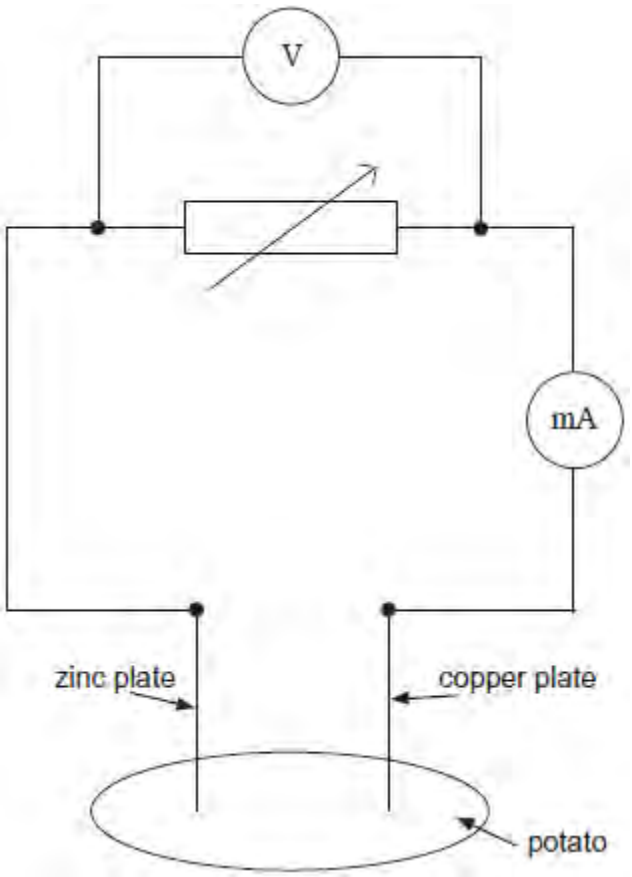
**Q1.**A 'potato cell' is formed by inserting a copper plate and a zinc plate into a potato. The circuit shown in **Figure 1** is used in an investigation to determine the electromotive force and internal resistance of the potato cell.

**Figure 1**




(a) State what is meant by electromotive force.

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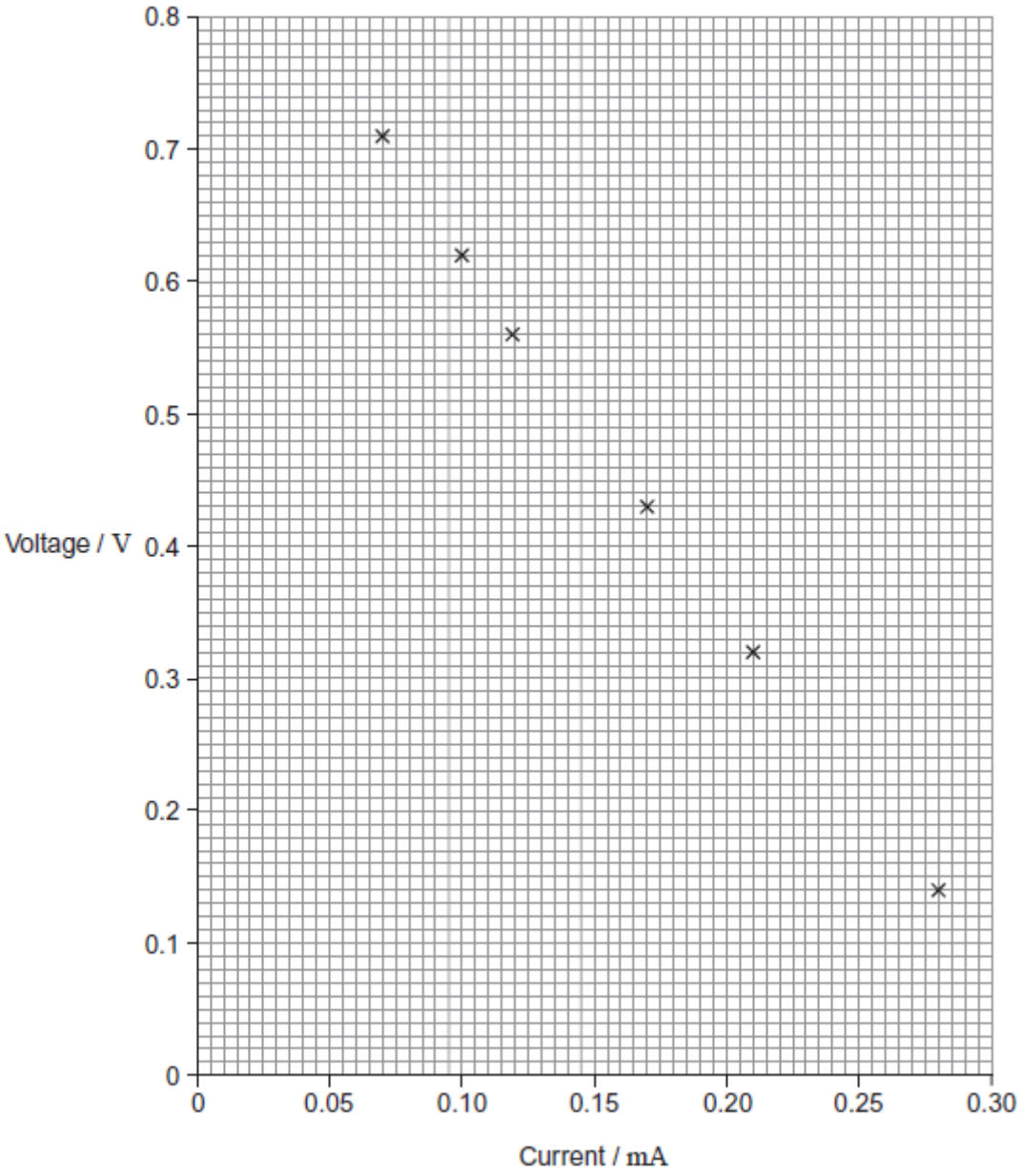
**(2)**

(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.

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**(1)**

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

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**(3)**

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

internal resistance = ..... Ω

**(3)**

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

Explain whether the LED will work as required.

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**(2)**
**(Total 11 marks)**

**Q2.**(a) (i) Describe how you would make a direct measurement of the emf $\varepsilon$ 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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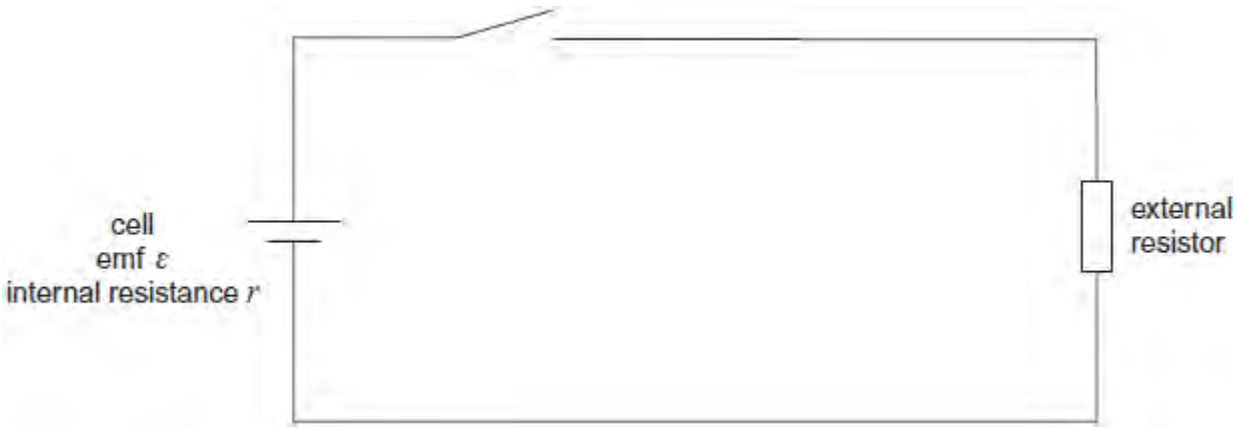
**(1)**

(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 $\varepsilon$ is the emf of the cell

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

**(1)**

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

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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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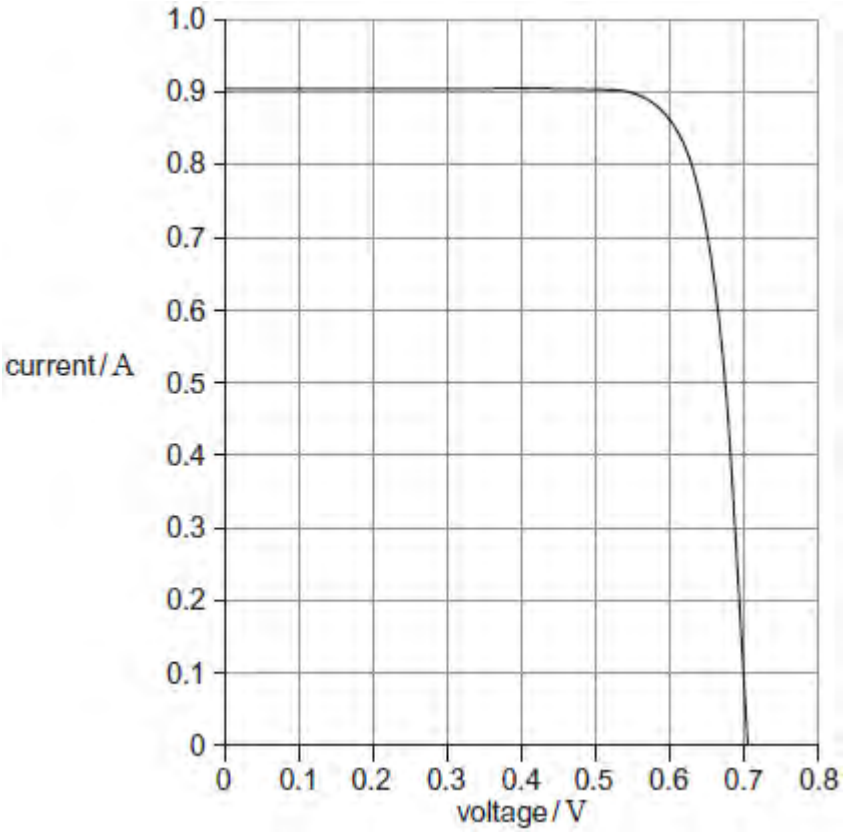
**(2)**
**(Total 9 marks)**

**Q3.** 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.

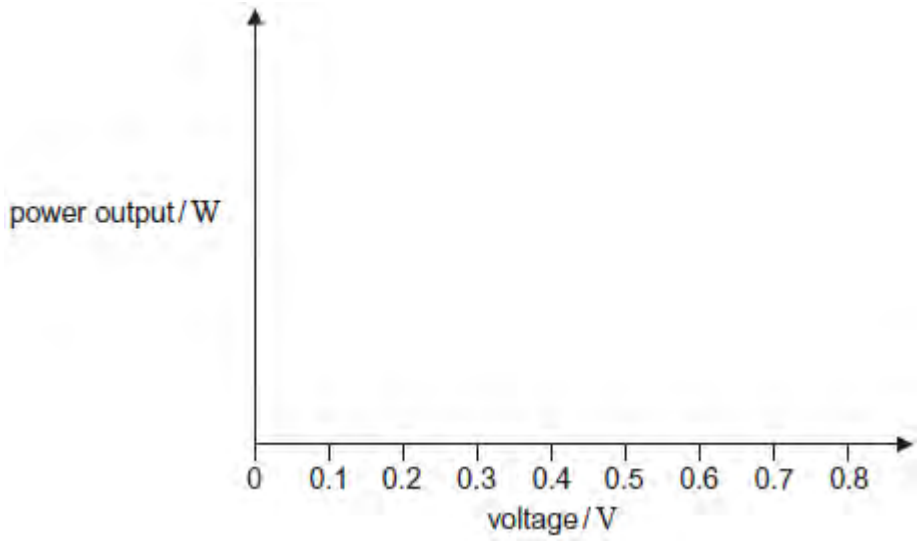



(a) (i) Using data from the graph above estimate the **maximum** power output from the solar cell.

**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.

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**(1)**

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

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

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number of cells .....

**(4)**

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

Your answer should refer to:

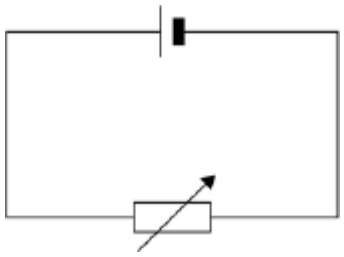
- any additional features that would be needed to ensure that the satellite's electrical systems operate continuously
- whether solar cell arrays are appropriate for space probes that travel to the edge of the solar system.

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

**(6)**

**(Total 18 marks)**

**Q4.** The cell in the circuit has an emf of 2.0 V. When the variable resistor has a resistance of 4.0 Ω, the potential difference (pd) across the terminals of the cell is 1.0 V.



What is the pd across the terminals of the cell when the resistance of the variable resistor is 12 Ω?

**A** 0.25 V ⬭

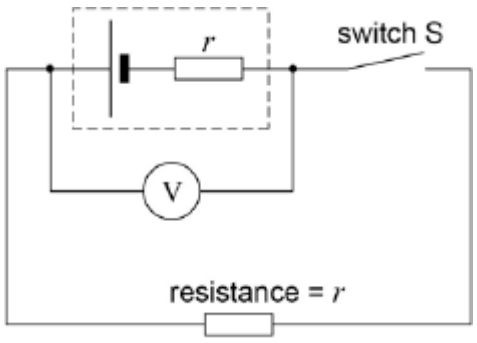
**B** 0.75 V ⬭

**C** 1.33 V ⬭

**D** 1.50 V ⬭

**(Total 1 mark)**

**Q5.** In the circuit shown, V is a voltmeter with a very high resistance. The internal resistance of the cell, $r$, is equal to the external resistance in the circuit.




external resistance

Which of the following is not equal to the emf of the cell?

**A** the reading of the voltmeter when the Switch S is open ⬭

**B** the chemical energy changed to electrical energy when ⬭

unit charge passes through the cell

**C** twice the reading of the voltmeter when the switch S is closed ⬭

**D** the electrical energy produced when unit current passes through the cell ⬭

**(Total 1 mark)**