LONDON SCIENCE COLLEGE

Name:

Date:

ELECTRICITY
TEST 2

AS-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

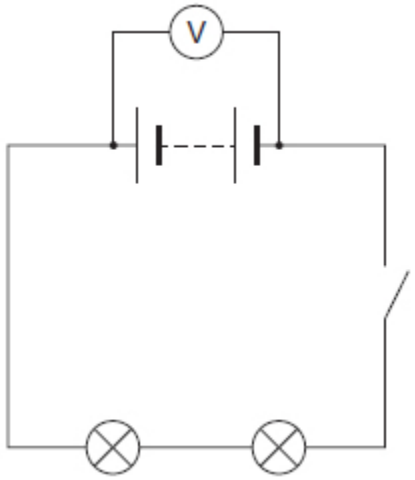
1 State what is meant by a superconductor.

_____

_____

(Total 1 mark)

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



(a) Define potential difference.

_____

_____

(1)

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

_____

_____

_____

_____

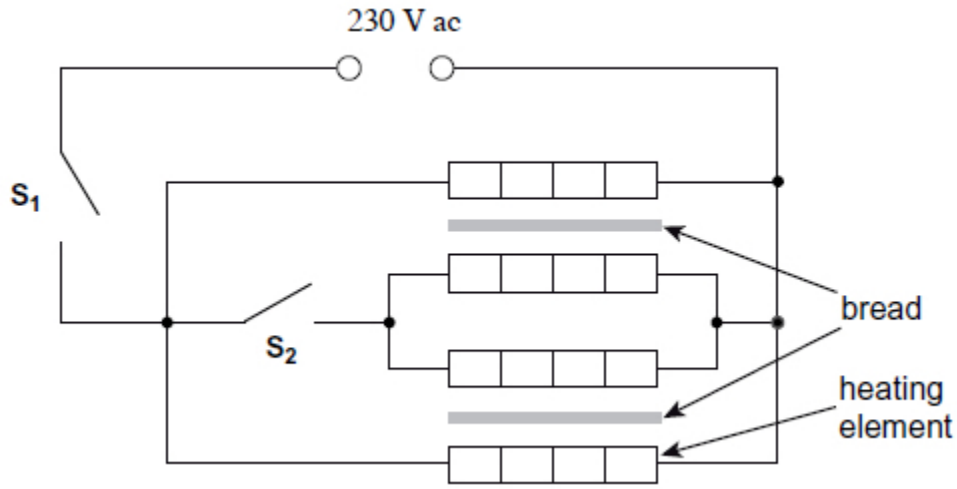
_____

_____

(3)

(Total 4 marks)

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



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

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

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

(a) Calculate the current in $\mathbf{S_2}$ 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.

_____

_____

_____

_____

_____

(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.

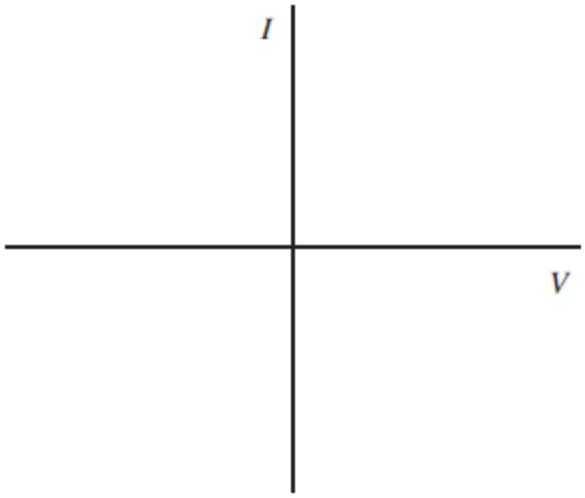
peak wavelength _____ m

(3)

(Total 15 marks)

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

Figure 1



(2)

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

_____

(1)

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

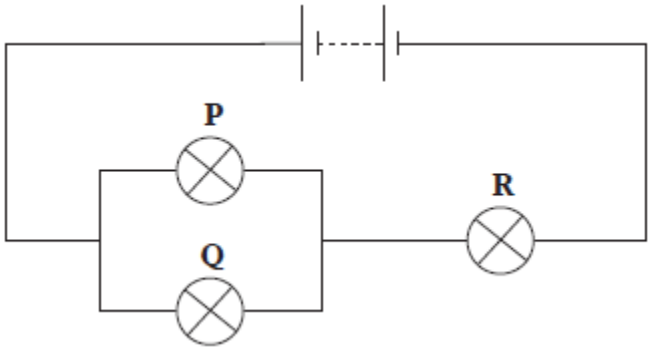
_____

_____

(1)

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

Figure 2.



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

_____

_____

_____

_____

_____

_____

(2)

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

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

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

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

(2)

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

_____

_____

_____

_____

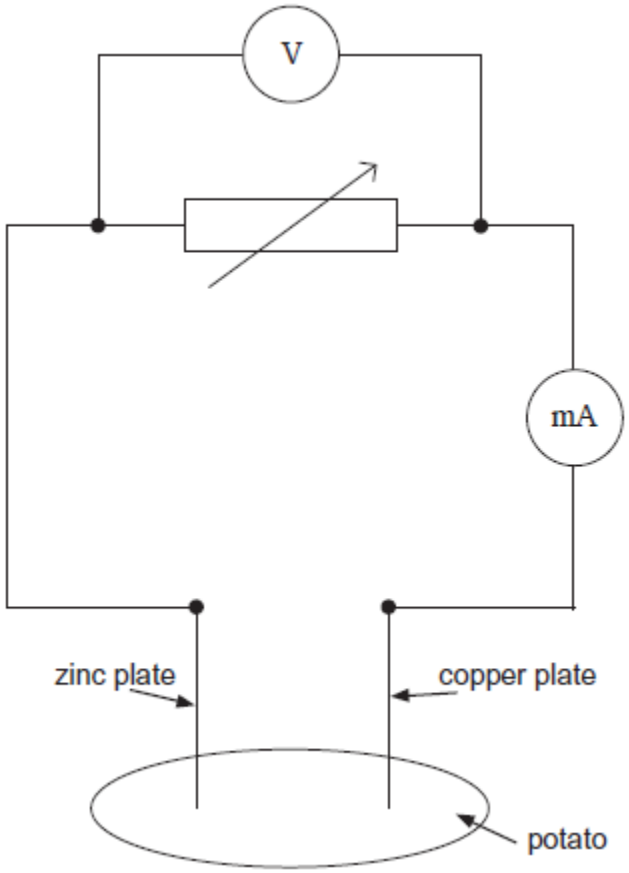
_____

(2)

(Total 10 marks)

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

Figure 1



(a) State what is meant by electromotive force.

_____

_____

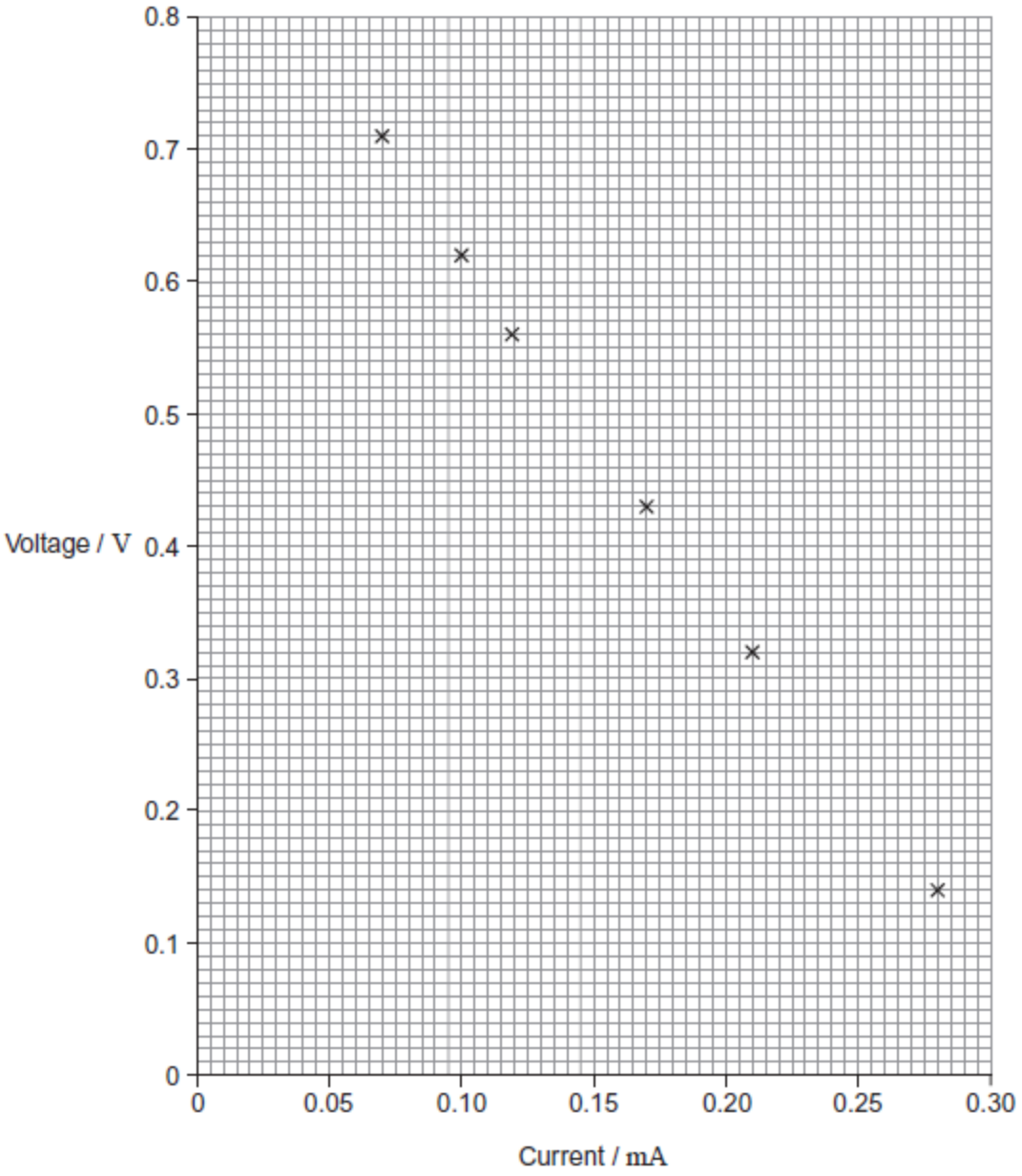
_____

_____

(2)

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

Figure 2



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

_____

_____

_____

_____

(1)

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

_____

_____

_____

_____

_____

_____

_____

(3)

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

internal resistance = _____ Ω

(3)

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

Explain whether the LED will work as required.

_____

_____

_____

_____

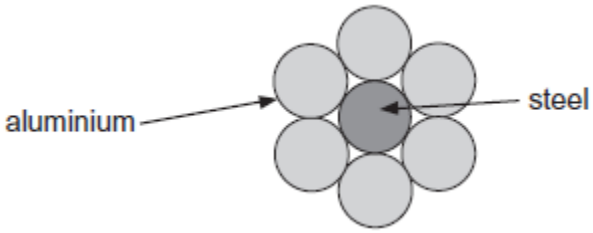
_____

_____

(2)

(Total 11 marks)

6 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.

_____

_____

_____

_____

_____

_____

_____

(3)

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

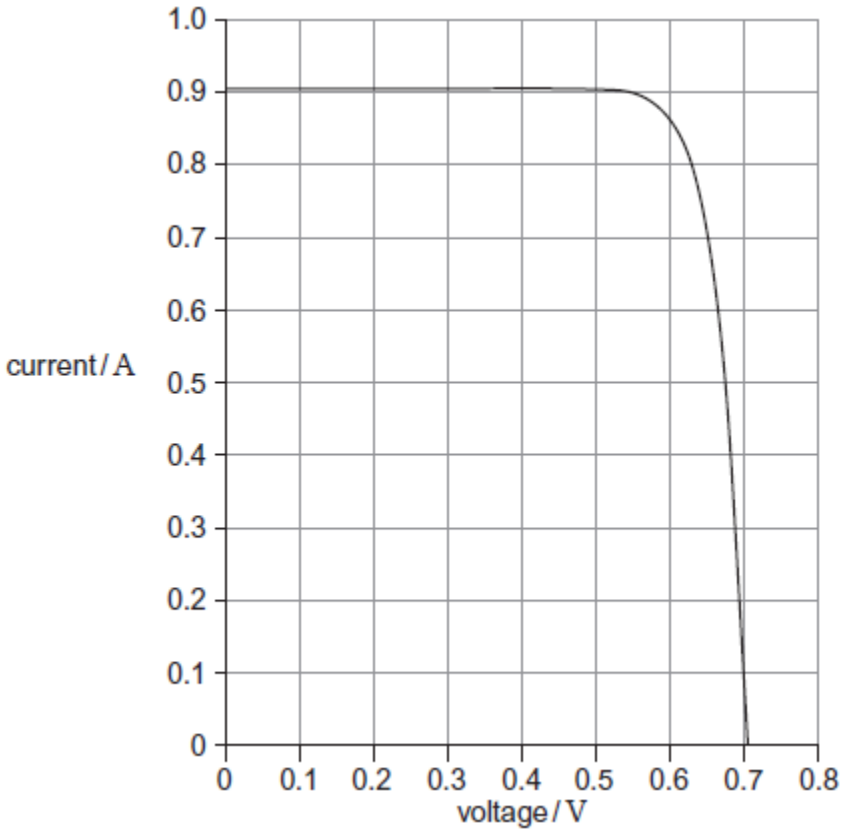
Calculate the total power loss for a 1.0 km length of cable.

Total power loss _____ W

(3)

(Total 10 marks)

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

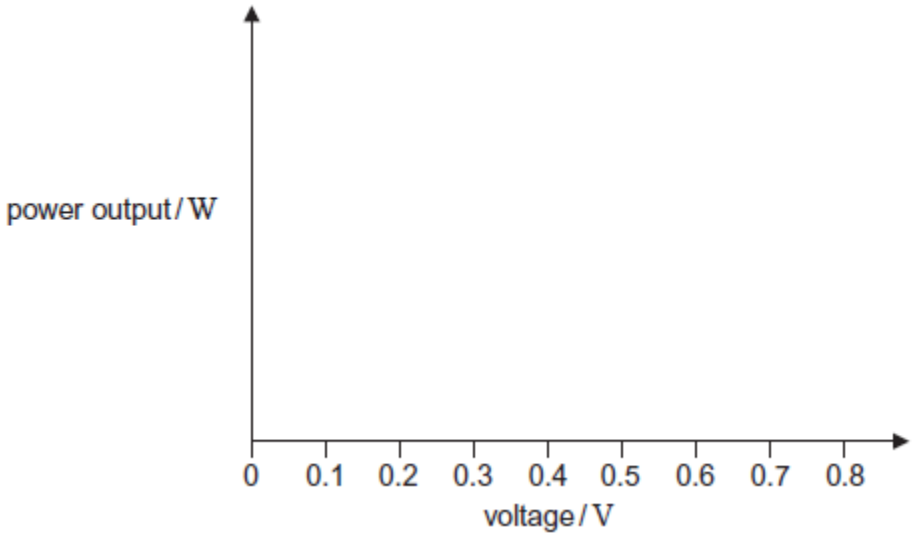


(a) (i) Using data from the graph above estimate the **maximum** power output from the solar cell.

maximum power _____ W

(2)

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



(2)

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

Calculate the area of the solar cell.

area _____ m^2

(3)

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

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

_____

_____

(1)

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

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

number of cells _____

(4)

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

Your answer should refer to:

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

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

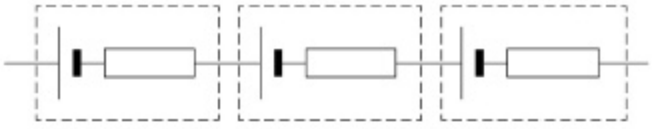
(6)

(Total 18 marks)

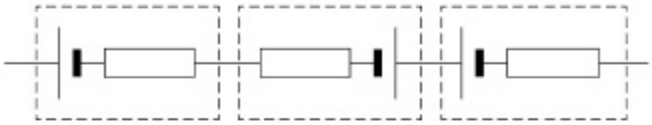
8 Three cells each have an emf ε = 1.5 V and an internal resistance r = 0.6 Ω.

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

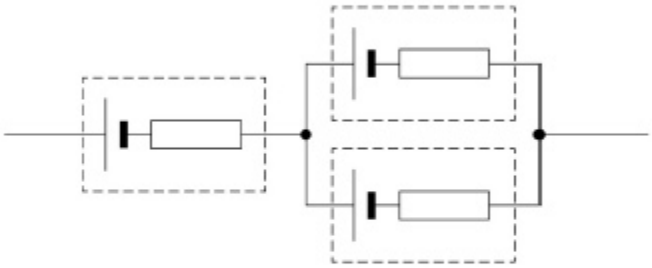
A



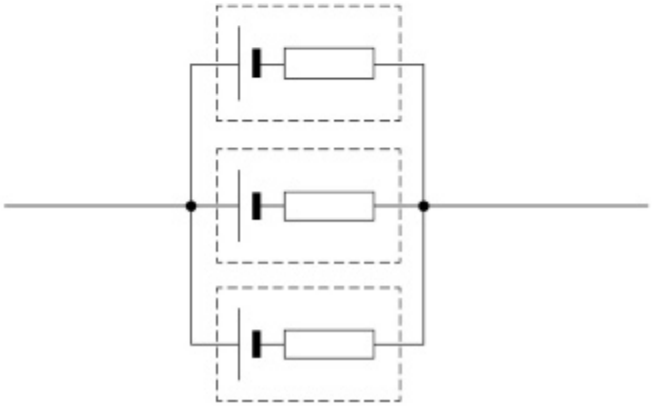
B



C



D



A ⬭

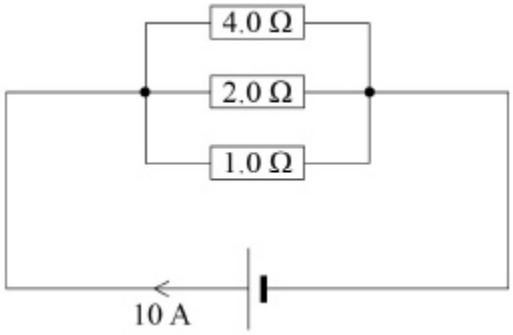
B ⬭

C ⬭

D ⬭

(Total 1 mark)

9 The current in the cell is 10 A as shown.



What is the current in the 2.0 Ω resistor?

A 0.35 A ⬭

B 2.86 A ⬭

C 3.50 A ⬭

D 7.14 A ⬭

(Total 1 mark)

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

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

A 111 J ⬭

B 390 J ⬭

C 6650 J ⬭

D 23 400 J ⬭

(Total 1 mark)