Electricity ASRevision Pack

A level physics (Greenford High School)

Electricity AS Revision Pack

Name: ____________________

Class: ____________________

Date: ____________________

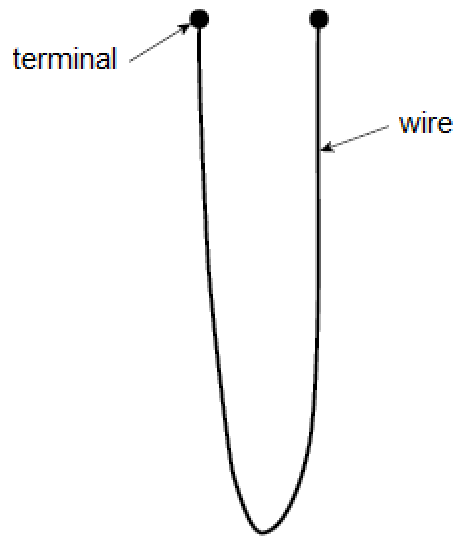
Time: **335 minutes**

Marks: **297 marks**

Comments:

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

Figure 1



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

Calculate the diameter of the wire.

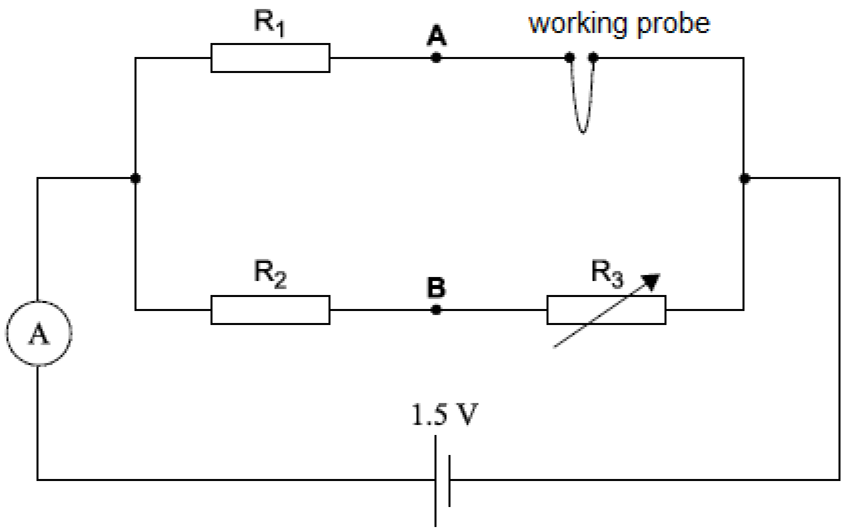
resistivity of metal in the wire = 9.7×10^{-8} Ω m

diameter = ____________________ m

(3)

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

Figure 2



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

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

resistance = ____________________ Ω

(1)

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

Calculate the current in R_3.

current = ____________________ A

(1)

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

resistance = ____________________ Ω

(3)

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

percentage change = ____________________ %

(2)

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

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

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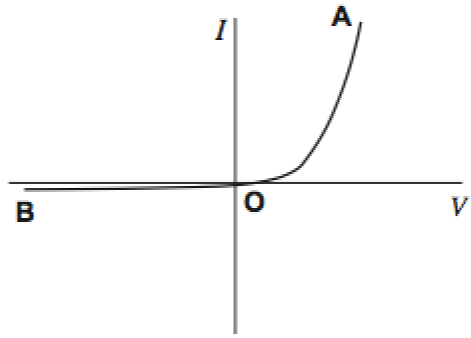
(2)

(Total 12 marks)

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



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

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

(2)

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

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

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

(6)

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

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(1)

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

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

(2)

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

(1)

(Total 12 marks)

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

Figure 1

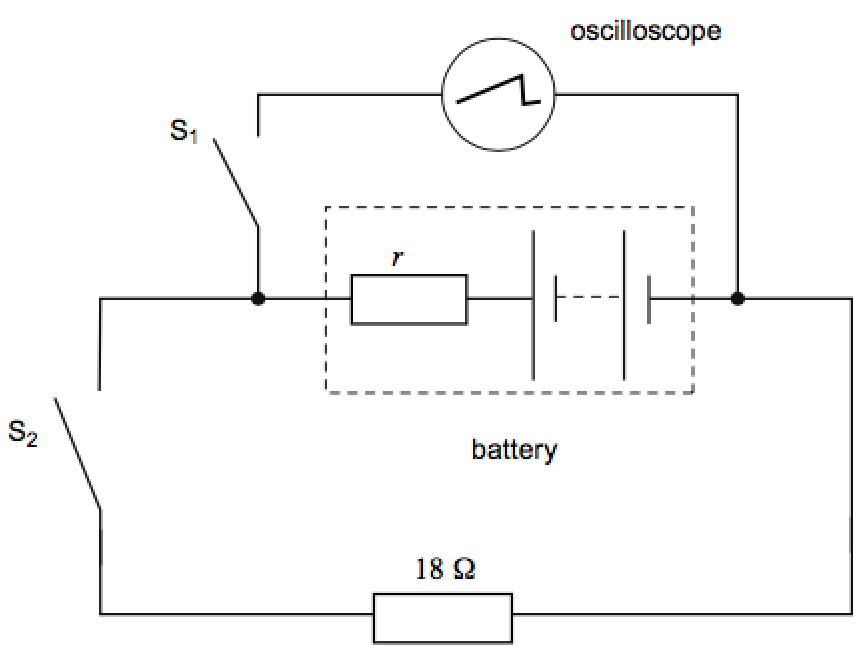
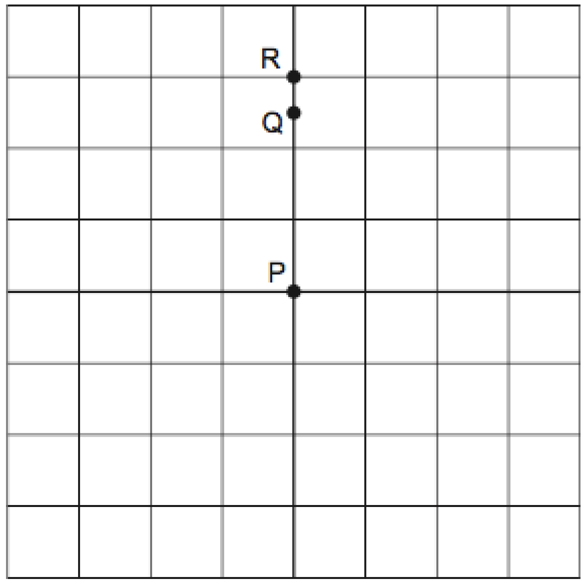


Figure 2 represents the screen of the oscilloscope. With switches S_1 and S_2 open, a bright spot is seen on the screen at P.

Figure 2



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

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

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(1)

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

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

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(1)

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

electrical quantity = ____________________

(1)

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

Explain why the spot moves from R to Q.

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(3)

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

current = ____________________ A

(2)

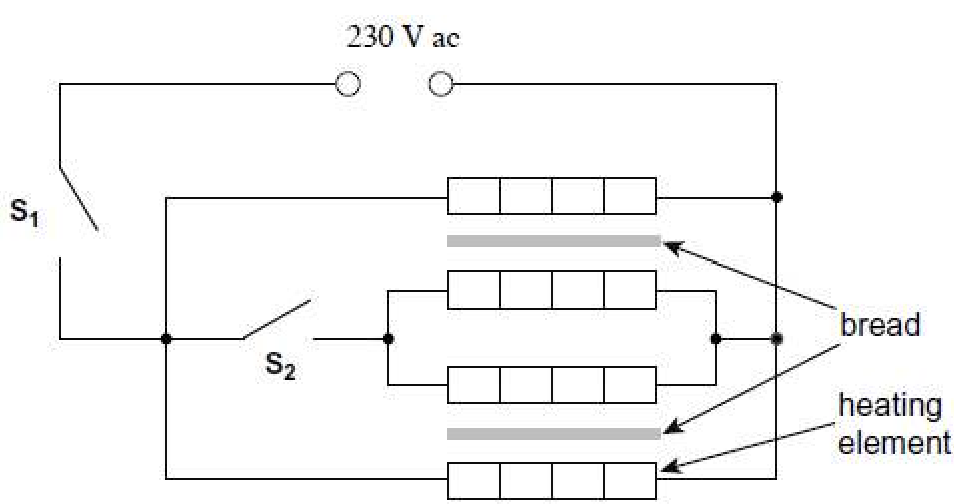
(e) Calculate the internal resistance of the battery.

internal resistance = ____________________ Ω

(2)

(Total 10 marks)

4 The diagram shows the circuit diagram for a two-slice electric toaster that is operated at a mains voltage of 230 V.



The toaster has four identical heating elements and has two settings: normal and low. On the normal setting both sides of the bread are toasted. On the low setting, only one side of the bread is toasted. The setting is controlled by switches $\mathbf{S_1}$ and $\mathbf{S_2}$.

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

Setting	$\mathbf{S_1}$	$\mathbf{S_2}$	**Power / W**
Low	closed	open	400
Normal	closed	closed	800

(a) Calculate the current in $\mathbf{S_2}$ when the normal setting is selected.

current ____________________ A

(2)

(b) (i) Show that the resistance of **one** heating element is approximately 260 Ω when the toaster is operating at its working temperature.

(2)

(ii) Calculate the total resistance when the normal setting is selected.

resistance ____________________ Ω

(2)

(iii) Each heating element is made of nichrome wire of diameter 0.15 mm.
The nichrome wire is wrapped around an insulating board.

Determine the length of nichrome wire needed to provide a resistance of 260 Ω.

resistivity of nichrome at the working temperature = 1.1×10^{-6} Ω m

length of wire ____________________ m

(3)

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

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(3)

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

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

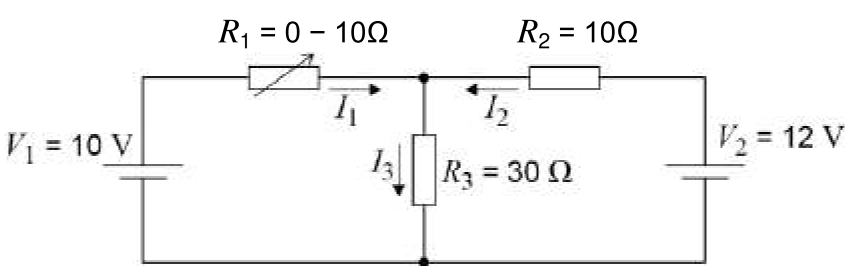
Give your answer to an appropriate number of significant figures.

peak wavelength ____________________ m

(3)

(Total 15 marks)

5 The cells in the circuit shown in the figure below have zero internal resistance. Currents are in the directions shown by the arrows.



R_1 is a variable resistor with a resistance that varies between 0 and 10 Ω.

(a) Write down the relationship between currents I_1, I_2 and I_3.

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(1)

(b) R_1 is adjusted until it has a value of 0 Ω.

State the potential difference across R_3.

potential difference = ____________________ V

(1)

(c) Determine the current I_2.

current = ____________________ J

(2)

(d) State and explain what happens to the potential difference across R_2 as the resistance of R_1 is gradually increased from zero.

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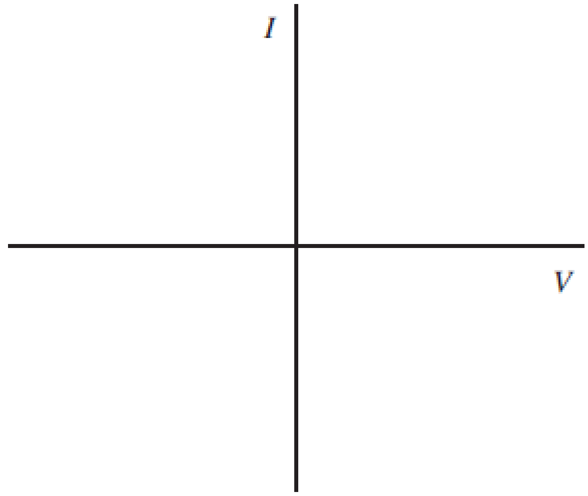
(3)

(Total 7 marks)

6

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

Figure 1



(2)

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

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(1)

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

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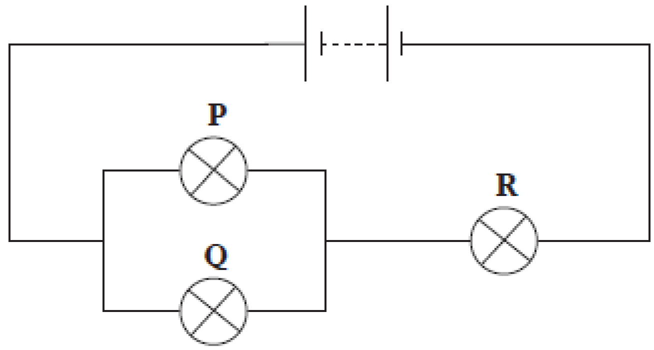
(1)

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

Figure 2.



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

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(2)

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

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

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

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

(2)

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

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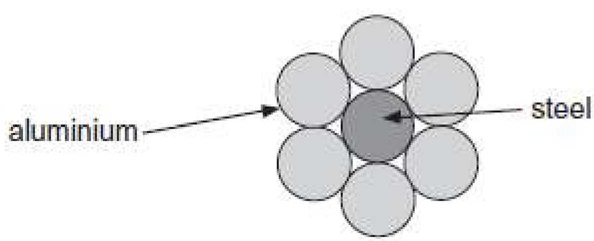
(2)

(Total 10 marks)

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



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

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

resistivity = ____________________ unit ___________

(4)

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

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(3)

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

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

Total power loss ____________________ W

(3)

(Total 10 marks)

8 (a) The power P dissipated in a resistor of resistance R is measured for a range of values of the potential difference V across it. The results are shown in the table below.

V / V	V^2 / V^2	P / W
1.00	1.0	0.21
1.71	2.9	0.58
2.25		1.01
2.67		1.43
3.00	9.0	1.80
3.27	10.7	2.18
3.50	12.3	2.43

(i) Complete the table above.

(1)

(ii) Complete the graph below by plotting the two remaining points and draw a best fit straight line.

(2)

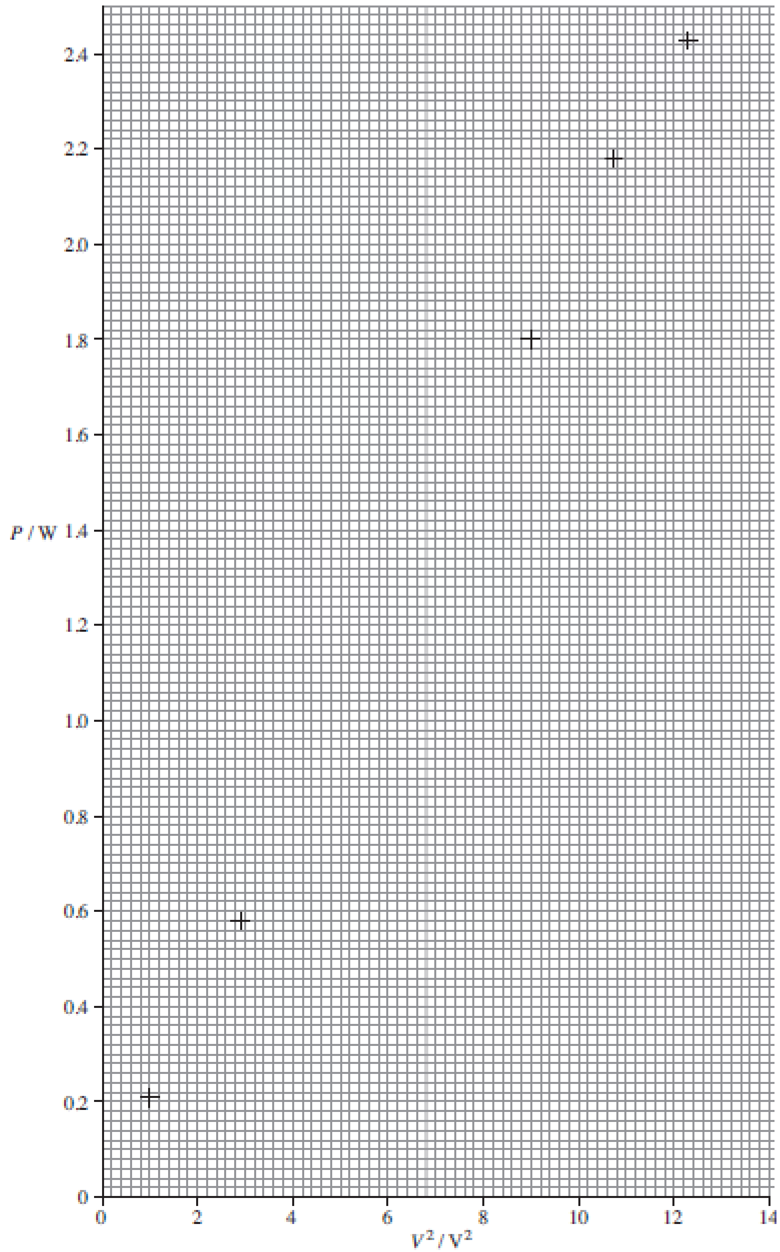
(iii) Determine the gradient of the graph.

gradient = ______________________

(3)

(iv) Use the gradient of the graph to obtain a value for R.

R = ______________________



(1)

(b) The following questions are based on the data in the table above.

(i) Determine the value of R when V = 3.50 V.

R = ____________________ Ω

(1)

(ii) The uncertainty in V is ± 0.01 V. The uncertainty in P is ± 0.05 W.

Calculate the percentage uncertainty in the value of R calculated in part (1).

percentage uncertainty = ____________________ %

(3)

(iii) Hence calculate the uncertainty in the value of R.

uncertainty = ____________________

(1)

(iv) State and explain whether the value of R you calculated in part (1) is consistent with the value of R you determined from the gradient in part (a)(iv).

(2)

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(Total 14 marks)

9 (a) (i) Describe how you would make a direct measurement of the emf ε of a cell, stating the type of meter you would use.

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(1)

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

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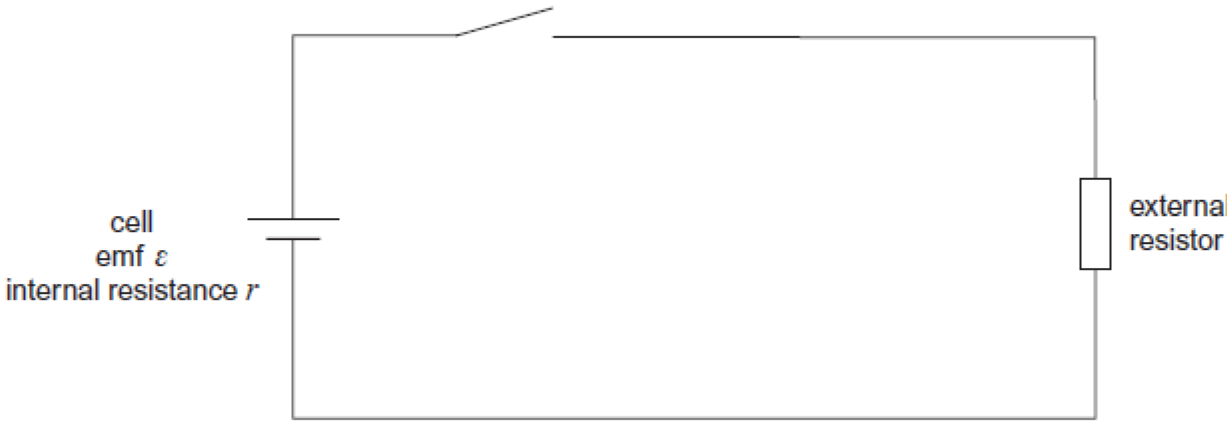
(1)

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



The student wishes to determine the efficiency of this circuit.

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

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

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

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

and V is the potential difference across the external resistor.

(1)

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

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(2)

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

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(2)

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

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(2)
(Total 9 marks)

10 The critical temperature of tin is −269 °C. The resistivity of tin increases as its temperature rises from −269 °C.

(a) (i) Define resistivity.

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(2)

(ii) State the significance of the critical temperature of a material.

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(2)

(b) A sample of tin in the form of a cylinder of diameter 1.0 mm and length 4.8 m has a resistance of 0.70 Ω.

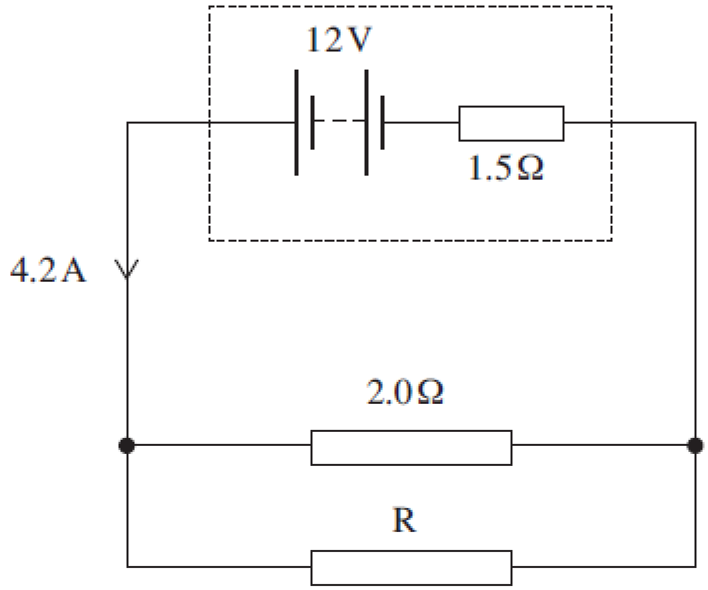
Use these data to calculate a value of the resistivity of tin.
State an appropriate unit for your answer.

resistivity ____________________ unit __________

(4)

(Total 8 marks)

11 The circuit diagram below shows a battery of electromotive force (emf) 12 V and internal resistance 1.5 Ω connected to a 2.0 Ω resistor in parallel with an unknown resistor, R. The battery supplies a current of 4.2 A.



(a) (i) Show that the potential difference (pd) across the internal resistance is 6.3 V.

(1)

(ii) Calculate the pd across the 2.0 Ω resistor.

pd ____________________ V

(1)

(iii) Calculate the current in the 2.0 Ω resistor.

current ____________________ A

(1)

(iv) Determine the current in R.

current ____________________ A

(1)

(v) Calculate the resistance of R.

R ____________________ Ω

(1)

(vi) Calculate the total resistance of the circuit.

circuit resistance ____________________ Ω

(2)

(b) The battery converts chemical energy into electrical energy that is then dissipated in the internal resistance and the two external resistors.

(i) Using appropriate data values that you have calculated, complete the following table by calculating the rate of energy dissipation in each resistor.

resistor	**rate of energy dissipation / W**
internal resistance	
2.0 Ω	
R	

(3)

(ii) Hence show that energy is conserved in the circuit.

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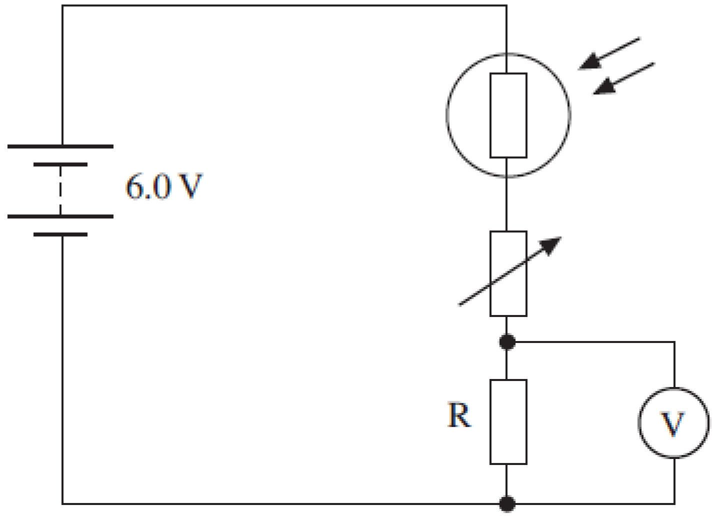
(2)

(Total 12 marks)

12 The circuit diagram below shows a 6.0 V battery of negligible internal resistance connected in series to a light dependent resistor (LDR), a variable resistor and a fixed resistor, R.



(a) For a particular light intensity the resistance of the LDR is 50 kΩ. The resistance of R is 5.0 kΩ and the variable resistor is set to a value of 35 kΩ.

(i) Calculate the current in the circuit.

current ____________________ A

(2)

(ii) Calculate the reading on the voltmeter.

voltmeter reading ____________________ V

(2)

(b) State and explain what happens to the reading on the voltmeter if the intensity of the light incident on the LDR increases.

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(2)

(c) For a certain application at a particular light intensity the pd across R needs to be 0.75 V. The resistance of the LDR at this intensity is 5.0 kΩ.

Calculate the required resistance of the variable resistor in this situation.

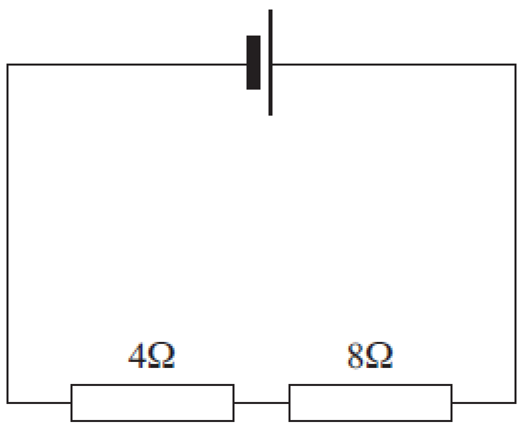
resistance ____________________ Ω

(3)

(Total 9 marks)

13 (a) The cell in **Figure 1** has an emf of 3.0 V and negligible internal resistance.

Figure 1



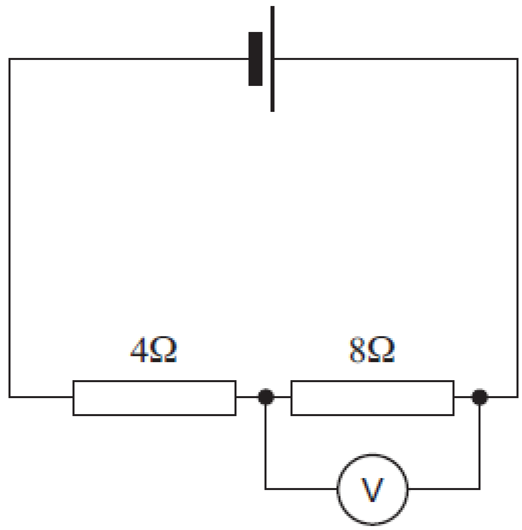
Calculate the potential difference across the 8 Ω resistor.

potential difference ____________________ V

(2)

(b) **Figure 2** shows the same circuit with a voltmeter connected across the 8 Ω resistor.

Figure 2



The voltmeter reads 1.8 V. Calculate the resistance of the voltmeter.

resistance ____________________ Ω

(3)

(Total 5 marks)

14 At room temperature a metal has a resistivity of 4.5×10^{-7} Ωm. A wire made from this metal has a radius of 0.70 mm.

(a) (i) Calculate the resistance of a 2.5 m length of the wire at room temperature.

resistance ____________________ Ω

(3)

(ii) Calculate the power dissipated in this length of wire when it carries a current of 20 mA. Assume the resistance of the wire is constant.

power ____________________ W

(2)

(b) The wire becomes superconducting as it is cooled. Draw a sketch graph on the axes below to show how the wire's resistivity would vary with temperature as it is cooled from room temperature θ_r.

(3)

(c) Explain why the efficiency of electrical power transmission is improved when conventional wires are replaced with superconducting wires.

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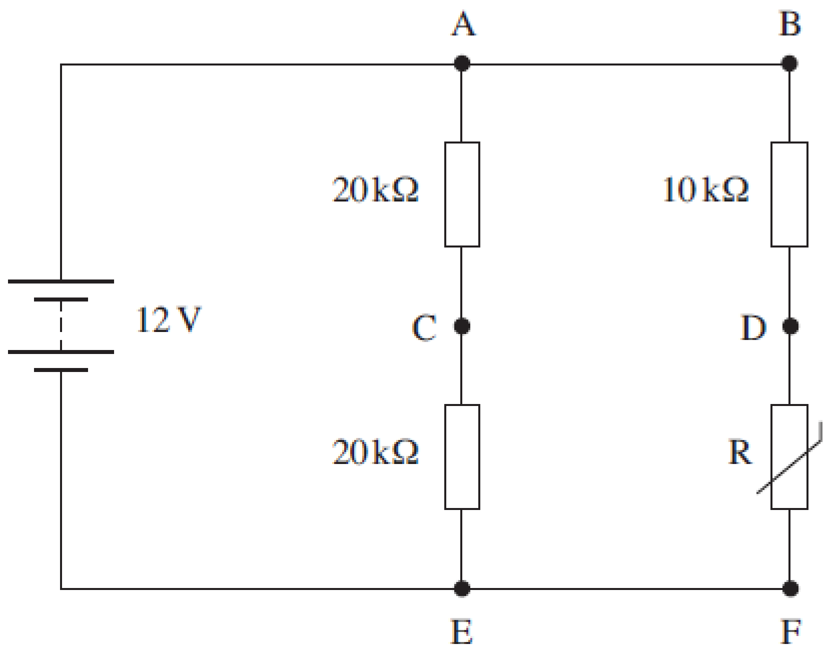
(1)

(Total 9 marks)

15 The circuit diagram below shows a 12 V battery of negligible internal resistance connected to a combination of three resistors and a thermistor.



(a) When the resistance of the thermistor is 5.0 kΩ

(i) calculate the total resistance of the circuit,

total resistance = ____________________ kΩ

(3)

(ii) calculate the current in the battery.

current = ____________________ mA

(1)

(b) A high-resistance voltmeter is used to measure the potential difference (pd) between points A-C, D-F and C-D in turn.
Complete the following table indicating the reading of the voltmeter at each of the three positions.

voltmeter position	**pd / V**
A-C	
D-F	
C-D	

(3)

(c) The thermistor is heated so that its resistance decreases. State and explain the effect this has on the voltmeter reading in the following positions.

(i) A–C ____

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(2)

(ii) D–F ____

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(2)

(Total 11 marks)

16 A cordless phone handset contains two rechargeable cells connected in series. Each cell has an emf of 2.0 V and, when fully charged, the combination stores energy sufficient to provide 850 mA for 1 hour.

(a) Calculate the total energy stored by the two cells when fully charged.

energy stored ____________________ J

(3)

(b) The internal resistance of each cell is 0.60 Ω.
Calculate the potential difference across the two cells when they are connected in series across a 20.0 Ω load.

potential difference ____________________ V

(3)

(Total 6 marks)

17 (a) Define the volt.

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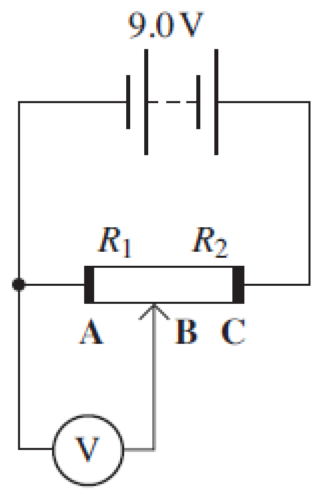
(1)

(b) To test the potential differences in a potential divider circuit, a student sets up the circuit of **Figure 1**. R_1 is the resistance of section **AB** and R_2 that of section **BC** of the potential divider. The battery has an emf of 9.0 V and negligible internal resistance

Figure 1



(i) Calculate the voltmeter reading when R_1 = 2.2 kΩ and R_2 = 1.8 kΩ. Assume that the voltmeter has infinite resistance.

voltmeter reading ____________________ V

(2)

(ii) State the benefit of using a high value of resistance in potential divider circuits.

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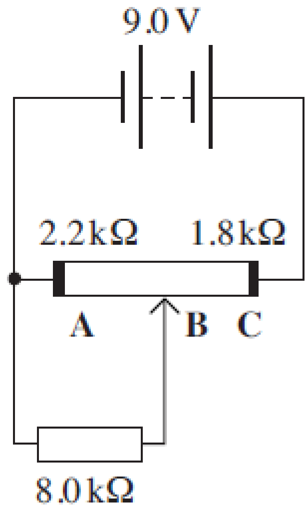
(1)

(iii) An 8.0 kΩ resistor is connected in the circuit to replace the voltmeter in **Figure 1**. This is shown in **Figure 2**.

Figure 2



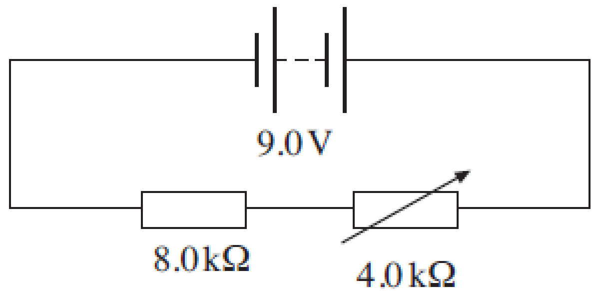
Calculate the potential difference across this resistor when the sliding contact **B** is in the position shown in **Figure 2**.

potential difference ____________________ V

(3)

(iv) The 8.0 kΩ resistor is now connected in a circuit with a 4.0 kΩ variable resistor as shown in **Figure 3**.

Figure 3



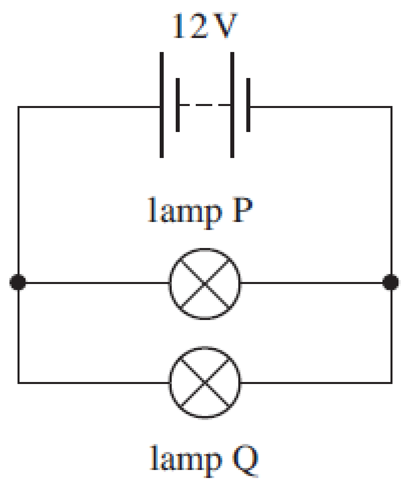
Compare this arrangement for controlling the current in the 8.0 kΩ resistor with the potential divider arrangement in **Figure 2**.

(2)

(Total 9 marks)

18 A battery of negligible internal resistance is connected to lamp P in parallel with lamp Q as shown in **Figure 1**. The emf of the battery is 12 V.

Figure 1



(a) Lamp P is rated at 12 V 36 W and lamp Q is rated at 12 V 6 W.

(i) Calculate the current in the battery.

answer = ______________________ A

(2)

(ii) Calculate the resistance of P.

answer = ______________________ Ω

(1)

(iii) Calculate the resistance of Q.

answer = ______________________ Ω

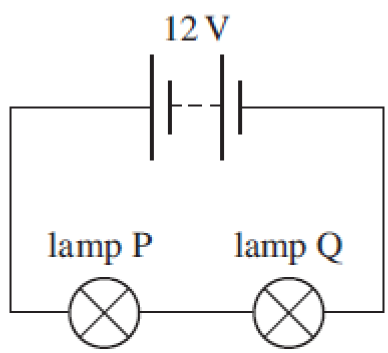
(1)

(b) State and explain the effect on the brightness of the lamps in the circuit shown in **Figure 1** if the battery has a significant internal resistance.

(3)

(c) The lamps are now reconnected to the 12 V battery in series as shown in **Figure 2.**

Figure 2



(i) Explain why the lamps will not be at their normal brightness in this circuit.

(2)

(ii) State and explain which of the lamps will be brighter assuming that the resistance of the lamps does not change significantly with temperature.

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(3)

(Total 12 marks)

19 **X** and **Y** are two lamps. **X** is rated at 12 V 36 W and **Y** at 4.5 V 2.0 W.

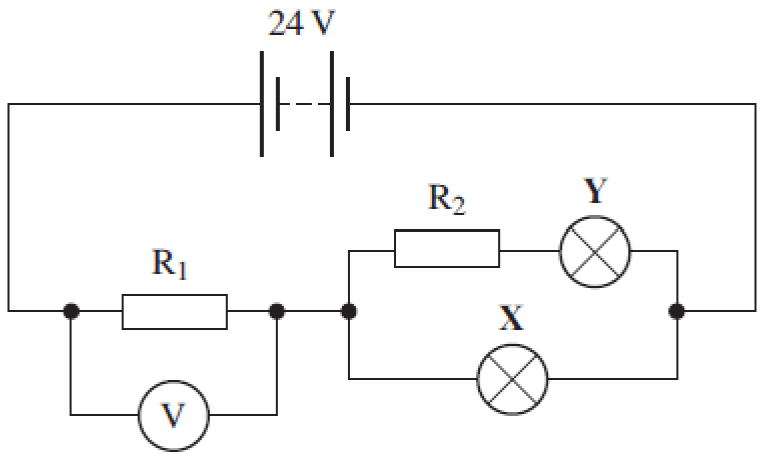
(a) Calculate the current in each lamp when it is operated at its correct working voltage.

X ______________________ A

Y ______________________ A

(2)

(b) The two lamps are connected in the circuit shown in the figure below. The battery has an emf of 24 V and negligible internal resistance. The resistors, R_1 and R_2 are chosen so that the lamps are operating at their correct working voltage.



(i) Calculate the pd across R_1.

answer ______________________ V

(1)

(ii) Calculate the current in R_1.

answer ______________________ A

(1)

(iii) Calculate the resistance of R_1.

answer ______________________ Ω

(1)

(iv) Calculate the pd across R_2.

answer ______________________ V

(1)

(v) Calculate the resistance of R_2.

answer ______________________ Ω

(1)

(c) The filament of the lamp in **X** breaks and the lamp no longer conducts. It is observed that the voltmeter reading decreases and lamp **Y** glows more brightly.

(i) Explain without calculation why the voltmeter reading decreases.

___

___

___

(2)

(ii) Explain without calculation why the lamp **Y** glows more brightly.

___

___

___

(2)

(Total 11 marks)

20 (a) The rating of a car headlamp is 12 V, 55 W.
The resistance in this headlamp is due to a thin piece of wire. At its working temperature, the wire has a length of 5.0×10^{-2} m and a cross-sectional area of 1.9×10^{-8} m^2.
Calculate, at the working temperature, the resistivity of the metal used to make the wire.
State an appropriate unit for your answer.

resistivity ______________________ unit ___________

(5)

(b) (i) Define the term electromotive force (emf).

___

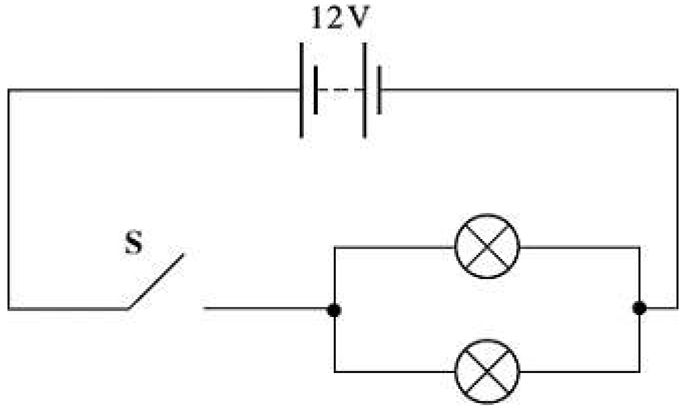
___

___

___

(2)

(ii) The figure below is a circuit diagram illustrating how two of these headlamps are connected to a car battery.



The car battery has an emf of 12 V.

When the switch **S** is closed there is a current of 9.1 A through the battery and a potential difference of 11.9 V across the headlamps.
Calculate the internal resistance of the car battery.

internal resistance ______________________ Ω

(2)

(c) A fault develops in one of the headlamps in the figure above causing its resistance to decrease.
State and explain how this fault affects the brightness of the other headlamp.

___

___

___

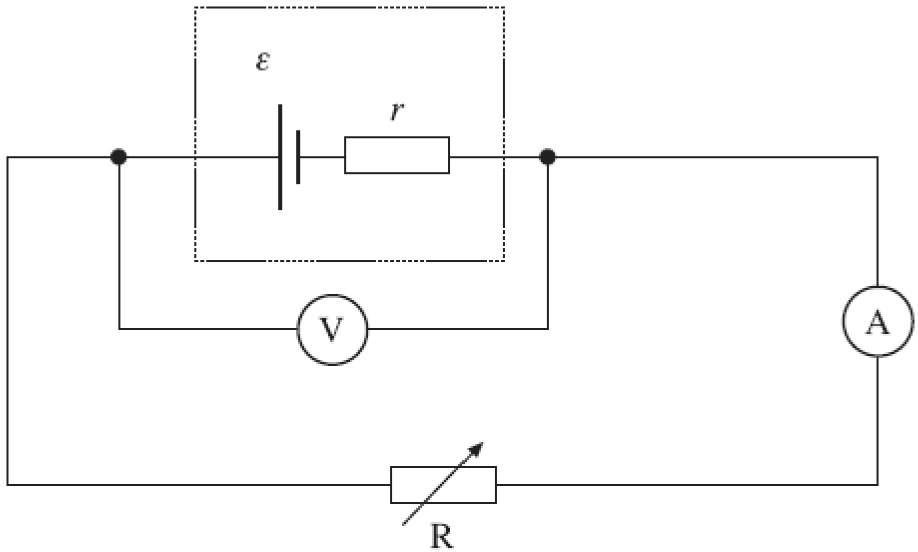
___

___

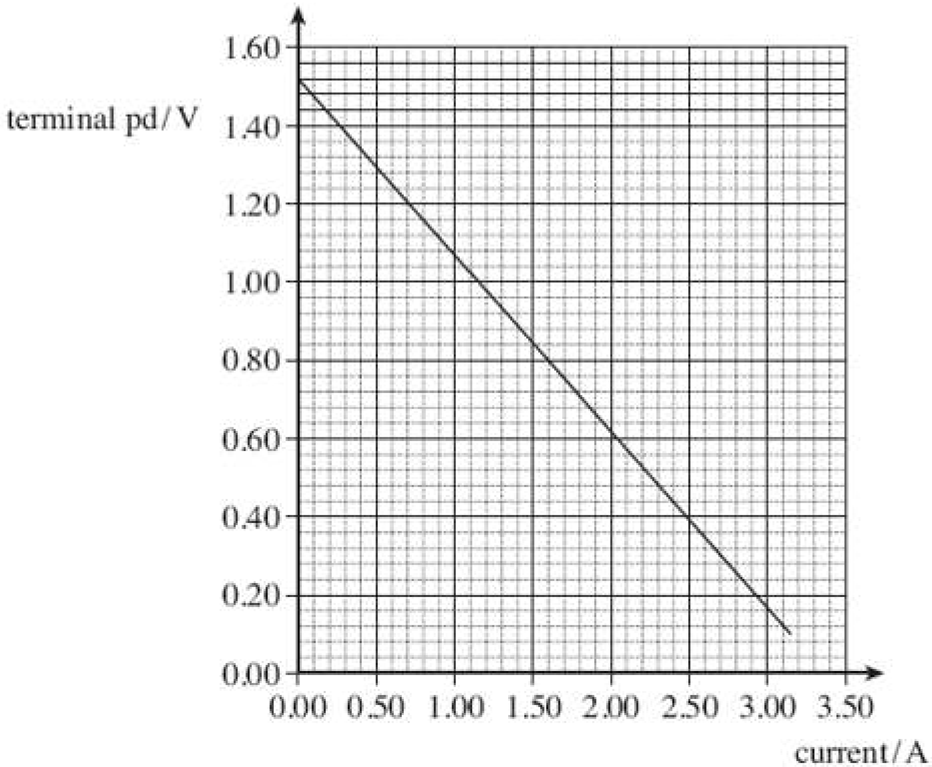
___

(3)
(Total 12 marks)

21 A cell of emf, ε, and internal resistance, r, is connected to a variable resistor R. The current through the cell and the terminal pd of the cell are measured as R is decreased. The circuit is shown in the figure below.



The graph below shows the results from the experiment.



(a) Explain why the terminal pd decreases as the current increases.

____

____

____

____

(2)

(b) (i) Use the graph to find the emf, ε, of the cell.

answer = ______________________ V

(1)

(ii) Use the graph above to find the internal resistance, *r*, of the cell.

answer = ______________________ Ω

(3)

(c) Draw a line on the graph above that shows the results obtained from a cell with

(i) the same emf but double the internal resistance of the first cell labelling your graph **A.**

(2)

(ii) the same emf but negligible internal resistance labelling your graph **B**.

(1)

(d) In the original circuit shown in part (a), the variable resistor is set at a value such that the current through the cell is 0.89 A.

(i) Calculate the charge flowing through the cell in 15 s, stating an appropriate unit.

answer = ______________________

(2)

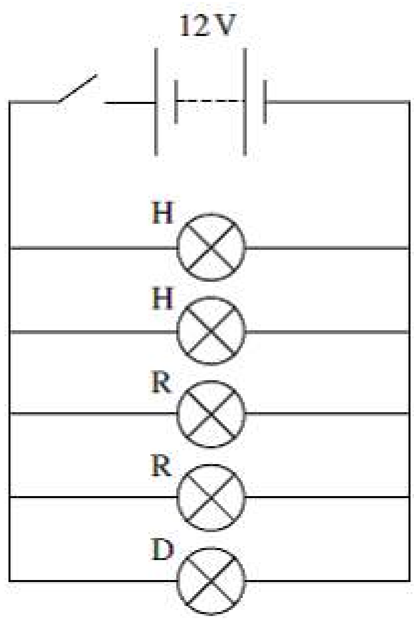
(ii) Calculate the energy dissipated in the internal resistance of the cell per second.

answer = ______________________ W

(2)

(Total 13 marks)

22 The Figure below shows a simplified circuit for the main lights on a car.
The battery has an emf of 12 V and no internal resistance.



The table below gives data about the lamps being used in the circuit. The resistances given are correct when the lamp is operating at its normal operating voltage.

LAMP	**OPERATING VOLTAGE V**	**RESISTANCE Ω**
H, headlight lamp	12	3.8
R, rear lamp	12	5.6
D, dashboard lamp	12	72

(a) (i) Calculate the power of a single headlight lamp when operating at 12 V.

power ______________________ W

(2)

(ii) Calculate the resistance of the combination of lamps when operating at 12 V.

resistance ______________________ Ω

(3)

(iii) Calculate the total power of the combination of lamps when operating at 12 V.

power ______________________ W

(2)

(b) The battery is replaced with one of a lower emf. State and explain how the resistance of the lamps would have to change in order to achieve the same brightness.

____

____

____

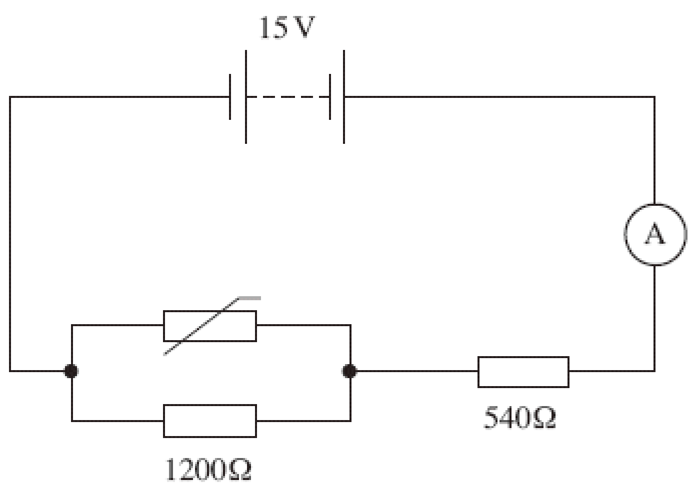
____

____

____

(2)
(Total 9 marks)

23 The circuit shown below shows a thermistor connected in a circuit with two resistors, an ammeter and a battery of emf 15V and negligible internal resistance.



(a) When the thermistor is at a certain temperature the current through the ammeter is 10.0 mA.

(i) Calculate the pd across the 540 Ω resistor.

answer = ______________________ V

(1)

(ii) Calculate the pd across the 1200 Ω resistor.

answer = ______________________ V

(1)

(iii) Calculate the resistance of the parallel combination of the resistor and the thermistor.

answer = ______________________ Ω

(2)

(iv) Calculate the resistance of the thermistor.

answer = ______________________ Ω

(2)

(b) The temperature of the thermistor is increased so that its resistance decreases. State and explain what happens to the pd across the 1200 Ω resistor.

____

____

____

____

(3)

(Total 9 marks)

24 (a) A sample of conducting putty is rolled into a cylinder which is 6.0×10^{-2} m long and has a radius of 1.2×10^{-2} m.

resistivity of the putty = 4.0×10^{-3} Ωm.

Calculate the resistance between the ends of the cylinder of conducting putty.
Your answer should be given to an appropriate number of significant figures.

answer = ____________________ Ω

(4)

(b) Given the original cylinder of the conducting putty described in part (a), describe how you would use a voltmeter, ammeter and other standard laboratory equipment to determine a value for the resistivity of the putty.

Your description should include

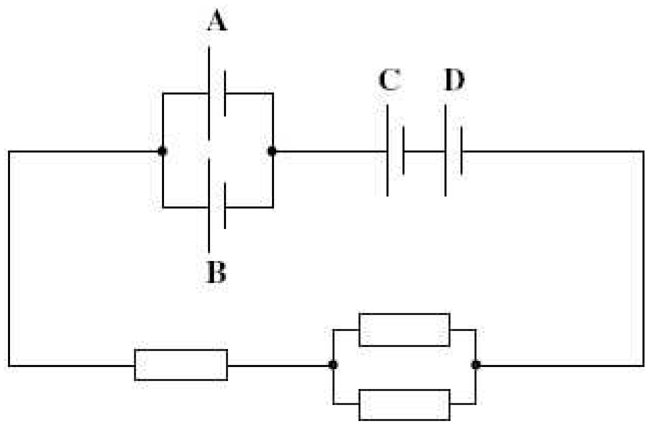
- a labelled circuit diagram,
- details of the measurements you would make,
- an account of how you would use your measurements to determine the result,
- details of how to improve the precision of your measurements.

The quality of your written communication will be assessed in this question.

(8)

(Total 12 marks)

25 The circuit in the diagram below contains four identical new cells, **A**, **B**, **C** and **D**, each of emf 1.5V and negligible internal resistance.



(a) The resistance of each resistor is 4.0 Ω.

(i) Calculate the total resistance of the circuit.

answer = ______________________ Ω

(1)

(ii) Calculate the total emf of the combination of cells.

answer = ______________________ V

(1)

(iii) Calculate the current passing through cell **A.**

answer = ______________________ A

(2)

(iv) Calculate the charge passing through cell **A** in five minutes, stating an appropriate unit.

answer = ______________________

(2)

(b) Each of the cells can provide the same amount of electrical energy before going flat. State and explain which two cells in this circuit you would expect to go flat first.

____

____

____

____

____

____

(3)

(Total 9 marks)

26 A student wishes to collect data so he can plot the *I-V* curve for a semiconductor diode.

(a) (i) Draw a suitable diagram of the circuit that would enable the student to collect this data.

(3)

(ii) Describe the procedure the student would follow in order to obtain an *I-V* curve for the semiconductor diode.

The quality of your written communication will be assessed in this question.

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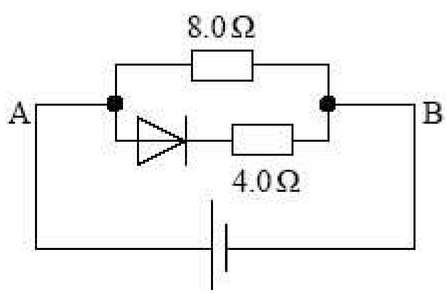
____

(6)

(b) The diagram below shows an arrangement of a semiconducting diode and two resistors.



A 12.0 V battery is connected with its positive terminal to A and negative terminal to B.

(i) Calculate the current in the 8.0 Ω resistor

____

____

____

answer ____________________ A

(2)

(ii) Calculate the current in the 4.0 Ω resistor if the p.d. across the diode, when in forward bias, is 0.65 V expressing your answer to an appropriate number of significant figures.

answer ____________________ A

(3)

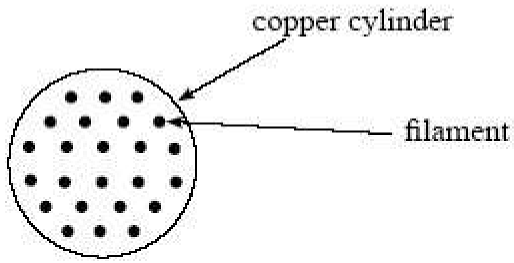
(Total 14 marks)

27 (a) Some materials exhibit the property of *superconductivity* under certain conditions.

- State what is meant by superconductivity.
- Explain the required conditions for the material to become superconducting.

(3)

(b) The diagram below shows the cross–section of a cable consisting of parallel filaments that can be made superconducting, embedded in a cylinder of copper.



(i) The cross–sectional area of the copper in the cable is 2.28×10^{-7} m^2. The resistance of the copper in a 1.0 m length of the cable is 0.075 Ω. Calculate the resistivity of the copper, stating an appropriate unit.

answer = ______________________

(3)

(ii) State and explain what happens to the resistance of the cable when the embedded filaments of wire are made superconducting.

____

____

____

(3)
(Total 9 marks)

28 A car battery has an *emf* of 12 V and an *internal resistance* of 5.0×10^{-3} Ω.

(a) (i) Explain what is meant by the emf of the battery.

____

____

(1)

(ii) Explain what is meant by the internal resistance of the battery.

____

____

(1)

(b) The battery is used to provide the starting motor of a car with a current of 800 A.

(i) Calculate the potential difference across the terminals of the battery.

answer = ____________________ V

(2)

(ii) Calculate the rate of dissipation of energy due to its internal resistance stating an appropriate unit.

answer = ____________________

(3)

(c) State and explain the effect of attempting to use a battery with a much higher internal resistance to start the car.

____

____

____

____

(2)

(Total 9 marks)

29 (a) For a conductor in the form of a wire of uniform cross-sectional area, give an equation which relates its resistance to the resistivity of the material of the conductor. Define the symbols used in the equation.

____

____

____

(2)

(b) (i) An electrical heating element, made from uniform nichrome wire, is required to dissipate 500 W when connected to the 230 V mains supply.
The cross-sectional area of the wire is 8.0×10^{-8} m^2. Calculate the length of nichrome wire required.

resistivity of nichrome = 1.1×10^{-6} Ω m

(ii) Two heating elements, each rated at 230 V, 500 W are connected to the 230 mains supply

(A) in series,
(B) in parallel.

Explain why only one of the circuits will provide an output of 1 kW.

(6)
(Total 8 marks)

30 Four resistors, each having resistance of 50 Ω, are connected to form a square. A resistance meter measured the resistance between different corners of the square. Determine the resistance the meter records when connected between the following corners.

(a) Between A and C, as in **Figure 1**.

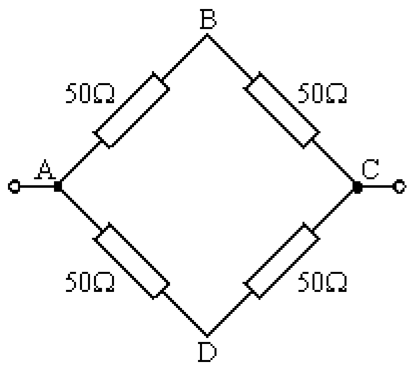


Figure 1

(2)

(b) Between A and B, as in **Figure 2**.

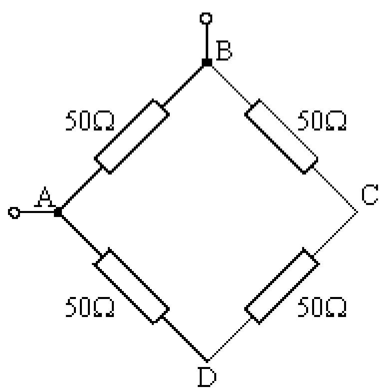


Figure 2

(3)

(Total 5 marks)

1 (a) *(use of $R = \rho l/A$)*
$A = 9.7 \times 10^{-8} \times 0.50/0.070$ ✓ **1**

$A = 6.929 \times 10^{-7}$ (m^2) ✓ **1**

diameter = $\sqrt{(6.929 \times 10^{-7} \times 4/\pi)} = 9.4 \times 10^{-4}$ (m) ✓

CE for third mark if incorrect area **1**

(b) $R = 1.5/0.66 = 2.3(\Omega)$ (2.27) ✓ **1**

(c) *(use of $V = IR$)*
$I = 1.5/(22 + 1.2) = 0.065$✓(A) (0.0647) ✓ **1**

(d) current in $R_1 = 0.66 - 0.0647 = 0.595$ (A) ✓

CE from 4.2/4.3 **1**

resistance of R_1 and probe = $1.5/0.595 = 2.52$ (Ω) ✓

alternative method: $1/2.3 = 1/23.2 + 1/(R_{probe} + 2.4)$ ✓ **1**

resistance of probe = $2.52 - 2.4 = 0.12$ (Ω) ✓

correct rearrangement ✓

range 0.1 – 0.15 ✓

accept 1 sig. fig. for final answer **1**

(e) cross-sectional area must decrease OR R α 1/A

indicated by downward arrow or negative sign which can be seen on answer line **1**

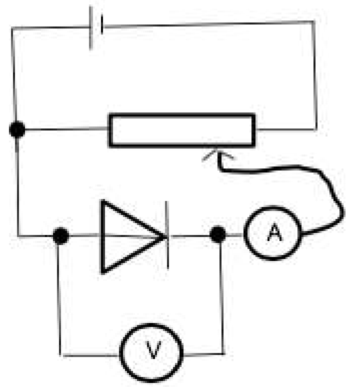
area decreases by 1.6% hence diameter must decrease by 0.8% ✓

accept 1% **1**

(f) ANY TWO FROM
correct reference to lost volts OR terminal pd OR reduced current ✓
reference to resistors not changing OR resistors constant ratio ✓
reference to voltmeter having high/infinite resistance (so not affecting circuit) ✓
reference to pd between AB being (very) small (due to closeness of resistance ratios in each arm) ✓
voltmeter (may not be) sensitive enough ✓

1
1
[12]

2 (a) (i)



correct diode bias for variable supply, must have some attempt to vary pd ✓

Condone variable resistor (condone missing arrow) don't allow thermistor symbol

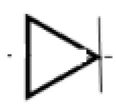
correct symbols and positions for voltmeter, ammeter:
voltmeter in parallel with diode only
ammeter in series with diode ✓

Allow mA symbol instead of A symbol for ammeter

Allow symbols for diode without line through triangle and / or with a circle

Diode symbol must consist of a triangle and a straight line at nose perpendicular to wiring in circuit.

allow voltmeter across ammeter and diode



2

(ii) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**
The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks
The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.
Candidate explains how to obtain sufficient values of I and V. They mention the need to limit the current through the diode and give an indication of the range and frequency of measurements. They discuss an advantage of using a data logger. Voltage does not exceed 1.0V, diode is forward biased

Intermediate Level (Modest to adequate): 3 or 4 marks
The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.
Candidate explains how to obtain sufficient values of I and V. Includes mention of diode is forward biased or suitable voltage for switch on mentioned or advantage of data logger

Low Level (Poor to limited): 1 or 2 marks
The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.
vary pd obtain several readings of *I* and *V*
or an advantage of using data logger
or forward biased
low level safety may include switch off / avoid overheating type arguments / don't touch

The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.
means of controlling pd across diode
indication of range and frequency of measurement
mention of limiting current to avoid damage to diode
a consideration of the advantages of a datalogger e.g. many readings, computer display of results
use of potential divider instead of series resistor

All signs of quality that could lift mark

Lower band

<u>vary pd</u> obtain several readings of I and V

<u>or</u> an advantage of using data logger or low level safety and action to minimise risk

Middle band

vary pd and obtain several readings of I and V, <u>at least 6 different values</u> ***including*** *an advantage of using data logger or mention of forward bias or mention of switch on voltage (0.6V) or safety*

Top Band

Mention of how to vary pd (seen in viable circuit) obtain several readings of I and V, <u>at least 6 different values (range given where maximum value of pd does not exceed 1.0V)</u>

mention of limiting current through diode using protective resistor

consider advantage of data logger

mention forward bias

must include potentiometer for 6 marks

must have voltage as independent, no current led arguments in Top band

Data logger advantages:

Not more accurate

Not removes human error

6

(iii) reverse connections to the power supply / battery / cell / reverse diode ✓

not switch wires around (need clear link to reversing connections at supply's terminals)

1

(b) (i) divide *V* by *I* for a reading from graph **or** uses $R = {}^{V}/_{I}$ for a reading from graph ✓

Treat gradient $= \frac{1}{R}$ *as TO*

repeat for different values of *V* and *I* ✓

Must score 1st mark to achieve 2nd

2

(ii) (Resistance) decreases ✓

Or resistance starts off very high and then becomes much lower

1

[12]

3 (a) time base is (switched) off ✓
TO for y-input switched off

not affected by x plates because these plates are not switched on

1

(b) (i) emf (of battery) ✓

not just terminal pd

TO applied for non-emf statements

Allow explanation of emf

1

(ii) (emf = 3 × 2.0 =) 6.0 V ✓

penalise 1 sf

1

(c) Because the pd across the y plates has decreased ✓

there is a current (in the battery) ✓

there is a pd / voltage across the internal resistance **or** there are (now) lost volts ✓

terminal pd decreases **or** terminal pd now less than emf **or** $IR = \varepsilon - Ir$ ✓

3

(d) *V*= 2.5 × 2.0 = 5 V
or (use of V=IR) by I = their incorrect voltage ÷18 ✓

Must see I as subject or their working leading to answer line for use of

I=0.28(A) ✓ cao

2

(e) (use of $\varepsilon = IR + Ir$)

$6.0 = 2.5 \times 2.0 + 0.28 \times r$

$$r = \frac{\varepsilon - IR}{I}$$

or correct rearrangement to make r subject

or sets $R_{(T)} = \frac{\varepsilon}{0.28}$ = 21.2 or 21.4 (ohms) with subject seen

or $\frac{1}{0.28}$ ✓

r = 3.4 to 3.6 Ω ✓

Ecf for I and V ecf ans = $\frac{6 - \text{their V}}{\text{their I}}$

2

[10]

4 (a) Correct substitution into P=VI

1.74 (A)

2

(b) (i) Correct substitution into R=V/I or V^2/P or P/I^2

264 (Ω)

Allow correct use of parallel resistor equation

2

(ii) Use of $1/R_T = 1/R_1 + 1/R_2$ or $R = V^2/P$

65 (66.1) (Ω)

2

(iii) $A = \pi(1.5 \times 10^{-4})^2/4$ or $\pi(7.5 \times 10^{-5})^2$ or 1.767×10^{-8} (m^2)

Substitution into $l = RA/\rho$ with their area

4.2 (4.18) (m)

2 marks for 17 (m), using of d instead of r

3

(c) Resistivity / resistance increases with increasing temperature

(Lattice) ions vibrate with greater amplitude

Rate of movement of charge carriers / electrons (along wire) reduced (for given pd)

ORA

Condone atoms for ions.

Accept "vibrate more".

Accept more frequent collisions occur between electrons and ions owtte

3

(d) $2.9 \times 10^{-3}/447$ or $2.9 \times 10^{-3}/174$ seen

$6.5\ (6.49) \times 10^{-6}$ (m)

Correct answer given to 2 sig fig

Condone use of 174 for T for C1 and B1 marks

Allow 3 sig fig answer if 2.90×10^{-3} used

3

[15]

5

(a) $I_3 = I_1 + I_2$ ✓ **1**

(b) 10 V ✓ **1**

(c) $I_2 = (12 - 10) / 10$ ✓

Allow ce for 10 V **1**

= 0.2 A ✓

The first mark is for the pd

The second is for the final answer **1**

(d) pd across R_2 increases

As R_1 increases, pd across R_1 increases as pd = $I_1 R_1$ ✓

First mark is for identifying that pd across R_1 increases (from zero). **1**

pd across R_3 = 10 V – pd across R_1

Therefore pd across R_3 decreases ✓

Second mark is for identifying that pd across R_3 must decrease **1**

pd across R_2 = 12 – pd across R_3

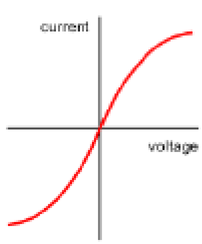
Therefore pd across R_2 increases ✓

Third mark is for identifying that this means pd across R2 must increase **1**

[7]

6

(a)



✓ ✓

first mark for linear at origin and decreasing gradient in either quadrant (linear region can be very small)

second mark for symmetry plus no dip at end or extended horizontal section at end

straight line scores zero **2**

(b) (i) resistance (of filament lamp) increases✓

1

(ii) filament lamp is a non-ohmic conductor as current is not (directly) proportional to voltage / resistance is not constant✓

proportionality can be shown using graph

1

(c) either

circuit / total resistance increases✓

(hence) current decreases and pd / voltage across R decreases✓

OR

resistance of PQ combination increases✓

(hence) greater share of pd / voltage across lamp P✓

implication that current is different in different parts of series circuits scores 0

implication that new total current is greater scores zero

voltage flowing loses second mark

2

(d) (i) (use of *energy = VIt*)

(energy converted by X = 60 × 120 × 3600 =) 2.59×10^7 J ✓

(energy converted by Y = 11 × 120 × 3600 =) 4.75×10^6 J ✓

Accept answers to 1 sig. fig.

2

(ii) in lamps energy is wasted as heat / thermal energy✓

specific lamp considered e.g. in lamp, X / filament lamp more energy is wasted OR in X / filament lamp less energy is converted to light / luminosity✓

2

[10]

7 (a) Use of $\rho = RA / l$)

cross sectional area= $\pi \times (3.7 \times 10^{-3})^2 = 4.3 \times 10^{-5}$ (m^2)✓

$\rho = \frac{3.3 \times 4.3 \times 10^{-5}}{1000}$ ✓ = $1.4(2) \times 10^{-7}$✓Ω m✓

area : lose first mark if use diameter as radius or fail to convert to m^2 (if both errors still only lose 1 mark)

CE area for next two marks but if uses diameter in place of area then lose first two marks

if leave length in km lose 2^{nd} mark but CE for answer

UNIT stand-alone 4th mark

4

(b) (current in) steel wire (is less than the current in an) aluminium wire as it has a higher resistivity / resistance OR aluminium is better conductor✓
the six aluminium wires are in <u>parallel</u> OR <u>total</u> cross-sectional area of aluminium is 6 times greater than steel wire✓
each aluminium wire carries three times as much current as the (single) steel wire✓

3

(c) resistance of 1 km of 6 Al cables in parallel = $\frac{1.1}{6}$ = 0.183 Ω✓

if ignored the steel wire then can score first and third mark

total resistance of the cable = 0.174 Ω✓
power loss per km = 32.3 kW (or 30.7 kW if they ignore the steel)✓
OR
power loss in 1 km of steel = 1.70kW✓
power loss in 1 km each of Al cable = 5.11 kW✓
total power loss per km = 32.4 kW (or 30.7 kW if they ignore the steel)✓
OR
calculate current in steel wire and aluminium wire (22.7 and 68.2) ✓
calculate power loss in aluminium wire and steel wire (1700 and 5115) ✓
calculate total power loss (1700 + 6 × 5115 = 32,4 kW) ✓

accept range 32 kW to 33 kW

if ignored steel wire
range for third mark is 30 kW to 31 kW

if wires treated as series resistors then zero

3

[10]

8 (a) (i) 5.1 and 7.1 ✓

Exact answers only

1

(ii) Both plotted points to nearest mm ✓

Best line of fit to points ✓

The line should be a straight line with approximately an equal number of points on either side of the line

2

(iii) Large triangle drawn at least 8 cm × 8 cm ✓

Correct values read from graph ✓

Gradient value in range 0.190 to 0.210 to 2 or 3 sf ✓

3

(iv) ($R = \frac{1}{\text{gradient}}$) = 5.0 Ω Must have unit ✓

Allow ecf from gradient value

No sf penalty

1

(b) (i) 5.04 (Ω) or 5.0 (Ω) ✓

(Allow also 5.06 Ω or 5.1 Ω, obtained by intermediate rounding up of 3.50^2)

From $R = \frac{V^2}{P}$

1

(ii) (Uncertainty in V = 0.29%)

Uncertainty in V^2 = 0.57%, 0.58% or 0.6% ✓

From uncertainty in V = 0.01 / 3.50 × 100%

Uncertainty in P = 2.1% ✓

From uncertainty in P = 0.05 / 2.43 × 100% = 2.1%

Uncertainty in R =2.6%, 2.7% or 3%

Answer to 1 or 2 sf only ✓

2.1 % + uncty in V^2 (0.6%) = 2.7%

Allow ecf from incorrect uncertainty for V^2 or P

3

(iii) (Absolute) uncertainty in R is (±) 0.14 or just 0.1 Ω (using 2.6%)

(or 0.15 or 0.2 Ω using 3%) ✓

Must have unit (Ω)

Must be to 1 or 2 sf and must be consistent with sf used from (ii)

No penalty for omitting ± sign

1

(iv) Works out possible range of values of R based on uncertainty in (iii), e.g. R is in range 5.0 to 5.2 Ω using uncertainty of ± 0.1 Ω ✓

No credit for statement to effect that the values are or are not consistent, without any reference to uncertainty

Allow ecf from (iii)

Value from (a)(iv) is within the calculated range (or not depending on figures, allowing ecf) ✓

Allow ecf from (a)(iv)

2

[14]

9 (a) (i) Voltmeter across terminals with nothing else connected to battery / no additional load. ✓

1

(ii) This will give zero / virtually no current ✓

1

(b) (i) $\frac{VI}{\varepsilon I}$

Answer must clearly show power: εI and VI, with I cancelling out to give formula stated in the question ✓

1

(ii) Voltmeter connected across cell terminals ✓

Switch open, voltmeter records ε
Switch closed, voltmeter records V
Both statements required for mark ✓

Candidates who put the voltmeter in the wrong place can still achieve the second mark providing they give a detailed description which makes it clear that:

To measure emf, the voltmeter should be placed across the cell with the external resistor disconnected

<u>And</u>

To measure V, the voltmeter should be connected across the external resistor when a current is being supplied by the cell

2

(c) Vary external resistor and measure new value of V, for at least 7 different values of external resistor ✓

Precautions - switch off between readings / take repeat readings (to check that emf or internal resistance not changed significantly) ✓

2

(d) Efficiency increases as external resistance increases ✓

Explanation
Efficiency = Power in R / total power generated
$I^2R / I^2(R + r) = R / (R + r)$
So as R increases the ratio becomes larger or ratio of power in load to power in internal resistance increases ✓

Explanation in terms of V and ε is acceptable

2

[9]

10 (a) (i) resistivity is defined as

$$\rho = \frac{RA}{l}$$

where R is the resistance of the material of length l ✓
and <u>cross-sectional</u> area A ✓

2

(ii) <u>below</u> the critical temperature / maximum temperature which resistivity / resistance ✓
is zero / becomes superconductor ✓

Any reference to negligible / small / very low resistance loses second mark

2

(b) (*use of* $\rho = \frac{RA}{l}$)

$\rho = 0.70 \times \pi \times 0.0005^2 / 4.8$ ✓ $= 1.1(5) \times 10^{-7}$ (1.1 – 1.2) ✓ ✓ Ω m ✓

First mark for substitution R and l
Lose 1 mark if diameter used as radius and answer is 4 times too big (4.4 – 4.8) OR if power of ten error

4

[8]

11 (a) (i) *(use of V=Ir)*
V= 4.2 × 1.5 ✓ = 6.3 (V)

1

(ii) pd = 12 − 6.3 = 5.7 V✓

NO CE from (i)

1

(iii) (*use of I = V / R*)
I = 5.7 / 2.0 = 2.8(5) A✓

CE from (ii)
(a(ii)/2.0)
accept 2.8 or 2.9

1

(iv) $I = 4.2 - 2.85 = 1.3(5)$ A ✓

CE from (iii)
(4.2 −(a)(iii))
accept 1.3 or 1.4

1

(v) $R = 5.7 / 1.35 = 4.2\ \Omega$ ✓

CE from (iv)
(a(ii) / (a)(iv))
Accept range 4.4 to 4.1

1

(vi) $$\frac{1}{R_{Parallel}} = \frac{1}{4.2} + \frac{1}{2.0} = 0.737$$ ✓

CE from (a)(v)

$R_{parallel} = 1.35\ \Omega$

second mark for adding internal resistance

$R_{total} = 1.35$ <u>+ 1.5</u>✓ = 2.85 Ω
OR
R = 12/4.2 ✓
R= 2.85 Ω ✓

2

(b) (i)

resistor	Rate of energy dissipation (W)
1.5 Ω internal resistance	$4.2^2 \times 1.5 = 26.5$✓
2.0 Ω	$2.85^2 \times 2.0 = 16.2$ (15.68 − 16.82)✓
R	$1.35^2 \times 4.2 = 7.7$ (7.1 − 8.2)✓

CE from answers in (a) but not for first value

2.0: $a(iii)^2 \times 2$

R: $a(iv)^2 \times a(v)$

3

(ii) energy provided by cell per second = 12 × 4.2 = <u>50.4</u> (W) ✓
energy dissipated in resistors per second = 26.5 + 16.2 + 7.7 = 50.4 ✓
(hence energy input per second equals energy output)

if not equal can score second mark if an appropriate comment

2

[12]

12 (a) (i) *(use of I = V / R)*

first mark for adding resistance values 90 k Ω

$I = 6.0 / (50\,000 + 35\,000 + 5000)$ ✓ $= 6.7 \times 10^{-5}$ A ✓

accept 7×10^{-5} or dotted 6×10^{-5}

but not 7.0×10^{-5} and not 6.6×10^{-5}

2

(ii) $V = 6.7 \times 10^{-5} \times 5000$ ✓ $= 0.33$ (0.33 − 0.35) V ✓

OR

$V = 5 / 90 \times 6$ ✓ $= 0.33$(V) ✓

CE from (i)

BALD answer full credit

0.3 OK and dotted 0.3

2

(b) resistance of LDR decreases ✓

need first mark before can qualify for second

reading increase because greater proportion / share of the voltage across R OR higher current ✓

2

(c) $I = 0.75 / 5000 = 1.5 \times 10^{-4}$ (A) ✓

(pd across LDR = 0.75 (V))

pd across variable resistor = 6.0 − 0.75 − 0.75 = 4.5 (V) ✓

$R = 4.5 / 1.5 \times 10^{-4} = 30\,000$ Ω ✓

or

$I = 0.75 / 5000 = 1.5 \times 10^{-4}$ (A) ✓

$R_{total}I = 6.0 / 1.5 \times 10^{-4} = 40\,000$ Ω ✓

$R = 40\,000 - 5000 - 5000 = 30\,000$ Ω ✓

3

[9]

13 (a) potential divider formula used or current found to be 0.25 A

C1

A1

allow 1 s.f.

2.0 V

1.0 V (with working) gains 1 mark

2

(b) main current =1.2 V / 4 Ω = 0.3 (A)

C1

R_{total} = 1.8 V / 0.3 A = 6 Ω or I_8 = 0.225 (A)

C1

R_V = 24 Ω

A1

3

[5]

14 (a) (i) calculated cross-sectional area = 1.54×10^{-6} (m^2) or *correct substitution*

C1

1.6×10^{-3} (treating r as A) gains 2

into resistivity equation *with incorrect powers of ten correct substitution*

C1

into resistivity equation *with correct powers of ten*

0.73 (Ω)

A1

3

(ii) Sub into $I^2 R$ irrespective of power of 10 [ecf from (a)(i)]

C1

2.96×10^{-4} (W)

A1

2

(b) line with positive slope (linear or curve)

B1

knee and vertical line shown in first 2 / 3 on temperature axis

B1

resistivity falling to zero above 0 K

B1

3

(c) (with no resistance there can be) <u>no</u> power loss

B1

1

[9]

15

(a) (i) **1/R $_{total}$ = 1/(40)**✓+1/(10+5) ✓= 0.09167
R $_{total}$ = 10.9 kΩ ✓

3

(ii) I = 12 / 10.9 k = 1.1 mA✓

1

(b)

position	pd / V
AC	6.0✓
DF	4.0✓
CD	2.0✓

C.E. for CD

3

(c) (i) AC: no change✓
constant pd across resistors / parallel branches(AE) ✓

no CE from first mark

2

(ii) DF: decreases✓
as greater proportion of voltage across fixed / 10 k Ω resistor ✓

no CE from first mark

2

[11]

16

(a) use of $E = ItV$ (or equivalent) or substitution into equation irrespective of powers of 10

C1

allow 2 for 6120 (J)

emf = 4.0 V

C1

1.22×10^4 J

A1

3

(b) Internal resistance = 1.2 (Ω)

C1

allow 2 for 0.22(6) V

Current calculated (0.19 A) or potential divider formula used 3.7(7) V

C1

A1

3

[6]

17 (a) 1 joule per coulomb (or equivalent)

B1

allow watt per amp

1

(b) (i) Use of potential divider formula

C1

allow 1 for 4.05 (V) or current of 2.25 (mA)

4.95 (V)

A1

2

(ii) reduced current

B1

1

(iii) use of parallel resistor formula

C1

leading to 1.72 (kΩ)

C1

pd = 4.4 (V)

A1

3

(iv) potential divider can provides sensitive control of current (from 0 - 1.1 mA)

B1

allow pot div can provide zero current ***and*** *variable resistor gives larger current*

variable resistor can provide larger current but cannot get near 0 A owtte

B1

2

[9]

18 (a) (i) *(use of P=VI)*

I = 36/12 + 6/12 ✓ = 3.5 (A) ✓

2

(ii) *(use of V=IR)*

R = 12/3 = 4 (Ω) ✓

1

(iii) *R* = 12/0.50 = 24✓ (Ω)

1

(b) terminal pd/voltage across lamp is now less OR current is less ✓

due to lost volts across internal resistance OR due to higher resistance ✓

lamps less bright ✓

3

(c) (i) current through lamps is reduced as resistance is increased **or** pd across lamps is reduced as voltage is shared ✓

hence power is less OR lamps dimmer ✓

2

(ii) lamp Q is brighter ✓

lamp Q has the <u>higher resistance</u> hence <u>pd/voltage</u> across is greater ✓

current is the same for both ✓

hence power of Q greater ✓

3

[12]

19 (a) (use of *P* = V/*I*)

$I = 36/12 = 3.0$ A ✓

$I = 2.0/4.5 = 0.44$ A ✓

2

(b) (i) pd = 24 − 12 = 12 V ✓

1

(ii) current = 3.0 + 0.44 = 3.44 A ✓

1

(iii) R_1 = 12/3.44 = 3.5 Ω ✓

1

(iv) pd = 12 − 4.5 − 7.5 V ✓

1

(v) R_2 = 7.5/0.44 = 17 Ω ✓

1

(c) (i) (circuit) resistance increases ✓

current is lower (reducing voltmeter reading) ✓

or correct potential divider argument

2

(ii) pd across Y **or** current through Y increases ✓

hence power/rate of energy dissipation greater **or** temperature of lamp increases ✓

2

[11]

20 (a) correct substitution into $P = V^2/R$
(condone power of 10 error)

C1

R = 2.62 (Ω) = 144/55 = 12^2/55

C1

correct substitution into ρ= RA/L
(condone error on R and/or power of 10 errors)

C1

resistivity = 9.9(5) × 10^{-7} (range 9.9 to 9.95 × 10^{-7})

A1

unit = Ω m

B1

5

(b) (i) joules per coulomb (of charge)/work done per unit charge
(treat reference to force as neutral)

M1

where charge moved (whole way) round circuit

A1

2

(ii) lost volts = 0.1 (V) or 0.1 seen as voltage

C1

r = 0.011 to 1.09 × 10^{-2} (Ω)

A1

2

(c) brightness decreases

B1

increased current (in circuit/battery)

B1

increased lost volts leading to decreased pd across bulb or decreased terminal pd

B1

3

[12]

21 (a) mention of pd across internal resistance **or** energy loss in internal resistance **or** emf > V ✔

pd across internal resistance/lost volts increases with current **or** correct use of equation to demonstrate ✔

2

(b) (i) *y – intercept* 1.52 V (± 0.01 V) ✔

1

(ii) identifies gradient as *r* **or** use of equation ✔

substitution to find gradient **or** substitution in equation ✔

r = 0.45 ± 0.02 Ω ✔

3

(c) (i) same intercept ✓

double gradient (must go through 1.25, 0.40 ± 1.5 squares) ✓

2

(ii) same intercept horizontal line ✓

1

(d) (i) (use of $Q = It$)

$Q = 0.89 \times 15 = 13$ ✓ C ✓

2

(ii) use of $P = I^2r$ ✓

$P = 0.89^2 \times 0.45$

$P = 0.36$ W ✓

2

[13]

22 (a) (i) $P = V^2/R$ with substitution: 144/any resistance

C1

37.9 (W)

A1

2

(ii) use of $1/R$ formula with substitution of some data even if not all five resistors

C1

correct calculation of $1/R$ (giving 0.897)

C1

1.11 (Ω)

A1

3

(iii) 144/their aii

C1

129 to 131 (W) **ecf**

A1

2

(b) lower resistance needed

B1

(to achieve) higher current (for I^2R to be the same)/
correct use of V^2/R

B1

2

[9]

23 (a) (i) voltage = 0.01 × 540 = 5.4 V **(1)**

1

(ii) voltage = 15 – 5.4 = 9.6 V **(1)**

1

(iii) (use of resistance = voltage/current)

resistance = 9.6/0.01 **(1)** = 960 Ω **(1)**

or R_T = 15/0.01 = 1500 Ω **(1)**

R = 150 – 590 = 960 Ω **(1)**

or potential divider ratio **(1)(1)**

2

(iv) (use of $1/R = 1/R_1 + 1/R_2$)

$1/960 = 1/200 + 1/R_2$ **(1)**

$1/R_2 = 1/960 – 1/1200$

R_2 = 4800 Ω **(1)**

2

(b) (voltage of supply constant)

(circuit resistance decreases)

(supply) current increases or potential divider argument **(1)**

hence pd across 540 Ω resistor increases **(1)**

hence pd across 1200 Ω decreases **(1)**

or resistance in parallel combination decreases **(1)**

pd across parallel resistors decreases **(1)**

pd across 1200 Ω decreases **(1)**

3

[9]

24 (a) (use of $R = \rho l/A$)

$R = 4.0 \times 10^{-3} \times 0.060$ **(1)**$/(\pi \times 0.012^2)$ **(1)**

$R = 0.53$ (Ω) **(1)**

2 significant figures **(1)**

4

(b) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

circuit must include:

voltmeter and ammeter connected correctly **(1)**

power supply with means of varying current **(1)**

2

QWC	descriptor	mark range
good-excellent	(i) Uses accurately appropriate grammar, spelling, punctuation and legibility. (ii) Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [may include bullet points and/or formulae or equations] An excellent candidate will have a working circuit diagram with correct description of measurements (including range of results) and processing. An excellent candidate uses a range of results and finds a mean value or uses a graphical method, eg *I-V* characteristics. They also mention precision eg use of vernier callipers.	**5-6**
modest-adequate	(i) Only a few errors. (ii) Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. An adequate candidate will have a working circuit and a description with only a few errors, eg do not consider precision. They have not taken a range of results and fail to realise that the diameter needs to be measured in several places.	**3-4**
poor-limited	(i) Several significant errors. (ii) Answer lacking structure, arguments not supported by evidence and contains limited information. Several significant errors, eg important measurement missed, incorrect circuit, no awareness of how to calculate resistivity.	**1-2**
incorrect, inappropriate or no response		**0**

The explanation expected in a good answer should include a coherent account of the procedure and include most of the following points.

- length with a ruler
- thickness/diameter with vernier callipers/micrometer
- measure voltage
- measure current
- calculate resistance
- use of graph, eg *I*-*V* or resistance against length
- use of diameter to calculate cross-sectional area
- mention of precision, eg vernier callipers or full scale readings for V and I
- flat metal electrodes at each end to improve connection

6

[12]

25 (a) (i) 6.0 (Ω) **(1)**

1

(ii) 4.5 (V) **(1)**

1

(iii) (use of $I = V/R$)

I = 4.5/6.0 = 0.75 (A) **(1)**

current through cell A = 0.75/2 = 0.375 (A) **(1)**

2

(iv) charge = 0.375 × 300 = 112 **(1)** C **(1)**

2

(b) cells C and D will go flat first or A and B last longer **(1)**

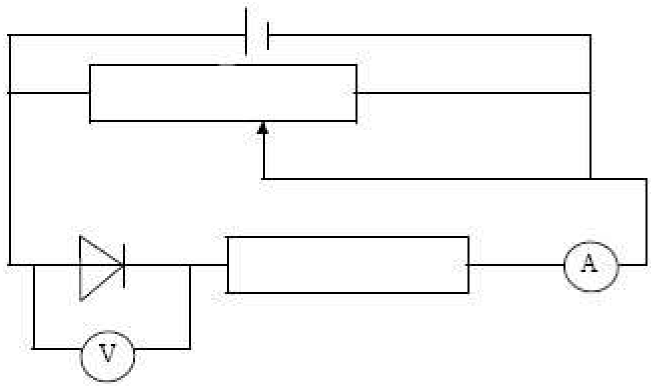
current/charge passing through cells C and D (per second) is double/more than that passing through A or B **(1)**

energy given to charge passing through cells **per second** is double or more than in cells C and D **(1)** or in terms of power

3

[9]

26 (a) (i)



suitable variable input (variable power supply or variable resistor) **(1)**

protective resistor **and** diode **forward** biased **(1)**

correct current **and** pd measuring devices **(1)**

3

(ii) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

QWC	descriptor	mark range
good-excellent	Uses accurately appropriate grammar, spelling, punctuation and legibility. Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [May include bullet points and/or formulae or equations]. Answer refers to at least 5 of the relevant points listed below.	**5-6**
modest-adequate	Only a few errors. Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. Answer refers to at least 3 or the relevant points listed below.	**3-4**
poor-limited	Several significant errors. Answer lacking structure, arguments not supported by evidence and contains limited information. Answer refers to no more than 2 of the relevant points.	**1-2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**

The explanation expected in a competent answer should include a coherent selection of the following physics ideas.

connect circuit up **(1)**

measure current (I) and pd/voltage (V) **(1)**

vary resistance/voltage **(1)**

obtain a range of results **(1)**

reverse connections to power supply (and repeat) **(1)**

plot a graph (of pd against current) **(1)**

mention of significance of 0.6V **or** disconnect between readings **or** change range on meters when doing reverse bias **(1)**

(b) (i) (use of $I = V/R$)

I = 12/8 **(1)**= 1.5A **(1)**

(ii) I = (12 – 0.65 **(1)**)/4 = 2.8 A **(1)** sig figs **(1)**

5

[14]

27 (a) superconductivity means a material has zero resistivity/resistance **(1)**

resistivity decreases with temperature **or** idea of cooling **(1)**

becomes superconducting when you reach the critical/certain/ transition temperature **(1)**

3

(b) (i) (use of $R = \rho l/A$)

$0.075 = \rho \times 1/(2.28 \times 10^{-7})$ **(1)** (must see working or equation)

$R = 1.7 \times 10^{-8}$ **(1)** Ωm **(1)**

(ii) **max 3 from**

the resistance decreases (to zero) **(1)**

copper still has resistance **(1)**

but this is in parallel with filaments (which have zero resistance) **(1)**

hence **total** resistance is zero **(1)**

current goes through filaments **(1)**

6

[9]

28 (a) (i) work done (by the battery) per unit charge **(1)**
or (electrical) energy per unit charge
or pd/voltage when open circuit/no current

(ii) the resistance of the materials within the battery **(1)**
or hindrance to flow of charge **in** battery
or loss of pd/voltage per unit current

2

(b) (i) (use of $E = V + Ir$)

$12 = V + 800 \times 0.005$ **(1)** (working/equation needs to be shown)

$V = 12 - 4 = 8.0\text{V}$ **(1)**

(ii) (use of $P = I^2r$)

$P = 800^2 \times 0.005$ **(1)** (working/equation needs to be shown)

$P = 3200$ **(1)** W **(1)** **or** J s^{-1}

5

(c) car will probably **not** start **(1)**

battery will not be able to provide enough current **(1)**
or less current
or lower terminal pd/voltage

2

[9]

29 (a) $R = \frac{\rho l}{A}$ **(1)**

ρ is resistivity, l is the length of the wire, A is the cross-sectional area **(1)**

2

(b) (i) $P = \frac{V^2}{R}$ **(1)**

$R = \frac{230^2}{500} = 106(\Omega)$**(1)** (105.8 Ω)

$l = \left(\frac{RA}{\rho}\right) = \frac{105.8 \times 8.0 \times 10^{-8}}{1.1 \times 10^{-6}} = 7.7$ m **(1)** (7.69 m)

(allow C.E. for incorrect value of R)

(ii) in series, voltage across each < 230 V or pd shared **(1)**

∴ power (= V^2/R) is less than 500 W in each **(1)**

in parallel, voltage across each = 230 V **(1)**

∴ correct rating, ∴ conclusion **(1)**

[or, in series, high resistance or combined resistance **(1)**

∴ low current **(1)**

in parallel, resistance is lower, ∴ higher current **(1)**

more power, justified **(1)**]

max 6

[8]

30 (a) between A and C: (each) series resistance = 100Ω **(1)**

(parallel resistors give) $\frac{1}{100} + \frac{1}{100} = \frac{1}{50}$ + = gives R_{AC} = 50Ω **(1)**

2

(allow C.E. for incorrect series resistance)

(b) between A and B: series resistance = 150Ω **(1)**

parallel = $\frac{1}{50} + \frac{1}{150}$ **(1)**

(allow C.E. for series resistance)

R_{AB} = 37.5Ω **(1)** (38Ω)

3

[5]