** $V = \frac{XY}{XZ}V_0$

☒ **B** $V = \frac{XZ}{XY}V_0$

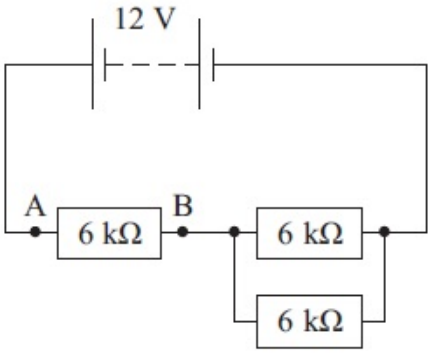
☒ **C** $V = \frac{XZ}{ZY}V_0$

☒ **D** $V = \frac{ZY}{XY}V_0$

(Total for Question = 1 mark)

Q19.

A combination of resistors is connected to a 12 V supply of negligible internal resistance.



The potential difference between points A and B is

☒ **A** 4 V

☒ **B** 6 V

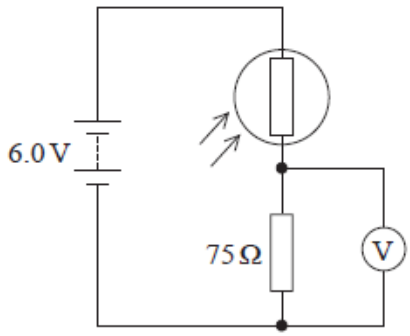
☒ **C** 8 V

☒ **D** 12 V

(Total for question = 1 marks)

Q20.

A student set up a circuit containing a light dependent resistor (LDR) in series with a fixed resistor as shown.



When the lamp was at a distance of 10 cm from the LDR, the reading on the voltmeter was 2.4V.

Calculate the resistance of the LDR at this distance.

(3)

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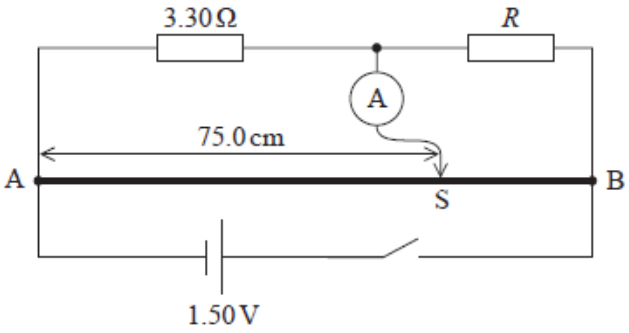
Resistance of the LDR = ...

(Total for question = 3 marks)

Q21.

A "metre bridge" is a circuit which can be used to measure an unknown resistance accurately. The metre bridge includes a metre length of nichrome wire.

The metre bridge circuit is shown. The circuit includes a resistor of resistance 3.30Ω, a very sensitive ammeter and a resistor of unknown resistance *R*.



A metal slider S can be moved along the nichrome wire and pressed firmly against it to make an electrical connection.

When the switch is closed and S is 75.0 cm along the nichrome wire, the ammeter reads 0 A because the potential difference across the ammeter is zero.

Calculate *R*.

(2)

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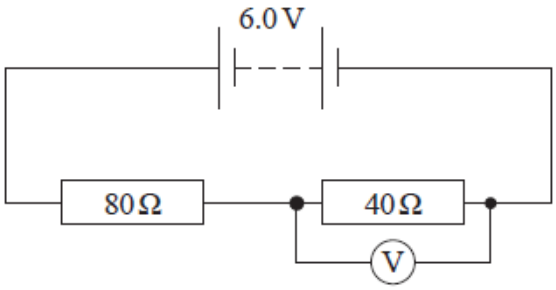
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R = ...

(Total for question = 2 marks)

Q22.

The circuit diagram shows two resistors in series across a battery of e.m.f. 6.0 V and negligible internal resistance. A voltmeter with low resistance is connected across the 40 Ω resistor.



The reading on the voltmeter is 1.8 V.

Calculate the resistance of the voltmeter.

(3)

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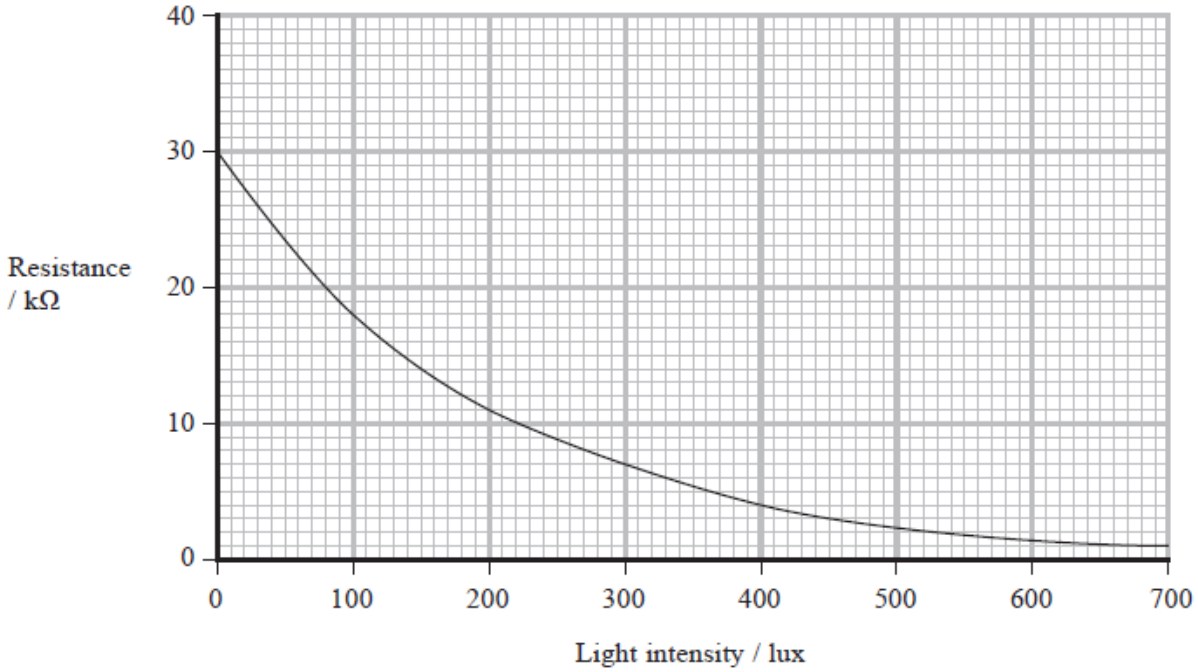
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Resistance of voltmeter = ...

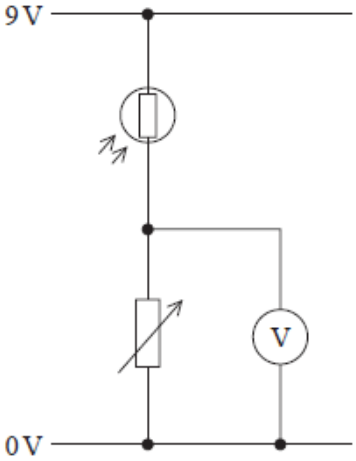
(Total for question = 3 marks)

Q23.

The graph shows how the resistance of a light dependent resistor (LDR) varies with the incident light intensity, measured in lux.



A student used the LDR in the light-sensing circuit shown below.



The variable resistor was set at a resistance of 4.5 kΩ.

Determine the light intensity when the potential difference shown on the voltmeter was 2.5 V.

(3)

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Ligt intensity = ... lux

(Total for question = 3 marks)

Q24.

Read the following extract and then answer the questions that follow.

Powdery dust, the by-product of fearsome meteor storms that pounded the Moon, coats much of the lunar surface. A build-up of this dust could damage sensitive machinery.

Scientists theorise that lunar dust must be electrostatically charged by ultraviolet solar radiation from the Sun. When ultraviolet radiation hits the Moon's "day side", the half that faces the Sun, it knocks electrons out of atoms in the lunar soil.

(a) Describe the particle model of ultraviolet radiation that explains how it can "knock electrons out of atoms".

(3)

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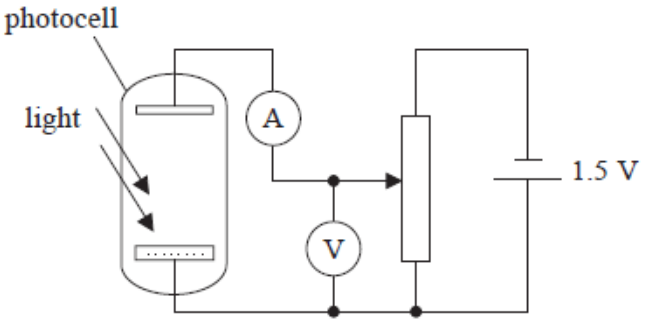
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(b) A teacher uses the arrangement below to demonstrate that electrons can be knocked out of a metal surface in a photocell by visible light.

The arrangement can also be used to measure the maximum kinetic energy of these electrons.



(i) Explain how the potential divider circuit can produce a range of values from 0 to 1.5 V on the voltmeter.

(3)

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(ii) The potential difference on the voltmeter is increased until the ammeter reading is zero.

The voltmeter reads 0.6 V at this instant.
State the maximum kinetic energy of the electrons in eV.

(1)

Maximum kinetic energy = ... eV

(c) Discuss whether the photocell arrangement in part (b) gives a valid demonstration of how dust particles become charged on the Moon.

(4)

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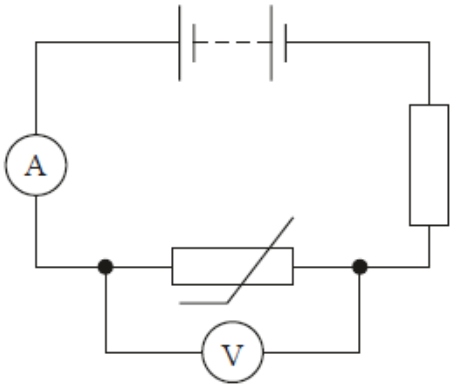
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(Total for question = 11 marks)

Q1.

A student investigated the effect of temperature on the resistance of a thermistor, using the circuit shown.



A negative temperature coefficient thermistor was used in this circuit.

With reference to the charge carriers in the thermistor, explain what happens to the p.d. across the thermistor as the temperature increases.

(3)

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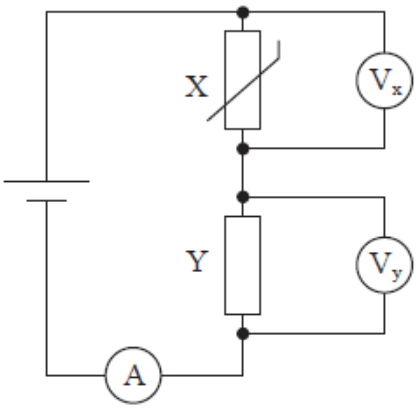
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(Total for question = 3 marks)

Q2.

The diagram shows a potential divider circuit that contains a negative temperature coefficient thermistor.



The temperature of the room containing the circuit increases.

Select the row of the table that correctly shows the changes in readings on the meters.

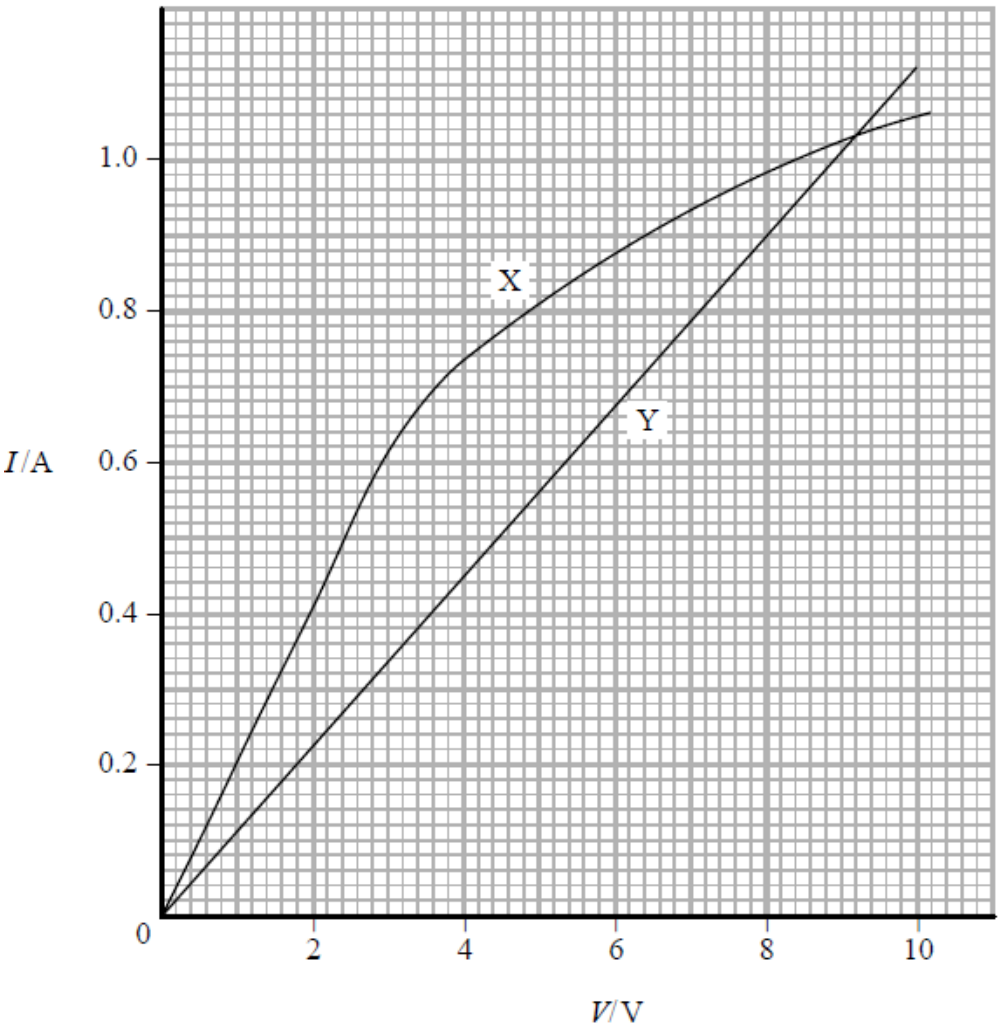
	V_x	V_y	A
☐ **A**	decrease	increase	decrease
☐ **B**	decrease	increase	increase
☐ **C**	increase	decrease	decrease
☐ **D**	increase	decrease	increase

(Total for question = 1 mark)

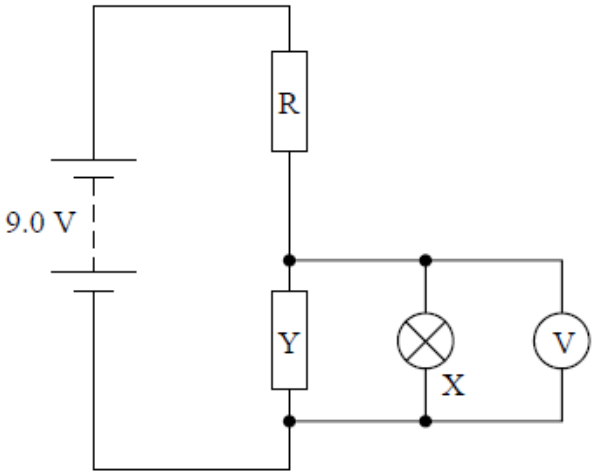
Q3.

The graph shows the variation of current *I* with potential difference *V* for two electrical components X and Y.

X is a filament bulb and Y is a fixed resistor.



A potential divider circuit consisting of components X and Y is connected to a 9.0 V supply in series with a fixed resistor R as shown. The supply has a negligible internal resistance.



The reading on the voltmeter is 3.0 V.

(i) Determine the current in the fixed resistor R.

(2)

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Current in the fixed resistor R = ...

(ii) Component X is removed from the circuit.

Explain, without further calculation, how this would change the voltmeter reading.

(3)

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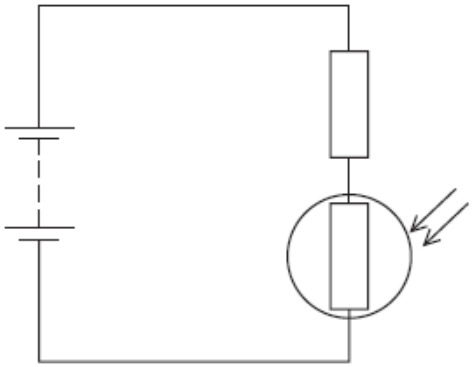
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(Total for question = 5 marks)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A light dependent resistor (LDR) and a resistor are connected to a battery, as shown.



The intensity of light incident on the LDR increases.

Which row of the table describes the change in the resistance of the LDR and the change in the potential difference across the resistor?

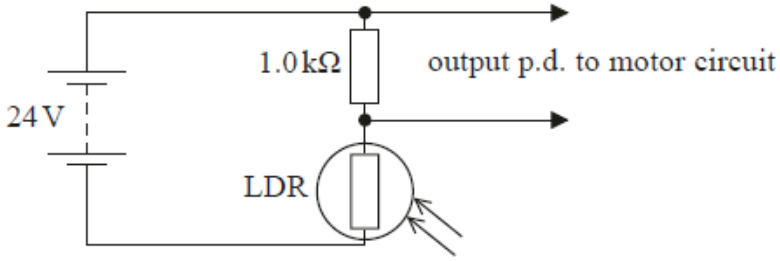
	Resistance of LDR	Potential difference across the resistor
☒ A	decreases	decreases
☒ B	decreases	increases
☒ C	increases	decreases
☒ D	increases	increases

(Total for question = 1 mark)

Q5.

A solar panel uses electromagnetic radiation from the Sun to generate electricity.
In one installation a sensor in the solar panel measures the intensity of radiation arriving from different directions. A motor rotates the solar panel so that it always faces the brightest part of the sky.

The circuit diagram shows how a light dependent resistor (LDR) can be used to produce an output potential difference (p.d.) that is dependent on the intensity of light. This output p.d. is connected to a motor circuit that operates the movement of the solar panel.



Initially the motor is switched off. The light intensity increases and the resistance of the LDR decreases to 750 Ω.

The motor switches on when the output p.d. is above 13 V.

Deduce whether this change in light intensity causes the motor to switch on.

(3)

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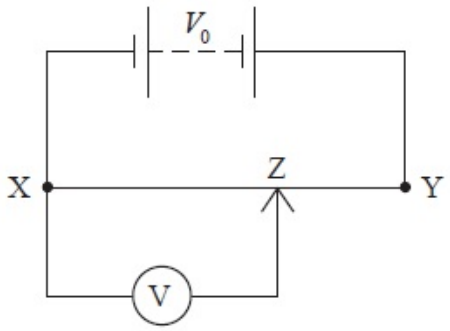
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(Total for question = 3 marks)

Q6. The diagram shows a uniform wire XY across which a potential difference V_0 is applied.



Which of the following correctly shows the output potential difference across XZ?

☒ **A** $V = \frac{XY}{XZ}V_0$

☒ **B** $V = \frac{XZ}{XY}V_0$

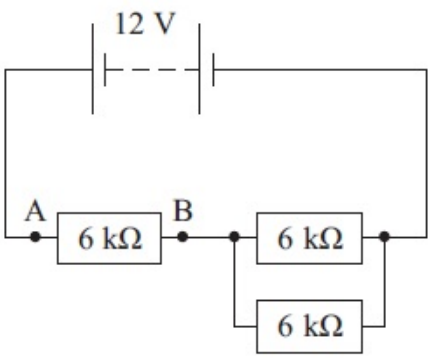
☒ **C** $V = \frac{XZ}{ZY}V_0$

☒ **D** $V = \frac{ZY}{XY}V_0$

(Total for Question = 1 mark)

Q7.

A combination of resistors is connected to a 12 V supply of negligible internal resistance.



The potential difference between points A and B is

☒ **A** 4 V

☒ **B** 6 V

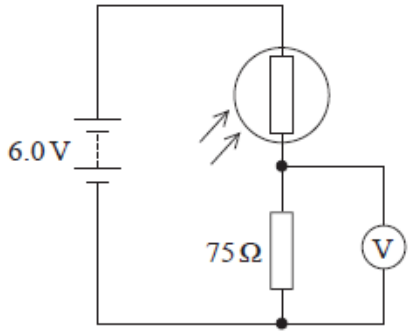
☒ **C** 8 V

☒ **D** 12 V

(Total for question = 1 marks)

Q8.

A student set up a circuit containing a light dependent resistor (LDR) in series with a fixed resistor as shown.



When the lamp was at a distance of 10 cm from the LDR, the reading on the voltmeter was 2.4V.

Calculate the resistance of the LDR at this distance.

(3)

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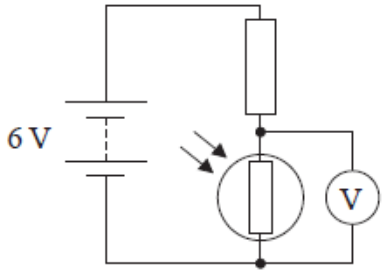
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Resistance of the LDR = ...

(Total for question = 3 marks)

Q9.

A light-dependent resistor (LDR) and resistor are connected in series with a 6V battery as shown. A voltmeter measures the potential difference across the LDR.



In daylight the voltmeter reads 3.0V.

Which reading is most likely if the circuit is now in total darkness?

(1)

☒ **A** a little above 0 V

☒ **B** a little below 3 V

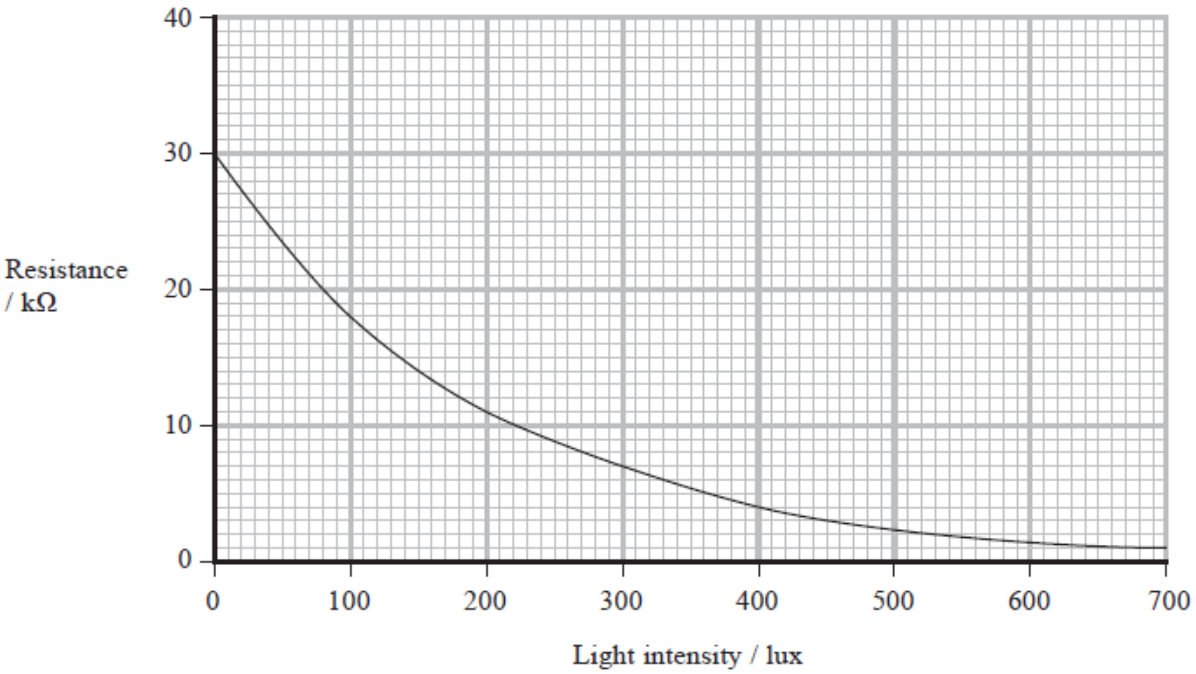
☒ **C** a little above 3 V

☒ **D** a little below 6 V

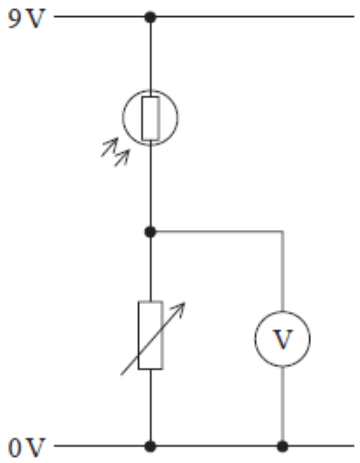
(Total for question = 1 mark)

Q10.

The graph shows how the resistance of a light dependent resistor (LDR) varies with the incident light intensity, measured in lux.



A student used the LDR in the light-sensing circuit shown below.



The student increased the resistance of the variable resistor whilst the light intensity was constant. The voltmeter recorded the potential difference across the variable resistor.

Explain what happened to the reading on the voltmeter.

(3)

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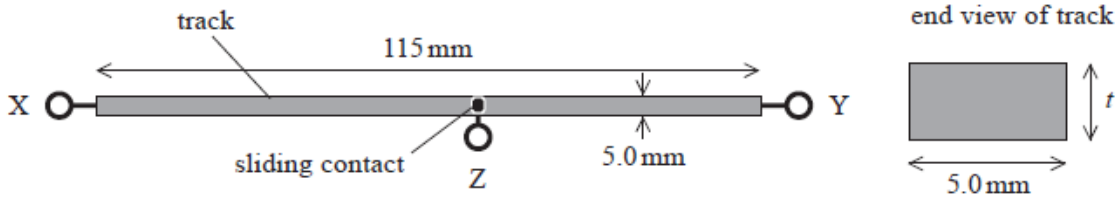
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(Total for question = 3 marks)

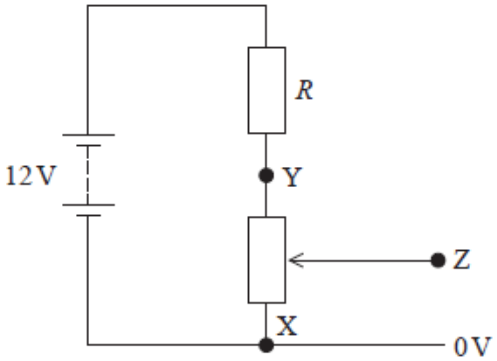
Q1.

A potential divider circuit may contain a component known as a potentiometer. One type of potentiometer consists of a track with terminals X and Y at either end. There is a sliding contact that can move along the track connected to a terminal Z as shown.



The length of the track is 115 mm and the width is 5.0 mm.

The potentiometer is used to monitor the displacement of a moving tool on a machine in a production line. The tool is attached to the sliding contact. The potentiometer is connected to a resistor of resistance *R* and a potential difference is applied as shown. The tool moves through a maximum displacement of 60 mm from end X, producing a maximum potential difference of 5.0 V between Z and X.



(i) Show that the potential difference between X and Y is about 10 V.

(2)

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(ii) Calculate the value of *R*.

(3)

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R = ...

(iii) When the circuit is assembled, using the correctly calculated resistance value and a battery of e.m.f. 12 V, it is found that the maximum output from the potentiometer is slightly less than 5.0 V.

Explain why the maximum output is slightly less than predicted.

(3)

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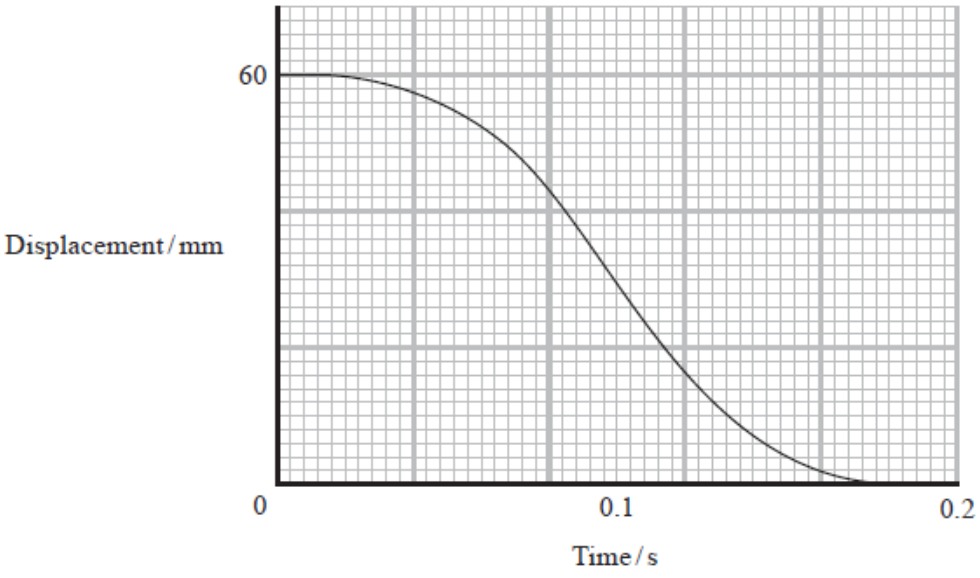
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(iv) The tool on the machine should not travel with a speed any larger than 0.8 m s^{-1} .

The graph shows how the displacement varies with time for the downward stroke of the moving tool.



Deduce whether this speed is exceeded by the moving tool.

(4)

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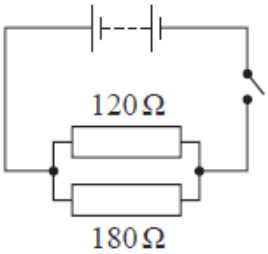
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(Total for question = 12 marks)

Q2.

This resistor combination is connected to a battery of e.m.f. ε and internal resistance *r*.



The switch is closed for 5 minutes.

Calculate the energy dissipated in the resistor combination.

ε = 9.0 V
r = 2.5 Ω

(4)

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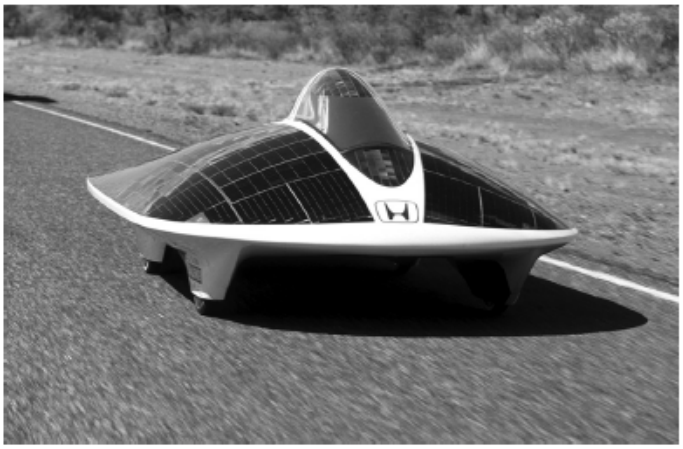
Energy dissipated in resistor combination = ...

(Total for question = 4 marks)

Q3.

The world solar challenge is set every two years, in Australia. The challenge is to complete a three thousand kilometre route with a vehicle powered only by the Sun.

Vehicles have their surfaces fitted with solar panels, as shown in the photograph.



(Source: © LAURENT DOUEK/LOOK AT SCIENCES/SCIENCE PHOTO LIBRARY)

One of the solar panels has an e.m.f. of 8.2 V when in sunlight. The terminal potential difference is 5.5 V when a current of 0.45 A is drawn from the solar panel.

Calculate the internal resistance of the solar panel in these conditions.

(3)

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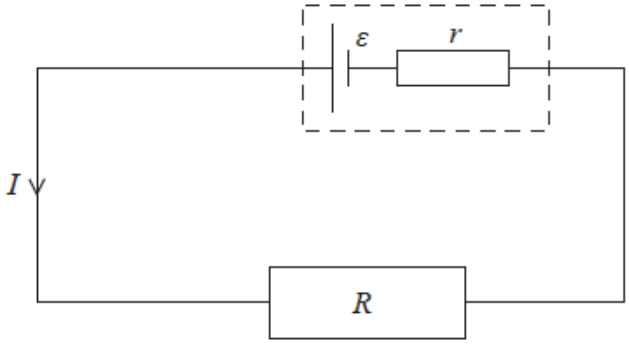
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Internal resistance = ...

(Total for question = 3 marks)

Q4.

The diagram represents a resistor of resistance R in a series circuit with a cell of e.m.f. ε and internal resistance r.



Which of the following correctly gives the potential difference V across the internal resistance?

☒ **A** $V = \dfrac{\varepsilon(R+r)}{r}$

☒ **B** $V = \dfrac{\varepsilon R}{R+r}$

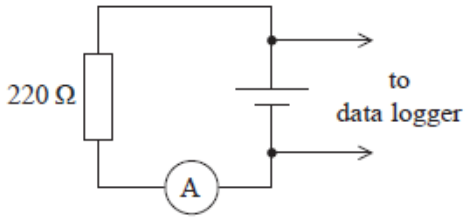
☒ **C** $V = \dfrac{\varepsilon(R+r)}{R}$

☒ **D** $V = \dfrac{\varepsilon r}{(R+r)}$

(Total for question = 1 mark)

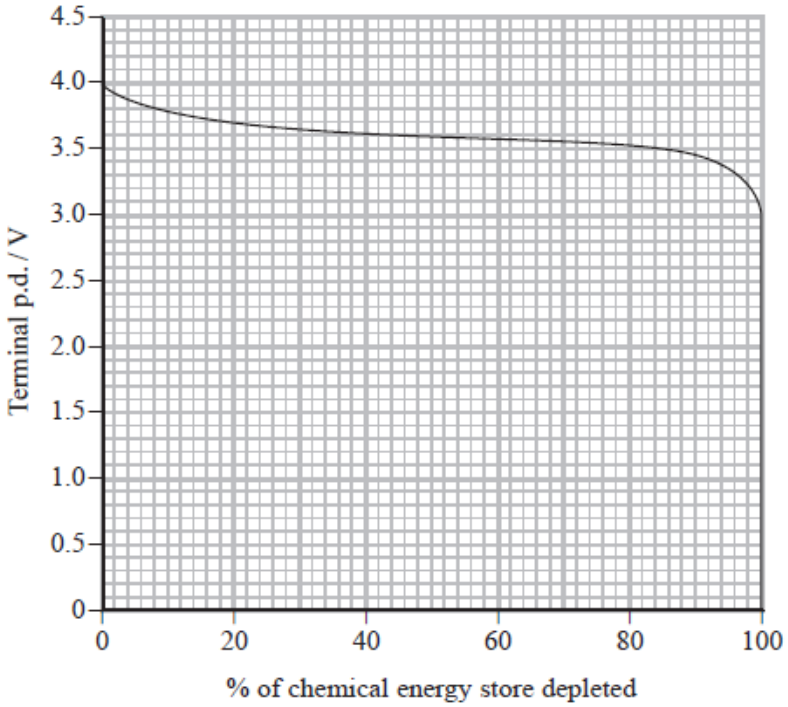
Q5.

A student is investigating how the internal resistance of a dry cell varies over time. She sets up the circuit shown to draw current from the cell.



The student proposes to use a data logger to monitor the terminal potential difference (p.d.) of the cell over a period of time.

The graph shows how the terminal p.d. varies as the chemical energy store in the cell is depleted.



(i) Explain, using the graph, why the current drawn from the cell decreases as the chemical energy store in the cell is depleted.

(2)

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(ii) Determine the internal resistance of the cell when its chemical energy store is 80% depleted. Assume that the e.m.f. of the cell remains constant at 4.0 V.

(3)

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Internal resistance = ...

(Total for question = 5 marks)

Q6.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A cell is connected across a resistor. After a while the internal resistance of the cell increases.

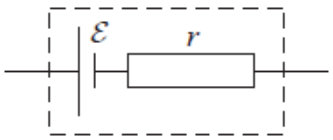
Which row of the table correctly shows the change in the current in the circuit and the change in the terminal potential difference across the cell?

	Current	Terminal potential difference
☐ A	decreases	decreases
☐ B	decreases	increases
☐ C	increases	decreases
☐ D	increases	increases

(Total for question = 1 mark)

Q7.

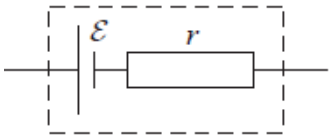
A cell may be represented as an e.m.f. ε in series with an internal resistance r.



A student used the relationship $V = \varepsilon - Ir$ and a graphical method to determine ε and r.
She connected a cell in a circuit and took a series of measurements of the current I in the cell and the potential difference V across the terminals of the cell.

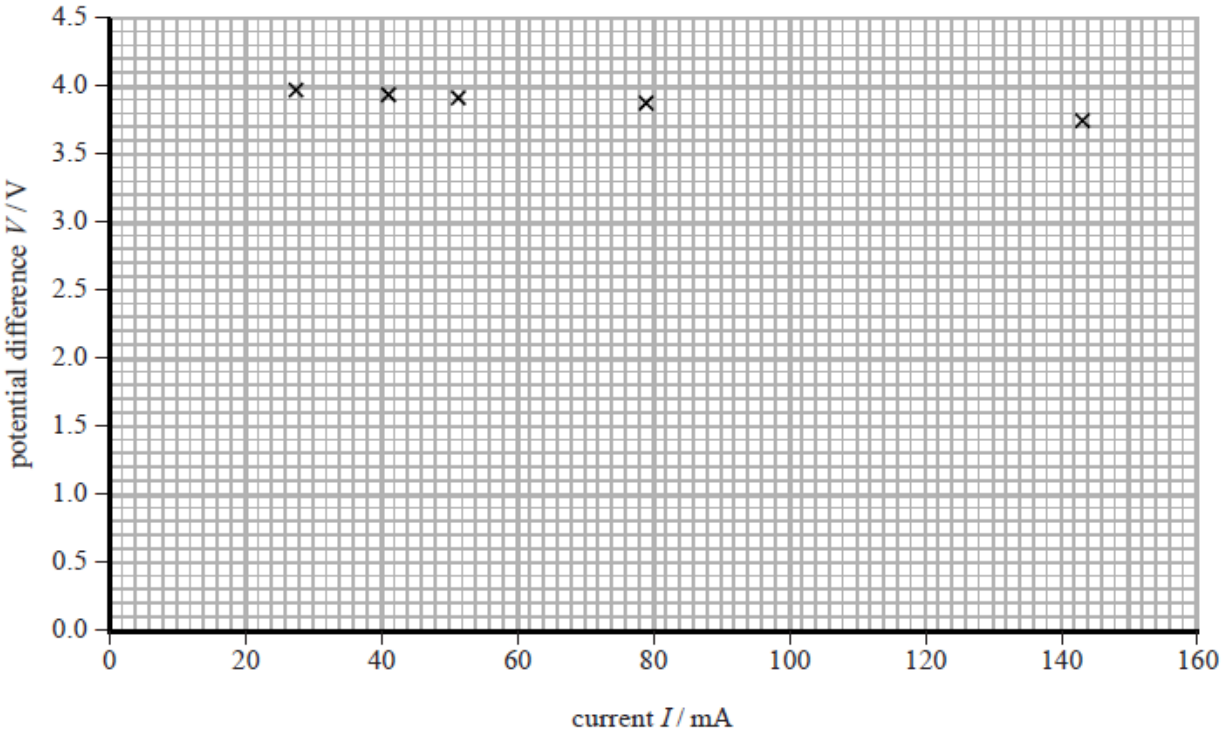
(a) Complete a circuit diagram of a circuit she could have used.

(2)



(b) The student's measurements are shown in the table and plotted on the graph.

I / mA	V / V
27.5	3.97
41.0	3.94
51.6	3.90
78.6	3.88
143.0	3.75



Determine values for ε and r from the graph and show how you obtained your answers.

(4)

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ε = ...

r = ...

(c) Explain how the graph could be constructed to obtain better values for ε and r.

(2)

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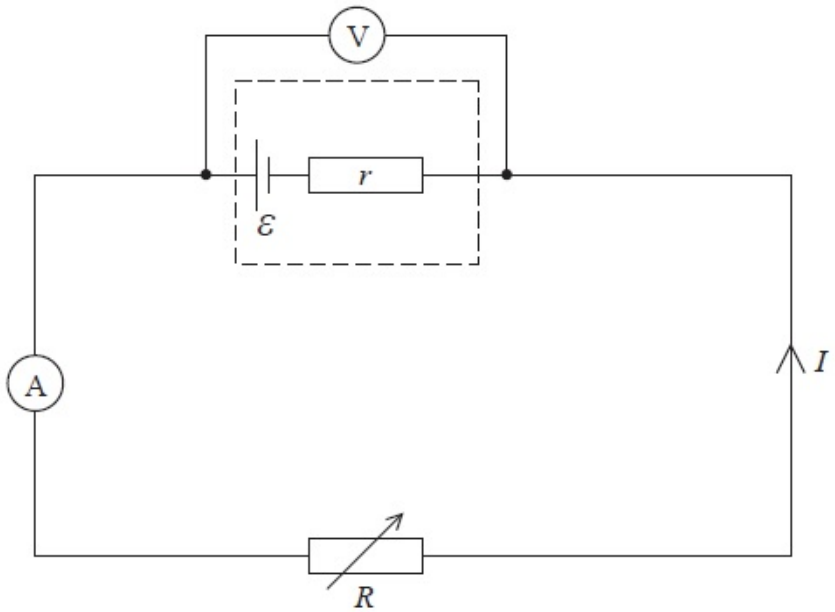
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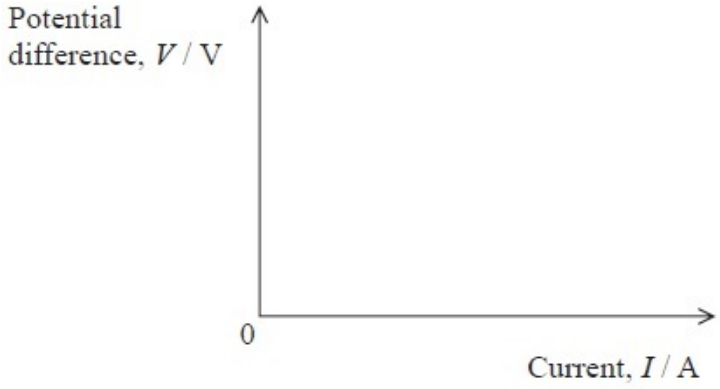
Q8. The diagram shows a circuit which may be used to find the emf ε and internal resistance r of a cell.



(a) As the resistance R of the variable resistor is varied, values of the current I in the circuit and the terminal potential difference V across the cell are recorded.

Sketch the graph of V against I and explain how it may be used to determine ε and r.

(5)



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*(b) We usually assume that ammeters have negligible resistance and voltmeters have infinite resistance.

The determination of ε and r is not affected by using an ammeter with non-negligible resistance but is affected by using a voltmeter with a low resistance.

Explain why.

(4)

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(Total for Question = 9 marks)

Q9.

A torch uses a 1.5 V dry cell. Over time, the light intensity produced by the torch decreases as the cell 'goes flat'.

Student B correctly determined the e.m.f. of an unused cell as 1.63 V and its internal resistance as 1.15 Ω.

He repeated this after the cell had been used for several weeks. When a voltmeter was connected directly across the used cell, the reading was 1.36 V.
A bulb of resistance 5.92 Ω was then connected across the used cell and the reading fell to 0.84 V.

Student A suggests that the cell goes flat as it is used because the e.m.f. decreases.
Student B suggests it is because the internal resistance increases.

Determine whether either student is correct about the changes in the cell as it goes flat.

(5)

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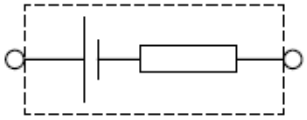
(Total for question = 5 marks)

Q10.

A student is asked to determine the e.m.f. and internal resistance of a cell using standard laboratory apparatus and a graphical method.

(a) The diagram below shows a cell with internal resistance. Add to the diagram to show the circuit she could use.

(2)



(b) Explain how she should determine the e.m.f. and internal resistance of the cell.
Your answer should include a sketch of the graph.

(5)

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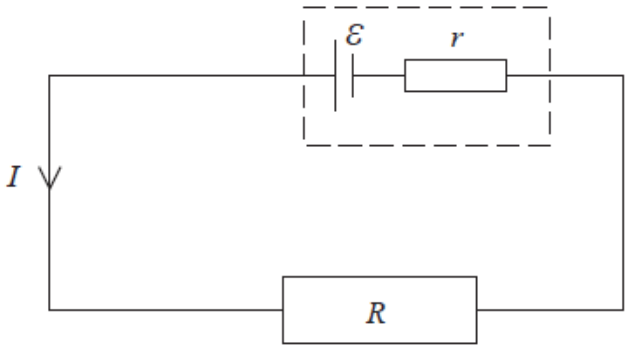
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(Total for question = 7 marks)

Q11.

The diagram shows a resistor of resistance R across a cell of e.m.f. ε and internal resistance r.



Which of the following is a correct expression for the current I?

☒ **A** $I = \varepsilon / r$

☒ **B** $I = \varepsilon / R$

☒ **C** $I = \varepsilon / (R + r)$

☒ **D** $I = \varepsilon / (R - r)$

(Total for question = 1 mark)

Q12. When a cell of e.m.f. 1.5 V is connected across a resistance of 6.6 Ω the current is Ω.21 A.

Calculate the internal resistance of the cell.

(3)

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Internal resistance = ...

(Total for Question = 3 marks)

Q13.

Which of the following correctly defines electromotive force?

(1)

☒ **A** Force per unit charge to move a charge across a component.

☒ **B** Force per unit charge to move a charge around a circuit.

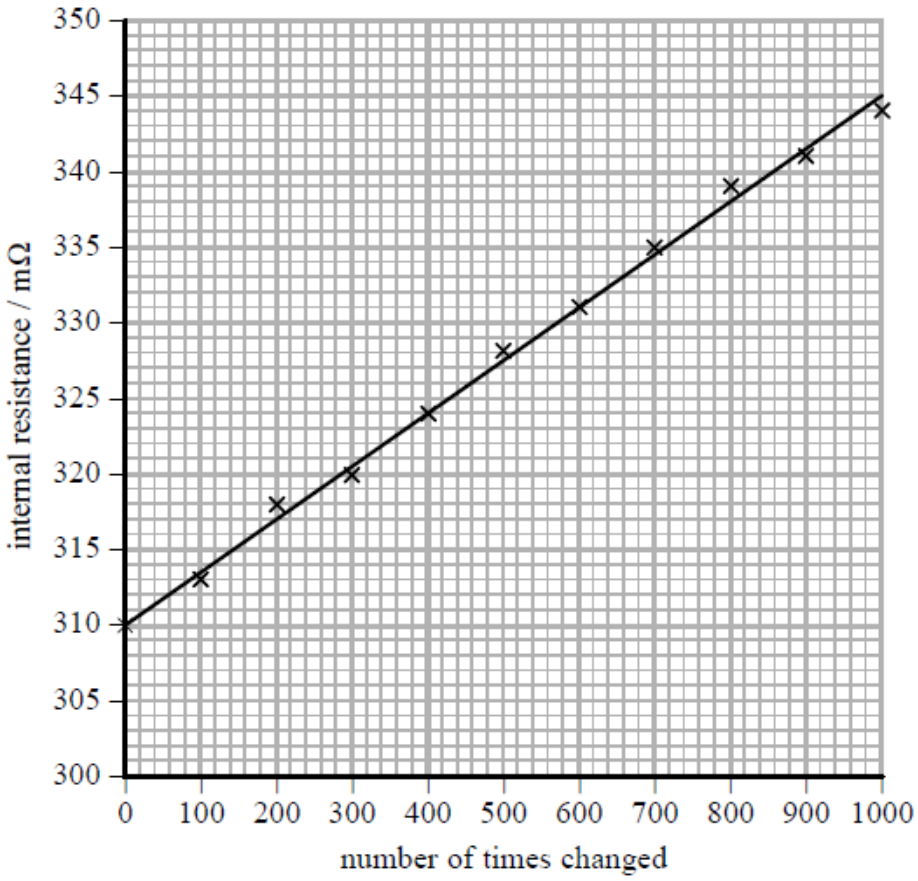
☒ **C** Work done per unit charge to move a charge across a component.

☒ **D** Work done per unit charge to move a charge around a circuit.

(Total for question = 1 mark)

Q14.

The cells used in a camera to charge the flash unit are 3.6 V lithium ion rechargeable cells. The data sheet supplied with such a cell includes a graph which shows how the internal resistance of the cell varies with the number of times it has been charged and discharged.



The cell is recommended for use in a camera flash charger which typically draws a supply current of 800 mA. The manufacturer claims that even after 500 charging cycles the cell terminal potential difference (p.d.) will be more than 99% of the terminal p.d. when new and supplying the same current.

Analyse the data from this graph to explain whether it supports the claim, supporting your answer with a calculation.

(4)

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(Total for question = 4 marks)

Q15.

Read the following press release and then answer the question that follows.

"Lockheed Martin Demonstrates Weapons Grade High Power Fiber Laser

BOTHELL, Wash., Jan. 28, 2014 – Lockheed Martin has demonstrated a 30-kilowatt electric fiber laser, the highest power ever documented while retaining beam quality and electrical efficiency.

The internally funded research and development program culminated in this demonstration, which was achieved by combining many fiber lasers into a single, nearperfect quality beam of light – all while using approximately 50 percent less electricity than alternative solid-state laser technologies. The unique process, called Spectral Beam Combining, sends beams from multiple fiber laser modules, each with a unique wavelength, into a combiner that forms a single, powerful, high quality beam."

(Source: Lockheed Martin Demonstrates Weapons Grade High Power Fiber Laser Wash Bothell, Jan 28, 2014)

A student uses a laser pointer to measure the internal resistance of a cell.
The laser uses a battery of three small cells.
The student obtains the following results:

Laser switched off	
Potential difference across cells	4.1 V
Current in cells	0 mA
Laser switched on	
Potential difference across cells	3.7 V
Current in cells	14 mA

(i) Calculate the internal resistance of the battery of cells.

(2)

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Internal resistance = ...

(ii) The student notices that the manufacturer of the laser pointer claims it is as efficient as industrial lasers. At a distance of several metres the laser pointer produces a circular spot of

diameter 6 mm and intensity 140 W m^{-2}.

Max power output < 5mW

Use this data and the data in the passage to evaluate the manufacturer's claim.

(5)

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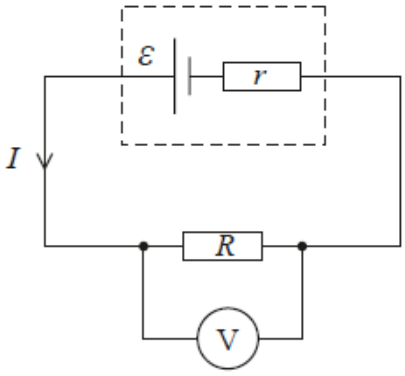
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(Total for question = 7 marks)

Q16.

A cell of e.m.f ε and internal resistance r is connected across a fixed resistor of resistance R. There is a current I in the circuit and a potential difference V across the fixed resistor.



The term 'lost volts' refers to the difference between the e.m.f. and the terminal potential difference.

Which of the following is an expression for the lost volts?

☒ **A** $I\,(R + r)$

☒ **B** Ir

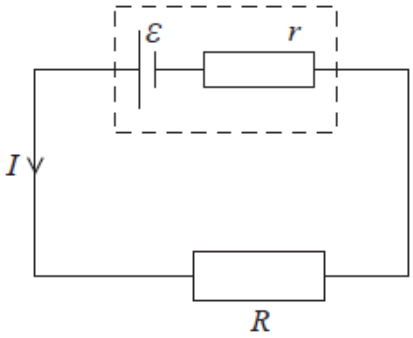
☒ **C** IR

☒ **D** $I(R - r)$

(Total for question = 1 mark)

Q17.

A cell of e.m.f. ε and internal resistance r is connected across an external resistor of resistance R.



Which is the correct expression for the terminal potential difference V of the cell?

☒ **A** $V = \varepsilon + Ir$

☒ **B** $V = \varepsilon - Ir$

☒ **C** $V = \varepsilon + IR$

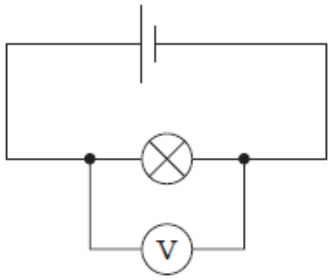
☒ **D** $V = \varepsilon - IR$

(Total for question = 1 mark)

Q18.

A torch uses a 1.5 V dry cell. Over time, the light intensity produced by the torch decreases as the cell 'goes flat'.

Student A sets up the following circuit in an attempt to measure the e.m.f. of a cell.



Explain why the voltmeter reading will **not** be the e.m.f. of the cell.

(2)

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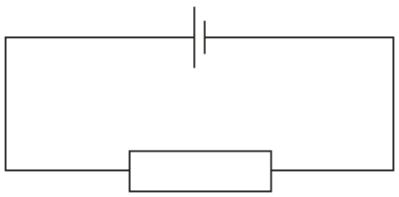
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(Total for question = 2 marks)

Q19.

A cell of e.m.f. 1.5 V is connected to a 5.0 Ω resistor. The terminal potential difference across the cell is 1.0 V.



Which of the following is the current in the circuit?

☒ **A** 0.1 A

☒ **B** 0.2 A

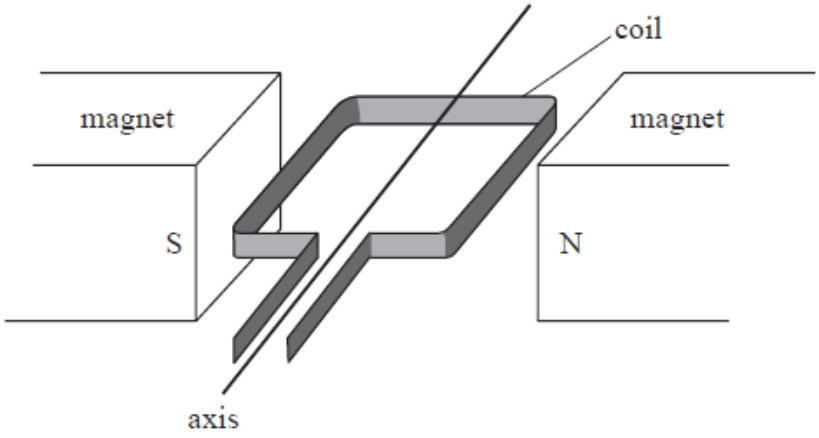
☒ **C** 0.3 A

☒ **D** 0.5 A

(Total for question = 1 mark)

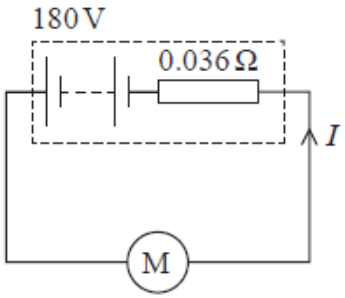
Q20.

Hybrid electric vehicles (HEV) use the same device both as a generator to charge the car battery and as an electric motor to support the propulsion system. A simplified diagram of the device is shown. The coil can rotate freely around the axis.



The circuit diagram shows a car battery connected to an electric motor for a HEV.

The battery has an electromotive force (e.m.f.) 180 V and internal resistance 0.036 Ω.



The motor has a maximum power of 88 kW.

(i) Show that the current I drawn by the electric motor when operating at this power would be given by the equation

$$0.036I^2 - 180I + 88\,000 = 0$$

(3)

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(ii) Solving the equation above produces an answer of $I = 550$ A. At maximum power, the car can accelerate from rest to sixty miles per hour in under 7 s.

The maximum charge capacity of the battery within this HEV is 6.1 amp-hour.

Deduce whether the battery could maintain this current for up to 7 s.

(2)

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(Total for question = 5 marks)