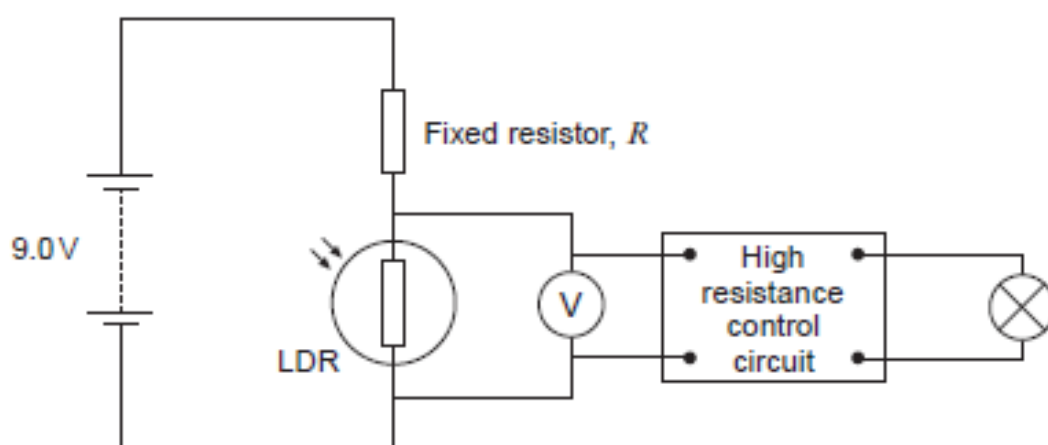


1.

1. (a) An engineer investigates the use of a light dependent resistor (LDR) as a light sensor in a potential divider circuit. He designs the following sensing circuit to operate a 230 V lamp in the dark.



The control circuit draws a negligible current. During his research, the engineer determines the following facts:

The control circuit requires at least 4.0 V to activate.

The LDR the engineer intends to use has a resistance of $2.4 \text{ k}\Omega$ at the light intensity required to switch the lamp on.

- (i) Explain how the current in the LDR changes as the light intensity decreases. [2]

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- (ii) Determine a suitable value for the fixed resistor R , which would allow the lamp to be switched on. [3]

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- (b) When installing the circuit, the engineer made the mistake of placing the lamp near to the LDR. The engineer noted that, when in the dark, the lamp kept turning on and off repeatedly rather than staying on. Explain why this was the case. [2]

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2. (a) (i) State what is meant by *electric current*.

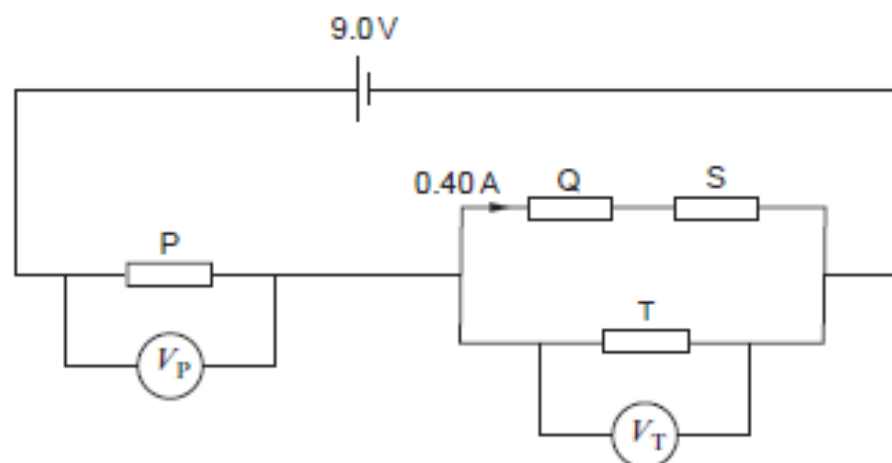
[1]

- (ii) Show that the unit of resistance, the ohm (Ω), can be expressed as:

[2]

$$\text{Js C}^{-2}$$

- (b) The following circuit shows an arrangement of identical resistors labelled P, Q, S and T connected to a fixed pd of 9.0 V. V_P and V_T are the pds across P and T respectively. There is a current of 0.40 A in Q and S.



- (i) Show that $V_P = 1.5 V_T$.

[2]

- (ii) Hence or otherwise show that the values given in the diagram are consistent with the resistance of each resistor being 4.5Ω .

[3]

- (c) Show that the total energy dissipated per second in the whole circuit is 15 times more than the energy dissipated per second in resistor Q. [3]

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- (d) Resistor T is now removed from the circuit. Explain the effect this will have on the ratio calculated in part (c). [3]

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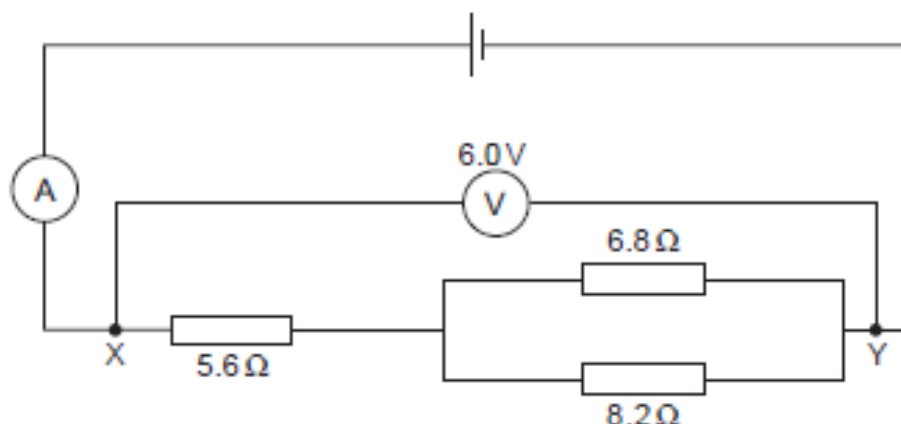
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3.

2. A circuit is set up as shown.



- (a) In the circuit shown, the potential difference between X and Y is 6.0 V . Explain what this statement means. [2]

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- (b) (i) Determine the reading on the ammeter if it has an instrument resolution of $\pm 0.01\text{ A}$. [4]

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- (ii) Calculate the potential difference across the $8.2\ \Omega$ resistor. [2]

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(iii) Calculate the power dissipated in the parallel resistor combination. [2]

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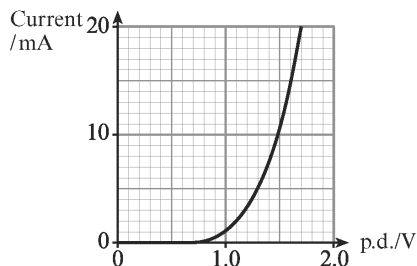
4. The current-voltage characteristics of a diode also apply to a light emitting diode (LED). A graph of current against potential difference for an LED is shown.

(a) (i) Calculate the resistance of the LED when the p.d. is 1.6 V. [2]

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(ii) Comment on the resistance of the LED at voltages below 1.0 V. Calculations are not required. [1]

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(b) (i) Explain how the graph shows that the LED does not obey Ohm's law. [1]

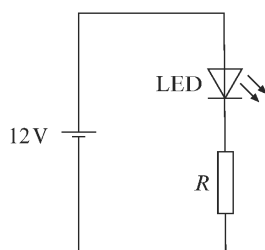
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(ii) Name one other device, other than a diode, to which Ohm's law does not apply. [1]

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(c) If the LED is connected across a supply of e.m.f. greater than 1.6 V, then the large current produced will destroy it. For this reason, LEDs usually have protective resistors in series with them to limit the current. The circuit shows this LED used as an indicator for a car alarm. The car battery supplies 12 V and the LED has an operating current of 15 mA. Determine the value, R , of the protective resistor needed. [3]



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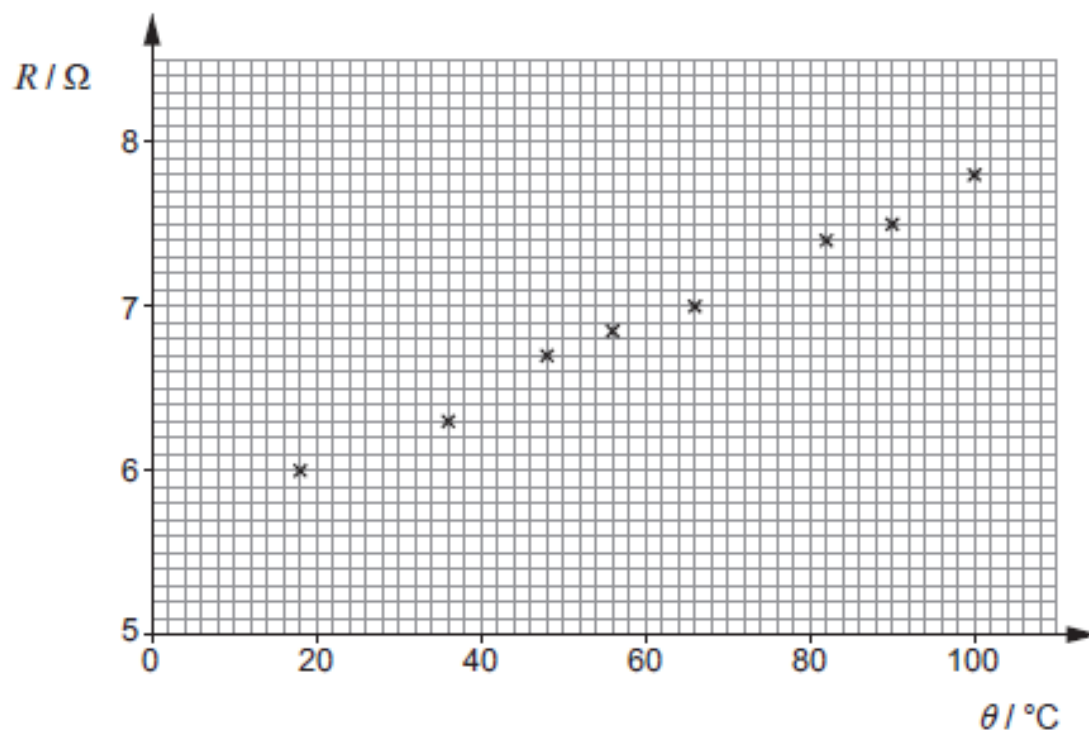
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5.

3. A student slowly heated a coil of insulated copper wire. He took readings of its temperature, θ , and resistance, R , at intervals. The readings are plotted below.



- (a) Bearing in mind the range of temperatures, suggest how the student heated the coil, and how he could have extended the range of temperatures down to just above 0°C . [2]

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- (b) Textbooks state that the resistance, R , of a metal wire is related to its celsius temperature, θ , by an equation of the form:

$$R = R_0 \alpha \theta + R_0$$

in which R_0 and α are positive constants.

- (i) Explain how the readings plotted support the equation. [3]

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(ii) Determine from the graph the values, with units, of:

I. R_0 ; [1]

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II. α . [3]

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6. (a) (i) Define resistance. [1]

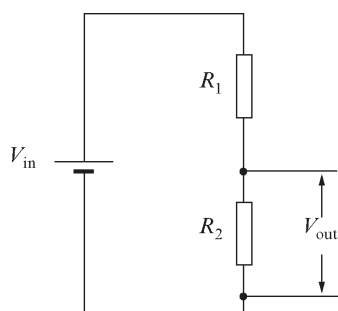
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- (ii) The unit of resistance is the ohm (Ω). Show that it is possible to express the Ω as [3]

$$\text{J s C}^{-2}$$

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- (b) The diagram shows a potential divider.



- (i) Write down an equation for the current through resistors R_1 and R_2 when the input pd V_{in} is applied as shown. [1]

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- (ii) Hence show that the output pd V_{out} is given by the equation [2]

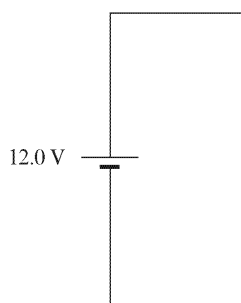
$$V_{\text{out}} = \frac{R_2}{R_1 + R_2} V_{\text{in}}$$

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- (c) Three resistors are available with values $40\ \Omega$, $40\ \Omega$ and $80\ \Omega$.

- (i) Draw a diagram showing how **two** of these resistors can be connected together to give a combined resistance of $20\ \Omega$. [2]

- (ii) Hence, using all three of the resistors, complete the following potential divider circuit for which $V_{\text{out}} = 2.4\ \text{V}$ when $V_{\text{in}} = 12.0\ \text{V}$. Clearly label the resistor values and V_{out} on your diagram. [2]



7.

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

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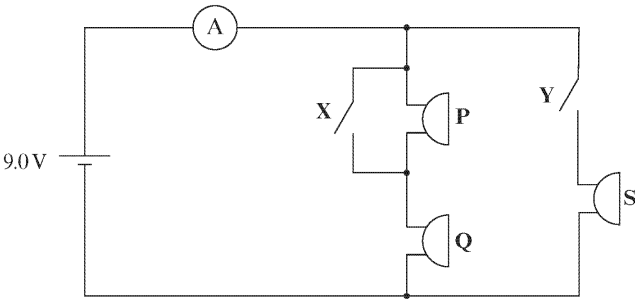
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(ii) The unit of resistance is the ohm (Ω). One of the following is a correct alternative unit to the ohm. Circle the correct one. [1]

VA^{-1} AV^{-1} JC^{-1} JS^{-1}

(b)



In the above circuit, buzzers **P**, **Q** and **S** are controlled using switches **X** and **Y**. **The buzzers are identical and their resistances remain constant.**

(i) The table shows the possible combinations of open and closed switches. When a switch is closed, charge can flow through it. Complete the table. The first row has been done for you. [3]

Switch combination	P	Q	S
X open, Y open	On	On	Off
X closed, Y open			
X open, Y closed			
X closed, Y closed			

- (ii) With **X** open and **Y** open, the ammeter reads 0.18 A. Calculate the resistance of **each** of the buzzers. [3]

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- (iii) Determine the reading on the ammeter when all three buzzers are on. [2]

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- (iv) When all three buzzers are on, show that
power used by **S** = $4 \times$ power used by **Q** [3]

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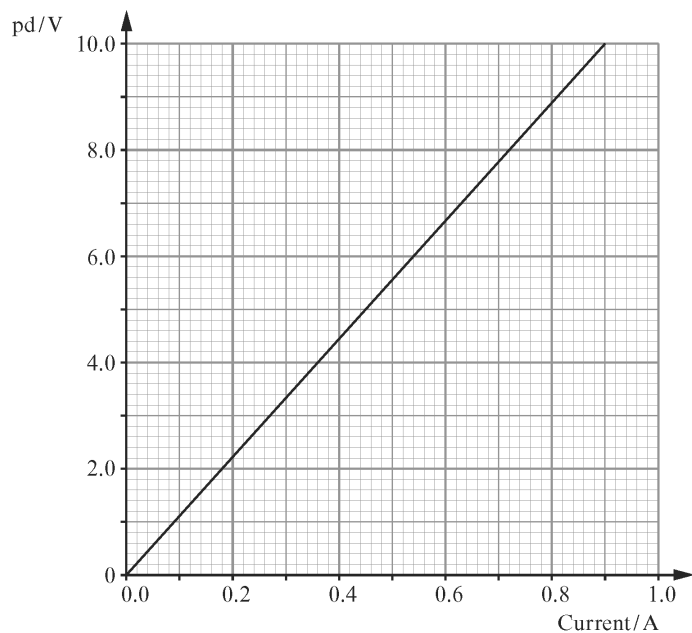
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8.

Experiments are carried out to determine the material from which a metal wire is made. Initially the resistivity of the metal is found. The wire's density is then determined and the results compared with known values of resistivity and density.

- (a) As a first step to finding the resistivity, an experiment investigates the relationship between pd and current for the wire. The results are shown in the graph.



- (i) Draw a circuit diagram to show how the above results could be obtained. The apparatus available includes a battery, a switch, a variable resistor, an ammeter and a voltmeter. [2]

(ii) The wire has length 3.2m and **diameter** 0.20mm. Use this information and the graph to calculate the resistivity of the material in the wire. [4]

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(iii) Using the information in the table, write down **two** possible materials for the wire. [1]

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Material	Resistivity / $\Omega \text{ m}$	Density / kg m^{-3}
Iron	0.97×10^{-7}	7 850
Platinum	1.06×10^{-7}	21 400
Tin	1.12×10^{-7}	7 300
Nichrome	1.10×10^{-6}	8 400

The mass of the wire is found to be 0.74 grammes. Explaining how you obtain your answer, determine the material from which the wire is made. [3]

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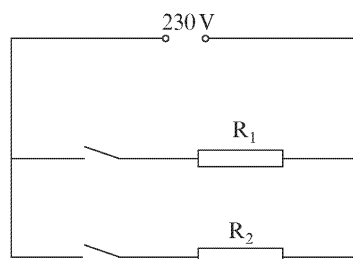
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9. (a) (i) State Ohm's law. [2]

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

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



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

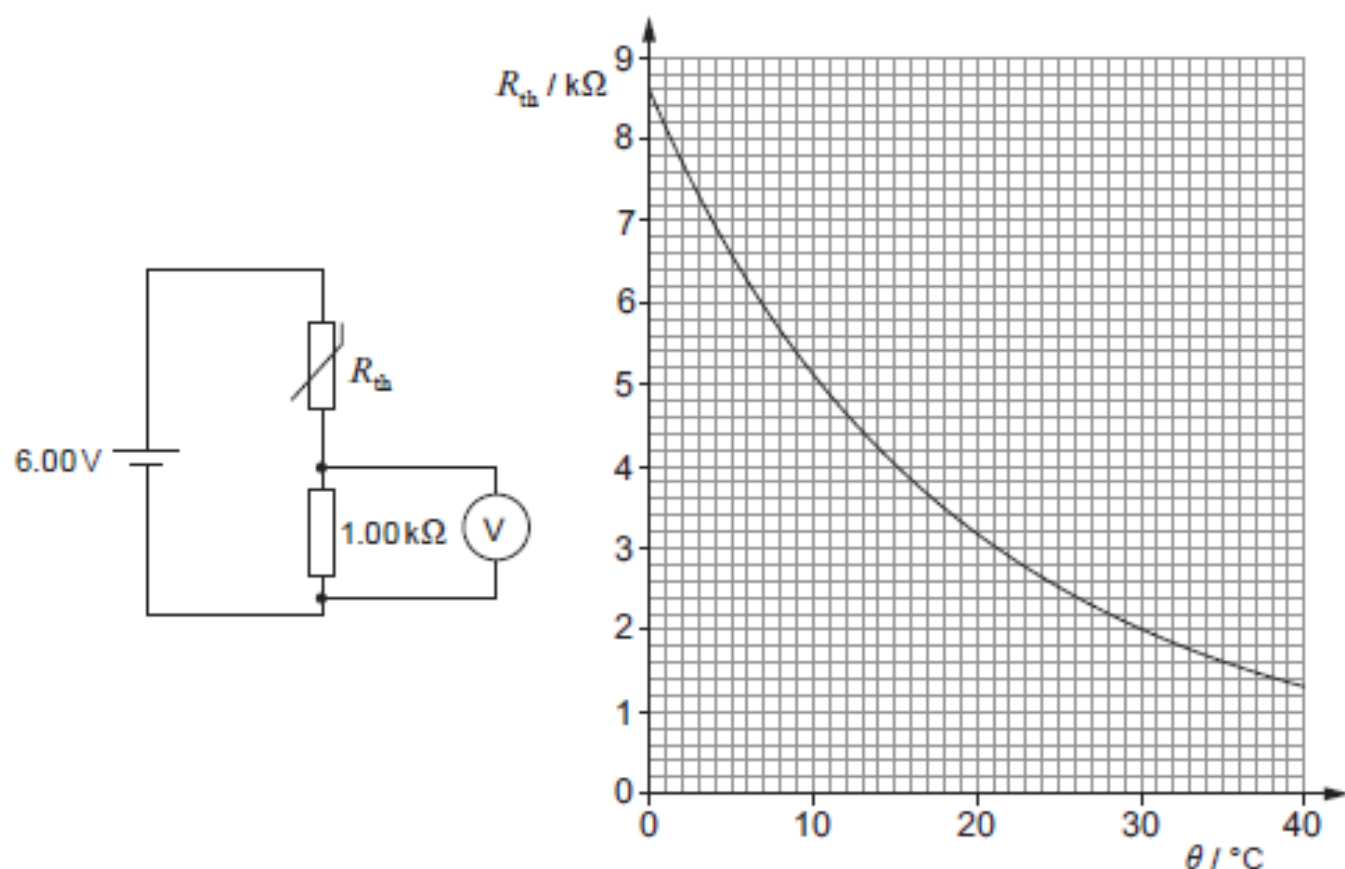
- (ii) Calculate the power output from the heating circuit with only R_1 switched on. [1]

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

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

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

10. 2. The resistance, R_{th} , of the thermistor in the circuit varies with temperature as shown in the graph.



- (a) Determine the temperature of the thermistor when the voltmeter reads 1.20 V. [3]

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- (b) The set-up can be used as a thermometer, with the thermistor used as a temperature probe. David suggests that there must be a simple rule of the type "an increase of 0.10 V in the voltmeter reading corresponds to a temperature increase of $n^{\circ}\text{C}$ in which n is a constant." Without further calculation, discuss whether he is right. [2]

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- (c) Explain why the current through the thermistor must be very low, in order for it to work properly as a probe to measure the temperature of its surroundings. [2]

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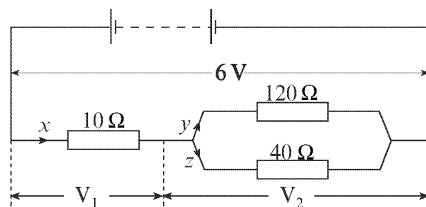
11.

- (a) (i) Using the idea of electric charge explain what is meant by *the electric current* in a conductor. [1]

- (ii) The unit of electric current is the ampère (A). One of the following is a correct alternative unit to the ampère. Circle the correct one. [1]

JC^{-1} Cs^{-1} Js^{-1} VA^{-1}

(b)



- (i) Write down the relationship between the currents x , y and z in the circuit. [1]

- (ii) The relationship you wrote down in (b)(i) is a consequence of which conservation law? [1]

(c) Calculate

- (i) the resistance of the combination of the three resistors, [3]

- (ii) the current x , [1]

- (iii) the potential differences, V_1 and V_2 , [2]

- (iv) the currents y and z . [2]

- (a) The unit of electrical resistance is the ohm (Ω). Two of the following are correct alternative units to the ohm. **Circle the correct two.** [2]

$$\text{VA}^{-1}$$

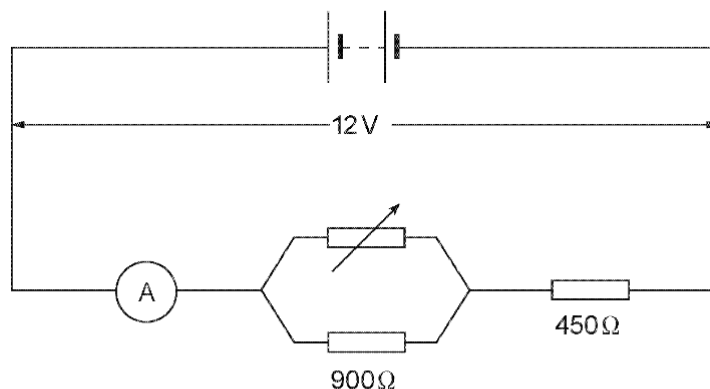
$$\text{V}^{-1}\text{A}$$

$$\text{WA}^{-2}$$

$$\text{Cs}^{-1}$$

Space for working if needed.

- (b) The circuit shows a variable resistor connected to two fixed resistors, an ammeter and a battery of emf 12 V. The battery has negligible internal resistance.



The variable resistor is adjusted so that the ammeter reads 0.01 A.

- (i) Calculate the potential difference across the 450Ω resistor. [1]

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- (ii) Calculate the potential difference across the 900Ω resistor. [1]

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- (iii) Calculate the resistance of the parallel combination of the 900Ω resistor and the variable resistor. [2]

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(iv) Calculate the resistance of the variable resistor.

[2]

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(c) The variable resistor is adjusted so that its resistance decreases. Explain in clear steps what happens to the potential difference across the 900Ω resistor. [3]

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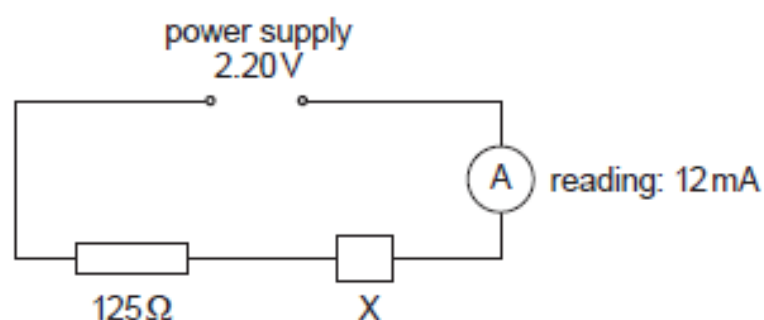
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1. (a) (i) State Ohm's law.

[1]

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

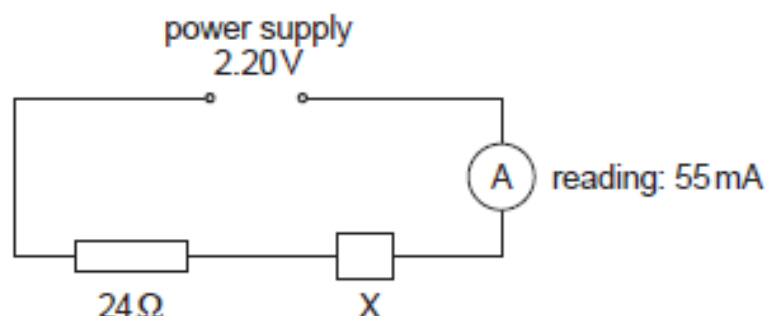
- (b) (i) An electrical component, X, is included in the circuit shown. The internal resistance of the power supply is negligible.



Show that the resistance of X in this circuit is approximately $60\,\Omega$.

[2]

- (ii) When the $125\ \Omega$ resistor in (b)(i) is replaced by a $24\ \Omega$ resistor, the reading on the ammeter increases, as shown below.



Evaluate whether or not X obeys Ohm's law, presenting your argument clearly. [2]

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- (iii) State, giving a reason, whether or not X could be a filament lamp. [1]

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- (c) A certain high temperature superconductor has a transition temperature of $-188\ ^\circ\text{C}$. The boiling point of liquid nitrogen is $-196\ ^\circ\text{C}$.

- (i) State what is meant by the *transition temperature* of a superconductor. [1]

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- (ii) Give one possible use for a high temperature superconductor and state why it would be an advantage for the transition temperature to be above the boiling point of liquid nitrogen. [2]

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4. (a) Describe how the resistance of a metal varies between 0K and 1000K. [Assume that the metal is superconducting below a certain temperature.] Account for this variation in resistance at higher temperatures.

[6 QER]

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- (b) Superconductors are used in MRI scanners and particle accelerators. Consider which of these two applications has been of greater benefit to society. [3]

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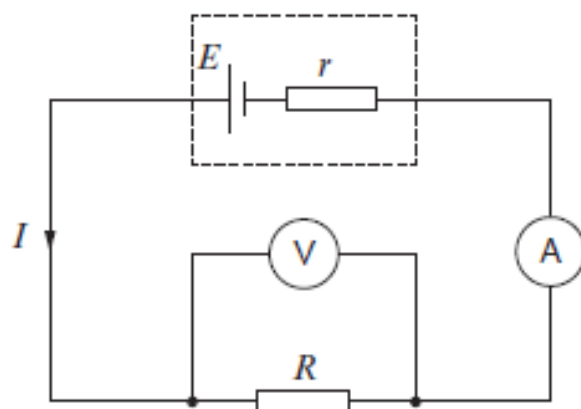
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1. The following circuit shows a cell of emf, E , and internal resistance, r , connected to a resistor of resistance, R .



- (a) An equation which can be applied to the above circuit is:

$$V = E - Ir$$

Explain this equation in terms of energy.

[4]

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- (b) Two students, Kiera and Tom, set up a circuit using two identical cells in series, each with an emf of 1.5V, to power a small heating coil. The heating coil dissipates power at the rate of 1050 mW and the pd across the coil is 2.5V.

Calculate:

- (i) the internal resistance of each cell;

[3]

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(ii) the energy dissipated in each cell in one minute.

[2]

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- (c) The students note that the cells get hot when the heater is switched on for long periods. Tom believes that adding an identical heating coil in parallel with the original would halve the energy dissipated in each cell. Kiera disagrees. She believes that the energy dissipated would increase by a factor of 3 if a coil is added in parallel. Investigate whether Kiera or Tom or neither of them is correct. [4]

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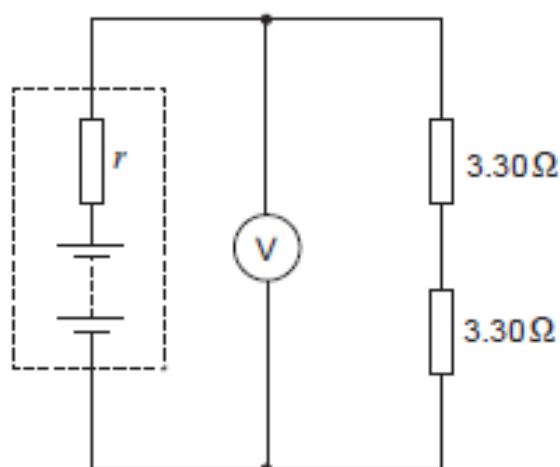
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16. 1. (a) Two $3.30\ \Omega$ resistors are connected in series across a battery of emf 4.80 V as shown. The voltmeter reads 4.33 V .

Diagram 1



- (i) State in terms of work or energy what is meant by the emf of a battery. [2]

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- (ii) Show that the internal resistance, r , of the battery is approximately $0.7\ \Omega$. [2]

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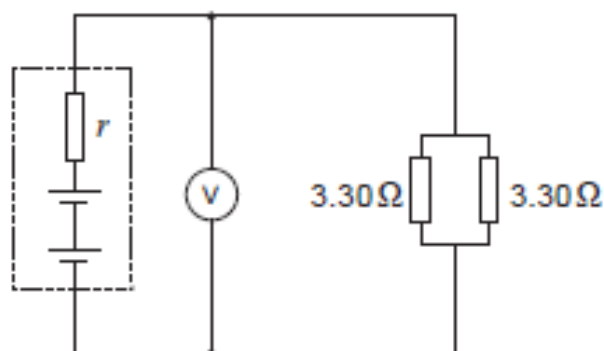
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- (iii) When the resistors are connected in parallel as shown below, the voltmeter reads 3.35 V .

Diagram 2



- (I) Without further calculation explain why you would expect the reading to be lower, now that there is a lower resistance across the cell terminals. [2]

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- (II) Calculate the number of electrons entering either of the resistors (shown in Diagram 2) per minute. [3]

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- (b) The heating element (a coil of wire) in an electric heater dissipates energy at a rate of 1.00 kW, when connected across the 230 V mains supply. Calculate:

- (i) the resistance of the coil; [2]

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- (ii) the energy dissipated per hour, giving your answer in megajoules (MJ). [1]

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- (c) For each megajoule of heat from an electric heater, approximately 0.08 m^3 of gas would have to be burned in a gas-fired electricity power station. For each megajoule of heat from a domestic gas fire or boiler, approximately 0.03 m^3 of gas is burned. Discuss whether the use of electric heaters in houses should be discouraged. Calculations are not required. [3]

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4. A length of wire of an unknown material is found at a crime scene. The diameter of the wire is measured as 0.28 ± 0.01 mm and its length 32.4 ± 0.1 cm. The resistance of the wire is measured as $0.085 \Omega \pm 5\%$.

(a) (i) Calculate the resistivity of the material of the wire.

[3]

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(ii) Calculate the absolute uncertainty in the resistivity.

[4]

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(iii) Evaluate whether it is possible to identify the unknown material from the table below.

[2]

Material	Resistivity ($10^{-8} \Omega \text{m}$)
Aluminium	2.65
Copper	1.68
Silver	1.59
Iron	9.71
Tungsten	5.60

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- (b) Anika applies a fixed potential difference of 6.0 V across a different piece of metal wire. At a temperature of 0 °C the current is found to be 0.30 A. At 50 °C the current is 0.24 A.

(i) Explain in terms of electrons why the current is smaller at 50 °C than at 0 °C. [4]

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(ii) Anika states that the resistance of the wire can be considered to be directly proportional to temperature in °C. Use the following table of data to determine whether Anika is correct. [3]

Temperature (°C)	Current (A)
10	0.29
30	0.26
50	0.24

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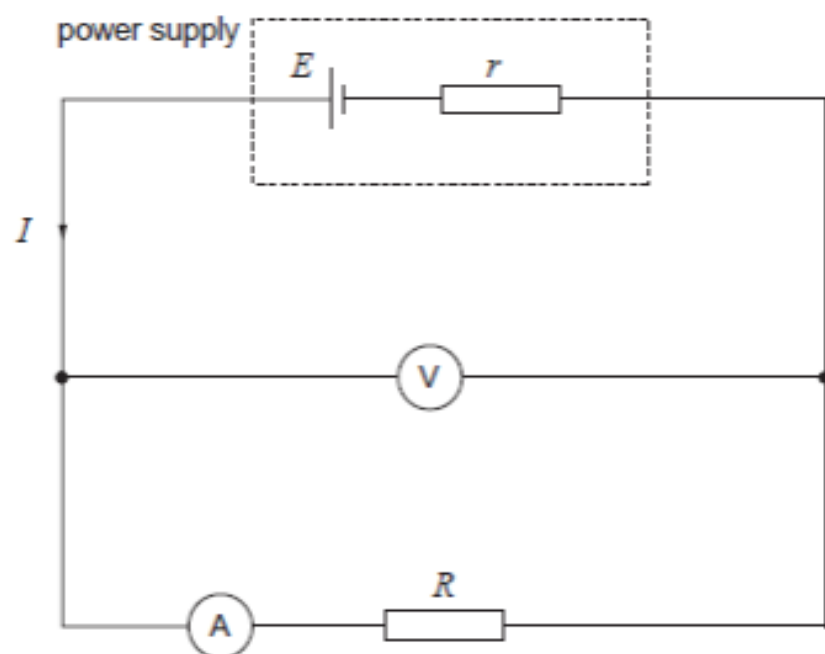
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5. Zhang Li sets up the following circuit and uses a spreadsheet to analyse her data as the load resistance, R , is varied.



	A	C	D	E	F
1					
2	Emf, E	Load resistance, R	Current, I	pd across R , V	Internal resistance, r
3	V	Ω	A	V	Ω
4	1.5	1.4	0.94	1.32	0.19
5	1.5	3.3	0.43	1.42	0.19
6	1.5	4.7	0.31	1.46	0.13
7	1.5	5.6	0.26	1.46	
8	1.5	8.0	0.19	1.49	0.17

- (a) Zhang Li uses 3 resistors of values 3.3Ω , 4.7Ω and 5.6Ω , to create various load resistance values. Show clearly how the value in cell C4 (column C and row 4) is obtained. [3]

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- (b) (i) Zhang Li uses the spreadsheet formula = $\frac{A4 - E4}{D4}$ to determine the internal resistance in cell F4. Explain in terms of energy why this is a valid method. [6]

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- (ii) Determine the internal resistance value for cell F7. [2]

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- (iii) Zhang Li can choose between $4.7\ \Omega$ resistors with power ratings of 0.25 W or 0.50 W. Justify, numerically, which resistor power rating she should use in the circuit. [3]

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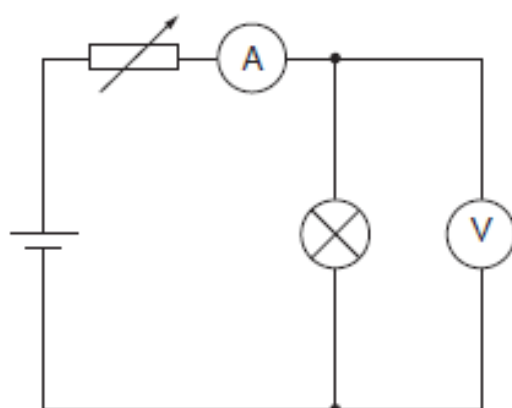
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2. Jasmine uses the following circuit to investigate how the resistance, R , of a filament lamp varies with the potential difference, V , across it.



- (a) Jasmine obtains a range of values for V and I . Describe briefly how she does this. [1]

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- (b) The relationship between R and V can be expressed as:

$$R = kV^n$$

where k and n are unknown constants. By taking logs of both sides of the equation, show how it can be written in the form $y = mx + c$. [2]

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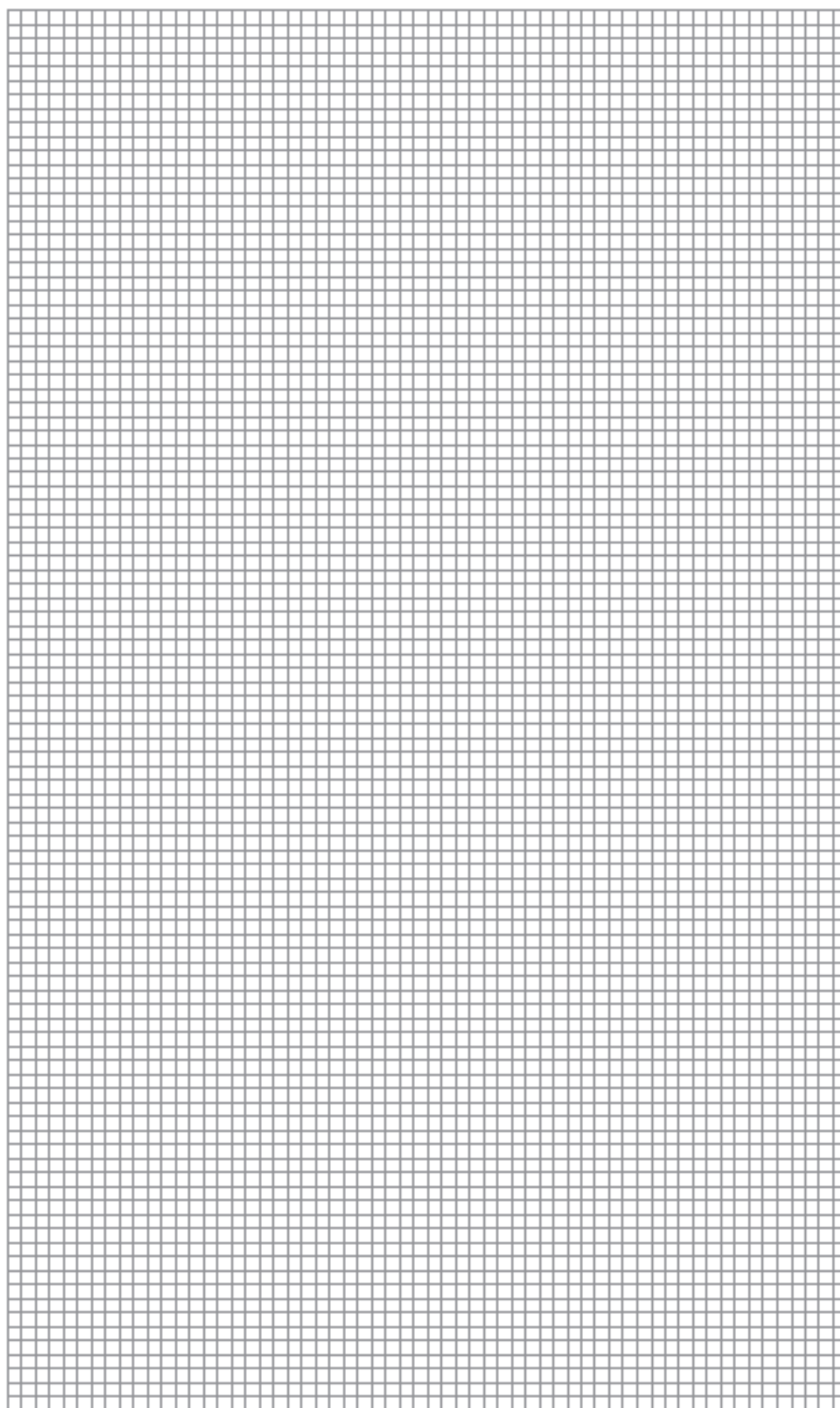
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- (c) Jasmine records the following data. Complete the table using an appropriate number of significant figures. [3]

V/V	I/A	R/Ω	$\log(V/V)$	$\log(R/\Omega)$
1.00	0.52			
2.00	0.72			
4.00	0.98			
6.00	1.20			
8.00	1.40			
10.00	1.54			

- (d) Draw a graph of $\log R$ (vertical axis) against $\log V$ (horizontal axis) and draw a line of best fit. Error bars are not required. [5]



- (e) (i) Use your graph to determine suitable values for k and n . [4]

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- (ii) Hence, write down an equation showing the relationship between R and V for this filament lamp. [1]

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- (f) Comment on the quality of Jasmine's results. [1]

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2. (a) A battery does not *store* charge. State what a battery *does* do in relation to charge in an electric circuit. [1]

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- (b) A battery consists of three cells, each of emf 1.60 V and internal resistance $0.10\ \Omega$, connected in series. The battery is connected to an electromagnet of resistance $1.20\ \Omega$.

- (i) Show clearly that the current is approximately 3 A . [The space is for a diagram if required.] [3]

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- (ii) Calculate the rate (in watts) at which:

- I. energy is dissipated by the electromagnet; [1]

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- II. the battery's chemical energy is being used. [1]

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- (iii) The answer to (b)(ii)II. is expected to be greater than the answer to (b)(ii)I. Explain where the missing energy goes. [2]

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- (c) A student wishes to maximise the current through the electromagnet. She has a spare cell of emf 1.50 V and internal resistance $0.50\ \Omega$. Evaluate whether or not she should put it in series with the battery, giving your calculations and conclusion clearly. [2]

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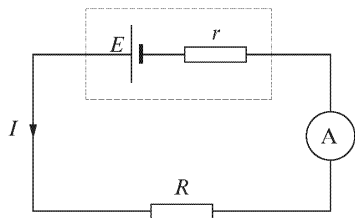
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21.

A student sets up the following circuit using a cell of emf E and internal resistance r .



(a) An equation which can be applied to the above circuit is

$$V = E - Ir$$

Explain, **in terms of energy**, the meanings of V , E and Ir .

[4]

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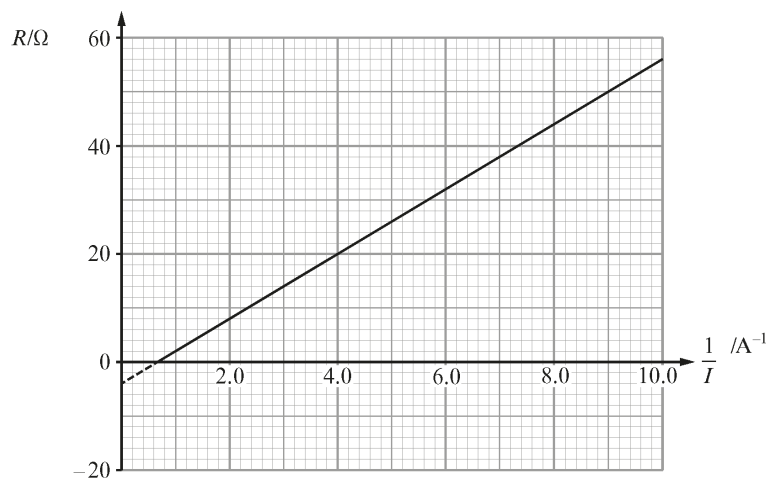
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- (b) The student measures the current I for different values of R . She then plots a graph of R against $\frac{1}{I}$.



The equation for this graph is

$$R = \frac{E}{I} - r$$

- (i) Use the graph to find the internal resistance, r , of the cell. [1]

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- (ii) Determine the emf of the cell. [2]

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- (iii) Referring to the graph, calculate the power dissipated in the resistor R when there is a current of 0.25 A. [4]

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- (c) A second identical cell is added in series with the original cell and the experiment is repeated.

- (i) Write down the emf and the internal resistance of the new combination of cells. [1]

emf = internal resistance =

- (ii) Hence, using the equation $R = \frac{E}{I} - r$, determine the value of R for this experiment when there is a current of 0.2 A. [1]

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- (iii) **Draw on the graph** the result of this experiment. [2]

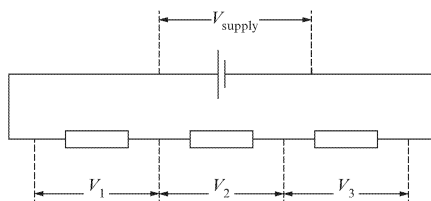
4. (a) Define the *potential difference* between two points in an electric circuit. [2]

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- (b) Three resistors are connected as shown.



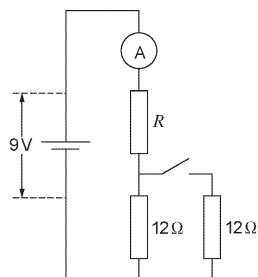
- (i) Complete the equation that relates all of the potential differences in the circuit: [1]

$V_{\text{supply}} = \dots\dots\dots$

- (ii) The equation you wrote down in (b)(i) is an example of which conservation law?[1]

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(c)



- (i) In the circuit shown, with the **switch open**, the ammeter reads 0.5A. Show that $R = 6\Omega$. [2]

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- (ii) The switch is now **closed**.

- (I) Calculate the (new) potential difference across R . [2]

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- (II) Calculate the (new) current through the ammeter. [2]

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- (III) More 12Ω resistors can be connected in parallel with the 12Ω resistors. Determine the **total** number of 12Ω resistors needed for the current through the ammeter to be 1.2A. [4]

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

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

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

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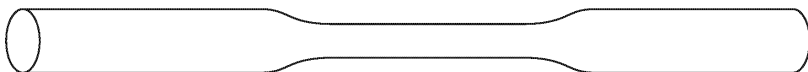
(iii) Calculate the mean drift velocity of the free electrons in the cable given that there are 6.0×10^{28} atoms per m^3 of aluminium and each atom contributes 3 free electrons. [3]

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



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

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

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

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24.

- (a) Derive, giving a labelled diagram, the relationship between the current I through a metal wire of cross sectional area A , the drift velocity, v , of the free electrons, each of charge e , and the number, n , of free electrons per unit volume of the metal. [4]
($I = nAve$).

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- (b) Calculate the drift velocity of free electrons in a copper wire of cross sectional area $1.7 \times 10^{-6} \text{ m}^2$ when a current of 2.0 A flows. [$n_{\text{copper}} = 1.0 \times 10^{29} \text{ m}^{-3}$]. [2]

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- (c) A potential difference is required across the copper wire in order for the current to flow. The size of the current depends on the wire's *resistance*. Explain in terms of free electrons, how this resistance arises. [2]

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(d) The copper wire in (b) is of length 2.5 m. When it carries a current of 2.0 A, it dissipates energy at the rate of 0.1 W. Calculate its resistivity. [4]

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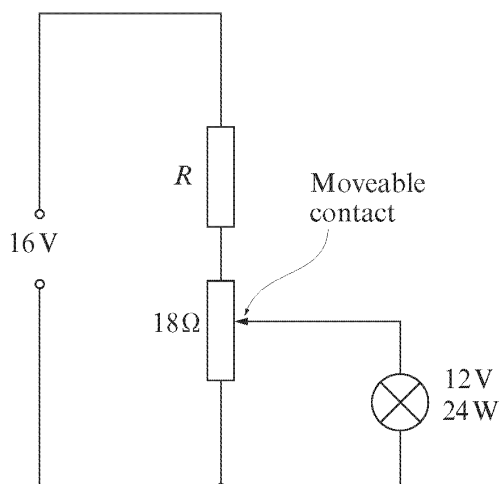
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(e) A second copper wire has the same volume as the wire in (d), but is longer. Complete the table below indicating whether the quantity given is **bigger**, **smaller** or **the same** for this longer wire. [3]

Quantity	For the longer wire this quantity is ...
Cross-sectional Area	
n , number of free electrons/unit volume	
Resistivity	

A student uses the circuit below to produce a current-voltage graph for a 12 V, 24 W filament lamp.



(a) Show clearly on the diagram the correct positions for the voltmeter and ammeter. [2]

(b) When the lamp is working normally, calculate

(i) the current flowing through it; [1]

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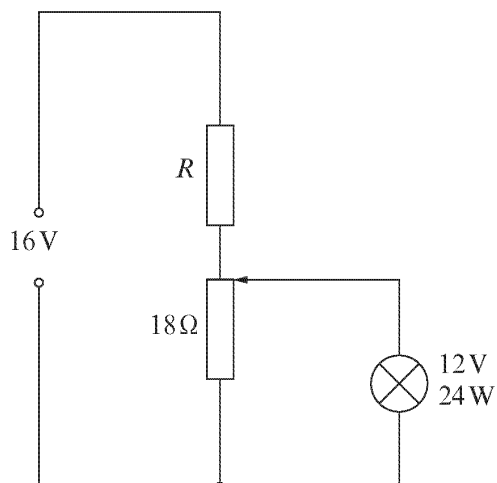
(ii) its resistance. [1]

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(c) The value of R is chosen so that the voltage across the lamp can be varied between 0 V and 12 V. The circuit below shows the position of the moveable contact when the lamp is operating normally (i.e. at 12 V).



Calculate the required value of R . [4]

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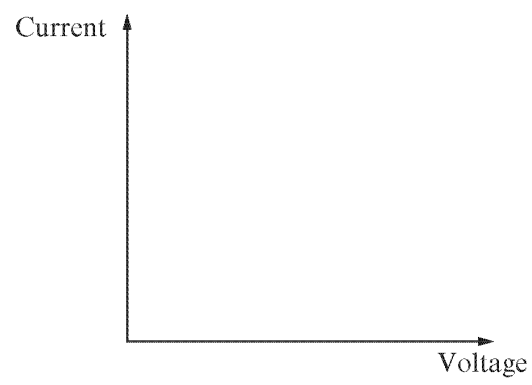
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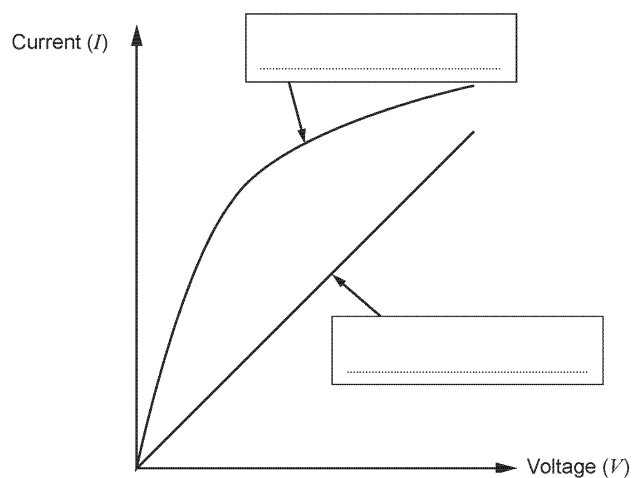
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(d) Sketch on the axes below the current-voltage graph expected for the filament lamp. [2]



- (a) Graphs are drawn for a metal wire at constant temperature and for the filament of a lamp.



- (i) Complete the boxes, labelling the graphs with the component they represent. [1]

- (ii) Suggest reasons for the different shapes of the two graphs. [5]

[illegible]

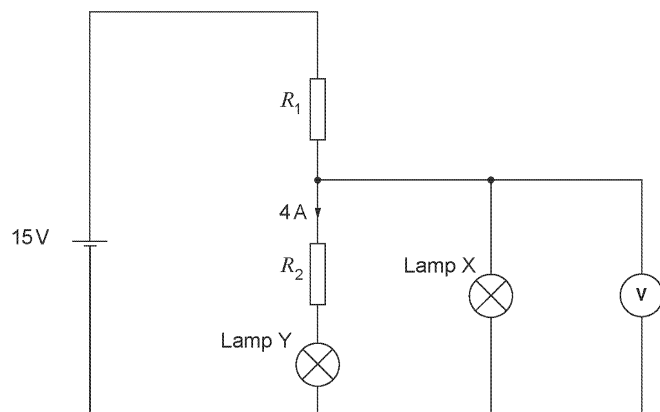
(b) X and Y are two lamps.

- (i) Lamp X is labelled at 12 V, 24 W. Calculate the current in the lamp when it operates at its rated voltage. [1]

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- (ii) Lamp Y is labelled at 6 V, 4 A. In the following circuit, the values of R_1 and R_2 are chosen so that **both lamps operate at their rated voltages**.



- (i) State the reading on the voltmeter. [1]

- (ii) Calculate the pd across R_2 . [1]

-
- (iii) Calculate R_2 . [1]

- (iv) Calculate R_1 . [3]

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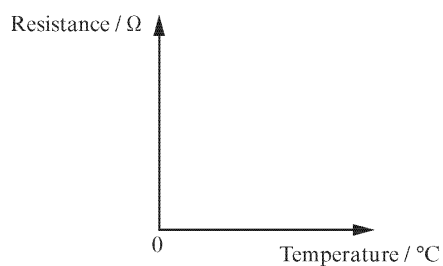
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27. (a) (i) Draw a labelled diagram of the apparatus you would use to determine the relationship between the resistance and temperature of a metal wire. [3]

- (ii) Sketch, on the axis below, a graph of the results you would expect from the experiment. [2]



- (b) (i) Explain in terms of particles how electrical resistance arises in metal conductors. [3]

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- (ii) Hence suggest an explanation for your results to the experiment in part (a). [2]

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

[2]

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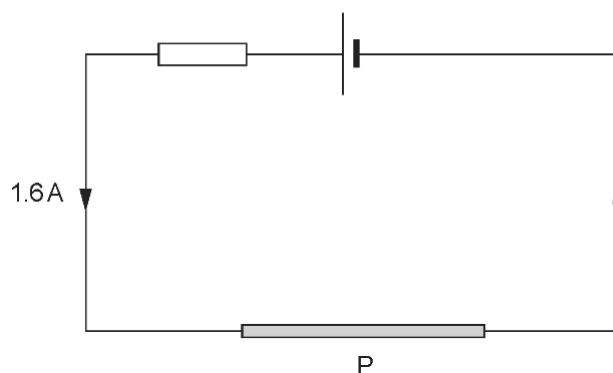
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- (ii) The wire (labelled P in the diagram) is connected to a fixed voltage source and a resistor to limit the current as shown. The wire is 0.4m long and has a cross-sectional area of $2.0 \times 10^{-6} \text{ m}^2$. When the current is 1.6A it dissipates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

[4]



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

$$I = nAve$$

Derive the formula. You may include a clearly labelled diagram.

[4]

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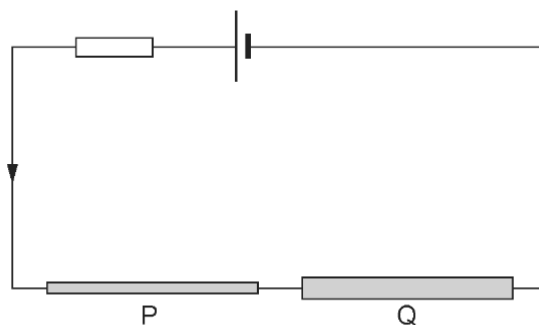
- (ii) Calculate the drift velocity of the free electrons in the wire in (a)(ii) when the current through it is 1.6 A. [$n = 6.4 \times 10^{28} \text{ m}^{-3}$] [2]

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



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

- (I) The current in the circuit containing both wires is
[less than 1.6 A] [equal to 1.6 A] [more than 1.6 A]. [1]
- (II) The current in P is [less than] [the same as] [greater than] the current in Q. [1]
- (III) The electron drift velocity in Q is [half] [the same as] [twice] [four times] the electron drift velocity in P. [1]

The current I in a metal conductor of cross-sectional area A is given by:

$$I = nAve$$

- (a) State the meanings of n and v . [2]

n

v

- (b) Show that the equation is correct in terms of units. [3]

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- (c) (i) The current in a copper wire is 2.0A. The wire has a cross-sectional area of 1.2 mm² and is 5.0m long. Calculate the time it takes a free electron in the wire to travel from one end to the other. [Take $n_{\text{copper}} = 8 \times 10^{28} \text{ m}^{-3}$.] [3]

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- (ii) The **same current** (2.0A) is now passed through a **thinner** wire of the **same length and material**. Use the above equation to explain the effect this change would have on the time for an electron to travel from one end to the other. [3]

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30. (a) (i) Draw a labelled diagram of the apparatus you would use to determine the relationship between the resistance and length of a metal wire.

[3]

(ii) Sketch a graph of your expected results.

[1]



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

[3]

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

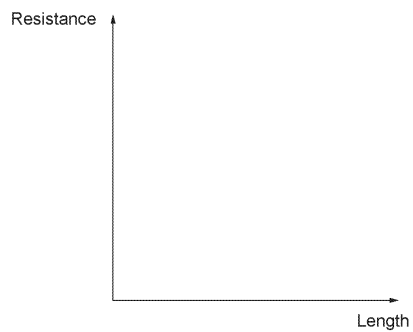
[3]

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

[3]

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

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



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

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

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

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